

# Geologic Resources Inventory Scoping Summary Fort Frederica National Monument, Georgia

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The Geologic Resources Inventory (GRI) provides each of 270 identified natural area National Park System units with a geologic scoping meeting and summary (this document), a digital geologic map, and a Geologic Resources Inventory report. The purpose of scoping is to identify geologic mapping coverage and needs, distinctive geologic processes and features, resource management issues, and monitoring and research needs. Geologic scoping meetings generate an evaluation of the adequacy of existing geologic maps for resource management, provide an opportunity to discuss park-specific geologic management issues, and if possible include a site visit with local experts.

The National Park Service held a GRI scoping meeting for the park units of the Southeast Coast Network (SECN) during the week of April 20–24, 2009 at Jacksonville, Florida. These units included Canaveral National Seashore (CANA), Castillo de San Marcos National Monument (CASA), Cumberland Island National Monument (CUIS), Fort Caroline National Memorial (FOCA), Fort Frederica National Monument (FOFR), Fort Matanzas National Monument (FOMA), Fort Pulaski National Monument (FOPU), and Timucuan Ecological and Historic Preserve (TIMU). Fort Frederica National Monument was discussed on April 20. Bruce Heise (NPS GRD) facilitated the meeting, presented an overview of the GRI program, and led the discussion regarding geologic processes and features at each NPS unit. Stephanie O'Meara (CSU) led the discussion of map coverage relevant to each unit. Randy Parkinson (RWParkinson Consulting) presented an overview of coastal regional geology and barrier island geomorphology. Participants at the meeting included NPS staff from the park, Geologic Resources Division (GRD), and Southeast Coast Network (SECN) and cooperators from the U.S. Geological Survey (USGS), Florida Geologic Survey (FGS), University of West Georgia (UWG), University of Georgia (UGA), Polk Community College (PCC), and Colorado State University (CSU) (see table 2).

This scoping summary highlights the GRI scoping meeting for Fort Frederica National Monument including the geologic setting, the plan for providing a digital geologic map, a summary of geologic resource management issues, a description of significant geologic features and processes, and a record of meeting participants.

## Park and Geologic Setting

Fort Frederica National Monument is located on St. Simons Island approximately 11.8 km (7.3 mi) northeast of Brunswick, Georgia. The 97.70 ha (241.42 acres) monument contains both the original fort, built on the east shore of the Frederica River, and one of the battle sites, Bloody Marsh, which lies southeast of the fort. Little Simons Island borders St. Simons Island to the north and northeast and Sea Island lies to the east. The Mackay River separates St. Simons Island from the mainland.

The depositional setting of Georgia's coast is related to plate tectonics. Most coastlines may be described as either a "collision" or a "trailing edge" coastline. On the California coast of North America, for example, the North American lithospheric plate is colliding with the Pacific plate. Rapid uplift, young mountain ranges and short rivers characterize these active margins. In contrast,

more passive, trailing edge coastlines, such as the eastern U.S. coast, are relatively stable, have a broader continental shelf, and form a “depositional” coast. Barrier islands are frequently found along these depositional coastlines.

St. Simons Island is one of 8 major islands and island groups that comprise the 160 km (100 mi) of Georgia’s coastline (Henry 2009). Barrier islands are rare along tide-dominated coasts, where tidal range exceeds 4 m (13 ft). Along coastlines such as eastern Florida, where tidal range is small and waves dominate the coastline, barrier islands form long, linear features. A mixed energy environment dominates Georgia’s coast where tidal range averages just higher than 1.8 m (6 ft) and wave action associated with seasonal storms and infrequent hurricanes modify the coastline (Henry 2009). Mixed-energy barrier islands tend to be short, wide at one end and narrow at the other. Relatively deep, stable, tidal inlets separate these short barrier islands. Extensive sand shoal systems accumulate at the mouth of tidal inlets, and longshore currents transport the sand to downcurrent recipients.

Georgia tidal marshlands include saltwater wetlands that predominate in the 5- to 8-km-wide (2- to 5-mi-wide) areas between the barrier islands and the mainland and the brackish to freshwater wetlands that extend inland along the estuaries for an additional 16 km (10 mi) or so (Henry 2009). Erosional remnants of Pleistocene and Holocene barrier islands and back barrier deposits are scattered throughout the tidal marshlands.

With the rise and fall of relative sea level over the past 20,000 years, shoreline complexes have been deposited on the coastal plain, landward of the current shoreline, as well as offshore. Surface sediments at Fort Frederica National Monument consist of back-barrier and barrier island material left behind by the Pleistocene (1.8 million years to 10,000 years ago) Silver Bluff and Holocene (10,000 years ago to present) shorelines. These deposits include bioturbated salt marsh material and beach to nearshore marine sand (Scott et al. 1986).

## **Regional Geology and Barrier Island Geomorphology (Randy Parkinson)**

Fort Frederica National Monument, Fort Pulaski National Monument, and Cumberland Island National Seashore are part of Georgia’s Coastal Plain, one of five major northeast-southwest trending geologic zones that define the landscape in the southeastern United States. From northwest to southeast, these geologic zones include the Appalachian Plateau, Ridge and Valley, Blue Ridge, Piedmont, and Coastal Plain provinces. The Coastal Plain is a broad and gently sloping landscape that consists of nearly horizontal sedimentary layers that were deposited, eroded, and modified over the past 100 million years and continues to be modified even today. Barrier islands, tidal creeks, and extensive marshlands mark the eastern edge of the province. To the west, the “Fall Line” represents the boundary between the Coastal Plain and Piedmont provinces. The Fall Line, identified on topographic maps by a series of waterfalls, marks an abrupt change in elevation between the low-lying plains and the rolling topography and foothills of the Piedmont. The Piedmont and the other elevated provinces formed from tectonic events spanning 250 million to 1 billion years ago. The provinces continue to undergo erosion and supply sediment via rivers and streams to the Coastal Plain and its barrier islands.

Linear features identified on the Coastal Plain represent previous coastlines and barrier islands associated with major fluctuations of sea level over the past 400,000 years. Sea level fell during periods of glacial advance and rose during interglacial periods when glaciers melted. Sea level began to rise about 20,000 years ago and rose rapidly until about 6,000 years ago when the present barrier islands along the eastern seaboard formed. The rapid rise in sea level drowned previously existing barrier islands. About 3,000 years ago, coastal features stabilized so that although sea level continues to rise and the coastline continues to retreat landward, the barrier islands, wetlands, lagoons, and other coastal features have maintained their geomorphic integrity.

To form, barrier islands require an abundant sediment supply, moderate to high wave energy, micro- to meso-tidal ranges of less than 4 m (13 ft), rising sea level, and a broad continental shelf. Barrier island morphology is controlled by both tidal range and wave height. Wave dominated barrier islands, such as those along the east coast of Florida, are long and straight. Short, crenulated barrier islands along Florida's panhandle and southwest coast are tide dominated. The short barrier islands along the Georgia coast result from a mixed wave and tidal energy.

Three conceptual models have been proposed for the origin of barrier islands: 1) dune drowning, 2) spit elongation, and 3) shoal emergence. Dune drowning occurs with a relative rise in sea level, which may inundate a mainland ridge of coastal dunes, thus forming a lagoon between the most seaward dune ridge and the mainland. Stable sea-level conditions and/or an abundant sand supply are conducive to the development of barrier islands by spit elongation. In the spit elongation model, longshore currents transport sand along the coast, and the sand is deposited on the flanks of headlands or at the downdrift ends of existing barrier islands. As these relatively thin spits of sand elongate, they form barriers that block embayments and form lagoons. Eventually, tidal inlets may separate the spits from the headland, forming a barrier island. Shoal emergence results when erosion and redistribution of sediment on the sea floor promotes the upward growth of a submerged sand bar. Shoal emergence is aided by a relative fall in sea level and a local surplus of sand that can maintain the barrier above the ocean's surface.

Barrier islands can be subdivided into a back barrier region, dune system, and beach (fig. 1). A lagoon or estuary separates the barrier island from the mainland. Flood-tidal deltas form on the incoming tide while the outgoing tide produces ebb-tidal deltas. During storms, washover fans distribute sediment into the back barrier and push the barrier island landward.

Sea level rise is a major driving force with regards to barrier island sustainability. With relative sea level rise (transgression), barrier islands migrate landward. Vertical cross-sections through present barrier island systems show this landward migration over time. Buried beneath today's beaches, for example, are yesterday's lagoon and mainland environments. Currently, the margins of North America are being subjected to coastal erosion. Understanding barrier island morphology and its dynamic association with sea level rise, tides, and wave energy may be used to project future coastline patterns.

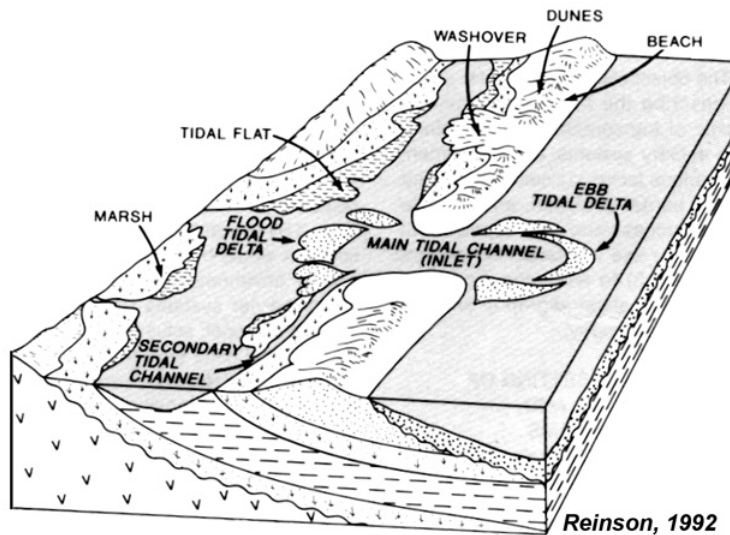


Figure 1. Common coastal environments associated with barrier islands. Schematic from Reinson (1992).

## Geologic Mapping for Fort Frederica National Monument

During the scoping meeting, Stephanie O'Meara (CSU) briefly displayed some of the main features of a GRI digital geologic-GIS map, which includes source map notes, legend, and cross sections, with the added benefit of being GIS compatible. The NPS GRI Geology-GIS Geodatabase Data Model incorporates the standards of digital map creation for the GRI Program and allows for rigorous quality control. Staff members digitize maps or convert digital data to the GRI digital geologic-GIS map model using ESRI ArcGIS software. Final digital geologic-GIS map products include GIS data in geodatabase and shapefile format, layer files complete with feature symbology, FGDC-compliant metadata, an Adobe Acrobat PDF help document that captures ancillary map data, and an ESRI ArcGIS ArcMap document file that displays the map, and provides a tool to access the PDF help document directly from an ArcMap document. Final data products are posted at <http://science.nature.nps.gov/nrdata/>. The data model is available at <http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm>.

When possible, the GRI Program provides large scale (1:24,000) digital geologic map coverage for each park's area of interest, which is often composed of the 7.5-minute quadrangles that contain park lands (fig. 2). Maps of this scale (and larger) are useful to resource managers because they capture most geologic features of interest and are spatially accurate within 12 m (40 ft). The process of selecting maps for management begins with the identification of existing geologic maps (table 1) and mapping needs in the vicinity of the park. Scoping session participants then select appropriate source maps for the digital geologic data or develop a plan to obtain new mapping, if necessary.

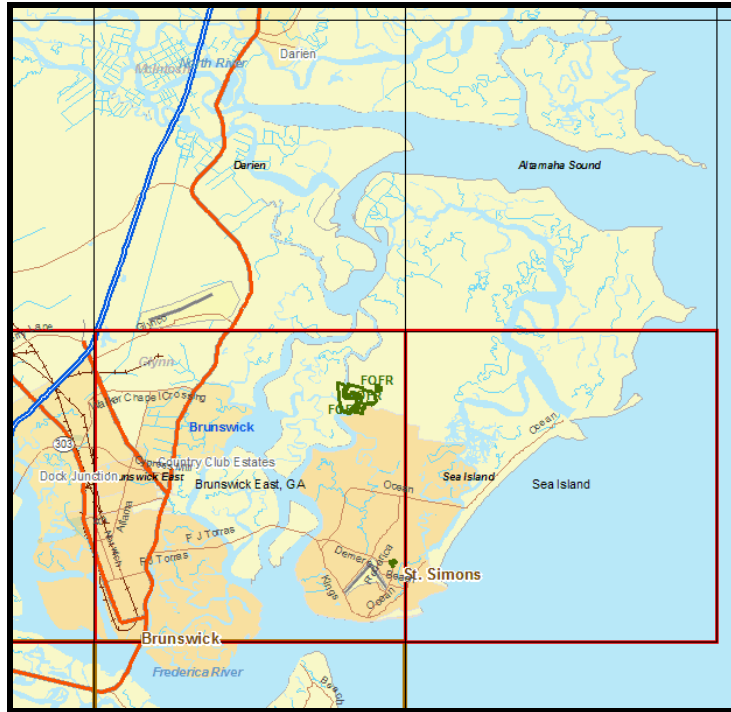


Figure 2. Area of interest for Fort Frederica National Monument (FOFR). The 7.5-minute quadrangles are labeled in black; names and lines in blue indicate 30-minute by 60-minute quadrangles, whereas names and lines in purple indicate 1x2 degree quadrangles. Green outlines indicate national preserve and memorial boundaries. Both Altamaha Sound and Darien 7.5-minute quadrangles were added to the area of interest at the scoping meeting by Mary Beth Wester (NPS-FOFR).

Map coverage is available for all of the areas of interest for Fort Frederica National Monument from:

- Kellam, M. F., M. M. Griffin, V. J. Henry, P. F. Huddleston, B. J. O'Connor, M. L. Pate, B. Q. Rado, T. M. Loretto, D. McCarthy, and L. M. Smith. 1986. *Geomorphology*. Scale 1:250,000. Environmental geologic atlas of coastal Georgia, Geologic Atlas GA-5, Plate 2. Atlanta, GA: Georgia Department of Natural Resources. (GRI Source Map ID 75115).

The GRI will determine if the map from the following reference incorporates the Kellam and others, 1986 map, and if it does, the digital data will be used to produce the GRI digital geologic map for FOFR. If Dicken and others (2005) does not incorporate the digital data of Kellam and others (1986), then the 1986 map of Kellam and others will be digitized to produce the GRI digital geologic map for FOFR.

- Dicken, C. L., S. W. Nicholson, J. D. Horton, M. P. Foote, and J. A. L. Mueller. 2005. *Preliminary integrated geologic map databases for the United States: Alabama, Florida, Georgia, Mississippi, North Carolina, and South Carolina*. Scale 1:100,000. Open-File Report OF-2005-1323. Reston, VA: U.S. Geological Survey. (GRI Source Map ID 74109).

**Table 1. GRI Mapping Plan for Fort Frederica National Monument**

| Covered Quadrangles | Relationship to the park | Citation                                                                                                                                                                                                 | Format | Assessment                           | GRI Action                                                                                                                                 |
|---------------------|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| Altamaha Sound      | Near park boundary       | Kellam, M. F., et al. 1986. <i>Geomorphology</i> . Scale 1:250,000. Environmental geologic atlas of coastal Georgia, Geologic Atlas GA-5, Plate 2. Atlanta, GA: Georgia Department of Natural Resources. | paper  | Map displays general surficial units | Digitize, but evaluate Dicken and others, 2005 digital data first to see if this digital data incorporates the Kellem and others, 1986 map |
| Darien              | Near park boundary       |                                                                                                                                                                                                          |        |                                      |                                                                                                                                            |
| Sea Island          | Near park boundary       |                                                                                                                                                                                                          |        |                                      |                                                                                                                                            |
| Brunswick East      | Contains the Park        |                                                                                                                                                                                                          |        |                                      |                                                                                                                                            |

A possible alternative to the 1986 Kellam and others map would be any coverage of this area similar to the 1981 C. T. Swann map, *Geology as applied to land-use management on Cumberland Island, Georgia*, published by the Department of Natural Resources, Environmental Protection Division, Georgia Geological Survey. C. J. Jackson (UGA, PCC) has agreed to research and determine if any such map exists. If so, it would be evaluated to determine if it supersedes the Kellam and others, 1986 map.

## Geologic Resource Management Issues

The principal geologic resource management issue discussed during the scoping session involved erosion along the Frederica River.

### Frederica River Bank Erosion

Boat wake from pleasure boats, high tidal flux, and waves generated by fluvial fetch (the area of the river's surface over which a constant and uniform wind generates waves) contribute to bank erosion. Part of the monument is now under water due to significant cutbank erosion. Bank erosion caused the quay wall from the old yacht club to deteriorate. The wall was recently rebuilt 180–270 m (200–300 yd) from the fort's magazine. The meandering channel morphology has been altered by multiple applications of riprap and other man-made changes. High tides cause further erosion and may be causing the rivers to widen, thus increasing fluvial fetch. A significant management concern is the possibility that increased bank erosion may destroy archeological resources along the river.

### Other geologic resource management issues

*Marsh loss.* Loss of marshland along stream edges and dieback of marshland due to snails may further increase the potential for bank erosion.

*Minor flooding.* Flooding from precipitation (not from river flooding) has occurred once in past nine years.

*Potential impact to 4 artesian wells.* Groundwater flowed from the 4 wells until 2 years ago when the wells dried up. This change may be due to recent development beyond the monument's boundaries.

*Potential shoaling in the river system.* Little is known about sedimentation and shoaling in the Frederica River.

*Potential installation of a new dock.* Since the tidal range is 1.5–2 m (4.9–6.6 ft) and 10.7 m (35 ft) of tidal mud flats are exposed during low tide, any new dock should be a floating dock.

*Potential impacts from a changing climate.* Long-term sea level rise may decrease marshland along the river and increase fluvial fetch. Salt marsh elevation monitoring continues to measure accretion and subsidence of the area. Long term sea level rise also may further inundate archeological resources along the river, cause a shift in the dominant vegetation in the adjacent marsh, and change salinity in the tidal prism. The rate of sea level rise may impact the degree of erosion along the riverbank. Climate change may also lead to an increase in the intensity and frequency of storms.

A boundary expansion is possible for Fort Frederica National Monument, but any expansion will encounter the same management issues.

## Features and Processes

The scoping session for Fort Frederica National Monument provided the opportunity to develop a list of geologic features and processes, which will be further explained in the final GRI report. Please note that the National Park Service monitoring manual (R. Young and L. Norby, editors. *Geological Monitoring*. Special paper. Geological Society of America, Boulder, CO.) is currently in press and will contain information on monitoring of geologic features and processes found in NPS coastal units. These features at Fort Frederica National Monument include:

- Fluvial processes and features, including channel geomorphology,
- Tidal inlets and tidal mud flats,
- Interaction of the tidal prism, river, and salt marsh,
- Groundwater seeps located inside the entrance to the monument,
- Submerged archeological resources,
- A very deep seated (buried) gravity anomaly,
- Remnants of past shell mining operations that are located in the southern end of the island but outside the monument's boundaries,
- Shells from area middens used to make the tabby concrete used in the construction of Fort Frederica and associated buildings,
- Indian mounds at Bloody Marsh,
- Paleontological resources. Larry West (NPS SECN) suggested consulting the recently published *Paleontological Resource Inventory and Monitoring* report for the SECN to review the paleontological resources in the monument (Tweet et al. 2009). The following information is from that report.

One unidentified fossil specimen from Fort Frederica National Monument is in the collections database of the Southeast Archeological Center (SEAC). The fossil was recovered from the barracks area in the courtyard site of the southeast quarter. Geological units in the subsurface at Fort Frederica produce fossils from surrounding areas, but no other

fossils have been discovered at the monument. Fossils may be found in cultural resource sites because colonists mined local middens for shells needed to make tabby concrete.

## References

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- Reinson, G. E. 1992. Transgressive barrier island and estuarine systems. In *Facies Models*, ed. R. G. Walker and N. P. James, 179-194. St. John's, Newfoundland, Canada: Memorial University, Geological Association of Canada.
- Tweet, J. S., V. L. Santucci, and J. P. Kenworthy. 2009. *Paleontological Resource Inventory and Monitoring: Southeast Coast Network*. Natural Resource Technical Report NPS/NRPC/NRTR – 2009/197. Fort Collins, CO: National Park Service, Natural Resource Program Center.

**Table 2. Scoping Meeting Participants**

| Name                  | Affiliation                      | Position                               | Phone                  | E-Mail                            |
|-----------------------|----------------------------------|----------------------------------------|------------------------|-----------------------------------|
| Bryant, Richard       | NPS TIMU & FOCA                  | Chief, Resource Management             | 904-221-7567           | richard_bryant@nps.gov            |
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| Corbett, Sara         | NPS SECN                         | Botanist                               | 972-882-9139           | sara_corbett@nps.gov              |
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| DeVivo, Joe           | NPS SECN                         | Network Coordinator                    | 404-562-3113<br>x 739  | joe_devivo@nps.gov                |
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| Fry, John             | NPS CUIS                         | Chief, Resource Management             | 912-882-4336<br>x 262  | john_fry@nps.gov                  |
| Graham, John          | Colorado State U.                | Geologist – Report Writer              | 970-581-4203           | rockdoc250@comcast.net            |
| Heise, Bruce          | NPS GRD                          | Geologist -<br>GRI Program Coordinator | 303-969-2017           | bruce_heise@nps.gov               |
| Jackson, C.J.         | University of<br>Georgia/Polk CC | Coastal Geologist                      | 863-258-4226           | jackson.cwjr@gmail.com            |
| Means, Harley         | Florida Geological<br>Survey     | Geologist                              | 850-487-9455<br>x 112  | guy.means@dep.state.fl.us         |
| O'Meara,<br>Stephanie | Colorado State U.                | Geologist, GRI Map Team<br>Coordinator | 970-225-3584           | Stephanie_O'Meara@partner.nps.gov |
| Parkinson, Randy      | RWParkinson<br>Consulting        | Coastal Geomorphologist                | 321-373-0976           | rwparkinson@cfl.rr.com            |
| Rich, Andrew          | NPS CASA &<br>FOMA               | Chief, Resource<br>Management          | 904-471-0116           | andrew_rich@nps.gov               |
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| Spechler, Rich        | USGS WRD                         | Hydrologist                            | 407-803-5523           | spechler@usgs.gov                 |
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| Wester, Randy         | NPS FOPU                         | Acting Superintendent                  | 912-786-5787           | randy_wester@nps.gov              |