

Memorandum – Coastal Engineering Review

Summary of Geologic Resources Inventory (GRI) Support Documents: Fort Sumter and Fort Moultrie National Historical Park (FOSU)

February 2026

Review Request Summary

The Geologic Resource Inventory (GRI) is one of 12 baseline natural resource inventory efforts within the National Park Service (NPS) Inventory and Monitoring (I&M) Division. The GRI is a cooperative effort between the NPS, Colorado State University, and the University of Alaska Fairbanks. It strives to advance science-based management of natural resources in the national parks and raise awareness about geology and the role that geologic features and processes play in the environment.

The GRI team, working closely with a variety of partners, provides each of the approximately 270 parks in the I&M networks with a geologic scoping meeting, digital geologic map data and poster, and a park-specific geologic report. These products are designed to enhance stewardship of park resources by providing valuable information about geologic formations, processes, hazards, and links among geology, history, and other natural resources. The National Park Service identified 13 coastal parks that have geologic scoping meeting summaries and at least one digital geologic map, but do not have a traditional GRI report: Biscayne National Park (BISC), Cape Cod National Seashore (CACO), Canaveral National Seashore (CANA), Castillo de San Marcos National Monument (CASA), Cumberland Island National Seashore (CUIS), Fire Island National Seashore (FIIS), Fort Caroline National Memorial (FOCA), Fort Frederica National Monument (FOFR), Fort Matanzas National Monument (FOMA), Fort Pulaski National Monument (FOPU), Fort Sumter and Fort Moultrie National Historical Park (FOSU), Gateway National Recreation Area (GATE), and Timucuan Ecological and Historic Preserve (TIMU). As of spring 2024, the GRI team is transitioning to a proposal-based system, and not all parks will receive a traditional report, including all 13 of the identified coastal parks. Many of these coastal parks were originally scoped in the early 2000s and have map products approaching or now exceeding 20 years old. Therefore, to provide a status update to the coastal parks in lieu of a traditional report, the GRI team requested assistance from EA Engineering, Science, and Technology, Inc., PBC (EA), with the following:

- Prepare park-specific literature reviews focused on geologic resources to provide a data resource for future work
- Prepare a literature review of service-wide and regional resources that could be useful to multiple parks
- Evaluate available digital geologic map data for each park and assess its relevance to coastal management needs

Literature Reviews

Introduction

The literature review for each park consists of an Excel spreadsheet listing all identified sources and PDF files for each source. The spreadsheet includes a link that opens the associated PDF file directly. These files for Fort Sumter and Fort Moultrie National Historical Park can be downloaded from the NPS DataStore at: <https://irma.nps.gov/DataStore/Reference/Profile/2317157>.

Methodology

To ensure consistency across parks, EA followed the steps below when searching for sources:

- Checked EA servers for project files already in EA possession or previously cataloged in literature reviews, annotated bibliographies, memorandum reference lists, and related materials.
- Reviewed the GRI Product Page (NPS 2024a) to identify GRI products previously compiled by the National Park Service for each park unit.
- Conducted an advanced search of NPS DataStore using the following methods:
 - In the Text Fields section, enter:
 - *Description* contains geolog*
 - OR *Title* contains geolog*
 - OR *Keyword* contains geolog*
 - In the Content Units section, enter the four-letter code for the park unit/select it from the list
- Completed a general Google search focused on scholarly articles. When results were excessive, searches were refined by applying a publication date cutoff of 2016 or 2017.
- Reviewed the following resources relevant to multiple parks:
 - Coastal engineering inventories of select parks (NPS 2013)
 - The NPS Paleontology Library, a repository for electronic copies of geology and paleontology publications, reports, and other media, including the following paleontological resource inventory types:
 - Park-specific Paleontological Resource Inventories (NPS 2024)
 - Service-wide Thematic Paleontological Resource Inventories (NPS 2023a)
 - I&M Network Based Paleontological Resource Inventories (NPS 2023b)
 - Shoreline change project maps for 88 ocean and Great Lake park units (NPS 2022)
- Reviewed reference lists from reports already identified, particularly those that were comprehensive, relevant, and/or recently published.
- Used the following resource topics as a starting point for search terms (this list is not exhaustive, and additional terms were added based on park-specific topics):

- | | |
|---------------------------|--------------------------------------|
| – Surficial features | – Saltwater intrusion |
| – Hydrogeomorphic map | – Sediment transport |
| – Unconsolidated deposits | – Hydrology and hydrogeology |
| – Storm impacts | – Nearshore/seafloor/benthic habitat |
| – Erosion | – Shoreline evolution |
| – Overwash | – Paleontology/fossils |
| – Breaches | – Land disturbance |
| – Inlet formation | – Seismicity |
| – Sea level rise | – Waves, currents, and tides |
| – Marshes | – Wind |

Spreadsheet Details

Column A, File Name: Each row in this column includes a unique filename identifier that corresponds to a specific PDF file included in the park folder. Each filename begins with the park four-letter identifier, followed by GRI, followed by a number. For example, “FIIS GRI_001”.

Column B, 1st-level Grouping: One of the following groupings was selected from the list below that matches (as much as possible) the document scope:

- General/natural resources
- Geology
- Coastal Processes/geomorphology
- Habitat
- Engineering

Column C, Date of Publication: This is provided separately from the citation for ease of review.

Column D, Citation: These use a modified APA-style format. Examples are provided below.

Example of a journal article:

Schwab, W. C., W. E. Baldwin, C. J. Hapke, E. E. Lentz, P. T. Gayes, J. F. Denny, J. H. List, and J. C. Warner. 2013. Geologic Evidence for Onshore Sediment Transport from the Inner Continental Shelf: Fire Island, New York. *Journal of Coastal Research* Volume 29, Issue 3: pp. 526–544.

Example of an agency report:

U.S. Army Corps of Engineers. 2007. *Atlantic Coast of Long Island, Fire Island Inlet to Montauk Point, New York Storm Damage Reduction Reformulation Study, Work Order 28, Inlet Modifications*. US Army Corps of Engineers, New York District, North Atlantic Division. 493 pp.

Column E, Short Title/Access: This includes the document title or a shortened version of the title and is linked directly to the associated PDF file.

Column F, Literature Review Summary: This includes the document abstract (if sufficiently concise) or a brief summary describing the scope and contents of the document, with a focus on relevance to geologic resources.

Column G, Keywords: This includes three to five keywords based on review of the document or keywords identified in NPS DataStore.

Column H, Notes: This is optional and is used to provide additional information, such as whether appendices are included as separate files or entries in the literature review.

FOSU Literature Review Summary

FOSU consists of two forts—Fort Sumter and Fort Moultrie—located at the entrance to Charleston Harbor on Sullivan’s Island. The literature review for this park includes 41 sources published between 1975 and 2023. EA developed keywords based on the coastal resources addressed in each reviewed source. These keywords are provided in column G of the spreadsheet and include the following.

- | | | |
|---|---------------------------------|---------------------------------|
| ▪ Aquatic species | ▪ Engineering with nature (EWN) | ▪ Phytoplankton pollution |
| ▪ Aquifer | ▪ Flora | ▪ Remote sensing |
| ▪ Bathymetry | ▪ Folly Island | ▪ Resilience |
| ▪ Beach profile | ▪ Foraminifers | ▪ Restoration |
| ▪ Biological resources | ▪ Freshwater discharge | ▪ River discharge |
| ▪ Breakwater | ▪ Geodatabase | ▪ Salinity |
| ▪ Charles Pinckney National Historic Site | ▪ Geology | ▪ Salt marshes |
| ▪ Charleston Harbor | ▪ Groundwater | ▪ Sea level rise (SLR) |
| ▪ Climate change | ▪ Habitat | ▪ Sediment transport |
| ▪ Coastal hazards | ▪ Historical analysis | ▪ Shallow nearshore environment |
| ▪ Contaminant distribution | ▪ Historical context | ▪ Shoreline |
| ▪ Contaminant transport | ▪ Historical land use | ▪ Shoreline change |
| ▪ Contamination dissolved oxygen | ▪ Hurricane Hugo | ▪ Shoreline erosion |
| ▪ Dunes | ▪ Hurricane | ▪ Sonar |
| ▪ Erosion | ▪ Hydrogeology | ▪ Storm impacts |
| ▪ Estuary conditions | ▪ LiDAR | ▪ Storm surge |
| ▪ Estuary habitat | ▪ Microfossils | ▪ Suspended sediment |
| ▪ Estuary | ▪ Modeling NNBS | ▪ Tidal creek |
| | ▪ Paleoenvironment | ▪ Tides |
| | ▪ Partially mixed estuary | ▪ Topo bathymetry |

- Topography
- Transmissivity
- Turbidity distribution
- Turbidity maximum zone
- Vegetation
- Vulnerability
- Water quality
- Wetland delineation
- Wetlands

In addition to park-specific literature reviews, a review was completed that includes service-wide and regional resources that may benefit multiple parks. These resources include vulnerability assessment protocols, monitoring protocols, climate change inventories/impacts, sea level rise scenarios/evaluations, coastal hazard assessments, and mapping tools that provide data for all parks, among others. Although resources are ideally provided as PDF documents, some are only useful when accessed digitally (e.g., mapping data).

Research and data are continually being published. These literature reviews may not be exhaustive; however, they provide a foundation for understanding the range of geologic resources in each park, as well as relevant internal National Park Service guidance and resources. The methodology described above may be used for future searches to update information, if desired.

Geologic Map Assessment

Introduction

Digital geologic maps reproduce all aspects of traditional paper maps, including notes, legend, and cross sections. Bedrock, surficial, and special purpose maps, such as coastal or geologic hazard maps, may be used by the GRI to create digital geographic information systems (GIS) data that meet park needs. These GIS data allow geologic information to be easily viewed and analyzed alongside other resource management information.

The GRI team compiled digital geologic maps for each of the 13 coastal parks: BISC, CACO, CANA, CASA, CUIS, FIIS, FOCA, FOFR, FOMA, FOPU, FOSU, GATE, and TIMU. As part of, and in parallel with, the GRI literature review process, EA assessed the relevance of the GRI GIS data sets (all available on the NPS DataStore; some exceeding 20 years old) to each park's current coastal management needs. This assessment is based in part on EA's perspective as technical experts well versed in NPS management requirements.

Methodology

This work was completed without the use of GIS software and instead relied on review of the GRI Scoping Meeting Summary and the GRI Ancillary Map Information document, both available on NPS DataStore. For each park, EA's assessment focused on answering the following questions about the GRI digital geologic map(s):

1. Are the source maps (i.e., the maps that GRI digitized to create the GIS data sets) comprehensive in terms of features relevant to the coastal park? If not, what gaps are there?
2. Are the source maps recent enough (relative to extreme storms, especially) to accurately represent the park's current configuration?
3. Does an online search yield any maps that are more relevant?

In addition to park-specific literature reviews, a review was completed that includes service-wide and regional resources that may benefit multiple parks. These resources include vulnerability and monitoring protocols, climate change inventories and impacts, sea-level-rise scenarios and evaluations, coastal hazard assessments, and mapping tools that provide data for all parks. Although resources are ideally provided as PDF documents, some are only useful when accessed digitally (for example, mapping data).

Research and data are continually being published. These literature reviews may not be exhaustive; however, they provide a basis for understanding the range of geologic resources in each park, as well as internal NPS guidance documents and resources that may be used. The methodology described above can be followed in future searches to update information, if desired.

FOSU Map Assessment

The information summarized below is based on the *Fort Sumter and Fort Moultrie National Historical Park GRI Ancillary Map Information Document* (NPS 2022b) and NPS DataStore records for the Fort Sumter and Fort Moultrie National Historical Park GRI map produced by the Geologic Resources Division (NPS 2022b). A summary scoping statement is not available for Fort Sumter and Fort Moultrie National Historical Park. Information specific to the FOSU GRI map is presented in table 1.

The only source map used for this GIS dataset is the geological features map. Because no scoping meeting was conducted, there is no guidance identifying additional maps or features needed to support resource management. However, information on coastal erosion rates and hazard areas, sea-level rise impacts and projections, sediment-budget assessments, and climate change impacts would provide additional guidance for managing coastal resources at the park.

Table 1. Summary of GRI map products for FOSU

GRI Map Product	Citation	Data Layers	Sources
Digital Geologic-GIS Map	NPS 2022b	Geologic Units (FOSUGLG), Geologic Contacts (FOSUGLGA), Structure Contour Lines, Base of Quaternary (FOSUCN1), Glacial Feature Lines (FOSUGFL), Geologic Cross Section Lines (FOSUSEC), Geologic Observation Localities (FOSUGOL) and Geologic Point Features (FOSUGPF).	<i>Geologic feature and attribution, including map text, unit descriptions, graphics, were derived from:</i> Weems, Robert E., Lemon, Earl M. Jr., and Chirico, Peter G., 1997, Digital Geology and Topography of the Charleston Quadrangle, Charleston and Berkeley Counties, South Carolina: U. S. Geological Survey, Open-File Report OF-97-531, scale 1:24,000 (Charleston Quadrangle (Digital Geology and Topography)). (GRI Source Map ID 5574). <i>Geologic features and attribution, including map text, unit descriptions, graphics, were sourced from a portion of:</i> Weems, Robert E., and Lemon, Earl M. Jr., 1993 Geology of the Cainhoy, Charleston, Fort Moultrie, and North Charleston Quadrangles, Charleston and Berkeley Counties, South Carolina: U.S. Geological Survey, Map I-1935, 2 sheets, scale 1:24,000 (Cainhoy, Charleston, Fort Moultrie, and North Charleston Quadrangles). (GRI Source Map ID 2530).

Are the source maps (i.e., the maps that GRI digitized to create the GIS data sets) reasonably comprehensive in terms of features relevant to the coastal park? If not, what gaps are there?

GRD used digitized data from Weems (1997) and digitized data from a georeferenced paper source map by Weems (1993) to produce the Digital Geologic GIS map. Features derived from these two source maps are reported to be within 12.2 meters (40 feet) of their actual locations. The map meets National Map Accuracy Standards; however, users should not assume that feature locations are exact.

Geologic unit information from both source maps is included and is listed below from youngest to oldest:

- Qaf - Artificial fill
- Qal - Alluvium
- Qht - Tidal-marsh deposits
- Qhs - Beach and barrier-island sands
- Qhm - Freshwater stream and swamp deposits
- Qhec - Estuarine deposits
- Qhes - Beach to barrier-island deposits
- Qwc - Wando Formation, clayey sand and clay facies
- Qws - Wando Formation, barrier sand facies (Mount Pleasant barrier system)
- Qwls - Wando Formation, barrier sand facies (Awendaw barrier system)

The map also includes four geologic cross sections, interpreted depositional environments for stratigraphic units, an isopach map of poorly consolidated Quaternary deposits, and auger-hole logs. A scoping summary document was not available for Fort Sumter and Fort Moultrie National Historical Park, and geologic resource management concerns and data gaps were not evaluated at this time.

Are the source maps recent enough (relative to extreme storms, especially) to accurately represent the park's current configuration?

The source maps are dated 1993 and 1997. Hurricanes and other storm events affecting the area, including Hurricane Irma in 2017, have resulted in flooding. Potential geologic impacts associated with these events are not represented in the GRI GIS datasets.

Does an online search yield any maps that are more relevant?

Additional online sources of GIS information include:

- Coastal Topographic LiDAR, Charleston County, SC (NOAA OCM 2025)
- FOSU Shoreline Change (NPS 2022c)
- Fort Sumter National Monument Topobathymetry (NPS 2021)
- FOSU Shoreline Map (NPS 2013b)

References list:

National Oceanic and Atmospheric Administration Office for Coastal Management (NOAA OCM).

- 2024 "2017 SC DNR Lidar DEM: Coastal Counties (Berkeley, Charleston and Williamsburg Counties)." Available online: <https://www.fisheries.noaa.gov/inport/item/57112>. Accessed March 2024.

- 2025 2025 SCDVA Lidar DEM: Charleston County, SC. Available online: <https://coast.noaa.gov/digitalcoast/contributing-partners/charleston-county.html>. Accessed March 2024.

National Park Service (NPS) Geologic Resources Inventory (GRI) program.

- 2013a “Coastal Engineering Projects Inventory.” National Park Service, Natural Resource Stewardship and Science. Available online: <https://irma.nps.gov/DataStore/Reference/Profile/2193512>. Accessed March 2024.
- 2013b Fort Sumter National Monument, South Carolina: Shoreline Map. Available online: <https://irma.nps.gov/DataStore/Reference/Profile/2252693>. Accessed March 2024.
- 2021 Fort Sumter National Monument (FOSU) Seafloor Mapping. Available online: <https://irma.nps.gov/DataStore/Reference/Profile/2287138>. Accessed March 2024.
- 2022a “Shoreline Change Project.” Natural Resource Stewardship and Science. Available online: <https://irma.nps.gov/DataStore/Collection/Profile/9272>. Accessed March 2024.
- 2022b “Digital Geologic-GIS Map of Fort Sumter and Fort Moultrie National Historical Park and Vicinity, South Carolina (NPS, GRD, GRI, FOSU, FOMU, CHPI, FOSU digital map) adapted from a U.S. Geological Survey Open-File Report map by Weems, Lemon and Chirico (1997), and a U.S. Geological Survey Miscellaneous Investigations Series Map by Weems and Lemon (1993).” National Park Service (NPS) Geologic Resources Inventory (GRI) program. Lakewood, CO. Available online: <https://irma.nps.gov/DataStore/Reference/Profile/1047564>. Accessed March 2024.
- 2022c Fort Sumter National Monument (FOSU) Shoreline Change. Available online: <https://irma.nps.gov/DataStore/Reference/Profile/2295476>. Accessed March 2024.
- 2023a “Thematic Paleontological Resource Inventory Reports.” Available online: <https://www.nps.gov/subjects/fossils/thematic-inventories.htm>. Accessed March 2024.
- 2023b “I&M Network Based Paleontological Resource Inventory Summary Reports.” Available online: <https://www.nps.gov/subjects/fossils/network-surveys.htm>. Accessed March 2024.
- 2024 “Park-specific Paleontological Resource Inventory Reports.” Available online: <https://www.nps.gov/subjects/fossils/park-surveys.htm>. Accessed March 2024.