National Park Service
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Natural Resource Stewardship and Science

Development of the Geomorphological Map for Governors Island, Ellis Island, and Liberty Island, Upper New York Bay

Principal Characteristics and Components

Natural Resource Report NPS/NRSS/GRD/NRR—2016/1346

ON THE COVER
Aerial imagery of (clockwise from left) Liberty Island, Ellis Island, and Governors Island, all managed by the National Park Service as part of the National Parks of New York Harbor. USDA Farm Service Agency imagery, obtained 15 July 2006 (pre-Sandy), extracted from Google Earth Pro on 21 April 2015.

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This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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NPS 019/135482, 356/135482, December 2016

Contents

Figures

Page

Tables

Page

Executive Summary

This report incorporates the geomorphological map, its philosophical underpinnings, legend descriptions, and the GIS data layers for Governors Island, Ellis Island, and Liberty Island. The theme of the map follows the current scientific organization of geomorphological mapping that includes morphometrics, causative processes, and evolutionary stages. Surface form was interpreted from sources that include recent orthophotos, Light Detection and Ranging (LiDAR) data sets, NPS publications, scientific literature, and field visits.

The geomorphological features of the site include: 1) remnants of glacial ground moraine topography created during the late phases of Wisconsinan continental ice advance; and 2) anthropogenic modifications to the natural topography, consisting of positive as well as negative changes. The geomorphological map and its legend portray the spatial association of the surface feature created during the glacial stages of landscape development, as well as the broad anthropogenic alterations of the landscape.

The geomorphological map is viewable as a full compilation of all of the data layers as well as user specified combinations of the data. Each of the map layers contained in this report meets the standards of Federal Geographic Data Committee (FGDC) compliant metadata. The full set of organized data layers is available from the National Park Service, Geologic Resources Division, PO Box 25287, Denver, Colorado, 80225 or via the Geologic Resources Inventory publications page http://go.nps.gov/gripubs (accessed 22 November 2016).

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Guidance and support for this project came from a host of NPS personnel that were sources of information and enthusiasm. Bruce Heise of the Geologic Resources Division of the NPS Natural Resource Stewardship and Science Directorate was instrumental in defining the final product. And, a special tribute is extended to Jason Kenworthy, NPS Geologic Resources Division, for his efforts in guiding this publication. We also thank Courtney Schupp and Charlie Finkl for their comments and suggestions that appreciably improved this report.

Site and Situation

Governors Island, Liberty Island, and Ellis Island are located in the Upper New York Bay (Fig. 1). The three islands are depicted on the U.S. Geological Survey (USGS) 1:24,000 topographical sheet of Jersey City, New Jersey (USGS 2011).

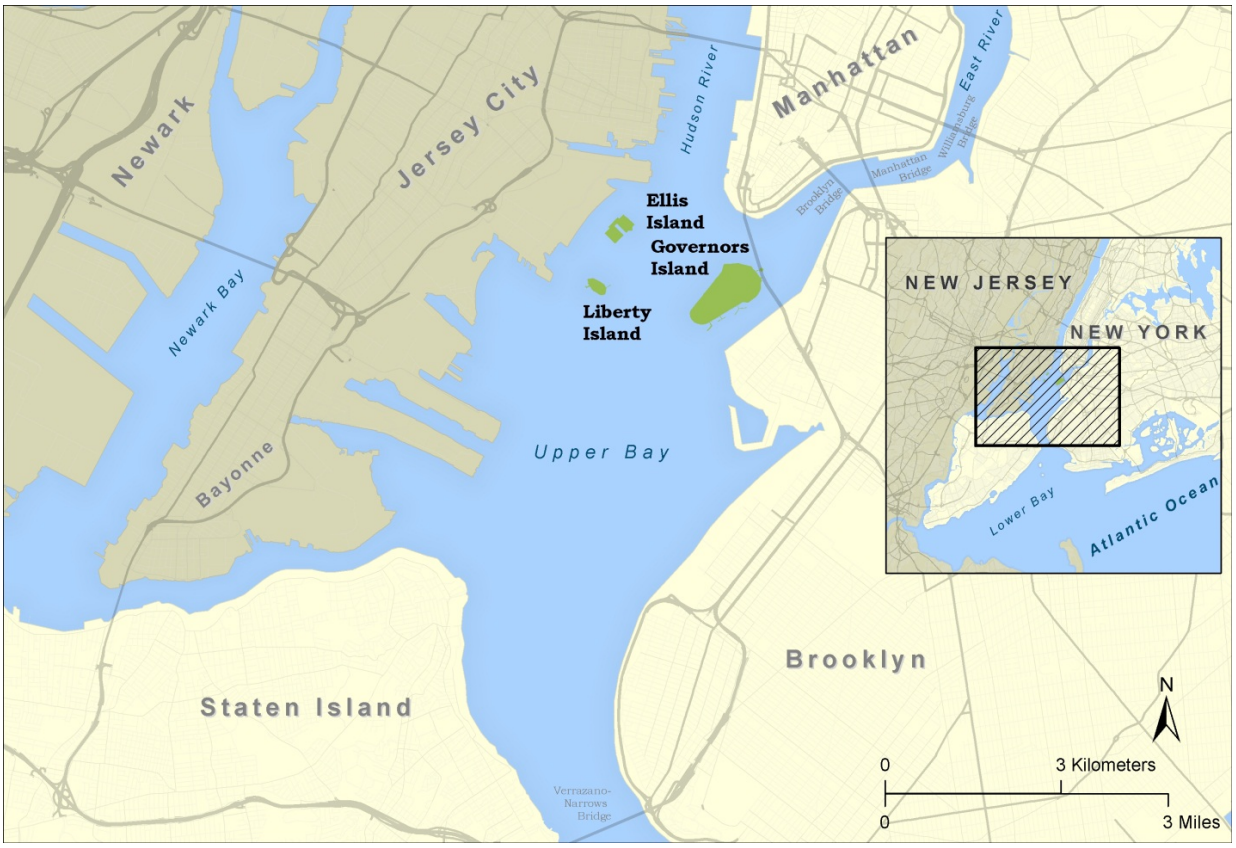

Figure 1. Location of Governors Island, Liberty Island, and Ellis Island in Upper New York Bay. Inset map depicts location of the islands in the New York – New Jersey metropolitan area.

Resources

A geographic information system (GIS) was developed for the construction of the geomorphological map of Governors Island, Liberty Island, and Ellis Island. The GIS includes orthophotos, light detection and ranging (LiDAR) data sets, and additional sources of geographical information that are described below (Table 1).

Table 1. Source and Quality of Spatial Data

Data	Year	Resolution	File Type	Source
Orthophotos	2010	0.5 ft.	.jp2	DoITT – City of New York
LiDAR	2010	-	LAS	Sanborn
Roads/Paths	2014	-	.osm	OpenStreetMap contributors
Buildings		-	.shp	NPS

Methodology of Topography Development

The initial approach of landform identification used recent orthophotos of the area, collected in April 2010, (Fig. 2) to establish the geographical coordinates of the geomorphological units. The next phase utilized 2010 bare earth LiDAR data for the area, collected by the Sanborn Map Company (2010), to create the topography of the landscape. The bare earth point cloud was interpolated (Golden Software 2011) into a 1 m resolution DEM using the Kriging method with a 20 m search radius (Fig 3). Raster-based images created through the application of the ArcGIS hillshade tool provided an enhanced depiction of the topography (Fig 4).

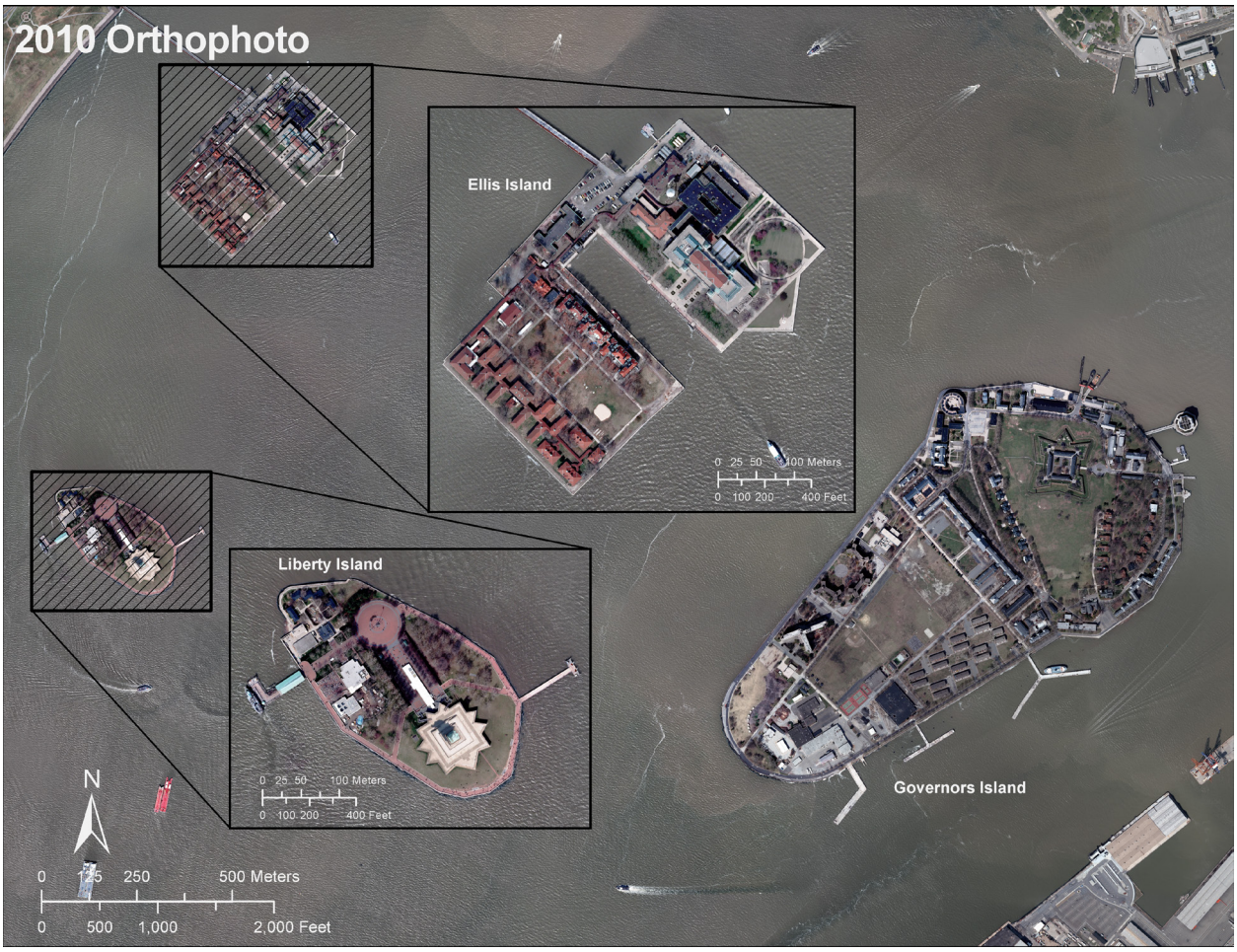

Figure 2. Orthophoto of Upper New York Bay Islands, scale of the two smaller islands is enlarged. (Source: Department of Information Technology & Telecommunications (DoITT) – City of New York)

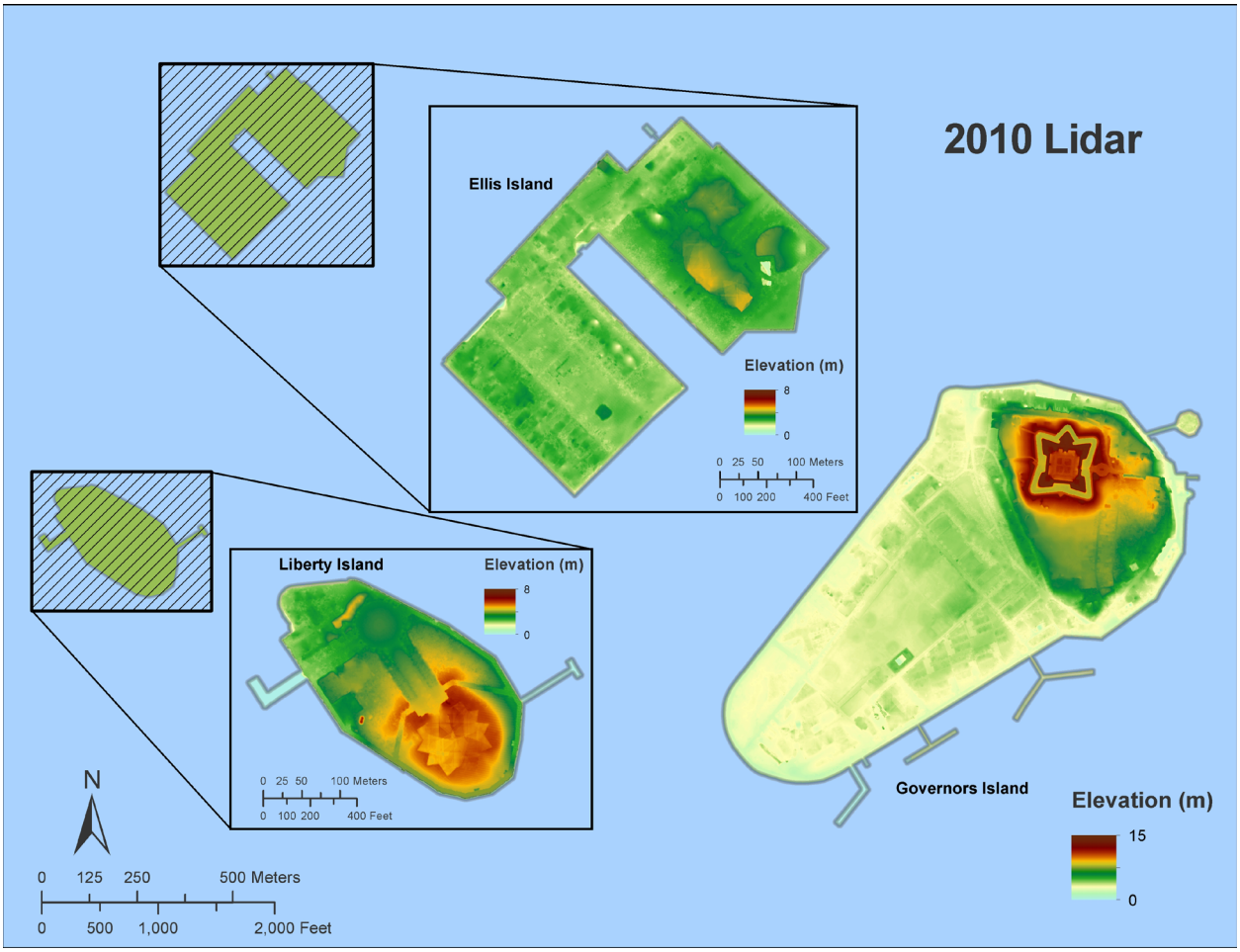

Figure 3. Digital elevation model (DEM) with elevation categories created from 2010 LiDAR data set with reduced point density, (Sanborn, 2010). Elevation range of Governors Island is twice that of the other two islands.

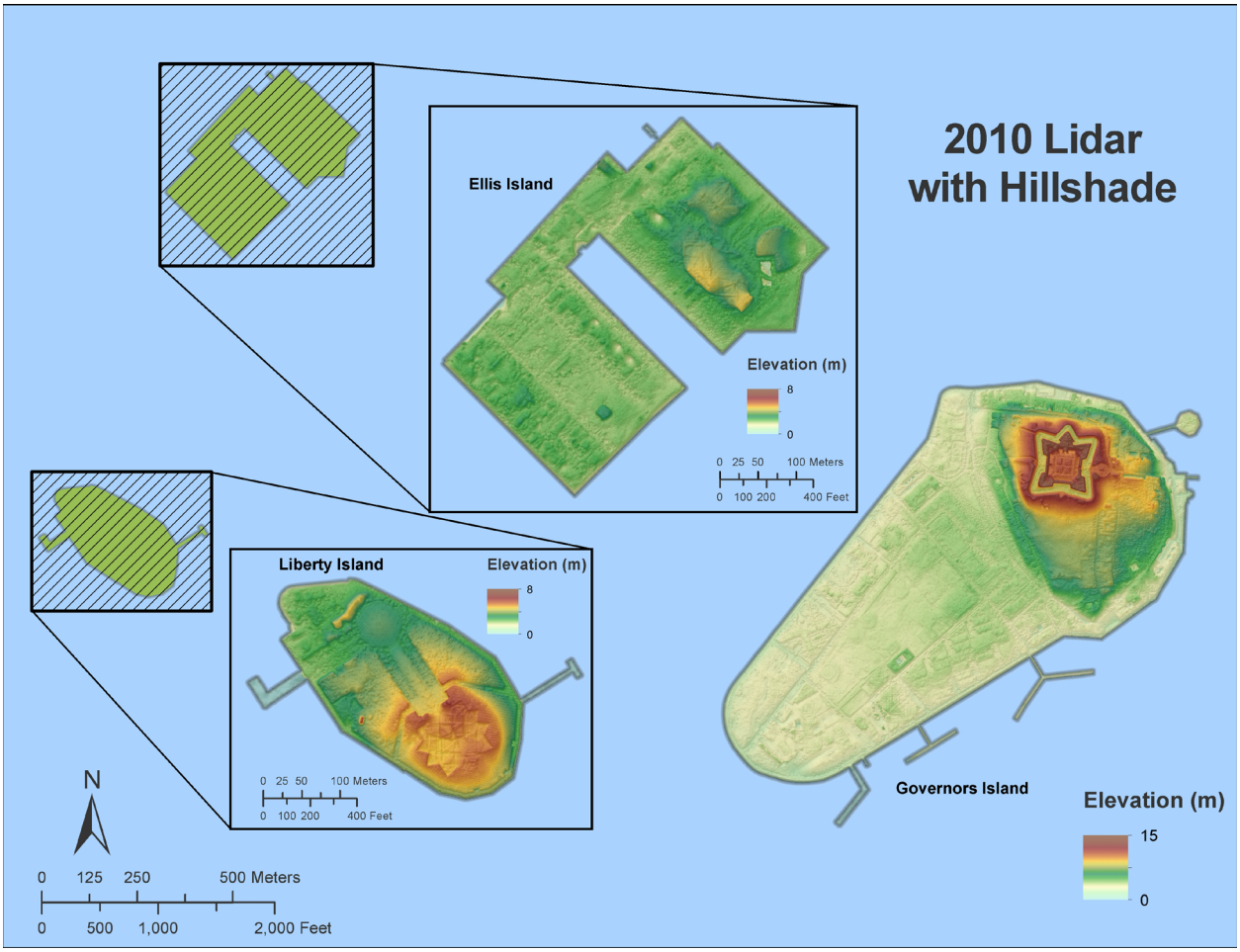

Figure 4. DEM with elevation categories and hillshade effect.

Geomorphological Evolution

The geomorphological development of the modern surface of the three islands incorporates a glacial origin because the maximum stages of Wisconsinan ice transported and deposited glacial till (unsorted sediment) and glacial drift (stratified sediment) over pre-existing bedrock in this location (Schuberth 1968). The combined glacial till and glacial drift produced an irregular topographical surface. Following retreat and melting of the continental glacial ice and the rise of sea level to near its present position, portions of the glacial deposits formed a few low islands in the harbor, designated herein as ground moraine. Because of the strategic location of these islands in the New York City harbor, the islands were sites of human modification very early in the settlement of this portion of the country. The best local sources of information on the modifications are NPS archeological reports (Griswold 2003; Thieme 2008; Ziesing 2013) that include descriptions of sediments exposed in archeological digs on the islands. The reports further describe the vast range of construction and landscape alteration on the ground moraine surface as well as fill and expansion of the surface area of the islands. Currently, a variety of shore structures and a bulkhead completely surround each of the three islands. There is very little natural geomorphological character of the islands' surface. The geomorphological map essentially portrays the topographical cores of the islands in contrast to the culturally-modified additions (Fig 5). The geomorphological map with the hillshade-effect added provides another view of the conditions on the islands (Fig. 6)

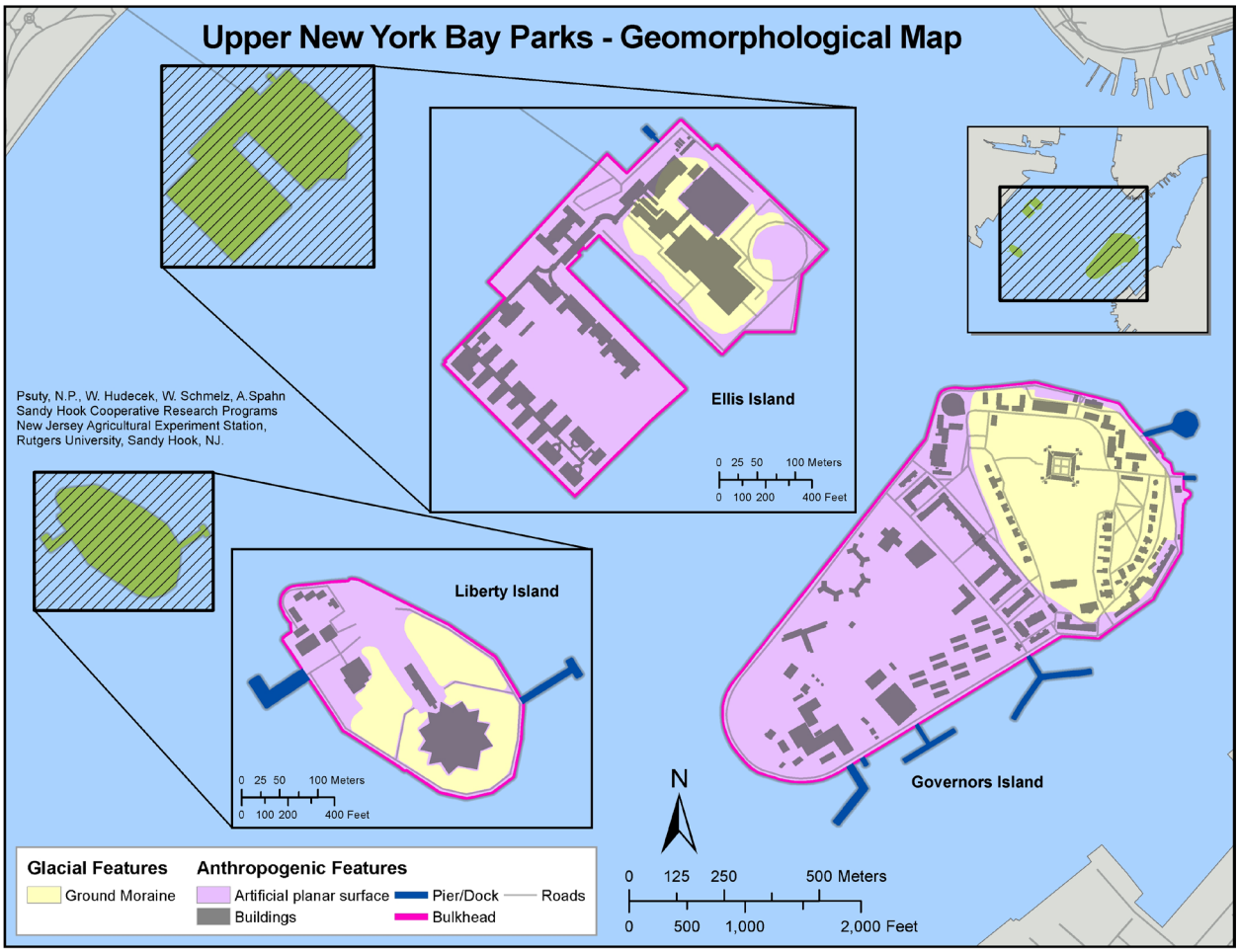

Figure 5. Geomorphological map of Governors Island, Ellis Island, and Liberty Island, incorporating anthropogenic features.

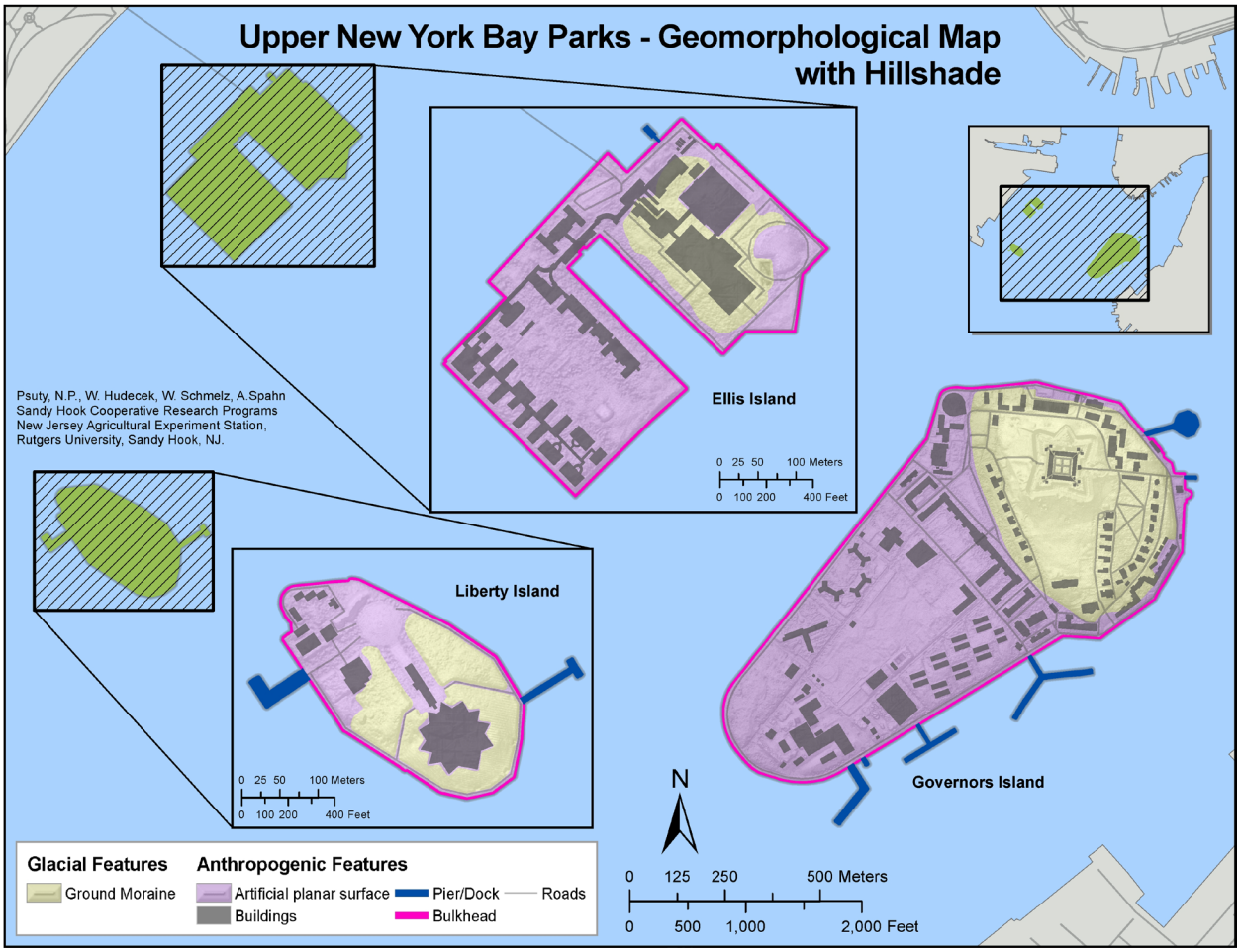

Figure 6. Distribution of geomorphological features with hillshade effect added to emphasize relief, New York Bay Islands.

Legend - Categories and Symbolization of Geomorphological Features

The conceptual approach to describing, depicting, and mapping the geomorphological characteristics of the site is based on the components of morphometrics, causative processes, and temporal sequence of development of the surface. This tripartite organization is the essence of modern geomorphological maps (Dramis et al, 2011) that combine the processes and the surface expression of the sedimentary formations (either in their erosional or depositional form). The legend (Fig. 7, Table 2) identifies the surface features and their associated causative processes, and adds the cultural imprint to the landscape.

Figure 7. Categories of geomorphological features and anthropogenic features on Upper New York Bay Islands.

Table 2. Geomorphological Features Found on the Upper New York Bay Islands.

Geomorphological classification	Conceptual Basis	Physical Description and Identification
1. Glacial Features		
Ground moraine	Broad, irregular surface created by the deposits of a continental glacier atop previous topography. Deposits may be stratified or unstratified.	Relatively flat irregular surface sloping gradually toward the margins of the island.
2. Anthropogenic Features		
Artificial planar surface	A human-made flat or planar surface that has been leveled to accommodate buildings, or consists of fill to enlarge the surface area of the island. Underlying topography is destroyed or covered.	Elevation of surface is nearly or completely homogeneous and level. It may cause an abrupt interruption of adjacent naturally occurring topography. Boundary of surface is often clearly visible on the orthophotos.
Bulkhead	Hardened border of the island. May be constructed of wood, metal, or concrete. Lines the entire island.	Straight edges of the island. Forms the boundaries of the fill as well as the ground moraine.
Pier/Dock	A structure built into the water for the mooring of ships and boats, or to accommodate pedestrians	Projections into the water visible on orthophotos. Constructed either as single units or in groups to constitute a marina or boat basin.
Roads	Roads and paths located within the islands.	Road data layers.
Buildings	Main buildings of the development.	Building data layer.

However, the three islands have been so modified by the anthropogenic manipulation of the surface that the only geomorphological category is the glacial ground moraine that gives elevation to the islands. The only other contributor to the surface form is the fill that has expanded the island area. Buildings, roads and paths, docks, and the ubiquitous bulkhead constitute the remainder of the legend.

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