Geologic Resources Inventory Scoping Summary
Fort Matanzas National Monument, Florida

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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 Matanzas 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 (Colorado State University) 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 Matanzas National Monument including the geologic setting, the plan for providing a digital geologic map, a summary of geologic resource management issues, a list of significant geologic features and processes, and a record of meeting participants.

Park and Geologic Setting

Fort Matanzas National Monument, along with the entire state of Florida, lies on the Floridian Plateau, a physiographic province approximately 800 km (500 mi) long and 400 to 640 km (250 to 400 mi) wide. The plateau, which has existed for millions of years, includes both emergent land and submerged continental shelf. Areas on the plateau have been alternately covered by seawater and exposed as dry land many times in the past so that marine and terrestrial deposits have been deposited one on top of the other.

The monument is located about 23 km (14.5 mi) south of St. Augustine, Florida. The Matanzas River splits the monument into two parts. East of the river, the monument occupies the southern tip of Anastasia Island, one of Florida's many barrier islands. The historic fort lies on the west bank of the river, on Rattlesnake Island. The Intracoastal Waterway separates Rattlesnake Island from the mainland. The Matanzas Inlet, which lies off the southern tip of Anastasia Island, connects the Matanzas River to the Atlantic Ocean. The ocean borders the eastern shoreline of Anastasia Island. Access to Fort Matanzas is by ferry from the Visitor Center on Anastasia Island.

In northeastern Florida, both waves and tides influence barrier island morphology. This mixed wave-tidal energy creates relatively short barrier islands, like Anastasia Island, with well developed dunes and extensive marshes and tidal flats. Tidal inlets are typically wide and deep. South of Matanzas Inlet, the long, narrow barrier islands of Florida's east coast reflect a wave-dominated system with limited sand supply and tidal influence (Davis 1997). Characteristically, tidal range is low and freshwater inflow is minor so that the tidal inlets that separate these Florida barriers are widely spaced and small (Morton and Miller 2005).

The barrier-island and tidal-inlet system of Florida's east coast extends for approximately 550 km (342 mi), making it the longest in the United States. The Matanzas Inlet is the only one of the 22 inlets that has not been modified by jetties or other stabilizing structures and so is in a constant state of flux (Davis 1997). The inlet has changed significantly from the inlet that existed in 1740 when the Spanish began construction of Ft. Matanzas on Rattlesnake Island. Along the east coast of Florida, Matanzas Inlet offers the largest nesting area of the least tern and is one of the few places along the east coast of Florida still open to recreational and commercial oyster and clam harvesting.

The surface geology of Fort Matanzas National Monument is composed of the Pleistocene (1.8 million years ago to 10,000 years ago) Anastasia Formation and Holocene (10,000 years ago to present) sediments (Scott et al. 2001). The Anastasia Formation formed in beach and shallow-water nearshore environments where sand grains and mollusk shells cemented together to form a sedimentary rock called a "coquina." The thickness of the Anastasia coquina is variable, but near St. Augustine the coquina is greater than 9 m (30 ft) thick. The Anastasia Formation typically anchors Florida's east coast barriers and in some areas, high foredunes develop that prevent overwashing and landward migration. The coquina was used in the construction of Fort Matanzas.

Regional Geology and Barrier Island Geomorphology (Randy Parkinson)

Fort Pulaski National Monument, Fort Frederica 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.

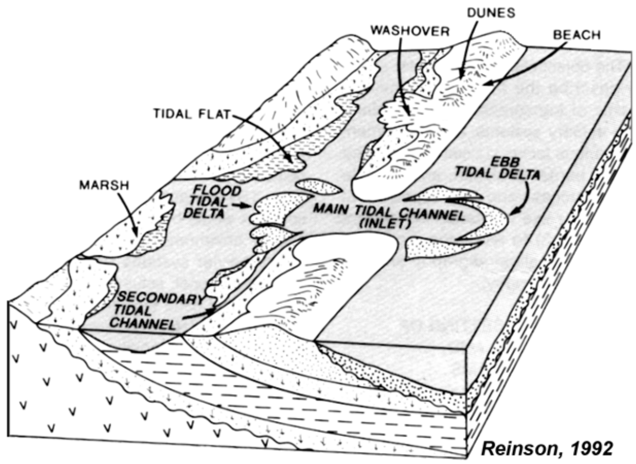

Figure 1. Common coastal environments associated with barrier islands. Schematic from Reinson (1992).

Geologic Mapping for Fort Matanzas 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.

Map coverage is available for all of the quadrangles of interest for FOMA from updated geomorphic digital data expected to be published by the Florida Geological Survey in January 2010. Harley Means (FGS) stated the new geomorphic map will incorporate updated mapping and would provide more detail than the existing geologic map of Florida (Scott et al. 2001).

The GRI will evaluate the quality of the FGS digital data and distribute an image of the data to Andrew Rich (NPS CASA, FOMA) and Linda York (NPS SERO) to determine the usefulness of the data to FOMA park resource management. The GRI will, in all likelihood, use this new work as the basis for the digital geologic map for the park.

Table 1. GRI Mapping Plan for Fort Matanzas National Monument

Covered Quadrangles	Relationship to the park	Citation	Format	Assessment	GRI Action
Matanzas Inlet	Includes FOMA park boundary	Unpublished Geomorphic Map of the State of Florida, Florida Geological Survey, 2010	digital	The digital map has not been finalized, and requires review by GRI, the park and others	Obtain GIS data from Florida Geological Survey in early 2010 and evaluate data quality and distribute map image to the park and others to assess the usefulness to the park
Dinner Island	Near FOMA park boundary	Unpublished Geomorphic Map of the State of Florida, Florida Geological Survey, 2010	digital	The digital map has not been finalized, and requires review by GRI, the park and others	Obtain GIS data from Florida Geological Survey in early 2010 and evaluate data quality and distribute map image to the park and others to assess the usefulness to the park

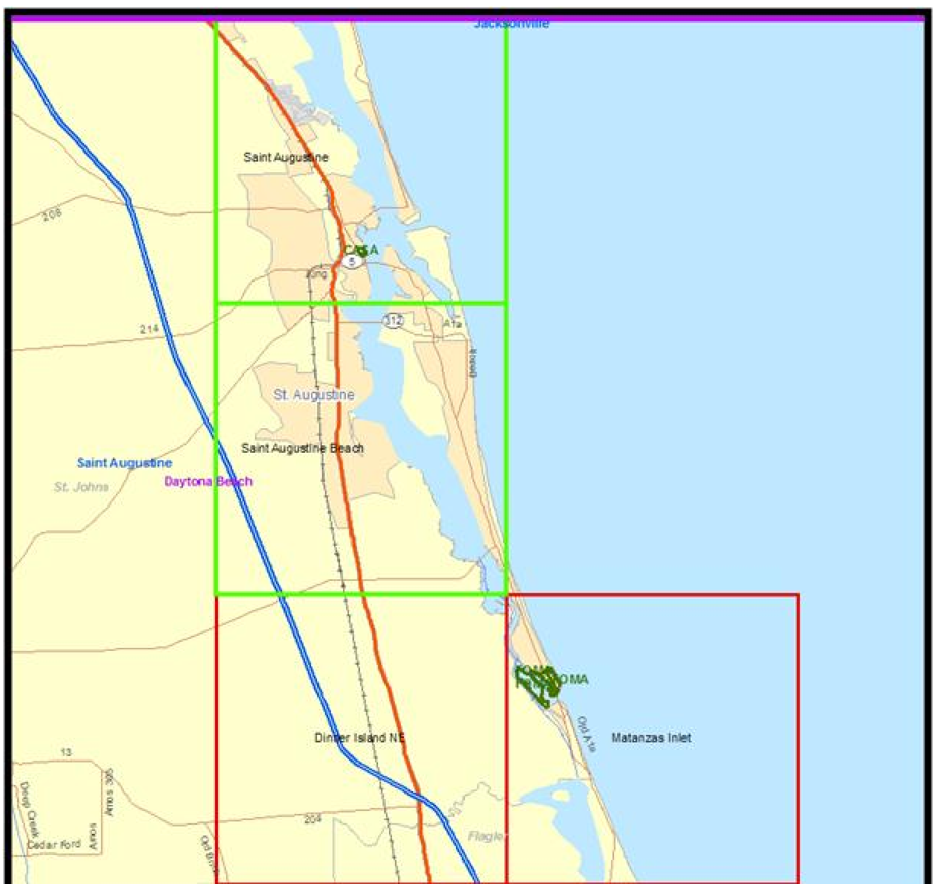

Figure 2. Area of interest for Fort Matanzas National Monument (FOMA) and Castillo de San Marcos National Monument (CASA). The 7.5-minute quadrangles are labeled in black; names and lines in blue indicate 30-minute by 60-minute quadrangles, whereas names and lines in purple indicate 1x2 degree quadrangles. Green outlines indicate national preserve and memorial boundaries.

At the scoping meeting Andrew Rich stated that the FGS digital data could prove useful to general park management issues outside the monument boundaries; however, more detailed geomorphic mapping may be needed for areas within and immediately adjacent to the monument, in particular in areas of active erosion at and near the fort.

More detail geomorphic mapping, as determined by Andrew Rich or Linda York, would require new mapping that leverages from recent LIDAR data. USGS Coastal Geologist Jim Flocks agreed to investigate what LIDAR coverage might be already available. Depending on the level of GRI funding, a solicitation for bids for a new map of the park could be announced in 2010 on the Federal Business Opportunities website, FedBizOpps.gov. Standards for the map product will be detailed in the solicitation but would likely include delivering a product similar to the detailed geomorphic mapping produced in the GRI Geology-GIS Geodatabase Data Model format for the GRI at Canaveral National Seashore.

Geologic Resource Management Issues

Fort Matanzas National Monument has geologic issues similar to those found at Cape Canaveral National Seashore. The principal geologic resource management issues discussed during the scoping session involved both natural and man-made processes affecting aeolian (windblown) and coastal features and impacts from a changing climate. Minor issues included restoring disturbed lands and groundwater quality.

Aeolian Issues

Visitors, storms, and overwash events not only compromise the integrity of the dune system at Fort Matanzas National Monument but they also threaten the habitat of the endangered Anastasia Island Beach Mouse. Trampling vegetation destabilizes the dunes, and storms have washed away some of the boardwalks built over the dunes. Storms also may destroy cultural sites in the dunes such as archaeology sites and middens. No dune fencing exists at Fort Matanzas National Monument.

Coastal Issues

Coastal issues involve the beach, tidal inlet, and Matanzas River bank. Natural processes such as waves, tides, transport of sediment by longshore current, and storm events constantly influence beach and shoreline morphology and keep the foredune-beach system in a state of dynamic equilibrium. Southward migration of sand is an ongoing, natural process although a jetty has been proposed to trap the sand. This proposal has not been implemented. State Road A1A spans Matanzas Inlet, connecting Anastasia Island to the private residences at Summer Haven, Florida, and this highway is expected to be maintained and kept open.

Every 2.7 years, dredging manipulates the lagoonal area on the backside of Anastasia Island, and dredging Matanzas Inlet has been suggested, as well. Dredged spoils piles have changed the hydrology in some areas. Wake from commercial and pleasure fishing boats causes erosion to the Matanzas River shoreline, and meandering tidal creeks may erode into onshore resources. Groins and reventments have been installed on some river beaches.

Six months ago, Piñon Inlet opened at the southern end of Rattlesnake Island, connecting the Matanzas River with the Intracoastal Waterway. The inlet widens daily and at the time of the scoping workshop, measured approximately 30 m (100 ft) wide at high tide. The state of Florida has suggested filling in the inlet. If the inlet is not filled in, tidal influence will increase.

Potential Impacts from a Changing Climate

Sea level rise due to changing climate may impact the dune-beach system and Matanzas Inlet more so than the fort, which lies 1.5 m (5 ft) above high tide. With climate change, storm intensity may increase and potentially destabilize dunes, roads, boardwalks, groins and other man-made structures. Rising sea level and storms may increase the potential for storm washover events and erosion of the foreshore, dunes, and riverbanks. Habitat for threatened and endangered species (T&E) may be altered and exotic species introduced into the area.

Whether or not the marsh is keeping pace with rising sea level is a management concern. Modeling continues with regard to rainfall, salinity changes in the lagoon, impacts on submerged aquatic vegetation (SAV), and exotic species of plants and animals. An overall temperature shift has resulted in the area becoming warmer. This warming effect has enabled more tropical plants to become established in central Florida.

Other Issues

Disturbed Lands. Disturbed lands needing restoration include spoil islands and a few man-made ditches on Rattlesnake Island. Efforts have been made to stabilize dunes against overwash.

Groundwater Quality. Groundwater quality in the upper Florida aquifer is poor. Bacteria count is high in some wells. Groundwater and surface water quality and monitoring is a function of the NPS Water Resources Division.

Features and Processes

The scoping session for Fort Matanzas 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 Matanzas National Monument include:

- *Aeolian*. Sand dunes and interdune areas. Freshwater ponds.
- *Lacustrine (lake)*. Fort Matanzas National Monument provides a migratory stopover and key breeding and wintering area for a variety of bird species as well as herp habitat. Freshwater habitats form in the swales of ridge-and-swale features.
- *Coastal*. Coastal features include the dune ridge, beach berm, beach face, low-tide terrace, washover fan deposits, and ebb tidal shoals. An offshore trough and sand bar develop in the surf zone. Matanzas Inlet borders the island to the south. A salt marsh (lagoon) and tidal creek system has developed in the protected intertidal waters behind Anastasia Island and surrounding Rattlesnake Island.
- *Seismic*. Geophysical data from the U.S. Geological Survey contain evidence of buried collapse features in the area. A spring, offshore from Crescent Beach, has an estimated flow of 1.4 to 8.5 cubic meter/sec (50 to 300 cubic feet/sec). Potential for seismic (i.e.

earthquake) disturbance in the area is minimal although a historic earthquake in Charleston, South Carolina rang the bell in St. Augustine and was probably felt in the Fort Matanzas area.

- *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.

  Fort Matanzas was constructed from fossil shell-laden rock from the Anastasia Formation. Whole specimens, fragments, and molds of mollusk shells are common in the Anastasia Formation with the donacid clam *Donax* being the dominant specimen. In addition to mollusks, Anastasia Formation fossils include foraminifera, coral, ghost crabs and their burrows, echinoids, and vertebrates. The Southeast Archeological Center (SEAC) contains one fossil specimen (FOMA 793) from Fort Matanzas National Monument. Recovered from a trench at the North Midden, Fort Matanzas Complex, the specimen is a porcupinefish or balloonfish (*Diodon*).
- *Mineral exploration*: Coquina mines still operate west of the park boundaries. Inactive quarries are located on the island.
- *Type sections*: The type section for the Anastasia Formation is on Anastasia Island, opposite St. Augustine.

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Table 2. Scoping Meeting Participants

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