



Northeast Coastal and Barrier Network Geomorphological Monitoring Protocol: Part II—Coastal Topography

Standard Operating Procedures

Version 2.00



November 2023

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SOP Tracking Table

The following table provides the versioning record for both this Standard Operating Procedure (SOP) document and the associated Protocol version number. For specific information on changes made to individual SOPs, please see the Revision History Logs at the end of each individual SOP.

SOP Tracking Table: Coastal Topography Monitoring (Checked SOPs are those modified on the date indicated)															
Date of Revision	Protocol Document Version #	SOP Document Version #	SOP 1 - Monitoring Design Background	SOP 2 - Equipment & Supplies	SOP 3 - Monuments, Transects, and Geodatabases	SOP 4 - Training for Field Data Collection	SOP 5 - Survey Timing and Mission Planning	SOP 6 - Basic Requirements for Data Collection	SOP 7 - Conducting the Survey	SOP 8 - Post-Survey Processing	SOP 9 - Change Calculation and Data Analysis	SOP 10 - Reporting	SOP 11 - Data Management	SOP 12 - Annual Operational Review	SOP 13 - Protocol/SOP Versioning
4/12/2013	1.00	1.00													
2/1/2023	2	2.00	X	X	X	X	X	X	X	X	X	X	X	X	X

SOP 1: Monitoring Design Background and Justification for Northeast Coastal and Barrier Network Parks

Version 2.00

1.1 Objective

The coastal topography protocol can be implemented in four of the Northeast Coastal and Barrier Network parks, Cape Cod National Seashore (CACO), Fire Island National Seashore (FIIS), Gateway National Recreation Area (GATE), and Assateague Island National Seashore (ASIS). Based on NCBN and/or park staffing capabilities, as well as funding levels, the Network currently (2023) has implemented the protocol at GATE and ASIS only, with field technicians from both the NCBN and ASIS, however, a sampling plan has been developed for all four parks and is presented in this SOP.

The information on the network of survey transects within each park, including description of the locations and attributes of each survey physical or virtual monument, is stored in GIS files maintained by the Project Lead and the NCBN Data Manager. Additionally, field booklets are created for each park with a brief description of each monument type and location, including aerial photos of the site, ground photos, and coordinates and elevation information. Data storage and creation of the field booklets are both described in *SOP 2: Establishment of Monuments, Transects, and Geodatabases*.

The line features for each park are stored as GIS files. The guidelines and procedures to create and store the transect lines are described in *SOP 3: Establishment of Monuments, Transects, and Geodatabases*.

The network of monuments and transects established for the four NCBN parks have a specific nomenclature according to the park's name (Table S1.1). For GATE, the park has multiple geographical sections within three park units. (Table S1.1).

Table S1.1. Nomenclature used in the Coastal Topography Protocol.

NCBN Park	Park Unit	Park Section	Protocol Nomenclature
ASIS	—	—	ASIS
CACO	—	—	CACO
GATE	Sandy Hook Unit	—	GATE_SHU
	Staten Island Unit	Great Kills	GATE_SIU_GK
	Staten Island Unit	Miller Field	GATE_SIU_MF
	Staten Island Unit	Fort Wadsworth	GATE_SIU_FW
	Jamaica Bay Unit	Breezy Point	GATE_JBU_BP
	Jamaica Bay Unit	Plumb Beach	GATE_JBU_PB
FIIS	—	—	FIIS

1.2 Identification of Sampling Locations for NCBN Parks

1.2.1 Background Information

The following is a description of the transects and monuments established for each of the four NCBN parks. Only GATE and ASIS have been verified in the field and currently being monitored.

Assateague Island National Seashore

In 1995, ASIS initiated a monitoring program that includes documentation of beach profile topography twice per year. The network of beach transects consists of 33 monuments spaced at 0.25 km intervals on the North End of the park and at 2 km intervals for the remainder of the Maryland coast. There are no transects in the Virginia section of Assateague Island in this program. The higher number of transects, and therefore the higher resolution of data, at the northern end of the island is related to an area of active management for the park, the ongoing North End Restoration project, and the effects of nearshore dredging.

The network of transects and monuments was first established by Taylor, Wisemann, and Taylor in 1993 (Taylor et al., 1994), and later expanded by NPS personnel in 1995. In 2004, the monuments were re-surveyed using newly-acquired GPS/GNSS RTK-capable survey equipment to verify their documented geographical coordinates.

The 33 transects have a constant azimuth of 111° defining the direction of data collection, roughly perpendicularly to the ocean shoreline. Some surveys cover the entire surface from oceanside to bayside. In these cases, the 291° azimuth defines the transect starting at the transect monument and directed toward the bayside.

The pre-existing network of 33 monuments and transects at Assateague have been maintained and continue to be monitored as part of this protocol (Figure S1.1).



Figure S1.1. Spatial network of monuments and transects at Assateague Island National Seashore, Maryland.

Cape Cod National Seashore

Cape Cod was the target of an intensive field research program conducted by Henry L. Marindin of the U.S. Coast and Geodetic Survey between 1887 and 1889 (Zeigler et al., 1964). The dataset corresponds to 229 beach profile lines, surveyed from the dune or bluff position to 1-2 km offshore, and spaced at 300 m intervals from Chatham to Provincetown. The NPS is working with the Provincetown Center for Coastal Studies to re-survey the "Marindin profiles" to determine the trends and dimensions of geomorphological changes along the Cape Cod coast. The re-occupation of some of these lines provides an opportunity to establish the current network of monuments and take advantage of a historical topographical dataset. From this dataset, a network of 22 transect locations have been identified to be used for continued monitoring (Figure S1.2), as resources permit. Establishment and verification of the monuments have not yet been completed.

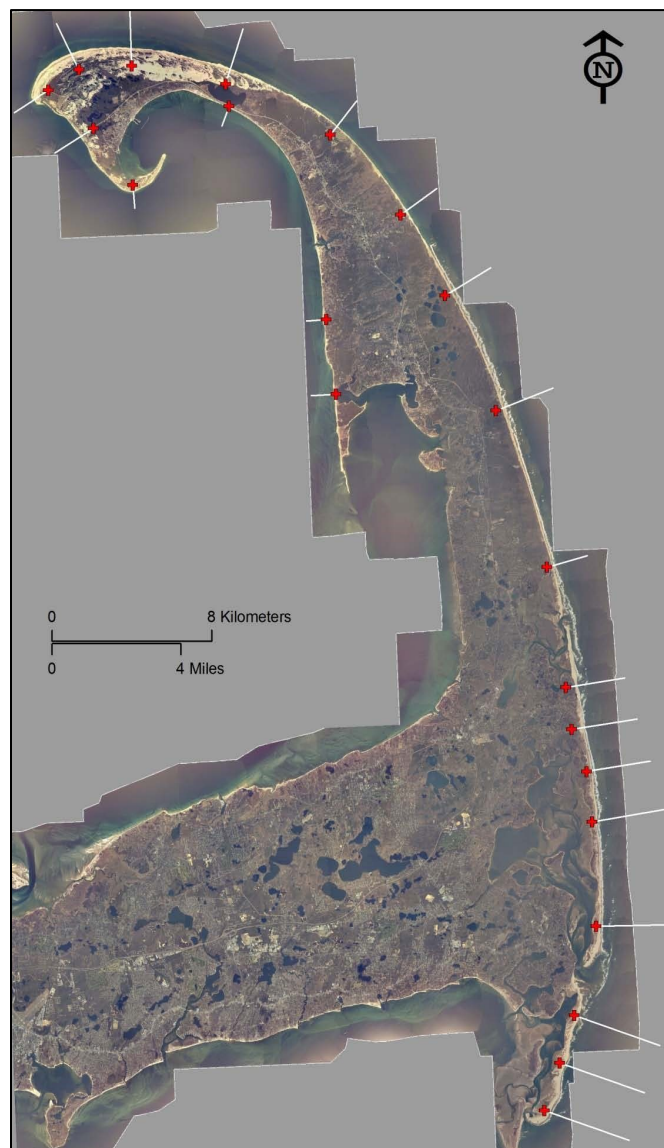


Figure S1.2. Proposed spatial network of physical monuments and transects at Cape Cod National Seashore, Massachusetts.

Gateway National Recreation Area

The network of transects at Gateway's three park units (Figure S1.3) was established by the team of Dr. Norbert Psuty from Rutgers University. At the Sandy Hook Unit, some pre-existing transects established as early as 1984 by Rutgers (Namikas, 1992) to monitor areas of special interest along Sandy Hook were included in the current network.

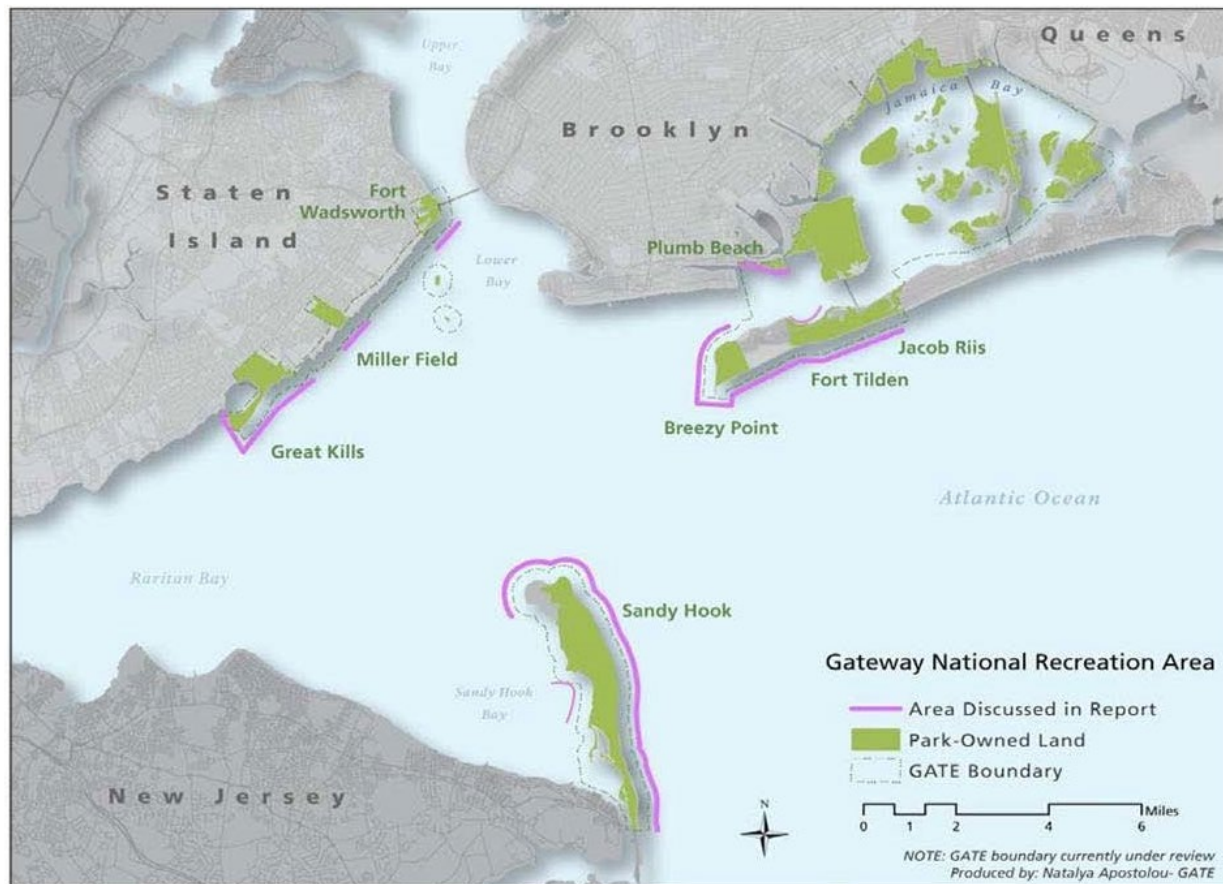


Figure S1.3. Locations where monuments and transects have been installed at the three Units of Gateway National Recreation Area, New York and New Jersey.

Sandy Hook Unit

The network at Sandy Hook is based on 17 transects spaced between 500 m to 1 km apart along the oceanside and bayside (Figure S1.4). Some gaps in the placement of monuments and transects on the bayside is due to the presence of seawalls. One of the monuments (SH9) is the starting point for two beach transects with different cross-shore orientations. Therefore, there are 17 total transects.

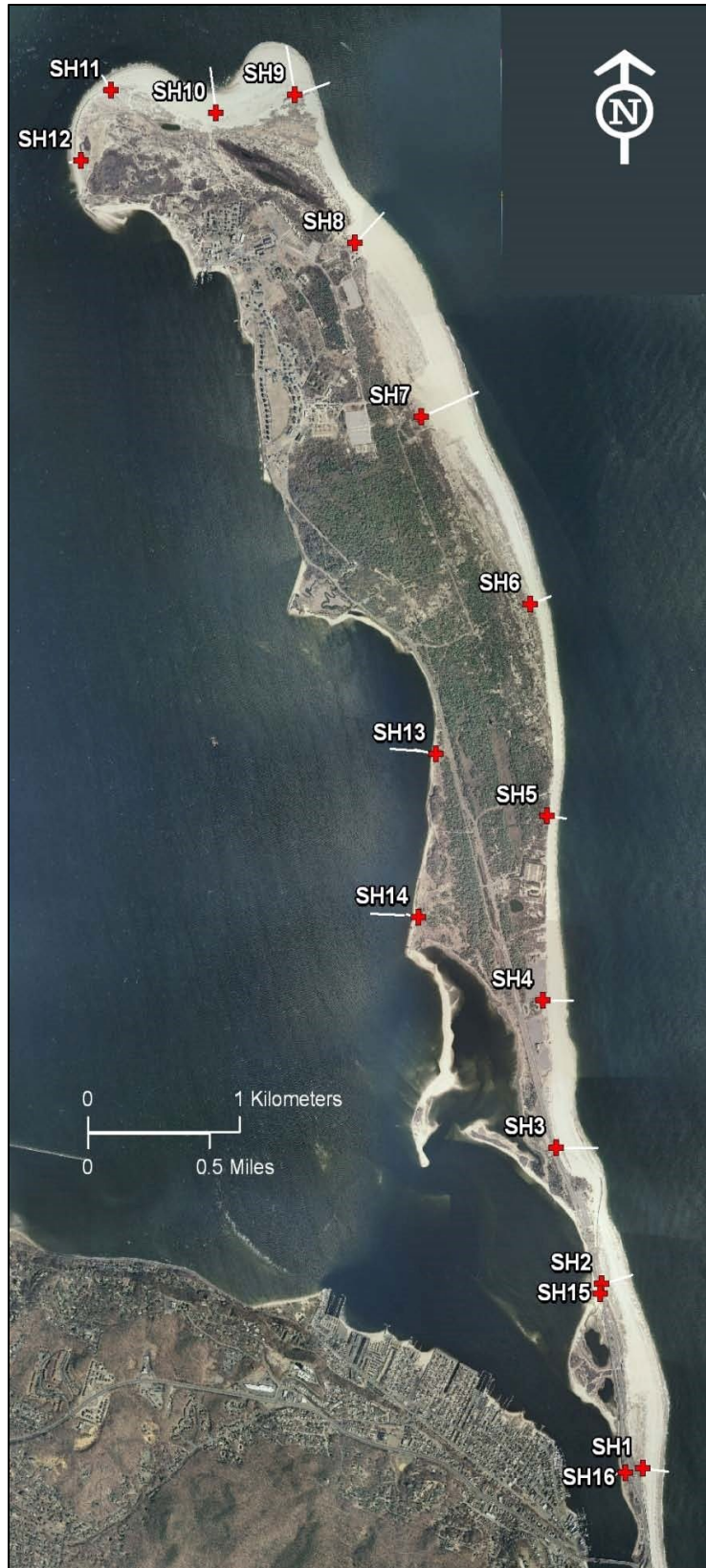


Figure S1.4. Spatial network of coastal topography monitoring monuments and associated transects at the Sandy Hook Unit of Gateway National Recreation Area, New Jersey.

Jamaica Bay Unit

The network of transects at Jamaica Bay is divided into the Breezy Point and Plumb Beach sections. Breezy Point has 11 transects along the oceanside and bayside, with a gap of 2 km in the area of the Breezy Point Cooperative (Figure S1.5). Plumb Beach's network consists of 5 transects spaced between 200 and 400 m alongshore (Figure. S1.6).



Figure S1.5. Spatial network of transect monuments and transect lines at Breezy Point, Jamaica Bay Unit of Gateway National Recreation Area, New York.



Figure S1.6. Spatial network of transect monuments and transect lines at Plumb Beach, Jamaica Bay Unit of Gateway National Recreation Area, New York.

Staten Island Unit

A total of 15 transects were established at Staten Island: 10 in Great Kills Park, 2 at Miller Field, and 3 at Fort Wadsworth (Figure S1.7).



Figure S1.7. Spatial network of transect monuments and transect lines at Great kills (GK), Miller Field (MF) and Fort Wadsworth (FW), Staten Island Unit of Gateway National Recreation Area, New York.

Fire Island National Seashore

Fire Island was included in the "Atlantic Coast of New York Monitoring Program" conducted by the U.S. Army Corps of Engineers, New York District; New York State Department of State; and New York Sea Grant. The objective of the program, conducted along the Long Island south shore, was to obtain and assemble data on coastal processes directed at addressing post-storm actions and long-term coastal erosion control (Morang, 2002). The program established a network of 84 monuments spaced 300-600 m alongshore, and included the survey of cross-shore profiles (spring and fall) between 1995 and 2001. Dr. Psuty from Rutgers University conducted beach profile surveys annually at Fire Island between 1982 and 2005 (prior to the development of this protocol) in areas of special concern to the communities and the NPS. The Rutgers' network of monuments consisted of 27 unevenly-spaced profiles between the communities of Kismet and Ocean Ridge. Input from each of the pre-existing networks was used to select the NCBN network of 38 monuments and transects (Figure S1.8).

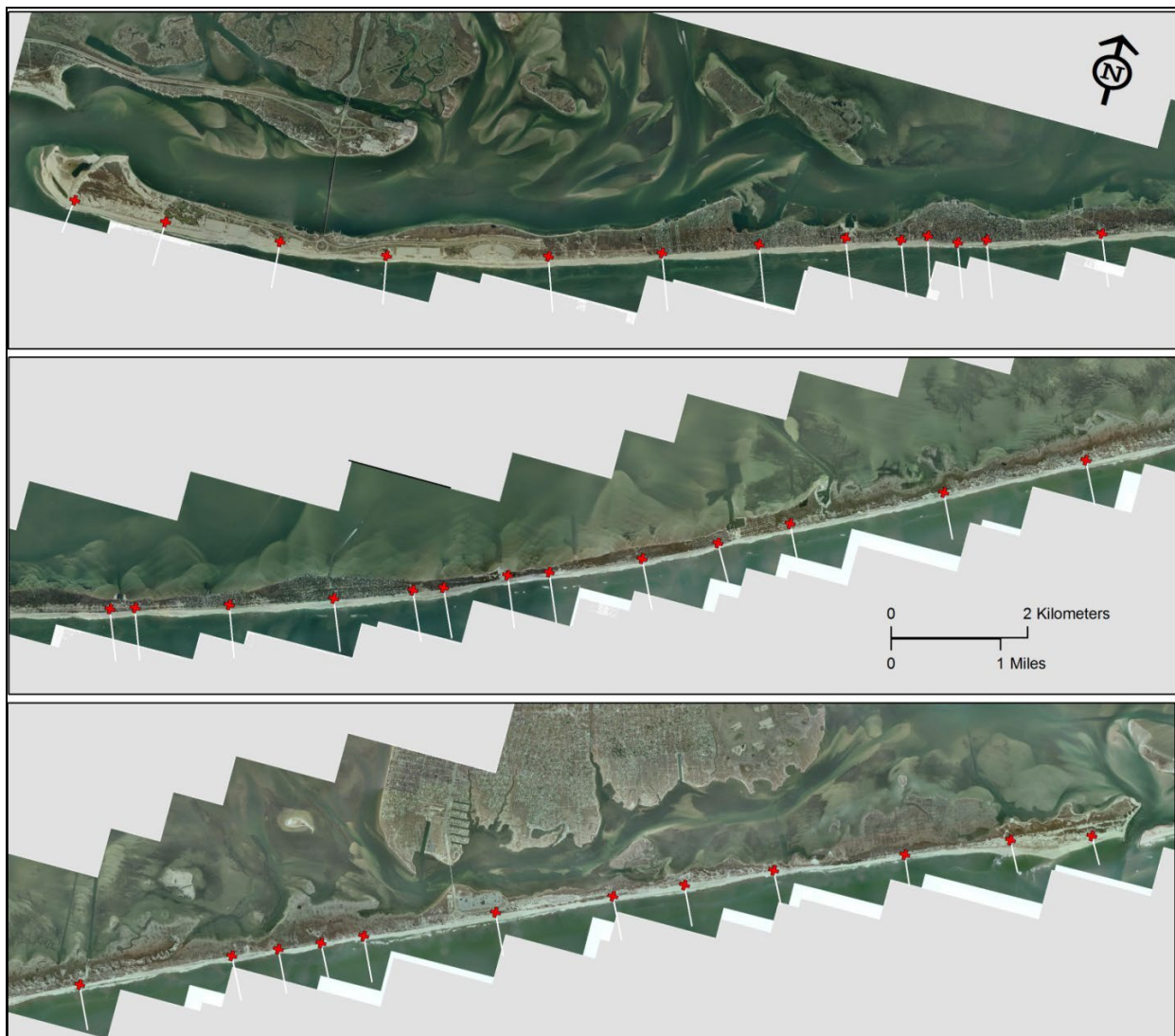


Figure S1.8. Spatial network of transect lines at Fire Island National Seashore, New York.

1.3 SOP 1 – Revision History Log

The following table lists all changes that have been made to *SOP 1: Monitoring Design Background and Justification for Northeast Coastal and Barrier Network Parks* since the original publication date. Any recommended or required changes added to the log must be complete and concise and promptly brought to the attention of the NCBN Protocol Lead. The Protocol Lead reviews and incorporates all changes and officially complete the Revision History Log of this SOP and the SOP Tracking Table for the SOP document. For complete instructions, please refer to *SOP 13: Protocol and SOP Versioning*.

SOP Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change
2.00	1/31/2023	Sara Stevens, NCBN Program Manager	Initial SOP created from a modified Protocol section	Moved to an SOP due to it containing park specific info

SOP 2: Equipment and Supplies

Version 2.00

2.1 Objective

This Standard Operating Procedure (SOP) details the items needed to execute the Northeast Coastal and Barrier Network (NCBN) Coastal Topography Monitoring Protocol. The protocol requires two major types of equipment, as well as a field data form and a field equipment checklist. The equipment types include:

1. Global Positioning System (GPS)/Global Navigation Satellite System (GNSS) system (must be capable of sub-meter horizontal accuracy).
2. Personal computer (PC) capable of communicating with the datalogger on the GPS/GNSS unit for pre- and post-survey activities.

2.2 Equipment

2.2.1 Survey-grade GPS/GNSS System

The GPS/GNSS system can be operated in different ways depending on the available equipment, but at a minimum field personnel must have one rover receiver unit and one field survey controller (Figure S2.1), such as when using a commercially or publicly-available correction service. For example, internet-based networked transport of Radio Technical Commission for Maritime Services (RTCM) via Internet Protocol (NTRIP) services offer corrections over cellular or wi-fi connections, while Precise Point Positioning (PPP) delivers such corrections via satellite, eliminating the need for field staff to set up and employ a local base-station. Where such services are not available or practical, a separate base station is required, as well as a radio repeater if extended range is needed (Figure S2.2).



Figure S2.1. The Trimble R8 GNSS receiver and Trimble TSC2 field survey controller (Sandy Hook, New Jersey, November 2009).



Figure S2.2. The Trimble 5700 Base station setup: in the foreground, the Zephyr geodetic antenna and the base receiver (inside the case), and in the background, the radio transmitter antenna (TRIMMARK 3 from Trimble) (Assateague Island, September 2009).

Fully integrated receivers with built-in antennas combine the GPS/GNSS receiver, antenna, and radio into a single compact unit (for example the Trimble R8 unit – Figure S2.1). Most of these units come with Bluetooth wireless technology built in and therefore do not need cables. Older GPS systems (e.g., the Trimble 5700, Figure S2.2) are composed of modular units and require an external radio and an external GPS antenna, and therefore the setup is more complex (for example the Trimble 5700 unit – Figure S2.2). Although the operational settings and setup may differ depending on the equipment used, there are critical settings and components that must be used to allow for consistent data collection across platforms.

2.2 Office Computer Equipment

2.2.1 Hardware

A PC that meets the minimum specifications for running GPS/GNSS and GIS software, and capable of communicating with the field survey controller is required. The NPS minimum standard for computer equipment meets these requirements.

2.2.2 Software

A program capable of transferring the data from the field survey controller and post-processing the collected field data (for example, Trimble Business Center or Leica Infinity) is required. Also required is Esri ArcGIS software for visualization, manipulation, and archiving of the data, along with Microsoft Office Excel, and the 2D Analyst application to analyze the beach profile data.

2.2.3 Internet Connectivity

An Internet connection (28.8kbps modem or faster) is needed for viewing the satellite almanac and tide charts (*SOP 5: Survey Timing and GPS/GNSS Mission Planning*) and maintaining the GPS/GNSS software/firmware updates.

2.3 Forms and Checklist

In addition to the GPS/GNSS and transportation equipment, field technicians also carry several important forms and SOPs used in the preparation and execution of each survey:

- [Coastal Topography Monitoring Field Equipment Checklist](#) (Figure S2.3)
- *SOP 7: Conducting the GPS/GNSS Coastal Topography Survey*
- [Coastal Topography Monitoring Field Data Form](#)

Coastal Topography Monitoring FIELD EQUIPMENT CHECKLIST	
GPS/GNSS Equipment Depending on the equipment used and which set-up is selected, the following items are among those required for the establishment of the GPS/GNSS system:	
Fully-Integrated Receiver Setup:	
<u>Rover Set-up:</u> ☐ Rover receiver ☐ Internal batteries, fully charged ☐ Radio antenna ☐ Field survey controller ☐ Pole ☐ Flat (topo) foot for pole ☐ Pole clamp ☐ Cell phone with data plan for cell phone correction option (if no base station is set up).	<u>Base station setup:</u> ☐ Base receiver ☐ Internal batteries, fully charged ☐ Radio antenna ☐ External battery, fully charged ☐ Tripod
Modular Unit Receiver Setup:	
<u>Rover Set-up:</u> ☐ Rover receiver ☐ Rover GPS/GNSS antenna ☐ Rover radio antenna ☐ Internal batteries, fully charged ☐ Field survey controller ☐ Pole ☐ Flat (topo) foot for pole ☐ Pole clamp ☐ Cables ☐ Cell phone with data plan for cell phone correction option (if no base station is set up).	<u>Base station setup:</u> ☐ Base receiver ☐ Base GPS/GNSS antenna ☐ Base radio transmitter ☐ Base radio antenna ☐ Cables ☐ Internal batteries, fully charged ☐ External batteries, fully charged ☐ Base receiver tripod ☐ Radio antenna tripod
Transportation Equipment ☐ ORV or 4x4 (required unless walking entire survey) ☐ Boards/rope or tow cable/shovel (recommended) ☐ Sufficient fuel (required) ☐ Extra fuel can (recommended) ☐ Tire pressure gauge (recommended) ☐ Personal flotation device (required if using a boat) ☐ Large drybag (required if using a boat)	
Version – 01-31-2023	

Figure S2.3 (page 1). Example of the Coastal Topography Monitoring Field Equipment Checklist. Download or view the most up to date list [here](#).

Coastal Topography Monitoring FIELD EQUIPMENT CHECKLIST
Other Equipment and Personal Items
☐ Transect Monuments Booklet ☐ GPS/GNSS receiver manual (optional) ☐ Park safety sheet with emergency contacts and list of emergency phone numbers (required) ☐ <i>SOP 6: Conducting the GPS/GNSS Coastal Topography Survey</i> (required) ☐ Coastal Topography Monitoring Field Data Form (required) ☐ Printed maps of area and monitoring site ☐ Satellite availability and PDOP information (recommended) ☐ Digital camera – fully charged (required) ☐ Cellular phone (personal or work – required for each monitoring staff member) ☐ Fully charged power pack to charge cell phones ☐ Secondary communication device (GPS satellite communication device) ☐ Two-way radio (if required by park) ☐ Dry bag for non-waterproof electronics ☐ Measuring tape ☐ Small toolkit ☐ Boots (e.g., hip boots or waders) ☐ Mosquito head netting or jacket (if needed) ☐ Goggles, safety glasses (provided) or sunglasses (personal) ☐ Work gloves ☐ Spare set of dry clothes (personal/optional – shirt, pants, socks) ☐ First aid kit (fully stocked, with guidelines for incident response. See NCBN First Aid Checklist) ☐ Personal medication (EpiPen, antihistamine, acetaminophen, ibuprofen, aspirin, Tecnu, etc.) ☐ Sunscreen (personal) ☐ Insect repellent (personal) ☐ Drinking water (2-3 liters – personal) ☐ Snacks/lunch (personal)
Version – 01-31-2023

Figure S2.3 (page 2). An example of the Coastal Topography Monitoring Field Equipment Checklist. Download or view the most up to date list [here](#).

2.4 SOP 2 – Revision History Log

The following table lists all changes that have been made to *SOP 2: Equipment and Supplies* since the original publication date. Any recommended or required changes added to the log must be complete and concise and promptly brought to the attention of the NCBN Protocol Lead. The Protocol Lead reviews and incorporates all changes and officially complete the Revision History Log of this SOP and the SOP Tracking Table for the SOP document. For complete instructions, please refer to *SOP 13: Protocol and SOP Versioning*.

SOP Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change
1.00	10/2012	Dennis Skidds, NCBN Data Manager	Initial SOP	Initial SOP
2.00	3/1/2022	Glenn Liu, GIS Technician, Rutgers University	Updated revision history log table. Minor text and formatting changes for consistency throughout SOP.	Full protocol update prescribed by Technical Steering Committee
2.00	1/30/2023	Robin Baranowski	Changed from SOP 1 to 2 (updates section, figure and table #s), update links and checklist	A new SOP was added, link updates available

SOP 3: Establishment of Monuments, Transects, and Geodatabases

Version 2.00

3.1 Objective

This SOP illustrates and describes in detail the types of survey monuments that are needed to conduct the Coastal Topography Protocol. Transect monuments are permanent and long-lasting physical structures used to mark the transect locations in the field and that provide a robust basis for long-term monitoring. They allow for the systematic and repeated collection of topographical data starting at a fixed location and along pre-defined transect lines. Besides the network of transect monuments established along the shoreline at each of the parks, each park also has to have high-accuracy survey control monuments to establish the GPS/GNSS base station or as pre- and post-accuracy assessment check-in locations, to be used in the real-time kinematic (RTK) surveying.

Methods of installation of new physical transect monuments are described, as well as the method for creating the associated transects and the auxiliary files for post-survey quality assurance and quality control (QA/QC). The information on the network of monuments within each park, the respective transects, and the auxiliary files are stored in two complimentary formats: a GIS database and field booklets with adequate description of the locations and attributes of each monument.

3.2 Monuments

3.2.1 Types of Monuments

Each park can have up to three types of monuments:

- 1 Survey Control Monuments: These are survey control points established with centimeter-level accuracy, computed through the National Oceanic and Atmospheric Administration (NOAA) Online Positioning User Service (OPUS) or established and maintained by the National Geodetic Survey (NGS). They are used to set up the GPS/GNSS base receiver needed for RTK surveying or for the pre- and post-survey accuracy assessment check-ins.
- 2 Physical Transect Monuments: These monuments mark the location of the starting point of the transect to be surveyed. These are highly accurate topographical points, established with a GPS/GNSS system.
- 3 Virtual Transect Monuments: These monuments are sets of coordinates for a point falling exactly on the transect. Coordinates are generated in GIS and stored on the survey controller unit. Virtual monuments can be used to replace a lost physical transect monument and may be especially useful for transects where maintaining a physical monument is difficult or unfeasible. An example is at Fire Island National Seashore, where continual inland transgression of the system makes the maintenance of physical monuments difficult. Virtual monuments can also be used when establishing new transects to implement this protocol rather than installing new, physical monuments.

A survey control monument can be a starting point for a transect and/or base-station location. The number of survey control monuments for a base-station location may vary per park and should correspond to the minimum locations needed to cover the entire survey area with the available equipment and duration of surveying.

3.2.2 Establishment of Survey Control and Physical Transect Monuments

When a new survey control monument or physical transect monument needs to be established, the field technician must decide on the preferential location for its installation according to the following criteria:

- Both survey control monuments and physical transect monuments should be permanent and long-lasting structures. The following provide examples of both survey control and physical transect monuments:
 - Pre-existing NGS or United States Army Corps of Engineers (USACE) metal-disk monuments
 - Pre-existing structures, such as fire hydrants or corners of curbs
 - Rods driven into the ground (metal rods or PVC pipes)
- All survey control monuments and physical transect monuments should be located inland and far from the reach of wave action. Inland of the foredune or far from the bluff's edge.
 - All monuments (survey control, physical transect and virtual transect) should be accessible to the field technician throughout the year, and preferably established:
 - Outside protected shorebird nesting areas
 - Outside private property
 - Far from un-navigable vegetation such as poisonous ivy or other thick vegetation.
- All monuments should be located far from objects that might obstruct or interfere with the broadcast of the GPS/GNSS radio signal, such as buildings or tree canopy.
- Both physical and virtual transect monuments should be established on a clear path to the shoreline, again, far from heavy vegetation and buildings that might function as an obstacle to the collection of topographic points along the transect line

3.2.3 Pre-existing NGS or USACE Survey Control Monuments

If a survey control monument from the NOAA NGS Control Network is available for the general area, it is recommended that it is used as a physical transect monument. These are stable, identifiable points (usually metal disks) established by extremely accurate observations. To access the complete list of these monuments, go to the [online interactive map](#). Each NGS survey control monument has an associated PID (Permanent Identifier) and a datasheet that provides information on the coordinates and elevation, as well as a description of its location and when it was last accessed (Figures S3.1 and S3.2).

The field technician should select control points that display both horizontal (coordinates) and vertical (elevation) information. From the list of available points under the “station record window”, select the point with the highest level of accuracy, given by the lowest order number. This information is under the “H-V” column, where H is the horizontal order, and V is the vertical order (Figure S3.1).

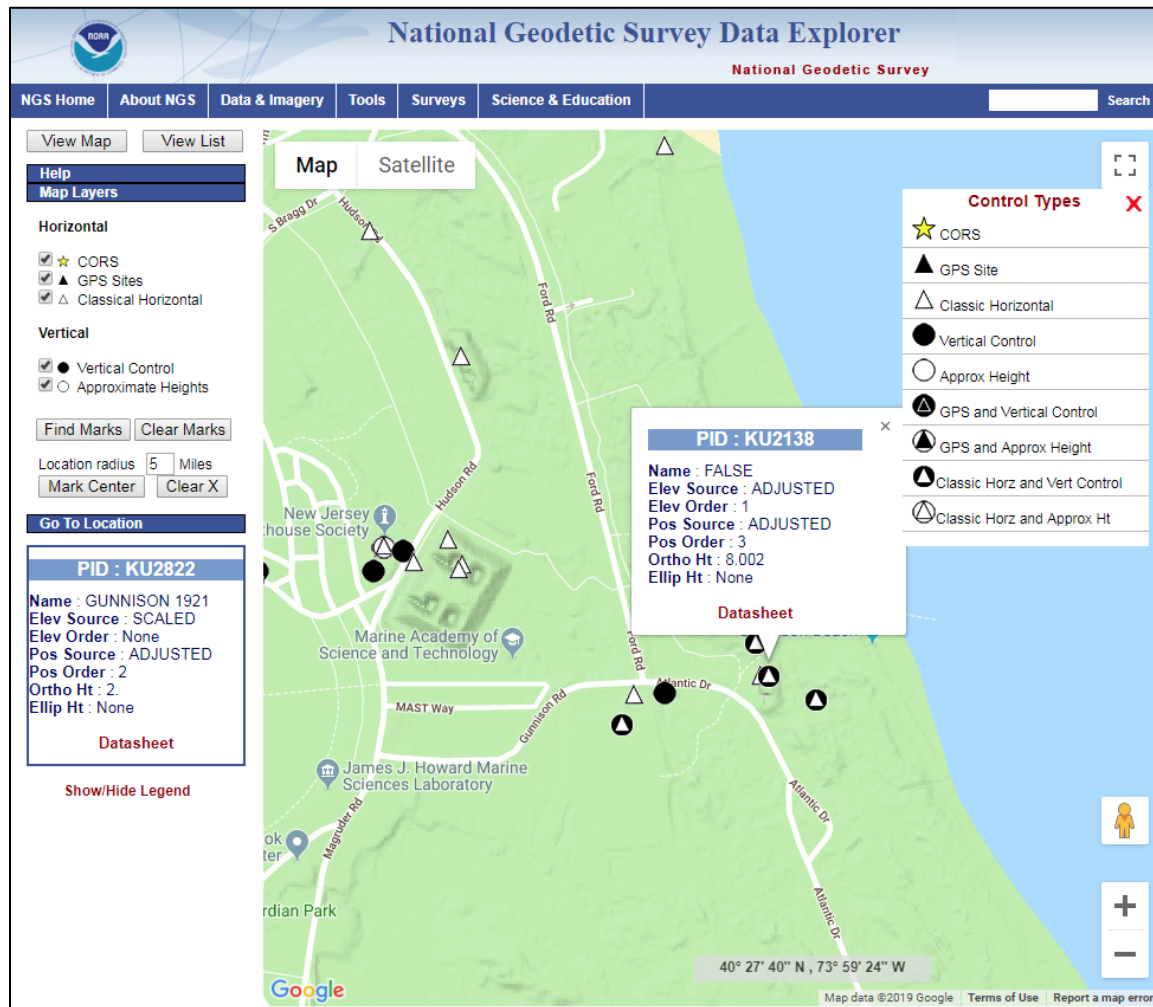


Figure S3.1. The [National Geodetic Survey Control Map website](#), showing the selection of a monument at Gateway National Recreation Area's Sandy Hook Unit - PID KU2138.

Use the information on the datasheet to locate the survey control monument in the field. Read the description of the station location carefully, use a handheld GPS and an updated georeferenced aerial photo to locate the metal disk in the field.

The NGS Data Sheet

See file [dsdata.pdf](#) for more information about the datasheet.

```

PROGRAM = datasheet95, VERSION = 8.12.5.2
1 National Geodetic Survey, Retrieval Date = MAY 15, 2019
KU2138 *****
KU2138 DESIGNATION - FALSE
KU2138 PID - KU2138
KU2138 STATE/COUNTY- NJ/MONMOUTH
KU2138 COUNTRY - US
KU2138 USGS QUAD - SANDY HOOK (1981)
KU2138
KU2138 *CURRENT SURVEY CONTROL
KU2138
KU2138* NAD 83(1996) POSITION- 40 27 35.80461(N) 073 59 42.19072(W) ADJUSTED
KU2138* NAVD 88 ORTHO HEIGHT - 8.002 (meters) 26.25 (feet) ADJUSTED
KU2138
KU2138 GEOID HEIGHT - -32.471 (meters) GEOID12B
KU2138 LAPLACE CORR - -3.30 (seconds) DEFLEC12B
KU2138 DYNAMIC HEIGHT - 7.998 (meters) 26.24 (feet) COMP
KU2138 MODELED GRAVITY - 980,201.1 (mgal) NAVD 88
KU2138
KU2138 HORZ ORDER - THIRD
KU2138 VERT ORDER - FIRST CLASS II
KU2138
KU2138.The horizontal coordinates were established by classical geodetic methods
KU2138.and adjusted by the National Geodetic Survey in September 1999.
KU2138.
KU2138.The orthometric height was determined by differential leveling and
KU2138.adjusted by the NATIONAL GEODETIC SURVEY
KU2138.in May 2006.
KU2138
KU2138.No vertical observational check was made to the station.
KU2138
KU2138.Significant digits in the geoid height do not necessarily reflect accuracy.
KU2138.GEOID12B height accuracy estimate available here.
KU2138
KU2138.Photographs are available for this station.
KU2138
KU2138.The Laplace correction was computed from DEFLEC12B derived deflections.
KU2138
KU2138.The dynamic height is computed by dividing the NAVD 88
KU2138.geopotential number by the normal gravity value computed on the
KU2138.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
KU2138.degrees latitude (g = 980.6199 gals.).
KU2138
KU2138.The modeled gravity was interpolated from observed gravity values.
KU2138
KU2138. The following values were computed from the NAD 83(1996) position.
KU2138
KU2138; North East Units Scale Factor Converg.
KU2138;SPC NJ - 180,703.696 192,824.482 MT 0.99992257 +0 19 39.6
KU2138;SPC NJ - 592,858.71 632,624.99 sFT 0.99992257 +0 19 39.6
KU2138;UTM 18 - 4,479,293.644 585,204.360 MT 0.99968936 +0 39 07.8
KU2138
KU2138! - Elev Factor x Scale Factor = Combined Factor

```

Figure S3.2. An example of the datasheet retrieved from the [National Geodetic Survey Control Map interactive website](#) for the Monument PID KU2138s.

In case the available NGS monuments closest to the selected transect location does not provide high accuracy levels, or possibly lacks the vertical or horizontal information, the surveyor might still use it as a transect monument or control monument. In this case, improved coordinates and elevation of the point has to be established by the field technician – as detailed below.

2.3.4 Pre-existing Structures

When no survey control monument is available for the selected location, then the field technician must establish the physical transect monument. Pre-existing structures are usually more robust and reliable, and therefore should be used whenever parking lots, buildings, and other infrastructure exist near the selected transect location. Corners of curbs and cement slabs, tops of fire hydrants, and corners of sturdy features are some examples of pre-existing structures that could be used (Figs S3.3 and S3.4). The field technician might need to use permanent spray paint or even insert a PK nail to ensure the permanency as well as to identify the site of the monument.



Figure S3.3. Monument located at corner of cement slab on the bike path at Fort Wadsworth, Gateway National Recreation Area; adequate space to site a GPS/GNSS rover receiver pole (Staten Island, New York, April 2009).



Figure S3.4. Monument location at corner of curb of a traffic island on a parking lot at Great Kills, Gateway National Recreation Area; adequate space for a GPS/GNSS base station or rover receiver pole (Staten Island, New York, August 2008).

2.3.5 Installation of New Physical Transect Monuments

If no pre-existing monuments or structures are available, and virtual monuments are not chosen to be used, then the surveyor must create one. Long metal rods are usually efficient but can also be dangerous to the park's visitors. PVC pipes set into a concrete base are safer and are easy to install. Furthermore, 5 cm diameter PVC pipes provide a functional base for the flat foot of the rover pole to collect XYZ data for QA/AC purposes. To install the PVC pipe, the surveyor needs the following:

- PVC pipe that is at least 1.3 meters long and 5 cm in diameter
- Drill
- Field hand-corer
- Container with fresh water (c. 2-3 L per monument)
- Cement (c. 4 kg per monument)
- Hammer

Procedure to install the PVC pipe monuments:

- In the office or lab, drill holes roughly 2.5 cm in diameter into a portion, about 0.5 m, of the PVC pipe (Figure S3.5a)
- In the field, dig a hole at least 1 m deep with the field hand-corer (Figure S3.5b)
- Insert the PVC pipe into the hole (the part with the drilled holes in the hole), no more than 35-40 cm of the pipe extending above the surface. Hammer the pipe into the ground until only 30 cm of the pipe is showing (it is recommended that a flat piece of wood be placed on top of the PVC pipe and the hammer strike the wood rather than the pipe directly) (Figure S3.5c).
- Insert a mixture of cement, water, and the sand that was dug out of the hole into and around the pipe (Figure S3.6a and S3.6b) until the PVC pipe is full. Place a sticker with the NPS logo on the PVC pipe (Figure S3.6c).



Figure S3.5. PVC pipe monument; a) PVC pipe with holes; b) coring in field, and c) final driving of PVC pipe into sand.



Figure S3.6. Installation of the PVC pipe monument, a) and b) inserting the cement, water, and sand into and around the pipe, and c) National Park Service logo on PVC pipe.

3.2.6 Physical and Virtual Transect Monument Identification

Monument IDs are assigned according to the name of the park, park unit or park section where they are being established according to the nomenclature defined for this Protocol (Table 4 of the Protocol and Table S3.1 of this SOP document). They are numbered according to their position in relation to the other monuments, numbered systematically starting with 1. Virtual transects include an

underscore, “V” within the naming convention such as CC1_V . ASIS is the only exception. In this case, the current identification, established in 1993 and 1995, continues to be used.

Table S3.1. Transect Monument identification according to the Northeast Coastal and Barrier Network’s Coastal Topography Protocol’s nomenclature.

Park	Unit	Section	Monument ID
Cape Cod National Seashore (CACO)	–	–	CC1, CC2,..., CCn
Gateway National Recreation Area (GATE)	Sandy Hook	–	SH1, SH2,..., SHn
	Jamaica Bay	Breezy Point	BP1, BP2,..., BPn
	Jamaica Bay	Plumb Beach	PB1, PB2,..., PBn
	Staten Island	Great Kills	GK1, GK2,..., GKn
	Staten Island	Miller Field	MF1, MF2,..., MFn
	Staten Island	Fort Wadsworth	FW1, FW2,..., FWn
Fire Island National Seashore (FIIS)	–	–	FI1, FI2,..., Fin
Example Virtual Transect ID	Fire Island		FI5_V, FI6_V....FI _n _V

3.2.7 Establishment of Monument Height and Position Information

The monument’s centimeter accurate coordinates and elevation is acquired with a survey-grade GPS/GNSS unit and is registered to the following spatial references:

Grid Coordinate System:	Universal Transverse Mercator (UTM)
UTM Zone Number:	18 (Gateway National Recreation Area, Assateague Island National Seashore, and Fire Island National Seashore) 19 (Cape Cod National Seashore)
Horizontal Datum:	North American Datum of 1983 (2011) epoch 2010.0
Vertical Datum:	North American Vertical Datum of 1988
Geoid Model:	GEOID18
Units:	Meters

Refer to the GPS/GNSS Equipment list under the Coastal Topography Monitoring Field Equipment Checklist (Form S2.1) in *SOP 2: Equipment and Supplies*. The following description on how to measure the monument coordinates and elevation is based on Trimble’s software terminology (as an example).

Physical Transect Monuments

Transect monuments are established by measuring a topo point in a GPS/GNSS survey mode. Refer to *SOP 7: Conducting the GPS/GNSS Coastal Topography Survey* for the different ways in which the GPS/GNSS unit can be set up. The example below uses the Trimble Access menu on a Trimble survey controller, but similar procedures can be done using other GPS/GNSS equipment and software (ex. SmartWorx Viva on a Leica controller)

- Create a Project/Job with the spatial references identified above and select the RTK survey style (refer to *SOP 6: Basic GPS/GNSS Requirements for Coastal Topography Data Collection* for further details)
- Position the rover receiver directly over the monument location
- After ensuring that the antenna is vertical and directly over the monument, use the controller to record a topographical point with a 30-second occupation time. Below is an example procedure in General Survey of the Trimble Access menu:
 1. In the main menu, go to “**Survey**”, “**Measure points**”
 2. Under “**Point name**” key in the Monument’s ID
 3. Under “**Method**” select “**Topo point**”
 4. Hit “**Options**” and set the occupation time to 30 seconds.
 5. Verify that the “**Antenna height**” is set to the correct height (height of the rover pole)
 6. Verify that the “**Measured to**” is set to “**Bottom of antenna mount**”
 7. Verify that the antenna is vertical and directly above the monument location, and hit “**Measure**”
 8. Wait for “**30s**” to show in the “**Time so far**” and hit “**Store**” (the antenna must remain stationary and vertical while the point is measured)
- In the office, download the survey files containing the collected data (example: .JOB and .DC for Trimble, .XCF file in the job directory in Leica) from the field survey controller to a computer using data transfer software (example: Trimble Data Transfer). Use the corresponding data export software (example: Trimble Business Center, Leica Geo Office or Leica Infinity) to open and retrieve the northing, easting, and elevation data of the measured monument.

Survey Control Monuments

Survey control monuments are control points that require higher accuracy and therefore are computed through the Online Positioning User Service (OPUS).

- In the field, set up the receiver antenna on a fixed height tripod (or bipod) at the monument location, determine that the receiver is level

- Create a Project/Job with the spatial references identified above
- Select the FASTSTATIC survey style
- Ensure that the antenna height (distance from antenna to the point) is entered correctly. This is the height of the tripod or pole. Record this number in your field data book.
- Enter 15 seconds for the receiver epoch rate
- Select save data to the receiver, or the field controller only if it can be kept connected to the receiver on-site
- Enter the appropriate point ID – the monument ID
- Measure the point for at least 8 hours* but not more than 24 hours. A longer-duration data file improves the accuracy of the solution.
- Alternatively, the surveyor may collect GPS/GNSS position data with the base receiver while simultaneously broadcasting and collecting data with the rover receiver unit. In this case, select the RTK & INFILL survey style instead of FASTSTATIC for the base receiver.
- Use the same specifications as above
- Select the “here” function and start the base receiver
- Use the usual RTK survey style for the rover receiver. Later, in the office, connect the base receiver (or the controller if this was where the data were stored) directly to the computer using the appropriate cable.
- Download the GPS/GNSS raw data file (format: .t01 if it was stored in the receiver, or .dat if it was stored in the controller) using the Import command in the Trimble Business Center software (for example)
- Wait at least 24 hours before submitting your data file to OPUS
- 24 hours after the data collection, open an Internet Browser and go to the [OPUS: Online Positioning User Service website](#).
- Follow the instructions (Figure S3.7):
 1. Enter your e-mail address
 2. Attach the GPS/GNSS raw observation data file (only one data file can be uploaded at a time) *Note: Raw data files may need to be converted to observation files via the [Convert to Rinex tool](#).*
 3. Select the antenna type used in the field data collection
 4. Enter the antenna height (in meters)
 5. Select: Upload to **STATIC**

OPUS: Online Positioning User Service
National Geodetic Survey

NGS Home | About NGS | Data & Imagery | Tools | Surveys | Science & Education | Search

ITRF2014 frame and GEOID18 now available in BETA

Try **BETA OPUS** to preview the **new GEOID18** and the **new ITRF2014 frame for CORS**.

Upload your data file.
Solve your GPS position & tie it to the National Spatial Reference System.

What is OPUS? FAQs

Choose File No file chosen
* data file of dual-frequency GPS observations. **sample**

NONE

antenna - choosing wrong may degrade your accuracy.

0.000 meters above your mark.
antenna height of your antenna's reference point.

* email address - your solution will be sent here. **Privacy Act Statement**

Options to **customize** your solution.

Upload to Rapid-Static for data 15 min. - 2 hrs. | Upload to Static for data 2 hrs. - 48 hrs.

* required fields
We may use your data for internal evaluations of OPUS use, accuracy, or related research.

Website Owner: National Geodetic Survey / Last modified by NGS.OPUS V 2.5.2 Aug 23 2018

NOS Home | NGS Employees | Privacy Policy | Disclaimer | USA.gov | Ready.gov | Site Map | Contact Webmaster

OPUS menu
home / upload
about OPUS
projects
shared solutions
support / feedback

OPUS Today
as of 2019-05-02T15:25 EDT

Category	Count
Rapid-Static	~450
Static	~650

Figure S3.7. The Online Positioning User Service ([OPUS](#)) Upload webpage and the fields required for data entering.

OPUS emails the solution usually in 10-15 minutes (Figure S3.8). The report includes the northing, easting, and elevation data (noted as ortho height in the report) as well as the information about the processing of the data file.

*If you cannot collect for 8 hours in one day, another option is to collect for 4 hours per day over a span of 3 days (one in the morning, then the afternoon, and then again in the late afternoon).

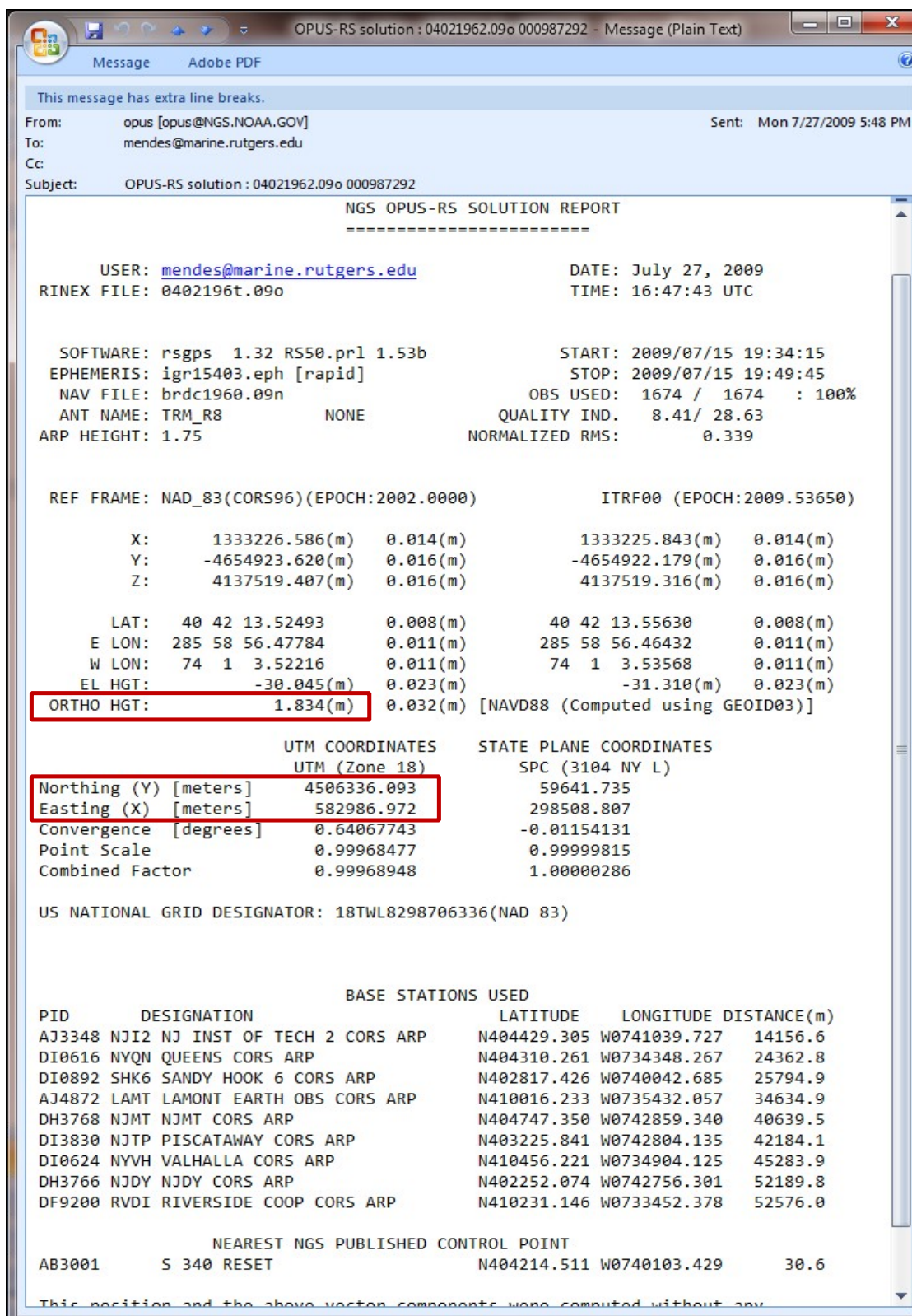


Figure S3.8. An example of an Online Positioning User Service (OPUS) Solution report sent via e-mail. Coordinates and elevation data are highlighted in red boxes.

3.3 Transects

Each transect monument has an associated transect to represent the line along which the topographical measurements are collected in the field. The network's GIS expert produces the transects in a GIS environment by creating a line feature class with one feature per monument (Figure S5.9) and making use of recent aerial imagery of the area of interest as background.

Characteristics of a transect in the GIS environment incorporates:

Starting point of the line	Monument location
Direction (azimuth) of the line	Towards the water and perpendicular to the general trend of the shoreline
Length of the line	At least 50 m into the water (though, technically speaking, each transect may be extended infinitely in each direction in order to accommodate changes in the beach location due to erosion and accretion.

3.4 QA/QC Auxiliary Files

Two auxiliary GIS feature classes representing the transect monument and transect buffer areas created in a GIS environment for QA/QC purposes (described in *SOP 8: Initial Post-Survey Processing*) for each park (Figure S3.9):

1. A polygon GIS feature class that represents the buffer areas within 0.05 m distance from the transect monument.
2. A polygon GIS feature class that represents the buffer areas within 0.5 m distance from the transects.

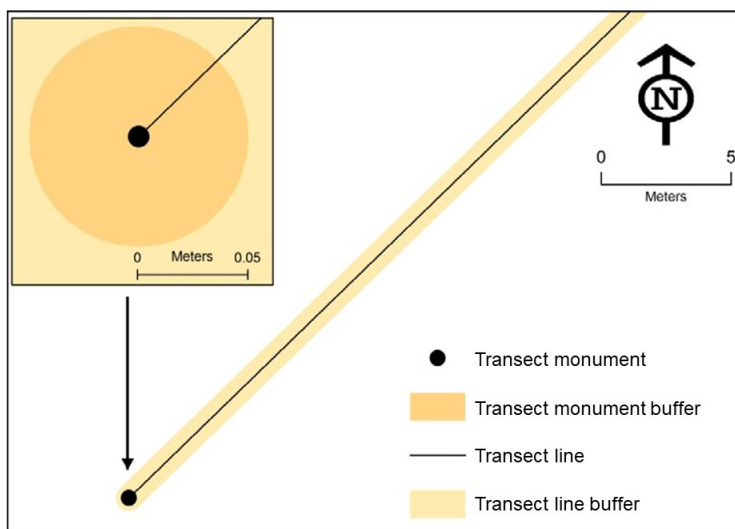


Figure S3.9. Quality assurance and quality control (QA/QC) auxiliary feature classes representing the transect monuments' and transects' buffer areas.

3.5 Transect and Monument Loss

Natural and anthropogenic events, such as storms or construction activity, may result in the loss of monuments and/or necessitate a shift in the surveyed transect. One example is the loss of monument SH9 at the dynamic tip of Sandy Hook (Figure S3.10). In such an event, there are several possible courses of action. The physical monument can be reinstalled, or a virtual monument can be used for future surveys along the transect.

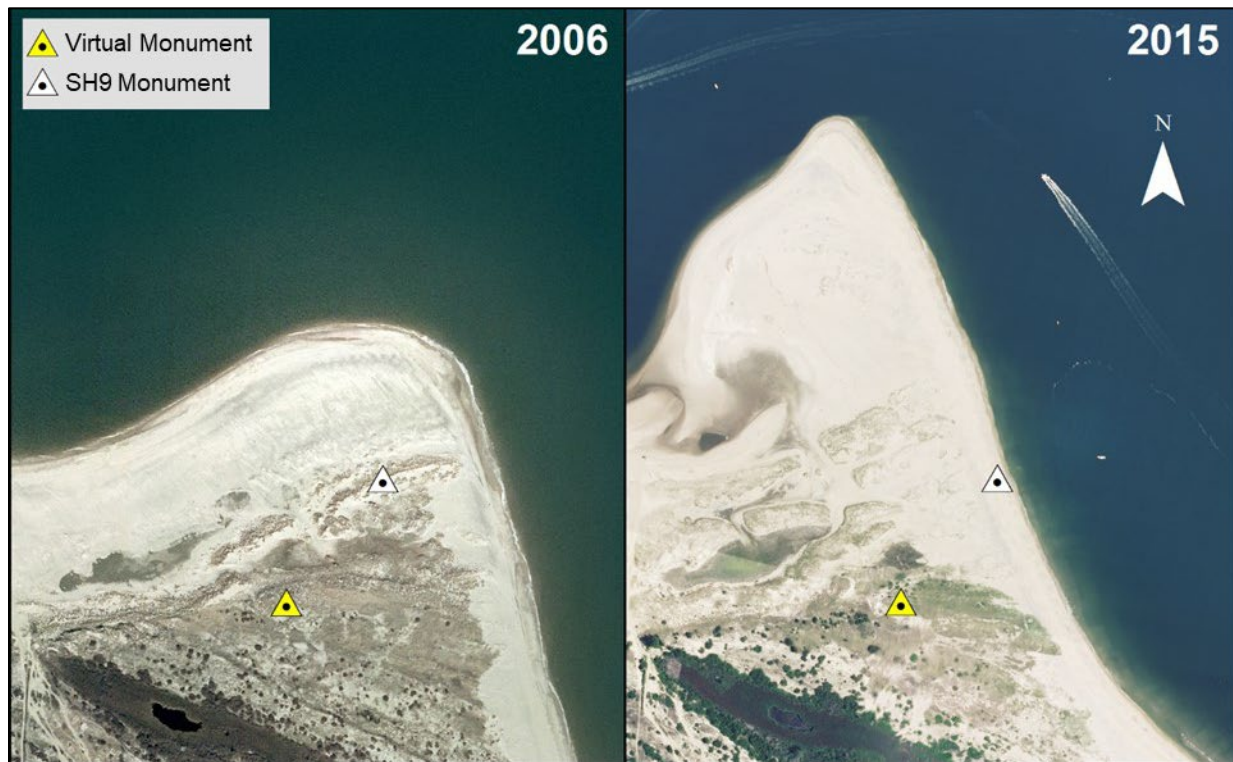


Figure S3.10. The northern tip in 2006 (left) and 2015 (right) of Gateway National Recreation Area's Sandy Hook Unit. The location of the lost monument SH9 (in white) and the current virtual monument used for surveying (in yellow).

Reinstallation of the transect monument requires careful consideration of its location relative to the original. If the new monument is reinstalled at a different location, causing a shift in the transect, or the new azimuth of the transect differs from the original, the new transect is given a new name/ID, while that of the original transect is designated as “retired.” For example, if transect “MF2” has changed from its original location, it should be retired and replaced with a new transect “MF3”. These changes must be documented and recorded in the GIS database maintained by the NCBN Data Manager. If the location and azimuth of the transect remains the same, but the monument has shifted along the transect, no naming changes need to be made. The new monument location should be included in the GIS database.

A virtual transect monument can be used in particularly dynamic environments where maintaining or reinstalling a physical monument is unfeasible. Virtual transect monuments are stored within the

survey controller and used to mark the boundary between the inland and seaward portions of the profiles. Similar to a physical transect monument, the position of a virtual monument should be maintained and any changes must be documented and updated in the GIS database. Use of virtual transect monuments is appropriate especially for a park like Fire Island National Seashore where the system experiences continual inland transgression, and loss of physical monuments is common.

3.6 GIS Database

Each park has an Esri geodatabase in which the survey control monument and transect monument locations, transects, and QA/QC auxiliary files are stored as four feature classes. For each park unit (where applicable) these four datasets reside in a feature dataset (Figure S3.11). The characteristics and properties of the features classes are detailed below. All feature classes are accompanied by Federal Geographic Data Committee (FGDC) compliant metadata, to be provided by the NCBN Data Manager.

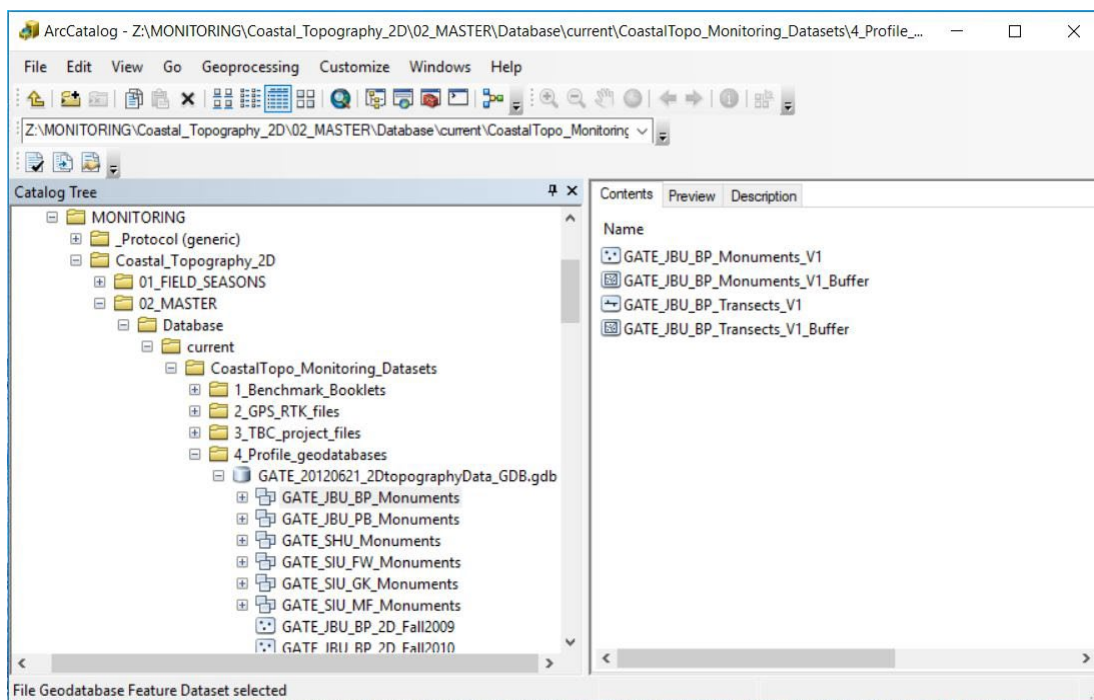


Figure S3.11. An example of the Esri geodatabase containing monument and transect feature classes for Breezy Point, Jamaica Bay Unit of Gateway National Recreation Area.

3.6.1 Monuments

The monument height and position information is stored as Esri point features with the following attribute fields and respective information (Table S3.2 and Figure S3.12):

The feature class name reflects the park and unit's name and has a version number associated with it, to allow for future alterations of the database (monument used as example):

GATE_JBU_BP_Monuments_V1
Protocol Nomenclature – “Monuments” – Version 1

Table S3.2. An example of the attribute fields of a monument feature class, Breezy Point, Jamaica Bay Unit, Gateway National Recreation Area.

Attribute	Field Name	Example
Monument ID	ID	BP1 or BP1_V (for virtual monuments)
Easting coordinate	X	596158.12
Northing coordinate	Y	4491377.80
Elevation	Z	5.253
Associated transect azimuth	Az	156°
Date established	Date_est	8/19/2008
Who established the monument?	Source	Rutgers University
Short physical description	Descrip	PK nail
Page number in the field booklet	Booklet_Pg	4
Purpose of monument	Purpose	Transect / base-station / accuracy assessment point
Quality of the monument establishment	Quality	GPS/GNSS measurement / OPUS solution

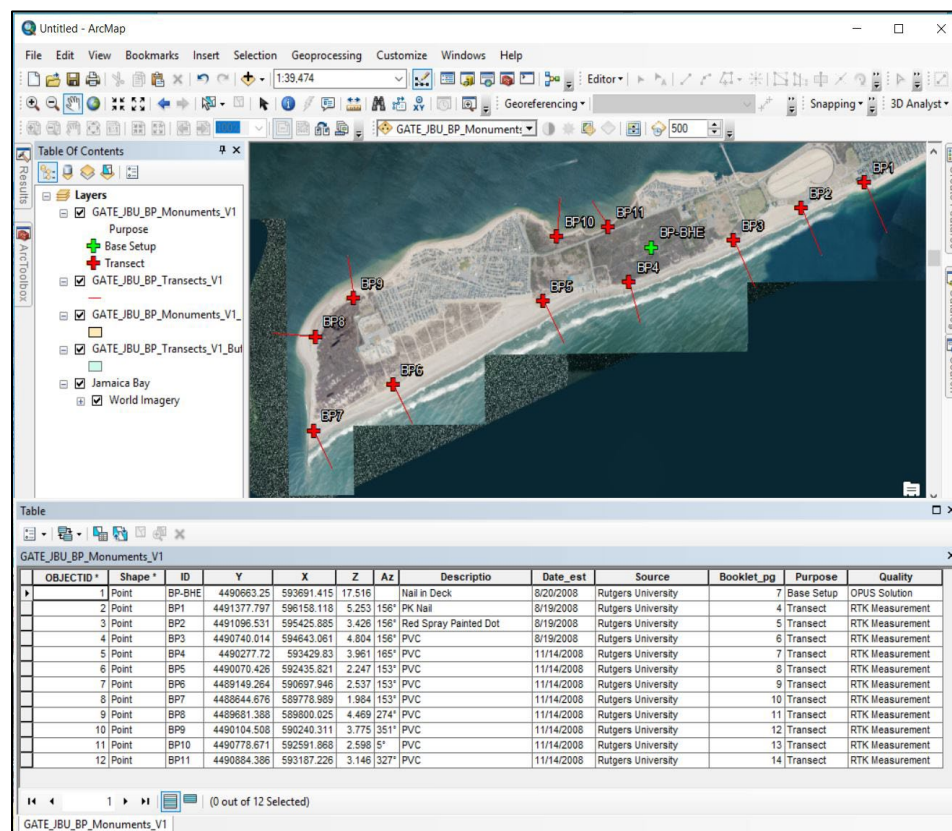


Figure S3.12. Monument feature classes for Breezy Point, Jamaica Bay Unit of Gateway National Recreation Area, New York.

3.6.2 Transects

The transect feature class contains three attribute fields (Table S3.3):

Table S3.3. Attribute fields of the park's transects' *feature class*.

Attribute	Field Name
Transect ID	Transect_ID
Transect Azimuth	Az
Transect Length	Shape_Length

Similar to monuments, the transect feature class name reflects the park's name and has a version number associated with it to allow for future alterations of the database:

GATE_JBU_BP_Transects_V1

Protocol Nomenclature – “Transects” – Version 1

3.6.3 QA/QC Auxiliary Files

The QA/QC auxiliary files corresponds to polygon features and only needs to contain an attribute field with the Transect monument and transect ID that apply to the buffer areas. The buffer areas feature classes has the same name of the monuments or transects to which they are associated, followed by the word “Buffer” (Figure S3.9):

GATE_JBU_BP_Monuments_V1_Buffer

GATE_JBU_BP_Transects_V1_Buffer

3.7 Field Booklet

Currently, GATE is the only complete park field booklet, and can be downloaded or viewed [here](#). Each remaining park unit will have a field booklet that includes the following:

- **Cover:** Must include the date of its creation and the version number – the same as the GIS database that it refers to.
- **Synopsis:** Describing the booklet purpose and organization, who created it and when.
- **Overall locator map:** Overall location of the park and units.
- **Small locator map:** With all the monuments included in the field booklet.
- **Individual pages with monument description:** The pages are ordered according to the monument ID. Base-station/check-in control monuments are placed at the end. The following elements are included in each page (identified in Figure S3.13):
 - A. **Monument ID:** Includes the purpose and quality of the monument.
 - B. **Description of the monument's location:** Short description of what it is and where it is in relation to a particular (distinctive) structure or feature.

- C. **Locator map of the overall park unit:** An aerial photo showing the location of the monuments in relation to the other monuments.
 - D. **Large scale map of the monument:** An inset of the aerial photo showing the location of the monument; the view must include the monument's ID and its respective transect and azimuth. Distinctive structures or features in the area should be identified on the map.
 - E. **Ground photos:** At least two ground photos clearly showing the monument. Photos must incorporate the surrounding area to help the surveyor locate it on the ground. The transect direction should be added to the image, as well as the identification of the distinctive structures or features in the area.
 - F. **Coordinates and elevation information:** A table with the point's easting, northing, and elevation values. The elevation value should specify the surface to which it is related (for example: top of fire hydrant). It should also include the date when the monument was established.
- **Table with monument elevations:** A table with the elevation of the points in meters and feet, relative to NAVD88 (with Geoid) and to NGVD29.
 - **Vertical datum information:** A figure and table showing the relationship of 1983-2001 tidal epoch water levels to NAVD88 (with Geoid) and to NGVD29.
 - **Booklet & Monument Log:** A table with the record of the version of the booklet along with notes on the changes that are made.

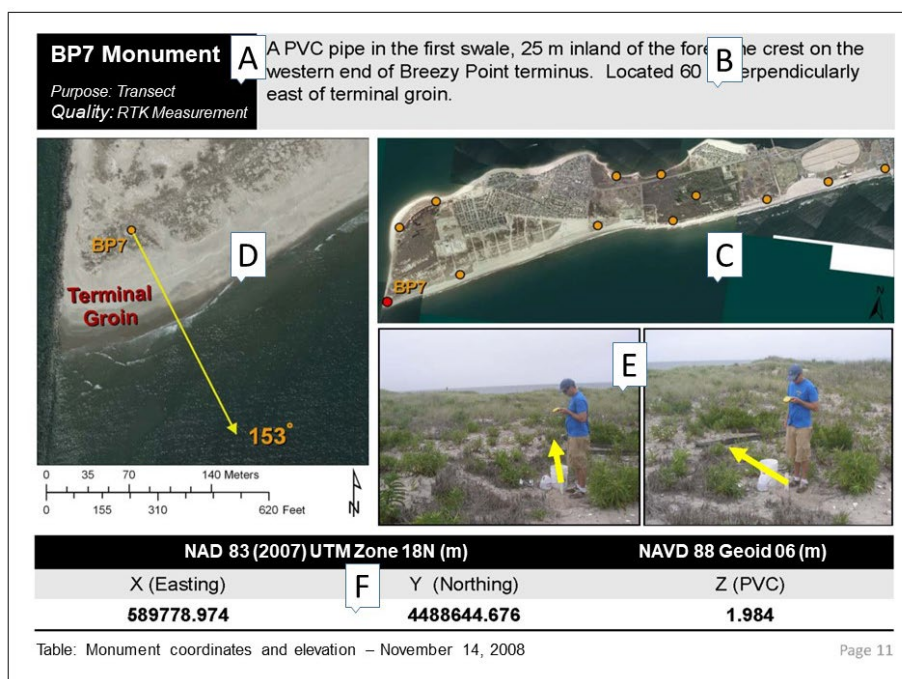


Figure S3.13. An example of elements describing monument BP7 in the Breezy Point, Jamaica Bay Unit of Gateway National Recreation Area, New York field booklet.

3.8 Database Maintenance

The Esri geodatabases and field booklets mentioned above are stored and maintained by the NCBN Data Manager. Any alterations to the monuments must be reported in order for alterations to be made accordingly.

3.9 SOP 3 – Revision History Log

The following table lists all changes that have been made to *SOP 3: Establishment of Monuments, Transects, and Geodatabases* since the original publication date. Any recommended or required changes added to the log must be complete and concise and promptly brought to the attention of the NCBN Protocol Lead. The Protocol Lead reviews and incorporates all changes and officially complete the Revision History Log of this SOP and the SOP Tracking Table for the SOP document. For complete instructions, please refer to *SOP 13: Protocol and SOP Versioning*.

SOP Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change
1.00	10/2012	Dennis Skidds, NCBN Data Manager	Initial SOP	Initial SOP
2.00	3/1/2022	Glenn Liu, GIS Technician, Rutgers University	Added section to address Transect/Monument Loss; description for both Control and Virtual Monuments; updated figures and links; generalized monument recording procedure	Full protocol update prescribed by Technical Steering Committee
2.00	1/31/2023	Robin Baranowski, NCBN BioTech	Changed from SOP 2 to 3 (updates section, figure and table #s)	A new SOP was added

SOP 4: Training for Field Data Collection

Version 2.00

4.1 Objective

This SOP establishes the responsibility for conducting training, details the content and frequency of network training, and identifies the target audience of training. Because there are a number of decision-making steps in the Coastal Topography Protocol, there is a need to provide for an understanding of coastal processes as a foundation for making beach feature identification. Training also explains and demonstrates the procedures required to assure safety in the field, mission planning, operation of the GPS/GNSS equipment, and post-survey data handling. Therefore, training is the basis for consistency in the execution of this protocol.

4.2 Implementation of Annual Safety Training

Whereas it is the goal of the Northeast Coastal and Barrier Network to ensure a safe working environment for all employees, cooperators, contractors, and volunteers (“staff”), each individual is responsible for ensuring his or her own safety in the field. Safety concerns should be brought to the attention of either the NCBN Program Manager or the NCBN Coastal Geomorphology Project Lead as soon as possible. Because coastal topography is monitored in several parks each year, it is critical that individual park policies regarding safety are respected and followed.

The Northeast Coastal and Barrier Network Coastal Geomorphological Monitoring Program Safety Plan was designed to provide an overview of safety issues that should be covered during preseason training and to serve as a first reference in case of an incident. Topics covered include emergency procedures and contacts, incident reporting, field preparation, safe field procedures, and vehicle safety. A Green-Amber Red Risk Assessment (GAR) has been conducted for this protocol, as has a Job Safety Analysis (JSA) that documents hazards associated with this protocol and recommends approaches to mitigate these hazards. Because the NCBN safety plan does not cover first aid procedures, it is recommended that field staff take training in wilderness first aid, or something similar.

The following can be found on the [NCBN Safety SharePoint site](#). Prior to the field season the following information must be reviewed and signed if applicable:

1. [*The Northeast Coastal and Barrier Network Coastal Geomorphological Monitoring Program Safety Plan*](#)
2. [*NCBN Coastal Geomorphological Monitoring Field Safety Item Checklist*](#)
3. [*Acknowledgement of Safety Training Form*](#) to be signed annually prior to field work
4. [*Safety Information Sheets*](#) for each park

4.3 Implementation of Training

A critical component of the Coastal Topography Protocol is the GPS/GNSS field survey of the beach transect. Successful execution of this task is contingent on properly trained personnel. The beach transect survey requires specific steps in preparation, data collection, and data processing. It is the responsibility of the Protocol Lead to develop and deliver a training program to provide a scientific and technical foundation for consistent and accurate data collection.

4.4 Frequency of the Training Sessions

Training is conducted prior to initial implementation of the protocol and thereafter at an interval of once every two years, or as needed due to staff or procedural changes. A field technician's initial training is to be conducted by personnel with substantial expertise and familiarity with the protocol. Subsequent trainings are likewise conducted in-person, when possible, but may also be done remotely via video conference.

4.5 Target Audiences

The Network shall provide training for two persons at each park. This establishes a core of competent and qualified field technicians. Additionally, data collection is improved when conducted by technicians with local knowledge. Training two persons per park also helps to reduce problems related to staffing or scheduling.

4.6 Training Syllabus

The purpose of training is to develop and maintain competence in the following:

1. Coastal geomorphology
 - a. Basic understanding of coastal process/response interaction
 - b. Fundamentals of cross-shore profile development
2. Mission planning – Choosing the right time to survey – *SOP 5: Survey Timing and GPS/GNSS Mission Planning*
 - a. Seasonal timing, tides, and selection of the survey window
 - b. Network of available monuments, establishment of transects and monuments, creation of the QA/QC auxiliary files and field booklets
 - c. GPS/GNSS mission planning
3. Using the equipment and conducting the survey
 - a. GPS/GNSS equipment components and preparation – *SOP 2: Equipment and Supplies*
 - b. GPS/GNSS and data logger setup and operation – *SOP 6: Basic GPS/GNSS Requirements for Coastal Topography Data Collection* and *SOP 7: Conducting the GPS/GNSS Coastal Topography Survey*
 - c. Collecting accuracy assessment data at monuments
 - d. Following the transect in the field using the survey controller

- e. Identifying transect features in the field and collecting the points
 - f. Finalizing the survey and saving data
 - g. Taking the field photographs
 - h. Taking field notes
 - i. Filling out the [*Coastal Topography Monitoring Field Data Form*](#)
4. Park-specific issues affecting data collection
 5. Post-survey processing – *SOP 8: Initial Post-Survey Processing*
 - a. Data downloading and exporting
 - b. Data backup
 - c. Initial quality assurance/quality control (QA/QC)
 6. Safety – See the [*Northeast Coastal and Barrier Network Coastal Geomorphological Monitoring Program Safety Plan*](#)

4.7 References

Northeast Coastal and Barrier Network. 2022. Northeast Coastal and Barrier Network Coastal Geomorphological Monitoring Program Safety Plan. Kingston, RI. Available at: <https://irma.nps.gov/DataStore/Reference/Profile/2291854> (accessed 30 December 2022.)

4.8 SOP 4 – Revision History Log

The following table lists all changes that have been made to *SOP 4: Training for Field Data Collection* since the original publication date. Any recommended or required changes added to the log must be complete and concise and promptly brought to the attention of the Northeast Coastal and Barrier Network (NCBN) Protocol Lead. The Protocol Lead reviews and incorporates all changes and officially complete the Revision History Log of this SOP and the SOP Tracking Table for the SOP document. For complete instructions, please refer to *SOP 13: Protocol and SOP Versioning*.

SOP Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change
2.00	3/1/2022	Scott Rasmussen NCBN Assistant Data Manager	This is a new SOP	A training SOP is necessary for training new field technicians
2.00	1/31/2023	Robin Baranowski, NCBN Biotech	Changed from SOP 2 to 3 (updates section, figure and table #s), updated training syllabus, added links material available on IRMA	A new SOP was added, new syllabus, links to material now available

SOP 5: Survey Timing and GPS/GNSS Mission Planning

Version 2.00

5.1 Objective

The objective of this SOP is to detail the process for selecting the temporal window for conducting the survey during the spring and fall seasons, the most likely times of the narrowest and widest beaches for the year, respectively. It describes the procedure for the long-range identification of the spring tide conditions as well as the satellite availability and geometric configuration and geometric position referred to as the position dilution of precision (PDOP). It addresses the variety of local resource related variables that may constrain conducting the survey, such as nesting seasons of endangered species.

Preparation for the field surveys are done at two different times: in the beginning of the year, when the two seasonal survey windows are identified, and a few weeks before each survey window, when specific variables are taken into consideration for selection of the survey days (Table S5.1).

Table S5.1. Timing of preparation for the coastal topography field surveys .

Beginning of the year	Prior to the survey
Survey windows	Tide stage
Tide condition	Satellite availability
Resource related issues	Storm events

5.2 Survey Windows

Over the course of a year, a sandy beach goes through a landward and seaward oscillation as the land/water surface contact (the shoreline) varies in position based on wave energy, sediment supply, and water level. These seasonal oscillations result in a narrowing and broadening of the beach. Observations of past summer and winter beaches at the Sandy Hook Unit (SHU) of Gateway National Recreation Area (GATE) demonstrate that beaches are at their narrowest by the middle of April (end of winter) and widest near the beginning of October (end of summer). Based on these observations and the general trends on other beaches in the Northeast Coastal and Barrier Network (NCBN), the optimal time for recording the seasonal oscillation of the beach is a six-week window in mid-March to late April and in mid-September to late October (Table S5.2). There is increased flexibility in conducting surveys slightly later in the spring because the shoreline position is not so dynamic and changes are more modest. Earlier spring surveys may more likely be followed by storm events, causing additional inland displacement of the shoreline. The reverse situation applies to the fall survey window. That is, earlier surveys +represent the accreting shoreline whereas later surveys are more likely to be impacted by storm events. However, conducting the survey outside the survey window is better than not conducting a survey.

Table S5.2. Approximate survey windows for each coastal topography survey season.

Survey season	Approximate window
Spring Survey	mid-March to late April
Fall Survey	mid-September to late October

5.3 Tide Condition

Within the survey windows, periods are pre-selected when the tidal range is maximized - spring tides. It is recommended that field surveys be conducted around the time of the lowest of the low tide levels reached during the spring tides, when the subaerial beach profile is at its maximum exposure.

The NCBN parks have semi-diurnal tides. There are two uneven high tides and two uneven low tides each day. Each month there are two periods when the difference between high and low tide (the tidal range) is at a maximum - spring tides - and when it is at a minimum - neap tides (Figure S5.1).

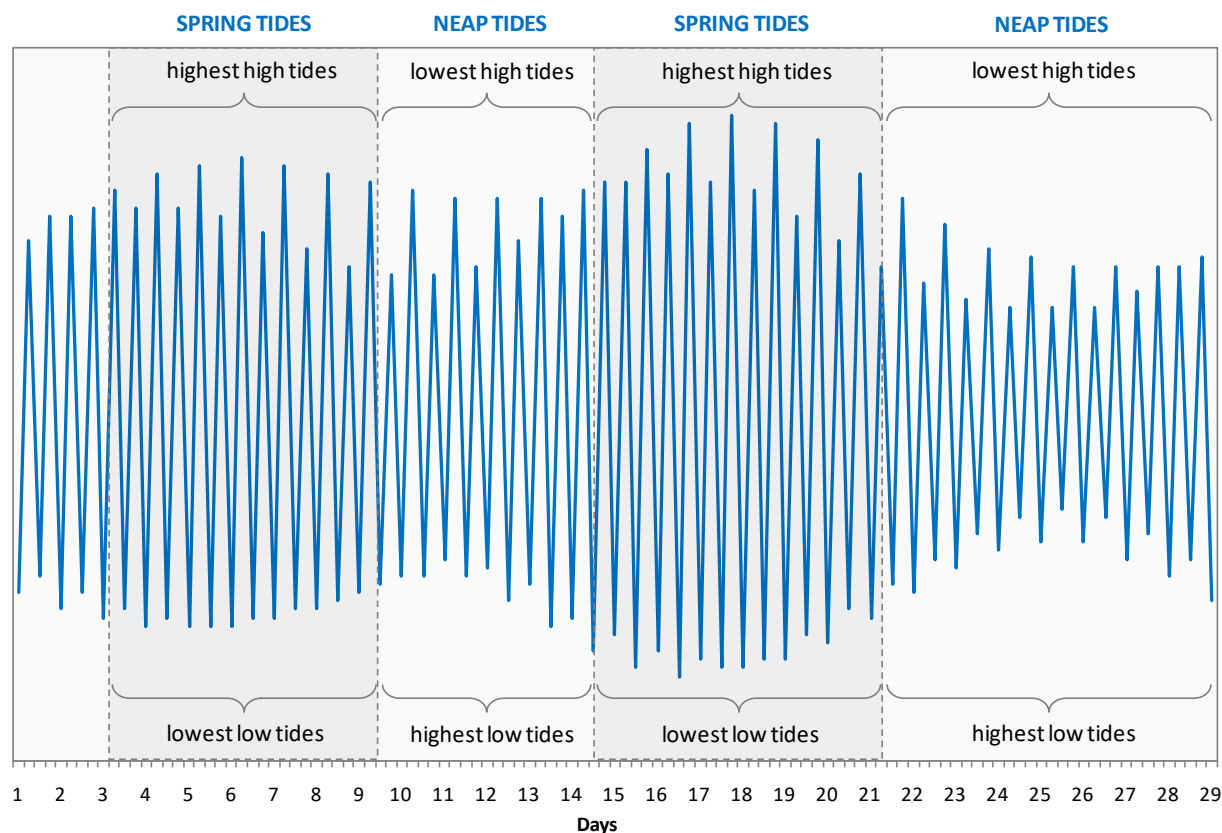


Figure S5.1. Tide predictions for Sandy Hook, New Jersey, depicting the periodic variations in semi-diurnal tidal ranges and the occurrence of spring tide ranges and neap tide ranges during the span of one month.

To select the best weeks to conduct the survey, the surveyor must retrieve NOAA's tide prediction charts for the tide gauge station closest to the park:

1. Go to the predicted tide calculations available at the [NOAA Tides & Currents website](#).
2. Select the **-NOAA Tide Predictions-** under the **-Tides/Water Levels-** tab for the tide gauge station closest to the park (Table S5.3):
3. Locate and press the **-Click Here for Annual Published Tide Tables-** button on the upper right portion of the screen and enter the specifications you desire to download tide data.

Table S5.3. Northeast Coastal and Barrier Network (NCBN) parks and information about their associated tide gauge.

NCBN Unit	Tide Gauge State	Tide Gauge Location	Tide Gauge Name
Assateague Island National Seashore	Maryland	Outer Coast	Ocean City Inlet
Cape Cod National Seashore	Massachusetts	Nantucket Sound and Nantucket Island	Nantucket
Fire Island National Seashore	New York	Sandy Hook Bay	Sandy Hook (Fort Hancock)
Gateway National Recreation Area	New Jersey	Sandy Hook Bay	Sandy Hook (Fort Hancock)

The predictions within the PDF are displayed in monthly tables that include information on the two highest and two lowest water levels that occur daily including the time of occurrence and the height above the selected datum. The full, new, and first and last quarter moons are indicated by symbols in the margins. The height information retrieved from the website is available in meters relative to mean lower low water (MLLW) for the current tidal epoch and is available for download in PDF, XML, and TXT formats.

Within each of the six-week survey windows designated for the spring and fall surveys, there are many available survey days around the dates of spring tide water levels. The surveyor should plan to conduct the surveys on the days with lowest low-tide levels that occur during the daytime, and the earliest in the survey window time frame to allow for rescheduling if necessary. Note that the selection of spring tides is not a strict requirement; it is simply recommended for ease of sampling when more of the low portion of the profile is exposed.

A couple of weeks prior to the established survey window, the surveyor must consult the tide prediction tables and select the days that allow for surveying during very low tides and during daylight. To maximize the surveying effort, the survey must be accomplished during the six hours around low tide, three hours before and three hours after. This time period provides the opportunity to collect more profile data during the span of time that the beach face is exposed.

Table S5.4 is an example of the spring 2012 survey planning for Gateway NRA, based on the tide prediction tables for the Sandy Hook tide gauge (Figure S5.2). A span of three and a half weeks within the mid-March to late April period incorporate spring tides - the ideal time for conducting the coastal topography surveys.

NOAA Tide Predictions

Station 14 8531680

Source: NOAA NOS/CO-OPS

Station Type: Harmonic

Time Zone: LST/DT

Datum: mean lower low water (MLLW) which is the chart datum of soundings

SANDY HOOK, New Jersey, 2012

Times and Heights of High and Low Waters

March					April					May					
Time	Height	Time	Height		Time	Height	Time	Height		Time	Height	Time	Height		
1	01:05 AM 4.2 128	16	03:14 AM 4.9 149	1	03:13 AM 4.4 134	16	04:51 AM 4.7 143	1	03:38 AM 4.7 143	16	03:38 AM 4.7 143	1	03:38 AM 4.7 143	16	03:38 AM 4.7 143
Th	07:59 AM 1.0 30	F	10:01 AM 0.3 9	Su	10:19 AM 0.8 24	M	11:22 AM 0.2 6	Tu	10:30 AM 0.4 12	W	10:30 AM 0.4 12	Th	10:30 AM 0.4 12	F	10:30 AM 0.4 12
	01:47 PM 3.6 110		03:49 PM 0.3 131		04:06 PM 4.1 125		05:27 PM 4.8 146		04:29 PM 4.9 149		04:29 PM 4.9 149		04:29 PM 4.9 149		04:29 PM 4.9 149
	07:50 PM 1.0 30		10:18 PM 0.4 12		10:28 PM 0.8 24		11:50 PM 0.4 12		10:59 PM 0.5 15		10:59 PM 0.5 15		10:59 PM 0.5 15		10:59 PM 0.5 15
2	01:58 AM 4.2 128	17	04:18 AM 4.8 146	2	04:17 AM 4.6 140	17	05:47 AM 4.7 143	2	04:42 AM 4.9 149	17	04:42 AM 4.9 149	2	04:42 AM 4.9 149	17	04:42 AM 4.9 149
F	09:05 AM 0.9 27	Sa	11:00 AM 0.4 134	3	11:11 AM 0.4 12	Tu	12:06 PM 0.1 3	3	11:22 AM 0.1 3	18	11:22 AM 0.1 3	3	11:22 AM 0.1 3	18	11:22 AM 0.1 3
	02:45 PM 3.6 110		04:53 PM 0.4 134		05:05 PM 4.5 137		06:18 PM 5.0 152		05:27 PM 5.4 165		05:27 PM 5.4 165		05:27 PM 5.4 165		05:27 PM 5.4 165
	09:01 PM 0.9 27		11:18 PM 0.3 9		11:25 PM 0.4 12				11:55 PM 0.1 3		11:55 PM 0.1 3		11:55 PM 0.1 3		11:55 PM 0.1 3
3	02:59 AM 4.3 131	18	05:20 AM 4.9 149	3	05:20 AM 4.8 146	18	12:37 AM 0.3 9	3	05:45 AM 5.0 152	18	12:37 AM 0.3 9	3	05:45 AM 5.0 152	18	12:37 AM 0.3 9
Sa	10:00 AM 0.7 21	Su	11:52 AM 0.0 0	4	11:59 AM 0.1 3	19	06:36 AM 4.8 146	4	12:12 PM -0.2 -6	19	12:12 PM -0.2 -6	4	12:12 PM -0.2 -6	19	12:12 PM -0.2 -6
	03:46 PM 3.8 116		05:54 PM 4.6 140		06:01 PM 5.0 152		12:48 PM 0.1 3		06:22 PM 5.8 177		06:22 PM 5.8 177		06:22 PM 5.8 177		06:22 PM 5.8 177
	10:00 PM 0.6 18						07:02 PM 5.2 158								
4	04:02 AM 4.5 137	19	12:11 AM 0.1 3	4	12:19 AM 0.0 0	19	01:22 AM 0.2 6	4	12:50 AM -0.3 -9	19	01:22 AM 0.2 6	4	12:50 AM -0.3 -9	19	01:22 AM 0.2 6
Su	10:50 AM 0.4 12	M	12:39 PM 5.0 152	5	06:17 AM 5.1 155	20	07:20 AM 4.9 149	5	06:43 AM 5.2 158	20	07:20 AM 4.9 149	5	06:43 AM 5.2 158	20	07:20 AM 4.9 149
	04:44 PM 4.1 125		06:16 PM -0.1 -3		12:46 PM -0.2 -6		01:28 PM 0.1 3		01:03 PM -0.4 -12		01:28 PM 0.1 3		01:03 PM -0.4 -12		01:03 PM -0.4 -12
	10:53 PM 0.3 9		06:45 PM 4.9 149		06:51 PM 5.5 168		07:41 PM 5.4 165		07:13 PM 6.2 189		07:41 PM 5.4 165		07:13 PM 6.2 189		07:13 PM 6.2 189
5	04:59 AM 4.8 146	20	01:00 AM 0.0 0	5	01:12 AM -0.4 -12	20	02:05 AM 0.1 3	5	01:45 AM -0.6 -18	20	02:05 AM 0.1 3	5	01:45 AM -0.6 -18	20	02:05 AM 0.1 3
M	11:37 AM 0.0 0	Tu	07:05 AM 5.1 155	6	07:09 AM 5.4 162	21	08:02 AM 4.9 149	6	07:37 AM 5.4 165	21	08:02 AM 4.9 149	6	07:37 AM 5.4 165	21	08:02 AM 4.9 149
	05:35 PM 4.5 137		01:22 PM -0.2 -6		01:34 PM -0.5 -15		02:07 PM 0.1 3		01:54 PM -0.6 -18		02:07 PM 0.1 3		01:54 PM -0.6 -18		02:07 PM 0.1 3
	11:45 PM -0.1 -3		07:30 PM 5.1 155		07:39 PM 5.9 180		08:18 PM 5.4 165		08:04 PM 6.5 198		08:18 PM 5.4 165		08:04 PM 6.5 198		08:18 PM 5.4 165
6	05:50 AM 5.1 155	21	01:46 AM -0.1 -3	6	02:04 AM -0.7 -21	21	02:46 AM 0.0 0	6	02:39 AM -0.8 -24	21	02:46 AM 0.0 0	6	02:39 AM -0.8 -24	21	02:46 AM 0.0 0
Tu	12:22 PM -0.3 -9	W	07:48 AM 5.1 155	7	07:58 AM 5.5 168	22	08:41 AM 4.8 146	7	08:29 AM -0.4 -12	22	08:41 AM 4.8 146	7	08:29 AM -0.4 -12	22	08:41 AM 4.8 146
	06:22 PM 5.0 152		02:03 PM -0.3 -9		02:21 PM -0.7 -21	23	02:45 PM 0.2 6		08:54 PM 5.4 165		02:45 PM 0.2 6		08:54 PM 5.4 165		02:45 PM 0.2 6
			08:10 PM 5.2 158		08:25 PM 6.2 189		08:53 PM 5.4 165				08:53 PM 5.4 165				
7	12:35 AM -0.4 -12	22	02:29 AM -0.2 -6	7	02:56 AM -0.9 -27	22	03:26 AM 0.0 0	7	03:31 AM -0.9 -27	22	03:26 AM 0.0 0	7	03:31 AM -0.9 -27	22	03:26 AM 0.0 0
W	06:36 AM 5.4 165	Th	08:28 AM 5.1 155	8	08:47 AM 5.6 171	23	09:20 AM 4.7 143	8	09:32 AM 5.4 165	23	09:20 AM 4.7 143	8	09:32 AM 5.4 165	23	09:20 AM 4.7 143
	01:07 PM -0.6 -18		02:42 PM -0.2 -6		03:09 PM -0.8 -24		03:21 PM 0.3 9		09:46 PM 6.4 195		03:21 PM 0.3 9		09:46 PM 6.4 195		03:21 PM 0.3 9
	07:06 PM 5.4 165		08:48 PM 5.3 162		09:13 PM 6.3 192		09:26 PM 5.3 162				09:26 PM 5.3 162				
8	01:25 AM -0.7 -21	23	03:11 AM -0.2 -6	8	03:46 AM -0.9 -27	23	04:04 AM 0.1 3	8	04:22 AM -0.8 -24	23	04:04 AM 0.1 3	8	04:22 AM -0.8 -24	23	04:04 AM 0.1 3
Th	07:21 AM 5.6 171	F	09:07 AM 5.0 152	9	07:58 AM 5.5 168	24	09:59 AM 4.5 137	9	10:18 AM 5.2 158	24	09:59 AM 4.5 137	9	10:18 AM 5.2 158	24	09:59 AM 4.5 137
	01:51 PM -0.8 -24		03:18 PM -0.2 -6		03:57 PM -0.7 -21		03:57 PM 0.4 12		10:40 PM -0.4 -12		03:57 PM 0.4 12		10:40 PM -0.4 -12		03:57 PM 0.4 12
	07:50 PM 5.7 174		09:24 PM 5.2 158		10:03 PM 6.3 192		09:59 PM 5.2 158		10:30 PM 6.2 189		09:59 PM 5.2 158		10:30 PM 6.2 189		09:59 PM 5.2 158
9	02:13 AM -0.9 -27	24	03:49 AM -0.1 -3	9	04:37 AM -0.8 -24	24	04:41 AM 0.3 9	9	05:13 AM -0.6 -18	24	04:41 AM 0.3 9	9	05:13 AM -0.6 -18	24	04:41 AM 0.3 9
F	08:06 AM 5.6 171	Sa	09:46 AM 4.8 146	10	10:32 AM 5.3 162	25	10:39 AM 4.3 131	10	11:17 AM 5.1 155	25	10:39 AM 4.3 131	10	11:17 AM 5.1 155	25	10:39 AM 4.3 131
	02:35 PM -0.9 -27		03:53 PM 0.0 0		04:46 PM -0.5 -15		04:31 PM 0.6 18		05:22 PM -0.1 -3		04:31 PM 0.6 18		05:22 PM -0.1 -3		04:31 PM 0.6 18
	08:35 PM 5.8 177		09:59 PM 5.1 155		10:58 PM 6.1 186		10:33 PM 5.0 152		11:38 PM 5.9 180		10:33 PM 5.0 152		11:38 PM 5.9 180		10:33 PM 5.0 152
10	03:02 AM -0.9 -27	25	04:27 AM 0.0 0	10	05:28 AM -0.6 -18	25	05:17 AM 0.4 12	10	06:06 AM -0.3 -9	25	05:17 AM 0.4 12	10	06:06 AM -0.3 -9	25	05:17 AM 0.4 12
Sa	08:54 AM 5.4 165	Su	10:25 AM 4.6 140	11	11:30 AM 5.0 152	26	11:21 AM 4.2 128	11	12:16 PM 4.9 149	26	11:21 AM 4.2 128	11	12:16 PM 4.9 149	26	11:21 AM 4.2 128
	03:19 PM -0.8 -24		04:26 PM 0.2 6		05:37 PM -0.2 -6		05:05 PM 0.8 24		06:17 PM 0.3 9		05:05 PM 0.8 24		06:17 PM 0.3 9		05:05 PM 0.8 24
	09:24 PM 5.8 177		10:33 PM 5.0 152		11:56 PM 5.8 177		11:09 PM 4.8 146				11:09 PM 4.8 146				
11	04:50 AM -0.8 -24	26	05:03 AM 0.2 6	11	06:23 AM -0.3 -9	26	05:53 AM 0.6 18	11	12:36 AM 5.5 168	26	05:53 AM 0.6 18	11	12:36 AM 5.5 168	26	05:53 AM 0.6 18
Su	10:46 AM 5.2 158	M	11:06 AM 4.3 131	12	12:31 PM 4.8 146	27	12:06 AM 0.0 122	12	07:01 AM 0.0 0	27	12:06 AM 0.0 122	12	07:01 AM 0.0 0	27	12:06 AM 0.0 122
	05:04 PM -0.7 -21		04:58 PM 0.4 12		06:33 PM 0.2 6		05:42 PM 0.9 27		07:15 PM 4.8 146		05:42 PM 0.9 27		07:15 PM 4.8 146		05:42 PM 0.9 27
	11:16 PM 5.7 174		11:08 PM 4.8 146				11:53 PM 4.7 143		08:19 PM 5.6 188		11:53 PM 4.7 143		08:19 PM 5.6 188		11:53 PM 4.7 143
12	05:41 AM -0.6 -18	27	05:39 AM 0.5 15	12	12:55 AM 5.5 168	27	06:35 AM 0.8 24	12	01:32 AM 5.2 158	27	06:35 AM 0.8 24	12	01:32 AM 5.2 158	27	06:35 AM 0.8 24
M	11:42 AM 4.9 149	Tu	11:49 AM 4.1 125	13	07:23 AM 0.1 3	28	12:54 PM 4.0 122	13	08:01 AM 5.0 160	28	12:54 PM 4.0 122	13	08:01 AM 5.0 160	28	12:54 PM 4.0 122
	05:52 PM -0.4 -12		05:30 PM 0.6 18	14	01:31 PM 4.6 140	29	06:26 PM 1.1 34		08:26 PM 5.8 184	29	06:26 PM 1.1 34		08:26 PM 5.8 184	29	06:26 PM 1.1 34
			11:46 PM 4.6 140		07:59 PM 0.5 15										
13	12:13 AM 5.5 168	28	06:17 AM 0.7 21	13	05:54 AM 5.2 158	28	12:43 AM 4.7 143	13	02:27 AM 4.9 149	28	12:43 AM 4.7 143	13	02:27 AM 4.9 149	28	12:43 AM 4.7 143
Tu	06:37 PM -0.2 -6	W	12:34 PM 3.9 119	14	08:30 AM 0.3 9	29	07:27 AM 0.9 27	14	09:01 AM 0.4 12	29	07:27 AM 0.9 27	14	09:01 AM 0.4 12	29	07:27 AM 0.9 27
	12:41 PM 4.7 143		06:06 PM 0.9 27	15	02:31 PM 4.5 137	30	01:43 PM 4.1 125	15	03:05 PM 4.8 146	30	01:43 PM 4.1 125	15	03:05 PM 4.8 146	30	01:43 PM 4.1 125
	06:47 PM 0.0 0				08:51 PM 0.7 21		07:27 PM 1.1 34		09:33 PM 0.9 27		07:27 PM 1.1 34		09:33 PM 0.9 27		07:27 PM 1.1 34
14	01:12 AM 5.3 162	29	12:29 AM 4.5 137	14	02:53 AM 5.0 152	29	01:38 AM 4.6 140	14	03:21 AM 4.7 143	29	01:38 AM 4.6 140	14	03:21 AM 4.7 143	29	01:38 AM 4.6 140
W	07:41 AM 0.1 3	Th	07:04 AM 0.9 27	15	09:35 AM 0.3 9	30	08:31 AM 0.8 24	15	09:56 AM 0.4 12	30	08:31 AM 0.8 24	15	09:56 AM 0.4 12	30	08:31 AM 0.8 24
	01:42 PM 4.4 134		01:22 PM 3.8 116		03:31 PM 4.5 137		02:36 PM 4.3 131		10:00 AM 4.8 146		02:36 PM 4.3 131		10:00 AM 4.8 146		02:36 PM 4.3 131
	07:55 PM 0.3 9		06:52 PM 1.0 30		10:00 PM 0.7 21		08:45 PM 1.1 34		10:32 PM 0.8 24		08:45 PM 1.1 34		10:32 PM 0.8 24		08:45 PM 1.1 34
15	02:12 AM 5.1 155	30	01:18 AM 4.4 134	15	03:52 AM 4.8 146	30	02:36 AM 4.7 143	15	04:16 AM 4.5 137	30	02:36 AM 4.7 143	15	04:16 AM 4.5 137	30	02:36 AM 4.7 143
Th	08:52 AM 0.3 9	F	08:09 AM 1.1 34		10:32 AM 0.3 9		09:34 AM 0.7 21		10:45 AM 0.4 12		09:34 AM 0.7 21		10:45 AM 0.4 12		09:34 AM 0.7 21
	02:44 PM 4.3 131		02:12 PM 3.8 116		04:30 PM 4.6 140		10:30 PM 4.5 137		11:23 PM 0.7 21		10:30 PM 4.5 137		11:23 PM 0.7 21		10:30 PM 4.5 137
	09:09 PM 0.5 15		08:02 PM 1.1 34		10:58 PM 0.6 18		09:57 PM 0.8 24				09:57 PM 0.8 24				
		31	02:13 AM 4.4 134	16	01:19 AM 1.0 30										
		Sa	09:19 AM 1.0 30	17	03:07 PM 3.9 119										
			03:07 PM 3.9 119	18	09:22 PM 1.1 34										
			09:22 PM 1.1 34	19											

Figure S5.2. NOAA tide predictions (meters) for March to mid-May, 2012 for Sandy Hook, New Jersey. Periods around spring tides with conditions favorable for conducting the survey during the period between early-March to late April are highlighted with the red dashed boxes (<http://tidesandcurrents.noaa.gov>).

5.4 Resource Related Issues

The park resource managers must be contacted once the survey windows have been determined, to identify the constraints that may exist due to park specific issues. The nesting seasons of endangered and protected species, or the occurrence of public activities may confine the survey window by restricting the access to the transect locations. If access to specific transects within the park is restricted at a specific point in a season, it is optimal to prioritize collection of data at the affected transect as soon as possible. Sometimes, this means that the survey must be split into multiple dates. Regular communication and cooperation is encouraged to ensure continuous collection of data, unimpeded by fencing or restricted access.

Additionally, contact should be made with any cooperating or neighboring agency, including management at state parks, county parks, other federal agencies, or other jurisdictional partners to learn of temporary limitations or constraints that might impact running the surveys.

5.5 Satellite Availability / Geometry and Space Weather Conditions

The positional data recorded by the GPS/GNSS unit are derived from the time signals sent from the constellation of satellites. For an RTK solution, influences on the accuracy of a derived 3-dimensional position include the atmospheric delays to transferring the satellite signal, multi-pathing, and receiver associated errors, as well as the number of satellites in the sky and the satellite geometry (the locations of the satellites in view relative to each other and to the receiver). The effect of satellite geometry can be quantified through a metric called the position dilution of precision (PDOP). The PDOP value can be calculated prior to the survey, and is an important planning consideration for surveys to be undertaken utilizing GPS receivers that are not capable of processing data from the entirety of available GNSS constellations. For GNSS capable receivers, this planning step is not necessary, but horizontal and vertical precision thresholds should be set within the survey controller to prevent the collection of inaccurate and/or imprecise data.

5.5.1 PDOP and Mission Planning

A PDOP below six is necessary to collect accurate and precise positions (Trimble 2007) and therefore needs to be considered in the date and time selection of the survey. PDOP is a predictable value that can be plotted for the planned survey day. There are a number of [free online mission-planning tools](#) that can be used to assess the predicted PDOP levels for a given date and location (Figure S5.3). In addition, many GPS/GNSS office software packages include mission-planning modules (e.g., the “Quick Plan” function within Trimble Pathfinder Office). PDOP fluctuates throughout the day as the satellites move in their orbits and change their relative geometry. PDOP values increase (worsen) if the receiver/antenna has an obstructed view of the sky or if satellites become unavailable. If an obstruction such as a building or high bluff is known to exist in the vicinity of a planned survey, many mission-planning tools allow the user to input the obstruction’s location in order to achieve a more accurate predicted PDOP value. PDOP values decrease (improve) with receivers that are capable of utilizing other GNSS in addition to the U.S. GPS (e.g., the Russian GLONASS or European Galileo systems). Mission-planning software tools generally allow users to define which GNSS they have access to, as well.

PDOP values are generally below the threshold of 6 at all times in the open beach-dune areas of the Northeastern Parks, with occasional values greater than 6 occurring near midday. Predictions of PDOP value are valid for a maximum of thirty days in advance, thereafter new predictions should be obtained.

Example procedure for obtaining predictions for PDOP prior to a survey:

1. Visit the [Trimble GNSS Planning Online website](#).
2. Select all GNSS' that your receiver is capable of utilizing (at least GPS).
3. Select the location of the planned survey on the map or enter coordinates.
4. Set the Elevation cutoff to 10°.
5. Set the anticipated date and time of the survey.
6. Click “*Apply*”
7. Select the Charts tab and scroll to the DOP chart.
8. Verify that PDOP is between zero and six for at least the majority of the survey day. If the PDOP frequently exceeds six, reschedule the survey to the next day in the survey window, and repeat the above steps.

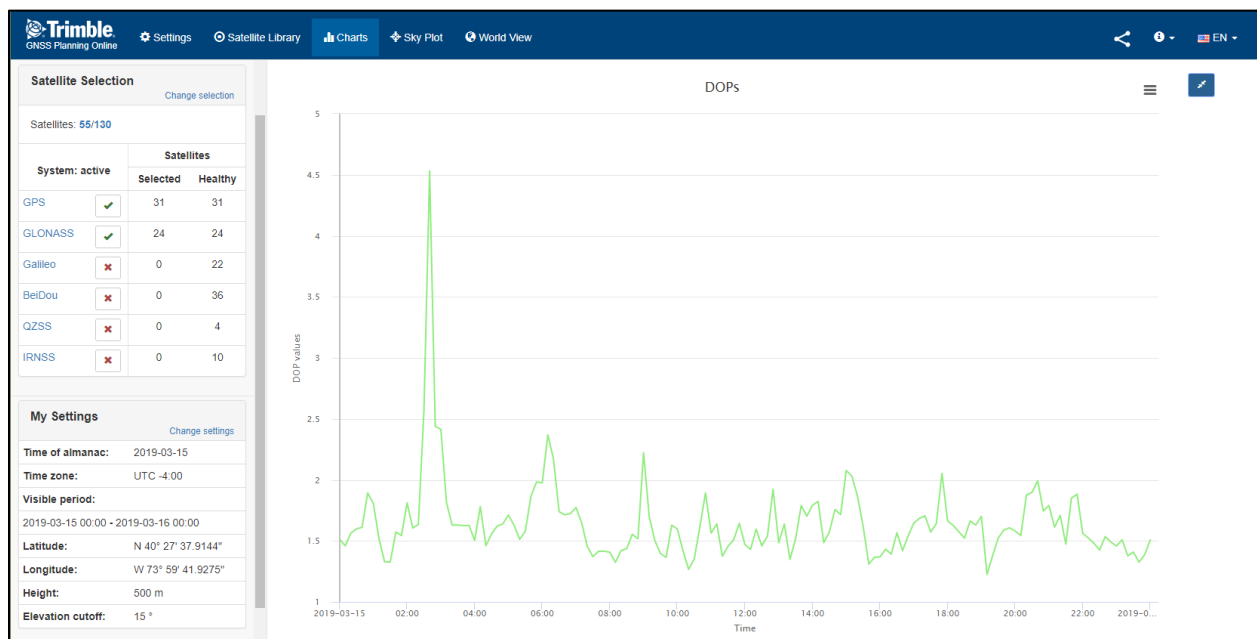


Figure S5.3. An example of the distribution of position dilution of precision (PDOP) values using the [Trimble GNSS online mission planning tool](#). PDOP values less than 6 generally meet the survey criteria.

5.5.2 Space Weather Conditions

Space weather events can have an impact on GPS/GNSS functions; for example, signal variations may occur during geomagnetic storms or other disturbances to the ionosphere. Space weather conditions should be checked online 24 hours before planned surveys and on the day of the survey.

To check space weather conditions:

- Go to the NOAA [Space Weather Prediction Center website](#)
- Browse to the “Global Positioning System (GPS) Community Dashboard”, under the “Dashboard” tab.
- Observe the 24-Hour, Latest, and Predicated Conditions on the top of the page (Figure S5.4). Ensure that there are no predicated events and that current conditions are green or -none-.

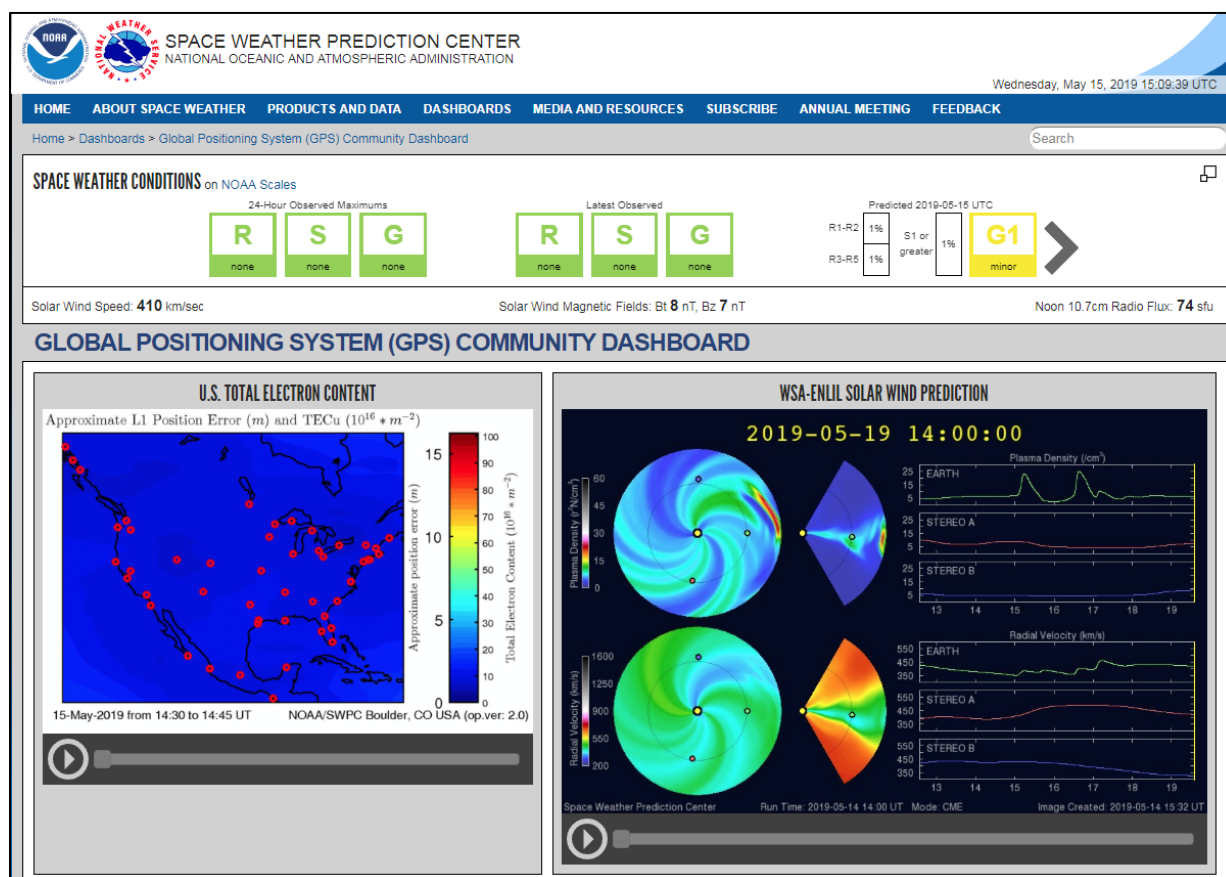


Figure S5.4. An example of space weather conditions for a given day. Note that all observations are in green and there are no impacts expected.

5.6 Storm Events

Storm events should not unduly delay the schedule of collection of the profile data. On the scheduled day of the survey, if the high tide water level is 0.35 m above the predicted high tide, do not conduct the survey. Use the survey window to conduct the survey once the storm surge has receded and

exposed the recovered beach face, generally around 5 days after the storm event. Because the objective of this monitoring protocol is to track the seasonal and longer-term changes in the beach topography, surveys should consistently record the end of winter and end of summer conditions represented by the spring and fall timing. Maintaining a record of the changes from season to season and year to year allows for a more consistent comparison both within a park and between parks.

The occurrence of a storm near the time of the spring survey does not bias the end of the winter season beach condition because this survey is used to track the cumulative effects of the entire storm season. However, the end of summer survey should be conducted early in the fall because the occurrence of storms only increase toward the end of the year and that condition may alter the summer sediment accumulation.

At the end of winter season and at the end of summer season surveying, it is better to conduct the survey and be prepared to repeat the surveys at a subsequent time if changing conditions warrant an additional survey to represent the end of the season.

5.7 References

Trimble 2007. GPS – The First Global Navigation Satellite System. Sunnyvale, CA: Trimble Navigation Limited. 144p.

5.8 SOP 5 – Revision History Log

The following table lists all changes that have been made to *SOP 5: Survey Timing and GPS/GNSS Mission Planning* since the original publication date. Any recommended or required changes added to the log must be complete and concise and promptly brought to the attention of the NCBN Protocol Lead. The Protocol Lead reviews and incorporates all changes and officially complete the Revision History Log of this SOP and the SOP Tracking Table for the SOP document. For complete instructions, please refer to *SOP 13: Protocol and SOP Versioning*.

SOP Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change
1.00	4/12/2013	Dennis Skidds, NCBN Data Manager	Initial SOP	Initial SOP
2.00	3/1/2022	Glenn Liu, GIS Technician, Rutgers University	Updated survey window description. Clarified that Spring HT is not a strict requirement. Revised satellite section and added Space Weather section from 3D Protocol. Updated figures.	Full protocol update prescribed by Technical Steering Committee
2.00	1/31/2023	Robin Baranowski, NCBN BioTech	Changed from SOP 4 to 5 (updates section, figure and table #s)	A new SOP was added

SOP 6: Basic GPS/GNSS Requirements for Coastal Topography Data Collection

Version 2.00

6.1 Objective

This SOP details the critical settings of the GPS/GNSS equipment for collecting topographical points. There are a number of parameters that need to be preconfigured within the survey style options as well as in the job properties, so that data collection is within the centimeter-accuracy specification. It is critical to ensure that the correct datum, coordinate system, and geoid are indicated during job setup. The standardization of the criteria for collecting topographical data assures that the survey is replicable and comparable.

6.2 Survey Style Properties

Survey styles define the parameters for configuring and communicating with the GPS/GNSS units (base and rover receivers), and for measuring and storing points. The Coastal Topography Protocol uses Real-time Kinematic or Network survey styles, a technique that employs a radio to broadcast signals from the base station to the rover, and calculates and records its position in real time. As an example, when using the Trimble R10, configure the survey style properties using the following settings listed in Table S6.1.

Note: The survey style configurations can be stored as a template within the field survey controller and re-used in each of the coastal topography seasonal surveys.

Table S6.1. Survey style properties to be used with this protocol.

Property	Setting
Survey Type	Real-Time-Kinematic Survey (RTK)
Rover and Base Options:	
Elevation Mask	Minimum 10° (angle below which satellites are not considered).
PDOP Mask	6.0 (highest PDOP value at which receiver computes positions)
Antenna Settings	Set to suit your equipment

6.3 Job Properties

The following are the necessary inputs in the properties of the job that are created for running the survey and storing the points. It is necessary to ensure that the data are collected in the correct coordinate system, datum, and geoid. The job can either be created in the office using the relevant software (example: Trimble Business Center or Leica Infinity) and then transferred to the field survey controller, or it can be created directly in the field survey controller. See table S6.2 for the recommended job setup fields and instructions.

Table S6.2. Job setup fields and instructions to be used with this protocol.

Field	Instruction and Sample Entry
Name of Job	<i>Protocol Nomenclature_ "2D" _date (yyyymmdd)</i> add "A", "B" to the end of the name if more than one rover is being used in the same day ex. CACO_2D_20100404, GATE_JBU_BP_2D_20190328A
Grid Coordinate System	Universal Transverse Mercator (UTM)
UTM Zone Number	18 (Gateway National Recreation Area, Assateague Island National Seashore, and Fire Island National Seashore) 19 (Cape Cod National Seashore)
Horizontal Datum	North American Datum of 1983 (2011) 2010.0
Vertical Datum	North American Vertical Datum of 1988
Geoid Model *	GEOID12B
Units	Meters
Active Map**	Monuments and transects from park's geodatabase

* Download the Geoid file from the Trimble website and upload it to the processing software (Trimble Business Center, Leica Infinity, etc.) and to the field survey controller. [Download the Geoid file.](#)

** Upload the feature classes from the park's Esri geodatabase (the monuments and transects created according to *SOP 2: Establishment of Monuments, Transects, and Geodatabases*) into the field survey controller, using the corresponding data transfer software (ex. Trimble Data Transfer Utility).

Note: The National Spatial Reference System (NSRS) is the spatial standard used to locate the coastal topography in this protocol. As technology progresses, the spatial reference system undergoes periodic updates related to datum realizations, thereby causing adjustments in the coordinates of the surveyed points. The NOAA National Geodetic Survey (NGS) releases these updates for the USA. As the NSRS is updated, shifts in position occur depending on location and produce offsets in horizontal and vertical coordinates. The original geodetic datum used for this protocol was NAD83 (CORS 96) (2002.0). In April 2012 there was an update released for the current NAD83 coordinate system. The current coordinate system is NAD83 2011 (2010.0) and it was accompanied by a new geoid model, GEOID12B. The update from the previous datum realization is cited as the National Adjustment of 2011 (NA2011) by NOAA NGS. It incorporates tectonic motion measured within the Continuously Operating Reference Station (CORS) network. This datum realization and future adjustments should produce only minor changes for the purposes of this protocol. Specific attention needs to be paid to the datum the survey monuments are referencing in order that comparison to previous realizations may be accommodated. To remain current and maximize comparability through time, visit the [National Geodetic Survey website](#).

6.4 SOP 6 – Revision History Log

The following table lists all changes that have been made to *SOP 6: Basic GPS/GNSS Requirements for Coastal Topography Data Collection* since the original publication date. Any recommended or required changes added to the log must be complete and concise and promptly brought to the attention of the NCBN Protocol Lead. The Protocol Lead reviews and incorporates all changes and officially complete the Revision History Log of this SOP and the SOP Tracking Table for the SOP document. For complete instructions, please refer to *SOP 13: Protocol and SOP Versioning*.

SOP Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change
1.00	4/12/2013	Dennis Skidds, NCBN Data Manager	Initial SOP	Initial SOP
2.00	3/1/2022	Glenn Liu, GIS Technician, Rutgers University	Emphasized importance of correct datum, coordinate system and geoid during job setup. Generalized any mentions of Trimble software and added Leica examples	Full protocol update prescribed by Technical Steering Committee
2.00	1/31/2023	Robin Baranowski, NCBN BioTech	Changed from SOP 5 to 6 (updates section, figure and table #s)	A new SOP was added

SOP 7: Conducting the GPS/GNSS Coastal Topography Survey

Version 2.00

7.1 Objective

The objective of this SOP is to describe the coastal topography data collection method. A preliminary part of the monitoring program is the selection of the survey window using the procedure in *SOP 5: Survey Timing and GPS/GNSS Mission Planning*. The survey is scheduled for the first convenient spring-tide low-tide in mid-March to late April (spring survey) and mid-September to late October (fall survey). The data collection can begin as soon as 3 hours before the predicted low tide, maximizing the time of exposure of the beach face and the time for surveying in dry conditions.

This SOP consists of four components. The first component is the initial preparation procedures that include the setup of the GPS/GNSS system, the display of the background survey control monuments and transects (created in *SOP 3: Establishment of Monuments, Transects, and Geodatabases*) on the field survey controller, and the initialization of the field data form. The second component is the identification and measurement of the physical or virtual transect monument, the conducting of the survey with the GPS/GNSS equipment, and the procedure to create a photographic record of the profile. The third component deals with natural or artificial perturbations to the beach profile, including natural features (e.g., scarps), hard structures (e.g., seawalls), and human interference (e.g., anglers). The fourth component ends the survey.

Throughout this SOP, example procedures and screenshots from General Survey of Trimble Access are provided. The same procedure may be done with other equipment and software, such as SmartWorx Viva on a Leica controller.

7.2 Preparation Procedures

7.2.1 GPS/GNSS Setup

Prior to the beginning of the survey, the GPS/GNSS equipment must be physically configured and set up. Depending on the equipment and personnel available and the area to be covered, the field technician can set up the instrument in a variety of ways:

Base + rover setup

Uses one base station that is temporarily set up in the field on a known location (control monument) and is sending corrections to the rover via a radio link. This setup is adequate to survey transects up to a 5 km distance from the base station (20 km with an external radio). As the distance increases, the atmospheric conditions at the rover and base station becomes increasingly different, resulting in a decrease in accuracy. The base receiver must be set up at a control monument (as described in *SOP 3: Establishment of Monuments, Transects, and Geodatabases*) and located as close as feasible to the planned survey area.

Multiple bases + rover setup

Used when multiple base receivers are available, two (or more) reference stations can be established at a control monument (as described in *SOP 3: Establishment of Monuments, Transects, and Geodatabases*), each operating independently. This is useful for surveying large areas (>20 km) because the surveyor can select the reference station that is closest to its location and continue surveying, without the need to stop the survey.

Base (single or multiple) + multiple rovers

Used when more than one rover can be in communication with one reference station at the same time. The existence of several rover units in the parks allows for teams of users to survey different transects at the same time, increasing the time efficiency of the data collection. The base receiver must be situated at a control monument (as described in *SOP 3: Establishment of Monuments, Transects, and Geodatabases*) and located as close as feasible to the planned survey area.

Rover + correction services

An increasingly popular alternative to the base and rover setup is the use of commercially or publicly-available correction services to access a network of reference stations (such as the National Geodetic Survey's Continuously Operating Reference Stations or "CORS" network) for real time correction. This is particularly useful in cases where communication between the rover and base is not possible (e.g., due to the presence of obstacles such as high bluffs). Internet-based Networked Transport of RTCM via Internet Protocol (NTRIP) services offer corrections over cellular or wi-fi connections. This option can have cell phone associated costs and require a plan with a carrier that supports the type of data connection that is necessary. The use of rovers and cellular-based NTRIP correction services has become the primary setup at some NCBN parks, such as Gateway National Recreation Area. Other services such as Precise Point Positioning (PPP) can similarly deliver such corrections via satellite. All such services eliminate the need for field staff to set up and employ a local base-station.

Additionally, a radio repeater (e.g., TRIMMARK from Trimble) may be used to increase the broadcast range of a base radio by receiving the base transmission and then rebroadcasting it on the same frequency. The radio repeater should be set up at a high location and within the range of the broadcasting capability of the base station (e.g., 1.5 km for Trimble R10).

For further details on how to set up the GPS/GNSS unit, refer to the equipment's user's manual, or contact the supplier.

Whichever option is used, the job configuration must follow the guidelines in *SOP 6: Basic GPS/GNSS Requirements for Coastal Topography Data Collection*. The surveyor must ascertain that once the rover unit is started the field survey controller must demonstrate that (Figure S7.1):

- Position dilution of precision (PDOP) ≤ 6.0
- Radio link is active
- At least 5 satellites are available
- Battery is providing power

Job name: SHU_2D_20190506

Properties

Coord. sys.: 18 North (UTM)

Units (Dist.): Meters

Linked files: None

Active map: 2

Feature library: None

Cogo settings: Ground

RTK H:0.012m V:0.018m ✓

Esc Accept

Figure S7.1. Trimble survey controller software job creation screen, post real-time kinematic - initialization (indicated by the green check) with information about the horizontal and vertical precision.

There is one job per:

- Field technician, if the survey is being done with more than one rover unit
- Day of survey, if the survey is conducted during more than one day
- Park, park unit or park section, according to the Protocol Nomenclature definition (Table S1.1 in *SOP 1: Monitoring Design Background and Justification for Northeast Coastal and Barrier Network Parks*)

7.2.2 Display Monuments and Transects on the Map

Once the rover is working, the field technician must determine that the background files with the park's monuments and transects (created according to *SOP 3: Establishment of Monuments, Transects, and Geodatabases* and uploaded according to *SOP 6: Basic GPS/GNSS Requirements for Coastal Topography Data Collection*) are activated in the map display of the Trimble survey controller (Figure S7.2).

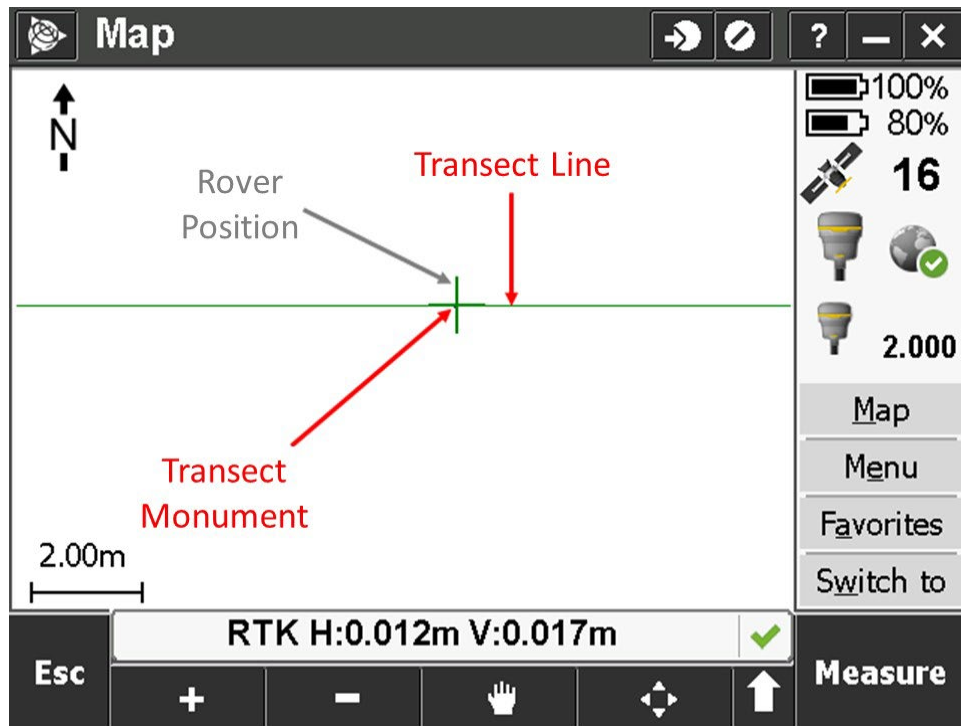


Figure S7.2. Trimble survey controller map feature screen showing one of the transect monuments, respective transect, and the rover position (represented by +) at Sandy Hook Unit, Gateway National Recreation Area.

7.2.3 Field Data Form

The [field data form](#) is used for all field notations. This information is necessary for post-processing of the data and facilitates the generation of accurate metadata. There is one field data form filled out per job. At the beginning of the survey, complete the fields of the “**Event Information**” (except for end time) and the “GPS/GNSS device” sections of the field data form using the following formats (Figure S7.3):

1. Date (mm/dd/yyyy) - Enter the date in the format shown.
2. Park Unit - The 4 character park identifier, CACO (Cape Cod National Seashore), ASIS (Assateague Island National Seashore), GATE (Gateway National Recreation Area), FIIS (Fire Island National Seashore), and the unit and section if applicable.
3. Observer’s name (first, last) - Enter the surveyor’s first and last name.
4. Protocol/SOP version (Protocol version #/SOP version #) – Version of the protocol document and SOP document used to guide field data collection. Example: v 2/v 2.00
5. Date of last storm event - This information should have been gathered during mission planning (see *SOP 4: Survey Timing and GPS/GNSS Mission Planning*).

Field Data Form – Coastal Topography Survey																																																											
Event Information Survey Date: 03/06/2019 Park Unit: GATE SHU Start Time: 13:40 End Time: 15:40 Observer's name: Katy Ames Protocol/SOP version: v 1.0 / v 1.0 Date of last storm event: 03/04/19																																																											
GNSS-RTK Device Rover Make, Model: Trimble TSC3 R10 Rover Serial Number: 5433475805 Base Station Make, Model: NA Base Station Serial Number: NA Base Benchmark used /CORS ref. station used: MAS1 Correction Service: Keynet																																																											
Surveyed Transects <table border="1"> <thead> <tr> <th>ID:</th> <th>Photos:</th> <th>Segmented:</th> <th>Notes (include monument condition, aspect of morphology, etc):</th> </tr> </thead> <tbody> <tr> <td>SH1</td> <td>1</td> <td>No</td> <td>could not find monument, could be buried</td> </tr> <tr> <td>SH2</td> <td>1</td> <td>No</td> <td>monument found</td> </tr> <tr> <td>SH3</td> <td>2</td> <td>No</td> <td>monument found</td> </tr> <tr> <td>SH4</td> <td>1</td> <td>No</td> <td>monument found</td> </tr> <tr> <td>SH3</td> <td></td> <td></td> <td></td> </tr> <tr> <td>SH3</td> <td></td> <td></td> <td></td> </tr> <tr> <td>SH3</td> <td></td> <td></td> <td></td> </tr> <tr> <td>SH3</td> <td></td> <td></td> <td></td> </tr> <tr> <td>SH3</td> <td></td> <td></td> <td></td> </tr> <tr> <td>SH3</td> <td></td> <td></td> <td></td> </tr> <tr> <td>SH3</td> <td></td> <td></td> <td></td> </tr> <tr> <td>SH3</td> <td></td> <td></td> <td></td> </tr> <tr> <td>SH3</td> <td></td> <td></td> <td></td> </tr> </tbody> </table>				ID:	Photos:	Segmented:	Notes (include monument condition, aspect of morphology, etc):	SH1	1	No	could not find monument, could be buried	SH2	1	No	monument found	SH3	2	No	monument found	SH4	1	No	monument found	SH3				SH3				SH3				SH3				SH3				SH3				SH3				SH3				SH3			
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Survey Notes (List any equipment problems, radio signal issues or obstacles encountered, etc.) <table border="1"> <thead> <tr> <th>Time of incident: (from GPS-RTK unit)</th> <th>Notes:</th> </tr> </thead> <tbody> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> </tbody> </table>				Time of incident: (from GPS-RTK unit)	Notes:																																																						
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*For extra survey notes, use additional blank page and attach to this form

Northeast Coastal and Barrier Network - Inventory and Monitoring Division
Coastal Geomorphology - Coastal Topography **Form S6-1**

Figure S7.3. An example of entries on a Coastal Topography Monitoring Field Data Form. Download or view the most up to date form [here](#).

Many of these initial values may be entered prior to going into the field. The “**Accuracy Checks**” section should be filled when performing the pre- and post-survey control monument check-ins or accuracy assessments. The “**Surveyed Profiles**” section of the field data form should be filled in as the field technician conducts the survey and visits each transect:

1. ID - The monument and transect ID (e.g., SH3)
2. Photos - The number of photos taken at the transect site
3. Segmented - Enter information indicating if the measurements along the transect were taken continuously or if the survey had to be segmented and different parts of the transect were surveyed at different times (see “Interruptions and segmented transects” below). Segmented: enter YES, not segmented: enter NO.
4. Accuracy Checks - enter information on the pre- and post-survey control monument check-ins at the control monument into “Observed Coordinates” and compare to its published.
5. Notes - enter information specific to the transect location, such as presence of scarps or bars, as well as the condition of the monuments.

Any notes regarding equipment problems, obstacles encountered, etc., should be entered in the “**Survey Notes**” section, and the time from the GPS/GNSS unit noted.

7.3 Conducting the Survey

7.3.1 Pre- and Post- Survey Control Monument Accuracy Assessment

Survey control monument checks-ins or more appropriately referred to as accuracy assessment check-ins, must be conducted at the beginning and end of each 2D survey for quality assurance and quality assessment purposes. Pre- and post-survey control monument checks-ins are performed at National Geodetic Survey (NGS) monuments or OPUS shared monuments. These accuracy assessment check-ins are recorded as 30-second continuous topo points. The observed values should be recorded in the field data form, and evaluated against the original monument coordinates. These coordinates can be obtained from the Interactive Monument Database (see the “**Monument**” subsection under *SOP 3: Establishment of Monuments, Transects, and Geodatabases*). As an example, the following steps apply when using the field survey controller and the Trimble survey controller software but may be performed with other controllers such as Leica (Figure S7.4):

1. Position the rover on the selected check-in monument
2. In the controller main menu go to: “**Survey**” → “**Measure points**”
 - i. Under “**Point name**” key in the monument’s ID (e.g., SH4)
 - ii. Under “**Code**” enter the season and year of the survey (e.g., spring 2010)
 - iii. Under “**Method**” select “**Topo point**”
 - iv. Verify that the “**Antenna height**” is set to the correct height (height of the rover pole)
 - v. Verify that the “**Measured to**” is set to “**Bottom of antenna mount**”
 - vi. Verify that the antenna is vertical and directly above the monument, and hit “**Measure**”
 - vii. Wait for “**30s**” to show in the “**Time so far**” and hit “**Store**” (the antenna must remain stationary and vertical while you collect this point). The occupation time of 30 seconds is set under the “**Options**” window of “**Measure points**” (Figure S7.4).
3. Verify the point location either with the reference points stored on the controller or by referring to the field booklet

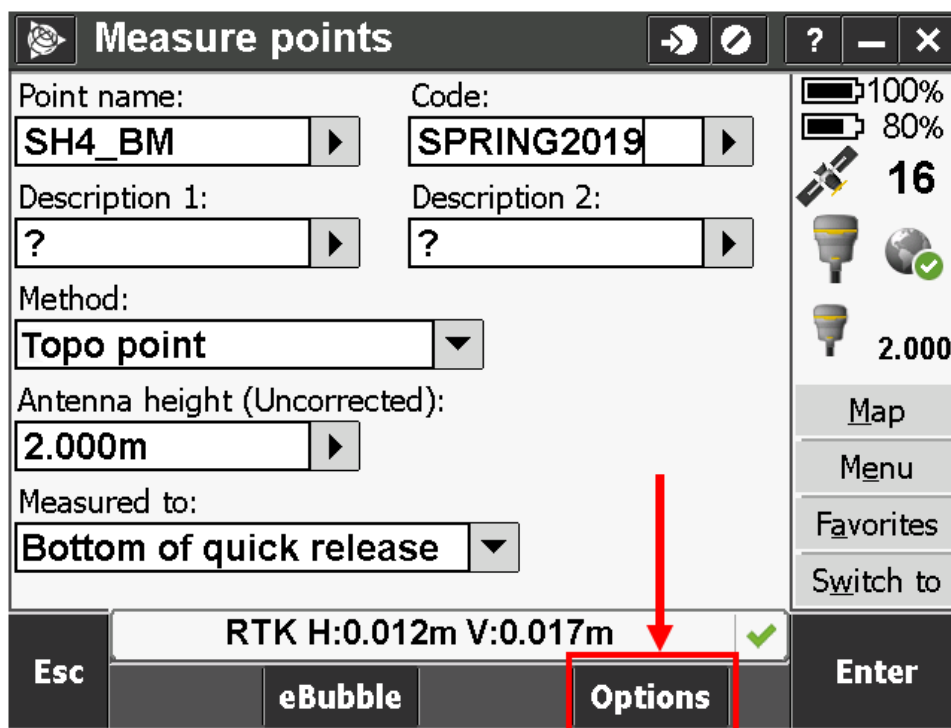


Figure S7.4. Trimble survey controller screen showing the collection of the monument position in the “Measure points” menu. Further settings for the measurement of the topo point, such as occupation time, can be accessed in “Options” (boxed in red) after “Method” has been set to “Topo point”.

7.3.2 Identification and Collection of the Starting Point Monument

The field technician should use the Trimble survey controller map feature with the background files of the monuments and transects, and the indications in the field booklet (map, photos and description) to locate the monument that identifies the starting point of the transect to be surveyed. The first measurement at the transect is of the monument location. If the monument is an NGS disk or deep-rod, a 30 second continuous topo measurement is recommended for quality-control purposes. Follow the procedure described in the previous section for pre- and post-survey control monument accuracy assessment check-ins. For all other cases, such as for physical and virtual transect monuments, a regular point measurement is sufficient.

7.3.3 Measuring Topographic Points Along the Transect

After collecting the monument point, the rover is positioned on the transect shown as a background file in the map feature screen of the field survey controller. Point measurements (XYZ) are collected with the GPS/GNSS rover receiver along the pre-established transect, starting at the monument and running perpendicular to the general trend of the shoreline. These do not require a lengthy occupation time as in the control monument check-ins. As an example, the following steps apply when using the field survey controller and the Trimble survey controller software, though other equipment such as Leica may be used (Figure S7.5 and S7.6):

1. Zoom the scale bar to “2m” in the “Map” screen, to establish the accuracy of the measurements

2. Position the rover on the transect immediately seaward of the monument. Verify on the “**Map**” screen, that the cross (rover position) aligns with the transect.
 3. Hit “**Measure**”
 4. In the new screen, key in the following information:
 - Under “**Point name**” key in the ID of the point:
 - **Monument’s ID_1** (e.g., SH4_1)
 - Under “**Code**” enter the season and year of the survey (e.g., spring 2010)
 - Under “**Method**” select “**Rapid point**”
 - Verify that the “**Antenna height**” is set to the correct height (height of the rover pole)
 - Verify that the “**Measured to**” is set to “**Bottom of antenna mount**”
 - Verify that the antenna is stationary and vertical, and hit “**Measure**”
 5. Go to the next point and repeat steps 2 through 4
- (After the first point, there is no need to change the point name. The following points keep the prefix – transect’s id – and changes the last number in an increasing order.)

Selection of the locations for measurement:

- 1 point is measured at least every 5 m
- 1 point is measured at every change in slope or inflection in order to characterize the main geomorphological features: including features such as the dune crest, dune toe, berm crest(s), swales, ridges, scarps, beach face, beach step, as well as any other component of the topography. (Figure S7.6)
- Points are measured at least until the elevation of 0 m NAVD88 is reached
- (Verify that the elevation of 0 m NAVD88 has been reached by selecting from the main menu “**Instrument**” → “**Position**”. The antenna’s current position and elevation is displayed)

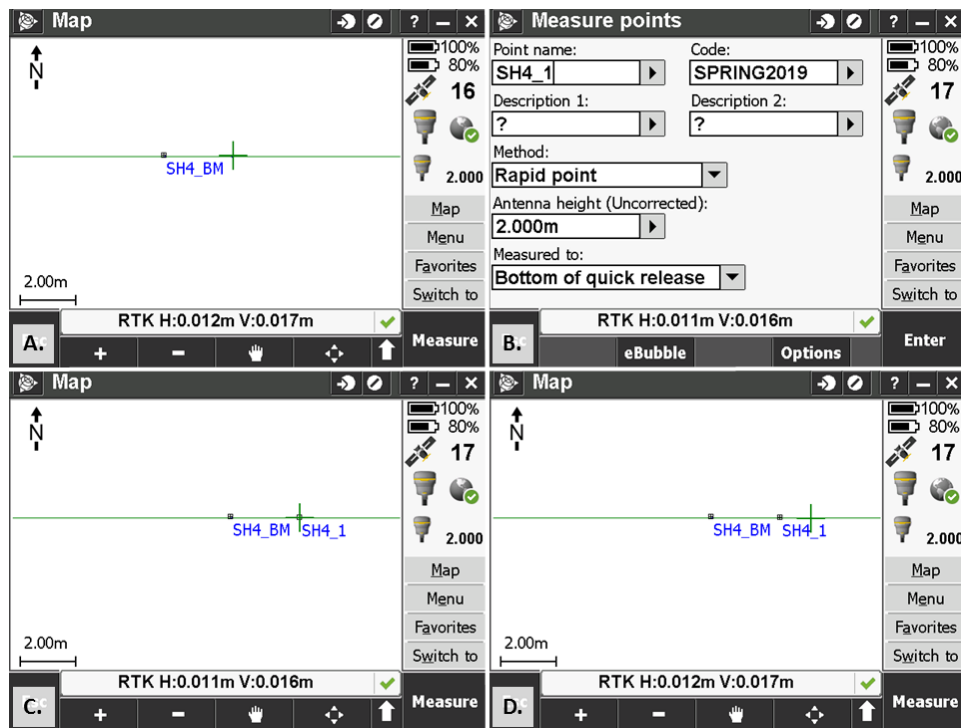


Figure S7.5. Trimble survey controller screen showing the collection of topographic points along the transect. A) *Map* screen showing the position of the rover (cross) over the transect; B) *Measure points* screen showing the options for the measurement of the rapid point; C) *Map* screen showing the collected point; and D) *Map* screen showing the position of the rover over the transect to collect the next point.



Figure S7.6. Measurement of topographic points along a transect at Plumb Beach, within the Jamaica Bay Unit of Gateway National Recreation Area. Example of points being measured at change in slope: at top and bottom of the feature.

Photographic Record

At least one photograph is taken at each transect to capture the general aspect of the dune/bluff feature present on the transect (Figure S7.7). The photograph must be taken always from the same angle so that the record is comparable:

1. Position yourself along the transect, at the base of the dune or bluff looking seaward
2. Walk 10 steps towards your right side – At Cape Cod NS, Assateague Island NS and at most of the units of Gateway NRA, this means towards the south
3. Take a picture from that position and looking directly towards the transect. When possible, some sort of marker (flag, sticks, etc.) could be placed along the survey line to help identify it in the photo.



Figure S7.7. Photograph of transect location, taken during the fall 2009 Coastal Topography survey conducted at Breezy Point, Jamaica Bay Unit of Gateway National Recreation Area (Breezy Point, November 2009).

The field technician may decide to take more than one photograph (and at different locations) if there are natural or artificial features that are creating unusual perturbations to the topography (see below) and that are worth documenting. The total number of photographs taken of a transect must be entered in the field data form in the “*Photos*” field under the “*Surveyed Transects*” section. Photographs should be timestamped and/or geotagged to ensure correct image files are associated to each transect.

7.4 Interruptions and Segmented Transects

7.4.1 Interruptions to the Survey

Natural or artificial conditions may be present along the beach transect that promote perturbations to the topography. In these cases, a note should be entered in the FDF under the respective surveyed transect notes, and the field technician should collect survey points according to the type of perturbation present (Table S7.1).

Table S7.1. Actions to take in the field when perturbations are encountered along the transect.

Type of the perturbation	Action in the field
Natural features: • Bluffs • Scarps	If the natural features are prominent – more than 0.5 m – collect points at the changes in slope in order to reproduce the morphological feature on the profile and in the data analysis. Follow the steps for segmented transects described below if the elevation difference is great.
Hard structures: • Seawalls • Bike paths	If a human-made structure intersects the transect location, the surveyor should measure points at the changes in slope of these features to reproduce them in the profile analysis (at least on the first survey). Structures of this nature are usually permanent and therefore do not have to be surveyed every time. After the first

Type of the perturbation	Action in the field
	survey, skip the area where the structure is present and proceed with the survey only in the natural area. Make a note on the field data form.
Human interference: • Anglers • Tire tracks	Avoid anglers or other visitors that may be on the transect by shortening the distance between points, never by increasing the spacing between points. Do the same thing for tire tracks, unless these occupy an area larger than 10 meters. In this case select a less disturbed surface within the area to measure the topographic point, but keeping the rover on the transect.
Fencing: • Plover fencing • Barbed wire	If the presence of fencing for protecting property or wildlife prevents the collection of data along portions of the transect, note this on the field data form. These gaps can be infilled with data from previous seasons in a process described in <i>SOP 9: Change Calculation and Data Analysis</i> .

7.4.2 Segmented Transects

In areas with bluffs, or other high features, the survey may have to be divided into two or more parts. For ease of access and to take advantage of the low tide, the field technician may have to survey the upper part of the bluff at one time (during high tide for example), and then survey the beach area at the low tide, producing an interrupted dataset of points for the same transect.

Also, in addition to the main transect direction (towards the shoreline), there may be a second direction with an inverse azimuth, defining a line starting at the monument but going away from the ocean shoreline. This is useful, for example, in areas of narrow barrier islands and spits for monitoring the changes in the full cross-section of the system, from the oceanside to the bayside.

In both these cases, the field technician must enter this information in the “***Segmented***” field under the “***Surveyed Transects***” section of the FDF, and a specific nomenclature must be used to ID the survey points:

1. If the transect is surveyed in segments (bluff/beach for example) add a prefix to the ID number entered during step 4 of the “***measuring topographic points along the transect***” specifications above. Use “***A***” for the segment closest to the monument and “***B***” (and the next letters) for the next segments:

Monument’s ID_ A1 (e.g., SH4_A1)

2. If the transect is surveyed in the opposite direction to the ocean shoreline (using the inverse azimuth) add the sign ***minus*** before the number:

Monument ’s ID_ -1 (e.g., SH4_-1)

7.5 Ending the Survey

After the daily survey is completed and the post-survey control monument accuracy assessment check-in is completed, end the survey and return to the office to:

1. Complete the [Coastal Topography Field Data Form](#)
2. Download the data and make a backup copy (*SOP 8: Initial Post-Survey Processing*) to avoid losing it due to equipment malfunction
3. Download and catalogue the photographs (*SOP 8: Initial Post-Survey Processing*)
4. Clean, store, and charge the equipment – to avoid equipment corrosion due to the salt water and sand, and to have it ready for the next day's survey if needed

7.6 SOP 7 – Revision History Log

The following table lists all changes that have been made to *SOP 7: Conducting the GPS/GNSS Coastal Topography Survey* since the original publication date. Any recommended or required changes added to the log must be complete and concise and promptly brought to the attention of the NCBN Protocol Lead. The Protocol Lead reviews and incorporates all changes and officially complete the Revision History Log of this SOP and the SOP Tracking Table for the SOP document. For complete instructions, please refer to *SOP 13: Protocol and SOP Versioning*.

SOP Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change
1.00	4/12/2013	Dennis Skidds, NCBN Data Manager	Initial SOP	Initial SOP
2.00	3/1/2022	Glenn Liu, GIS Technician, Rutgers University	Added procedure mandatory Pre-and Post-Survey Monument Check-in. Removed requirement for BM check at each profile. Emphasized usage of Rover + Cell Correction method. Updated Figures and FDF. Added Fencing as a category for interruptions.	Full protocol update prescribed by Technical Steering Committee
2.00	1/30/2023	Dennis Skidds, NCBN Data Manager	Update Preparation Procedures, Coastal Topography Monitoring Field Data Form and link	Update of GPS/GNSS procedures, and to form available
2.00	1/31/2023	Robin Baranowski, NCBN BioTech	Changed from SOP 6 to 7 (updates section, figure and table #s)	A new SOP was added

SOP 8: Initial Post-Survey Processing

Version 2.00

8.1 Objective

This SOP describes how to download, export, and perform quality assurance and quality control (QA/QC) of the survey data immediately following the field data collection. It is meant to ensure that no data are lost due to equipment failure and to determine if the survey needs to be repeated. This SOP consists of four components. The first component summarizes the data download procedures and the export into Esri feature classes. The second component describes the initial quality control steps necessary for accurate and systematic processing, as well as the creation of metadata. The third component describes the handling and storage of the photographic record. Finally, the fourth component describes the way in which all original, corrected, and processed data products should be assembled and delivered to the Northeast Coastal and Barrier Network (NCBN) Data Manager for storage and analysis. The procedural steps are illustrated using the Trimble Business Center software.

8.2 Data Download, Export and Creation of Esri Feature Classes

8.2.1 Data Download

Immediately upon completion of the survey and return to the office, the GPS/GNSS job is downloaded from the field survey controller to a computer hard-drive. Use the Trimble Data Transfer software (or similar tool) to transfer both the Data Collector File (.dc) and Job File (.job). Create a backup copy of the .dc and .job files by saving it to a separate external drive. The data should be retained on the field survey controller until quality checks can be made.

8.2.2 Data Export

Create a project in Trimble Business Center (TBC) software (or other data processing software, such as Leica Geo Office or Leica Infinity) with the settings described on *SOP 6: Basic GPS/GNSS Requirements for Coastal Topography Data Collection*, and save it with the name that includes the following information:

Protocol Nomenclature_”2D”_season and year

e.g.: *GATE_SHU_2D_Fall2018*

The following procedure, written for TBC version 5.7.0., guides the user through obtaining a .csv export from the survey files:

1. Import the .job file (or .dc if the former is unavailable) that was downloaded from the field survey controller into TBC.
2. Select the job’s survey points collected at the transect monument locations and along the transects. If you are working with the .job file, make sure that the vectors are selected as well.
3. Select the *Custom tab* under the Export command pane and click the “**Export Format Editor**”. Click “**New**” to create a new Export Format and set a name of your choice.

4. Double click the created Export Format to open the “**Export Record**” window (Figure S8.1). Make sure the following settings are set and click “**Next**”:
 - A. “Include Header” is checked
 - B. Record Type is “Delimited”
 - C. Delimiter is “comma”
 - D. Default file extension is “.csv”
 - E. Encoding is “ASCII”
 - F. Text qualifier is “none”
 - G. Decimal separator is “.”

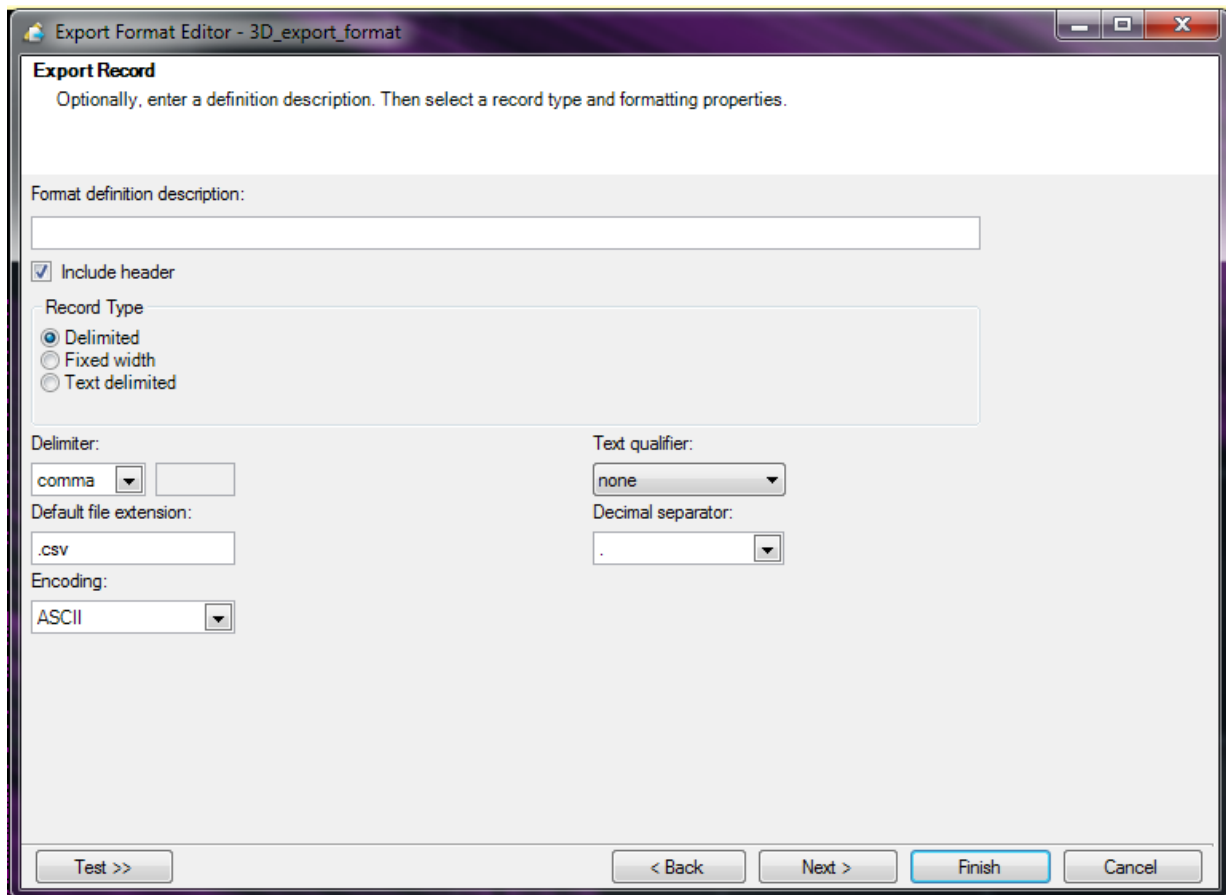


Figure S8.1. The Export Record window within the Export Format Editor.

5. Within the “**Export Fields**” window, select “**Point**” from the “**Data type**” dropdown. Add the following fields with the appropriate settings (Table S8.1 and S8.2) to the “**Export Record**” and click “**Finish**”:

Table S8.1. Export Fields for 2D data and their associated settings.

Field Name	Location	Settings
Point ID	General	None
Feature Code	General	None
Latitude (Local)	General	Units are “Decimal degrees” Check “apply to all”
Longitude (Local)	General	Units are “Decimal degrees” Check “apply to all”
Ellipsoid Height (Local)	General	Units are “Meter” Check “apply to all”
Northing	General	Units are “Meter” Check “apply to all”
Easting	General	Units are “Meter” Check “apply to all”
Elevation	General	Units are “Meter” Check “apply to all”
H. Precision	GNSS Vector Observation.	Units are “Meter” Check “apply to all”
V. Precision	GNSS Vector Observation	Units are “Meter” Check “apply to all”
From Point ID	GNSS Vector Observation	None
Attributes	General	Check everything Delimiter for all selections are “:” with the exception of the “ ” for the final delimiter.
End Time	GNSS Vector Observation	None

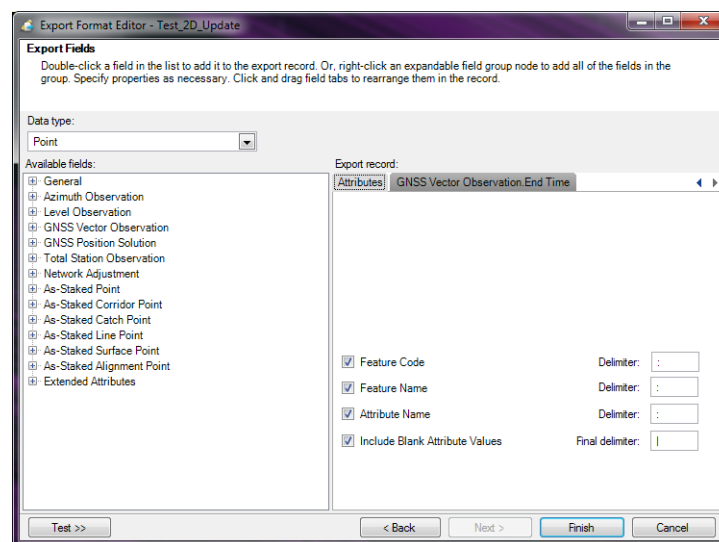


Figure S8.2. Selecting Export Fields (“Attributes” for this example) and changing their settings.

6. In the “**Export**” command pane, select the newly created export format and set the name and export location to export the .csv (Figure S8.3). The file name is the same as the job file from which the data are being exported: Protocol Nomenclature_”2D”_date (yyyymmdd) e.g.: GATE_SHU_2D_20181010.
7. Click “**Export**”: to create the data file.

Use the same TBC project to import the remaining job files for the park, park unit, or park section survey season, and go through the data export procedure for each individually.

TBC automatically creates a file folder (in the same folder selected to create the TBC project) with all the imported survey files (.job and .dc) and with the exported feature class files (.csv).

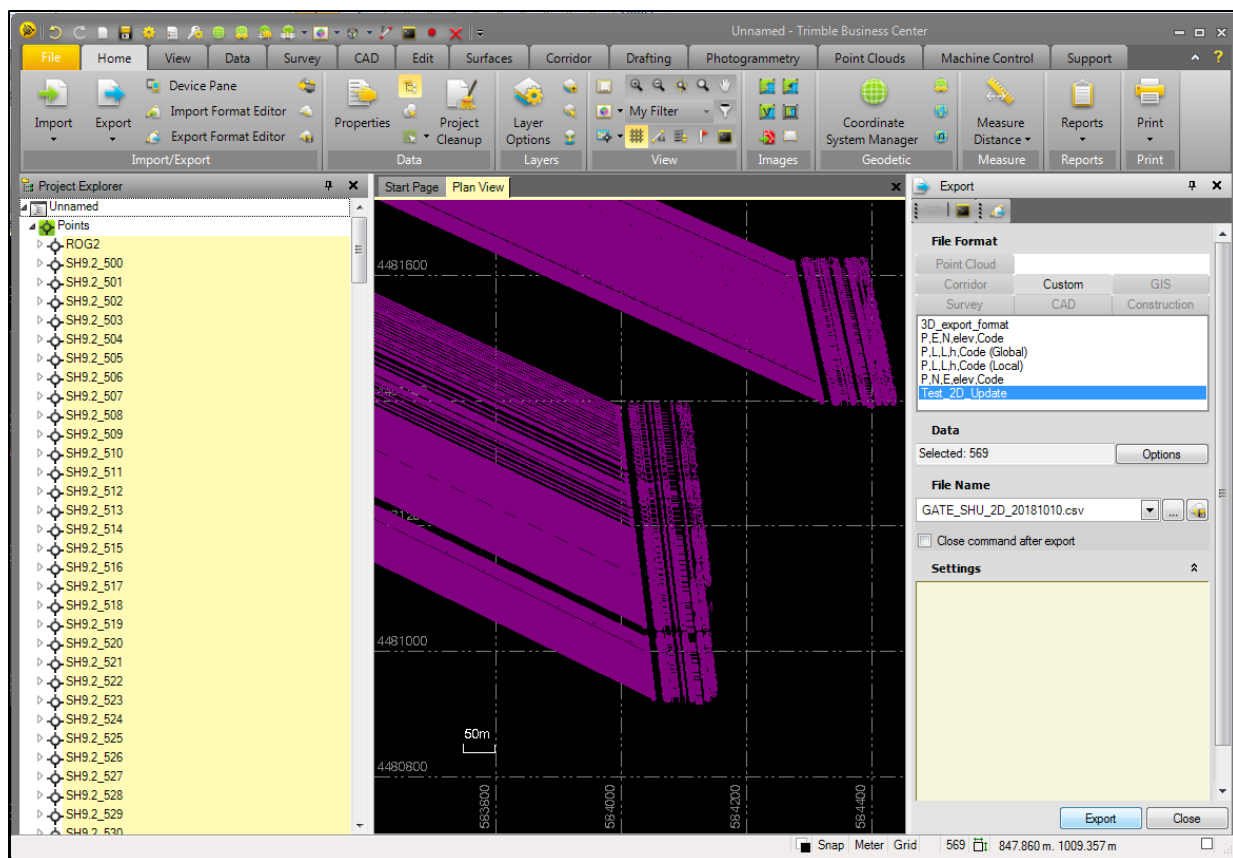


Figure S8.3. Trimble Business Center software screen showing the plan view of the points collected in the field and vectors to the reference station. The “Export” command pane is on the right.

8.2.3 Viewing the Exported Data in Esri ArcGIS

The exported .csv file can be converted to an Esri feature class or shapefile through the following steps:

1. Obtain a copy of the master geodatabase for your site from the NCBN Data Manager, or create a new geodatabase containing the park's transect monuments, transect, and auxiliary files with the buffer areas (see *SOP 3: Establishment of Monuments, Transects, and Geodatabases*).
2. Open Esri ArcGIS and locate the “**Add Data**” under “**File**”. Within this dropdown, click the “**Add XY Data**” option (Figure S8.4)

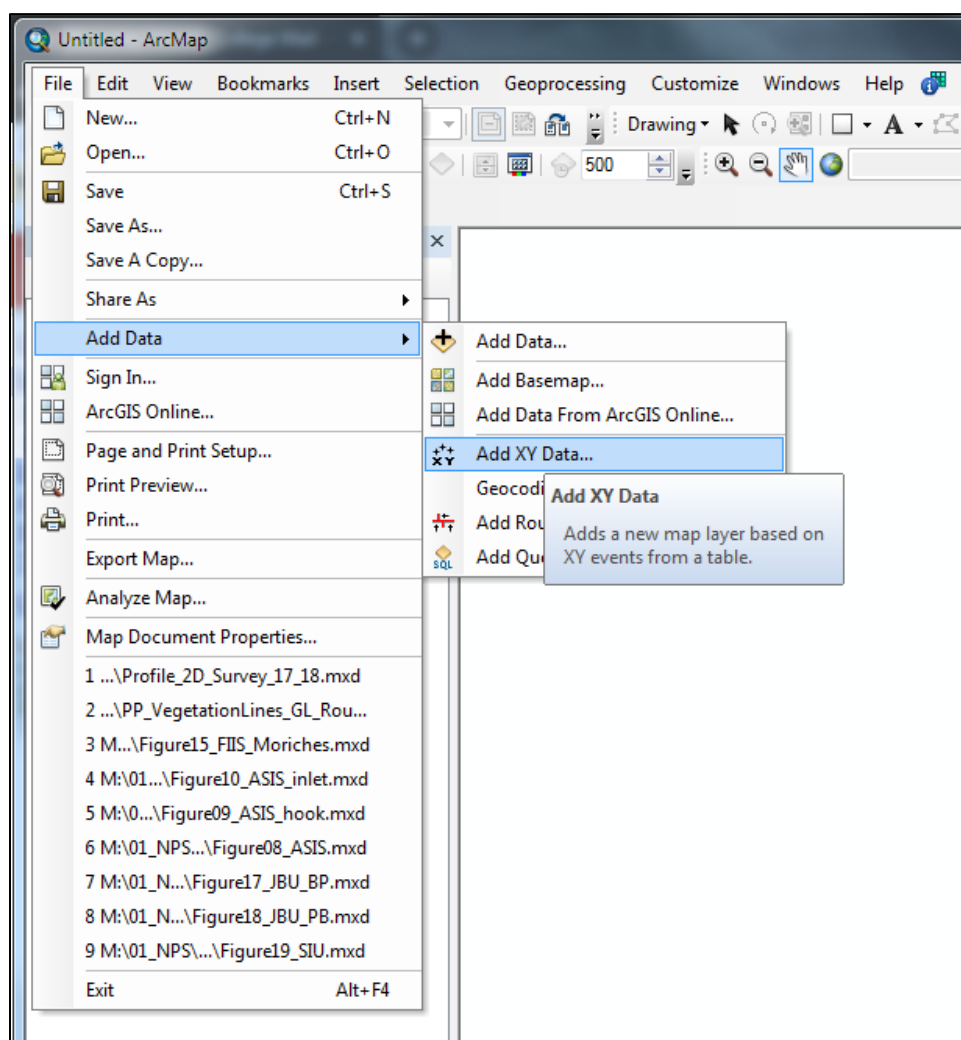


Figure S8.4. Using the “Add XY Data” to convert data in the exported .csv to an event layer.

3. Click the small folder icon and navigate to the location of the exported “.csv” file. Specify the X, Y, and Z fields from the headers present within the exported csv. Indicate the coordinate system (e.g., NAD_1983_2011_UTM_Zone18N) and click “**OK**” (Figure S8.5).

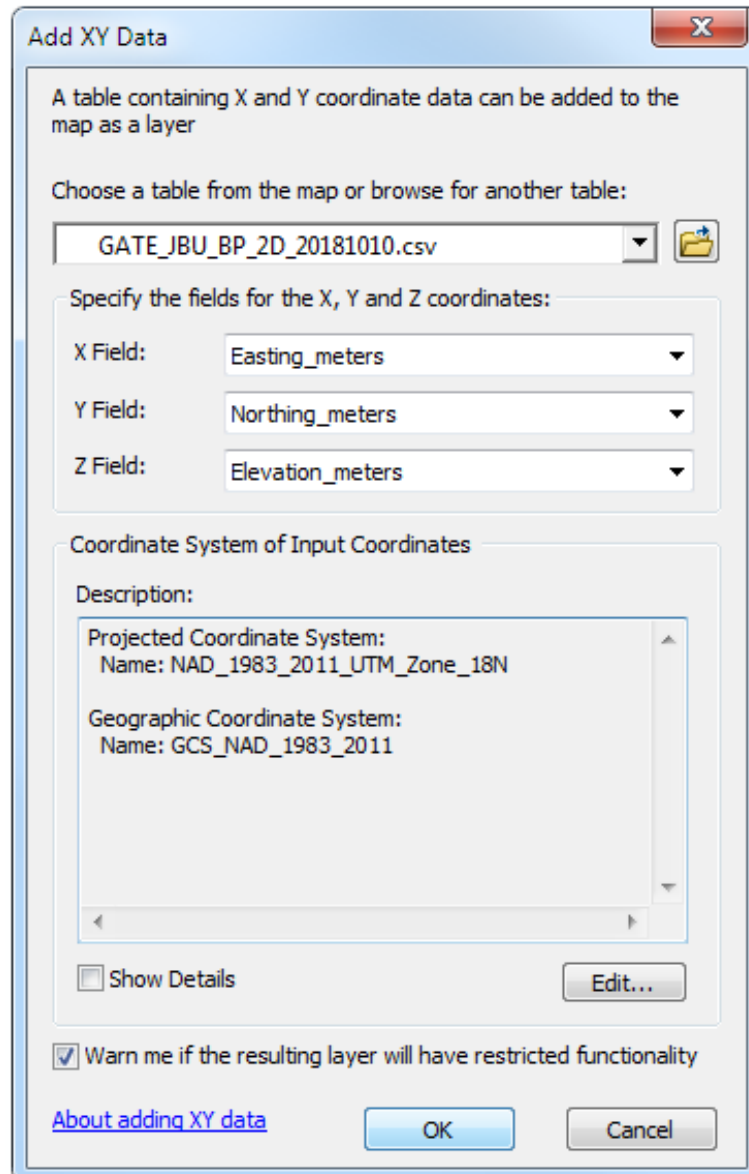


Figure S8.5. Specifying the path to the csv, names of several key columns, and the coordinate system.

4. Right-click the resultant event layer within the Table of Contents and select the “**Export Data**” option under “**Data**” (Figure S8.6).

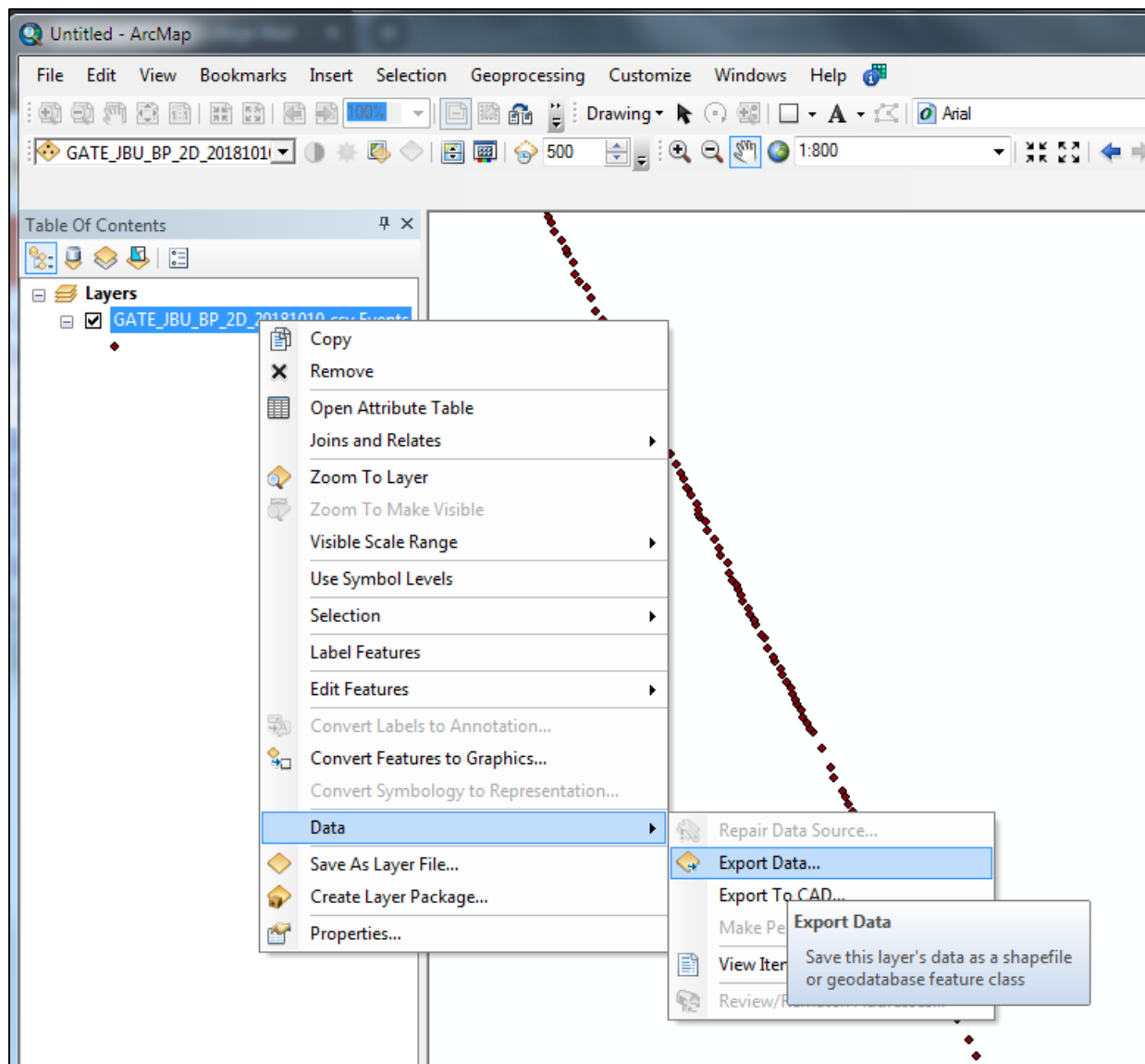


Figure S8.6. Navigating to the “Export Data...” option.

5. In the “**Export Data**” window, ensure that the “**Output feature class**” is named and set to the location of your choice and that “**All features**” is selected within the “**Export**” dropdown (Figure S8.7).

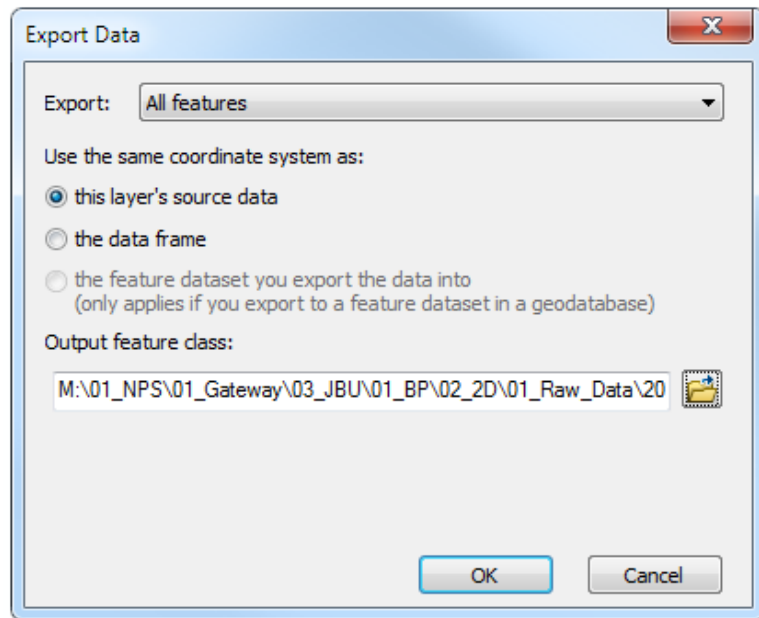


Figure S8.7. Options within the “Export Data” window.

8.3 Quality Control Check and Metadata Creation

8.3.1 Quality Control Check

Plot the exported Esri point feature class against the park’s transect monuments, transects, and auxiliary files with the buffer areas (from the GIS database created according to *SOP 3: Establishment of Monuments, Transects, and Geodatabases*) in a GIS platform to verify the following (Figure S8.8):

1. The starting point of each transect measured in the field is coincident with the respective monument – inside the 0.05 m buffer area, and within 0.05 m distance in the vertical component.
2. The collected points along the transect are aligned with the pre-established transects – inside the 0.5 m buffer area.

Conduct the verification by using the “**Selection by Location**” tool in ArcGIS or a similar tool to detect points outside the polygons. If the points are outside the buffer area, then this means that there was a problem with the survey and the surveyor must evaluate the need to return to the transect location and re-run the survey. Once the data have been verified and checked for accuracy, finish filling in the field data form.

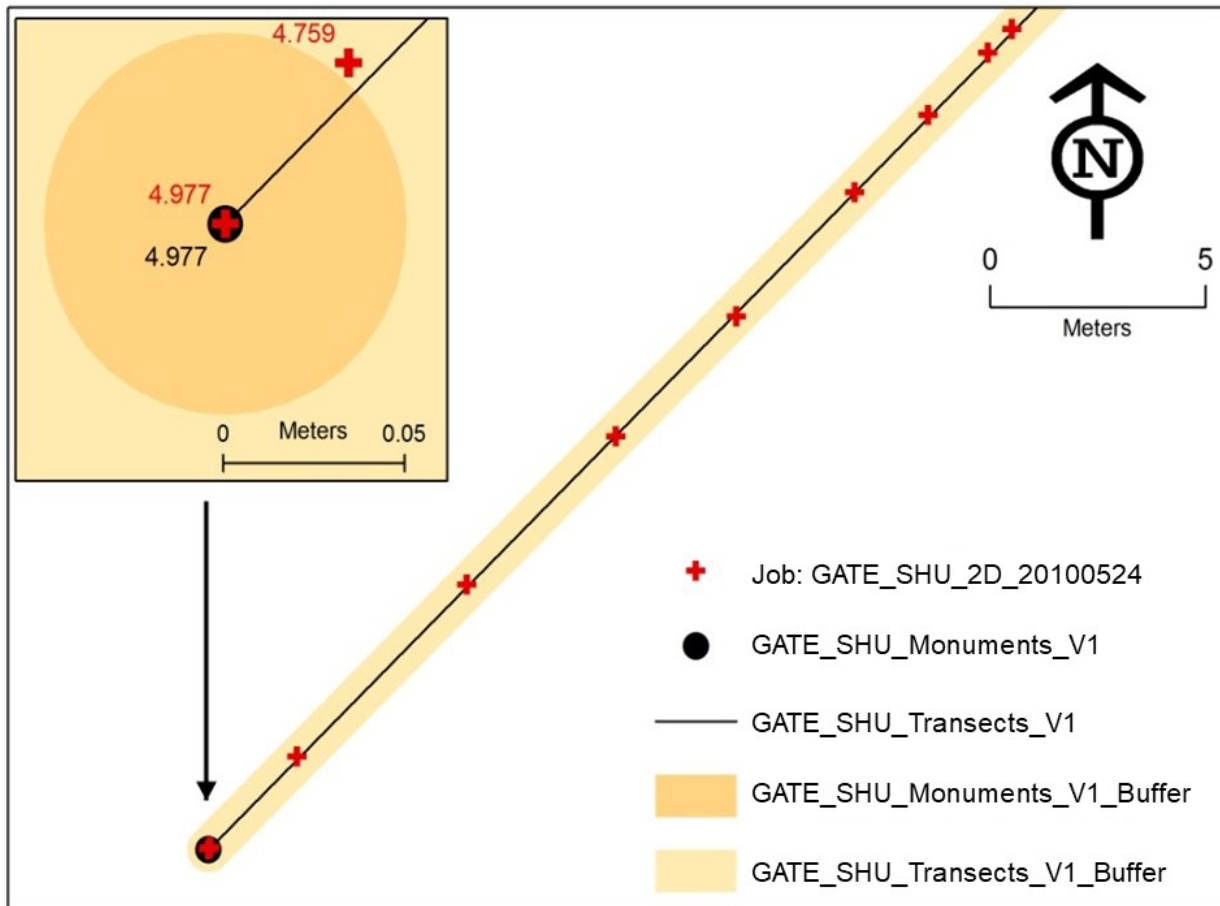


Figure S8.8. Location of the survey points collected at the transect monument and along the transect and the respective 0.05 m and 0.5 m buffer areas. The elevations of the original monument (black circle, black font) and the collected point at the monument (red cross, red font) are displayed in the inset.

8.3.2 Metadata Creation

The data download, export, and verification must be done at the end of each daily survey. At the end of the survey period, when all surveys for a park have been run and verified for accuracy, Federal Geographic Data Committee (FGDC) compliant metadata must be created to accompany the final text file (.csv) deliverables. The NCBN Data Manager provides field staff with a metadata template for the Coastal Topography Monitoring Protocol that already contains much of the relevant information regarding the collection of the profile points. Most of the remaining information to be included is derived directly from the field sheet completed prior-to and during the data collection process. Table S8.2 summarizes where this information should be included in the metadata file.

Table S8.2. Organizational comparison of field data and metadata files.

Field form data	Metadata tag
Park unit	Abstract keywords
GPS/GNSS unit make and model	Process step, process description
Who processed the data	Process step, process contact
Software used to download, post-process data; base station(s) used; description of any data editing	Process step, process description

8.4 Photographic Record

The photographs must be downloaded into the computer and catalogued. Use the information on the TBC project to verify the time of collection of each transect and compare it to the time of the picture to assure the correspondence between the two. Check the field data form to verify how many photos were taken at each transect site and rename the photographs to reflect the transect's ID and date of the survey to which they refer:

GATE_SHU_SH10_20100524

Protocol Nomenclature_Transect's ID_date (yyyymmdd)

If there is more than one photograph per transect, add a suffix to the name with the number of the photo:

GATE_SHU_SH10_20100524_1

Protocol Nomenclature_Monument ID_date (yyyymmdd)_number of photo

Each photo should not exceed 800 x 600 pixels in size. Use an image/photo editing software (e.g., Office Picture Manager from Microsoft) to resize the photographs if needed.

Create a backup copy of the raw (full-quality) photographs by saving it to the same CD or external drive used to save the survey files as described above.

8.5 Final Product Delivery

Following all of the quality control procedures and creation of metadata, the final dataset of the surveyed profiles are sent to the NCBN Data Manager for storage, analysis, and archiving in the NCBN Coastal Topography Database. The following data products are required for each sampling event, i.e., each sampling occasion captured by a single field data form:

- Original survey files (ex: .job and .dc, or Leica folder) downloaded from the GPS/GNSS receiver (.zip file format)
- Text file containing survey data with the specified export fields, datum, and geoid (.csv format)

- Scanned copy of the field data form (.pdf)
- Photographs taken during survey (.jpg format, combined in a .zip archive file)

These items should be [emailed](#) to the Data Manager shared via a secure file-sharing service, or saved to digital media and mailed to:

Northeast Coastal and Barrier Network
Data Manager
URI Dept. of Natural Resources Science
1 Greenhouse Rd.
Kingston, RI 02881

8.6 SOP 8 – Revision History Log

The following table lists all changes that have been made to *SOP 8: Initial Post-Survey Processing* since the original publication date. Any recommended or required changes added to the log must be complete and concise and promptly brought to the attention of the NCBN Protocol Lead. The Protocol Lead reviews and incorporates all changes and officially complete the Revision History Log of this SOP and the SOP Tracking Table for the SOP document. For complete instructions, please refer to *SOP 13: Protocol and SOP Versioning*.

SOP Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change
1.00	4/12/2013	Dennis Skidds, NCBN Data Manager	Initial SOP	Initial SOP
2.00	3/1/2022	Glenn Liu, GIP, Rutgers	Split old SOP 7 into 2. First section is now focused on Change Calculation and Analysis. Updated uncertainty values, changed text for long-term comparisons. Inclusion of net comparisons for annual report.	Full protocol update prescribed by Technical Steering Committee
2.00	1/31/2023	Robin Baranowski, NCBN BioTech	Changed from SOP 7 to 8 (updates section, figure and table #s)	A new SOP was added

SOP 9: Change Calculation and Data Analysis

Version 2.00

9.1 Objective

This SOP describes the derivation of the beach profiles from the survey points; it consists of two components: 1) the first component describes the method for using the Excel application 2D Analyst to generate the profile cross-sections and to derive dimensional parameters of each profile; 2) how the suite of measurements derived from the beach profiles is used to portray temporal and spatial geomorphologic change.

9.2 Generation of Beach Profile Cross-Sections, and Calculation of Dimensional Parameters

The Coastal Topography Protocol uses the Excel application 2D Analyst, created by Rutgers University and the Northeast Coastal and Barrier Network (NCBN) and is available upon request from the NCBN Data Manager. 2D Analyst allows the user to plot the profile data in a distance/elevation chart, and derives the following dimensional parameters according to the type of morphology present:

For beach profiles with foredune features:

- Cross-section area above NAVD88 incorporating an uncertainty metric
- NAVD88 distance from transect monument
- Foredune crest height
- Foredune crest distance from transect monument

For beach profiles with bluff features:

- Cross-section area above NAVD88 incorporating an uncertainty metric
- NAVD88 distance from transect monument
- Bluff's edge elevation
- Bluff's edge distance from transect monument

The post-quality assurance and quality control (QA/QC) profile data collected along each profile are stored in the NCBN Coastal Topography Monitoring Database and can be exported in a format that is suitable for analysis in 2D Analyst (including .xlsx, .csv, .txt, and other formats). See the [Database User's Guide](#) for instructions for accessing the profile data.

9.2.1 Profile Visualization with 2D Analyst: Initial Steps

Each profile dataset is selected and run through 2D Analyst independently to derive the dimensional parameters. To initiate the visualization and calculation process, follow the procedure below:

1. Open 2D Analyst and navigate to the “**Metrics**” worksheet. Note that some boxes are brown-colored. These boxes are user editable. White boxes should not be modified (Figure S9.1).

Season 3			
Distance to Water	0.00	Dune/Beach Threshold	1.5
Total Area	0.00	Threshold elevation used in lateral profile	
Position of Dune Crest/Bluff Edge	✓ #N/A	Water Threshold	0
Elevation of Dune Crest/ Bluff Edge	✓ #N/A	Threshold elevation used in lateral profile	
Position of Base of Dune/Bluff	✓ #N/A	Dune or Bluff [D/B]	0
Elevation of Base of Dune/Bluff	✓ #N/A		
Dune Area	0.00	Season 1 Name	Spring 2018
Position of Berm Crest	✓ #N/A		
Elevation of Berm Crest	✓ #N/A		
Beach Area	0.00		

Figure S9.1. Examples of user editable and non-editable boxes in the “Metrics” worksheet.

2. Locate column “**M**” on the Metrics worksheet. Column M may not be visible until the user scrolls horizontally, to the right within the worksheet. Check the following fields and fill in values if necessary (Table S9.1):

Table S9.1. Selection of user edited variables in the Metrics Worksheet and descriptions of how to determine their value.

Field	How to determine value
Dune/Beach Threshold	The elevation (in meters) that serves as the boundary between the dune and beach features. This must be visually determined for the site and profile.
Water Threshold	The elevation (in meters) to which the seaward extent of profiles are extrapolated. This is usually 0.
Profile ID	The name of the profile
Dune or Bluff [D/B]	Enter ‘D’ if the profile has a dune feature, and ‘B’ if the profile has a bluff feature.
Inland Extent	The distance (in meters) from the transect monument to the inland-most point that is used for area calculations and visualizations. Usually, this is determined by the earliest available survey season for annual reports to ensure comparability of metrics through time. If significant changes (major erosion, overwash, elimination of features) occur at the profile, this measure may need to be reconsidered. For trend reports, the farthest inland extent of the reporting period is used.
Season [1-3] Name, Original Season Name	Name of the season (ex. Spring 2017). 2D Analyst supports the simultaneous display and comparison of three seasons and 1 “Original” season, it is usually the first available survey within the available data.

- Display and area calculations for each profile are dependent upon proper sorting of the data points. This can be done in the “*Scrap work*” worksheet or a separate Excel document. Using the data for the portion of the profile obtained through the previous procedure, sort to place the monument point in the top row, with each following row proceeding inland or seaward. The sort column depends upon the orientation of the profile you are visualizing; for example, if the profile runs more east-west than north-south, sort by easting. If the profile runs more north-south and east-west, sort by northing. The sort direction (ascending vs descending) depends upon the position of the water relative to the profile and is determined so that the sorted result places the transect monument in the top row (Figure S9.2).

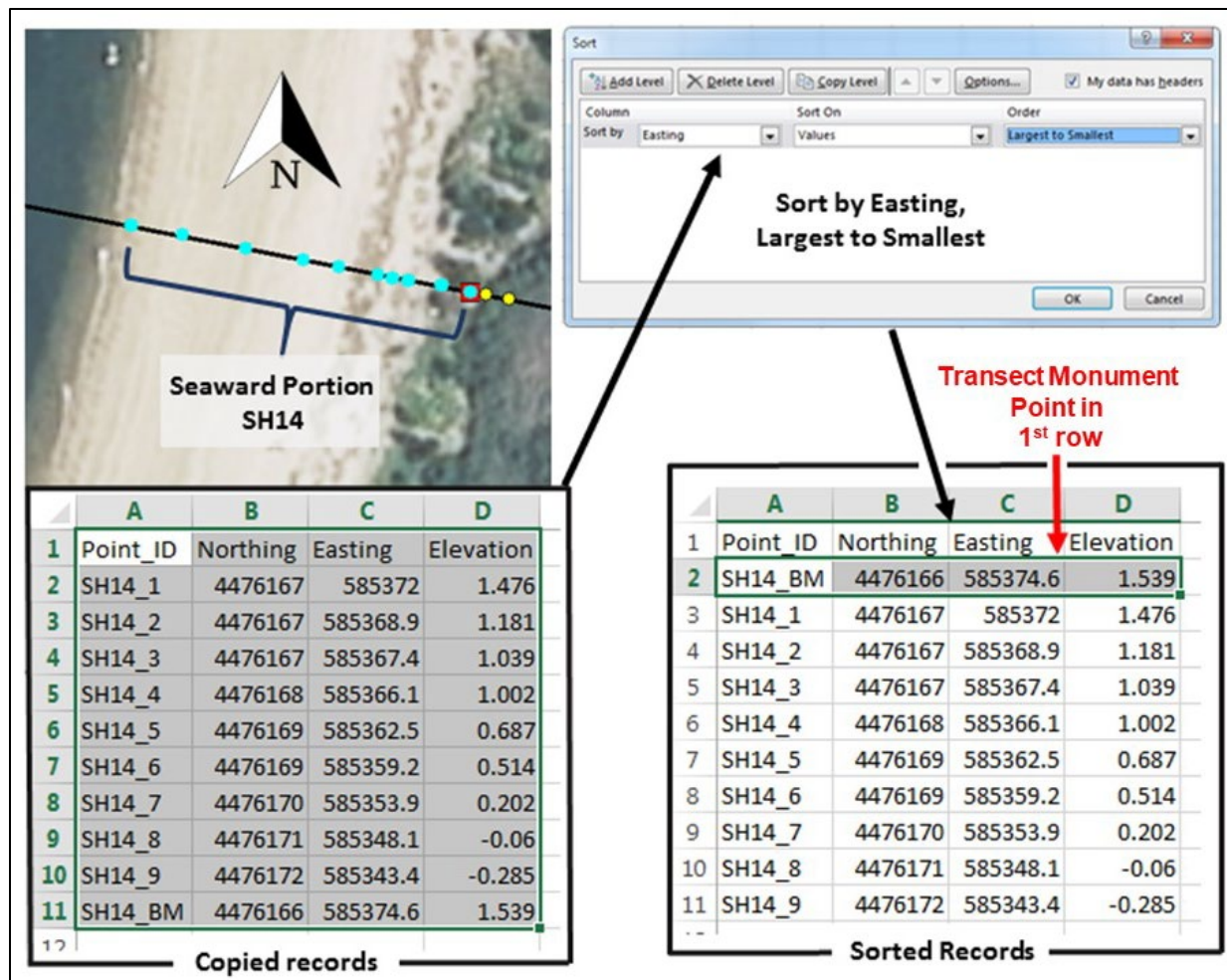


Figure S9.2. Point sorting example for seaward portion of SH14, spring 2018 survey data. The sort order and sort column varies depending upon the profile orientation and portion.

- Reorganize the profile data so that the columns are in the following order: Point ID, Easting (X), Northing (Y), and Elevation (Z). Copy the data for the target portion of the profile.
- Navigate to the corresponding worksheet (“*Season #*” for the seaward portion; “*Season # Inland Data*” for the inland portion). Paste the data copied in Step 4 into the brown section of

the “**Input Data**” box (Figure S9.3). To avoid overwriting the existing color formatting, ensure that “**Values Only**” is specified in the paste options. Repeat this step for any other portion of the profile, if applicable.

	A	B	C	D	E	F	G
1	Input Data						
2							
3	ID	Easting (X)	Northing (Y)	Elevation	Code		Code
4	SH14_BM	585374.6	4476166.184	1.539			DC
5	SH14_1	585371.989	4476166.77	1.476			DB
6	SH14_2	585368.888	4476167.267	1.181			CE
7	SH14_3	585367.411	4476167.48	1.039			CB
8	SH14_4	585366.079	4476167.819	1.002			BC
9	SH14_5	585362.501	4476168.506	0.687			
10	SH14_6	585359.222	4476169.176	0.514			
11	SH14_7	585353.913	4476170.252	0.202			
12	SH14_8	585348.099	4476171.426	-0.06			
13	SH14_9	585343.378	4476172.338	-0.285			
14							Dune Infill Typ
15							Complete Inf

(Ctrl) ▾
 Original Inland Data **Season 1** Season 1 Inland Data
 Select destination and press ENTER or choose Paste

Figure S9.3. Location to insert data within the “Input Data” box of the “Season #” worksheet.

6. Inspect the visualization located in the “**Profile Chart**” worksheet. The x-axis limits may need to be manually adjusted, depending upon each profile length. Below are some common errors and how to fix them:
 - a. Noisy/jagged profiles: this may be due to multiple measurements with conflicting elevation values in close proximity. Examine the point IDs in question in ArcMap and delete or remove points that are not representative of the profile.
 - b. Long horizontal lines/stretched out profiles: See if “**Easting and Northing**” columns have been switched.
7. Depending upon the portion of the profile you are visualizing, proceed to the corresponding instructions in the “**Profile Adjustments and Infill**” section below to ensure that all metrics are computing properly.

9.2.2. 2D Analyst: Profile Adjustments and Infill

Additional adjustments must be made to each portion of the profile visualized in the procedure above. These are critical steps to ensure that all 2D metrics are computed correctly by 2D Analyst. Below are specific instructions for each portion:

Inland Portion Instructions

1. The inland limit of the collected profile data for the season must be adjusted to match the established extent for that profile, thereby ensuring comparability of metrics between seasons. See Table S9.1 for further instructions on determining the inland extent.
 - a. If the inland-most point is seaward of the extent, data should be infilled from the previous season(s) through the following procedure:
 - i. Follow the instructions described in the “**Infill Procedure**” below to obtain the necessary data.
 - ii. Paste the infill data at the bottom of the current season’s “**Input Data Box**”
 - iii. Check the “**distance**” column (column N) to verify if the distance exceeds the inland extent. If this is the case, follow the instructions for using the Inland Extent Interpolator tool below. If not, continue to infill from previous seasons until the inland extent is reached.
 - b. If the inland-most point is landward of the extent, the point at the inland extent must be interpolated using the collected data. This is done using the Inland Extent Interpolator tool located in each “**Season # Inland Data**” sheet. See the sub-procedure below:

Using the Inland Interpolator Tool

- i. Verify there is a value next to the “**Inland Extent**” variable. If not, indicate the value under the corresponding box in the “**Metrics**” worksheet.
- ii. Find first point beyond the inland extent using the values in the “**distance**” column (column N). Copy this point and the point before it (seaward of the inland extent) so that you have two points on either side of the inland extent for interpolation.
- iii. Paste the records into the corresponding columns in the Interpolator Tool, in the area colored brown.
- iv. Navigate to column N, titled “**distance**”, indicating the distance along the profile landward of the monument. Copy the corresponding distance records for the points copied in Step a (these are on the same row as the copied data points).
- v. Paste the distance values into the Interpolator Tool. The point ID, easting, northing, and elevation for the interpolated point should automatically calculate in the row below (Figure S9.4).

	A	B	C	D		M	N
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							

	A	B	C	D		M	N
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							

	A	B	C	D		M	N
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							

Figure S9.4. Pasting data into the Inland Extent Interpolator Tool. Data from the “Input Data” section are boxed in red, whereas distance data from column N is boxed in blue. Information for the interpolated point are automatically generated once all points are entered.

- vi. Copy the data for the interpolated point to the Input Data section. Replace the first point beyond the inland extent in the current season with the interpolated point. Remove all points beyond the inland extent and paste all deleted records in the “**Removed Points**” section within the “**Scrap Space**” box. The final point’s distance should now match the inland extent (Figure S9.5).

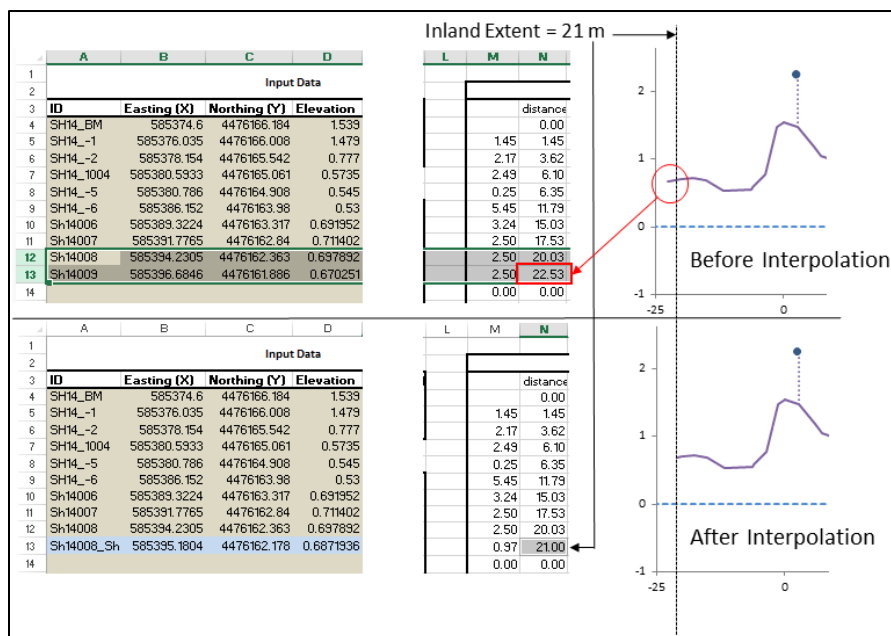


Figure S9.5. Deriving the inland extent by interpolation. Top panel illustrates the profile dataset before interpolation. The distance boxed in red is greater than the Inland Extent. Bottom panel shows the profile after using the inland interpolator with an inland extent that matches the established values. The row containing the interpolated point is highlighted in blue.

- To compute the profile's cross-section area, the polygon created by the profile must be closed on the inland portion. This is accomplished by drawing an additional point below the NAVD88 threshold using the “**Inland Extent Dropdown Tool**”. Copy the last point of the inland portion of the profile. Paste the point into its corresponding columns within the Inland Extent Dropdown Tool. Copy the data for the point automatically generated in the row below and paste it at the bottom of the current season's data within the “**Input Data**” box (Figure S9.6).

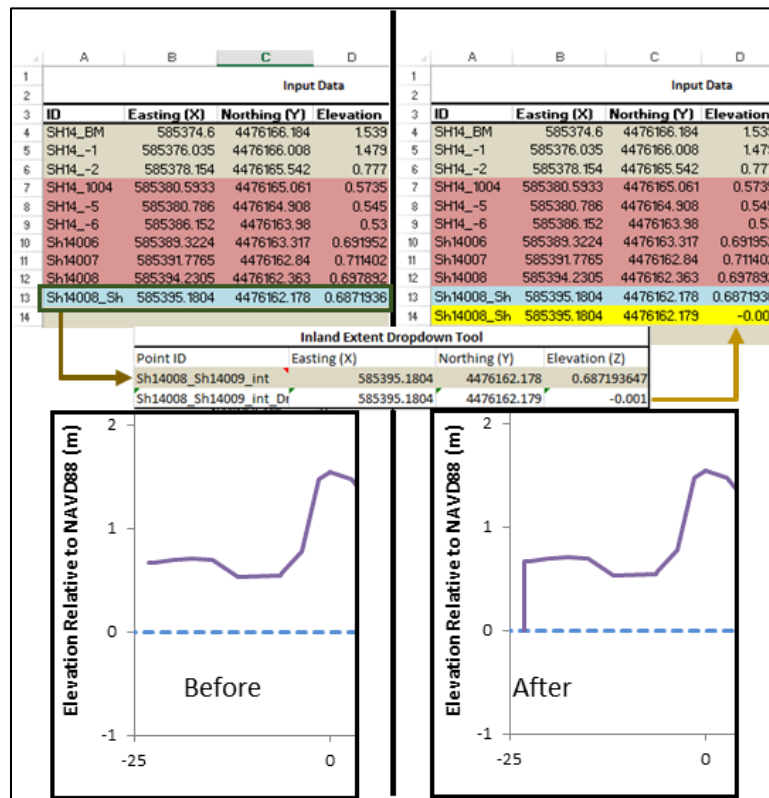


Figure S9.6. Process of adding an additional point to the inland extent that crosses the NAVD88 threshold, closing the polygon on the inland portion to prepare for calculation of cross-section area. The infilled data are colored in dark red, the interpolated point from the previous step is colored in blue, and the resultant value from the Inland Extent Dropdown Tool is highlighted in yellow

Instructions for the Seaward Portion

- Verify that there are no major data gaps in this section of the profile. If the data in the seaward portion does not reach the transect monument due to gaps in collection, take the following steps to close this gap with data from previous season(s):
 - Follow the instructions described in the “**Infill Procedure**” below to obtain the necessary data.
 - Paste the data before the current season's first point. Within the scrap space, indicate the infill points and their source season.

- To compute the profile's cross-section area, the shape created by the profile must be closed on the seaward portion. Check to see if the last point on the seaward portion is below the NAVD88 threshold. If the seaward-most point is not below the threshold, copy the data for the last two points of the seaward portion into the corresponding columns of the Slope Extrapolation Tool, found in each “*Season #*” sheet (Figure S9.7). Copy the generated point to the bottom of the input data box of the “*Season #*” worksheet to add the extrapolated point and close the shape on the seaward portion (Figure S9.8).

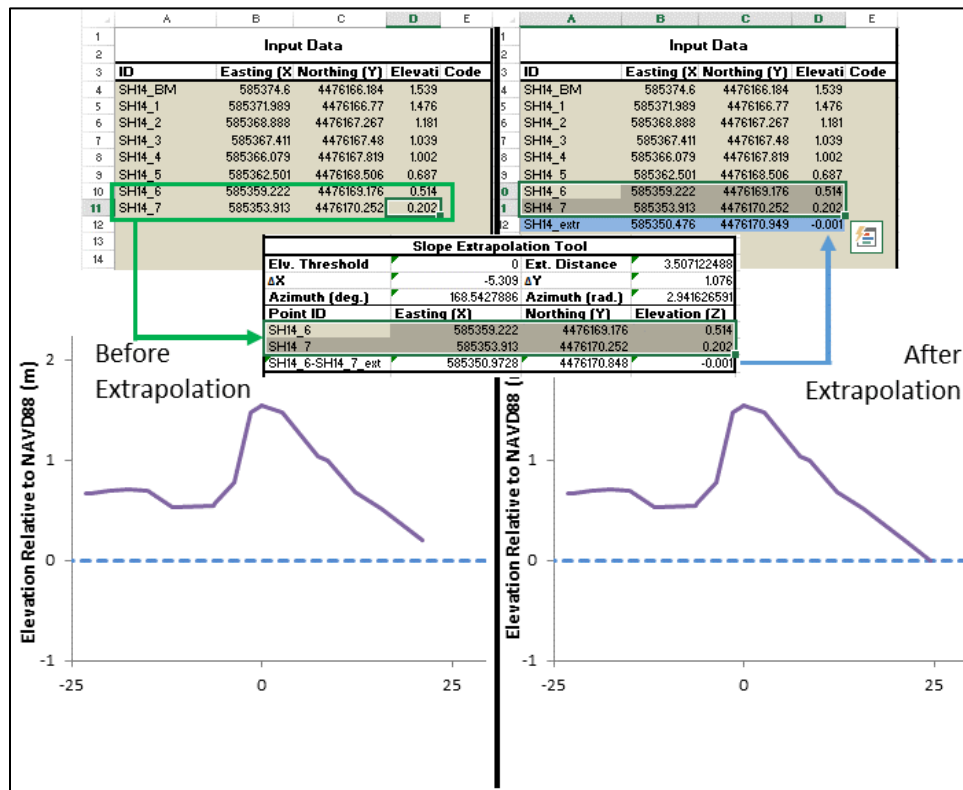


Figure S9.7. Extrapolation of the profile to the NAVD88 level threshold level using the last two points of the seaward data (boxed in green) and the Slope Extrapolation Tool. Extrapolated point highlighted in blue. This closes the portion of the polygon on the seaward side of the profile.

Infill Procedure

- In a GIS environment, add the survey data from the previous season and identify the first point beyond the inland-most point in the current season.
- Select and copy the records for this and all points inland of it (Figure S9.8). Sort and reorganize the columns as performed in Steps 3 and 4 of “*Profile Visualization with 2D Analyst: Initial Steps*”.

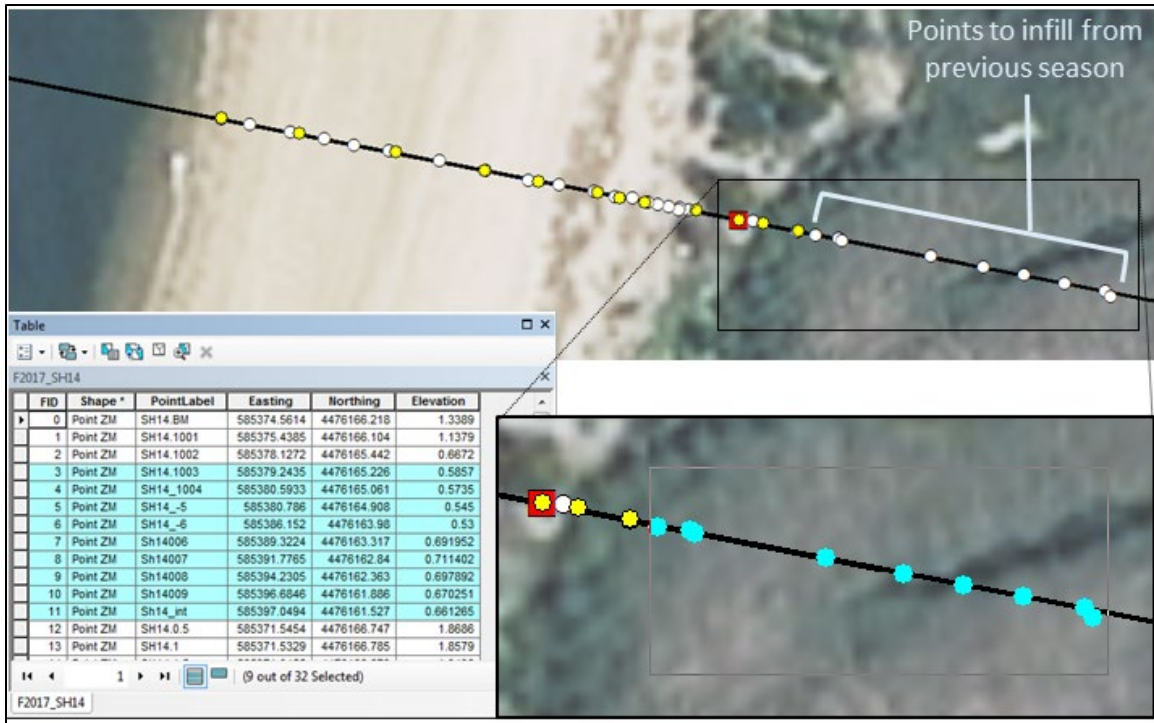


Figure S9.8. Selecting infill points from the previous season at SH14. Data points for the current season are in yellow and points from the previous season are in white. Selected points are highlighted in light blue.

- After adding the data to the respective portion of the profile, locate the “**Beach Infill Type**” and “**Dune Infill Type**” boxes within the worksheet (Figure S9.9). Indicate the infill type, using the letters indicated in the box. A complete infill indicates that the entire feature along the portion of the profile is composed of infilled data. A partial infill indicates that only a section of the feature was infilled.

Input Data				Code Dictionary	
ID	Easting (X)	Northing (Y)	Elevati Code		
SH14_BM	585374.6	4476166.184	1.539	DC	Dune Crest
SH14_1	585371.989	4476166.77	1.476	DB	Base of Dune
SH14_2	585368.888	4476167.267	1.181	CE	Cliff Edge
SH14_3	585367.411	4476167.48	1.039	CB	Base of Cliff
SH14_4	585366.079	4476167.819	1.002	BC	Berm Crest
SH14_5	585362.501	4476168.506	0.687		
SH14_6	585359.222	4476169.176	0.514		
SH14_7	585353.913	4476170.252	0.202		

Infill Flags	
Dune Infill Type	N
Complete Infill	C
Partial Infill	P
No Infill	N
Beach Infill Type	N
Complete Infill	C
Partial Infill	P
No Infill	N

Figure S9.9. Infill Flags box, located in both the “Season #” and “Season # Inland Data” worksheets.

9.2.3 2D Analyst: Final Steps

The following steps provide guidance on adding dune and bluff markers to the profile as well as the verification of computed metrics. Perform these steps after making the necessary profile adjustments to each portion of the profile.

1. Visually inspect the profile in the “*Profile Chart*” worksheet and identify the dune crest.
2. Return to the worksheet that contains the point and insert the symbol “*DC*” in the corresponding row under the “*Code*” column. This should create the dune crest marker for the profile. Additional adjustments to the dune crest pin can be made through options located in the “*Metrics*” worksheet (Figure S8.10). Markers for other features, such as the dune base, can be added; see the Code Dictionary for the corresponding code and check the “*Chart Pins*” box within the “*Metrics*” worksheet to verify the “*Display Base of Bluff/Dune Pin*” is set to “*Y*”.

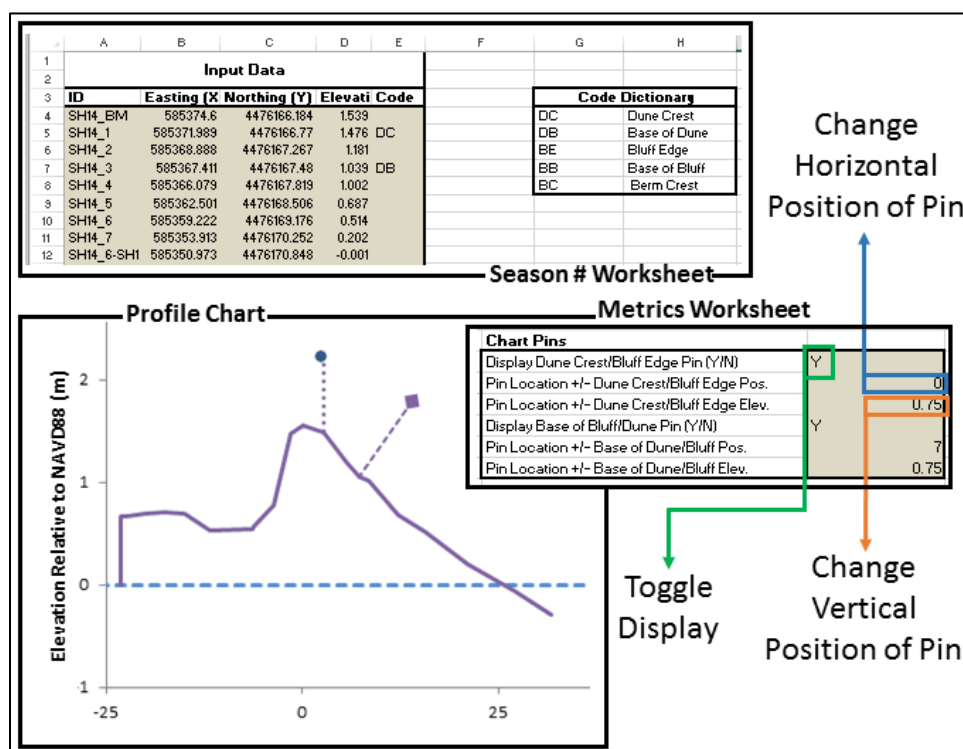


Figure S9.10. The addition of the dune crest pin involves visually identifying the feature in the Profile Chart, adding the “DC” code in the Season # Worksheet, and making visual adjustments in the Metrics Worksheet.

3. Return to the “*Metrics*” worksheet and inspect the values in the “*Season 1*” and “*Uncertainty*” boxes. The cross-section areas and corresponding uncertainty values should have been automatically computed. These can also be seen in the left-most tables on the “*Metrics*” worksheet that summarizes the data with the cross-section area, associated uncertainty, and infill flag (if applicable).

Repeat the procedure described in the sections above (Initial Steps, Profile Adjustment, and Final Steps) for succeeding seasons. 2D Analyst supports the display of up to three seasons and one additional season (currently denoted as “spring 2011” in Figure S9.11) that is usually the oldest surveyed season. If this is the first reporting period, this season can be left blank.

J	K	L	M	N	O	P
Season 3						
Distance to Water	47.65		Dune/Beach Threshold		Dune Area	
Total Area	35.94		1.5		Spring 2011 -	3.06 ± 0.26 m ²
Position of Dune Crest/Bluff Edge	26.55		Threshold elevation most internal profile line at least one landward		Spring 2018 -	0.05 ± 0.00 m ²
Elevation of Dune Crest/ Bluff Edge	1.58		Water Threshold		Fall 2018 -	0.00 ± 0.00 m ²
Position of Base of Dune/Bluff	10.26		0		Spring 2019 -	0.33 ± 0.01 m ²
Elevation of Base of Dune/Bluff	0.78		Threshold elevation most internal profile line exactly one landward and seaward			
Dune Area	0.33		Dune or Bluff [D/B]		Beach Area	
Position of Berm Crest	13.07		0		Spring 2011 -	42.01 ± 1.86 m ²
Elevation of Berm Crest	0.61				Spring 2018 -	35.62 ± 1.95 m ²
Beach Area	35.61		Profile ID		Fall 2018 -	42.56 ± 1.98 m ²
			SH14		Spring 2019 -	35.61 ± 1.90 m ²
Dune Area Parameters						

Figure S9.11. Tables summarizing values in the “Metrics” worksheet. As data for each season are added, this table is automatically filled with the calculated values.

9.3 Uncertainty Metrics for Elevation and Cross Section Area

A calculation of profile uncertainty was developed for the 2016-2017 report (Psuty et al., 2017) and has been applied to all reports thereafter. A vertical uncertainty of ± 0.04 m is incurred by point collection and affects all vertical distance metrics (profile elevation). This vertical uncertainty then translates to a cross-section area uncertainty of ± 0.04 m² for every meter a profile extends (to NAVD88), applying to dune cross section area (extent of profile that exceeds dune threshold, beach cross section area (extent below dune threshold) and total cross section area (Psuty et al. 2012). This value is multiplied by the total length of each feature along the profile to yield the uncertainty. Uncertainty metrics are currently computed through the 2D Analyst procedure described above.

9.4 Quantifying Change by Comparison of the Dimensional Parameters

9.4.1 Seasonal Changes

The seasonal changes, either spring-to-fall or fall-to-spring, are the differences in topography between consecutive surveys (Figure S9.12). Generally, the summer season is represented by the spring-to-fall comparison and should be characterized by an enhancement of the beach profile, reflected by the increase in the profiles’ dimensional parameters. Bluff features should remain stable in the summer period. The winter season, represented by the fall-to-spring comparison in general should show a reduction of the beach profiles’ dimensional parameters, corresponding to an erosional scenario.

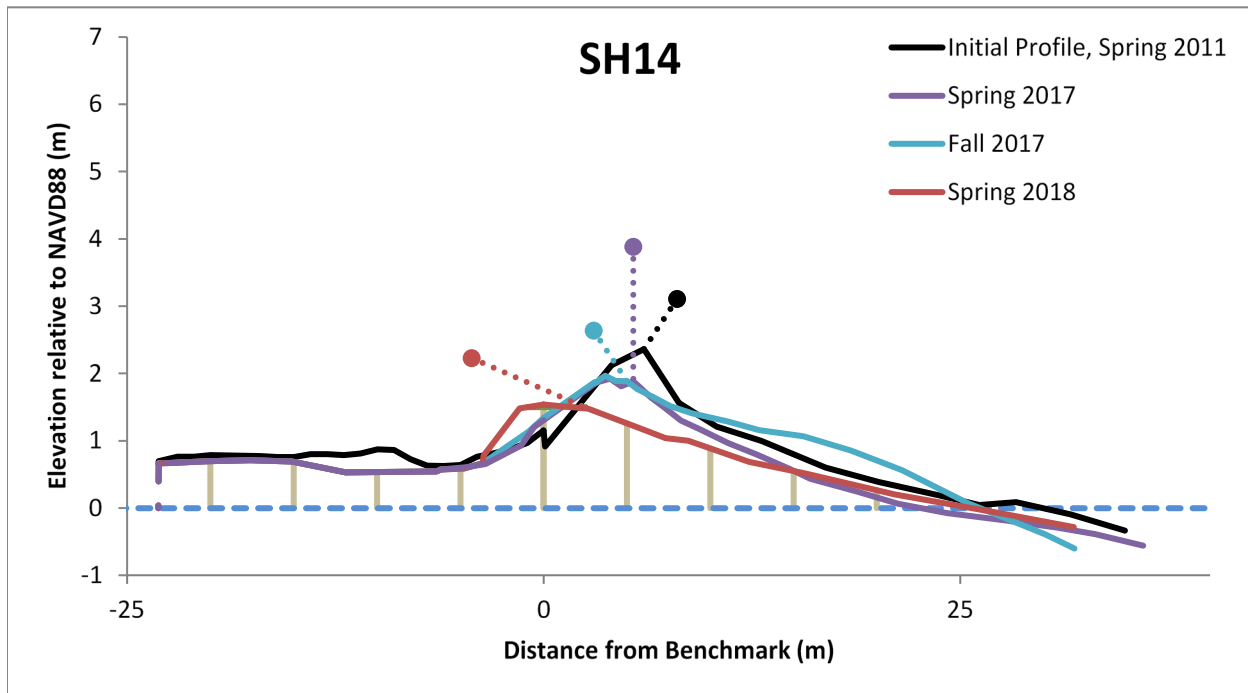


Figure S9.12. Comparison of the cross-sections of profile SH14 for spring 2018 through and spring 2019 (Sandy Hook Unit of Gateway National Recreation Area, New York).

The dimensional parameters derived from the profiles are compared between survey seasons and are used to portray the temporal and spatial geomorphological change at each park (Figure S9.13). Data sets presented in tabular form should include summary statistics. The mean seasonal change represents the average change of the dimensional parameters for the totality of the measured profiles along the park shoreline. The standard deviation of seasonal change is a measure of the spread of difference values about the mean change calculation. Other statistical measurements may be calculated, such as maximum and minimum change, and median and mode, to describe and display the distributional characteristics of the dataset. The graphical portrayal of alongshore change in dimensional parameters conveys the spatial variation of these changes within the park (Figure S9.13).

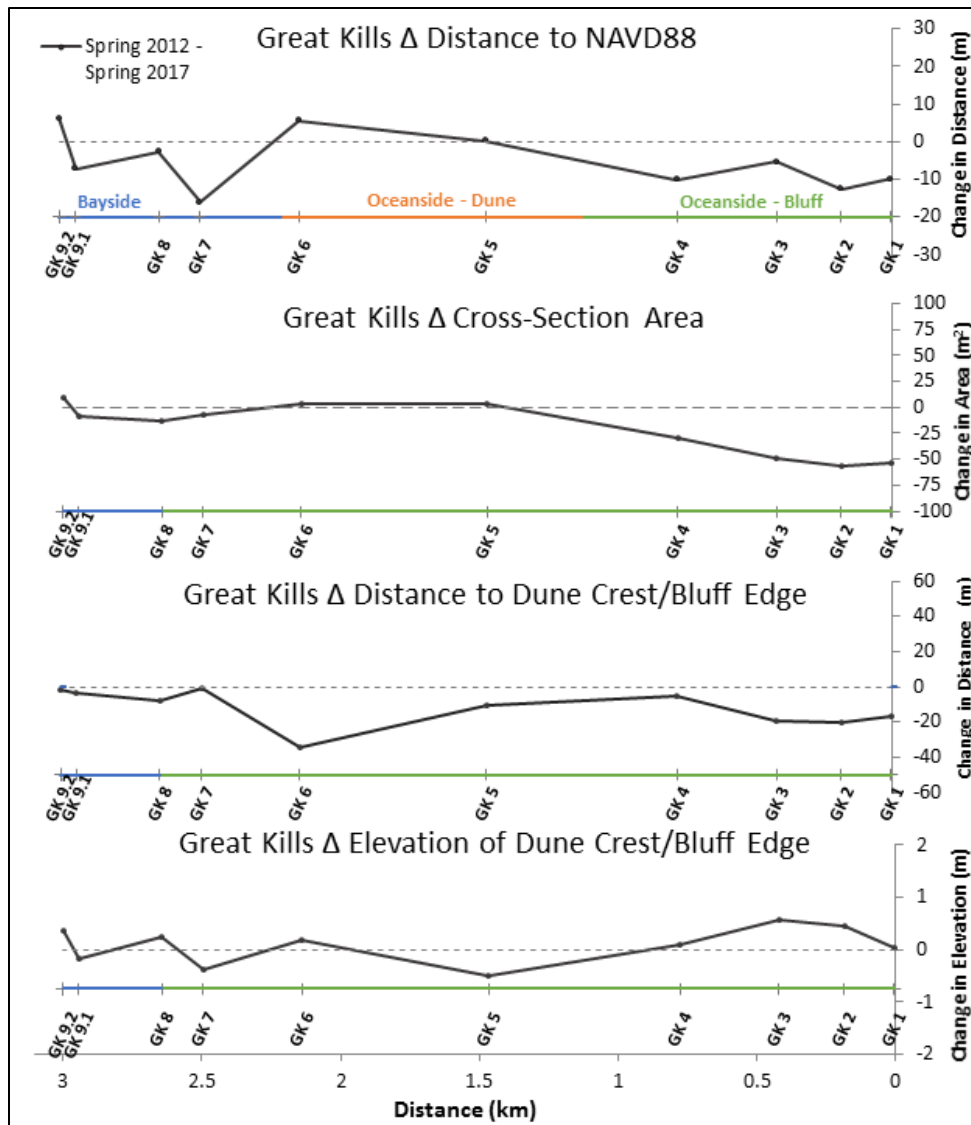


Figure S9.13. Graphical portrayal of the change of the dimensional parameters between Spring 2012 and Spring 2017 for the profiles at Great Kills (Staten Island Unit, Gateway National Recreation Area, New York).

9.4.2 Annual Comparisons

The measure of annual change compares the dimensional parameters of the same season over a span of twelve months. Because the seasonal variation is absent from this comparison, the change reflects the short-term balance of sediment budget (loss of sediment should produce a reduction of the dimensional parameters, whereas gain of sediment should produce an increase). Although the change in beach morphology does represent the positive or negative sediment budget, it may also represent the contrast in storm frequency and severity. Thus, annual comparisons are valuable but they are short-term measures that incorporate a variety of variables. Similar to the seasonal comparison, the change in dimensional parameters should be portrayed in tabular form and uncertainty metrics (Table S9.2). The graphical portrayal of the change in dimensional parameters for all the profiles along the park help evaluate the alongshore variation of these changes (Figure S9.13).

9.4.3 Long-term Comparisons

Longer-term change in beach profile morphology is the change over any period of time greater than one year. If only two beach profiles are used to represent a long time period, they should be from the same season so that seasonal change does not bias the calculation of differences.

The change in the dimensional parameters may be analyzed by comparing the endpoints of the data series or the analysis may include the individual seasonal data sets, incorporating a series of shorter-term differences. By comparing the sequence of difference measurements over time, the trend in the dataset may be determined. The trend may be a simple observation of the increase or decrease in the mean difference per year of any or all the dimensional parameters. The trend could also involve the calculation of the mean rate of change of the annual differences of the dimensional parameter, as well as a similar comparison of the seasonal differences. This approach identifies the internal variation in beach profile morphology in reaching its final location. Any of these measures of change in the dimensional parameters generate a suite of numbers upon which statistical analyses may be performed to summarize the trend of the change. Trend analysis becomes more meaningful with a longer record of beach profile change. A minimum of five years should be used to begin to depict long-term trends of change utilizing the methods in this protocol.

9.5 References

Psuty, N. P., and Others. 2017. Northeast Coastal and Barrier Network monitoring of shoreline position (1D) and coastal topographical (2D) change: 2016-2017 annual summary report for Gateway National Recreation Area. Natural Resource Data Series. NPS/NCBN/NRDS—2017/1118. National Park Service. Fort Collins, Colorado

9.6 SOP 9 – Revision History Log:

The following table lists all changes that have been made to *SOP 9: Change Calculation and Data Analysis* since the original publication date. Any recommended or required changes added to the log must be complete and concise and promptly brought to the attention of the NCBN Protocol Lead. The Protocol Lead reviews and incorporates all changes and officially complete the Revision History Log of this SOP and the SOP Tracking Table for the SOP document. For complete instructions, please refer to *SOP 13: Protocol and SOP Versioning*.

SOP Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change
1.00	10/2012	Dennis Skidds, NCBN Data Manager	Initial SOP	Initial SOP
2.00	3/1/2022	Glenn Liu, GIS Technician, Rutgers University	Rewrite of 2D Analyst Procedure, split SOP 7 into Data Analysis and Reporting (SOP 8)	Full protocol update prescribed by Technical Steering Committee
2.00	1/31/2023	Robin Baranowski, NCBN BioTech	Changed from SOP 8 to 9 (updates section, figure and table #s)	A new SOP was added

SOP 10: Coastal Topography Reporting

Version 2.00

10.1 Production of Reports on Coastal Topography

Reports are produced periodically by the park or by the Northeast Coastal and Barrier Network (NCBN) Protocol Lead that portray the measured changes in coastal topography coastal topography in narrative, tabular, and graphical formats. There are two types of products: an Annual Data Summary Report and a Project Trend Report. The Annual Data Summary Report summarizes the data from the previous year whereas the Project Trend Report is produced on a five-year schedule and includes information on trends and interpretations of the cumulative dataset of a park. These reports are submitted to the park management, posted to the National Park Service (NPS) Integrated Resource Management Applications (IRMA) online repository, and are also be archived alongside the protocol database at the NCBN.

10.1.1 Annual Data Summary

The Annual Data Summary is a summary of the geomorphological change data over the period of one year (three surveys). Annual reports are generally of limited utility except in cases where they may have direct bearing on a particular park resource management issue.

General statistics (mean and standard deviation) are included for the two seasonal changes as well as the one annual change. The Annual Project Report is organized into sections to present the data in narrative, tabular, and graphical form. The sections are as follows:

1. Introduction
2. Site and situation
3. Timing of coastal topography surveys
4. Natural and anthropogenic events affecting the geomorphology
5. Areas of special interest
6. Changes to the protocol
7. Coastal topography surveys data sets, summary statistics, and portrayal of change
8. Information for management and recommendations
9. Problems/concerns
10. Appendices
11. Bibliography

10.1.2 Park Trend Reports

The Park Trend Reports are a summary of the full database of coastal topography incorporating the previous five years' worth of data collected since the last trend report. It is a comprehensive complement of analyses that synthesize the geomorphology change data, and provide scientific

interpretation of the trends revealed in the numerical analyses. The sections of the report are as follows:

1. Introduction
2. Site and situation
3. Timing of coastal topography surveys
4. Natural and anthropogenic events affecting the geomorphology
5. Areas of special interest
6. Changes to the protocol
7. Coastal topography surveys data sets, summary statistics, and portrayal of change
8. Trend analysis, description and interpretation
9. Information for management and recommendations
10. Problems/concerns
11. Appendices
12. Bibliography

10.2 SOP 10 – Revision History Log

The following table lists all changes that have been made to *SOP 10: Coastal Topography Reporting* since the original publication date. Any recommended or required changes added to the log must be complete and concise and promptly brought to the attention of the Northeast Coastal and Barrier Network (NCBN) Protocol Lead. The Protocol Lead reviews and incorporates all changes and officially complete the Revision History Log of this SOP and the SOP Tracking Table for the SOP document. For complete instructions, please refer to *SOP 13: Protocol and SOP Versioning*.

SOP Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change
2.00	3/1/2022	Glenn Liu, GIS Technician, Rutgers University	Split SOP 8 into two SOPs - Data Analysis (SOP 8) and Reporting (SOP 9) to retain consistency with SOPs in 1D Protocol.	Full protocol update prescribed by Technical Steering Committee
2.00	1/31/2023	Robin Baranowski, NCBN BioTech	Changed from SOP 9 to 10 (updates section, figure and table #s)	A new SOP was added

SOP 11: Data Management

Version 2.00

11.1 Objective

Proper data management and standardization are essential to the effective utilization of information gained through geomorphological monitoring activities. This SOP provides guidelines for the development, storage, and distribution of monitoring data associated with the Northeast Coastal and Barrier Network (NCBN) Coastal Topography Monitoring Protocol. It describes how information and data generated at various points during the data-collection, analysis, and reporting processes are to be organized, stored, and disseminated, and who is responsible for these tasks Table S 11.1. This SOP describes the file management system used for this protocol, and details how monitoring data are stored in the NCBN Coastal Topography Monitoring Database. The SOP also outlines the procedures for performing data quality assurance and quality control (QA/QC), archiving both spatial and tabular datasets, and making the data publicly accessible via National Park Service information clearinghouses.

For more detailed policy information, consult the formal [information management plan](#) for all NCBN monitoring protocols.

11.2 Definition of the Coastal Topography Dataset

The Coastal Topography Monitoring Program produces a number of electronic and paper data files that include raw and post-processed spatial datasets, a SQL Server relational database, and scanned field forms. The large number and variety of files require conscientious and formal attention to their management. It is the responsibility of the NCBN Data Manager and Protocol Lead to assemble, maintain, and make available the various components of the coastal topography dataset described here.

11.2.1 Baseline Data

Prior to data collection at a given park, an extensive array of survey control monuments and either physical and virtual transect monuments are located and/or created, and transects along a defined azimuths are established. For each park (or park unit, in the case of Gateway National Recreation Area), the following “baseline” datasets have been created for use by survey personnel to guide data collection in the field and for quality control purposes once the data have been downloaded from the GPS/GNSS equipment:

1. One Esri point feature class containing all survey control monuments and transect monument locations
2. One Esri feature class containing all corresponding transect features
3. One or more field booklets containing location information and other metadata regarding the above features (.pdf format)
4. One Esri polygon feature class containing a 0.05 m buffer of each transect monument location (for QA/QC purposes)

5. One Esri polygon feature class containing a 0.5 m buffer of each transect feature (for QA/QC purposes)

All Esri feature classes described above are stored in geodatabases (one per park) in order to facilitate uploading of these data to GPS/GNSS controllers for use in the field. The XYZ coordinates of all point features and azimuth for all transects is also stored in the central SQL Server database, allowing for formal tracking and documentation of these key features. They are also used within the database to virtually recreate the polygon buffer features for additional quality control.

11.2.2 Survey Data

Once initial post-processing and export procedures have been completed by survey personnel (see *SOP 7: Initial Post-Survey Processing*), all relevant data are delivered for each park, twice per year, to the NCBN Data Manager or Protocol Lead. Files are delivered in digital format by mail or as compressed archive files via email or secure file-sharing service. Required deliverables are:

1. Original survey files (ex: .job and .dc, or Leica folder) downloaded from the GPS/GNSS survey equipment (.zip file format)
2. Text file containing survey data with the specified export fields, datum, and geoid (.csv format)
3. Scanned copy of the field data form (.pdf)
4. Photographs taken during survey (.jpg format, combined in a .zip archive file)

Normally, all four deliverables are included for each survey “event”, defined as all data elements associated with survey activities described on a single field data form. The only exception to this may occur when original survey files contain data from multiple events and are processed in the office as such. In cases where these files cannot be separated out by event, it is acceptable to deliver the original combined files, and the Protocol Lead or Data Manager notes this in the database.

11.2.3 Analysis and Reports

In addition to the collection and initial processing of coastal topography monitoring data, NCBN personnel or contracted investigators periodically conduct analyses of topographic change using the GPS/GNSS profiles. These investigators also produce annual and long-term trend reports summarizing and interpreting the results from the above analyses. Copies of these reports are delivered to the NCBN Protocol Lead and sent for appropriate peer review. Published reports are stored on the NCBN data servers in text and Adobe .pdf format and made available via the NPS Data Store and NCBN website. Interim datasets produced during analysis are not formally retained.

11.3 The Coastal Topography Monitoring Database

All raw data collected as part of the Coastal Topography Monitoring Protocol is entered into the [NCBN Coastal Topography Monitoring database](#), and a [SQL Server relational database](#) that is compliant with the NPS Inventory and Monitoring Division Database Standards. Key aspects of the database design include:

1. Ease of data entry, mirroring as closely as possible the processes for recording data on protocol field sheets.

2. Built-in quality assurance features (e.g., primary keys, referential integrity, cascading edits though multiple tables, lookup tables, numeric range limits, etc.).
3. Standardized formatting allowing for ease of data sharing and cross dataset analyses.

11.3.1 Data Entry

The NCBN Data Manager or Protocol Lead is responsible for entering all data into the central SQL Server database. Data collected using paper field forms should be entered as soon as possible following data collection when field technicians' memories are fresh and discrepancies in the data are more easily resolved. The paper copies should be retained and stored on site. The [NCBN Coastal Topography Monitoring Database User's Guide](#) provides comprehensive instructions on entering raw data and associated artifacts into the database.

11.3.2 Baseline Datasets

As mentioned above, the horizontal coordinates and elevations of all survey control monuments and transect monuments, as well as the azimuth value for all transects, is stored in the central SQL Server database. All such data must be entered into the database *prior* to any survey data associated with those monuments or transects. Baseline data are entered under the "Locations" menu of the [database's online interface](#).

For each profile location, investigators have developed and surveyed monument locations and permanent transects against which subsequent RTK GPS data is compared. Survey control monument features are stored in Esri feature classes (one per park or park unit, when applicable), as are the initial profile line features. These files, as well as their accompanying metadata are generated once and should be placed in the appropriate geodatabase in the folder "4_Profile_geodatabases." Field guides describing the locations of these features should be located in the folder "1_Monument_Booklets."

11.3.3 Survey Event Data

Prior to incorporating the actual coordinates and elevations of transect points collected in the field, information from the field data form concerning the date, time, observers, etc., associated with that survey event are entered under the "**Surveys**" menu of the above mentioned online data-entry application. All fields under the "**Survey Event**" and "**Survey Notes**" tabs can be entered before submitting the form.

11.3.4 GPS/GNSS Coordinates

The GPS/GNSS coordinates (horizontal positions plus elevations) are the core data of the Coastal Topology Monitoring Protocol and compose the basis for all analyses. In order to facilitate their incorporation into the monitoring database, these raw data are exported from the original GPS/GNSS survey files in a specifically formatted text file (see *SOP 8: Initial Post-Survey Processing*). The data can then be appended to the database using the associated Desktop Client Import Tool (available for download from "**Home**" menu of the online data-entry app). The import process includes several quality assurance checks on the data, informing the user if serious anomalies were encountered (e.g., missing fields) and preventing data with serious quality issues from being appended.

After successful upload of the coordinate data, the user will notice upon revisiting the survey event in the online app that the “*Surveyed Transects*” and “*Survey Measurements*” have been populated. The user can then add any notes concerning specific transects from the field data form in the “*Notes*” field of the “*Survey Transects*” tab, and both tabs include flags for any records that did not pass one or more data validation rules.

11.3.5 GPS/GNSS Files

The original GPS/GNSS survey data files (i.e., “raw data”) are an integral component of the coastal topography dataset, allowing for the recreation and replication of any subsequent calculations or derivations. The raw data files that are directly downloaded from the GPS/GNSS data collector contain information beyond the horizontal vertical point positions, including information concerning the precision and accuracy of the positions, time and date of collection, equipment used, number of satellites, signal to noise ratio, etc. If Trimble GPS/GNSS data collectors such as the R10 or R8 are used, these data are in proprietary data collector (.dc) and job (.job) formats. If there is any question as to whether prescribed GPS/GNSS data collection parameters have been exceeded, the NCBN Data Manager or Protocol Lead can refer to these files to determine that GPS/GNSS unit settings for data collection have been correctly applied.

Because these files are typically in non-tabular and proprietary formats, their content is not entered directly into the database. Rather the files themselves are stored as stand-alone objects or “artifacts” and associated with the appropriate survey event record in the database. Detailed procedures for uploading these files to the database using the Desktop Client Import Tool mentioned above can be found in *Database User’s Guide*. Once uploaded, they are accessible to users under the “*Survey Artifacts*” tab when viewing a survey event in the online database app.

11.3.6 Field Data Forms

The field data forms collected in conjunction with the individual RTK-GPS/GNSS surveys (one form per day per surveyor) provide information essential to the usability and verification of the dataset. If not already converted, the NCBN Data Manager or Protocol Leader scans hard-copy field data forms and export them as Adobe .pdf files. These files are then uploaded to the database as artifacts using the Desktop Client Import Tool (as described for the raw GPS/GNSS data files, above).

11.3.7 Digital Photographs

Digital photographs are taken to document the condition of each transect during RTK-GPS/GNSS data collection. Additional photos may also be taken to document any unusual features encountered (e.g., the presence of a large scarp, overwash areas, etc.). All photos associated with a single survey event are included in a single .zip archive file, which is then uploaded to the database as an artifact using the Desktop Client Import Tool.

11.3.8 Spatial Data Validation

All collected data undergo initial quality control checks before being delivered to the NCBN (see *SOP 8: Initial Post-Survey Processing*). Upon receipt, the Data Manager or a designated technician familiar with GIS software also validate these spatial features using the following procedures:

1. In a GIS, overlay all features on well-documented GIS vector and imagery data for the park unit. The NCBN Data Manager can provide the appropriate spatial datasets, such as:
 - Current orthophotography
 - Georeferenced park visitor maps
 - Best available park boundary coverages
 - Wetlands
 - Hydrography
 - Roads
2. Label and visually inspect the location of all station features. Note any apparent discrepancies, such as:
 - Features located partially or wholly outside of the park boundary
 - Features associated with habitat types other than the beach-dune-bluff system
 - Two or more sampling stations sharing the same coordinates
3. Check all monument features flagged by the database as falling outside of their corresponding quality control buffer features. Any features falling outside of their respective buffers without an apparent explanation should be brought to the attention of the survey team.
4. Check for completeness of the dataset.
 - Have all transects been surveyed?
 - Do all survey events indicate successful accuracy assessment check-ins at known survey control monuments?
 - Does each survey event have at least the minimum associated artifacts (.zip archive of raw datasets, .pdf copy of the field data forms, and .zip archive containing transect photos)?

For all noted discrepancies, it is advisable to first consult the original data for obvious causes of error, such as incorrect projection information. Remaining questions should be resolved by first consulting the associated field sheets and/or contacting the survey team who collected the data. If the problem cannot be corrected, the feature is appropriately flagged in the database and the survey team collects a new feature as soon as possible. All changes should be described, initialed, and dated on the field sheet and noted in the protocol database.

11.3.9 Data Verification

In order to minimize transcription errors, all survey event data is verified against the original field data forms by a second person. If no park staff members are available, the Project Lead or Data Manager should verify 100% of the data entry. Fields indicating the verification of records (date verified, reviewer's name, etc.) are included within the database. In addition, a random 10% of records are reviewed a second time by the Protocol Lead. The Protocol Lead conveys the results of this comparison to the Data Manager, who incorporates the information into the database's metadata file during the annual review/archiving process.

The Coastal Topography Monitoring Database contains features designed to aid the Protocol Lead in the data verification process. These features can be found in the database “**Reports**” menu. (These reports summarize data that are otherwise stored or displayed in multiple tables and forms within the database, greatly facilitating visual inspection of the records.) Reports can be created to check that all records have indeed been verified for a field season.

11.4 Data Backup

11.4.1 Local Data Backup

Incremental backups of the NCBN servers are made daily and are maintained on a weekly basis, culminating in a full backup at the end of each week. Weekly backup tapes are retained for six months. Semi-annual full backups are retained in perpetuity at an off-site data archive.

11.4.2 SQL Server Database Backup

Backups are triggered within SQL to do full nightly backup files. The files are retained on physical storage for National Information Solutions Cooperative (NISC) Commvault tasks to collect and backup within NISC standards. NISC assures that the files are stored on physical disks for 90 days. After 90 days, the files are converted to tape and stored off-site for 3 years.

11.4.3 Export to American Standard Code for Information Interchange (ASCII)

As software and hardware evolve, datasets must be consistently migrated to new platforms, or they must be saved in formats that are independent of specific platforms or software (e.g., ASCII text delimited files). NCBN archiving procedures include saving datasets in both their native format (typically MS-Access or SQL Server database format) and as sets of ASCII text files. As a platform- and software-independent format, ASCII text files ensure future usability of the data in a wide range of applications and platforms.

As part of the annual archiving of the Coastal Topography Monitoring Database, the NCBN Data Manager or Protocol Lead produces such ASCII text files for all data from that year using the export functionality under the “**Reports**” tab of the database (or an analogous tool).

11.5 Archiving

Datasets associated with the Coastal Topography Monitoring Protocol is archived on an annual basis, both in their native formats as well as ASCII text files. Quality control checks are then performed on these ASCII files to ensure that the numbers of records and fields correspond to the source dataset and that conversion has not created errors or data loss.

Following each year of data collection (one spring and one fall field season), the Data Manger archives a dataset consisting of the following elements:

1. A copy of the exported Coastal Topography Monitoring data from the current year (with accompanying Federal Geographic Data Committee (FGDC) compliant metadata), as described above
2. Digital (.pdf) copies of the field forms from each survey for that year
3. Digital (.jpg) copies of all photos from each survey for that year

4. Digital (.txt and .pdf) copies of the Protocol and SOP document used for that year
5. Digital (.txt and .pdf) copies of any Annual Data Summaries or Long-term Monitoring Reports associated with the data collected in that year.

The archive is placed on the NCBN data server in the appropriate directory location, i.e.:

\\MONITORING\Coastal_Topography\03_ARCHIVE\[Year]

Archives, along with all data files residing on the NCBN data servers, are backed up daily (incremental), weekly (full), and twice per year (off-site).

11.6 Database Revision Control

On an annual basis, the Data Manager or Protocol Lead is responsible for identifying and documenting any changes needed for the Coastal Topography Monitoring Database (see [Annual Data Management Checklist](#), Figure S11.1). The Data Manager is then responsible for making these changes to the database, the accompanying Database User's Guide, and this Data Management SOP (See *SOP 13: Protocol and SOP Versioning*).

11.7 Data Distribution

Access to NCBN data products are facilitated via a variety of information systems that allow users to browse, search, and acquire NCBN data and supporting documents. All annual data summaries and long-term reports are posted on the [NCBN website](#) and accessible through the NPS Integrated Resource Management Applications Data Store ([IRMA](#)). The monitoring data itself is made available via the reporting capabilities of the SQL Server database's online application (as allowed, depending on park staff's determination of sensitivity of those data. Requests for the data can also be made by contacting the NCBN Data Manager:

Northeast Coastal and Barrier Network
Data Manager
University of Rhode Island
Room 105 Coastal Institute
1 Greenhouse Road
Kingston, RI 02881

Task	Responsible person(s)	Date completed	Person(s) completing task	Comments
Baseline data provided to survey teams at each park prior to field work	Data Manager / Project Lead			
Data collected, post processed, initial quality check procedures	Survey technicians			
Field sheets scanned and converted to .pdf	Survey technicians			
Data products delivered to Northeast Coastal and Barrier Network	Survey technicians			
All data entered into SQL Server database	Data Manager / Project Lead			
Data 100% verified	Project Lead			
Data 10% verified	Project Lead			
Spatial data validated	Project Lead			
Federal Geographic Data Committee (FGDC) compliant metadata developed for all final datasets	Data Manager			
Copies of certified data, metadata, reports, etc. are archived digitally on the NCBN file share	Data Manager / Project Lead			
New annual, cumulative Data Package containing certified datasets and metadata posted to NPS Data Store (IRMA)	Data Manager			
Trend reports (if applicable) posted to NPS Data Store (IRMA)	Data Manager			
Annual Operational Protocol Review conducted	Project Lead			
Any revisions to the protocol or database are made	Data Manager / Project Lead			

Version – 01-31-2023

Figure S11.1. An example of the Annual Data Management Checklist of data management tasks described in SOPs. Download or view the most up to date list [here](#).

11.8 SOP 11 – Revision History Log:

The following table lists all changes that have been made to *SOP 11: Data Management* since the original publication date. Any recommended or required changes added to the log must be complete and concise and promptly brought to the attention of the NCBN Protocol Lead. The Protocol Lead reviews and incorporates all changes and officially complete the Revision History Log of this SOP and the SOP Tracking Table for the SOP document. For complete instructions, please refer to *SOP 13: Protocol and SOP Versioning*.

SOP Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change
1.00	10/2012	Dennis Skidds, NCBN Data Manager	Initial SOP	Initial SOP
2.00	3/1/2022	Glenn Liu, GIS Technician, Rutgers University	Formerly SOP 8. Updated final deliverables list and links.	Full protocol update prescribed by Technical Steering Committee
2.00	1/31/2023	Dennis Skidds, NCBN Data Manager	Update Annual Data Management Checklist and link	Update to checklist
2.00	1/31/2023	Robin Baranowski, NCBN BioTech	Changed from SOP 10 to 11 (updates section, figure and table #s)	A new SOP was added

SOP 12: Annual Operational Review

Version 2.00

12.1 Objective

The purpose of conducting an annual operational review for the Coastal Topography Monitoring Protocol is to obtain feedback on protocol implementation, ensure that the written protocol remains in sync with annual monitoring activities, document changes in procedures and equipment that may have occurred during the field season, capture lessons learned, and document potential changes that may need to be made to the protocol or SOPs.

The annual operational review first involves post-field survey check-ins. Following each spring and fall survey, check-ins are conducted by the Protocol Lead who meets individually with the field staff/data collector(s) at each park to discuss any issues that may have occurred during the survey at that park. Check-ins occur within one-two weeks after data is collected in the spring and the fall. Check-in discussion notes are taken by the Protocol Lead and all notes become part of the Annual Operational Review Report.

At the end of the year and prior to the new field season, the annual operational review virtual meeting is held by the Northeast Coastal and Barrier Network (NCBN) Protocol Lead, that includes all field technicians, the Program Manager, and Data Manager. This provides a collaborative opportunity for the Network staff and field technicians to discuss the annual implementation of the protocol as a group. This might entail discussing issues with equipment, data collection, post-processing data, and anything else that may need to be discussed relative to protocol implementation in the NCBN parks. The operational review may also lead to a more in-depth science review by the NCBN Geomorphological Monitoring Technical Steering Committee.

12.2 Process and Timing

12.2.1 Post-Field Survey Check-ins

Check-ins are held with individual field surveyors within one to two weeks following each spring and fall survey. A post-data collection interview is conducted (see [Post-Survey Check-In Form Questionnaire](#), Figure S12.1).

Post-Survey Check-In Form

Northeast Coastal and Barrier Network Geomorphological Monitoring

Date:

Park Name:

NCBN staff conducting the check-in:

Field surveyors being interviewed:

NCBN Protocols used during survey:

Questions:

1. Was the data collected at all sites?
2. Was the data collected within the prescribed survey window?
3. Was the data collected at least one week after a storm event?
4. Was a pre- and post-survey check-in taken for each survey event?
5. Were there any safety concerns experienced by any of the surveyors?
6. Are you aware of any situations where you or someone else deviated from the protocol?
Please describe the situation and any data that may have been affected.

Version – 01-31-2023

Figure S12.1. An example of the Post-Survey Check-In Form questionnaire that is given as a post-data collection interview. Download or view the most up to date list [here](#).

12.2.2 Annual Operational Review Meeting

Prior to the annual operational review meeting, final feedback is solicited from all field surveyors by the Protocol Lead, using the “Operational Review Collaborator Feedback for Geomorphological Monitoring” [survey form](#).

12.3 Participants

Check-ins and the annual conference call participants can include network and park staff, cooperators, contractors, and any others involved with data collection, management, and analysis. Additional subject-matter experts can also be included, if appropriate.

12.4 Scope of the Annual Operational Review

The annual operational review covers SOPs and operational documents related to annual implementation of the NCBN Coastal Topography Monitoring Protocol.

1. Situations where SOPs were not followed is identified and documented.
 - a. Did these situations affect data quality or utility?
 - b. Note that if a safety risk is identified in the field, the field crew must not visit sites or implement methods that risk their safety. In this situation, the crew should document their decision in the monitoring database, and it is recorded as a deviation from the protocol. The operational review must consider the situation and determine if protocol changes to protect safety are needed, as well as whether the proposed changes require a scientific review.
2. Places where SOPs need clarification is documented.
 - a. How were the unclear situation(s) handled in the field?
 - b. Consider other networks that may be implementing the protocol and identify changes that would need to be communicated to them.
3. Situations where new SOPs may be needed are identified.
 - a. Were new equipment, methods, or data management practices used? New SOPs need scientific review if they affect the monitoring approach or quality of the data.
4. Potential changes to streamline or improve procedures are identified (including new equipment).
 - a. The only situation where a change to procedures or equipment does not require a scientific review is where a change is required due to unforeseen events (e.g., sudden discontinuation of a key piece of equipment by the manufacturer).
 - b. For changes to methods and planned changes to equipment, a side-by-side comparison of the old and new methods or equipment should be conducted, with results to be scientifically reviewed prior to implementing changes.
5. Data management procedures are reviewed.
 - a. Ensure there are clear linkages between the SOPs, field data forms, and database(s).

- b. Determine if there are any concerns throughout the data life cycle (i.e., planning and preparation through data collection to review, reporting and archiving).
 - c. Ensure that data quality standards have been followed.
 - d. Ensure that the protocol database meets, at least, the mandatory database requirements as outlined in the Inventory and Monitoring Division (IMD) Database Standards, including handling of protected records.
 - e. Identify potential changes that need to be made to data management procedures in order to maintain or enhance quality assurance and quality control (QA/QC).
- 6. Safety Review
 - a. Discuss any incidents or near misses, and actions taken or needed.
 - b. Solicit suggestions for making procedures safer, including equipment improvement and training needs.
 - c. Discuss any implications for sampling design and methods, e.g. whether additional situations for excluding sites for safety reasons are needed.
- 7. State of the science.
 - a. Do changing needs, new conditions, or emerging information (from the network or external sources) suggest the need for a scientific review?

12.5 Outcomes of the Operational Review

1. A Coastal Topography Monitoring Operational Review report that is completed annually following the final review meeting. The report includes the check-in notes, annual review meeting minutes, agenda and results of questionnaires, and documentation of known deviations from protocol methods.
2. Documentation of suggestions for improving the protocol/SOPs and decisions regarding the suggestions. Note that some suggestions may trigger a scientific review.
3. Documentation of deviations between the protocol and the field implementation that could potentially affect data quality or utility for that year. For these deviations, document whether the deviation needs to be addressed with changes or clarifications to procedures. Update the database with affected data appropriately flagged and documented.
4. Identification and verification that safety risks associated with protocol implementation are appropriately mitigated. For any newly identified or incompletely mitigated risks, approve a plan (tasks and timeline) for mitigating the risks and updating the network safety documents.
5. Updated and approved SOPs with minor revisions or scheduling of a Coastal Topography Monitoring Technical Steering Committee meeting to consider major revisions.
6. Identification of factors encountered in the use of new equipment that might affect data quality or comparability, particularly when use of new equipment is driven by unplanned or unforeseen circumstances or when "old" equipment is unavailable for conducting side-by-side comparisons.

7. Revised SOPs or new SOPs.
8. Revised QA/QC documentation as needed.
9. Updated supplementary materials as needed.
10. Identification for the need to schedule a Coastal Geomorphology Technical Steering Committee meeting, if major changes are required to update the protocol, or a more in-depth scientific review is necessary due to questions that have arisen through implementation of the protocol and/or the operational review.

12.6 Staff Responsibility

1. The operational review is managed by the Protocol Lead. The Network Program Manager reviews the annual operational review report and associated documents. Field technicians participate in the Check-in meetings and annual operational review meeting.
2. The Network Program Manager contacts the Regional Program Manager to request a scientific review if needed, but operational reviews generally do not result in a need for scientific or external review.
3. Networks with PIPs based on another protocol are ultimately responsible for contacting the Protocol Lead(s) who administer the original protocol annually for the results of the operational review. However, the Protocol Lead is strongly encouraged to inform networks with PIPs of the operational review, solicit feedback about PIP implementations, and distribute the results of the operational review. As of FY 2022, this includes the Southeast Coast Network (SECN) and the Gulf Coast Network (GULN).
4. Changes to SOPs that stem from an operational review are reviewed and approved by the Network Program Manager. The Regional Program Manager must review and approve changes to the narrative.
5. Review documents must be stored alongside the data and other documentation for that field season on the network's server.

Note: In addition to this SOP, please review the following document for further details:

Mitchell, B., A. Chung-MacCoubrey, J. Comiskey, L. Garrett, M. MacCluskie, B. Moore, T. Philippi, G. Sanders and J.P. Schmit. 2018. Inventory and Monitoring Division protocol review guidance. Natural Resource Report NPS/NRSS/IMD/NRR—2018/1644. National Park Service, Fort Collins, Colorado.

12.7 SOP 12 – Revision History Log

The following table lists all changes that have been made to *SOP 12: Annual Operational Review* since the original publication date. Any recommended or required changes added to the log must be complete and concise and promptly brought to the attention of the NCBN Protocol Lead. The Protocol Lead reviews and incorporates all changes and officially complete the Revision History Log of this SOP and the SOP Tracking Table for the SOP document. For complete instructions, please refer to *SOP 13: Protocol and SOP Versioning*.

SOP Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change
2.00	3/1/2022	Dennis Skidds, NCBN Data Manager	Throughout	Full protocol update prescribed by Technical Steering Committee
2.00	1/31.2023	Dennis Skidds, NCBN Data Manager	Update Post-Survey Check-In Form Questionnaire and link	Update to questions
2.00	1/31/2023	Robin Baranowski, NCBN BioTech	Changed from SOP 11 to 12 (updates section, figure and table #s)	A new SOP was added

SOP 13: Protocol and SOP Versioning

Version 2.00

13.1 Objective

Due to the long-term nature of the Northeast Coastal and Barrier Network (NCBN) monitoring program, revisions to the Protocol and to the Standard Operating Procedure (SOP) document is necessary from time to time. Careful documentation of changes to the Protocol and its related SOP document, along with a library of previous versions, are essential for maintaining consistency in the collection, summary, analysis, and reporting of data.

13.2 Methods to Tracking Revisions

A Protocol Revision History Log (e.g. Figure S13.1) is found at the end of the Protocol and tracks the version numbers and reason for the changes made over time. Information entered in these logs should be complete and concise. The log tracks the versions, date of revisions, author(s) of revisions, location of changes within the document, description of changes, and the reason the changes were made. Author information must include full name, title, and affiliation.

Protocol Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change
1.00	4/12/2013	Dennis Skidds, NCBN Data Manager	NA	Initial Protocol
2.00	3/1/2022	Glenn Liu, Geoscientist-in-the-Parks (GIP), Rutgers	Updated figures and text throughout the Protocol Added details to description of uncertainty	Full Protocol update prescribed by Technical Steering Committee

Figure S13.1. An example of the Protocol Revision History Log reflecting revision scenarios and associated versioning of the Protocol.

A similar Revision History Log (e.g. Figure S13.2) can be found at the end of each individual SOP within the main SOP document. These logs track the SOP document versions, date of revisions, author(s) of revisions, location of changes within the individual SOP, description of changes, and the reason the changes were made. Author information must include full name, title, and affiliation.

SOP Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change
1.00	4/12/2013	Dennis Skidds, NCBN Data Manager	Initial SOP	Initial SOP
2.00	3/1/2022	Glenn Liu, GIP, Rutgers	E.g., Emphasized requirement for GPS/GNSS system with sub-meter accuracy (p.44)	Full protocol update prescribed by Technical Steering Committee
2.01	2/15/2023	Robin Baranowski	Add new equipment to Field Item checklist	New item being used in the field

Figure S13.2. An example of a SOP Revision History Log reflecting revision scenarios and associated versioning of the Protocol and/or SOP document.

The SOP Tracking Table (e.g. Figure S13.3) tracks the relationships between the Protocol and the SOP document. The individual SOPs also contain a Revision History Log found at the end of each SOP, and describe changes made to that SOP in detail.

SOP Tracking Table: Coastal Topography Monitoring (Checked SOPs are those modified on the date indicated)															
Date of Revision	Protocol Document Version #	SOP Document Version #	SOP 1: Monitoring Design Background	SOP 2 - Equipment	SOP 3 - Training	SOP 4 - Monuments, Transects, and Geodatabases	SOP 5 - Survey Timing	SOP 6 - Collection of Data	SOP 7 - Conducting the Survey	SOP 8 - Post-Survey Processing	SOP 9 - Data Analysis	SOP 10 - Reporting	SOP 11 - Data Management	SOP 12 - Annual Operational Review	SOP 13 - Protocol/SOP Versioning
4/12/2013	1.00	1.00													
3/1/2022	2.00	2.00		X	X	X	X	X	X	X	X	X	X	X	X
Examples below															
2/15/2023	2.00	2.01		X							X				
5/1/2024	2.00	2.02			X			X				X			
3/6/2025	3.00	3.00		X		X							X	X	

Figure S13.3. An example of the SOP Tracking Table reflecting revisions associated with versioning of the Protocol and SOP document, and tracking what individual SOPs were revised over time.

13.3 Instructions for Recording Revisions

13.3.1 Major revisions (Occur to both the Protocol and SOP Document)

Major revisions are those that involve changes in methodology that could influence the resulting data values and the ability to compare newly-collected data with data collected using a previous version. Major revisions require updating both the Protocol and SOP document and require a whole number version change designated with the next whole number in the sequence (2.0, 3.0, 4.0...) (See Figures S13.1 and S13.3).

Major revision examples may include, but are not limited to:

- addition of monitoring objectives
- changes to the sampling design
- changes to reporting requirements
- addition of new metrics

Steps to making major revisions

1. Revise the Protocol as needed.
2. Assign the Protocol a new version number (the next whole number in the sequence: 2.0, 3.0, 4.0...).
3. Incorporate the new version number in the following places:
 - The cover page
 - The title page
 - The citation
 - The Protocol Revision History Log at the end of the Protocol
4. In the Protocol Revision History Log, explain the reason the change was made, location and description of the change, along with the revision date and author.
5. Update the SOP document with the Protocol's new version number. Incorporate the new version number in the following places:
 - The cover page
 - SOP Tracking Table at the beginning of the SOP document (add a new row to include the date of the revision of the Protocol and SOP document)
 - At the beginning of each individual SOP, under the title of the SOP (every individual SOP should have the same version number)
6. In the new row of the SOP Tracking Table, place an “X” in the cells of SOPs that were also revised during this revision.
7. If SOPs were revised, update their individual SOP Revision History Log with the new version number (that matches the Protocol and SOP document version number), explain the reason the change was made, the location and description of the change, along with the revision date and author.
8. Follow all Inventory and Monitoring Program (I&M) peer review guidelines, and acquire the appropriate level of peer review and approval from or by the Network Program Manager and the Regional I&M Program Manager.
9. Submit the new version of the Protocol to Fort Collin’s publications management team to be published.
10. PDF the newly versioned SOP document and upload it to the Integrated Resource Management Applications ([IRMA](#)) Portal record as a new version. Note, the SOP document

is no longer be published as part of the NPS NRSS reporting series, but rather a stand-alone publication.

13.3.2 Minor revisions (Occur to the SOP Document Only)

Minor revisions only occur to the SOP document and are those that do not represent a change in the underlying methods or procedures used to generate data values for the Protocol's existing data set. Minor revisions include small changes in, or clarification of procedures. A change in any individual SOP requires an update of the SOP document version number. SOP version numbers for minor revisions increase incrementally by hundredths (1.01, 1.02 . . .) (See Figure S13.2 and S13.3), and again, increase by whole numbers for major revisions in association with the Protocol.

Steps to making minor revisions

11. Edit any individual SOPs that you need to update.
12. Update the SOP Revision History Log at the end of the individual SOP that has been revised with these specific details:
 - Include the date the revision was made, the author, the location and description of the change, and the reason for the change
13. Update the SOP Tracking Table at the beginning of the SOP document.
 - Add a new row in the SOP Tracking Table with an SOP document version number increased by hundredths from the last version
 - Place an "X" in the cells of the SOPs that had content updates during this minor revision of the SOP document
14. Update the new SOP document version number in the following places:
 - On the cover page (under the title of the document)
 - At the beginning of each individual SOP (under the title of each individual SOP)
 - **Note:** Every individual SOP must have the same version number
15. PDF the new versioned SOP document and upload to the IRMA record as a new version.

13.4 SOP 13 – Revision History Log

The following table lists all changes that have been made to *SOP 13: Protocol and SOP Versioning* since the original publication date. Any recommended or required changes added to the log must be complete and concise and promptly brought to the attention of the NCBN Project Lead. The Project Lead reviews and incorporates all changes and officially complete the Revision History Log of this SOP and the SOP Tracking Table for the SOP document.

SOP Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change
1.00	4/12/2013	Dennis Skidds, NCBN Data Manager	Initial SOP	Initial SOP
2.00	3/1/2022	Sara Stevens, NCBN Program Manager	Complete revision	Full protocol update prescribed by Technical Steering Committee
2.00	1/31/2023	Robin Baranowski, NCBN BioTech	Changed from SOP 12 to 13 (updates section, figure and table #s)	A new SOP was added

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