



Northeast Coastal and Barrier Network Geomorphological Monitoring Protocol

Part II – Coastal Topography

Natural Resource Report NPS/NCBN/NRR—2012/591



ON THE COVER

Talisman, Fire Island National Seashore, NY.

Photograph by: Norbert P. Psuty

Northeast Coastal and Barrier Network Geomorphological Monitoring Protocol

Part II – Coastal Topography

Natural Resource Report NPS/NCBN/NRR—2012/591

Dr. Norbert P. Psuty
Tanya M. Silveira
Andrea Spahn

Rutgers University
Institute of Marine and Coastal Sciences
Sandy Hook Cooperative Research Program
74 Magruder Road
Sandy Hook, NJ 07732

Dennis Skidds

National Park Service
Northeast Coastal and Barrier Network
University of Rhode Island
Kingston, RI 02881

October 2012

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Report Series is used to disseminate high-priority, current natural resource management information with managerial application. The series targets a general, diverse audience, and may contain NPS policy considerations or address sensitive issues of management applicability.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received formal, high-level peer review based on the importance of its content, or its potentially controversial or precedent-setting nature. Peer review was conducted by highly qualified individuals with subject area technical expertise and was overseen by a peer review manager.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available from <http://www.nps.gov/nero/science/> and the Natural Resource Publications Management website (<http://www.nature.nps.gov/publications/NRPM>).

Please cite this publication as:

Psuty, N. P., T. M. Silveira, A. J. Spahn, and D. Skidds. 2012. Northeast Coastal and Barrier Network geomorphological monitoring protocol: Part II - coastal topography. Natural Resource Report NPS/NCBN/NRR—2012/591. National Park Service, Fort Collins, Colorado.

Contents

	Page
Figures.....	vii
Tables.....	ix
Standard Operating Procedures (SOPs).....	xi
Appendices.....	xi
Executive Summary.....	xiii
Acknowledgements.....	xv
Protocol Narrative.....	xvii
Background and Objectives.....	1
Introduction.....	1
Goal and Objective.....	1
The Oceanside Coastal Ecosystem.....	3
The Process of Evaluating Vital Signs.....	5
The Components of Coastal Topography.....	6
Components of the Coastal Profile.....	7
Major Geomorphological Features.....	8
Sediment Budget.....	9
Geotemporal Elements of Sediment Budget.....	11
Monitoring Objectives.....	13
Measuring Coastal Topography.....	14
Basics of Topography.....	14
Benchmarks.....	17
Beach Profile Collection.....	18
Field Methods and Equipment.....	19

Contents (continued)

	Page
Geodetic GPS Unit.....	20
Monitoring Design	23
Establishment of the Spatial Monuments Network	23
Assateague Island National Seashore	24
Cape Cod National Seashore	25
Gateway National Recreation Area	25
Fire Island National Seashore	25
Survey Frequency and Timing.....	32
Field Methods	35
Field Season Preparations and Mission Planning.....	35
Conducting the Topographic Survey	35
Post-survey Data Download and Initial QA/QC	36
Data Management	37
Data Analysis and Reporting	39
Generation of Beach Profile Cross-section, and Calculation of Dimensional Parameters.....	39
Data Analysis and Reports.....	39
Personnel Requirements and Training.....	41
Roles and Responsibilities	41
Qualifications and Training	41
Frequency of the Training Sessions.....	42
Target Audiences	42
Training Syllabus	42
Operational Requirements	43

Contents (continued)

	Page
Annual Workload and Field Schedule	43
Facility and Equipment Needs	43
Procedure for Revising and Archiving Previous Versions of the Protocol	45
Literature Cited	47

Figures

	Page
Figure 1. Locations of the eight NPS units in the Inventory and Monitoring Program of the Northeast Coastal and Barrier Network.....	2
Figure 2. The Ocean Beach-Dune Ecosystem Model illustrates the relationships amongst the agents of change, stressors, and ecosystem response (after Roman and Barrett 1999).	4
Figure 3. Aerial view of Fire Island National Seashore, showing the shoreline variation due to the alongshore and cross-shore sediment transport acting upon the coast. Photo by Dr. James R. Allen (September 1988).....	7
Figure 4. Beach-dune-bluff profile morphology.....	8
Figure 5. Typical beach profile associated with a positive sediment budget, incorporating multiple dune ridges and wide beach berm.	10
Figure 6. Typical beach profile at a coastal bluff, where the deficit of incoming sediment promotes a very narrow beach and the presence of a retreating bluff.....	10
Figure 7. Groin between the Neponsit & Belle Harbor communities and Jacob Riis Park (GATE), causing sediment accumulation on the updrift side and erosion and inland beach displacement on the downdrift side. Aerial image accessed February 2010 at bing.com/maps/	12
Figure 8. Aerial view of a portion of Cape Cod National Seashore, at the northern margin of Nauset Bay, showing the alongshore variation and transition between two very different geomorphological units, the sand barrier and marshland to the south, and the bluffs to the north. Aerial image accessed February 2010 at bing.com/maps/	12
Figure 9. Three-dimensional characteristics of the coastal topography.....	15
Figure 10. Typical beach profile showing the relationship between the 1983-2001 tidal epoch tidal datums, NGVD29 and NAVD88. (Source: NOAA tide gauge at Sandy Hook)	16
Figure 11. Examples of a) metal disks survey benchmarks and b) witness post label, established by USACE and NGS.....	17
Figure 12. Collection of measurements of beach topography: a) planar view showing some of the XYZ measurements along a profile line perpendicular to the general trend of the shoreline, b) cross-section view of the collected data portrayed as elevations along the profile line.....	18

Figures (continued)

	Page
Figure 13. Trimble R8 GPS unit (base receiver on tripod, and rover receiver on pole) used for conducting topographical surveys at Gateway National Recreation Area (Sandy Hook, July 2006).	21
Figure 14. Spatial network of survey monuments and profile lines at Assateague Island National Seashore, MD.	26
Figure 15. Spatial network of survey monuments and profile lines at Cape Cod National Seashore, MA.	27
Figure 16. Location of the three Units of Gateway where benchmarks have been installed.	28
Figure 17. Spatial network of survey monuments and profile lines at the Sandy Hook Unit of Gateway National Recreation Area, NJ.....	29
Figure 18. Spatial network of survey monuments and profile lines at Breezy Point, Jamaica Bay Unit of Gateway National Recreation Area, NY.....	30
Figure 19. Spatial network of survey monuments and profile lines at Plumb Beach, Jamaica Bay Unit of Gateway National Recreation Area, NY.....	30
Figure 20. Spatial network of survey monuments and profile lines at Great kills (GK), Miller Field (MF) and Fort Wadsworth (FW), Staten Island Unit of Gateway National Recreation Area, NY.....	31
Figure 21. Spatial network of survey monuments and profile lines at Fire Island National Seashore, NY.....	32
Figure 22. Changes in beach profile morphology, associated with seasonality of coastal energetics.	33

Tables

	Page
Table 1. The fourteen Vital Signs identified during the Northeast Coastal and Barrier Network.....	6
Table 2. Tidal datums as defined by the Center for Operational Oceanographic Products and Services(http://tidesandcurrents.noaa.gov/).....	16
Table 3. Relationship of 1983-2001 Tidal Epoch water levels to NAVD88 and NGVD29. (Source: NOAA tide gauge at Sandy Hook)	16
Table 4. Survey grade GPS units owned by the NCBN parks.	20
Table 5. Nomenclature used in the Coastal Topography Protocol.....	24

Standard Operating Procedures (SOPs)

	Page
SOP1: Equipment and Supplies	51
SOP2: Establishment of Benchmarks, Transects, and Geodatabases	55
SOP3: Survey Timing and Mission Planning	73
SOP4: Settings for Collection of Topography	79
SOP 5: Conducting the Survey	81
SOP 6: Initial Post-Survey Processing.....	93
SOP 7: Data Analysis and Reporting.....	99
SOP 8: Data Management.....	111
SOP 9: Revising the Protocol	123

Appendices

	Page
Appendix A: Field Booklet of Benchmark Locations at Breezy Point, Jamaica Bay Unit, Gateway National Recreation Area	127
Appendix B: Annual data management checklist	139

Executive Summary

Coastal Topography was ranked as one of the top variables for monitoring following a review of Vital Signs in the coastal parks of the Northeast Coastal and Barrier Network. Changes in coastal topography, whether caused by erosion or accretion, vary both spatially and temporally.

Understanding these variations is key to early recognition of potential problems affecting natural resources and cultural resources in coastal parks. For managers, an understanding of the spatial and temporal patterns of geomorphologic change is basic to optimal management of any coastal park because the interface of marine and land systems: 1) is highly dynamic and driven by multiple forcing mechanisms; 2) results in alterations to resource patterns and dynamics at habitat and ecosystem levels; and 3) can eventually result in the loss of static resources.

The establishment of local, long-term monitoring programs provides metrics (SI, meters) to help understand the processes that are driving coastal change of beaches, dunes, and bluffs within the parks. The Coastal Topography monitoring protocol will be applied to the four coastal parks in the NCBN: Assateague Island National Seashore, Cape Cod National Seashore, Gateway National Recreation Area, and Fire Island National Seashore. Monitoring will be accomplished with state-of-the-art GPS equipment that collects topographic data along pre-established locations spaced at regular intervals augmented by areas of special concern to the parks. A Spatial Monuments Network of high quality reference points will be established for each of the NCBN parks, providing a robust basis for long-term monitoring. Spring and fall surveys conducted in accordance with standard operating procedures will generate coastal topography datasets that will be organized and assembled by a data manager into a national database for subsequent retrieval and additional examination. Dimensional parameters will be measured to describe the beach-dune-bluff system, and attributes will be compared and analyzed in a cross-shore and alongshore perspective, providing information about the temporal and spatial changes on beach-dune-bluff morphologies in the parks. The overall goal is to create a replicable means of data gathering that is efficient, adheres to scientific principles, and meets the management needs of the coastal parks.

Acknowledgements

As with other projects that are very broad in scope, there are many people who have assisted in the compilation of information and testing of the protocol. Others assisted in providing support to the theme of the project and in sharing their experiences. Their contributions have been very helpful in bringing forth this document. Special appreciation is extended to the following in the National Park Service: Sara Stevens, Program Manager of the Northeast Coastal and Barrier Network; Courtney Schupp and Neil Winn of the Assateague Island National Seashore; Mark Adams and Megan Tyrrell of the Cape Cod National Seashore; Mike Bilecki of the Fire Island National Seashore; Dave Avrin, Bruce Lane, Mark Christiano, Jeanne McArthur, Kathy Mellander, Hollis Provins, Chris Olijnyk, and Tony Luscombe of the Gateway National Recreation Area. In addition, recognition is extended to: Graham Giese and Mark Borrelli of the Provincetown Center for Coastal Studies; Keith Noonan, Phil Karrber, Joe Petrocelli, and Gary Conk of the State of New Jersey Howard Lab crew; and members of the Rutgers team over the years consisting of Dan Soda, Paul Zarella, Peter Dennehy, Peter Shipton, Barry Shafer, Mario Resina, Aaron Love, William Hudacek, Jake McDermott, and John Gagnon.

Protocol Narrative

The following table lists all changes that have been made to this Protocol Narrative 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 project leader. The project leader will review and incorporate all changes, officially complete the revision history log, and change the date and version number on the title page. For a complete set of instructions, please refer to SOP#9 – Revising the Protocol.

Version 1.00 – July 2010

Revision History Log:

New Version #	Previous Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change

Background and Objectives

Introduction

A major issue in all coastal parks is the amount of sediment being moved along the coast through time (sediment budget), and how that affects the beach and dune topography. Sediment budget affects the quality of the natural and cultural resources as well as the general infrastructure present in the coastal parks. It is among the most basic of concerns related to being at the shore. Bird (1985) indicates that at least 70 % of the world's sandy shorelines are eroding and the percentage is expected to increase because of sea-level rise and sediment manipulation by human actions. Working Groups within the Intergovernmental Panel on Climate Change suggest that sea-level will rise from 18 to 59 cm during the present century (IPCC, Working Group I 2007b) and that coastal change will be an immediate consequence of this inundation (IPCC, Working Group II 2007a). New coastal geomorphological models are emerging that consider the effects of sea-level rise on shoreline change and landform evolution (Davidson-Arnott 2005; Psuty and Silveira 2010). They are both a guide to the potential effects of continuing global change and a plea to gather data appropriate to the testing and calibration of the models. They are harbingers of the concern and interest in the quality of the coastal system, in the shepherding of coastal resources, and in the datasets describing these resources (Van der Lee 2009).

The Northeast Coastal and Barrier Network (NCBN) was created by the National Park Service (NPS), as part of the congressionally-mandated Natural Resource Challenge, to ensure the systematic collection and use of scientific data in managing the nation's parks (NPS NCBN 2003). Within this structure, the NCBN is developing a series of scientific protocols to address a variety of natural resource issues appropriate to coastal locations. This document represents the second protocol for geomorphological monitoring in the eight parks that comprise the NPS NCBN (Fig. 1). The initial protocol (Part I - Ocean Shoreline Position) focuses on the collection and analysis of the ocean shoreline position, and is available at: <http://science.nature.nps.gov/im/units/ncbn/vs/shoreline.aspx>. The second protocol (Part II - Coastal Topography) focuses on the collection and analysis of two-dimensional coastal topography as a means to characterize beach, dune, and bluff systems.

Goal and Objective

A primary goal of the NCBN coastal geomorphological program is to provide information to park managers and to improve the understanding of the dynamic nature of coastlines, including the temporal and spatial patterns of change in NCBN parks that describe the condition of marine and coastal areas and support informed management decisions. The specific objective of this coastal topography monitoring protocol is to characterize the variability in beach, dune, and bluff topographical characteristics and determine trends along the coastline in Network parks over seasonal, annual, and long-term (five years or more) scales.

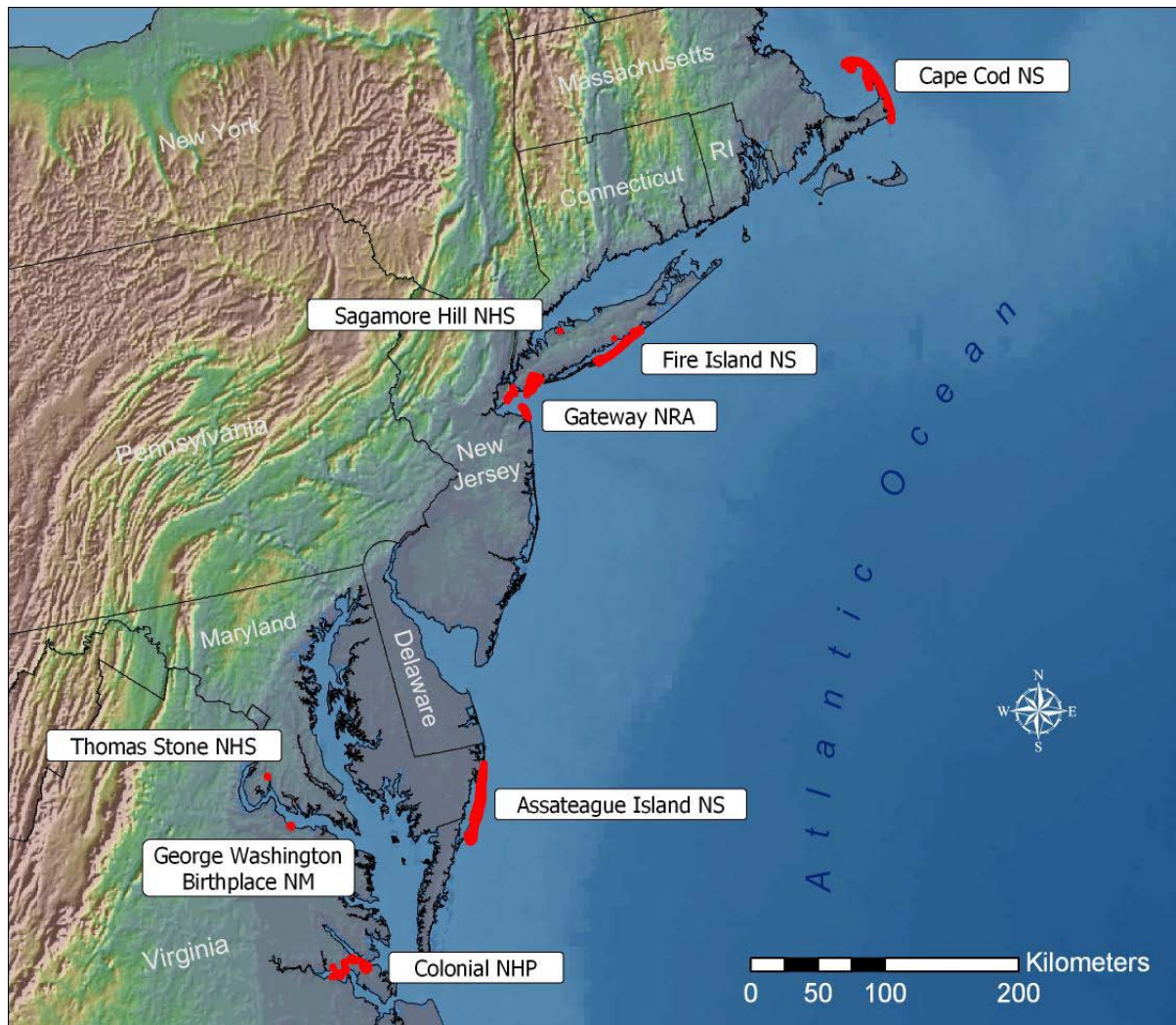


Figure 1. Locations of the eight NPS units in the Inventory and Monitoring Program of the Northeast Coastal and Barrier Network.

The NCBN coastal geomorphology program and its protocols are based upon three underlying principles:

1. All protocols developed by the Network must have a scientific foundation. Collaboration with the scientific community will ensure that all geomorphological monitoring protocols are based on well-established scientific principles of coastal characterization, processes, and response. Because coastal geomorphology is a complex subject, valid interpretation of the data will require the active involvement of knowledgeable coastal scientists. All measurements are in the International System of Units (SI) (meters).
2. Data must address significant park management issues. Park managers and natural resource staff were active participants in the planning and scoping process in the development phase of the geomorphological protocols. The objectives identified in this protocol reflect a consensus of issues considered relevant at the park level. This protocol

focuses on recording and assembling the geomorphological dataset to enable better-informed management decisions.

3. All protocols and their components must be feasible to implement at the Network level. Although the scientific and management value of the monitoring data were both critical factors in determining which vital signs or indicators were selected for monitoring, the practicality and feasibility of implementation across the Network were important as well.

Compared to shoreline position, landscape features and patterns at the inland reach of wave domination (upper beach, dunes, and bluffs) are less variable indicators of changes in coastal morphology. As a result, significant changes and trends associated with these features are more easily detected and applied to park management decision making. Beach, dune, and bluff erosion and migration often involve direct threats to natural and cultural resources, park infrastructure, and even to human safety, and are a major management issue in many parks. This monitoring program provides crucial information to the scientific understanding of the evolution of park coastal geomorphology, and it contributes to the scientific foundation for resource-management decision-making. Among the deliverables identified by coastal scientists and park managers are:

- Changes in dimension and location of coastal topographic features that may indicate changes in habitat that, in turn, require management action
- Sediment budget calculations that provide information on the amount of sediment available to the upper portion of the beach, acting as a buffer to park infrastructure

The Coastal Topography protocol includes a number of highly detailed standard operating procedures (SOPs). They are intended to ensure the consistency and repeatability essential to any long-term monitoring program. These SOPs will be modified and revised as technology improves and better methods for monitoring coastal geomorphological change are developed.

The Oceanside Coastal Ecosystem

The basis for the coastal geomorphological monitoring protocol is the beach-dune conceptual model (modified from Roman and Barrett 1999) that relates the physical processes and cultural impacts (agents of change) to the vectors of change (stressors) and to the responses of the coastal ecosystem (Fig. 2). Fundamental to the model is an awareness that the coastal system is dynamic and that it is interacting at a variety of geographical and temporal scales. The model consists of an assemblage of natural and cultural agents and processes that generate characteristics of the coastal landscape. As the relative magnitude of the agents and processes vary, they cause alterations to the hydrology and sediment budget and consequently to the landscape. Furthermore, there is a continuous interaction and feedback amongst the evolving components that drive additional changes and alterations. A primary manifestation of the alteration in the coastal system is a shift in shoreline position and modification of the beach, dune, and bluff topography. These coastal geomorphological changes result in an ecosystem response that incorporates changes in the physical environment and in the community structure and function (Fig. 2).

The primary natural disturbances that drive geomorphological change are sea-level rise, sediment supply, and wave climate. These natural factors influence coastal geomorphological response at different temporal scales including individual events (storms), cyclic variations (seasonal), and

annual and multi-year (long-term) trends (Carter 1988; Psuty and Ofiara 2002). One of the effects of sea-level rise is inland displacement of the shoreline and alteration of the coastal profile. When coupled with erosion produced by a prevailing sediment deficit, the rate of inland shoreline displacement is increased (National Research Council 1987; Warrick et al. 1993), and the elements of coastal topography evolve (Nicholls et al. 2007; Psuty and Silveira 2010). Whereas sea-level rise and sediment supply are the primary factors causing the change, wave climate is responsible for the nearshore processes of waves and currents that steer the local sediment transport and consequently control the site-specific coastal configuration (Trenhaile 1997).

Ocean Beach-Dune Ecosystem Model

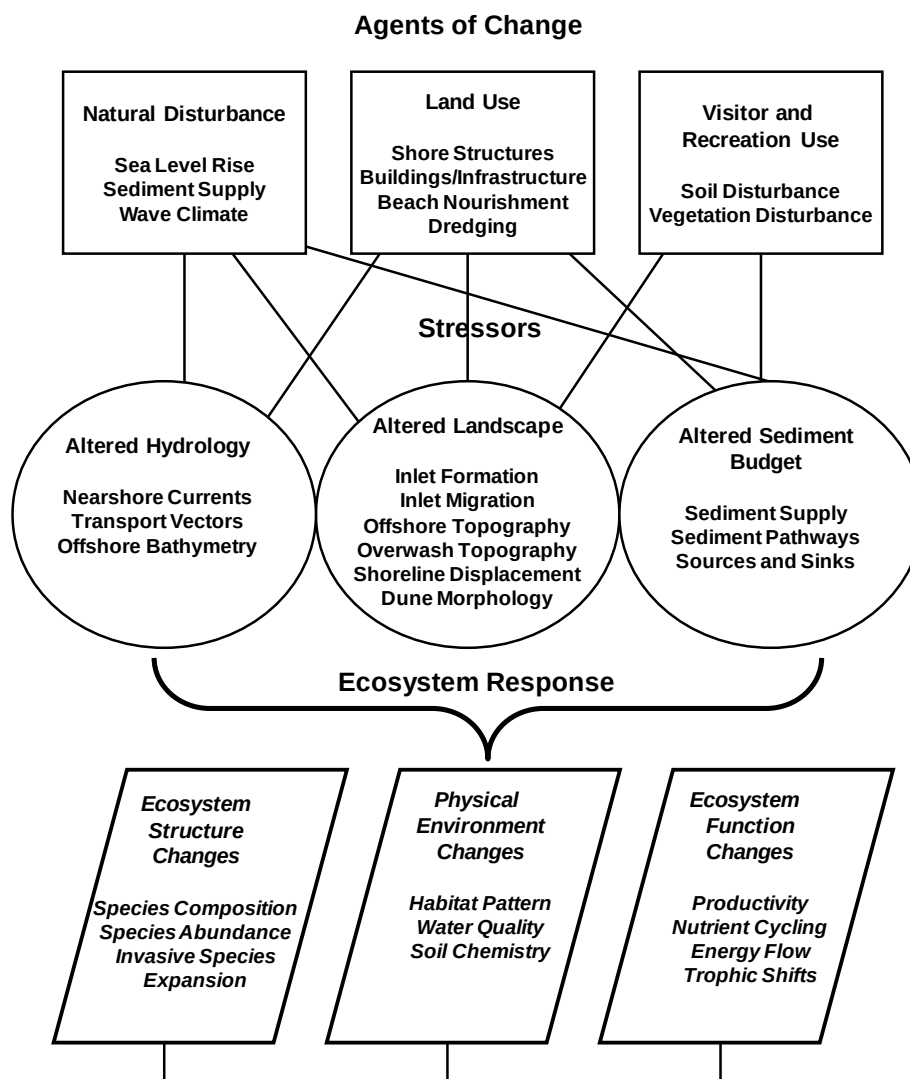


Figure 2. The Ocean Beach-Dune Ecosystem Model illustrates the relationships amongst the agents of change, stressors, and ecosystem response (after Roman and Barrett 1999).

Local conditions such as the underlying geologic framework, bathymetry, offshore topography, and sediment sources and sinks interact with the primary factors and the coastal processes to influence the characteristics and the rates and direction of the coastal system alterations (Carter 1988; Honeycutt and Krantz 2003). In addition to natural causes, coastal changes are often accelerated by human-produced perturbations such as dredging and channel relocation, groins and jetties, and beach and dune manipulation (Walker 1990; Nordstrom 2000). These human influences can cause alterations to waves, currents, and availability and mobility of sediment. The combinations of natural processes and anthropogenic modifications interact to cause significant morphological change affecting cultural and natural resources. Particularly, displacement of the coastal topography as well as changes in the width and/or volume of the beach may result in the destruction of cultural resources, facilities, and other infrastructure (Stevens et al. 2005).

Coastal ecosystem response may consist of adjustments to resource patterns and dynamics, and may eventually lead to the loss of fixed natural resources (Roman and Nordstrom 1988). These responses often elicit secondary changes in ecosystem structure or function. Structural changes in species composition or competitive interactions generally reflect landscape-level alterations in the quantity and quality of specific habitats. Similarly, functional changes in productivity or nutrient cycling may occur as a product of storm events and the associated reduction in habitat complexity. More subtle physical changes also include alterations in geo-chemical and hydrological conditions, such as groundwater quality and quantity. The magnitude and scope of the resultant coastal ecosystem response is complex, highly variable, and can often be cumulative. At the extreme, this includes the alteration of habitats and of core ecosystem processes. For example, erosion of an existing coast may create new aquatic habitat, or overwash fans may fill in a wetland environment to create new terrestrial habitat.

The Process of Evaluating Vital Signs

Geomorphological change is important to the evolution of the coastal ecosystem, and in some cases, when it affects natural and cultural resources, recreational features, and facilities or infrastructure, the change presents complex challenges to park management. In order to address the full range of scientific and management concerns, multiple scoping workshops were convened to identify issues of general importance and to make specific recommendations for monitoring. Throughout the scoping process, the lack of adequate data to track and respond to geomorphological change was consistently identified as a high priority management issue.

Demonstrating the complexity of the coastal geomorphological process, twenty-nine potential monitoring variables (vital signs) of geomorphological change were identified by the workshops (NPS NCBN 2003). The indicators were evaluated and ranked for data value and feasibility of implementation at the Network level, and shoreline position and elements of the coastal topography were consistently identified as of high information value and capable of monitoring with existing methods (Table 1).

Table 1. The fourteen Vital Signs identified during the Northeast Coastal and Barrier Network

Geomorphological Change	Vital Sign	Monitoring Methods	Feasibility	Data Value
Shoreline Position	Shoreline position	1D & 2D GPS, 2D & 3D Survey, Aerial Photography, LIDAR	high	high
Coastal Topography	Dune, beach, bluff, bluff morphology	LIDAR, Aerial Photography, 2D & 3D Survey	high	high
	Edge of vegetation	LIDAR, 1D, 2D GPS, Aerial Photography	high	high
	Landcover	LIDAR, 2D & 3D Survey	high	high
	Overwash fans/flood plains	LIDAR, 1D & 2D GPS, 2D & 3D Survey, Aerial Photography	medium	high
	Shore type	Aerial Photography, 2D & 3D GPS, 2D & 3D Survey	medium	medium
Anthropogenic Modifications	Locations of structures and disturbances	Aerial Photography, 1D & 2D GPS, 2D & 3D Survey	medium	high
Marine Geomorphology	Sediment quantity Sediment size	Terrestrial and Marine Sediment Samples	medium	medium
	Geologic framework	Acoustic Survey, Seismic Survey, Core Samples	low	high
	Depths	Acoustic Survey, Bathymetric LIDAR, Sled survey	low	medium
	Migrating shoals & bodies	Acoustic Survey, Bathymetric LIDAR	low	high
Marine Hydrography	Tide range	Local & Regional Tide Gauge	high	high
	Relative sea level position	Water Level Gauge	high	high
	Wave and current characteristics	Local Gauge -Regional Gauge	low	high

Geomorphological Change Workshops; they are ranked for data value and feasibility of implementation at the Network level (NPS NCBN 2003).

The Components of Coastal Topography

Detailed knowledge of the hydrodynamic forcing of sediment mobilization, transport, and deposition, and measurements of morphologic change and ecosystem response at the park level are key to understanding the coastal geomorphology of the NCBN parks (Allen 2000). Coastal topography is a response of the system that can be effectively measured and monitored, providing high value datasets across time and space that can be used to address park management issues.

The beach is an accumulation of unconsolidated material that is being transported and redistributed in response to the hydrodynamic forcing agents (Short 1999). The result is a process/response interaction that extends from the dune area, across the exposed beach and into the water out to a depth where little or no sediment is being transported (Komar 1998). Depending on the direction of the waves reaching the beach, sediment can be transported both across the beach (cross-shore) as well as along the coast (alongshore), resulting in a complex littoral transport system and a variety of beach morphologies (Fig. 3).



Figure 3. Aerial view of Fire Island National Seashore, showing the shoreline variation due to the alongshore and cross-shore sediment transport acting upon the coast. Photo by Dr. James R. Allen (September 1988)

Components of the Coastal Profile

The major beach features develop parallel to the shore over large areal expanses (Fig. 3). Beach profiles illustrate these major features by providing shore-normal cross-sections or beach profiles (Fig. 4). The portion of the beach that is permanently underwater is mainly acted upon by the waves and currents. This area is usually flat with the presence of one or more submerged bars. The intertidal portion of the beach is known as the beach face. This is the sloping part of the beach that is subjected to the periodic incursion of the water by the tides, and is acted upon by the currents and waves, and their wash and backwash processes. The area above the effect of the tide is the subaerial portion of the beach, which includes the presence of berms and dune or bluff features, and is only affected by waves during extreme storm events.

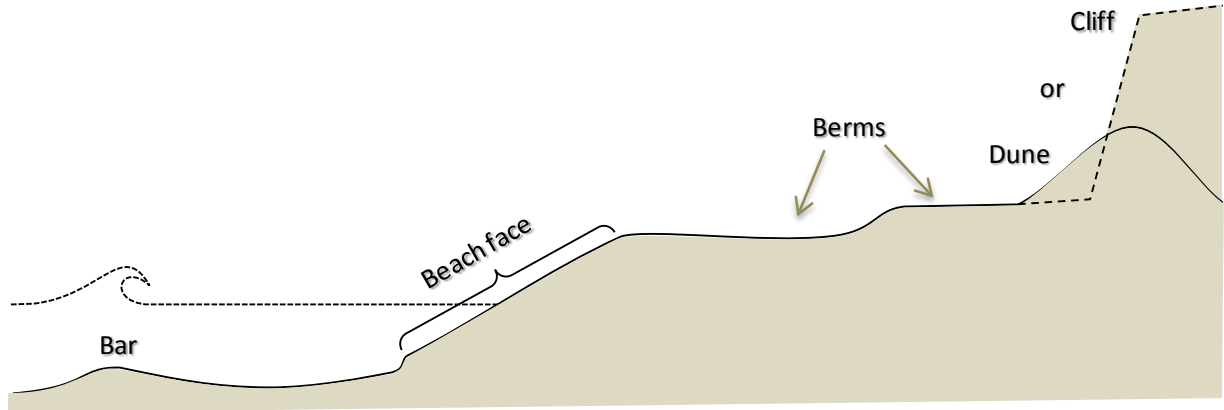


Figure 4. Beach-dune-bluff profile morphology.

The different portions of the beach have different dynamics, because they are subjected to different processes at different time-scales. These differences are represented by the morphological features present in each portion of the beach. The areas that are constantly or intermittently submerged are the most variable portions of the beach, because they are acted upon by waves and currents. The ocean shoreline position (subject of the first part of this protocol) reflects the changes occurring at the beach face level. The beach face width and slope change in response to the high-frequency tidal-cycle oscillations as well as to the episodic storm events. The subaerial area, on the other hand, is less changeable and the major changes of the landscape features, such as the berms, dunes, and bluffs, respond to lower-frequency events and embody the longer-term evolution in coastal morphology.

Major Geomorphological Features

The overall morphology of the beach is a product of the physical processes of waves, winds, and currents acting upon the beach, the composition of its sediments, and the sediment transport vectors that occur (Komar 1998). In response to the characteristics of the waves, the local physical settings and the sediment type and availability, the beaches will exhibit different morphologies and features, as well as different spatial magnitudes. Thus, the dimensions and form of the major geomorphological features provide a direct measure of the coastal system condition and trends. The major geomorphological beach features that will be monitored through this protocol are:

- Beach face - the beach face corresponds to the sloping intertidal portion of the beach profile. It is a highly dynamic feature that changes with the variation in wave conditions, with the sediment size, and the water levels. In general, the slope of the beach face is a measure of the wave energy. Storm conditions will flatten the beach face, whereas calmer wave conditions will promote a steeper one.
- Beach berm - the beach berm is the nearly horizontal portion of the beach that lies above the mean high tide elevation, and therefore is only acted upon by the highest waves that reach above that elevation. Some beaches have more than one beach berm (incorporating a storm berm), and some beaches have no berm. Its width varies with the amount of

sediment available to the beach-dune system. The berm will widen if onshore sediment transport is dominant (usually during milder wave activity), and will narrow if offshore sediment transport is dominant (usually during storms).

- **Foredune** - the foredune is a shore-parallel sand ridge that is located immediately inland of the beach berm. It develops where pioneer vegetation traps the sand that is transported inland from the beach berm and beach face, primarily by wind action. Foredunes are sites of sediment accumulation and storage, and their position, height, width, and volume are measures of the amount of sediment available to the overall beach system. The foredune is the least variable feature of the beach profile, and its characteristics and position are altered primarily under extreme events when waves reach above the beach berm. Its position in the beach profile is much more conservative than any other feature, therefore its variation is a measure of the longer-term coastal evolution.
- **Bluff** – bluffs exist along coasts that consist of bare rock, consolidated sediment, or unconsolidated sediment, and that are retreating under the attack of waves. The marine erosion produces a vertical face that may or not be separated from the surf by a narrow beach. The rates of retreat depend on the composition and resistance of the bluff material, and bluff of unconsolidated sediments show the most rapid erosion. Extreme wave action during storms promotes undercutting of the bluff and subsequent landslides and slumping. In other cases, landslides may be caused by other processes (e.g. rainfall, faults), and waves transport the accumulated debris at the base of the bluff. Bluff recession is episodic and often shows high spatial variability.

Sediment Budget

Sediment budget is a very important variable in the maintenance of coastal morphology and the dynamics of sediment transfers in the beach-dune sand-sharing system (Psuty and Silveira, 2010). For a beach to be maintained in place, the sources of sediment must be equal to the losses through a specified time, corresponding to a balanced sediment budget. Accretional coastal features are associated with a positive sediment budget, whereas erosional coastal features occur with a negative sediment budget.

Accretional coastal features

If the quantities of sediment input are greater than the losses, then the sediment budget is positive, the shoreline will be displaced seaward, the beach berm will widen and create space for a new foredune to establish. A positive sediment budget will promote a wide beach profile, with topographical features that reflect the accretionary trend of that area: a wide beach berm and well-developed multiple dune ridges (Fig. 5). This is the case of the beaches at the downdrift ends of the parks where sediment is being accumulated, such as the beaches at the western end of Breezy Point (GATE), or the beaches in areas of positive sediment input at Assateague Island.

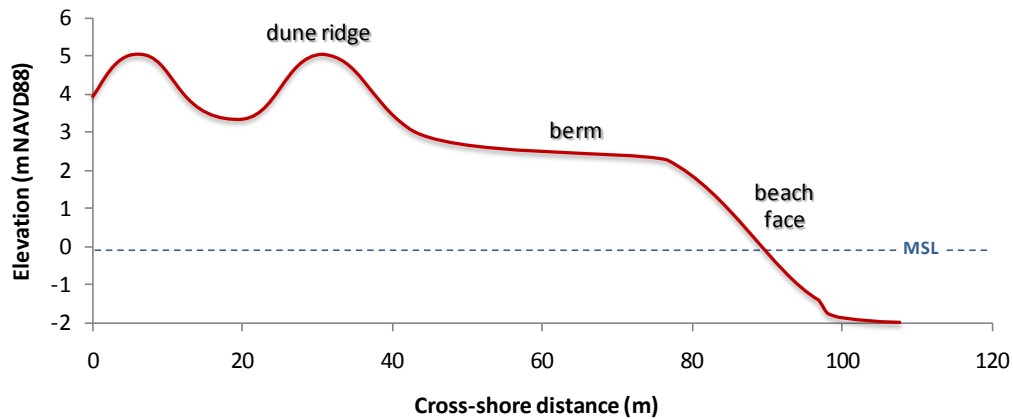


Figure 5. Typical beach profile associated with a positive sediment budget, incorporating multiple dune ridges and wide beach berm.

Erosional coastal features

If sediment input is less than the losses, then there is a negative sediment budget and the shoreline and beach-dune morphology will be displaced inland. Under a situation of negative sediment budget, a net inland displacement of the beach-dune system will occur and the topography of the beach will retain its dimensions and features while shifting in space (Psuty and Silveira 2010). However, the existence of accommodation space is necessary for this inland migration and morphological evolution to occur. The lack of accommodation space under a negative budget scenario will result in losses of dimension and form, with narrow beaches having little or no space for dune development. In some cases, an extreme negative sediment budget scenario may result in coastal bluffs (Fig. 6). This is the case of the beaches that constitute the central part of Cape Cod, and of the beaches at the eastern end of the Great Kills Park (GATE).

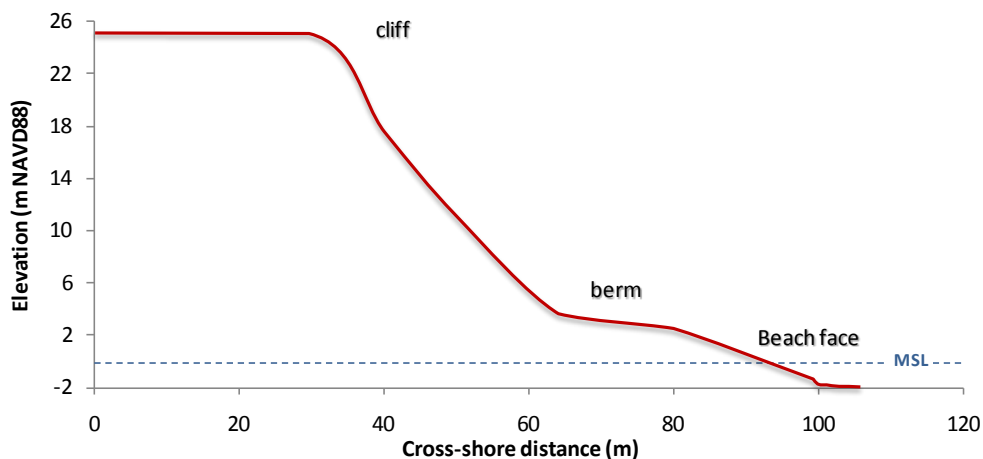


Figure 6. Typical beach profile at a coastal bluff, where the deficit of incoming sediment promotes a very narrow beach and the presence of a retreating bluff.

Geotemporal Elements of Sediment Budget

Early recognition of the importance of sediment input is seen in the coastal classification of Valentin (1952) that describes geomorphological outcomes related to sediment budget in a spatial context. The theme of temporal variation in morphological evolution is added by Bloom (1965) with the incorporation of sea-level rise as another factor influencing the creation of topographical components at the local and regional scales. As described in Finkl (2004), the combination of spatial (alongshore) and temporal variables associated with sediment supply and sediment budget drive the evolution of coastal topography. This geotemporal relationship is at the core of periodic monitoring because measurements of topography depict the outcomes of sediment budget at a site and permit a comparison of alongshore sites. It is the combination of vectors of change in the spatial and temporal context (geospatial) that fuels the 2-D monitoring program and brings the sequence of process-response geomorphological features to the fore.

In areas of variable sediment supply, there will be an alongshore variation in the characteristics of the coastal topography and the beach-dune system. These transitions are usually easily identified, and can be grouped into geomorphological units with similar beach profile dimensions and forms. Variations in the wave regime (direction and height) acting upon and along the coast, presence of inlets or headlands, as well as the presence of engineered structures such as jetties and groins, influence the alongshore sediment pathway and may be used to identify these geomorphological units (Fig. 7). In the case of Cape Cod National Seashore, the nature of the substrate, the variation in wave regime and sediment supply results in at least three units that undergo changes at different scales and frequencies. The central part of Cape Cod consists of high bluffs, whereas the southern and northern ends of Cape Cod are low-lying coasts composed of dune and beach systems (Fig. 8). Gateway National Recreation Area is a fairly large geographical area with considerable variety in processes and forms. The cultural manipulation of the sediment supply and the resulting spatial variation in sediment budget cause the existence of a variety of geomorphological units defined by updrift erosion and consequent downdrift accumulation (Psuty et al. 2010).



Figure 7. Groin between the Neponsit & Belle Harbor communities and Jacob Riis Park (GATE), causing sediment accumulation on the updrift side and erosion and inland beach displacement on the downdrift side. Aerial image accessed February 2010 at bing.com/maps/



Figure 8. Aerial view of a portion of Cape Cod National Seashore, at the northern margin of Nauset Bay, showing the alongshore variation and transition between two very different geomorphological units, the sand barrier and marshland to the south, and the bluffs to the north. Aerial image accessed February 2010 at bing.com/maps/

Monitoring Objectives

Ultimately, a full understanding of how the beach morphology is changing over time, and at each given location, depends on our knowledge of the processes of cross-shore and alongshore sediment transport. The sediment input from one stretch of shore to the next and the sediment exchanges within the beach-dune or beach-bluff system create localized suites of resulting coastal features that can be measured and characterized through the acquisition of beach profiles. The collection of beach profiles provides a cross-shore visualization of the beach topography, generating information on the two-dimensional aspect of the morphological components: form, elevation, and extent. The systematic collection of beach profiles at specific locations, and related to established field benchmarks, fosters the analysis of these morphological features through time and space.

The wide range of physical settings along the NCBN parks results in a variety of different typical beach profiles between, and even within, parks. Different morphologies at different elevations may be found depending on exposure to waves, sediment availability, presence of human manipulations and structures, etc. Throughout the spectrum of environmental conditions and the beach morphodynamic states found along the parks, there are a number of coastal features that can be measured and compared through time, resulting in a characterization of the coastal topography and its evolution through time (seasonal and long term) as well as space (alongshore comparison) (Short and Trembanis 2004; Ruggiero et al. 2005). The key diagnostic topographical features of beach profiles include the dune or bluff, the beach berm, and the beach face.

Understanding the dynamics of changes in these features over time, through standardized data collection, will provide a scientific basis for informed resource management (National Research Council 1995). Many of the NCBN parks currently monitor their coastal topography and have great historical datasets that can be used for long-term comparison to support decisions on infrastructure protection as well as resource management (e.g. Psuty and Pace 2009; Rogers et al. 2009; Rodriguez 2004). The assemblage of reliable and consistent data enables robust statistical analysis, yielding a better understanding of episodes, cycles, and trends (Colwell and Thom 1994; Dolan and Hayden 1983).

Monitoring coastal topography on a park-wide scale provides knowledge of the spatial and temporal variation in sediment transfers and sediment budget and creates a fundamental database for use in park management. The collection of coastal topography data twice a year, in the early spring (the fully developed winter beach) and the early fall (the fully developed summer beach) leads to the accumulation of a time series of seasonal beach states that represent the annual theoretical maximum and minimum configurations of the beach-dune profile. Each annual dataset portrays the magnitude of variation caused by the changes in the seasonal wave climate acting on the beach sediment supply. Monitoring of the seasonal variation contributes an understanding of the range of changes that occur in the morphology and the positive and negative displacements that relate to the contrast of higher energy and lower energy conditions. Additionally, seasonal contrasts offer a dimension of the range of changes that are not available at the annual scale. Longer-term comparisons of beach topography reveal changes created by differences in sediment availability and intensity of formational processes. Furthermore, the creation of a spatial network of beach profiles distributed along the park's shoreline provides

information on the alongshore variation, and characterization of the Park's geomorphological units.

The objective of the NCBN coastal topography monitoring protocol is to identify the seasonal, annual, and long-term (five-years or more of protocol-derived data sets) trends and variability in time and space of beach/dune/bluff morphology in the Network parks. Meeting this objective will address the following questions:

- What are the seasonal dimensions of the coastal features?
- What are the annual dimensions of the coastal features?
- What are the long-term, five years or more, dimensions of the coastal features?
- What are the directional displacements of the coastal features?
- What are the spatial and temporal trends in the displacement of the coastal features?

Accomplishing the objective of this protocol requires the following steps:

1. Standardization of the survey methodology
2. Design and construction of the database
3. Reporting of the assembled data
4. Scientific analysis and interpretation

Measuring Coastal Topography

Measurement of coastal topography is accomplished through the collection of topographical data along beach profiles that extend perpendicular to the shoreline. A matrix of geo-referenced control points provides the mechanism for the systematic tracking of the variations of the beach profile, and standard state-of-the-art practices of surveying are used to assure consistency in data collection. The systematic and repeated collection of topographical data starting at fixed location (benchmarks) and along pre-defined profile lines allows for tracking of the long-term variation of the beach/dune/bluff morphology.

Basics of Topography

Acquisition of topographical data involves measurements of the earth's surface in its spatial location, as well as its elevation. The spatial location is measured in terms of coordinates - distances from a starting point measured along two axes: longitude and latitude, also known as easting and northing, or X and Y (Fig. 9). The elevation component adds the third dimension, known as Z, needed to portray the 3-dimensional aspect of the earth's surface.

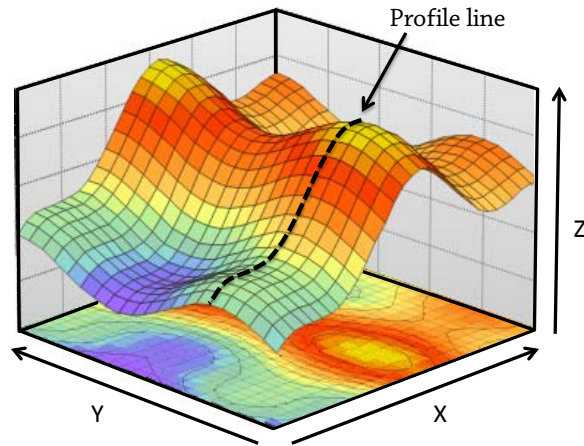


Figure 9. Three-dimensional characteristics of the coastal topography.

For the purpose of the present protocol, easting and northing are measured in meters relative to the Universal Transverse Mercator (UTM) projection and grid system. All the parks of the Northeast Coastal and Barrier Network are located in Zone 18 North, except for Cape Cod, which is located on Zone 19 North. The North American Datum of 1983 (NAD83 (CORS96)) is the horizontal datum applied. [**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 will occur depending on location and will produce offsets in horizontal and vertical coordinates. The current geodetic datum used for this protocol is NAD83 (CORS 96) (2002.0). In April 2012 there will be an update released for the current NAD83 coordinate system. The new coordinate system will be NAD83 2011 (2010.0) and it will be accompanied by a new geoid model. 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 at: <http://www.ngs.noaa.gov/>.*]

The elevation is measured relative to a base elevation, known as a vertical datum. The North American Vertical Datum of 1988 (NAVD 88) is the most recent and most commonly used in the US. NAVD 88 is a fixed datum, determined by geodetic leveling, established relative to a specific zero point that does not change through time. Before NAVD88 was established in 1991, the National Geodetic Vertical Datum of 1929 (NGVD29) was the vertical control datum widely used in the US.

Another type of vertical datum is the tidal datum, expressed relative to a mean water level obtained from tide observations conducted through the National Ocean Service over a 19-year time period that includes all of the tidal variations caused by earth-sun-moon relationships and sea-level change, referred to as a National Tidal Datum Epoch. Tidal datums change with every tidal epoch, and the most common tidal datums used are listed and described in Table 2. An example of the relationship between the 1983-2001 tidal epoch tidal datums and the NAVD88

and NGVD29 geodetic datums are represented on a typical beach profile, using the tide gauge measurements at Sandy Hook, NJ (Fig. 10 and Table 3).

Table 2. Tidal datums as defined by the Center for Operational Oceanographic Products and Services (<http://tidesandcurrents.noaa.gov/>).

Tidal Datum		Description
MHHW	Mean Higher High Water	Average of the higher high water height of each tidal day observed over the Tidal Epoch
MHW	Mean High Water	Average of all the high water heights observed over the Tidal Epoch
MSL	Mean Sea Level	Arithmetic mean of hourly heights observed over the Tidal Epoch
MLW	Mean Low Water	Average of all the low water heights observed over the Tidal Epoch.
MLLW	Mean Lower Low Water	Average of the lower low water height of each tidal day observed over the Tidal Epoch.

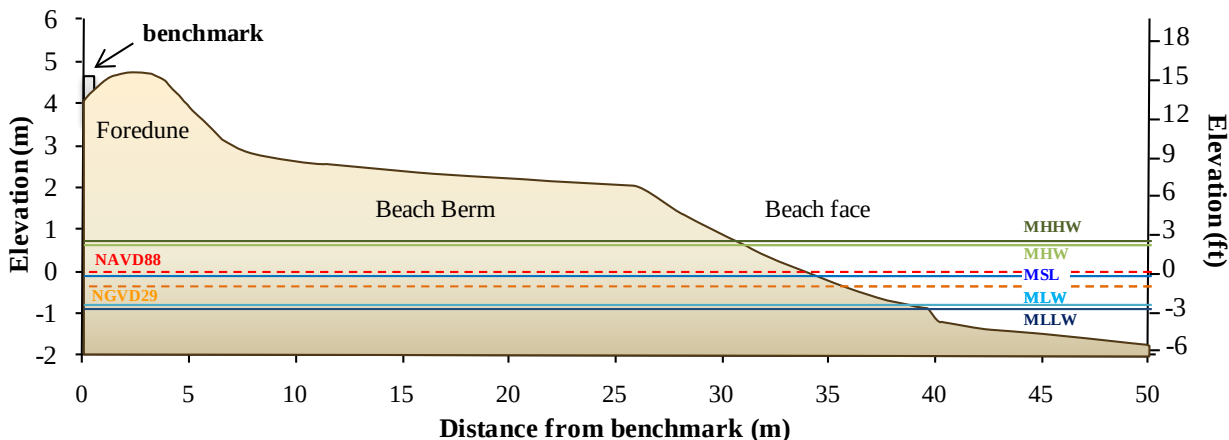


Figure 10. Typical beach profile showing the relationship between the 1983-2001 tidal epoch tidal datums, NGVD29 and NAVD88. (Source: NOAA tide gauge at Sandy Hook)

Table 3. Relationship of 1983-2001 Tidal Epoch water levels to NAVD88 and NGVD29. (Source: NOAA tide gauge at Sandy Hook)

Elevation of tidal datums and NGVD29 relative to NAVD88	Meters	Feet
Mean Higher High Water (MHHW)	0.734	2.41
Mean High Water (MHW)	0.634	2.08
North American Vertical Datum of 1988 (NAVD88)	0.00	0.00
Mean Sea Level (MSL)	-0.073	-0.23
National Geodetic Vertical Datum of 1929 (NGVD29)	-0.332	-1.09
Mean Low Water (MLW)	-0.800	-2.62
Mean Lower Low Water (MLLW)	-0.858	-2.81

Benchmarks

The rationale for collecting topography data along profile lines relies on creating a line that can be re-surveyed, thereby providing topographies that can be compared. No matter the method of data collection, the changes in elevation along the profile line can always be compared if the data are measured relative to the same control point.

Permanent structures, known as benchmarks or survey monuments, are used to mark the profile locations in the field, helping the surveyors re-locate and re-survey the same profile lines. Benchmarks are established to be permanent and long-lasting structures that provide a robust basis for long-term monitoring using this protocol. Therefore, they are established inland, far from the reach of the wave activity, usually behind the foredune or far from the bluff's edge.

Benchmarks may correspond to pre-existing structures, such as fire hydrants or corners of curbs, or they can be established by the surveyors. There are different types and ways of establishing survey monuments. The surveyor may use rods, wooden stakes, or PVC pipes driven into the ground to mark the location of the profiles lines. The most sophisticated are stamped metal disks set into concrete or rock, or attached to long stainless steel rods driven into the ground. These are typical of the benchmarks used by the National Geodetic Survey (NGS) and the US Army Corps of Engineers (USACE) (Fig. 11a). They usually exhibit their ID and date of installation. In areas of loose sand, where the marker could be easily buried, there is usually a sign (witness post) marking its location (Fig. 11b). Information on the NGS benchmarks (including description, coordinates and elevation, and directions to the benchmark) is available on the internet through an interactive map viewer at: <http://www.ngs.noaa.gov/ims/NgsMap2/viewer.htm>. Some of the USACE benchmarks information has been integrated into the NGS database.

Besides being used as monuments to mark the location of the profile lines surveyed for coastal topography analysis, some benchmarks may also be used as control points to establish the GPS-RTK base station. Benchmarks may also serve as high quality reference points and can be used to check for accuracy during surveys. Each park will have a network of profile benchmarks established along the shoreline, and a number of high-accuracy control benchmarks needed for Real-time Kinematic surveying (see SOP#2 - Establishment of Benchmarks, Transects and Geodatabase).



Figure 11. Examples of a) metal disks survey benchmarks and b) witness post label, established by USACE and NGS

Beach Profile Collection

Successive measurements of the elevations of the beach surface are taken along the pre-established profile line, at some distance interval, or whenever there is a change in the slope of the beach surface (Fig. 12). The measurements of XYZ points are then portrayed in terms of elevations of the beach surface along the extent of the profile, providing a cross-sectional representation of the beach, referred to as the beach profile (Fig. 12).

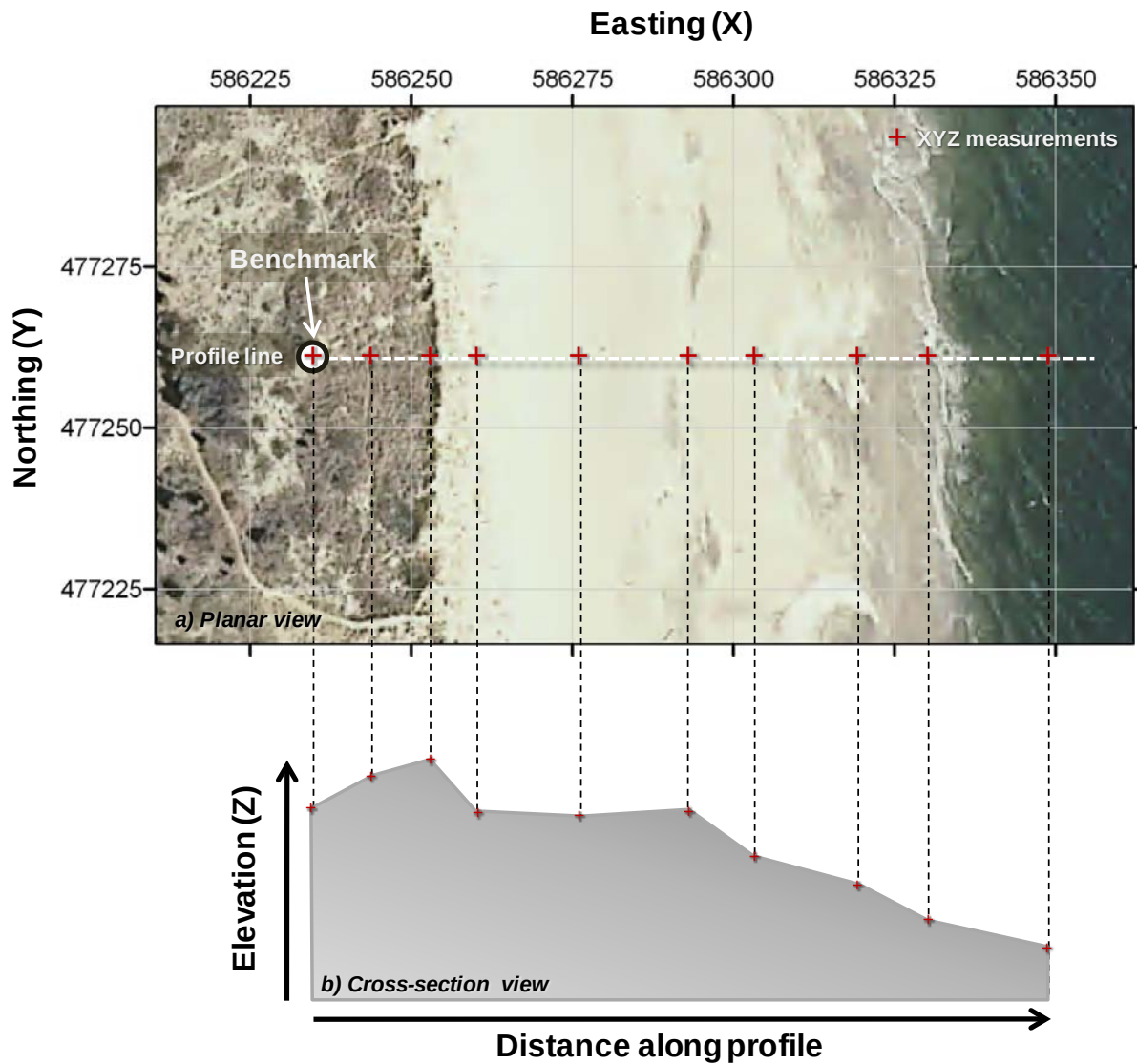


Figure 12. Collection of measurements of beach topography: a) planar view showing some of the XYZ measurements along a profile line perpendicular to the general trend of the shoreline, b) cross-section view of the collected data portrayed as elevations along the profile line.

Field Methods and Equipment

There are several types of field equipment used to collect beach profile topography. The simplest tools are the leveling techniques that involve a fixed initial reference point, with a known elevation, from which horizontal and vertical distances are measured. Some of the methods that involve this technique are the “hand level method”, the "horizon method" (Emery 1961), and the water level method (Andrade and Ferreira 2006). These tools are simple and easy to use, but are time consuming in their measurement and recording, and provide a maximum of 1-2 cm of accuracy in elevation change at each measured point, leading to accumulative error.

Other methods involve the use of optical techniques, and include the use of instruments (electronic or not) such as dumpy levels, automatic levels, theodolites and total stations (Ghilani and Wolf 2008). Electronic devices allow for data storage in data loggers, making it easier for field data gathering and processing. The total station is the most precise method to measure topography, providing XYZ data with accuracies on the order of millimeters over the length of a beach profile. The only limitation is that the method requires the total station to be established and maintained at a known point, and that it is always in line-of-sight of the reflecting prism.

The Global Positioning System (GPS) of topographical data acquisition is becoming increasingly important in geomorphological and morphodynamic studies (Baptista et al. 2008). GPS methods rely on the broadcast of signals from a constellation of 24 satellites that orbit around the Earth, controlled by a network of ground stations. Four satellites are sufficient to provide real-time XYZ positions to an accuracy that ranges from several meters to centimeters, depending on the equipment. The most sophisticated GPS equipment, referred to as survey grade or geodetic, can measure a position to within 1-2 cm in the horizontal dimension, and 2-4 cm in the vertical., and does not have the problem of accumulative error. Combined with a real-time kinematic (RTK) survey style that captures points in very short times and requires no post-processing, the GPS-RTK approach involves the use of two GPS receivers (base and rover) in constant radio communication between each other. The base receiver works as the reference station, established at a point with known coordinates and elevation, sending real-time corrections to the rover receiver as it occupies successive points along a profile. The rover can be used freely within a 20 km range from the base station, allowing for coverage of large areas for surveying. However, measurement accuracy drops approximately 1 cm per each 10 km distance from the base. Also, terrain, buildings, and tree canopy can obstruct the satellite signal and make it difficult for the GPS rover to acquire positions.

The most recent techniques for measuring coastal topography include airborne methods that collect a very dense grid of XYZ points acquired by LiDAR (Light Detection and Ranging) systems (Brock et al. 2002). LiDAR acquires data automatically from an airborne platform, and relies on an active sensory system that uses an infrared laser to measure distances to the ground, and to calculate positions and elevations. It provides for the collection of large topographical datasets over wide areas in a very short time period, but the elevation data have an accuracy of about 15 cm. LiDAR surveys are being acquired on a two-year interval for the NCBN parks, providing supplemental topographic datasets of the beach/dune systems in the network's ocean parks.

Geodetic GPS Unit

For the purpose of this protocol, which is directed to establishing seasonal and annual variation as its basic temporal consideration, the geodetic GPS unit was selected as the most suitable equipment and RTK as the survey style to collect coastal topography data (Fig. 13). RTK is preferred over the post-processing kinematic (PPK) style because it is one less step in the procedure and because it allows for a real-time quality check and accurate field data collection along pre-established profile lines. At present, the NCBN owns four complete survey grade GPS units (base + rover), described in Table 4.

The geodetic GPS equipment offers the best compromise between cost and quality of data provided. Although not as accurate as the total station, combining the GPS unit and the RTK survey style (hereafter referred to collectively as GPS-RTK) is a very time-efficient method of topographic data collection when compared with the other ground survey methods. It is less expensive and allows for better temporal programmability when compared to LiDAR. The equipment is highly portable, and the survey method allows access to remote areas without much constraint. The level of accuracy attained with the GPS-RTK approach is adequate for the analysis that is performed on the topographical datasets, because variations of the beach surface and volumes at a seasonal scale are on the order of meters. Furthermore, the GPS field survey controller (a handheld field computer) allows for easy data collection and storage and provides the advantage of displaying results in real time. Importantly, the controller can display background layer files with the location of the benchmarks and profile lines, allowing field verification crucial to the field data collection in this protocol. Therefore, the combination of speed of conducting the survey, the real-time calculation and storage of highly accurate data points, and the field views and verification of the survey lines supports the GPS-RTK approach.

Table 4. Survey grade GPS units owned by the NCBN parks.

Park	Manufacturer	Model	Year	Receiver Type
ASIS	Trimble	R8 GNSS	2010	Base and Rover
GATE	Trimble	R8	2005	Base
	Trimble	R8	2005	Rover
	Trimble	R8 GNSS	2009	Base and Rover
CACO	Trimble	R8 GNSS	2009	Base and Rover
	Trimble	R8 GNSS	2009	Base and Rover



Figure 13. Trimble R8 GPS unit (base receiver on tripod, and rover receiver on pole) used for conducting topographical surveys at Gateway National Recreation Area (Sandy Hook, July 2006).

The RTK system can and should also be used to acquire survey-quality positions for benchmarks and control points in the field. The NGS Online Positioning User Service (OPUS: <http://www.ngs.noaa.gov/OPUS/>) provides free processing of GPS data files (measured according to guidelines) to provide coordinates that are highly accurate.

The RTK system offers a number of advantages because it can be set up and operated in a variety of ways, depending on the equipment and personnel available, the area to be covered, and the local constraints:

- Base + Rover setup: Uses one base station that is temporarily emplaced in the field at a known location and is sending corrections to the rover via a radio link. This setup is adequate to survey profiles within a 20 km distance radius from the base station. As the distance increases, the atmospheric conditions at the rover and base station will become increasingly different, resulting in a decrease in accuracy.
- Multiple Bases + Rover setup: Used when multiple base receivers are available, two (or more) reference stations can be established, each operating independently. This is useful for surveying large areas (>20 km distance radius from the base station), 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 profile lines at the same time, increasing the time efficiency of the data collection.

- Rover + cell phone correction: In the absence of a base receiver, or in cases where communication between rover and base is not possible (sometimes due to presence of obstacles), the user may communicate through a cell phone service provider to gain access to an external network of reference stations provided by the National Geodetic Survey (NGS), known as CORS network (Continuously Operating Reference Stations: <http://www.ngs.noaa.gov/CORS/cors-data.html>). In this case, the RTK correction is provided through the internet and accessed by the user via a cell phone connected to the rover in the field. This option has cell phone associated costs, and requires a plan with a carrier that supports the type of data connection that is necessary.

Additionally, a radio repeater may be setup and used to pick up the base station radio signal and broadcast the signal farther within the survey area. The NCBN parks have a number of TRIMMARK™ 3 radio modems that can be used for this purpose.

Monitoring Design

Establishment of the Spatial Monuments Network

This protocol focuses on the collection of profiles as a means to track and measure site specific and alongshore variability of the topographical changes within the Network's coastal parks (ASIS, CACO, FIIS, and GATE). Profiles are surveyed from an established network of benchmarks or monuments that have been created along the entire length of the ocean beach at each of the parks. The distribution of the monument sites was selected according to the following criteria:

- Representation of the park's geomorphological units
- Representation of areas of special concern
- Distribution and quality of previously-established monuments
- Evenly-spaced distribution
- Ease of access

Monitoring coastal topographies and their vectors of change is especially important in areas where cultural and natural resources are of special concern to the park. Further, an evenly-spaced distribution allows for an additional metric in the characterization of the overall coastal shoreline. Pre-existing monument networks established by the NPS or other institutions were analyzed and subjected to quality evaluation, such as confirmation of their location in the field and verification of their coordinates. Further, the incorporation of pre-existing benchmarks used for acquiring coastal topographical data extends the opportunity for comparison between the data acquired with this protocol and previously acquired topographical data. Whenever there is the need for installation of new survey monuments in the spatial network, the establishment should follow the guidelines and requirements described in SOP#2 - Establishment of Benchmarks, Transects, and Geodatabase. The new benchmarks' coordinates and elevations will be acquired with a RTK unit and will be registered to NAD83(CORS96) and NAVD88, in meters.

The information on the network of survey monuments within each park, including description of the locations and attributes of each survey benchmark, will be stored in GIS files available from the GIS specialist of each park, and from the NCBN data manager. Additionally, a field booklet will be created for each park with a brief description of each benchmark location, including aerial photos of the site, ground photos, and coordinates and elevation information. The storage of the data and creation of the field booklets are described in SOP#2 - Establishment of Benchmarks, Transects, and Geodatabase.

Each benchmark will have an associated profile line, along which the field measurements are collected (Fig.12). This line feature is established in the office and created using ESRI ArcGIS, and represents a line that starts at the benchmark and is directed towards the shoreline. The line is drawn orthogonal to the general trend of the shoreline and has an associated azimuth. The line features will be stored in GIS files associated with the benchmarks files, and will be included in the field booklet. The guidelines and procedures to create and store the profile lines are described in SOP#2 - Establishment of Benchmarks, Transects, and Geodatabase. Shoreline trend lines have been established for GATE, FIIS, CACO, and ASIS in the protocol for monitoring shoreline change (Psuty, et al., 2010a).

The Spatial Monuments Network established for each of the NCBN parks, and the associated Database produced by the Coastal Topography Protocol will have specific nomenclature according to the park's name (Table 5). Specifically for Gateway National Recreation Area, the park will be divided into Sections that correspond to different geographical locations for the purpose of this Protocol (Table 5).

Table 5. 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
		Great Kills	GATE_SIU_GK
	Staten Island Unit	Miller Field	GATE_SIU_MF
		Fort Wadsworth	GATE_SIU_FW
	Jamaica Bay Unit	Breezy Point	GATE_JBU_BP
		Plumb Beach	GATE_JBU_PB
FIIS			FIIS

The following is a description of the Spatial Monuments Network established for each of the NCBN parks:

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 profiles consists of 23 monuments spaced at 1 km intervals on the North End of the park and at 2 km intervals for the remainder of the Maryland coast. There are no profile transects in the Virginia section of Assateague Island in this program. The higher number of transects at the northern end of the island is related to the ongoing North End Restoration project, and the effects of nearshore dredging.

The network of 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 RTK survey equipment to verify their documented geographical coordinates.

The 23 profile lines have a constant azimuth of 111° defining the direction of data collection, roughly perpendicularly to the ocean shoreline. Some profile surveys cover the entire surface from oceanside to bayside. In these cases, the 291° azimuth defines the profile line starting at the benchmark and directed towards the bayside.

The pre-existing network of monuments and 23 profile lines at Assateague are maintained and used for application of the present protocol (Fig. 14).

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 Dr. Graham Giese of the Provincetown Center for Coastal Studies to resurvey 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 benchmarks and take advantage a historical topographical dataset. From this dataset, a network of 22 monuments locations is proposed to be used for the application of the present protocol (Fig. 15), although the verification and establishment of the monuments in the field has yet to be completely accomplished.

Gateway National Recreation Area

The network of monuments at Gateway's three units (Fig. 16) was established by the team of Dr. Norbert Psuty from Rutgers University for the purpose of applying this protocol. At the Sandy Hook Unit, some pre-existing benchmarks established as early as 1984 by Rutgers (Namikas 1992) to monitor areas of special interest along Sandy Hook were included in the network.

Sandy Hook Unit

The network of monuments at the Sandy Hook consists of 16 benchmarks spaced between 500 m to 1 km apart along the oceanside and bayside (Fig. 17). Some gaps in the bayside are due to the presence of seawalls. One of the benchmarks (SH9) is the starting point for two beach profile lines with different cross-shore orientations. Therefore, the total of surveyed profile lines is 17

Jamaica Bay Unit

The network of monuments at Jamaica Bay is divided into the Breezy Point section and the Plumb Beach section. Breezy Point has 11 benchmarks along the oceanside and bayside, with a gap of 2 km in the area of the Breezy Point Cooperative (Fig. 18). Plumb Beach's network consists of 5 benchmarks spaced between 200 and 400 m alongshore (Fig. 19).

Staten Island Unit

A total of 14 benchmarks were established at Staten Island: 9 in Great Kills Park, 2 at Miller Field, and 3 at Fort Wadsworth (Fig. 20).

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 an assessment of 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 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 new network of 38 monuments for the application of the present protocol (Fig. 21). The verification and establishment of the monuments in the field is yet to be done.



Figure 14. Spatial network of survey monuments and profile lines at Assateague Island National Seashore, MD.



Figure 15. Spatial network of survey monuments and profile lines at Cape Cod National Seashore, MA.

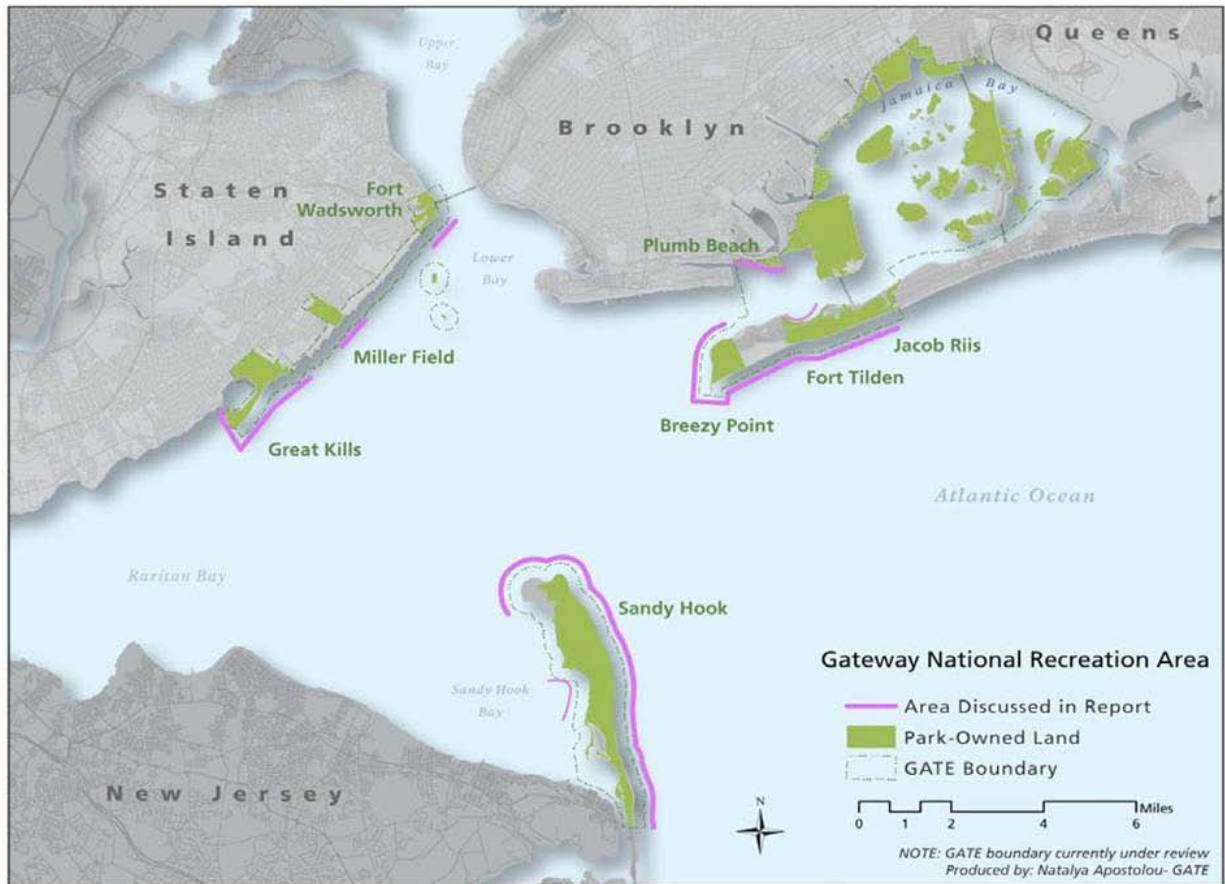


Figure 16. Location of the three Units of Gateway where benchmarks have been installed.



Figure 17. Spatial network of survey monuments and profile lines at the Sandy Hook Unit of Gateway National Recreation Area, NJ.



Figure 18. Spatial network of survey monuments and profile lines at Breezy Point, Jamaica Bay Unit of Gateway National Recreation Area, NY.

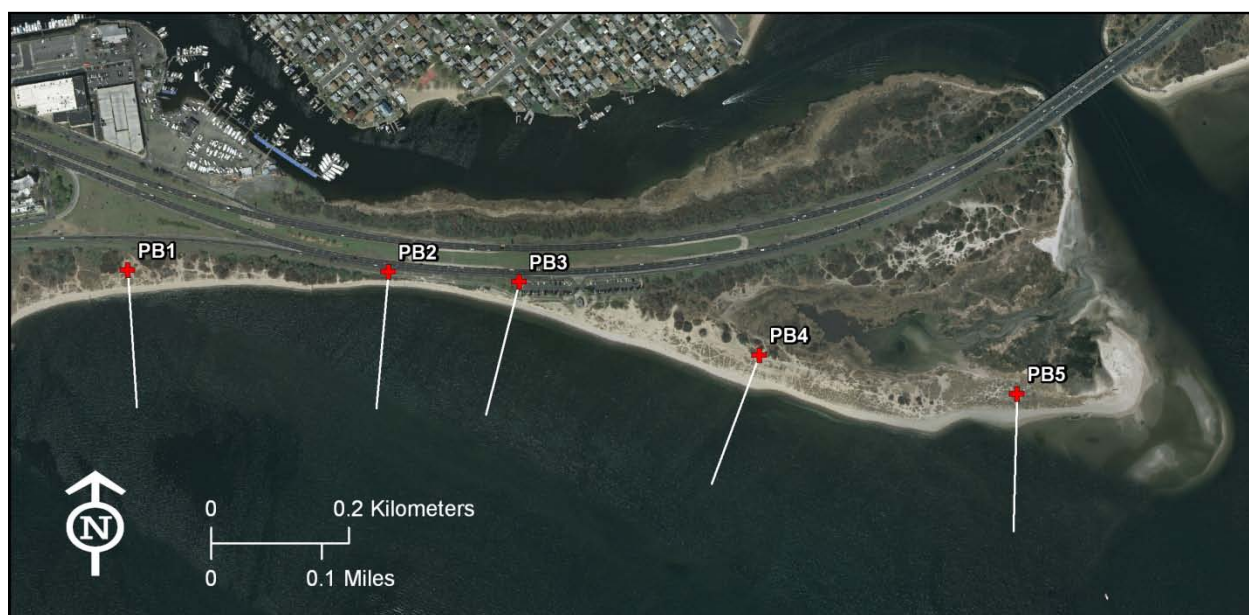


Figure 19. Spatial network of survey monuments and profile lines at Plumb Beach, Jamaica Bay Unit of Gateway National Recreation Area, NY.



Figure 20. Spatial network of survey monuments and profile lines at Great kills (GK), Miller Field (MF) and Fort Wadsworth (FW), Staten Island Unit of Gateway National Recreation Area, NY.

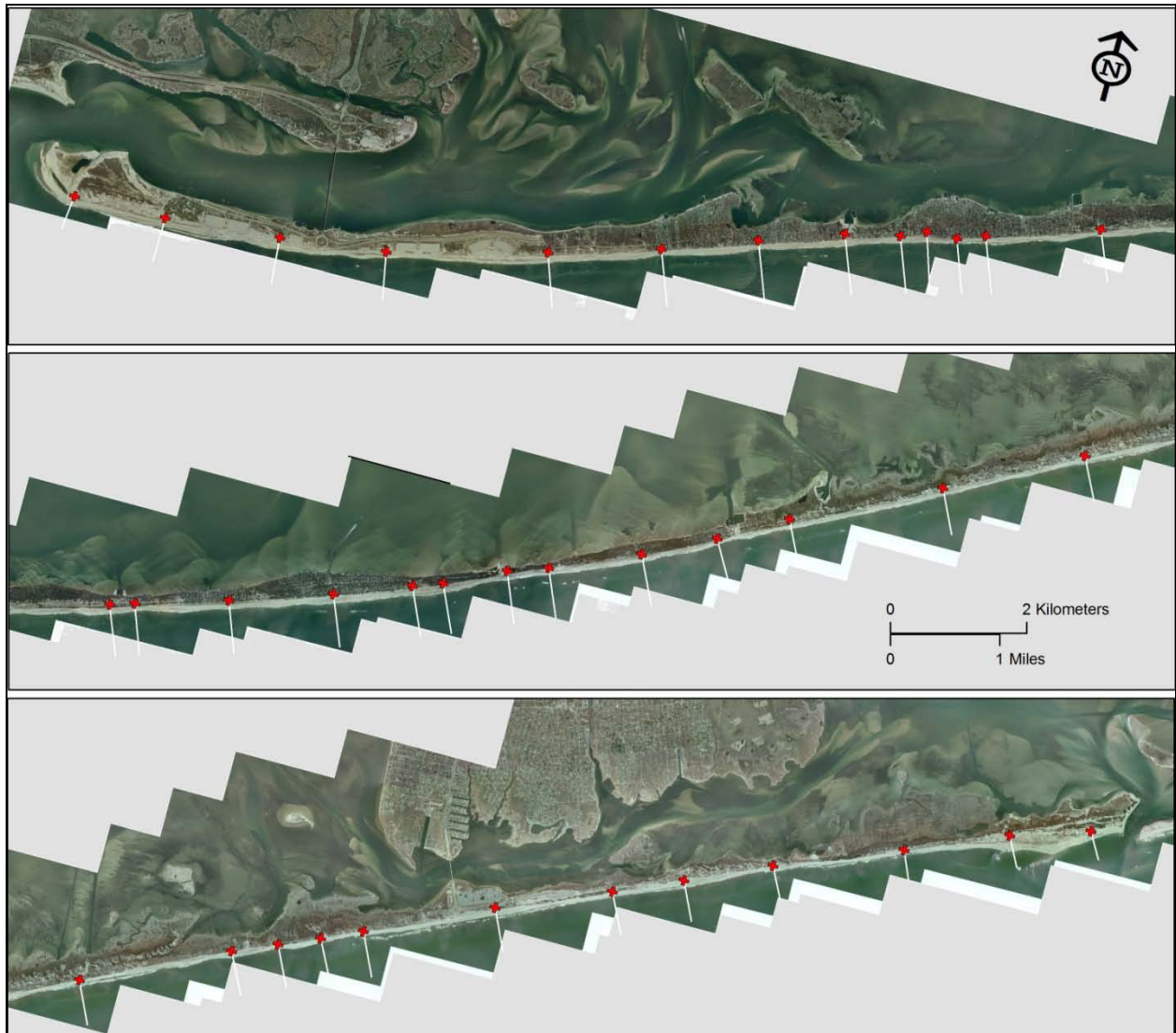


Figure 21. Spatial network of survey monuments and profile lines at Fire Island National Seashore, NY.

Survey Frequency and Timing

The morphology of the full beach-dune system profile changes with the seasonal variations in the wave-energy levels (Komar 1983). Commonly, winter storms produce higher and more energetic wave conditions leading to mobilization of the sediments in the beach face, berm, and dune, and promoting the transfer of the sediment to a high berm (storm berm) adjacent to the foredune and to the subaerial portion of the beach, which is stored in the form of sand bars. At an extreme condition, the high berm is completely eroded and the foredune base is scarped. This offshore transfer profile configuration is referred to as the winter profile (Fig. 22). During the summer, waves are smaller and less energetic, and the sediment is transported back to the intertidal and subaerial portions of the beach, leading to the widening of the beach berm and recovery of the dune. This profile configuration is referred to as the summer profile (Fig. 22).

Bluff coastlines behave in a different manner. Because they are inherently erosional coastal features, bluffs respond to seasonal variations in the wave-energy levels by retreating at different rates. Bluff recession is usually accelerated during winter when severe storms with higher wave energy impact the coast and promote scouring and slumping of the bluff face. The beach that may or may not exist at the base of the bluff will also change with the seasonal variability in the wave regime. The beach will be narrower during the winter and wider in the summer.

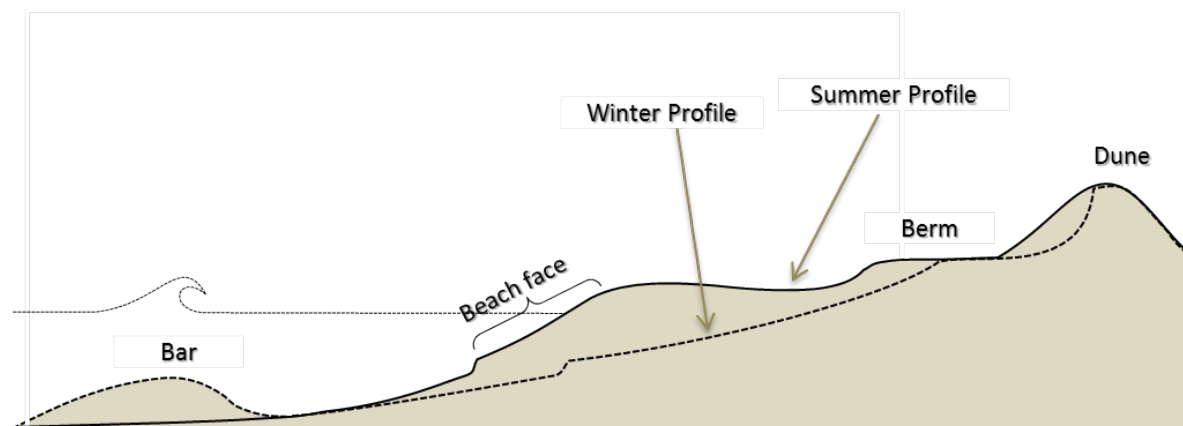


Figure 22. Changes in beach profile morphology, associated with seasonality of coastal energetics.

The configurations of the winter and summer profiles typically reach their peak expression around the end of the winter and summer seasons, respectively. Likewise, bluff retreat and beach loss is maximized around the end of the storm season. In order to track this seasonal variation, beach profile surveys will be conducted twice per year and timed to capture the general occurrence of the maximum seasonal (winter/summer) state. The winter profile will be surveyed in mid-March to late April and the summer profile in mid-September to late October (SOP#3 - Survey Timing and Mission Planning).

Field surveys are conducted around the lowest of the low tide levels that are reached during spring tides. Conducting the survey during this condition promotes maximum exposure of the beach profile, and provides the opportunity to collect more data during the span of time that the beach face is exposed. The survey should be accomplished during the 6 hours around low tide, 3 hours before and 3 hours after the predicted time of low tide.

The topographical survey should be conducted when minimum satellite availability and satellite geometry specifications are met (SOP#3 - Survey Timing and Mission Planning and SOP#4 - Settings for Collection of Topography). Timing of the surveys may also be affected by park specific issues such as the presence of species of concern or public activities that constrain the conducting of the topographical survey. Park management should always be consulted in advance when planning the survey. Details for timing and mission planning are provided in SOP#3 – Survey Timing and Mission Planning

The topographical surveys will provide information that describes the beach and dune characteristics and their seasonal variation (Fig. 22), as well as their alongshore spatial

variability. Further, supplemental beach profiles may also be measured after a major storm event, providing information on the magnitude of short-term variations of the beach (Forbes et al. 2004). This information can be of great value to both park managers and coastal scientists. The protocol can and should be applied in pre-and-post-storm beach profile surveys, whenever possible. Because numerous storms of varying intensity and duration are expected to affect a given park in a typical year, the decision of when to conduct these additional surveys is problematic. Local observation and judgment must be exercised in making the determination whether or not to conduct the supplemental surveys.

Field Methods

Field Season Preparations and Mission Planning

In the beginning of the year, the two seasonal survey windows should be identified according to the monitoring design (SOP#3 - Survey Timing and Mission Planning). Tide prediction tables from the "NOAA Tides and Currents" website should be consulted and a list of potential survey dates and times should be established and prioritized. Satellite availability and satellite geometry predictions, available from the Internet, should also be taken into account in the survey window selection. Once the survey windows have been identified, the field equipment should be committed on the NCBN's online GPS Scheduler.

Prior to the survey, the field team should check the field equipment to make sure all the items are working properly and that all batteries are charging (SOP#1 - Equipment and Supplies). All the survey background files (SOP#2 – Establishment of Benchmarks, Transects, and Database) must be uploaded into the field survey controller (SOP#4 - Settings for Collection of Topography). The field team must check the time of low tide for the days of the survey, and notify park personnel and neighbors of the activity (SOP#3 - Survey Timing and Mission Planning).

Conducting the Topographic Survey

Prior to the beginning of the survey, the GPS equipment must be set up to assure that the radio signal is being broadcast by the base station and received by the rover over the area being surveyed. Depending on the method used, more than one base station might have to be set up, or repeaters might have to be used to extend the range of the radio signal. Once the GPS system is configured and working, the surveyor, or team of surveyors (each with a rover GPS unit) will make use of the field booklet and the field survey controller to locate the benchmarks that mark the starting points of the profiles.

For quality-control purposes, the first measurement at the profile is of the benchmark location. The rover is then positioned on the profile line shown as a background file in the screen of the field survey controller. Data are collected with the GPS rover receiver along the pre-established profile line, starting at the benchmark and following the azimuth that is running perpendicular to the general trend of the shoreline. Point measurements (XYZ) are taken at some distance interval (no more than 5 meters), or whenever there is a change in the slope of the beach surface, and continuing seaward until at least the elevation of 0 m NAVD88, defining a position low on the beach face, is reached (the electronic equipment is not designed to be immersed).

In areas with bluffs, the survey may have to be divided into two parts. For ease of access and to take advantage of the low tide, the surveyor may have to survey the upper part of the bluff at one time, and then survey the beach area at the low tide time, producing an interrupted dataset of points for the same profile line. In this case, a specific nomenclature is used to ID the survey points (SOP#5 - Conducting the Survey).

At least one photograph is taken at each profile line to capture the general aspect of the dune/bluff feature present on the profile. Additional details are included in SOP#5 - Conducting the Survey.

Post-survey Data Download and Initial QA/QC

Immediately upon completion of the survey and return to the office, the survey job is downloaded from the field survey controller to a computer hard-drive and a backup copy created. The data should be retained on the field survey controller until quality checks can be made. The downloaded job is imported into the Trimble Business Center software (or similar) and the data are exported and converted into ESRI geodatabase feature classes. The profiles' data are plotted in ArcMap and the coordinates of the starting point at each profile line, as well as the general alignment between the collected points and the pre-established profile lines, are checked for accuracy assessment. Two auxiliary files representing benchmark and geodatabase (SOP#2 - Establishment of Benchmarks, Transects and Geodatabase).

The photographs are transferred into the computer and renamed to reflect the profile's ID and date of the survey to which they refer. The Field Data Form (FDF) is completed and reviewed. Following all of the quality control procedures and creation of metadata, the final dataset of the surveyed profiles (job files, TBC project, exported files, feature classes, FDFs, and photographs) will be sent to the NCBN data manager. Additional details are included in SOP#6 - Initial Post-Survey Processing.

Data Management

The NCBN Coastal Topography Monitoring Protocol generates a variety of data products that will be archived in a central MS Access database, overseen and controlled by the NCBN data manager (SOP#8 - Data Management). These datasets will be retrievable for broad-based usage and analysis. To better understand the structure of the archiving system and the type of information available, a User's Guide to the database has been produced that describes the elements of the data input and the categories of Coastal Topography data. The User's Guide also describes the procedures for retrieving information. Data storage and retrieval are vital elements of the NCBN shoreline monitoring effort.

Data Analysis and Reporting

Generation of Beach Profile Cross-section, and Calculation of Dimensional Parameters

The topographical data collected in the field in the form of coordinates and elevation (XYZ) will be portrayed as elevations of the beach surface along the extent of the profile, providing a cross-sectional representation of the beach (Fig. 12). SOP#7 - Data Analysis and Reporting describes the procedure for manipulating the profile data, and includes the step-by-step methodology for plotting and analyzing the beach profiles.

Construction of the profiles utilizes 2D Analyst, an Excel application created for this Protocol to generate the profile cross-sections and calculate the dimensional parameters of each profile. A step-by-step description is presented in SOP#7 on how to use 2D Analyst and derive the dimensional parameters according to the type of morphology present:

For beach profiles with foredune features:

- Cross-section area above NAVD88 = total area of the beach profile
- NAVD88 distance from Benchmark = measure of the beach width
- Foredune crest height
- Foredune crest distance from Benchmark

For beach profiles with bluff features:

- Cross-section area above NAVD88 = total area of the beach profile
- NAVD88 distance from Benchmark = measure of the beach width
- Bluff's edge elevation
- Bluff's edge distance from Benchmark

The measured parameters are stored in a data matrix for subsequent analysis. Optional metrics may be derived from the datasets using 2D Analyst, such as the Bluff base or Dune toe position and elevation, or the cross-section area of selected geomorphological features (e.g.: subaerial beach, dune, or bluff area).

Data Analysis and Reports

The dimensional parameters generated from the analysis of each beach profile will be compared and analyzed in a tabular and graphic portrayal, providing information about the temporal and spatial changes on beach morphology in the parks (SOP#7 - Data Analysis and Reporting).

A suite of summary statistics (mean, maximum, minimum, and standard deviation values) will be calculated for each of the parks and profiles, describing the dimensions of the change in the cross-section beach area, the NAVD88 contour position, and in the dune and bluff features. Site-specific patterns of accretion/erosion and migration of components of the profiles will be accessed through this cross-shore analysis.

The dimensions of change calculated for each profile will be compared spatially along the park to assess the alongshore variability of the beach morphology. The spatial relationship between profiles may be quantified and correlated to assess patterns of alongshore transport.

Annual reports will be produced to describe the seasonal changes as well as the year-to-year variations (SOP#7 - Data Analysis and Reporting). Longer-term reports will be produced at 5-year intervals to look at trends in the geo-temporal changes in the park (SOP#7 - Data Analysis and Reporting).

Personnel Requirements and Training

Roles and Responsibilities

The NCBN is responsible for the development and implementation of the protocol and has assigned a Network staff-person as project manager. The project manager is responsible for coordinating protocol development as well as an implementation plan and schedule that is suited to the needs of the individual Network parks. The project manager will work closely with Network parks and their designated cooperators to develop and implement this protocol.

The coastal topography protocol is designed to utilize local staff for field data collection. The data collection is improved through the use of personnel who have a basic understanding and working knowledge of the park and its resources. Because of their familiarity with its appearance, local personnel are much better situated to perform periodic observations of the beach. Their participation will thus greatly enhance accurate and consistent collection of data along the profile lines to reflect the major topographic beach features. The use of local staff also limits or prevents the problem of schedule overlap - where Network staff and cooperators might be expected to work in multiple parks at or around the same time. Consistent feature identification and measurement is important, and assignment of data collection to a single or small number of Network-trained observers is highly recommended.

The data management aspect of the monitoring effort is the shared responsibility of the field surveyor, the park and Network data managers, and the Network project manager. The field surveyor is responsible for field data collection, initial data download, and initial QA/QC. The field surveyor should work closely with the Network and/or park GIS specialist for additional post-processing, data verification and data validation, preliminary data editing, and export to the designated GIS format. The Network project manager is responsible for data documentation (metadata), data summary, and basic analysis and reporting. Ultimately, the NCBN geomorphological monitoring project manager has the responsibility to see that adequate QA/QC procedures are built into the database management system and that appropriate data handling procedures are followed.

Qualifications and Training

An essential component in the collection of coastal topography data is a knowledgeable, competent, and attentive field surveyor. The field surveyor must be able to identify the major topographic features along the beach profile, and to consistently collect points that will reflect and portray those features. The field surveyor should have:

- A basic understanding of coastal processes, and familiarity with the resource and appearance of the major coastal features
- Competence and experience in the operation of all equipment being used in the survey

The project manager needs to be knowledgeable in the data gathering methodology and is responsible for developing and delivering a training program to provide a scientific and technical foundation for consistent and accurate data collection by properly trained personnel at the park's level.

Frequency of the Training Sessions

Training shall be conducted prior to initial implementation of the protocol and thereafter at a minimum interval of once every two years, or as needed due to staff or procedural changes.

Target Audiences

The Network shall provide training for two persons at each park. This will establish a core of competent and qualified coastal topography surveyors with local knowledge. Training two persons per park also helps to reduce problems related to staffing or scheduling.

Training Syllabus

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

1. Basic Coastal Geomorphology:
 - a. Basic understanding of coastal process/response interaction
 - b. Fundamentals of cross-shore and alongshore profile development
2. Field Season Preparations and Mission Planning:
 - a. Seasonal timing, tides, and selection of the survey window
 - b. Network of survey monuments, establishment of benchmarks, creation of profile lines, creation of the QA/QC auxiliary files, and field booklets
 - c. GPS scheduling
3. Using the equipment and conducting the Survey
 - a. How to set-up the GPS equipment and start a job
 - b. How to follow the profile line in the field survey controller
 - c. How to ID and collect the points
 - d. Where to collect points
 - e. Where and how to take the field photographs
4. Post-survey processing
 - a. Filling out the Field Data Form
 - b. Data downloading and exporting
 - c. Data backup
 - e. Initial quality assurance/quality control (QA/QC)

Operational Requirements

Annual Workload and Field Schedule

Topographic surveys will be conducted in early spring (mid March to late April) and early fall (mid September to late October), a period that coincides with the peak expression of seasonal beach variability in the NCBN ocean parks. The unpredictability of extreme tide and weather events precludes the scheduling of surveys to specific annual dates.

The surveys require one person, although the survey could benefit from the use of one or more additional staff if qualified persons and the necessary equipment are available. Tide oscillation is a constraint to the acquisition of the data, limiting the daily survey time to the 6 hours around the predicted time of low tide. The NCBN parks will present different workloads because they have different spatial networks of monuments, with a different number of beach profiles to be surveyed. Additionally, site-specific constraints that have to do with access to the benchmarks will limit the number of profiles that can be surveyed in one day. For example, GATE's network of monuments covers six coastal areas spread throughout the three Units (Sandy Hook, Jamaica Bay, and Staten Island), which are between 10 and 70 km apart. In the case of CACO, the combined bluff and beach profiles cannot be surveyed continuously, requiring that the surveyor visits the same profile line twice. Equipment availability is also a constraint. The existence of only one base station limits the area that can be surveyed by the rover unit to a 20 km radius, and frequently to a shorter distance because of obstacles and/or absence of a powerful radio signal transmitter communicating with the receiver. Due to these potential constraints, additional base-station setup is required to cover the entire park's spatial network of profiles.

In general, it is estimated that one profile takes approximately 20-30 minutes to be surveyed (collection of points and photograph). Given the time to travel between benchmarks and additional equipment setup, it is estimated that 5-10 beach profiles can be surveyed in one day, depending on the park and the number of surveyors. Considering the spatial network of profiles established for each park, the estimated workload is as follows:

Assateague Island National Seashore:	1 GPS unit / 22 beach profiles	→ 5 days
Cape Cod National Seashore:	1 GPS unit / 20 beach profiles	→ 4 days
Fire Island National Seashore:	1 GPS unit / 38 beach profiles	→ 7 days
Gateway National Recreation Area:	2 GPS units / 46 beach profiles	→ 6 days

The pre- and post-survey workload is expected to be similar for all the parks. Survey preparations and mission planning should take one workday to accomplish, and post-processing should take two to three days.

Facility and Equipment Needs

The minimum equipment needed for the field survey consists of a GPS receiver, and a field survey controller. If two or more surveyors work simultaneously, field equipment requirements will increase accordingly. Should a park lack the proper equipment, the Network will attempt to arrange access to the items necessary to conduct the survey.

A computer and peripheral devices with appropriate ports and cables, RTK jobs processing software (e.g. Trimble Business Center) for download, initial QA/QC, and export to ESRI GIS format are required to complete the initial tasks. The GIS component consists of the ESRI ArcGIS software. Office computing needs and other equipment items are detailed in SOP #1 – Equipment and Supplies.

Procedure for Revising and Archiving Previous Versions of the Protocol

Over time, revisions to both the Protocol Narrative and to specific Standard Operating Procedures (SOPs) are to be expected. Complete documentation of changes to the protocol and a library of previous protocol versions are essential for maintaining consistency in data collection and for appropriate treatment of the data during data summary and analysis. The MS Access database for each monitoring component contains a field that identifies which version of the protocol was being used when the data were collected. The rationale for creating a narrative with supporting SOPs is based on the following:

- The Protocol Narrative is a general overview of the protocol that gives the history and justification for doing the work and an overview of the sampling methods, but it does not provide all of the procedural details. The Protocol Narrative will only be revised if major changes are made to the protocol.
- The SOPs, in contrast, are very specific step-by-step instructions for performing a given task. They are expected to be revised more frequently than the Protocol Narrative.
- When a SOP is revised, in most cases, it is not necessary to revise the Protocol Narrative to reflect the specific changes made to the SOP.
- All versions of the Protocol Narrative and SOPs will be archived in a Protocol Library.

The steps for changing the protocol (either the Protocol Narrative or the SOPs) are outlined in SOP #9 - Revising the Protocol. Each SOP contains a Revision History Log that should be filled out each time a SOP is modified to explain why the change was made, and to assign a new Version Number to the revised SOP. The project manager will be responsible for archiving the new version of the SOP and/or Protocol Narrative in the Long Term Ecological Monitoring Protocol Library.

Literature Cited

- Allen, J. R., 2000. Vital Signs of Northeast Coastal Park Resource Change: Shoreline Monitoring Group Report. National Park Service Internal Report.
- Andrade, F. and M. A. Ferreira. 2006. A simple method of measuring beach profiles. *Journal of Coastal Research*. 22(4):995-999.
- Baptista, P., L. Bastos, C. Bernardes, T. Cunha, and J. Dias. 2008. Monitoring sandy shores morphologies by DGPS - A practical tool to generate digital elevation models. *Journal of Coastal Research*. 24(6):1516-1528.
- Bird, E. C. F. 1985. Coastal Changes: A Global Review. John Wiley & Sons, London.
- Bloom, A. L. 1965. The explanatory description of coasts. *Zeitschrift für Geomorphologie*. NF 9:422-436.
- Brock, J. C., C. W. Wright, A. H. Sallenger, W. B. Krabill, and R. N. Swift. 2002. Basis and methods of NASA Airborne Topographic Mapper Lidar surveys for coastal studies. *Journal of Coastal Research*. 18(1):1-13.
- Carter, R.W.G., 1988. Coastal Environments: An Introduction to the Physical, Ecological and Cultural Systems of Coastlines. Academic Press, London, 617 p.
- Colwell, P. J. and B. G. Thom. 1994. Morphodynamics of coastal evolution. Pages 33–86 in: Carter, R. W. G. and C. D. Woodroffe, editors. Coastal Evolution: Late Quaternary Shoreline Morphodynamics. Cambridge University Press, Cambridge, United Kingdom.
- Davidson-Arnott, R. 2005. Conceptual model of the effects of sea level rise on sandy coasts. *Journal of Coastal Research*. 21(6):1166-1172.
- Dolan, R. and B. Hayden. 1983. Patterns and prediction of shoreline change. Pages 123–150 in: Komar, P. D., editor. Handbook of Coastal Processes and Erosion. CRC Press, Boca Raton, FL.
- Emery, K. O. 1961. A simple method of measuring beach profiles. *Limnology and Oceanography*. 6(1):90-93
- Finkl, C. W. 2004. Coastal classification: Systematic approaches to consider in the development of a comprehensive scheme. *Journal of Coastal Research*. 20(1):166-213.
- Forbes D. L., G. S. Parkes, G. K. Manson, and L. A. Ketch. 2004. Storms and shoreline retreat in the southern Gulf of St. Lawrence. *Marine Geology*. 210:169–204.
- Ghilani, C. D. and P. R. Wolf. 2008. Elementary surveying: An introduction to geomatics. 12th Edition. Pearson Prentice Hall, NJ.

Literature Cited (continued)

- Honeycutt, M. C. and D. E. Krantz. 2003. Influence of the geologic framework on spatial variability in long-term shoreline change, Cape Henlopen to Rehoboth Beach, Delaware. *Journal of Coastal Research*. Special Issue 38.
- IPCC. 2007a: Climate change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson, editors. Cambridge University Press, Cambridge, United Kingdom and New York, NY.
- IPCC. 2007b: Climate change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Avery, M. Tignor, and H. L. Miller, editors. Cambridge University Press, Cambridge, United Kingdom and New York, NY.
- Komar, P. D. Editor. 1983. Handbook of Coastal Processes and Erosion. CRC Press, Boca Raton, FL.
- Komar, P. D. 1998. Beach processes and sedimentation, Second Edition. Prentice Hall, Upper Saddle River, NJ.
- Morang, A. 2002. Atlantic Coast of New York Monitoring Program: Cross-shore Profiles, Quality-control Procedures, Monumentation and Data Archiving. TR-02-16. U.S. Army Corps of Engineers Coastal Hydraulics Laboratory, Vicksburg, MS.
- National Research Council. 1987. Responding to changes in sea level: Engineering implications. National Academy Press, Washington, D.C.
- National Research Council. 1995. Beach nourishment and protection. National Academy Press, Washington, D.C.
- Nicholls R. J., P. P. Wong, V. R. Burkett, J. O. Codignotto, J. E. Hay, R. F. McLean, S. Ragoonaden, C. D. Woodroffe. 2007. Coastal systems and low-lying areas. Pages 315-356 in: M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, C. E. Hanson, editors. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK.
- Nordstrom, K. F. 2000. Beaches and dunes of developed coasts. Cambridge University Press, Cambridge, UK.
- NPS NCBN - National Park Service Northeast Coastal and Barrier Network. 2003. Geomorphological Monitoring Workshops Report. NPS Internal Report.

Literature Cited (continued)

- Psuty, N. P. and D. D. Ofiara. 2002. Coastal hazard management: Lessons and future directions from New Jersey. Rutgers University Press, New Brunswick, NJ.
- Psuty, N. P., M. Duffy, J. F. Pace, D. E. Skidds, and T. M. Silveira. 2010a. Northeast Coastal and Barrier Network geomorphological monitoring protocol: part I—ocean shoreline position. Natural Resource Report NPS/NCBN/NRR —2010/185. National Park Service, Fort Collins, Colorado.
- Psuty, N. P. and J. P. Pace. 2009. Sediment management at Sandy Hook, NJ: An interaction of science and public policy. *Geomorphology*. 104:12-21.
- Psuty, N. P., P. Dennehy, T. Silveira, and N. Apostolou. 2010b. Coastal geomorphology of the ocean shoreline, Gateway National Recreation Area: Natural evolution and cultural modifications, a synthesis. Natural Resource Report NPS/NERO/NRR—2010/184. National Park Service, Fort Collins, CO.
- Psuty, N. P. and T.M. Silveira. 2010. Global climate change: An opportunity for coastal dunes? *Journal of Coastal Conservation*. 14(2):153-160.
- Rodriguez, A. H. 2004. Needs assessment, creation, and utilization of the coastal geotoolbox. Masters Thesis. University of Rhode Island, Depart. of Natural Resources Science.
- Rogers, S. S., G. Giese, and M. Adams. 2009. Anomalous accretion along outer Cape Cod shoreline possibly linked with eolian transport associated with parabolic dune field. *Geological Society of America Abstracts with Programs*. 41(3):85.
- Roman, C. T. and K. F. Nordstrom. 1988. The effect of erosion rate on vegetation patterns of an East Coast barrier island. *Estuarine, Coastal and Shelf Science*. 26:233-242.
- Roman, C. T. and N. E. Barrett. 1999. Conceptual framework for the development of long term monitoring protocols at Cape Cod National Seashore. USGS Patuxent Wildlife Research Center. Cooperative National Park Service Studies Unit, Narragansett, RI.
- Ruggiero, P., G. M. Kaminsky, G. Gelfenbaum, and B. Voigt. 2005. Seasonal to interannual morphodynamics along a high-energy dissipative littoral cell. *Journal of Coastal Research*. 21(3):553-578.
- Short, A. D. Editor. 1999. Handbook of beach and shoreface morphodynamics. Wiley and Sons, New York, NY
- Short, A. D. and A. C. Trembanis. 2004. Decadal scale patterns in beach oscillation and rotation, Narrabeen Beach, Australia - time series, PCA and wavelet analysis. *Journal of Coastal Research*. 20(2):523-532.

Literature Cited (continued)

- Stevens, S., B. Milstead, M. Albert, and G. Entsminger, 2005. Northeast Coastal and Barrier Network Vital Signs Monitoring Plan. Technical Report NPS/NER/NRTR - 2005/025. National Park Service. Boston, MA.
- Taylor, Wiseman, and Taylor, 1993. GPS Survey Report . Taylor, Wiseman and Taylor Engineering Company, Mount Laurel, NJ.
- Trenhaile, A. S. 1997. Coastal dynamics and landforms. Oxford University Press, New York, NY.
- Valentin, H. 1952. Die Küstern der Erde. Petermanns Geographische Mitteilungen, Ergänzungsheft Nr. 246.
- Van der Lee, W. T. B. 2009. Practical experiences in monitoring and dynamic preservation of the Dutch coast: A case study. Pages 85-94 *in*: Pye, K. and W. Ritchie, Eds. The Measurement of Coastal Change. Proceedings of the St. Fergus Symposium. Aberdeen Institute for Coastal Science and Management, Aberdeen, UK.
- Walker, H. J. 1990. The coastal zone. Pages 271-294 *in*: Turner, B. L., editor. The Earth as transformed by human action. Cambridge University Press, Cambridge, UK.
- Warrick, R. A., E. M. Barrow, and T. M. L. Wigley, editors. 1993. Climate and sea level change: observations, projections and implications. Cambridge University Press, Cambridge, UK.
- Zeigler, J. M., H. J. Tasha, and G. S. Giese. 1964. Erosion of the cliffs of outer Cape Cod: Tables and graphs. Woods Hole Oceanographic Institution, No. 64-21. Woods Hole, MA.

SOP1: Equipment and Supplies

Version 1.0 (July 2010)

The following table lists all changes that have been made to this Standard Operating Procedure 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 Project Leader. The project leader will review and incorporate all changes, officially complete the revision history log, and change the date and version number on the title page. For complete instructions, please refer to SOP#9 – Revising the Protocol.

Revision History Log:

New Version #	Previous Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change

This standard operating procedure details the items needed to execute the Coastal Topography monitoring protocol. The field equipment and office equipment are described and a field item checklist provided.

Field Equipment

- Geodetic GPS system:
The GPS system can be operated in different ways, depending on the equipment available, but as a minimum the park must have one Rover receiver unit and one field survey controller (Fig. S1.1). Fully integrated receivers with built-in antennas combine the GPS receiver, antenna, and radio into a single compact unit (for example the Trimble R8 unit – Fig. S1.1). Most of these units come with Bluetooth wireless technology built in, and therefore do not need cables. Older GPS systems are composed of modular units and require an external radio and an external GPS antenna, and therefore the set-up is more complex (for example the Trimble 5700 unit – Fig. S1.2). 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. These requirements will be explained in SOP#4 - Settings for Collection of Topography.
- Survey monuments booklet:
The survey monuments booklet is specific to each park and has a brief description of each benchmark location, including aerial photos of the site, ground photos, and coordinates and elevation information. The creation of the field booklets is described in SOP#2 - Establishment of Benchmarks, Transects and Geodatabase.



Figure S1.1. The Trimble R8 GNSS receiver and Trimble TSC2 field survey controller (Sandy Hook, November 2009).

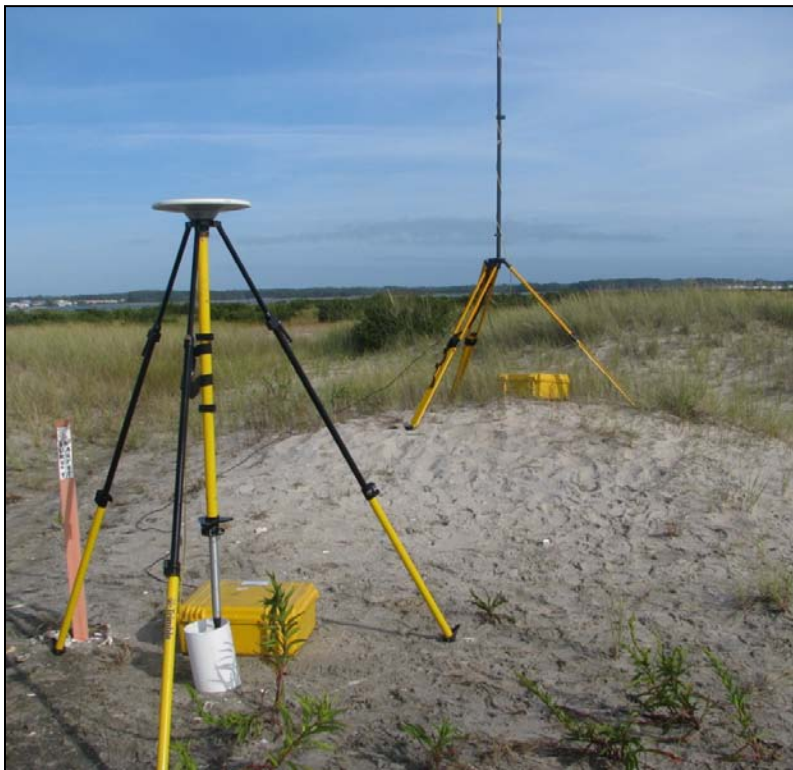


Figure S1.2. The Trimble 5700 Base station setup: in the foreground, the Zephyr geodetic antenna and the base receiver (inside the case), and in the background, the radio transmitter antenna (TRIMMARK 3 from Trimble) (Assateague Island, September 2009).

- Waders or rubber boots:
They are needed by the surveyor to go out to the water depth of 0.0 m (NAVD88) at each surveyed profile.
- Digital Camera
- Field copy of Field Data Form (Form S5.1)
- Field copy of SOP#5 - Conducting the Survey
- Emergency and Safety Supplies:
The surveyor must carry a cell phone or radio, and a list with the park's contacts and emergency phone numbers
- Field copy of the Field Equipment Checklist (Fig. S1.3)
- Four-wheel drive transportation if needed
- Measuring tape

Office Equipment

- Computer:
A PC that meets the minimum specifications for running GPS and GIS software, and capable of communicating with the field survey controller is required. The NPS minimum standard for computer equipment meets these requirements.
- 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) is required.
ESRI ArcGIS software for visualization, manipulation, and archiving of the data.
Microsoft Office Excel and the 2D Analyst application to analyze the beach profile data.
- Internet connectivity:
An internet connection (28.8kbps modem or faster) is needed for viewing the satellite almanac and tide charts (SOP#3 - Survey Timing and GPS Mission Planning) and maintaining the GPS software/firmware updates.

FIELD ITEM CHECKLIST**Form S1.1****1. GPS Equipment**

Depending on the equipment used and which set-up is selected, the following items are amongst those required for the establishment of the GPS system:

Fully-Integrated Receiver Setup:	
Rover setup:	Base station setup:
☐ Rover receiver	☐ Base receiver
☐ Pole	☐ External battery
☐ Internal batteries	☐ Internal batteries
☐ Flat foot for pole	☐ Tripod
☐ Radio antenna	☐ Radio antenna
☐ Pole clamp	
☐ Field survey controller	

Modular Unit Receiver Setup:	
Rover setup:	Base station setup:
☐ Rover receiver	☐ Base receiver
☐ Pole	☐ Internal batteries
☐ Rover GPS antenna	☐ Base GPS antenna
☐ Flat foot for pole	☐ External batteries
☐ Rover radio antenna	☐ Base radio transmitter
☐ Pole clamp	☐ Base receiver tripod
☐ Internal batteries	☐ Base radio antenna
☐ Cables	☐ Radio antenna tripod
	☐ Cables
☐ Field survey controller	

☐ Cell phone with data plans for cell phone correction option (if no base station is set up).

2. Other Items

- ☐ Survey Monuments Booklet
- ☐ Waders or rubber boots
- ☐ Digital Camera
- ☐ Field copy of SOP#5 - Conducting the Survey
- ☐ Field copy of Field Data Form (Form S5.1)
- ☐ Cell phone or radio with charged battery
- ☐ List of emergency and park contact phone numbers
- ☐ GPS manual (optional)
- ☐ Measuring tape
- ☐ Small Toolkit

Figure S1.3. Field item checklist (Form S1.1).

SOP2: Establishment of Benchmarks, Transects, and Geodatabases

Version 1.0 (July 2010)

The following table lists all changes that have been made to this Standard Operating Procedure 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 Project Leader. The project leader will review and incorporate all changes, officially complete the revision history log, and change the date and version number on the title page. For complete instructions, please refer to SOP#9 - Revising the Protocol.

Revision History Log:

New Version #	Previous Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change

This standard operating procedure illustrates and describes in detail the types of survey monuments that are needed to conduct the Coastal Topography Protocol. Benchmarks or survey monuments are permanent and long-lasting structures used to mark the profile 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 profile benchmark established along the shoreline at each of the parks, each park will also have high-accuracy control benchmarks to establish the GPS base station, to be used in the Real-time Kinematic surveying.

Methods of installation of new survey monuments are described, as well as the method for creating the associated profiles lines and the auxiliary files for post-survey QA/QC. The information on the network of survey monuments within each park, the respective Profile Lines and the auxiliary files will be stored in two complimentary formats: a GIS database and field booklets with adequate description of the locations and attributes of each survey benchmark. This SOP is divided into the following sections:

- Benchmarks
- Profile Lines
- QA/QC auxiliary files
- GIS database
- Field booklet
- Database maintenance

Benchmarks

Types of Benchmarks

Each park will have two types of benchmarks:

- 1) Profile Benchmarks: They mark the location of the starting point of the profile to be surveyed. These are highly accurate topographical points, established with a GPS system, that form the basis for standard surveying techniques using the RTK survey style.
- 2) Base-station Benchmarks: They are used to set up the GPS base receiver needed for RTK surveying. They are control points within centimeter accuracy, computed through the Online Positioning User Service (OPUS).

A benchmark can be simultaneously a Profile and Base-station Benchmark, depending on the characteristics and quality of its establishment. The number of Base-station Benchmarks 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.

Benchmark Establishment

When a new benchmark, either for base-station or profile line, needs to be established, the surveyor must decide on the preferential location for its installation according to the following criteria:

- All benchmarks should be permanent and long-lasting structures:
 - Pre-existing NGS or USACE metal-disks benchmarks
 - Pre-existing structures, such as fire hydrants or corners of curbs
 - Rods driven into the ground (metal rods or PVC pipes)
- All benchmarks should be located inland and far from the reach of wave action:
 - Inland of the foredune
 - Far from the bluff's edge
- All benchmarks should be accessible to the surveyor throughout the year:
 - Outside protected shorebird nesting areas
 - Outside private property
 - Far from vegetation that might cause allergic reaction
- All benchmarks should be located far from objects that might obstruct or interfere with the broadcast of the GPS radio signal:
 - Far from buildings or tree canopy
- Profile Benchmarks specifically should be established on a clear path towards the shoreline:
 - Far from heavy vegetation and buildings that might function as an obstacle to the collection of topographic points along the profile line

Pre-existing NGS or USACE Metal-disks Benchmarks

If a benchmark from the NGS Control Network is available for the general area, it is recommended that it is used as a survey monument. These are stable, identifiable points (usually metal disks) established by extremely accurate observations. To access the complete list of these benchmarks, go to the online interactive map at: www.ngs.noaa.gov/ims/NgsMap2. Each benchmark 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 (Figs. S2.1 and S2.2).

The surveyor 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 (Fig. S2.1).

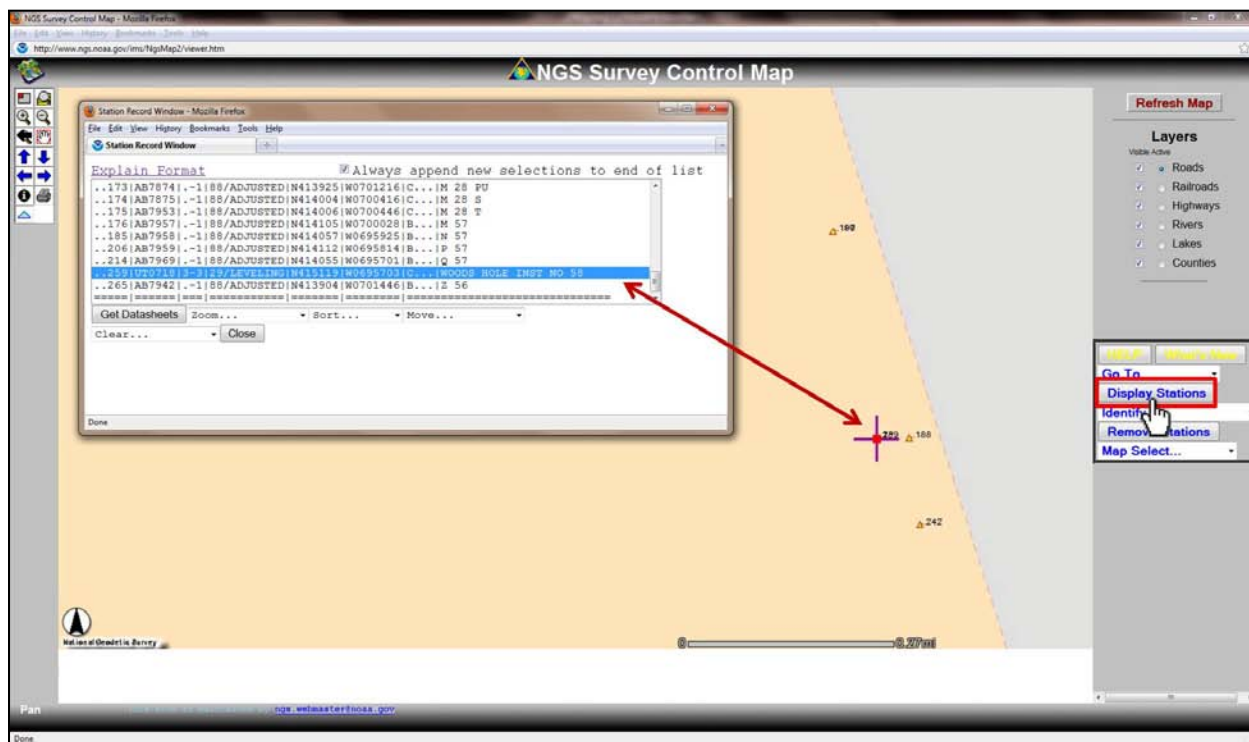


Figure S2.1. The NGS Survey Control Map website, showing the selection of a monument at CACO - PID UT0718 (www.ngs.noaa.gov/ims/NgsMap2).

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

```

map_ds.pri - Mozilla Firefox
File Edit View History Bookmarks Tools Help
map_ds.pri
UT0718 *****
UT0718 DESIGNATION - WOODS HOLE INST NO 58
UT0718 PID - UT0718
UT0718 STATE/COUNTY- MA/BARNSTABLE
UT0718 USGS QUAD -
UT0718
UT0718 *CURRENT SURVEY CONTROL
UT0718
UT0718* NAD 83(1996) - 41 51 18.95919(N) 069 57 03.29788(W) ADJUSTED
UT0718* NAVD 88 - 17.93 (+/-2cm) 58.8 (feet) VERTCON
UT0718
UT0718 LAPLACE CORR- -0.48 (seconds) DEFLEC99
UT0718 GEOID HEIGHT- -27.82 (meters) GEOID03
UT0718 HORZ ORDER - THIRD
UT0718 VERT ORDER - THIRD ? (See Below)
UT0718
UT0718.The horizontal coordinates were established by classical geodetic methods
UT0718.and adjusted by the National Geodetic Survey in June 1998.
UT0718.No horizontal observational check was made to the station.
UT0718
UT0718.The NAVD 88 height was computed by applying the VERTCON shift value to
UT0718.the NGVD 29 height (displayed under SUPERSEDED SURVEY CONTROL.)
UT0718.The vertical order pertains to the NGVD 29 superseded value.
UT0718
UT0718.The Laplace correction was computed from DEFLEC99 derived deflections.
UT0718
UT0718.The geoid height was determined by GEOID03.
UT0718
UT0718; North East Units Scale Factor Converg.
UT0718;SPC MA M - 846,161.857 328,623.896 MT 0.99998262 +1 02 26.0
UT0718;SPC MA M - 2,776,116.03 1,078,160.23 sFT 0.99998262 +1 02 26.0
UT0718;UTM 19 - 4,634,143.895 421,068.783 MT 0.99967666 -0 38 04.3
UT0718
UT0718! - Elev Factor x Scale Factor = Combined Factor
UT0718!SPC MA M - 1.00000155 x 0.99998262 = 0.99998417
UT0718!UTM 19 - 1.00000155 x 0.99967666 = 0.99967821
UT0718
UT0718 SUPERSEDED SURVEY CONTROL
UT0718
UT0718 NAD 83(1992)- 41 51 18.95650(N) 069 57 03.29711(W) AD( ) 3
UT0718 NAD 83(1986)- 41 51 18.95495(N) 069 57 03.29257(W) AD( ) 3
UT0718 NAD 27 - 41 51 18.56656(N) 069 57 05.23022(W) AD( ) 3
UT0718 NGVD 29 (07/19/86) 18.20 (m) 59.7 (f) LEVELING 3
UT0718
UT0718.Superseded values are not recommended for survey control.
UT0718.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
UT0718.See file dsdata.txt to determine how the superseded data were derived.
UT0718
Done

```

Figure S2.2 Example of the datasheet retrieved from the NGS Survey Control Map interactive website for the Monument *PID* UT0718 (www.ngs.noaa.gov/ims/NgsMap2).

In case the available NGS benchmark closest to the selected profile location does not provide high accuracy levels, or possibly lacks the vertical or horizontal information, the surveyor might still use it as a Profile or Base-station Benchmark. In this case, improved coordinates and elevation of the point will have to be established by the surveyor – as detailed below.

Pre-existing Structures

When no NGS monument is available for the selected location, then the surveyor must establish the benchmark. 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 profile location. Corners of curbs and cement slabs, top of fire hydrants and corners of sturdy features are some examples of pre-existing structures that could be used as benchmarks (Figs S2.3 and S2.4). The surveyor 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 benchmark.



Figure S2.3. Benchmark located at corner of cement slab on the bike path at Fort Wadsworth, GATE; adequate space to site a GPS rover receiver pole (Staten Island, April 2009).



Figure S2.4. Benchmark location at corner of curb of a traffic island on a parking lot at Great Kills, GATE; adequate space for a GPS base station or rover receiver pole (Staten Island, August 2008).

Installation of New Benchmarks

If no pre-existing benchmarks or structures are available, 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, easy to install, and are long-lasting structures. 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 will need 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 benchmark)
- Cement (c. 4 kg per benchmark)
- Hammer
- Stickers with NPS logo

Procedure to install the PVC pipe benchmarks:

- In the office or lab, drill holes into a portion, about 0.5 m, of the PVC pipe (Fig. S2.5a)
- In the field, dig a hole at least 1 m deep with the field hand-corer (Fig. S2.5b)
- 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) (Fig. S2.5c).
- Insert a mixture of cement, water, and the sand that was dug out of the hole into and around the pipe (Figs. S2.6a and S2.6b) until the PVC pipe is full. Place a sticker with the NPS logo on the PVC pipe (Fig. S2.6c).



Figure S2.5. PVC pipe benchmark; a) PVC pipe with holes; b) Coring in field, and c) final driving of PVC pipe into sand.



Figure S2.6. Installation of the PVC pipe benchmark, a) and b) Inserting the cement, water and sand into and around the pipe, and c) NPS logo on PVC pipe.

Benchmark Identification

Benchmark 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 5 of Narrative and Table S2.1). They are numbered according to their position in relation to the other benchmarks, numbered systematically starting with 1. ASIS is the only exception. In this case, the current identification, established in 1993 and 1995, continues to be used.

Table S2.1. Benchmark identification according to the Protocol's nomenclature.

Park	Unit	Section	Benchmark ID
CACO			CC1, CC2,..., CCn
GATE	Sandy Hook		SH1, SH2,..., SHn
		Breezy Point	BP1, BP2,..., BPn
	Jamaica Bay	Plumb Beach	PB1, PB2,..., PBn
		Great Kills	GK1, GK2,..., GKn
	Staten Island	Miller Field	MF1, MF2,..., MFn
		Fort Wadsworth	FW1, FW2,..., FWn
FIIS			FI1, FI2,..., FI n

Establishment of Benchmark Height and Position Information:

The benchmarks' coordinates and elevation will be acquired with a GPS-RTK unit and will be registered to the following spatial references:

- Grid Coordinate System: Universal Transverse Mercator (UTM)
- UTM Zone Number: 18 (GATE, ASIS and FIIS)
19 (CACO)
- Horizontal Datum: North American Datum of 1983
- Vertical Datum: North American Vertical Datum of 1988
- Geoid Model: GEOID09
- Units: Meters

To acquire high-accuracy GPS positions in the field, the surveyor will need a geodetic GPS Unit. Refer to the GPS Equipment list under the Field Equipment Checklist (Form S1.1) in SOP#1- Equipment and Supplies. The following description on how to measure the benchmark coordinates and elevation is based on Trimble's software terminology (as an example).

Profile benchmarks

Profile benchmarks are established by measuring a Topo point in a GPS survey mode. Refer to SOP#5 - Conducting the Survey for the different ways in which the GPS unit can be set up.

- Create a Project/Job with the spatial references identified above and select the RTK survey style (refer to SOP#4 - Settings for Collection of Topography for further details)
- Position the rover receiver directly over the benchmark location
- In the controller main menu go to:
Survey → Measure points
Under ***-point name-*** key in the Benchmark's ID
Under ***-method-*** select ***-topo 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 vertical and directly above the benchmark location, and hit ***-measure-***
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 Job file (format: .dc) from the field survey controller to a computer using the Trimble Data Transfer software (or similar tool). Use Trimble Business Center to open and retrieve the northing, easting, and elevation data of the measured benchmark.

Base-station Benchmarks

Base-station Benchmarks 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 benchmark location, determine that the receiver is level
- Create a Project/Job with the spatial references identified above
- Select the FASTSTATIC survey style
- Insure 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 benchmark ID
- Measure the point for at least 8 hours* but not more than 24 hours. A longer-duration data file will improve the accuracy of the solution.

Alternatively, the surveyor may collect GPS 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 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 on 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:
<http://www.ngs.noaa.gov/OPUS/>
- Follow the instructions (Fig. S2.8):
 1. Enter your e-mail address
 2. Attach the GPS raw data file (only one data file can be uploaded at a time)
 3. Select the antenna type used in the field data collection
 4. Enter the antenna height (in meters)
 5. Select: Upload to **STATIC**

Opus will email the solution usually in 10-15 minutes (Fig. S2.9). The report will include 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 can not 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).



OPUS: Online Positioning User Service



upload

[view](#)

[about](#)

compute an accurate position for your GPS data file

- enter your [email address](#)
- attach your [DATA file](#) of GPS obs, dual-freq.(L1/L2) only
- select your [antenna type](#)
 Integrated Antenna (R8) Model 2
- add your [antenna height](#)
 meters
- 5a. customize your solution, report, and publishing [options](#)
- or-
- 5b. choose a [processor](#)
 for data > 15 min. < 2 hrs.
 for data > 2 hrs. < 48 hrs.

Figure S2.8. The OPUS Upload webpage and the fields required for data entering (<http://www.ngs.noaa.gov/OPUS/>).

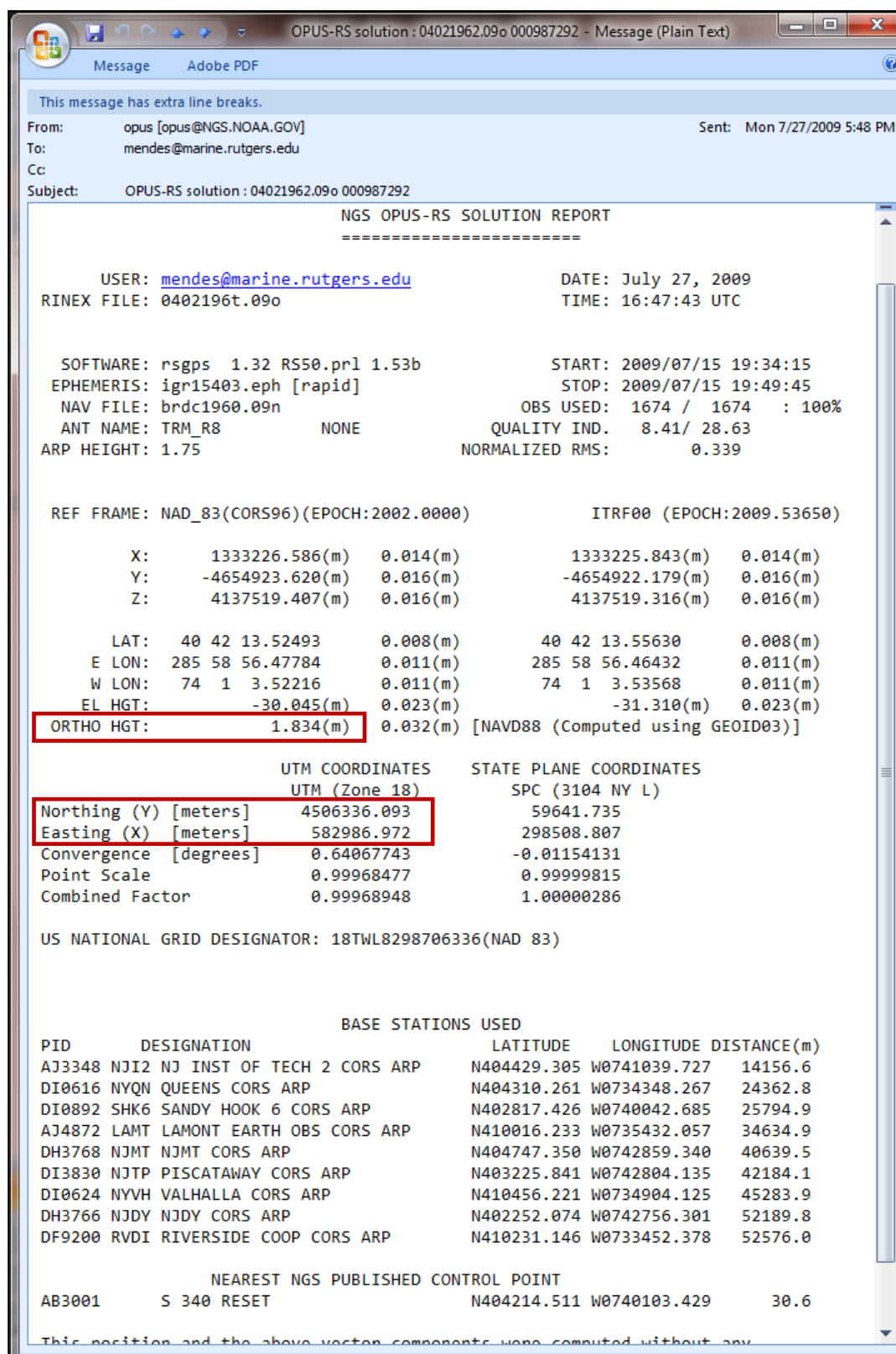


Figure S2.9. Example of an OPUS Solution report sent via e-mail. Coordinates and elevation data are highlighted in red boxes (<http://www.ngs.noaa.gov/OPUS/>).

Profile Lines

Each Profile Benchmark will have an associated profile line to represent the line along which the topographical measurements are collected in the field. The park's GIS expert will produce the profile lines in a GIS environment by creating a line feature class with one feature per benchmark (Fig. S2.10), and making use of recent aerial imagery of the area of interest as background. Characteristics of a profile line in the GIS environment will incorporate:

Starting point of the line	→ benchmark 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 meters into the water

QA/QC Auxiliary Files

Two auxiliary ESRI feature classes representing the Profile Benchmark and Profile Line buffer areas will be created in a GIS environment for QA/QC purposes (described in SOP #6 – Initial Post-Survey Processing) for each park:

1. A polygon ESRI feature class that represents the buffer areas within 0.05 meters distance from the Profile Benchmarks.
2. A polygon ESRI feature class that represents the buffer areas within 0.5 meters distance from the Profile Lines.

Use the “Buffer” tool under the “Analysis Tools” in ArcToolbox to create polygons that portray the specified areas around the Profile Benchmarks and Profile Lines (Fig. S2.10).

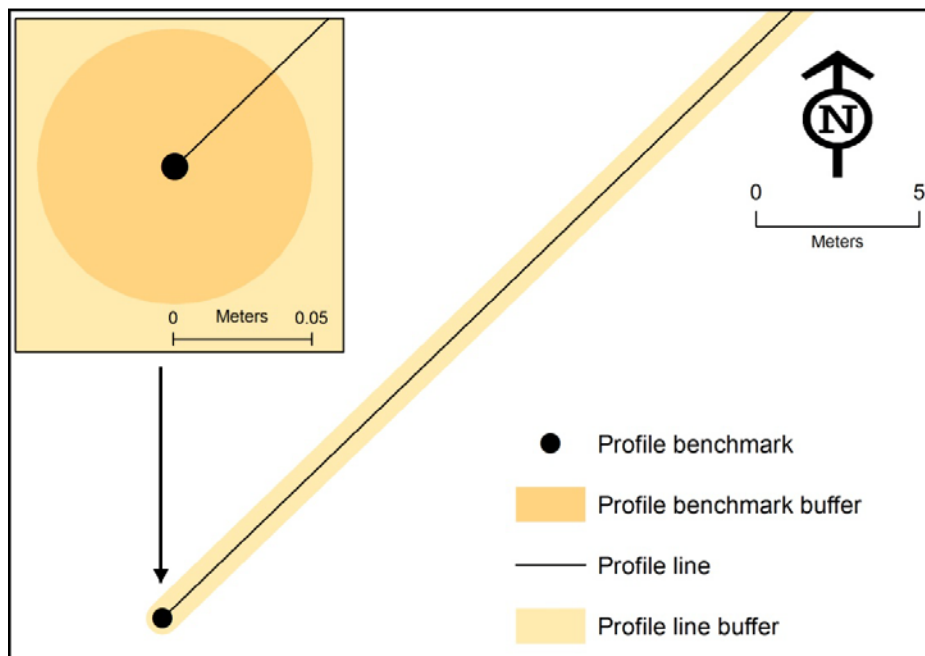


Figure S2.10. QA/QC auxiliary feature classes representing the Profile Benchmarks' and Profile Lines' buffer areas.

GIS Database

Each park will have an ESRI geodatabase in which will be stored the Benchmarks, Profile Lines, and QA/QC auxiliary files as four *feature classes*. For each park unit (where applicable) these four datasets will reside in a feature dataset (Fig. S2.11). The characteristics and properties of the *features classes* are detailed below. All the feature classes will have metadata, to be provided by the NCBN Data Manager.

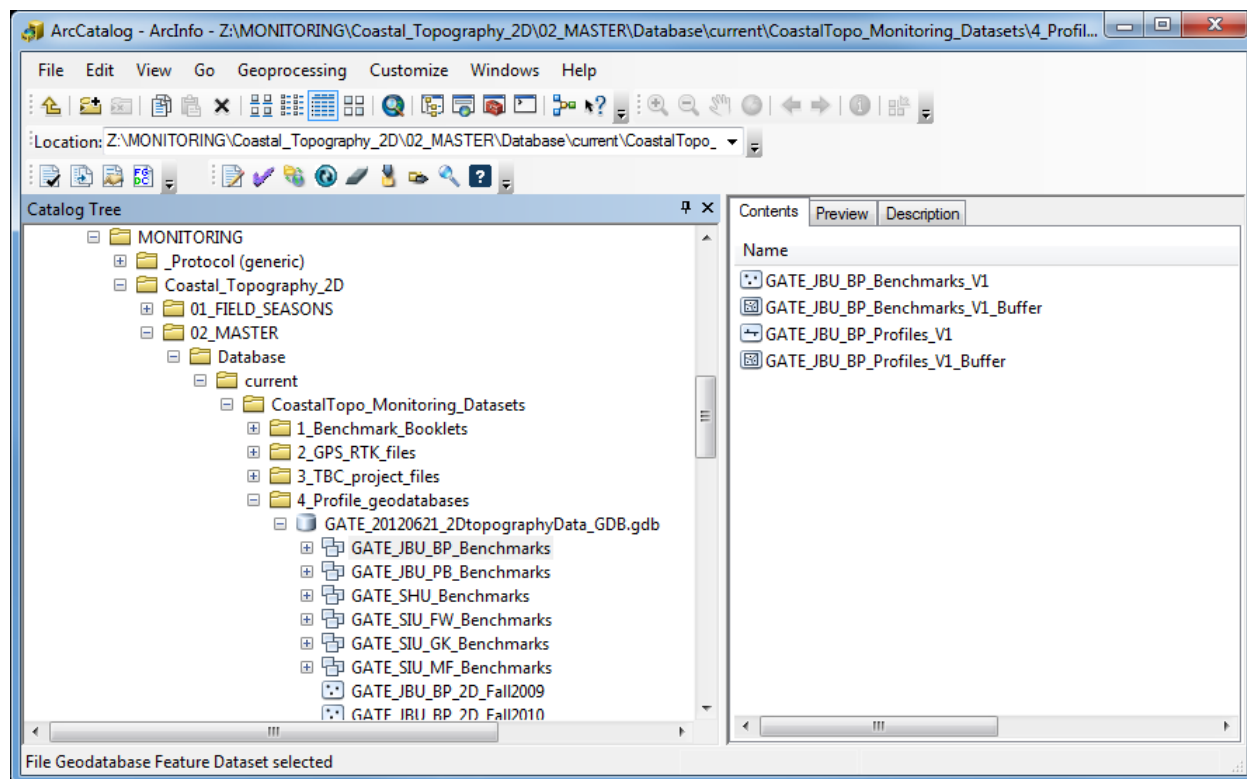


Figure S2.11. An example of the ESRI geodatabase containing benchmark and profile line feature classes for Breezy Point, Jamaica Bay Unit of Gateway National Recreation Area.

Benchmarks

The benchmark height and position information will be stored as ESRI *point features* with the following attribute fields and respective information (Table S2.2 and Fig. S2.12):

The *feature class* name will reflect the park and unit's name and will have a Version number associated with it, to allow for future alterations of the database:

GATE_JBU_BP_Benchmarks_V1

Protocol nomenclature – “Benchmarks” – Version 1

Table S2.2. An example of the attribute fields of the Benchmarks *feature class*, Breezy Point, Jamaica Bay Unit, GATE.

Attribute	Field Name	Example
Benchmark ID	ID	BP1
Easting coordinate	X	596158.12
Northing coordinate	Y	4491377.80
Elevation	Z	5.253
Associated profile Azimuth	Az	156°
Date benchmark was established	Date_est	8/19/2008
Who established benchmark	Source	Rutgers University
Short description of what is the benchmark	Descrip	PK nail
Page number of benchmark in the field booklet	Booklet_Pg	4
Purpose of benchmark	Purpose	Profile / Base-station
Quality of the benchmark establishment	Quality	GPS measurement / OPUS solution

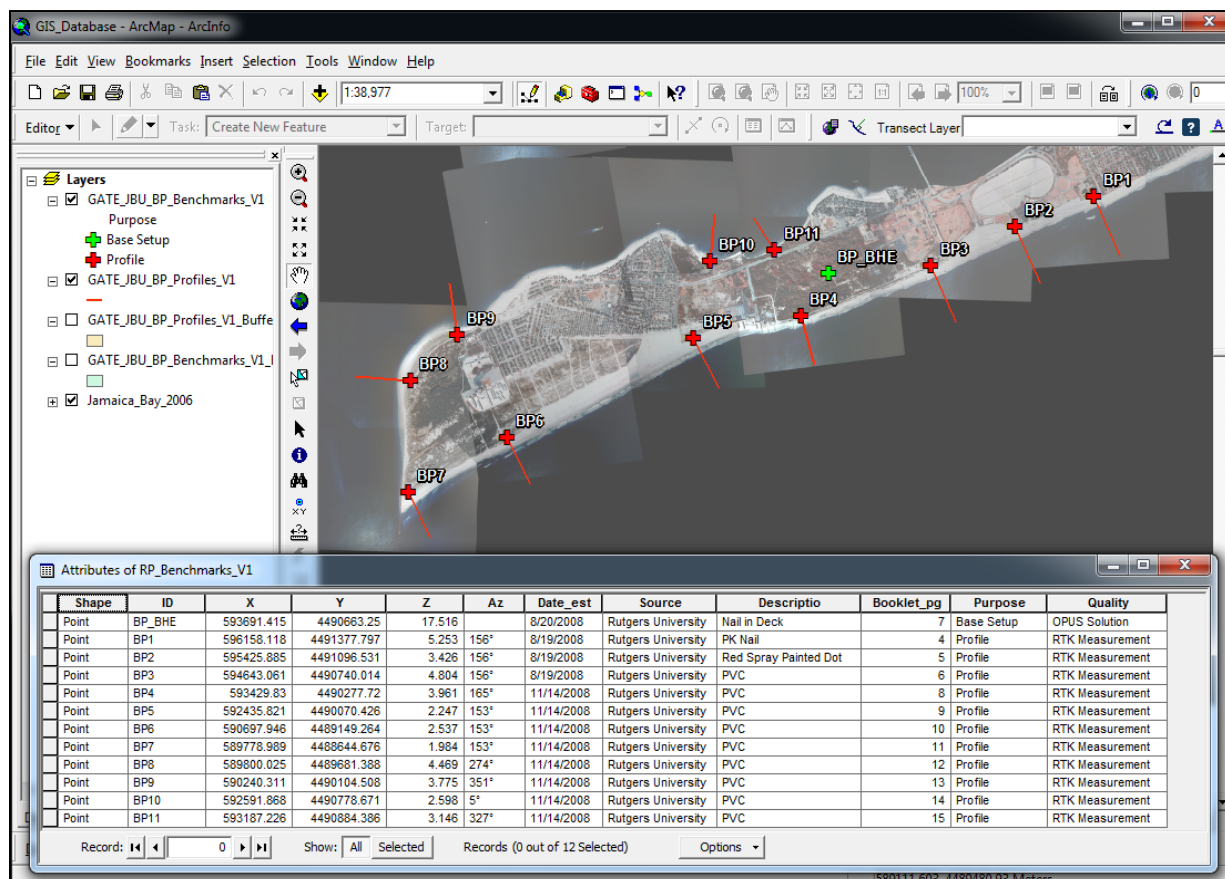


Figure S2.12. Benchmarks' *Feature class* for Breezy Point, Jamaica Bay Unit of Gateway National Recreation Area, NY.

Profile Lines

The Profile Lines' *feature class* will contain three attribute fields (Table S2.3):

Table S2.3. Attribute fields of the park's Profile Lines' *feature class*.

Attribute	Field Name
Profile ID	Profile_ID
Profile Azimuth	Az
Profile Length	Shape_Length

Similar to the benchmarks, the profile lines' *feature class* name will reflect the park's name and will have a Version number associated with it, to allow for future alterations of the database:

GATE_JBU_BP_Profiles_V1

Protocol nomenclature – “Profile” – Version 1

QA/QC Auxiliary Files

The QA/QC auxiliary files will correspond to polygon *features* and will only need to contain an attribute field with the Profile Benchmark and Profile Line ID that apply to the buffer areas. The Buffer areas *feature classes* will have the same name of the Benchmarks or Profile Lines to which they are associated, followed by the word “Buffer” (Fig. S2.9):

GATE_JBU_BP_Benchmarks_V1_Buffer

GATE_JBU_BP_Profiles_V1_Buffer

Field Booklet

Each park unit will have a field booklet that will include (See Appendix A for an example of a Field Booklet):

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 benchmarks included in the Field Booklet.

Individual pages with Benchmark description:

The pages will be ordered according to the benchmark ID. Benchmarks that are exclusively base-station benchmarks will be placed at the end. The following elements will be included in each page (identified in Fig. S2.13):

A. Benchmark ID

Includes the purpose and quality of the benchmark.

B. Description of the benchmark 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 benchmark in relation to the other benchmarks.

D. Large scale map of the benchmark

An inset of the aerial photo showing the location of the benchmark; the view must include benchmark's ID and its respective profile line 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 benchmark. Photos must incorporate the surrounding area to help the surveyor locate it on the ground. The profile line 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 benchmark'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 benchmark was established.

Table with Benchmark elevations:

A table with the elevation of the benchmarks in meters and feet, relative to NAVD88 and to NGVD29.

Vertical Datum information:

A figure and table showing the relationship of 1983-2001 tidal epoch water levels to NAVD88 and to NGVD29.

Booklet & Benchmark Log:

A table with the record of the version of the booklet, along with notes on the changes that are made.

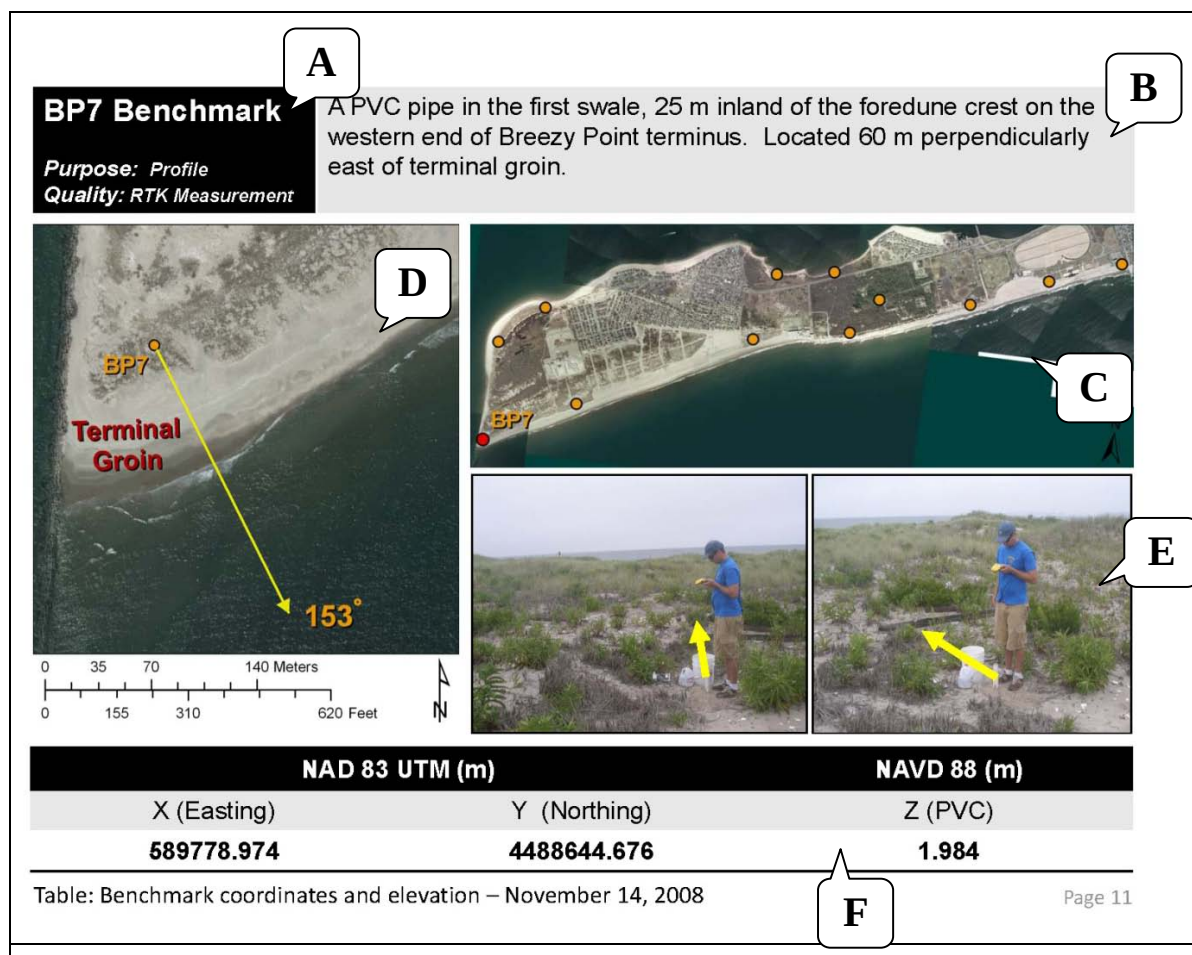


Figure S2.13. Example of benchmark elements describing BP7 in the Breezy Point, Jamaica Bay Unit of Gateway National Recreation Area, NY Field booklet.

Database Maintenance

The ESRI geodatabases mentioned above (with benchmarks, profile lines, and buffer areas) and Field Booklets will be stored and maintained by the GIS specialist of each park, and the NCBN data manager. Any alterations to the benchmarks must be reported to them in order for alterations to be made accordingly.

To access the parks' geodatabase and Field booklet contact the Data Manager at:

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

SOP3: Survey Timing and Mission Planning

Version 1.0 (July 2010)

The following table lists all changes that have been made to this Standard Operating Procedure 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 Project Leader. The project leader will review and incorporate all changes, officially complete the revision history log, and change the date and version number on the title page. For complete instructions, please refer to SOP#9 – Revising the Protocol.

Revision History Log:

New Version #	Previous Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change

The objective of this Standard Operating Procedure (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 (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 will be 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 S3.1).

Table S3.1. Timing of preparation for the field surveys.

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

Survey Windows

Observations of past summer and winter beaches at the Sandy Hook Unit of Gateway National Recreation Area 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 Barrier Network, the optimal time for recording the seasonal oscillation of the beach is a six-week window during the following periods:

Spring survey	→ mid-March to late April
Fall survey	→ mid-September to late October

Tide Condition

Within the survey windows, periods are pre-selected when the tidal range is maximized - spring tides. Field surveys will be conducted around 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 (Fig. S3.1).

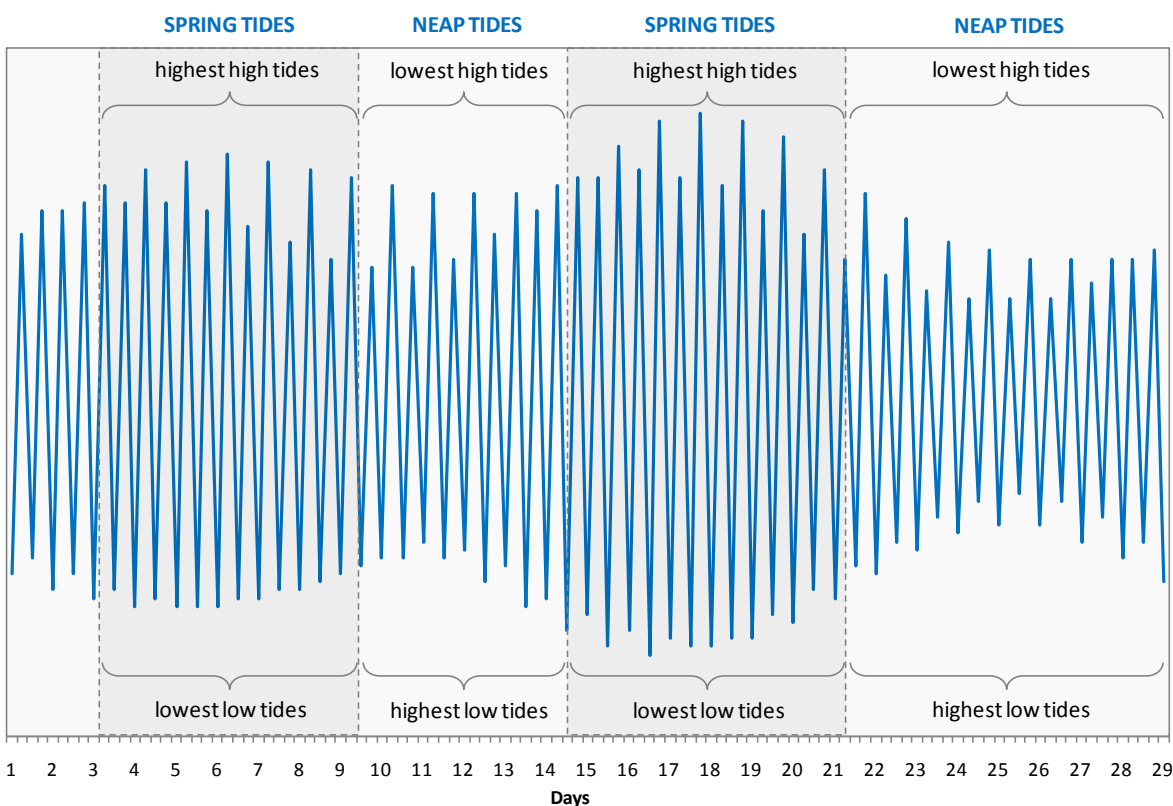


Figure S3.1. Tide predictions for Sandy Hook, NJ, depicting the periodic variations in semi-diurnal tidal ranges and the occurrence of spring tide ranges and neap tide ranges during the span of a month.

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 following NOAA website:
<http://tidesandcurrents.noaa.gov/>
2. Select the "High/Low Tide Predictions" for the tide gauge station closest to the park:
 - ASIS MD Outer Coast → Ocean City Inlet
 - GATE NJ Sandy Hook Bay → Sandy Hook (Fort Hancock)
 - FIIS NJ Sandy Hook Bay → Sandy Hook (Fort Hancock)
 - CACO MA Nantucket Sound → Nantucket
and Nantucket Island

The predictions are displayed in monthly tables that include the following information on the two highest and two lowest water levels that will occur daily:

- Date → month, day and year (mm/dd/yyyy)
- Day → Day of the week
- Time → Predicted time of occurrence (hh:mm)
Time refers to Local Standard Time (LST) or, Local Daylight Time (LDT)
- Height → Predicted elevation of the water level
Height refers to the High tide (H) or Low tide (L) levels

The height information retrieved from the website is available in meters relative to Mean Lower Low Water (MLLW) for the current tidal epoch.

Within each of the six-week survey windows designated for the spring and fall surveys, there will be 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.

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 should be accomplished during the six hours around low tide, three hours before and three hours after the predicted time of low tide. This time period provides the opportunity to collect more profile data during the span of time that the beach face is exposed.

The following is an example of the spring 2012 survey planning for GATE, based on the tide prediction tables for the Sandy Hook Tide Gauge (Table S3.1). A span of three weeks and a half within the mid-March to late April period incorporate spring tides - the ideal time for conducting the coastal topography surveys.

Table S3.1. NOAA tide predictions (meters) for the months of March and April, 2012 for Sandy Hook, NJ. Periods of spring tide conditions during the period between mid-March to late April are highlighted with the red dashed boxes (<http://tidesandcurrents.noaa.gov/>).

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

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 profile locations.

The NCBN's GPS Units are available for all researchers to use and share, and are intended to be used in the myriad of field surveys that are undertaken in the NCBN's parks. Therefore the equipment should be reserved in advance, ideally in the beginning of the year when the survey windows are identified. To schedule the use of the GPS unit, go to the NCBN's online GPS Scheduler at http://www.edc.uri.edu/gps_scheduler/.

The rules to borrowing the GPS units and making a reservation are listed on the website, as well as the contacts of the people in charge of the units.

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.

Satellite Availability

The positional data recorded by the GPS unit are derived from the time signals sent from the constellation of satellites, and the receiver requires signals from at least four satellites in order to determine its 3-dimensional location. Nonetheless, more important than the finite number of satellites is the satellite geometry (the locations of the satellites in view relative to each other and to the receiver) that affects the accuracy of the receiver's final position solution. The effect of the satellite geometry is quantified as the Position Dilution Of Precision (PDOP), which is a unitless value that changes continuously as the satellites move across the sky. 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. Therefore, the best data collection time can be selected based on reports and graphs of expected PDOP values, indicating when the satellite geometry can provide the most accurate results. Values range from 1.0 to infinity, and a low PDOP indicates a higher probability of accuracy, whereas a high PDOP indicates a lower probability of accuracy.

A couple of weeks prior to the survey window the surveyor must consult the predicted PDOP values for the planned survey days:

1. Download the latest GPS Almanac files with the information about the entire GPS satellite constellation, and data on every satellite's orbit from the Trimble website at <http://www.trimble.com/gpsdataresources.shtml>
Note: Predictions of PDOP value are valid for a maximum of thirty days in advance.
2. Use the Trimble Business Center "Planning Utility" Tool (for example) to examine the DOP Position Plot (Fig. S3.2)
3. Schedule the survey days based on the satellite coverage information and considering that a PDOP below 6.0 is necessary to collect accurate and precise positions

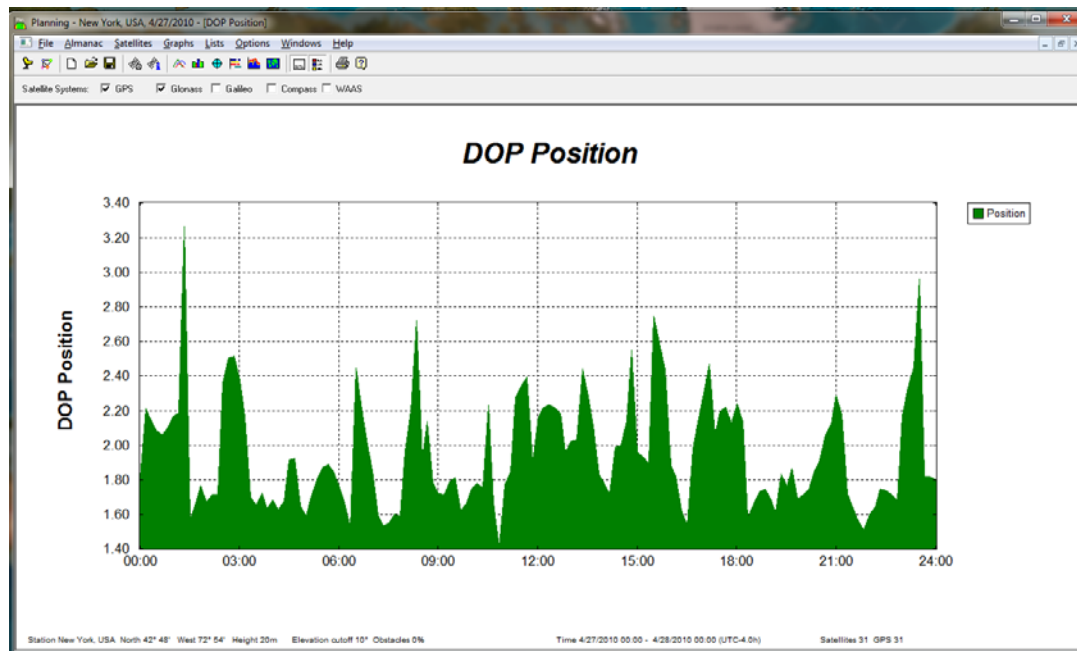


Figure S3.2. An example of the distribution of PDOP values using the Trimble Planning Utility software. PDOP values between 1.0 and 6.0 are needed to collect accurate and precise positions.

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 meters 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 will not bias the end of the winter season beach condition because this survey is 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 will 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.

References:

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

SOP4: Settings for Collection of Topography

Version 1.0 (July 2010)

The following table lists all changes that have been made to this Standard Operating Procedure 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 Project Leader. The project leader will review and incorporate all changes, officially complete the revision history log, and change the date and version number on the title page. For complete instructions, please refer to SOP#9 – Revising the Protocol.

Revision History Log:

New Version #	Previous Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change

This SOP details the critical settings of the GPS 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. The standardization of the criteria for collecting topographical data assures that the survey is replicable and comparable.

Survey Style Properties

Survey Styles define the parameters for configuring and communicating with the GPS units (base and rover receivers), and for measuring and storing points. The Coastal Topography Protocol uses Real-time Kinematic survey style, 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 R8, configure the survey style properties using the following settings:

- 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 the receiver computes positions)
 - Antenna settings: Set to suit your equipment

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.

Job Properties

The following are the necessary inputs in the properties of the Job that will be created for running the survey and storing the points. The Job can either be created in the office using Trimble Business Center and then transferred to the field survey controller, or it can be created directly in the field survey controller.

- Name of the Job: CACO_2D_20100404
Protocol nomenclature_”2D”_date (yyyymmdd)
add “_a, _b” to the end of the name if more than one rover is being used in the same day
- Grid Coordinate System: Universal Transverse Mercator (UTM)
- UTM Zone Number: 18 (GATE, ASIS and FIIS)
19 (CACO)
- Horizontal Datum: North American Datum of 1983(CORS 96)
- Vertical Datum: North American Vertical Datum of 1988
- Geoid Model: GEOID09 *
- Units: Meters
- Active Map: The benchmarks from the park’s geodatabase **

** Download the Geoid file from the Trimble website and upload it to Trimble Business Center and to the field survey controller. Download the Geoid file at:*

http://www.trimble.com/geomaticsoffice_ts.asp?Nav=Collection-71

*** Upload the feature classes from the park’s ESRI geodatabase (the benchmarks and profile lines created according to SOP#2) into the field survey controller, using the 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 will occur depending on location and will produce offsets in horizontal and vertical coordinates. The current geodetic datum used for this protocol is NAD83 (CORS 96) (2002.0). In April 2012 there will be an update released for the current NAD83 coordinate system. The new coordinate system will be NAD83 2011 (2010.0) and it will be accompanied by a new geoid model. 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 at: <http://www.ngs.noaa.gov/>.

SOP 5: Conducting the Survey

Version 1.0 (July 2010)

The following table lists all changes that have been made to this Standard Operating Procedure 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 Project Leader. The project leader will review and incorporate all changes, officially complete the revision history log, and change the date and version number on the title page. For complete instructions, please refer to SOP#9 – Revising the Protocol.

Revision History Log:

New Version #	Previous Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change

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#3 – Survey Timing and 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 system, the display of the background Benchmarks and Profile Lines (created in SOP#2) on the field survey controller, and the initialization of the field data form. The second component is the identification and measurement of the profile Benchmark, the conduction of the survey with the GPS 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. Form SOP#5-1 is provided at the end of this SOP.

Preparation Procedures

GPS Setup

Prior to the beginning of the survey, the GPS equipment must be physically configured and set up. Depending on the equipment and personnel available, and the area to be covered, the surveyor 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 benchmark) and is sending corrections to the rover via a radio link. This setup is adequate to

survey profiles up to a 20 km distance from the base station. As the distance increases, the atmospheric conditions at the rover and base station will become increasingly different, resulting in a decrease in accuracy. The base receiver must be set up at a base-station benchmark (as described in SOP#2) 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 base-station benchmarks (as described in SOP#2), 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 profile lines at the same time, increasing the time efficiency of the data collection. The base receiver must be situated at a base-station benchmark (as described in SOP#2) and located as close as feasible to the planned survey area.

Rover + Cell Phone Correction

In the absence of a base receiver, or in cases where communication between rover and base is not possible (sometimes due to presence of obstacles such as high bluffs), the surveyor can access an external network of reference stations provided by the National Geodetic Survey (NGS), known as CORS network (Continuously Operating Reference Stations). The GPS correction is provided through the internet and accessed by the surveyor via a cell phone connected to the rover in the field. This option has cell phone associated costs, and requires a plan with a carrier that supports the type of data connection that is necessary.

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 R8).

For further details on how to set up the GPS 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#4 - Settings for Collection of Topography. The surveyor must ascertain that once the rover unit is started the field survey controller must demonstrate that (Fig. S.5.1):

- PDOP $\leq$ 6.0
- Radio Link is active
- At least 5 satellites are available
- Battery is providing power

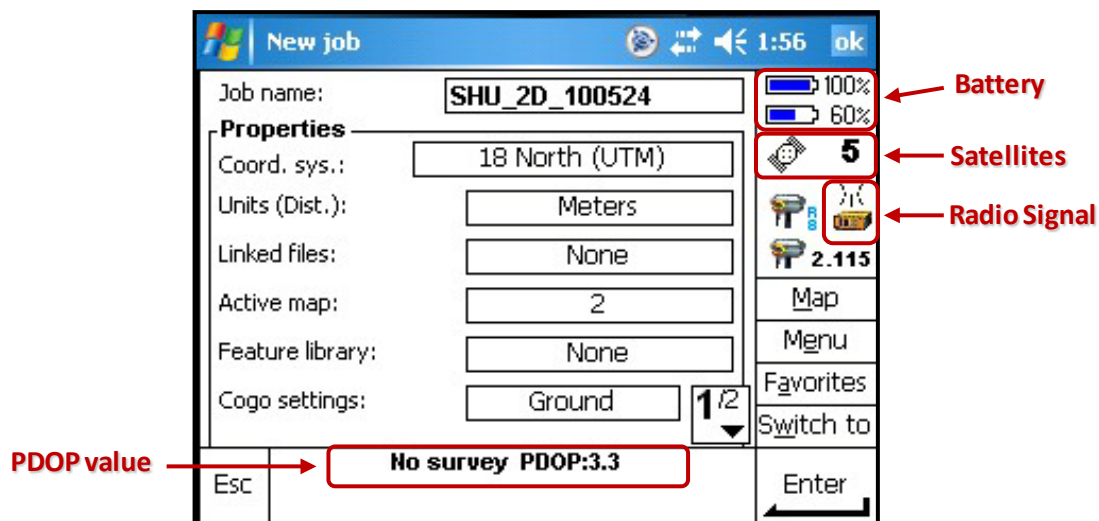


Figure S5.1. Trimble Survey Controller software screen showing information about the rover unit status during Job creation.

There will be one Job per:

- Surveyor, 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 5 of Narrative)

Display Benchmarks and Profile Lines on the Map:

Once the rover is working, the surveyor must determine that the background files with the park's Benchmarks and Profile Lines (created according to SOP#2 and uploaded according to SOP#4) are activated in the Map feature of the Trimble Survey Controller (Fig. S.5.2).

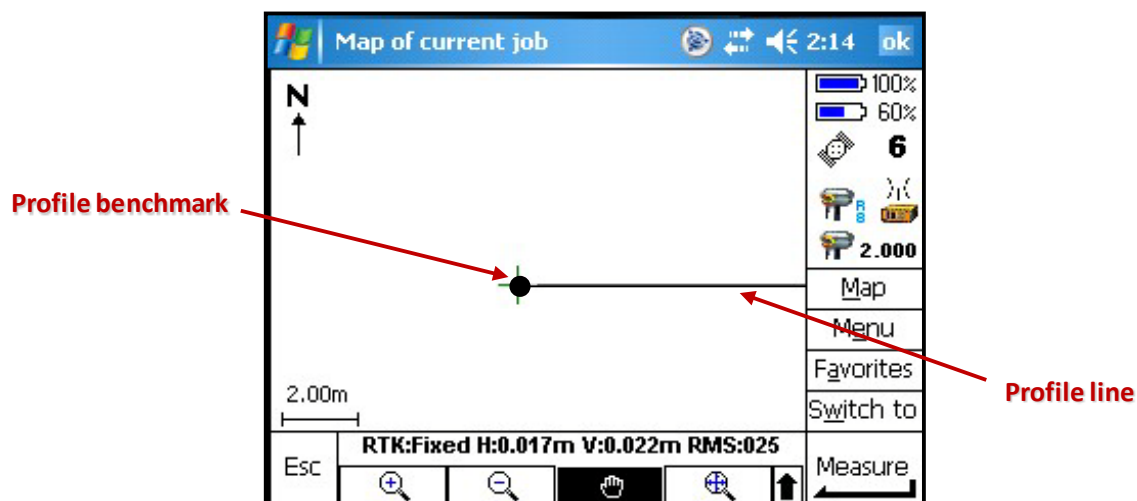


Figure S5.2. Trimble Survey Controller map feature screen showing one of the profile benchmark and respective profile line, and the rover position (represented by +) at Sandy Hook Unit, GATE.

Field Data Form

The Field Data Form (FDF) is used for all field notations (Fig. S5.3 and Form SOP#5-1). This information is necessary for post-processing of the data and facilitates the generation of accurate metadata. There will be one FDF filled out per Job. At the beginning of the survey, complete the fields of the “Event Information” (except for End time) and the “GPS Device” sections of the FDF using the following formats:

1. Date (mm/dd/yyyy) - enter the date in the format shown.
2. Park Unit – The 4 character park identifier, CACO, ASIS, GATE, FIIS, 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 (GMP version #/SOP version #) – Version of the protocol used to guide field data collection.
5. Date of last storm event – This information should have been gathered during mission planning (see SOP#3 - Survey Timing and Mission Planning).

Field Data Form - Coastal Topography Survey			
Event Information		Surveyed Profiles	
Survey Date:	03/31/2010	ID	Photos: Segmented: Notes (include Benchmark condition, aspects of morphology, etc...):
Park Unit:	GATE - SHU	SH1	1 No
Start Time:	12:30 PM	SH2	1 No
End Time:	4:00 PM	SH3	1 No Presence of swash bar (photo)
Observer's name:	Andrea Spahn	SH4	1 No
Protocol/SOP version:	GMP v 1.0 / SOP# 5 v 1.0	SH5	1 No Scarped dune
Date of last storm event:	03/30/2010	SH6	2 No
GPS-RTK Device		SH15	1 Yes
Make and Model:	Trimble R8	SH16	1 Yes
Set-up:	Base + 2 Rovers + TRIMMARK		
Base Benchmark used / CORS ref. station used	P10		
Survey Notes (List any equipment problems, radio signal issues or obstacles encountered, etc.)			
Time of incident: (from GPS-RTK unit)	Notes:		
3:00 PM	Lost radio signal when at the base of the scarp on the bayside		

*For extra survey notes, use additional blank page and attach to this form

Figure S5.3. Example of entries on the Field Data Form (Form SOP#5-1).

Many of these initial values may be entered prior to going into the field. The “Surveyed Profiles” section should be filled in as the surveyor conducts the survey and visits each profile location:

1. ID - the Benchmark and Profile Line ID (e.g., SH3)
2. Photos - the number of photos taken at the profile site
3. Segmented - enter information indicating if the measurements along the Profile Line were taken continuously or if the survey had to be segmented and different parts of the profile were surveyed at different times (see “3. Interruptions and segmented profiles” below). Segmented: enter YES, not segmented: enter No.
4. Notes - enter information specific to the profile location, such as presence of scarps or bars, as well as the condition of the benchmarks.

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

Conducting the Survey

Identification and Collection of the Starting Point Benchmark

The surveyor should use the Trimble Survey Controller Map feature with the background files of the Benchmarks and Profile Lines, and the indications on the field booklet (map, photos and description) to locate the benchmark that identifies the starting point of the profiles to be surveyed. For quality-control purposes, the first measurement at the profile is of the benchmark location. A 30 second measurement will be taken at the benchmark. As an example, the following steps apply when using the field survey controller and the Trimble Survey Controller software (Fig. S5.4):

1. Position the rover on the profile benchmark
2. In the controller main menu go to:

Survey → Measure points

Under ***-point name-*** key in the benchmark’s ID (e.g., SH4)

Under ***-code-*** enter the season and year of the survey (e.g., spring 2010)

Under ***-method-*** select ***-topo 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 vertical and directly above the benchmark, and hit ***-measure-***

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)

3. Verify the point location either with the reference points stored on the controller or by referring to the field booklet

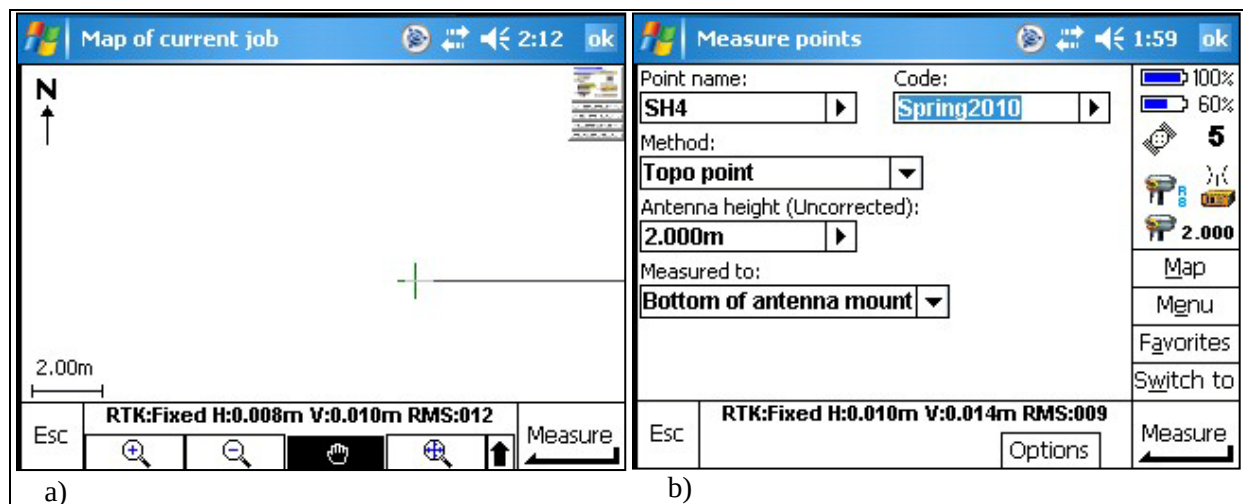


Figure S5.4. Trimble Survey Controller screen showing the collection of the benchmark position. a) Map screen showing the position of the rover (cross) over the benchmark, at the beginning of the profile line; and b) *Measure Points* screen showing the options for the measurement of the topo point.

Measuring Topographic Points Along the Profile Line

After collecting the benchmark point, the rover is positioned on the profile line shown as a background file in the Map feature screen of the field survey controller. Point measurements (XYZ) are collected with the GPS rover receiver along the pre-established profile line, starting at the benchmark, and running perpendicular to the general trend of the shoreline. As an example, the following steps apply when using the field survey controller and the Trimble Survey Controller software (Figs. S5.5 and S5.6):

1. Zoom the scale bar to **-2m-** in the Map screen, to establish the accuracy of the measurements
2. Position the rover on the profile line immediately seaward of the benchmark. Verify on the **-map-** screen, that the cross (rover position) aligns with the profile line.
3. Hit **-measure-**
4. In the new screen, key in the following information:

Under **-point name-** key in the ID of the point:

Benchmark'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 will keep the prefix - benchmark's id - and will change the last number in an increasing order)

Selection of the locations for measurement:

→ 1 point is measured at least every 5 meters

→ 1 point is measured at every change in slope, 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, . (Fig. S5.6)

→ 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 will be displayed)

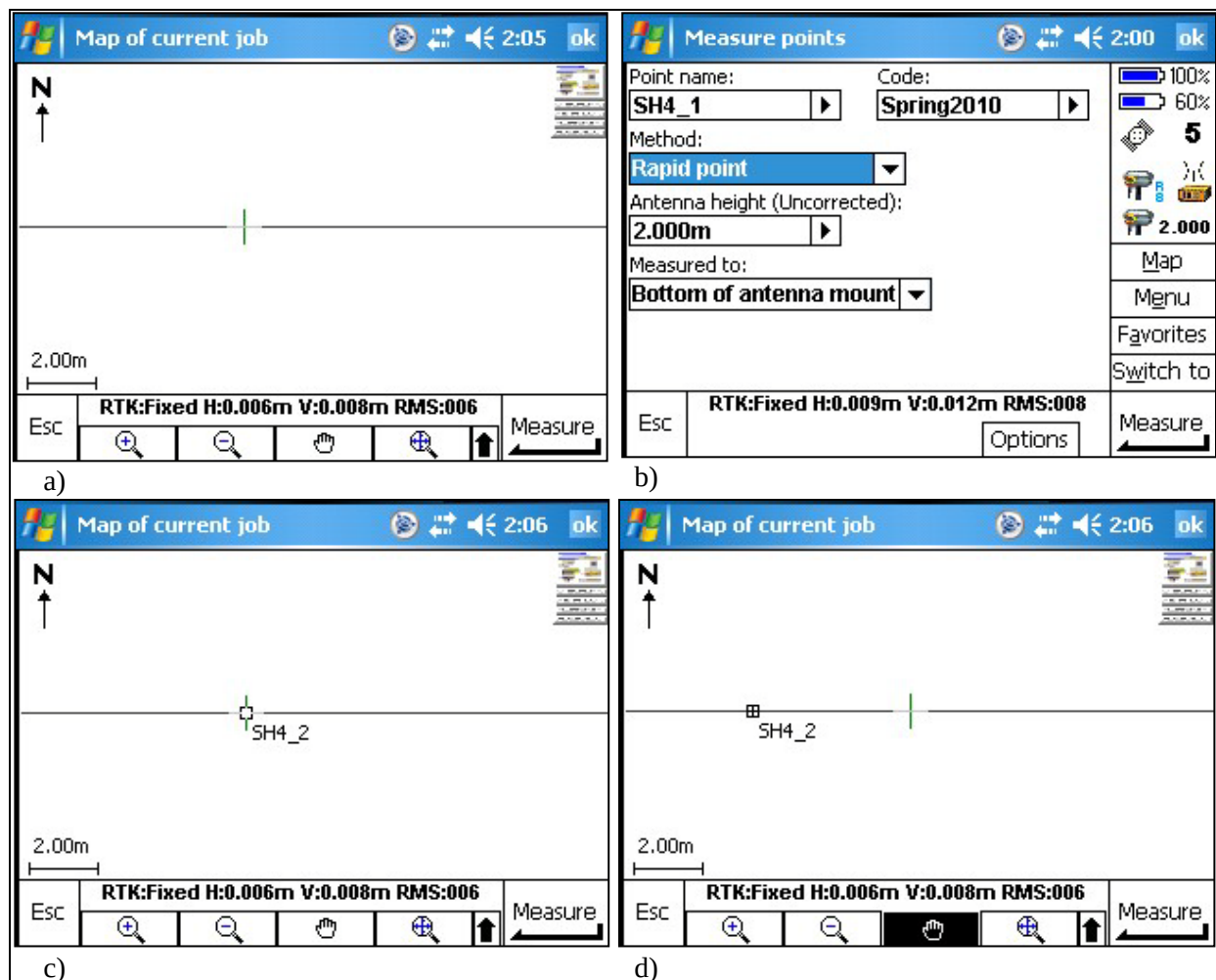


Figure S5.5. Trimble Survey Controller screen showing the collection of topographic points along the profile line. a) *Map* screen showing the position of the rover (cross) over the profile line; b) *Measure Points* screen showing the options for the measurement of the rapid point; c) *Map* screen showing the collected point; and d) *Map* screen showing the position of the rover over the profile line to collect the next point.

Photographic record

At least one photograph is taken at each profile line to capture the general aspect of the dune/bluff feature present on the profile (Fig. S5.7). The photograph must be taken always from the same angle so that the record is comparable:

1. Position yourself along the profile line, at the base of the dune or bluff looking seaward
2. Walk 10 steps towards your right side – At CACO, ASIS and at most of the units of GATE, this will mean towards the south
3. Take a picture from that position and looking directly towards the profile line. When possible, some sort of marker (flag, sticks, etc.) could be placed along the survey line to help identify it in the photo.



Figure S5.6. Measurement of topographic points along the profile line. Example of points being measured at change in slope: at top and bottom of the feature (Sandy Hook, May 2010).



Figure S5.7. Photograph of profile location, taken during the fall 2009 Coastal Topography survey conducted at Breezy Point, Jamaica Bay Unit of GATE (Breezy Point, November 2009).

The surveyor 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 profile must be entered in the FDF in the “Photos” field under the “Surveyed Profiles” section.

Interruptions and Segmented Profiles

Interruptions to the Survey

Natural or artificial conditions may be present along the beach profile that promote perturbations to the topography. In these cases, a note should be entered in the FDF under the respective surveyed profile notes, and the surveyor should collect survey points according to the type of perturbation present (Table S5.1).

Table S5.1. Actions to take in the field when perturbations are encountered along the profile line.

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 profiles described below if the elevation difference is great.
Hard structures:	Seawalls Bike paths	If a human-made structure intersects the profile 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 survey, skip the area where the structure is present and proceed with the survey only in the natural area. Make a note on the FDF.
Human interference:	Anglers Tire tracks	Avoid anglers or other visitors that may be on the profile line 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 profile line.

Segmented Profiles

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 surveyor 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 profile line.

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

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

1. If the profile 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 profile line” specifications above. Use A for the segment closest to the benchmark and B (and the next letters) for the next segments:

Benchmark’s ID_ A1 (e.g., SH4_A1)

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

Benchmark’s ID_ -1 (e.g., SH4_-1)

Ending the Survey

After the daily survey is completed, end the survey and return to the office to:

1. Complete the Field Data Form
2. Download the data and make a backup copy (SOP#6) to avoid losing it due to equipment malfunction
3. Download and catalogue the photographs (SOP#6)
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

Field Data Form - Coastal Topography Survey

Form SOP#5-1:

Event Information		Surveyed Profiles			
Survey Date:					Notes (include Benchmark condition, aspects of morphology, etc.):
Park Unit					
Start Time:					
End Time:					
Observer's name:					
Protocol/SOP version:					
Date of last storm event:					
GPS-RTK Device					
Make and Model:					
Set-up:					
Base Benchmark used / CORS ref. station used					
Survey Notes (List any equipment problems, radio signal issues or obstacles encountered, etc.)					
Time of incident: (from GPS-RTK unit)		Notes:			

**For extra survey notes, use additional blank page and attach to this form*

SOP 6: Initial Post-Survey Processing

Version 1.0 (July 2010)

The following table lists all changes that have been made to this Standard Operating Procedure 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 Project Leader. The project leader will review and incorporate all changes, officially complete the revision history log, and change the date and version number on the title page. For complete instructions, please refer to SOP#9 – Revising the Protocol.

Revision History Log:

New Version #	Previous Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change

This SOP describes how to download, export, and perform QA/QC checks 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 NCBN data manager for storage and analysis. The procedural steps will be illustrated using the Trimble Business Center software.

Data Download, Export and Creation of ESRI Feature Classes

Data Download

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

Data Export

Create a project on Trimble Business Center (TBC) software with the settings described on SOP#4 - Settings for Collection of Topography, and save it with the name that includes the following information:

Protocol Nomenclature_”2D”_season and year

e.g.: GATE_SHU_2D_Spring2010

Once the project has been created (Fig. S6.1):

1. Import the .dc file that was downloaded from the field survey controller
2. Select the Job's survey points collected at the profile benchmarks' locations and along the profile lines
3. Select the *Custom tab* under the Export command pane and save the data as an ESRI feature class (.xml) with the following format:

P, E, N, elev, Code

(Point ID, Easting, Northing, Elevation, Code)

The file name will be the same as the Job file from which the data are being exported:

Protocol Nomenclature_”2D”_date (yyyymmdd)

e.g.: *GATE_SHU_2D_20100524*

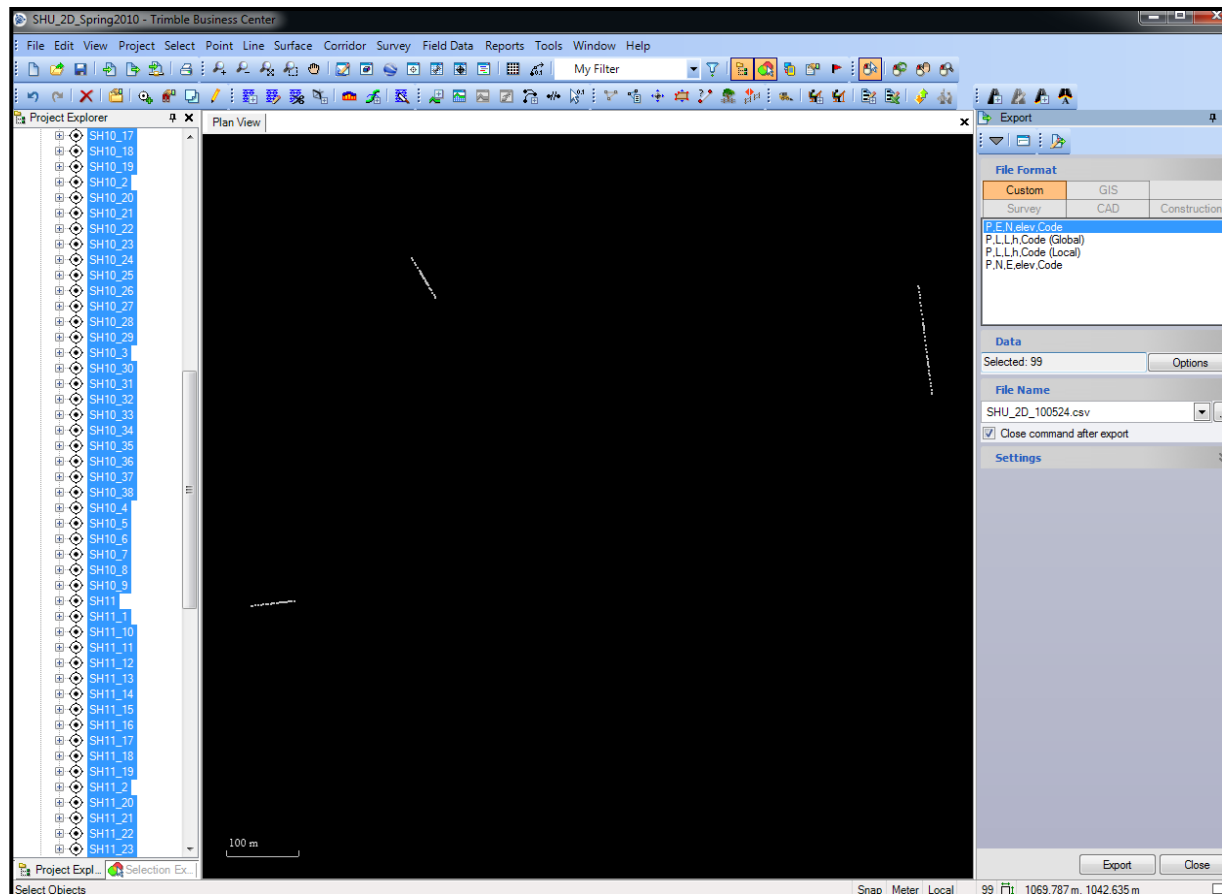


Figure S6.1. Trimble Business Center software screen showing the plan view of the points collected in the field (3 profiles in the central black background area) and the Export command pane (on the right).

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 will automatically create a file folder (in the same folder selected to create the TBC project) with all the imported Job files (.dc) and with the exported feature class files (.xml).

Viewing the Exported Feature Class in ArcMap

The exported .xml file will be imported as an ESRI feature class 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 Profile Benchmarks, Profile Lines, and auxiliary files with the buffer areas (see SOP#2).
2. Open ArcCatalog, right-click the geodatabase into which you want to import the feature class, and choose and point to Import > XML Workspace Document... Click XML Workspace Document (Figure S6.2).
3. Click Data and navigate to the .xml workspace file from which you want to import data.
4. Click Next.
5. Any naming conflicts display in red. To change a suggested name in the Target Name column, type over it.
6. Open ArcMap and add the newly imported feature class

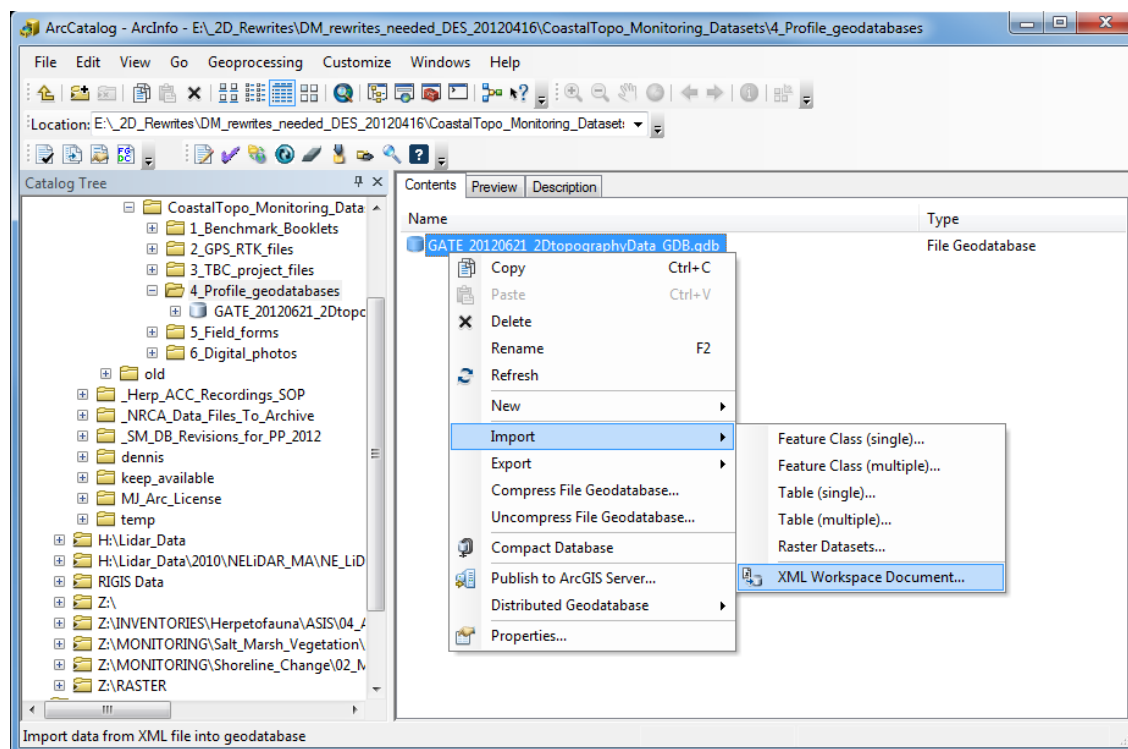


Figure S6.2. Using ArcCatalog to import the .xml workspace.

QA/QC Check and Metadata Creation

QA/QC Check

Plot the exported ESRI point feature class against the park's Profile Benchmarks, Profile Lines, and auxiliary files with the buffer areas (from the GIS database created according to SOP#2) in ArcMap to verify the following (Fig. S6.3):

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

Conduct the verification by using the *-Selection by Location-* tool in ArcMap 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 profile location and re-run the survey. Once the data have been verified and checked for accuracy, finish filling in the Field Data form.

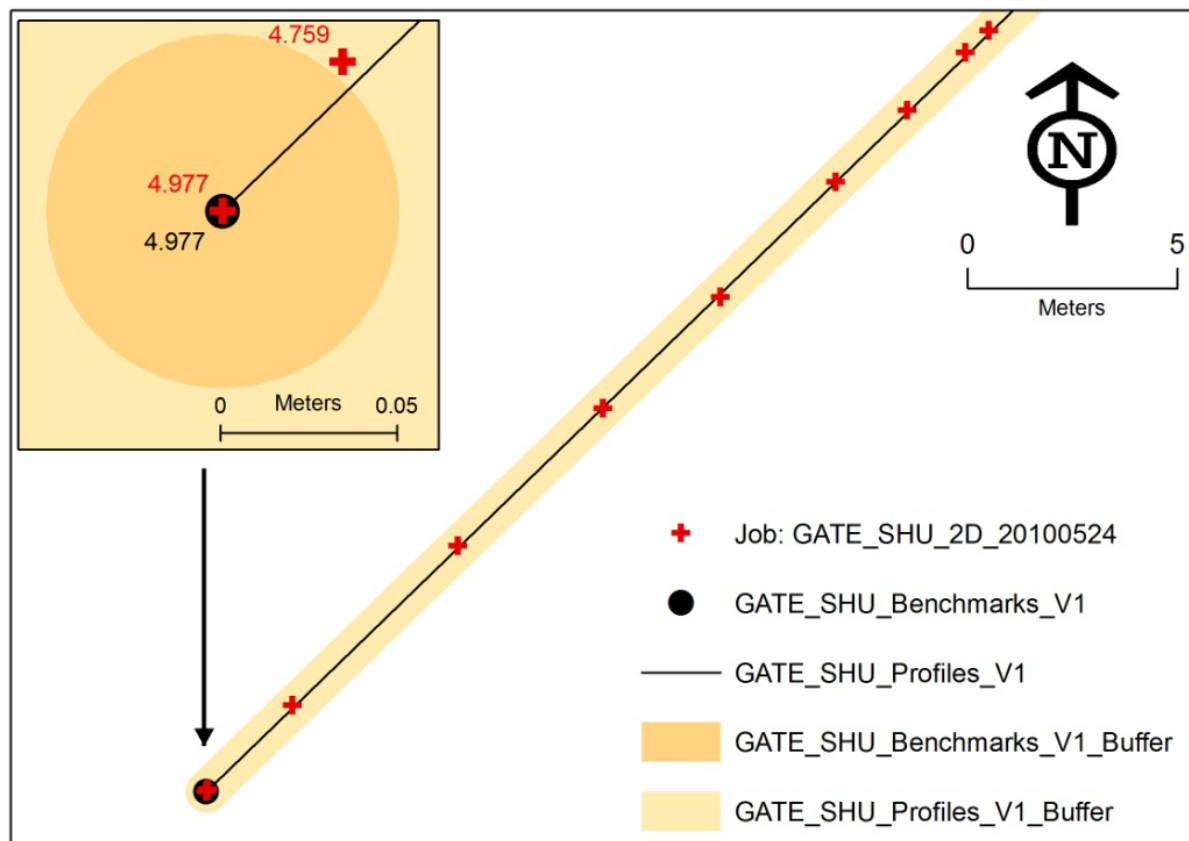


Figure S6.3. Location of the survey points collected at the profile benchmark and along the profile line and the respective 0.05 m and 0.5 m buffer areas. The elevations of the original benchmark (black circle, black font) and the collected point at the benchmark (red cross, red font) are displayed in the inset.

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 have been run and verified for accuracy, the feature classes derived from each Job file must be merged to create one feature class per Park, Park Unit or Park Section (use the *-Merge-* tool in ArcMap). Metadata must be created for each of the Park Units' feature classes.

The NCBN data manager will provide the parks with a metadata template for the Coastal Topography Protocol that already contains much of the relevant information regarding the collection of the profile points. Most of the remaining information to be included will be derived directly from the field sheet completed prior-to and during the data collection process. Table S6.1 summarizes where this information should be included in the metadata file.

Table S6.1. Organizational comparison of field data and metadata files.

Field form data	Metadata tag
Park Unit	Abstract Keywords
GPS 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

Table S6.1. Organizational comparison of field data and metadata files.

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 profile line 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 profile site and rename the photographs to reflect the profile's ID and date of the survey to which they refer:

GATE_SHU_SH10_20100524

Protocol Nomenclature_ Benchmark's ID _ date (yyyymmdd)

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

GATE_SHU_SH10_20100524_1

Protocol Nomenclature_ Benchmark's ID _ date (yyyymmdd) _ number of photo

Each photo must not exceed 800 x 600 pixels in size, to facilitate sharing the photo file with the NCBN data manager. 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 Job (.dc file) as described above.

Final Product Delivery

Following all of the quality control procedures and creation of metadata, the final dataset of the surveyed profiles will be sent to the NCBN data manager. The following data products should be delivered to the NCBN data manager for storage, analysis, and archiving in the Coastal Topography Database:

- All original job files (.dc) downloaded from the GPS-RTK unit
- TBC project folder with all the jobs imported (one per Park, Park Unit, or Park Section)
- ESRI point feature classes (.xml format) (one per Park, Park Unit, or Park Section) with metadata
- Hard or scanned copies of all field data forms
- Photographs taken during survey

These items should be emailed to the data manager (see website for address: <http://www.nature.nps.gov/im/units/ncbn/>), posted via the NPS public FTP site, or saved to disc and mailed to:

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

SOP 7: Data Analysis and Reporting

Version 1.0 (July 2010)

The following table lists all changes that have been made to this Standard Operating Procedure 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 Project Leader. The project leader will review and incorporate all changes, officially complete the revision history log, and change the date and version number on the title page. For complete instructions, please refer to SOP#9 – Revising the Protocol.

Revision History Log:

New Version #	Previous Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change

This SOP describes the derivation of the beach profiles from the survey points; it consists of three components: the first component describes the method for using the Excel application 2D Analyst to generate the profile cross-sections, derive dimensional parameters of each profile, and store the data sets in a matrix. The second component describes how the suite of measurements derived from the beach profiles is used to portray temporal and spatial geomorphologic change. The third component presents a series of guidelines that describe the composition of the data portrayal and analysis used in the production of the Annual Report and in the Project Term Report.

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

The Coastal Topography protocol uses the Excel application 2D Analyst 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
- NAVD88 distance from Benchmark
- Foredune crest height
- Foredune crest distance from Benchmark

For beach profiles with bluff features:

- Cross-section area above NAVD88
- NAVD88 distance from Benchmark
- Bluff's edge elevation
- Bluff's edge distance from Benchmark

The raw profile data collected along each profile is stored in the ESRI feature class created in SOP#6. The attribute table of the feature class stores the points' information (coordinates and elevation) To access the raw profile data follow the steps:

1. Open ESRI ArcMap Desktop and add the feature class containing the profile data
2. R-click on the feature class in the Table of Contents, and select Open Attribute Table
3. Select the records in the table that correspond to the data collected along the profile being analyzed, except for the Benchmark point (Fig. S7.1). R-click on the selected records and choose Copy Selected.

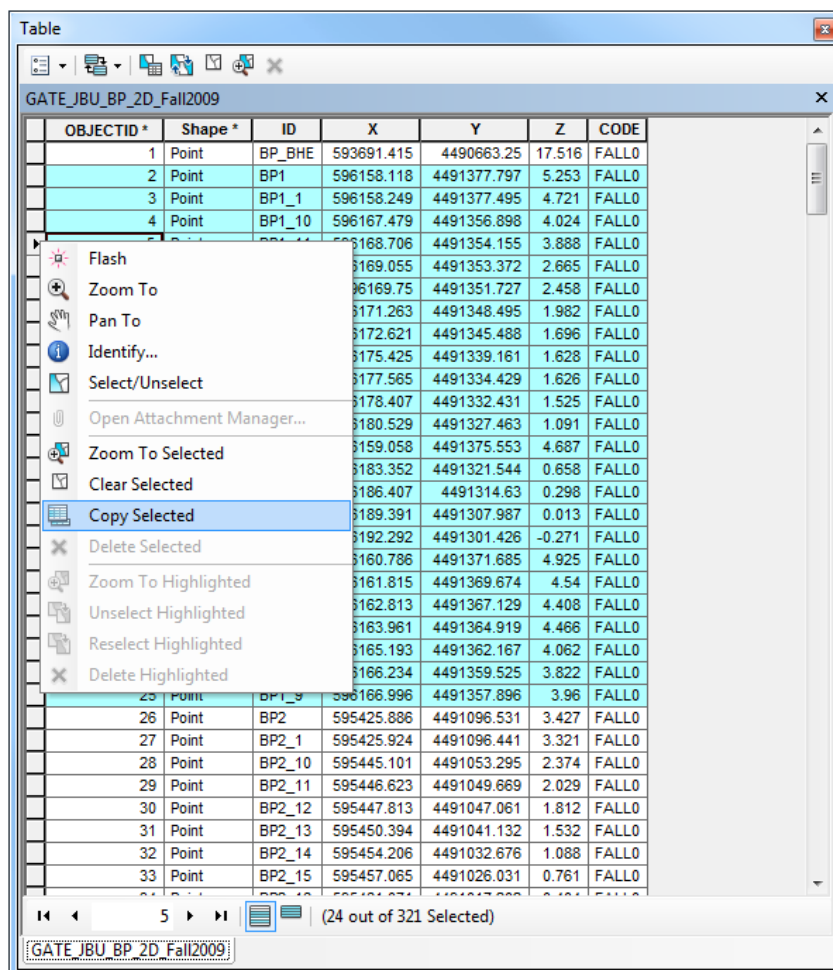


Figure S7.1. Selecting and copying profile data in ArcMap Desktop.

4. Open Microsoft Office Excel, and paste the copied records in a new, blank worksheet

Each profile dataset will be selected and run through 2D Analyst independently to derive the dimensional parameters:

1. Open 2D Analyst and select - *enable Macros* -
2. Save the 2D Analyst file with the name of the profile that is going to be analyzed, as follows:

Protocol Nomenclature_ Benchmark's ID _ Season and Year

e.g.: *GATE_SHU_SH10_Spring2010*

3. From the previously opened Excel worksheet, select the cells that correspond to the data collected along the profile being analyzed, except for the Benchmark point (Fig. S7.2)

ID	X	Y	Z	Code
SH10	584033.958000000000	4481068.232000000000	2.570000000000	FALL09
SH10_1	584033.864000000000	4481068.898000000000	2.325000000000	FALL09
SH10_10	584028.887000000000	4481109.570000000000	1.765000000000	FALL09
SH10_11	584028.750000000000	4481110.865000000000	1.944000000000	FALL09
SH10_12	584028.334000000000	4481113.649000000000	1.608000000000	FALL09
SH10_13	584027.810000000000	4481117.205000000000	1.613000000000	FALL09
SH10_14	584027.632000000000	4481119.188000000000	1.646000000000	FALL09
SH10_15	584027.476000000000	4481120.807000000000	1.423000000000	FALL09
SH10_16	584026.849000000000	4481126.054000000000	1.322000000000	FALL09
SH10_17	584026.252000000000	4481131.115000000000	1.322000000000	FALL09
SH10_18	584025.539000000000	4481136.476000000000	1.451000000000	FALL09
SH10_19	584024.728000000000	4481142.660000000000	1.398000000000	FALL09
SH10_2	584033.236000000000	4481073.478000000000	2.345000000000	FALL09
SH10_20	584024.132000000000	4481148.609000000000	1.550000000000	FALL09
SH10_21	584023.439000000000	4481153.680000000000	1.781000000000	FALL09
SH10_22	584023.077000000000	4481157.589000000000	1.763000000000	FALL09
SH10_23	584022.779000000000	4481159.670000000000	1.867000000000	FALL09
SH10_24	584022.541000000000	4481161.461000000000	1.614000000000	FALL09
SH10_25	584022.293000000000	4481163.297000000000	1.584000000000	FALL09
SH10_26	584022.077000000000	4481165.312000000000	1.752000000000	FALL09
SH10_27	584021.921000000000	4481166.191000000000	1.683000000000	FALL09
SH10_28	584021.719000000000	4481167.715000000000	1.492000000000	FALL09
SH10_29	584021.065000000000	4481173.021000000000	1.448000000000	FALL09
SH10_3	584032.540000000000	4481079.651000000000	2.187000000000	FALL09
SH10_30	584020.406000000000	4481179.080000000000	1.377000000000	FALL09
SH10_31	584019.544000000000	4481185.233000000000	1.164000000000	FALL09
SH10_32	584018.867000000000	4481191.210000000000	0.957000000000	FALL09
SH10_33	584018.176000000000	4481196.494000000000	0.750000000000	FALL09
SH10_34	584017.560000000000	4481202.430000000000	0.549000000000	FALL09
SH10_35	584016.878000000000	4481206.681000000000	0.481000000000	FALL09
SH10_36	584016.354000000000	4481211.401000000000	0.221000000000	FALL09
SH10_37	584015.867000000000	4481215.920000000000	-0.051000000000	FALL09
SH10_38	584015.295000000000	4481219.234000000000	-0.234000000000	FALL09
SH10_4	584032.061000000000	4481083.147000000000	2.211000000000	FALL09
SH10_5	584031.438000000000	4481088.482000000000	1.659000000000	FALL09
SH10_6	584030.710000000000	4481094.086000000000	1.402000000000	FALL09
SH10_7	584030.311000000000	4481097.163000000000	1.639000000000	FALL09
SH10_8	584029.898000000000	4481101.303000000000	1.968000000000	FALL09
SH10_9	584029.257000000000	4481106.753000000000	1.774000000000	FALL09
SH11	583343.873000000000	4481203.178000000000	1.904000000000	FALL09
SH11_1	583343.300000000000	4481203.727000000000	1.660000000000	FALL09

Figure S7.2. Select the cells with the ID, X, Y and Z data relative to the profile being analyzed. Do not include the Benchmark point.

- Copy the selection and Paste it into the “STEP 1: ENTER PROFILE DATA BELOW:” area of the 2D Analyst file (Fig. S7.3)

STEP 1: ENTER PROFILE DATA BELOW:

ID	Eastings (X)	Northing (Y)	Elevation
SH10_1	584033.864	4481068.898	2.325
SH10_10	584028.887	4481109.57	1.765
SH10_11	584028.75	4481110.865	1.944
SH10_12	584028.334	4481113.649	1.608
SH10_13	584027.81	4481117.305	1.613
SH10_14	584027.632	4481119.188	1.646
SH10_15	584027.476	4481120.807	1.423
SH10_16	584026.849	4481126.054	1.322
SH10_17	584026.252	4481131.115	1.322
SH10_18	584025.539	4481136.476	1.451
SH10_19	584024.728	4481142.66	1.398
SH10_2	584033.236	4481073.478	2.345
SH10_20	584024.132	4481148.609	1.55
SH10_21	584023.439	4481153.68	1.781
SH10_22	584023.077	4481157.589	1.763
SH10_23	584022.779	4481159.67	1.867
SH10_24	584022.541	4481161.461	1.614
SH10_25	584022.293	4481163.297	1.584
SH10_26	584022.077	4481165.312	1.752
SH10_27	584021.921	4481166.191	1.683
SH10_28	584021.719	4481167.715	1.492
SH10_29	584021.065	4481173.021	1.448
SH10_3	584032.54	4481079.651	2.187
SH10_30	584020.406	4481179.08	1.377
SH10_31	584019.544	4481185.233	1.164
SH10_32	584018.867	4481191.21	0.957
SH10_33	584018.176	4481196.494	0.75
SH10_34	584017.56	4481202.43	0.549
SH10_35	584016.878	4481206.681	0.481
SH10_36	584016.354	4481211.401	0.221
SH10_37	584015.867	4481215.92	-0.051
SH10_38	584015.295	4481219.234	-0.234
SH10_4	584032.061	4481083.347	2.211
SH10_5	584031.438	4481088.482	1.659
SH10_6	584030.71	4481094.066	1.402

STEP 2: DOES THE DATA NEED TO BE SORTED?

Yes (continuous profile)
 (1, 2, 3, etc)

Yes (segmented profile)
 (A1, A2, B1, etc)

No

STEP 3: ENTER ELEVATION THRESHOLD: 0

Total area above threshold: 0.00
 *Square units

Distance from starting point of profile to elevation threshold: 0.00

Important information about this program:
 The 2D Analyst was created to perform the quantitative analysis of the beach profile data collected within the Northeast Coastal and Barrier Network Geomorphological Monitoring Protocol: Part II—Coastal Topography
 The process steps are made assuming that the profile data entered in Step 1 are in agreement with the format enounced in the Protocol.

Figure S7.3. Paste the selected and copied cells into 2D Analyst, in the area of “STEP 1: ENTER PROFILE DATA BELOW:”

- In “STEP 2: DOES THE DATA NEED TO BE SORTED?” of 2D Analyst, select one of the options according to the data inserted in STEP 1:

The profile data were collected continuously and the ID column data are not sorted from smallest to largest number

→ select 1st button:

Yes (continuous profile)

The profile data were collected in segments and therefore include a letter prefix and the ID column data are not sorted from smallest to largest number

→ select 2nd button:

Yes (segmented profile)

The profile’s ID column data are sorted from smallest to largest number

→ select 3rd button:

No

The Program will automatically perform the calculations and derive the distance/elevation sequence of the profile.

6. Select the -GRAPH- spreadsheet in the lower right corner of 2D Analyst to preview the beach profile.
7. In “STEP 3: ENTER ELEVATION THRESHOLD:” of the -DATA- spreadsheet in 2D Analyst enter “0” – the elevation of NAVD88.
8. The “Cross-section area above NAVD88” and the “ NAVD88 distance from Benchmark” will be displayed in the grey box of 2D Analyst:

“Total area above threshold:”	➔	Cross-section area above NAVD88
“Distance from starting point of profile to elevation threshold:”	➔	NAVD88 distance from Benchmark

9. Look at the beach profile portrayal in the -GRAPH- spreadsheet and depending on the beach morphology present, identify the point that marks the position, the elevation, and the distance from the Benchmark of:
 - a) The foredune crest (Fig. S7.4), or
 - b) The bluff’s edge (Fig. S7.5)

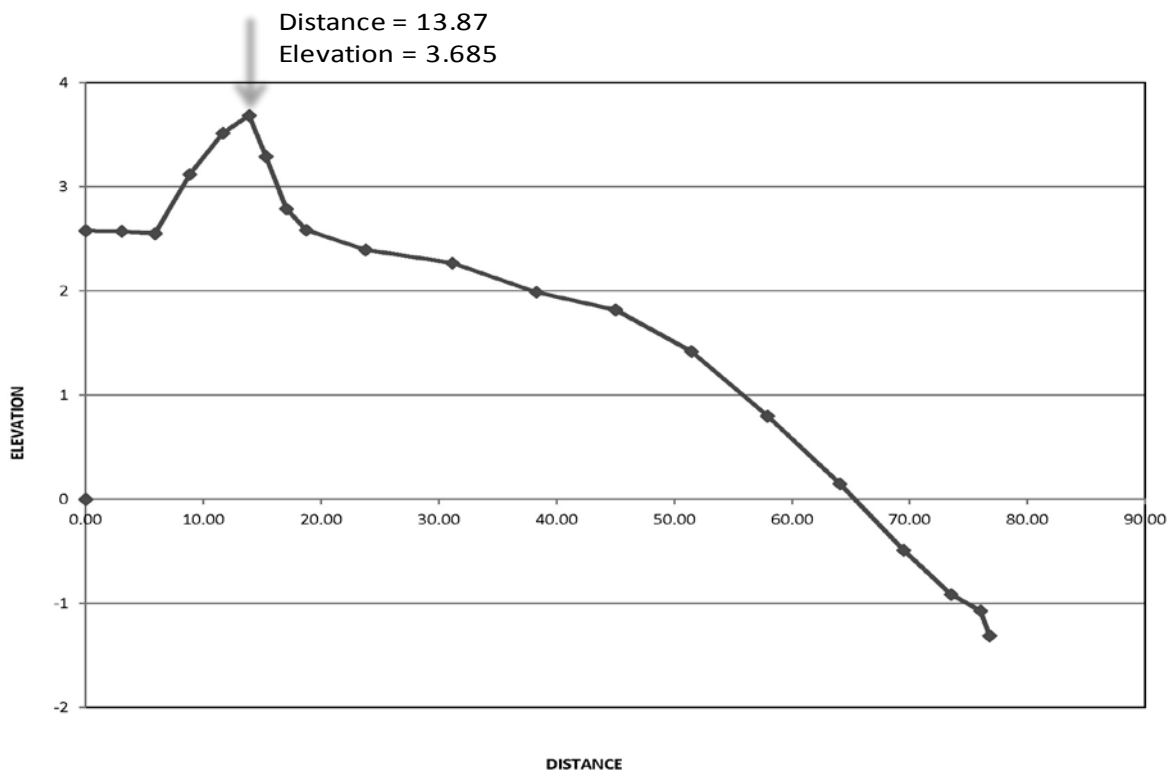


Figure S7.4. Identification of the point on the beach profile graphical portrayal that represents the foredune crest position, elevation, and distance from the benchmark.

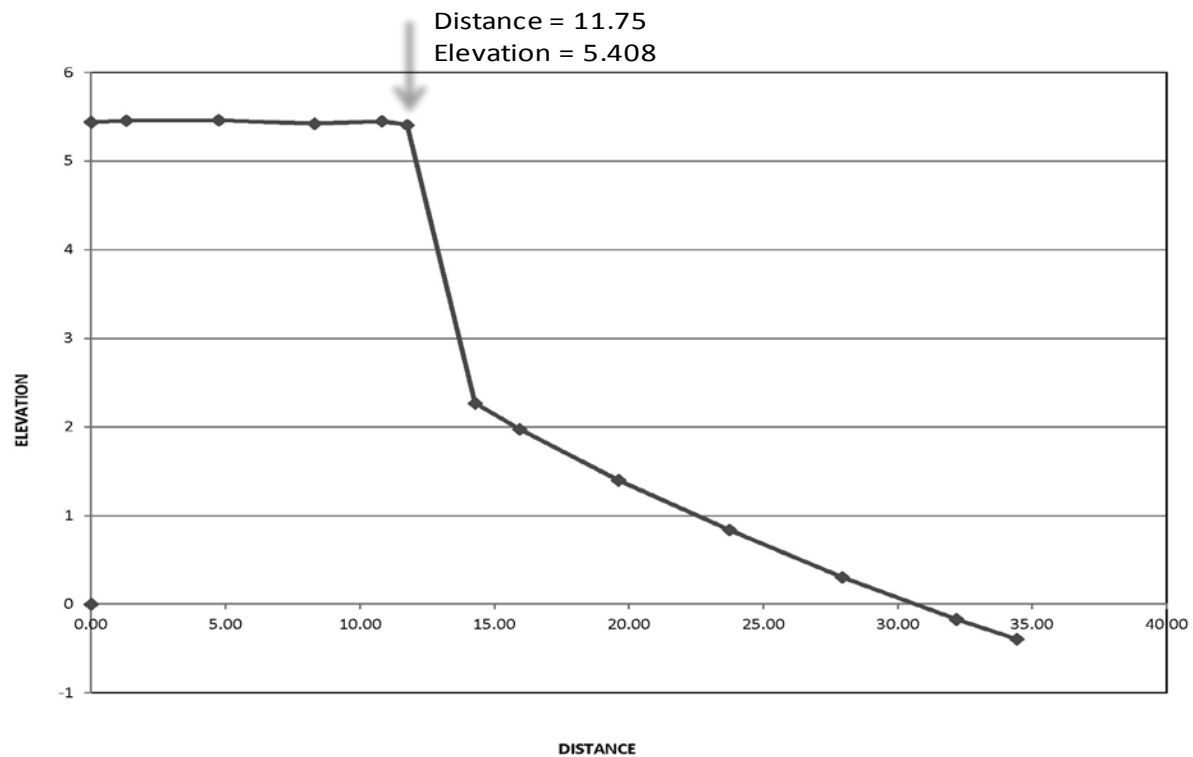


Figure S7.5. Identification of the point on the beach profile graphical portrayal that represents the bluff's edge position, elevation, and distance from the benchmark.

Repeat steps 1 through 9 for each profile and save the 2D Analyst files into the same project folder.

The dimensional parameters derived from the beach profiles are stored in a Data Matrix with the measurements for all the park's profiles for each survey season and with the summary statistics for each Park, Park Unit, or Park Section, according to the Protocol Nomenclature (Table S7.1). The Matrix will be created in an Excel spreadsheet and the dimensional parameters derived in 2D Analyst, will be copied to the matrix. The statistics will include the mean, standard deviation, maximum, and minimum values for the overall beach profiles monitored along the park.

Table S7.1. Data Matrix with dimensional parameters and summary statistics derived from the beach profiles at Great Kills (Staten Island Unit of Gateway National Recreation Area, NY) for the fall 2009 survey.

Dimensional Parameters for Great Kills – Fall 2009						
Benchmark	Cross-section Area above NAVD88 (m ²)	NAVD88 distance from Benchmark (m)	Profile with foredune features		Profile with bluff features	
			Foredune crest elevation (m)	Foredune crest distance f/ Benchmark (m)	Bluff edge elevation (m)	Bluff edge distance f/ Benchmark (m)
GK1	118.66	40.26			4.39	21.83
GK2	68.03	27.58			4.95	8.94
GK3	90.83	30.64			5.41	11.75
GK4	64.11	31.51			3.30	12.03
GK5	141.32	66.06	3.83	14.32		
GK6	122.93	51.43	3.66	21.93		
GK7	85.13	58.67	2.90	18.35		
GK8	45.04	30.04			2.25	15.54
GK9.1	46.26	31.90	2.96	7.05		
GK9.2	77.38	58.99	2.73	7.45		
Mean	85.97	42.71	3.22	13.82	4.06	14.02
StDev	32.74	14.62	0.50	6.58	1.28	4.96
Max	141.32	66.06	3.83	21.93	5.41	21.83
Min	45.04	27.58	2.73	7.05	2.25	8.94

Quantifying Change by Comparison of the Dimensional Parameters Seasonal Changes

The seasonal changes, either spring-to-fall or fall-to-spring, are the differences in geomorphology between consecutive surveys (Fig. S7.6). 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.

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 (Table S7.2 and Fig. S7.7). Data sets presented in tabular form should include summary statistics. The mean seasonal change will represent 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 (Fig. S7.8).

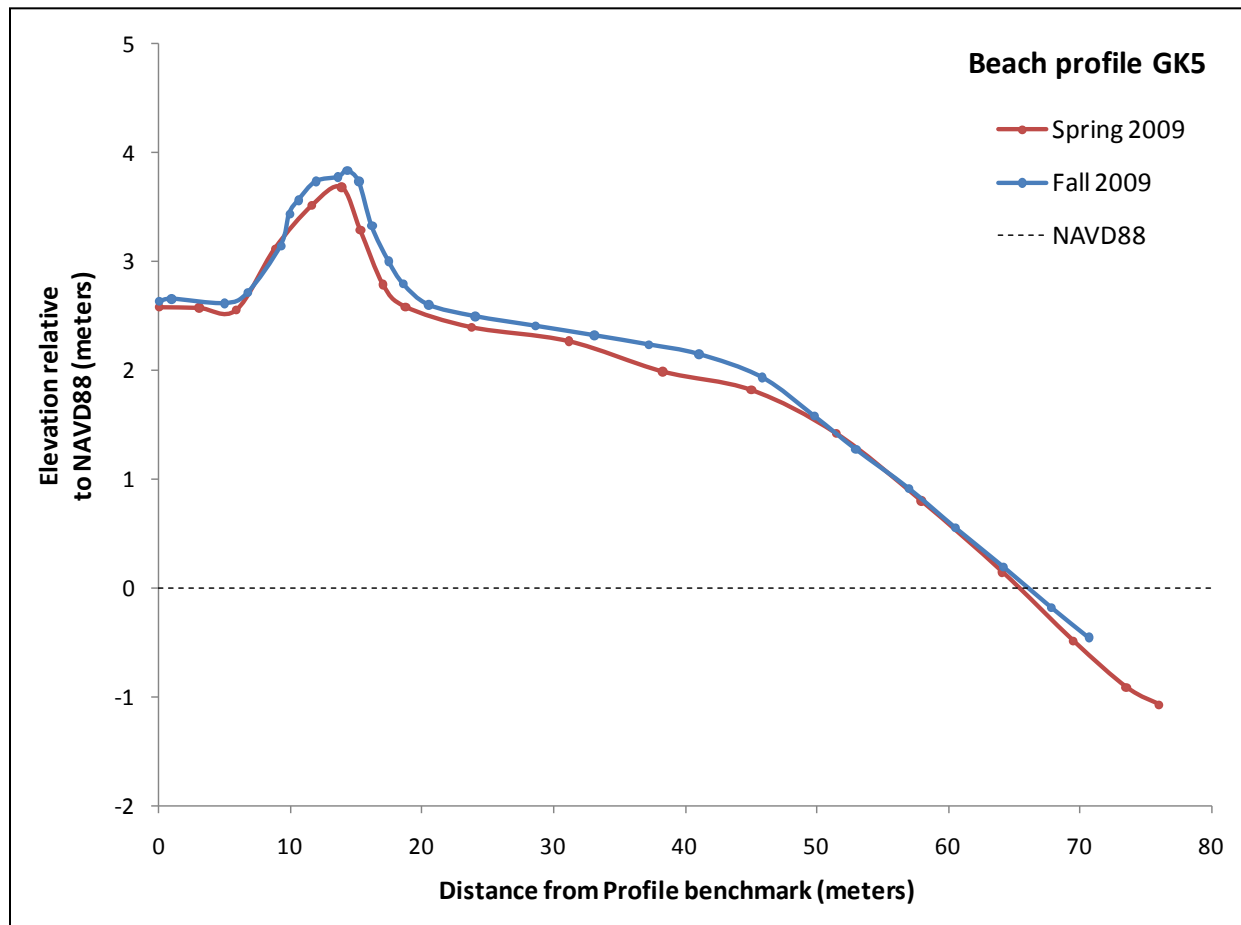


Figure S7.7. Comparison of the cross-sections of Beach Profile GK5 for spring and fall 2009 (Great Kills, Staten Island Unit of Gateway National Recreation Area, NY).

Table S7.2. Data Matrix with the change of the dimensional parameters and summary statistics between spring and fall 2009 for the beach profiles at Great Kills (Staten Island Unit of Gateway National Recreation Area, NY). All values in meters except for cross-section area that is in square meters.

Change in the Dimensional Parameters for Great Kills – Spring to Fall 2009						
Benchmark	Cross-section Area above NAVD88 (m ²)	NAVD88 distance from Benchmark (m)	Foredune features		Bluff features	
			Foredune crest elevation (m)	Foredune crest distance f/ Benchmark (m)	Bluff edge elevation (m)	Bluff edge distance f/ Benchmark (m)
GK1	3.29	1.83			0.10	-0.07
GK2	5.92	2.28			0.11	-0.35
GK3	-0.31	1.53			0.08	-0.87
GK4	-1.05	0.35			0.12	-1.15
GK5	7.35	0.75	0.15	0.45		
GK6	5.43	0.05	0.18	1.67		
GK7	3.62	2.07	0.07	0.30		
GK8	-2.09	-1.15			0.01	-0.74
GK9.1	0.77	-0.01	0.10	-0.87		
GK9.2	7.10	0.35	0.13	0.50		
Mean	3.00	0.80	0.11	0.34	0.08	-0.64
StDev	3.48	1.10	0.06	0.82	0.04	0.43
Max	7.35	2.28	0.18	1.67	0.12	-0.07
Min	-2.09	-1.15	0.00	-0.87	0.01	-1.15

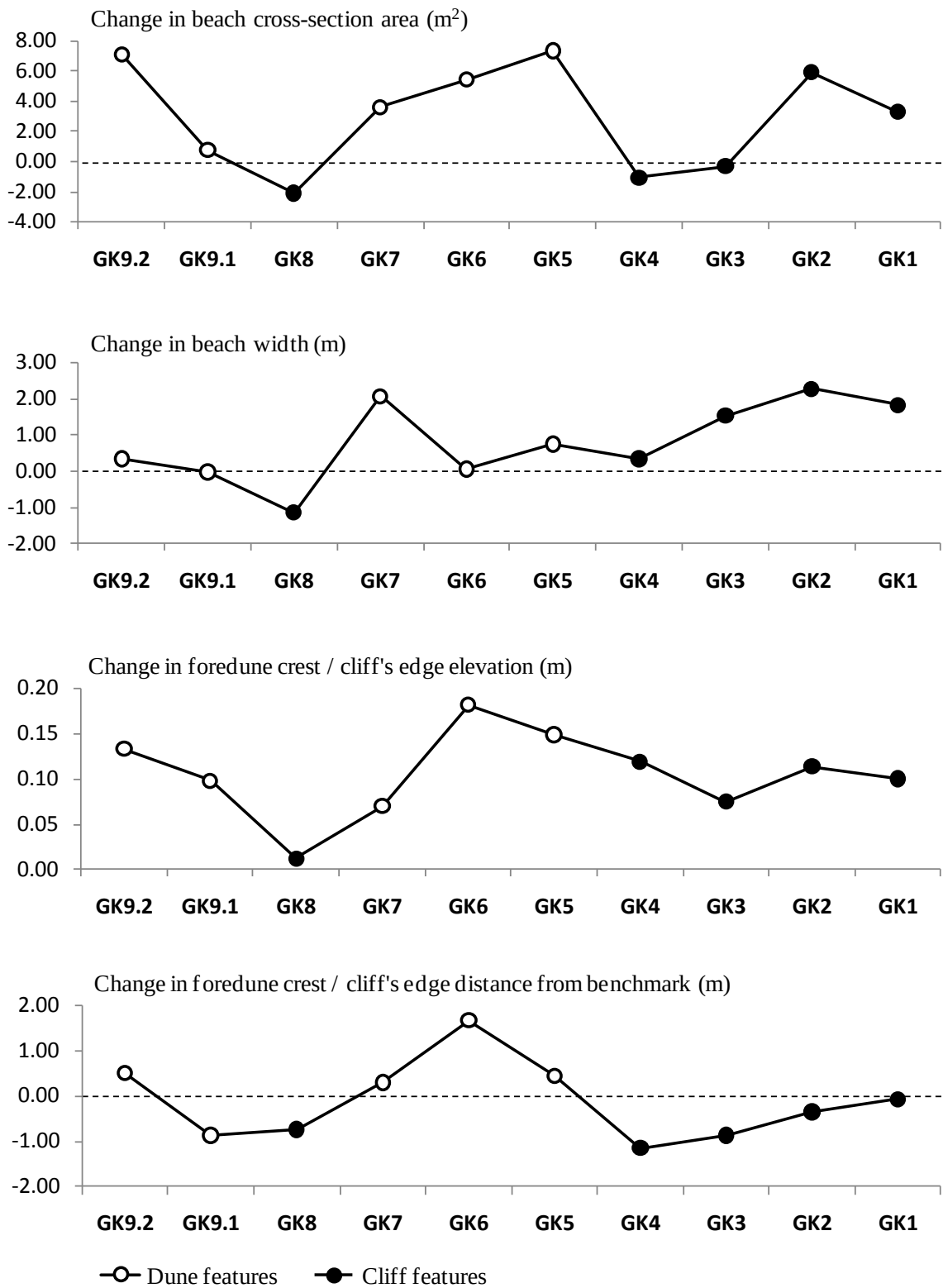


Figure S7.8. Graphical portrayal of the change of the dimensional parameters between spring and fall 2009 for the beach profiles at Great Kills (Staten Island Unit of Gateway National Recreation Area, NY).

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 supply (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 include summary statistics, such as mean and standard deviation (Table S7.2). The graphical portrayal of the change in dimensional parameters for all the profiles along the park will help evaluate the alongshore variation of these changes (Fig. S7.8).

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 will 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.

Production of Reports

Annual Project Report

The Annual Project Report is a summary of the geomorphological change data over the period of one year (three surveys). General statistics (mean and standard deviation) will be 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 cultural 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

Project Trend Report

The Project Trend Report is a summary of the full database of coastal topography, with an emphasis on the previous five years. 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 cultural 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

SOP 8: Data Management

Version 1.0 (July 2010)

The following table lists all changes that have been made to this Standard Operating Procedure 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 Project Leader. The project leader will review and incorporate all changes, officially complete the revision history log, and change the date and version number on the title page. For complete instructions, please refer to SOP#9 – Revising the Protocol.

Revision History Log:

New Version #	Previous Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change

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 Network's 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. 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 QA/QC, archiving both spatial and tabular datasets, and making the data publicly accessible via National Park Service information clearinghouses.

A formal information management plan for all NCBN monitoring protocols is available at http://science.nature.nps.gov/im/units/ncbn/products/Data_manage/NCBN_DM_Plan_2004Dec15v2.pdf and should be consulted for more detailed policy information.

Definition of the Coastal Topography Dataset

The Coastal Topography Monitoring program will produce a number of electronic and paper data files that will include raw and post-processed spatial datasets, a Microsoft Access relational database, and scanned field forms. The large number and variety of files will require conscientious and formal attention to their management. It is the responsibility of the Network Data Manager and Project Leader to assemble, maintain, and make available the various components of the Coastal Topography dataset described here.

Baseline Data

Prior to data collection at a given park, an extensive array of survey benchmarks are located and/or created, and profile lines along a defined azimuth 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 equipment:

1. One ESRI point feature class containing all survey benchmark locations
2. One ESRI feature class containing all corresponding profile line features
3. One or more field booklets containing location information and other metadata regarding the above benchmarks and profile lines. Stored in Adobe Portable Document File (.pdf) format.
4. One ESRI polygon feature class containing a 0.05 m buffer of each survey benchmark location (for QAQC purposes)
5. One ESRI polygon feature class containing a 0.5 m buffer of each profile line feature (for QAQC purposes)

Survey Data

Once initial post-processing and export procedures have been completed by survey personnel (see SOP#6 – Initial Post-Survey Processing), the following datasets will be delivered for each park, twice per year, to the NCBN Data Manager or Project Leader. Files will be delivered in digital format by mail via CD/DVD or as compressed archive files via email or FTP.

1. All raw RTK-GPS data files, including Trimble data collector (.dc format) and job (.job format) files downloaded from the GPS unit
2. Scanned versions of all field data forms (Adobe .pdf format) associated with each Trimble job file
3. One Trimble Business Center (TBC) project file (.vce format)
4. One ESRI feature class (.xml format) containing all profile points having undergone quality control procedures as outlined in SOP#6 – Initial Post-Survey Processing.
5. Metadata for the above feature class which complies with Federal Geographic Data Committee (FGDC) standards and the NCBN spatial metadata template (available from the NCBN Data Manager)
6. All digital photographs taken at each profile location during the survey.

Analysis and Reports:

In addition to the collection and initial processing of shoreline positional data, Network personnel or contracted investigators will periodically conduct analyses of topographic change using the GPS profiles. These investigators will also produce annual and long-term (five-year) reports summarizing and interpreting the results from the above analyses. Copies of these reports will be delivered to the NCBN project leader and stored primarily in Adobe .pdf format.

The Microsoft Access Database

All raw data collected annually as part of the Coastal Topography Monitoring Protocol will be entered into the NCBN Coastal Topography Monitoring database, a Microsoft Access relational

database that is compliant with the NPS Inventory and Monitoring Program Natural Resource Database Template (NRDT) version 3.2 (<http://science.nature.nps.gov/im/apps/template/index.cfm>). Key aspects of the database design include:

- Ease of data entry, mirroring as closely as possible the processes for recording data on Protocol field sheets;
- Built-in quality assurance features (e.g., primary keys, cascading edits through multiple tables, lookup tables, numeric range limits, etc.); and
- Standardized formatting allowing for ease of data sharing and cross dataset analyses.

File Management and Documentation:

It is the responsibility of the NCBN Data Manager or designated Project Leader to assemble and maintain the various components of the Coastal Topography Dataset described above. The monitoring protocol generates a number of raw data products and reports that are not suitable for direct storage within a relational database, including raw and post-processed GPS data files, Trimble Business Center project files, ESRI feature classes, scanned field sheets (.pdf), and digital photographs. In order to ensure proper functioning of the Coastal Topography Monitoring Database and to generally ease the data retrieval process, the Database User's Guide identifies a coherent, consistent directory structure to store data files.

The master (i.e., most current) version of the Coastal Topography Monitoring Database will reside on the Network file server under the main drive in the file structure outlined in Figure S8.1.

In order for hyperlinks within the database to work properly, the main folder 'CoastalTopo_Monitoring_Datasets' should be placed at the same directory level as the Microsoft Access monitoring database itself (Fig. S8.1) and within the structure of the main 'CoastalTopo_Monitoring_Datasets' folder (Fig. S8.2). This directory structure, along with naming conventions for the various file types, is outlined in detail in Section 1.1 of the Database User's Guide

.

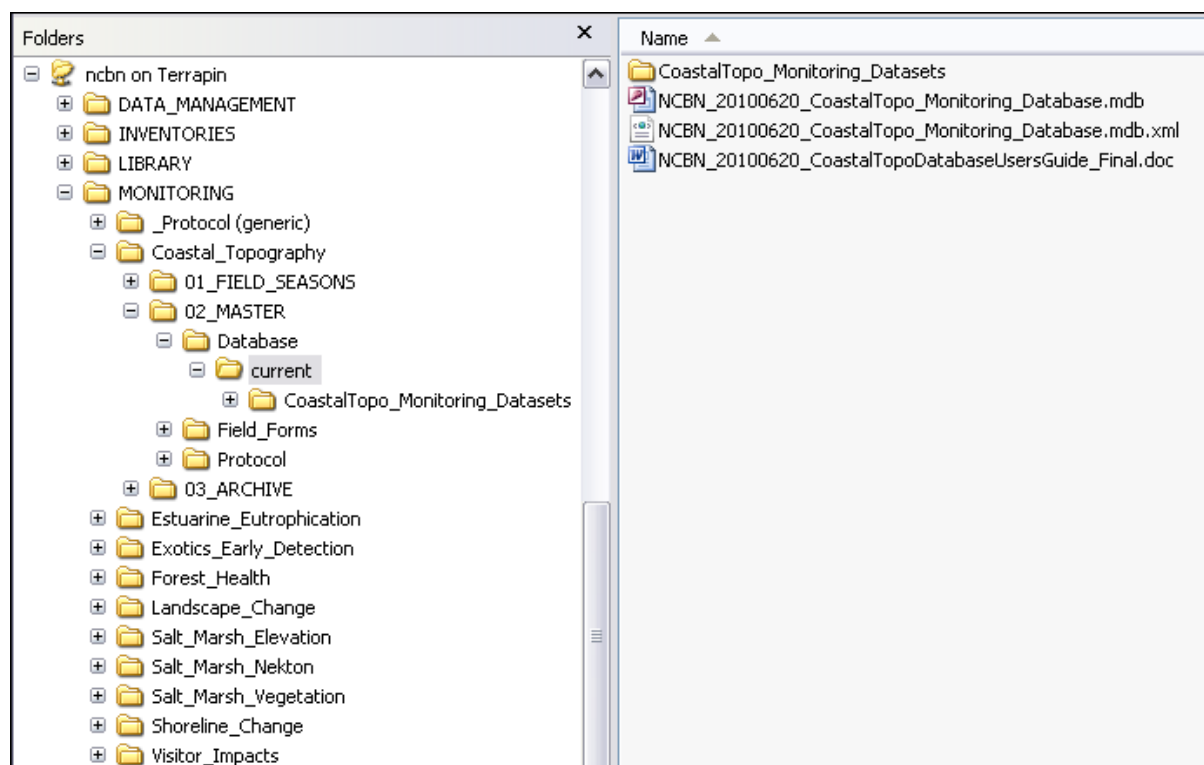


Figure S8.1. Location of Access database within the Network file server directory structure.

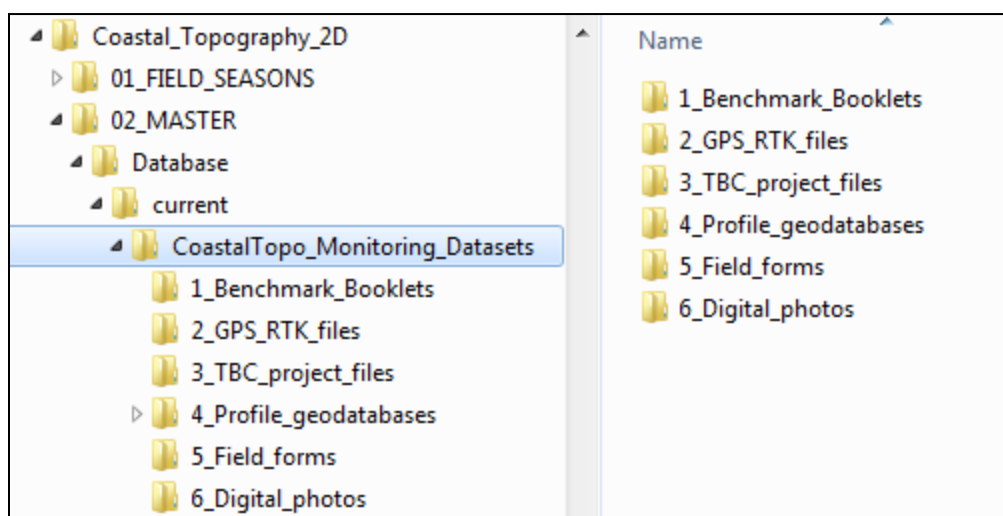


Figure S8.2. Directory structure for data files associated with the Coastal Topography Monitoring Database.

Data Entry

The NCBN Data Manager or designated Project Leader will be responsible for entering all data into the Access database. Data collected using paper field sheets 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. *NCBN Coastal Topography Monitoring Database User's Guide*, provides comprehensive instructions on entering raw data into the Microsoft Access application.

Baseline datasets

For each profile location, investigators have developed and surveyed benchmark locations and permanent transects against which subsequent RTK GPS data will be compared. Benchmark 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_Benchmark_Booklets."

GPS files

The original GPS data points 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 data collector contains information beyond the horizontal vertical point positions, including information concerning the precision and accuracy of the position, time and date of collection, equipment used, number of satellites, signal to noise ratio, etc. If Trimble GPS data collectors such as the R8 or 5700 are used, these data will be in proprietary data collector (.dc) and job (.job) formats.

If there is any question as to whether prescribed GPS data collection parameters have been exceeded (see SOP #4), the NCBN Data Manager or Project Leader should refer to these files to determine that GPS unit settings for data collection have been correctly applied.

Because these files are typically in non-tabular and proprietary formats, their content are not entered directly into the database. Rather the files themselves are linked in the database via a stored, relative directory path. Step-by-step procedures for linking these files to the database are found in the Database User's Guide.

All exported RTK-GPS coordinates derived from the above Trimble job files are exported as ESRI feature classes (.xml format). These files are stored in geodatabases (one per park) in the folder "4_Profile_geodatabases" and are also linked to the database via stored relative path information. A single Trimble Business Center project (.vce) file is similarly stored in the folder "4_TBC_project_files" and is linked within the database.

GPS coordinates

The RTK-GPS coordinates (horizontal positions plus elevations) are the core data of the Coastal Topology Monitoring Protocol and compose the basis for all subsequent analyses. In order to store these data in a manner that facilitates their ability to be searched, filtered, and exported for analysis, these coordinates are extracted from the attribute tables of each of the above-mentioned ESRI feature classes and are subsequently appended to a single data table within the Access

database. The Database User's Guide outlines the process for importing these data from the deliverables in #2 above.

Field data forms

The Field Data Forms collected in conjunction with the individual RTK-GPS 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 Project Leader will scan hard-copy field data forms and export them as Adobe .pdf files. These files are then stored in the folder "5_Field_forms" and linked within the database according to the steps outlined in the Database User's Guide.

Digital photographs

Digital photographs are taken to document the condition of each profile during RTK-GPS data collection. Additional photos may also be taken to document any unusual features encountered during data collection (e.g., the presence of a large scarp, overwash areas, etc.). These files are stored in the folder "6_Digital_photos" and linked within the database according to the steps outlined in the Database User's Guide.

Spatial Data Validation

All features within the benchmark (point) and profile (line) feature classes undergo initial QA/QC before being delivered to the NCBN (see SOP#6). Upon receipt, the Data Manager or a designated technician familiar with GIS software will also validate these spatial features using the following procedures:

1. In a GIS, overlay all features on available, well documented GIS vector data and imagery for the park unit. The NCBN Data Manager will provide the appropriate spatial datasets, such as:
 - DOQQ's or other 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-cliff system
 - Two or more sampling stations sharing the same coordinates
3. Check all benchmark and profile features against their corresponding quality control buffer features described above. Any features falling outside of their respective buffers should be brought to the attention of the survey team.

For all noted discrepancies, it is advisable to first consult the original feature class attribute tables to rule out possible errors resulting from manipulating the original coordinate data in Microsoft Excel, text editors, etc. Such potential errors would include those arising from the improper transcription of coordinates or 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 will be removed from the final dataset and the survey team will collect a new feature as soon as possible. All changes should be indicated and initialed on the field sheet and noted in the protocol database.

Data Verification

In order to minimize transcription errors, each line of data will be verified against the original field data sheets by a second person. If no staff members are available, the Project Leader 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, 10% of records will be reviewed a second time by the Project Leader. The Project Leader will convey the results of this comparison to the Data Manager, who will incorporate the information into the database's metadata file during the final review / archiving process.

The Coastal Topography Monitoring Database contains features designed to aid the Project Leader in the data verification process. These features can be found from the database Main Menu by clicking 'Analysis and Reports' → 'Export Data to Excel.' (These Excel files summarize data that are otherwise stored or displayed in multiple tables and forms within the database, greatly facilitating visual inspection of the records.)

Once all field data for a season have been entered into the database, the Project Leader should export the *Profile Verification* Excel file and check that coordinates exist for each profile with a given park and year.

Finally, in order to ensure that all records have indeed been verified for a field season, the Project Leader should export the *Data Verification* Excel file and determine that the *Last_Name* and *Verified_Date* fields are complete.

Data Backup

Local Data Backup

Tape backups of the Coastal Topography Monitoring project directory (including the protocol and database) are made daily per an arrangement with the University of Rhode Island Field Technical Support Center (URI FTSC). Incremental (daily) backups of NCBN data drives 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.

Export to ASCII for Backup

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 delimited files). NCBN archiving procedures include saving datasets in both their native format (typically MS-Access or Excel spreadsheet 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 Network Data Manager will produce such ASCII text files for all tabular data within the database. A Microsoft Access utility designed for this task called “Exportdb” is available via the NPS I&M Intranet (http://www1.nrintra.nps.gov/im/datamgmt/dtbases/links_sources/data_tools/exportdb.zip), or on the NCBN main data server at \DATA_MANAGEMENT\Tools\NRDTv3\add_ons. Exportdb will write the following ASCII comma-delimited text files for each database:

- TABLEDEF.txt - This file will contain one record for every table in the selected database. Fields in the file include Table_Name, Table_Description, Table_Format, Number of Fields, Export_Date.
- FIELDDEF.txt - This file will contain one record for every column in every table in the selected database. Fields in the file include Table_Name, Field_Name, Field_Description, Field_Type, and Field_Width.
- One comma-delimited ASCII text file containing all the data rows in each table in the selected database.

Exportdb displays a single form containing three function buttons (Fig. S8.3):

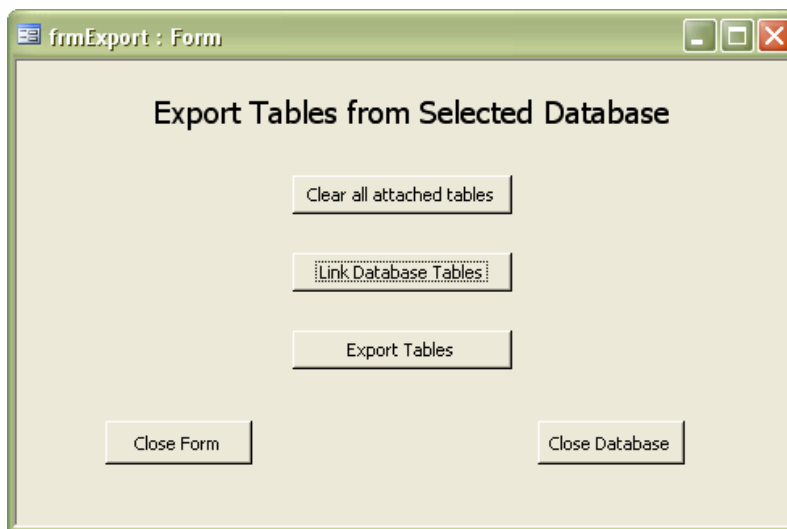


Figure S8.3. Screenshot of the Exportdb Microsoft Access utility displaying a single form containing three function buttons.

The "Clear all attached tables" button will clear all tables linked from previous sessions. The "Link Database Tables" button will open a browse window to allow the selection of the Microsoft Access database for export. (Note: the utility will not export tables that are linked to a back-end database.)

The "Export Tables" button will open a browse window to allow selection of the destination directory for the text files. Once a directory is selected, the export will be performed.

Alternatively, the following procedure can be used to export tables directly from the Monitoring Database:

1. In the Database window, click the name of the table, and then on the File menu, click Export
2. In the Save as type box, click Text Files (*.txt; *.csv; *.tab; *.asc)
3. Click the arrow to the right of the Save in box, and select the drive or folder to export to
4. In the File Name box, enter a name for the file (or use the suggested name), and then click Export

Archiving

Datasets associated with the Coastal Topography Monitoring Protocol will be archived on an annual basis, both in their native formats as well as ASCII text files. Archived datasets will include both tabular data in MS-Access format as well as spatial data. Network staff members are responsible for preparing tabular data from the protocol for archival following completion of standard QA/QC procedures. The Network Data Manager then prepares the tabular data for archiving by creating:

- A set of ASCII comma-delimited text files for the tabular data files and tables comprising the dataset
- An XML file that preserves relationships between tables for each MS-Access database
- A readme.txt file that explains the contents of each ASCII file, file relationships, and field definitions

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. If possible, a second reviewer, preferably a program scientist, checks the ASCII files and documentation to verify that tables, fields, and relations are fully explained and presented in a way that is useful to secondary users.

Following each field season, the Data Manager will archive a dataset consisting of the following elements:

1. A copy of the Coastal Topography Monitoring database containing all data from the current field season (with accompanying FGDC-compliant metadata)
2. Spatial datasets and FGDC-compliant metadata for all station locations visited during the past year
3. ASCII text file versions of the data products mentioned above
4. Digital (.pdf) copies of the field forms from each survey for that year
5. A digital (.pdf) copy of the final Annual Report
6. Once every five years, a copy of the Long-term Report

When a project dataset is ready to be archived, the Data Manager will package all relevant files into a compressed archive file (e.g., ZIP or RAR file format), that will adhere to the following naming convention:

NCBN_[Date]_[Author]_CoastalTopoMonData_Archive_Final.rar

The archive will be 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 server, are backed up daily by the URI Environmental Data Center, and archived off-site with the NPS Boston Support Office twice per year.

Database Revision Control

Because the Coastal Topography Monitoring Database follows the NPS I&M Program's Natural Resource Database Template v.3x (NRDT v.3x), a table describing database revision history (tbl_Db_Revisions) and linking to the database metadata (tbl_Db_Meta) is included as a core table in each component database file (i.e., front end and two back end Access files). Revisions will be performed periodically by or in conjunction with NCBN staff as the need arises and should be documented fully in the above tables, as well as in the database metadata.

On an annual basis, the Data Manager or Project Leader is responsible for identifying and documenting any changes needed for the Coastal Topography Monitoring Database. 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 #9 - Revising the Protocol).

Data Distribution

Access to NCBN data products will be facilitated via a variety of information systems that allow users to browse, search, and acquire Network data and supporting documents. All annual and long-term reports will be posted on the NCBN website

(<http://www.nature.nps.gov/im/units/ncbn/>) and accessible through the NPS NatureBib online citations database (<https://science1.nature.nps.gov/naturebib>). Metadata associated with all

spatial and tabular datasets will be posted on the NPS Data Store (<http://science.nature.nps.gov/nrdata/>) though requests for the actual data will be made by contacting the NCBN Data Manager:

A detailed checklist of data management tasks can be found in Appendix B.

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

Fax: 401-874-4561

SOP 9: Revising the Protocol

Version 1.0 (July 2010)

The following table lists all changes that have been made to this Standard Operating Procedure 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 Project Leader. The project leader will review and incorporate all changes, officially complete the revision history log, and change the date and version number on the title page. For complete instructions, please refer to SOP#9 – Revising the Protocol.

Revision History Log:

New Version #	Previous Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change

Due to the anticipated duration of the NCBN monitoring program, revisions to the Protocol Narrative and to individual Standard Operating Procedures (SOPs) will be necessary from time to time (O’Ney 2005). Careful documentation of changes to the Narrative and its related SOPs, along with a library of previous versions, are essential for maintaining consistency in the collection, summary, analysis, and reporting of data.

The Revision History Logs found at the beginning of the narrative and each protocol SOP list all edits to that section since the original publication date. Information entered in these logs should be complete and concise. The logs track the previous version date and number, date of revision and new version number, author(s) of revision, location of changes within the document, description of change, and the reason the change was made. Author information must include full name, title, and affiliation.

The Master Version Table found immediately after the Protocol Narrative’s Revision History Log tracks the relationships between the Narrative and the associated SOP’s. The use of this table is discussed in detail below.

Instructions for Recording Revisions

Protocol users must promptly notify the Project Leader about recommended and/or required changes. The Project Leader will then review and incorporate all changes, update the Revision History Log and Master Version Table, and change the date and version number on the title page.

Minor Revisions

Minor revisions 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. Version numbers for minor revisions increase incrementally by hundredths (1.01, 1.02 . . .).

Major Revisions

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, such as:

- Addition of monitoring objectives
- Changes to the sampling design
- Changes to reporting requirements
- Addition of new variables

Major revisions are designated with the next whole number in the sequence (2.0, 3.0, 4.0...).

Coordinating Narrative and SOP Versions

In order to track the most current version numbers of all SOPs associated with a particular protocol version, the Project Leader will also maintain the Master Version Table, which immediately precedes the Narrative's Revision History Log. A new entry must be made each time the Narrative and/or any SOPs are modified. In cases where the Narrative and/or one or more SOPs have undergone only minor revisions, the overall protocol version number will itself increase incrementally by hundredths. In cases where the Narrative and/or one or more SOPs have undergone a major revision (whether or not other sections have undergone minor revisions), the overall protocol version number will increase incrementally by whole numbers. The Master Version Table tracks the relationships between the protocol narrative and the associated Standard Operating Procedures (Fig. S9.1).

Master Version Table: Coastal Topography Monitoring Protocol and Standard Operating Procedures												
Date of Revision	Protocol	Narrative	SOP #1	SOP #2	SOP #3	SOP #4	SOP #5	SOP #6	SOP #7	SOP #8	SOP #9	SOP #10
1/1/2010	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6/1/2010	1.01	1.01	1.01	1.00	1.00	1.00	1.01	1.00	1.00	1.00	1.01	1.01
8/2/2010	2.00	1.01	1.01	1.00	1.00	2.00	1.01	1.00	1.00	1.00	1.01	1.01
1/10/2011	3.00	2.00	1.01	1.00	1.01	2.01	1.02	1.00	1.00	1.01	1.02	1.01

Figure S9.1. Example of Master Version Table reflecting possible revision scenarios and associated numbering of the protocol.

The Project Leader will also update all associated field forms to reflect the change in protocol version. Users noting discrepancies in versions between the protocol, SOPs, data values, and field forms should notify the Project Leader so that corrections can be made and documentation kept current.

Reviewing Suggested Protocol Revisions

All suggested edits require review by the Project Leader for clarity and technical soundness. Small changes or additions to existing methods will be reviewed by NCBN staff. However, if a significant change in methods is recommended, additional expert review may be required.

Communicating Changes to Investigators / Users

Once changes have been made, the updated document is posted on the NCBN web site (<http://www.nature.nps.gov/im/units/ncbn/>) and is added to the National Vital Signs Monitoring Protocol Database

(<http://science.nature.nps.gov/im/monitor/VitalSigns/BrowseProtocol.aspx>). All previous versions are archived in the NCBN information system and can be obtained by contacting the Data Manager. Each time an SOP is revised, the Project Leader ensures that all known users obtain a current copy of the SOP and receive the necessary briefing material and/or training to understand and incorporate the change(s). Users are encouraged to visit the network web site and/or contact the Project Leader at least once per season to check for updates associated with the monitoring protocol.

References

O’Ney, S. E. 2005. Standard operating procedure #11: Revising the protocol, Version 1.0. In: Regulatory water quality monitoring protocol. Version 1.0, Appendix E. Bozeman (MT): National Park Service, Greater Yellowstone Network.

Appendix A: Field Booklet of Benchmark Locations at Breezy Point, Jamaica Bay Unit, Gateway National Recreation Area

BREEZY POINT

GATEWAY NATIONAL RECREATION AREA

Spatial Network of Survey Monuments



V.2

November 2011

Table of Contents

Booklet Synopsis.....	1
Breezy Point Location Map.....	2
Survey Benchmarks map.....	3
Benchmark Locations and Descriptions:	
BP1	4
BP2	5
BP3	6
BP4	7
BP5	8
BP6	9
BP7	10
BP8	11
BP9	12
BP10.....	13
BP11.....	14
BP-BHE	15
Benchmark Elevations.....	16
Vertical Datums.....	17
Booklet Version Log.....	18

Booklet Synopsis

This booklet includes site and descriptive information on the Spatial Network of Survey Benchmarks and Profile Lines at Breezy Point, Jamaica Bay Unit of Gateway National Recreation Area, NY. GIS files associated with this booklet are available from the GIS specialist of the Gateway National Recreation Area. This effort is part of the program associated with the development of a *Coastal Geomorphological Monitoring Protocol* for the NPS Northeast Coastal and Barrier Network I&M Program. The benchmarks are intended to be used as:

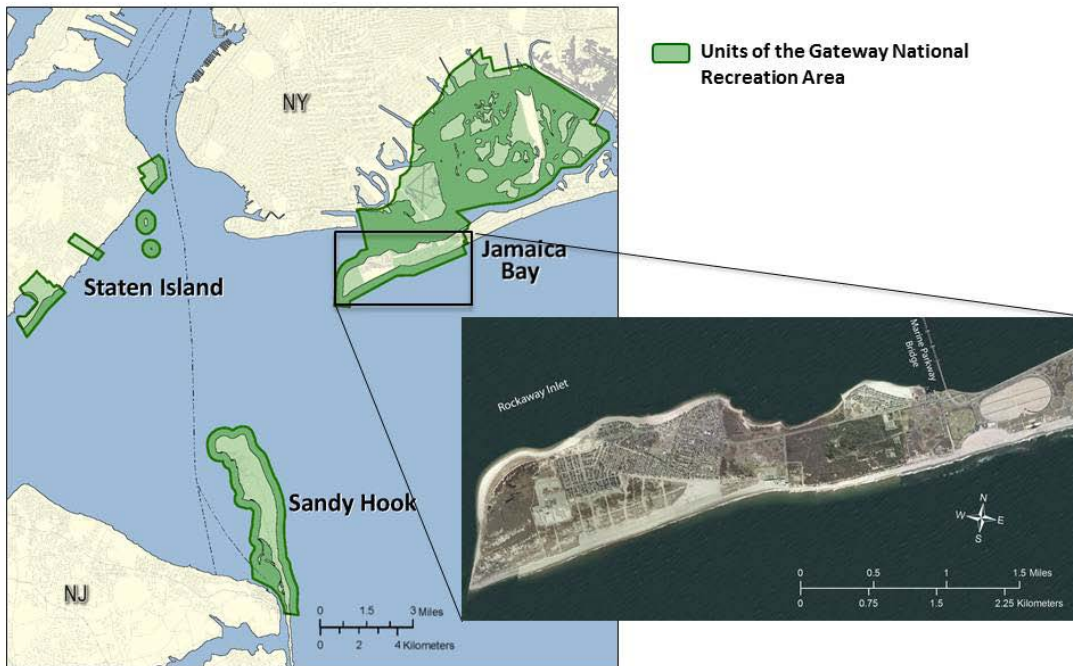
- 1) Profile Benchmarks that occupy the location of the starting point of the profiles surveyed in accordance with the Coastal Topography Protocol. These are highly-accurate topographical points, established with a GPS-RTK system that is the basis for standard surveying techniques.
- 2) Base-station Benchmarks used to set-up the GPS-RTK base receiver needed for Real-time Kinematic surveying. They are control points within centimeter accuracy, computed through the Online Positioning User Service (OPUS).
- 3) Control points for other field surveys (all benchmarks).

The benchmarks are intended to be permanent structures taking a variety of forms, including 2" PVC pipe set into a concrete base, PK survey nails, and spray-painted marks. All the benchmark are registered to the North American Datum of 1983 (CORS 96) (NAD83), using the Universal Transverse Mercator (UTM) projection, and North American Vertical Datum of 1988 (NAVD88) vertical datum, in meters.

This booklet includes a brief description of each benchmark location, as well as two aerial photos of the site, two ground photos, and a table with the coordinates and elevation of each benchmark. One aerial photo is a smaller-scale locator map, whereas a second aerial photo is a larger-scale image of the benchmark site and, when applicable, incorporates the cross-shore profile direction and the corresponding azimuth in yellow. Generally, one of the ground photos is a close up of the benchmark and the other photo captures local landmarks that provide orientation relative to the site. Both photos incorporate either yellow arrows indicating the direction of the profile from the benchmark or light blue arrows indicating the benchmark location if it is a control point and not used for the profile surveys. The table presents the X (Easting), Y (Northing), and Z (elevation) values relative to NAD 1983 and NAVD 1988 in meters. The benchmark elevation table at the back of the booklet contains vertical data relative to National Geodetic Vertical Datum of 1929 (NGVD29) and NAVD 1988 (in meters and feet) derived through the application of the Corpscon 6.0.1 software available from the US Army Corps of Engineers (<http://crunch.tec.army.mil/software/corpscon/corpscon.html>).

Report prepared in November 2011 by:
 Norbert P. Psuty, Andrea Spahn, Tanya M. Silveira, Peter M. Dennehy, and William Hudacek
 Sandy Hook Cooperative Research Programs, Institute of Marine and Coastal Sciences
 Rutgers, The State University of New Jersey

Location of Breezy Point-Riis Park, Rockaway Peninsula, Queens County, NY



Modified from the map produced by Mark Christiano – DNR GATE

Page 2

Location of Survey Benchmarks Breezy Point-Riis Park, Gateway National Recreation Area



Page 3

BP1 Benchmark

Purpose: Profile

Quality: RTK Measurement

A survey PK nail on the fifth post from the west supporting the wooden bulkhead in the dunes on the east end of Jacob Riis Park. 18 m southeast from the bulkhead's western end.



NAD 83 UTM (m)

NAVD 88 (m)

X (Easting)

Y (Northing)

Z (survey PK nail)

596158.118

4491377.797

5.253

Table: Benchmark coordinates and elevation – August 19, 2008

Page 4

BP2 Benchmark

Purpose: Profile

Quality: RTK Measurement

A red spray-painted dot on the cement base of railing just east of an entrance road to the boardwalk. 45 m east of the clock tower in Jacob Riis Park and 150 m west of the western end of the Jacob Riis bath-house



NAD 83 UTM (m)

NAVD 88 (m)

X (Easting)

Y (Northing)

Z (spray-painted dot)

595425.885

4491096.531

3.426

Table: Benchmark coordinates and elevation – August 19, 2008

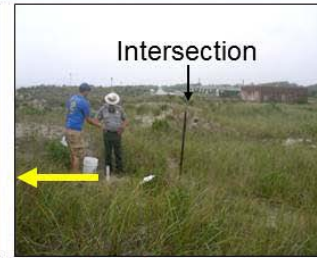
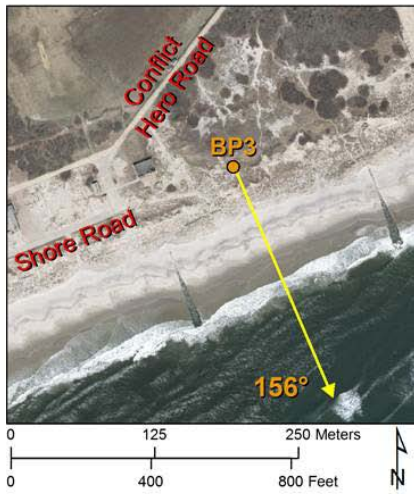
Page 5

BP3 Benchmark

Purpose: Profile

Quality: RTK Measurement

A PVC pipe located 100m east of the intersection of Conflict Hero and Shore Roads in Fort Tilden. At same azimuth as the direction of Shore Road.



NAD 83 UTM (m)		NAVD 88 (m)
X (Easting)	Y (Northing)	Z (top of PVC)
594643.061	4490740.014	4.804

Table: Benchmark coordinates and elevation – August 19, 2008

Page 6

BP4 Benchmark

Purpose: Profile

Quality: RTK Measurement

A PVC pipe located 200 m east of the turn on western end of Shore Rd. 20 m northwest of the road at the end of the small footpath on the southeast side of Bunker Kessler.



NAD 83 UTM (m)		NAVD 88 (m)
X (Easting)	Y (Northing)	Z (top of PVC)
593429.830	4490277.720	3.961

Table: Benchmark coordinates and elevation – November 14, 2008

Page 7

BP5 Benchmark

Purpose: Profile

Quality: RTK Measurement

A PVC pipe located in first swale, 50 m inland from the foredune crest, and 20 m west of the Beach Road. Located on the western end of Fort Tilden, 130 m east of the border of the Community beach.



NAD 83 UTM (m)		NAVD 88 (m)
X (Easting)	Y (Northing)	Z (top of PVC)
592435.821	4490070.426	2.247

Table: Benchmark coordinates and elevation – November 14, 2008

Page 8

BP6 Benchmark

Purpose: Profile

Quality: RTK Measurement

A PVC pipe located in the first swale, 30 m inland of the foredune crest, and 25 m east of Surf Club Path. Path is easternmost of the two National Park Service paths and is 175 m west of the border of the NPS beach and community housing beach.



NAD 83 UTM (m)		NAVD 88 (m)
X (Easting)	Y (Northing)	Z (top of PVC)
590697.946	4489149.264	2.537

Table: Benchmark coordinates and elevation – November 14, 2008

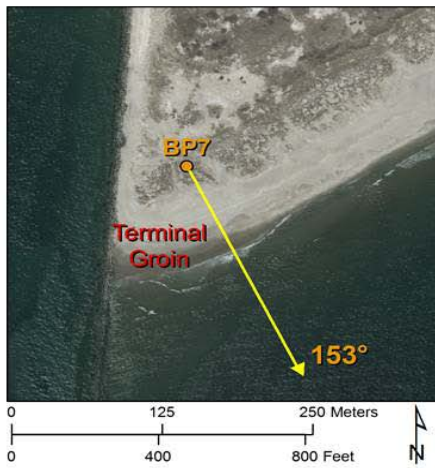
Page 9

BP7 Benchmark

Purpose: Profile

Quality: RTK Measurement

A PVC pipe located in the first swale, 25 m inland of the foredune crest on the western end of Breezy Point terminus. Located 60 m perpendicularly east of terminal groin.



NAD 83 UTM (m)		NAVD 88 (m)
X (Easting)	Y (Northing)	Z (top of PVC)
589778.989	4488644.676	1.984

Table: Benchmark coordinates and elevation – November 14, 2008

Page 10

BP8 Benchmark

Purpose: Profile

Quality: RTK Measurement

A PVC pipe located in the first swale 30 m inland from the foredune crest and 120 m north northwest of small cement building in the dunes.



NAD 83 UTM (m)		NAVD 88 (m)
X (Easting)	Y (Northing)	Z (top of PVC)
589800.025	4489681.388	4.469

Table: Benchmark coordinates and elevation – November 14, 2008

Page 11

BP9 Benchmark

Purpose: Profile

Quality: OPUS Solution

A PVC pipe located in the dunes 45 m landward of the foredune crest. 120 m west of the National Park Service bayside access road to the beach.



NAD 83 UTM (m)		NAVD 88 (m)
X (Easting)	Y (Northing)	Z (top of PVC)
590240.649	4490102.989	3.618

Table: Benchmark coordinates and elevation – November 6, 2011

Page 12

BP10 Benchmark

Purpose: Profile

Quality: RTK Measurement

A PVC pipe located 5 m inland on top of the scarp. Benchmark is in a small clearing between the trees 200 m east of the first groin east of the Yacht Club. Located 30 m east of inland salt marsh.



NAD 83 UTM (m)		NAVD 88 (m)
X (Easting)	Y (Northing)	Z (top of PVC)
592591.868	4490778.671	2.598

Table: Benchmark coordinates and elevation – November 14, 2008

Page 13

BP11 Benchmark

Purpose: Profile

Quality: RTK Measurement

A PVC pipe located 5 m inland on top of scarp. Located on a small clearing between dense growth of mixed vegetation. 300 m east of second groin east of the yacht club.



NAD 83 UTM (m)

NAVD 88 (m)

X (Easting)

Y (Northing)

Z (top of PVC)

593187.226

4490884.386

3.146

Table: Benchmark coordinates and elevation – November 14, 2008

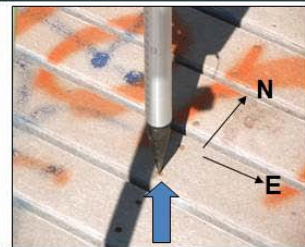
Page 14

BP-BHE Benchmark

Purpose: Base Setup

Quality: OPUS Solution

A nail located on the northeast corner of the platform on top of Battery Harris East. It is in the third row of nail in from the eastern railing and the fourteenth nail in from the north side of the deck. There is an arrow pointing to the correct nail.



NAD 83 UTM (m)

NAVD 88 (m)

X (Easting)

Y (Northing)

Z (nail)

593691.415

4490663.250

17.516

Table: Benchmark coordinates and elevation – August 20, 2008

Page 15

Benchmark Elevations

Vertical data relative to the North American Vertical Datum of 1988 (NAVD88) and the National Geodetic Vertical Datum of 1929 (NGVD29) in meters and feet.

(source: Corpscon 6.0.1 USACE)

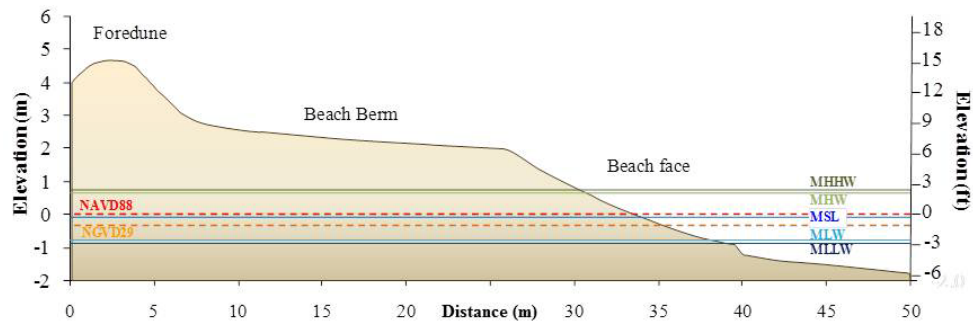
Benchmark	NAVD88 Meters	NAVD88 Feet	NGVD29 Meters	NGVD29 Feet
BP1	5.253	17.234	5.589	18.337
BP2	3.426	11.240	3.762	12.343
BP3	4.804	15.761	5.139	16.860
BP4	3.961	12.995	4.295	14.091
BP5	2.247	7.372	2.582	8.471
BP6	2.537	8.323	2.873	9.426
BP7	1.984	6.509	2.321	7.615
BP8	4.469	14.662	4.806	15.768
BP9	3.618	11.870	3.955	12.976
BP10	2.598	8.524	2.933	9.623
BP11	3.146	10.322	3.481	11.421
BP-BHE	17.516	57.467	17.851	58.566

Page 16

Vertical Datums

Relationship of 1983-2001 tidal epoch water levels to the North American Vertical Datum of 1988 (NAVD88) and the National Geodetic Vertical Datum of 1929 (NGVD29).

(Source: NOAA tide gauge at Sandy Hook)



Elevation of tidal datums and NGVD29 relative to NAVD88	Meters	Feet
Mean Higher High Water (MHHW)	0.734	2.41
Mean High Water (MHW)	0.634	2.08
North American Vertical Datum of 1988 (NAVD88)	0.00	0.00
Mean Sea Level (MSL)	-0.073	-0.23
National Geodetic Vertical Datum of 1929 (NGVD29)	-0.332	-1.09
Mean Low Water (MLW)	-0.800	-2.62
Mean Lower Low Water (MLLW)	-0.858	-2.81

Page 17

Booklet & Benchmark Log

When a benchmark is updated, a new version of the booklet will be published. A record of the version of the booklet, along with notes on the changes are in this log.

Booklet Version	Date Issued	Changes
BP-V.1	07/2010	First benchmarks established.
BP-V.2	11/2011	BP 9 Replaced, Booklet updated.

Page 18

Appendix B: Annual data management checklist

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 Leader			
Data collected, post processed, initial QA/QC	Survey technicians			
Field sheets scanned and converted to .pdf	Survey technicians			
Data products delivered to NCBN	Survey technicians			
All data entered into Access database	Data Manager / Project Leader			
Data have been exported and verified against field sheets	Data Manager or Project Leader			
Spatial data have been validated	Data Manager / Project Leader			
Verified data have been used to generate the semi-automated annual summary report	Project Leader and Quantitative Ecologist			
Draft of Final Report Completed	Project Leader and Quantitative Ecologist			
FGDC compliant Metadata have been developed for all final spatial datasets	Data Manager			
Copies of Final Report, verified data, and metadata are archived digitally	Data Manager / Project Leader			
Analog copies of final report are archived	Data Manager / Project Leader			
Verified data, metadata posted to NPS Data Store (via NRInfo portal)	Data Manager			
Final Report posted to NatureBib (via NRInfo portal)	Data Manager			
Any revisions to the protocol or database are made	Data Manager / Project Leader			

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 962/117416, October 2012

National Park Service
U.S. Department of the Interior



Natural Resource Stewardship and Science

1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov

EXPERIENCE YOUR AMERICA™