

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science Directorate
Geologic Resources Division



Castillo de San Marcos National Monument and Fort Matanzas National Monument

GRI Ancillary Map Information Document

Produced to accompany the Geologic Resources Inventory (GRI) Digital Geologic Data for Castillo de San Marcos National Monument and Fort Matanzas National Monument.

cafo_geology.pdf

Version: 7/21/2014

Geologic Resources Inventory Map Document for Castillo de San Marcos National Monument and Fort Matanzas National Monument

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Geologic Resources Inventory Map Document



Castillo de San Marcos National Monument and Fort Matanzas National Monument, Florida

Document to Accompany Digital Geologic-GIS Data

[cafo_geology.pdf](#)

Version: 7/21/2014

This document has been developed to accompany the digital geologic-GIS data developed by the Geologic Resources Inventory (GRI) program for Castillo de San Marcos National Monument (CASA) and Fort Matanzas National Monument (FOMA)

Attempts have been made to reproduce all aspects of the original source products, including the geologic units and their descriptions, geologic cross sections, the geologic report, references and all other pertinent images and information contained in the original publication.

National Park Service (NPS) Geologic Resources Inventory (GRI) Program staff have assembled the digital geologic-GIS data that accompanies this document.

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About the NPS Geologic Resources Inventory Program

Background

Recognizing the interrelationships between the physical (geology, air, and water) and biological (plants and animals) components of the Earth is vital to understanding, managing, and protecting natural resources. The Geologic Resources Inventory (GRI) helps make this connection by providing information on the role of geology and geologic resource management in parks.

Geologic resources for management consideration include both the processes that act upon the Earth and the features formed as a result of these processes. Geologic processes include: erosion and sedimentation; seismic, volcanic, and geothermal activity; glaciation, rockfalls, landslides, and shoreline change. Geologic features include mountains, canyons, natural arches and bridges, minerals, rocks, fossils, cave and karst systems, beaches, dunes, glaciers, volcanoes, and faults.

The Geologic Resources Inventory aims to raise awareness of geology and the role it plays in the environment, and to provide natural resource managers and staff, park planners, interpreters, researchers, and other NPS personnel with information that can help them make informed management decisions.

The GRI team, working closely with the Colorado State University (CSU) Department of Geosciences and a variety of other partners, provides more than 270 parks with a geologic scoping meeting, digital geologic-GIS map data, and a park-specific geologic report.

Products

Scoping Meetings: These park-specific meetings bring together local geologic experts and park staff to inventory and review available geologic data and discuss geologic resource management issues. A summary document is prepared for each meeting that identifies a plan to provide digital map data for the park.

Digital Geologic Maps: 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 and meet park needs. These digital GIS data allow geologic information to be easily viewed and analyzed in conjunction with a wide range of other resource management information data.

For detailed information regarding GIS parameters such as data attribute field definitions, attribute field codes, value definitions, and rules that govern relationships found in the data, refer to the NPS Geology-GIS Data Model document available at: <http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm>

Geologic Reports: Park-specific geologic reports identify geologic resource management issues as well as features and processes that are important to park ecosystems. In addition, these reports present a brief geologic history of the park and address specific properties of geologic units present in the park.

For a complete listing of Geologic Resource Inventory products and direct links to the download site visit the GRI publications webpage http://www.nature.nps.gov/geology/inventory/gre_publications.cfm

GRI geologic-GIS data is also available online at the NPS Data Store Search Application: <http://irma.nps.gov/App/Reference/Search>. To find GRI data for a specific park or parks select the appropriate park

(s), enter "GRI" as a Search Text term, and then select the Search Button.

For more information about the Geologic Resources Inventory Program visit the GRI webpage: <http://www.nature.nps.gov/geology/inventory>, or contact:

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The Geologic Resources Inventory (GRI) program is funded by the National Park Service (NPS) Inventory and Monitoring (I&M) Division.

GRI Digital Maps and FGS Source Map Citation

The GRI digital geologic-GIS maps for Castillo de San Marcos National Monument (CASA) and Fort Matanzas National Monument (FOMA):

GRI Digital Geomorphic Map of Castillo de San Marcos National Monument and Fort Matanzas National Monument and Vicinity, Florida (*GRI MapCode CAFG*)

GRI Digital Geologic Map of of Castillo de San Marcos National Monument and Fort Matanzas National Monument and Vicinity, Florida (*GRI MapCode CAFO*)

Both maps were produced from digital data from the following Florida Geological Survey preliminary digital data and map.

Williams, C.P., Cichon, J.R. and Hartman, L.M., 2014, Geomorphology and Geology of Selected Coastal Regions in Northeastern Florida (Castillo de San Marcos National Monument and Fort Matanzas National Monument); Florida Geological Survey, preliminary digital data and map, scale 1:24,000. (*GRI Source Map ID 75749*).

Additional information pertaining to each source map is also presented in the Source Map Information (CAFOMAP) table included with the GRI geology-GIS data.

GRI Digital Geomorphic Map of Castillo de San Marcos NMON and Fort Matanzas NMON

Geomorphic Map Unit List

The Geomorphic units present in the GRI Digital Geomorphic Map of Castillo de San Marcos National Monument and Fort Matanzas National Monument are listed below. Units are listed with their assigned unit symbol and unit name (e.g., Qabbd - Active blowout/Blowout dune). Units are listed by geomorphic environment as per the source map. Information about each geologic unit is also presented in this dataset's Geomorphic Unit Information (CAFGUNIT) table included with the GRI geologic-GIS digital data.

Supratidal Units

[Qabbd](#) - Active blowout/Blowout dune

[Qdtf](#) - Deflation troughs or flats

[Qdn](#) - Dunes

[Qfd](#) - Foredune

[Qpd](#) - Primary dunes

[Qrd](#) - Relict dune and ridge

[Qsd](#) - Secondary dunes

Intertidal Beach Units

[Qc](#) - Coquina

[Qsb](#) - Sand beach

[Qwfod](#) - Washover fan/Overwash deposits

Intertidal Marsh Deposits

[Qnww](#) - Non-vegetated wetland

[Qsm](#) - Salt marsh

[Qso](#) - Salt ponds

[Qtc](#) - Tidal creek

Intertidal/Subtidal Flat Units

[Qb](#) - Bioherms

[Qcl](#) - Channel levee

[Qtf](#) - Tidal flat

Subtidal Units

[Qetd](#) - Ebb tide delta

[Qftd](#) - Flood tide delta

[Qic](#) - Inlet channel

Coastal-Riverine Units

[Qfw](#) - Freshwater wetland

[Qol](#) - Oxbow lakes

[Qpn](#) - Pond (natural)

[Qs](#) - Swamp

Anthropogenic Units

[Qdm](#) - Dams

[Qdma](#) - Docks/Marinas/Anchorage

[Qdc](#) - Dredged channels
[Qds](#) - Dredged spoil
[Qf](#) - Fill
[Qg](#) - Groins
[Qhs](#) - Historic structures
[Qi](#) - Impoundments
[Qj](#) - Jetties
[Qmd](#) - Mosquito ditches
[Qp](#) - Piers
[Qqbp](#) - Quarry/Borrow Pit
[Qrr](#) - Rip rap
[Qsp](#) - Stormwater ponds

Geomorphic Map Unit Descriptions

Descriptions of all geomorphic units were provided by the source map. ([FGS Geomorphic Map](#); *GRI Source Map ID 75749*).

Supratidal Map Units

Qabbd - Active blowout/Blowout dune (Recent)

Trough to scoop depressions formed by wind erosion, especially in primary dunes along the Atlantic Ocean shoreline, where vegetation may be destabilized due to the exposed sediment and turbulent nature of the wind environment off the Atlantic Ocean acting upon these depositional systems. Active blowouts were mapped by enclosing non-vegetated areas and some partially vegetated areas that were blown out from the primary dune.

Qdtf - Deflation troughs or flats (Recent)

Differentiated from active blowouts because of the broader trough expression and moderately flat topography that develops between dune sets in areas with more active dune formation and destruction. Within the study area, this is mapped adjacent to the dynamic environment north of Matanzas Inlet in Fort Matanzas National Monument, but some small, unidentified features of like nature may exist in the area south of St. Augustine Inlet within Anastasia State Park.

Qdn - Dunes (Recent)

Dunes are low ridges related to either shoreline processes or windblown sediment deposition. They consist primarily fine to medium quartz sands and shell material, with traces of heavy minerals and muscovite, and occur along the entire coast in the study area. The more general dune category was reserved for areas removed from the more active dune environments along the Atlantic Ocean shoreline, but includes interpreted features that may not be of similar depositional age. A significant portion of the dune areas have been modified by development. Every effort was made to interpret the geomorphic unit rather than the development modifications.

Qfd - Foredune (Recent)

Consists primarily of windblown quartz sand and shell material that may also have some shoreline-related deposition. These range from vegetated with native dune grasses to non-vegetated, and are found in the zone between the beach and the primary dune in localities where excess sediment supply fosters formation of a new dune feature. Given time, these have the potential to be established as primary dunes if not destroyed by erosion in storm events.

Qpd - Primary dunes (Recent)

Primary dunes run parallel to the modern coast and occur between the beach and interior dune units. These are noted as the first and most significant dunes of elevation adjacent to the Atlantic Ocean shoreline. They may contain shoreline deposited sediments, though the primary source is windblown quartz sand and shell material from the beach environment. Where found in urban areas, all attempts were made to map the natural dune system over urban modification.

Qdr - Relict dune and ridge (Recent)

This map unit covers the majority of the western study area with smaller remnants located in the salt marshes adjacent to the Guana, Tolomato and Matanzas rivers and the Intracoastal Waterway and the core of Anastasia Island. Much of this area is geologically mapped as Quaternary Beach Ridge and Dune, except where the Anastasia Formation is at or near the land surface. Sediments typically consist of quartz sands with clay, organics and shell fragments as minor constituents. The dune ridges parallel the modern shoreline and are related to deposition of coastal sediments, of barrier island morphology, formed over several stages of sea level transgressions in which sea levels were, for a time, higher than modern sea level. Lower elevation swamp to marsh habitats equate to dune swales formed between adjacent ridges. They are also significant predictors of location of surface water flow in the area that is dominated by a trellis drainage pattern. Relict dune units were interpreted in areas of urban modification. Anthropogenic units taking precedent over relict dunes include stormwater ponds, dredged channels and dredged spoil.

Qsd - Secondary dunes (Recent)

Secondary dunes occur between primary dunes and interior dune units. These may have elevations similar to or slightly lower than the primary dunes, but are removed from the immediate shoreline environment. The nature of their formation is akin to the primary dunes, but by age of deposition or excess sediment supply they are no longer adjacent to the beach environment. Many secondary dunes occur within developed areas. Every effort was made to interpret the geomorphic unit rather than development modifications. In areas of extreme anthropogenic modification, it was not possible to recognize secondary dunes and they were lumped into a different geomorphic unit (most commonly dunes).

Intertidal Map Units

Qc - Coquina (Recent)

Coquina is a detrital limestone deposit that locally consists dominantly of whole and broken fragments of mollusk shells and some echinoids with a variable component of quartz sand. These are calcite cemented and formed during the Late Pleistocene when sea level was comparable to modern sea level. The coquina outcrops are included within the Anastasia Formation. Presumably, past climate was drier, and supersaturation of dissolved ions and cations in the shoreface allowed for the chemical deposition of calcite. A modern equivalent is being deposited at Loggerhead Key in Dry Tortugas National Park in Florida. Coquina crops out along the beach from Washington Oaks Gardens State Park north to Marineland. It is also found cropping out in, and just south of, Matanzas Inlet and the Intracoastal Waterway between Marineland and Washington Oaks Gardens State Park. Its presence at the shoreline is significant because it functions like a natural version of shoreline armoring and thus protection of these resources is critical. It is mapped by grouping adjacent coquina outcrops together.

Qsb - Sand beach (Recent)

The dominant beach map unit occurs between the ocean shoreline and the modern dune complex. The beach is dominated by quartz sand and shell fragments. The ocean shoreline is estimated based on true color imagery (2011 St. Johns County, 2010 Flagler County). Dunes were delineated utilizing the true color imagery and LiDAR (2008 St. Johns County, 2009 Flagler County). To a lesser extent, sand beach was further delineated adjacent to inlets where deposition of sand has created thin strips of beach parallel to the Matanzas and Tolomato rivers. South of Matanzas Inlet, deposition of sand has closed a former inlet and a large portion of the tidal creek, making the sand beach unit extend from the shoreline and up the former tidal creek. Sand deposition in this area continues to rapidly expand, but the delineation is based on the 2011 true color imagery.

Qwfod - Washover fan/Overwash deposits (Recent)

These are shoreline geomorphologic features formed when storm events break through the barrier dunes from the ocean side and sand is transported from the beach and dunes to the lagoon side of the island. Overwash deposits that have naturalized to salt marsh were not identified. Only those features that are within what otherwise are various dune environments were delineated separately. These include areas of overwash sediments and occur in the vicinity of Salt Run on Anastasia Island and south of Matanzas Inlet. Salt Run is the former location of St. Augustine Inlet prior to human modification and ensuing natural processes in the twentieth century. The present location of St. Augustine Inlet is very near to the inlet location at the time of Spanish colonization. Washover Fan/Overwash Deposits are mapped by enclosing sediments that have been transported via water and wave energy from the dune complex toward the lagoons.

Intertidal Marsh Map Units

Qnvw - Non-vegetated wetland (Recent)

These are hydric surfaces that lack vegetation due to high levels of salinity and/or sediment disturbance at the toe of uplands and dredged spoil. The saline non-vegetated wetlands are caused by the precipitation of salts on sand flats or depressions that are normally only flooded during the spring portion of tidal cycles. This map unit is located throughout the salt marsh and is clearly delineated on the true color image as a bright white to white-gray feature.

Qsm - Salt marsh (Recent)

Salt marsh consists of areas where inundation is dictated by tidal fluctuations. The main salt-tolerant plant species are represented by *Spartina alterniflora* and *Juncus roemerianus*. The study area also contains locally abundant mangroves, particularly black mangrove, *Avicennia germinans*, and reveals the region is transitional between temperate and subtropical marsh plant species. The black mangroves tend to be more shrub-like and thus distinct mangrove swamps are not delineated. This map unit extends the entire length of the study area between the dunes on the barrier island side and the relict dunes on the landward side of the lowland occupied by the Guana, Tolomato and Matanzas rivers and the Intracoastal Waterway. Some areas contain large groupings of salt marsh islands interspersed with tiny tidal creeks. Every effort was made to identify salt marsh islands separately. In those areas where this wasn't feasible salt marsh islands were delineated by grouping islands together.

Qso - Salt ponds (Recent)

Naturally formed ponds, located within salt marsh environments.

Qtc - Tidal creek (Recent)

This map unit encompasses all natural rivers and creeks and the twentieth century anthropogenic Intracoastal Waterway located in the intertidal environment. Natural tidal creeks are most abundant in salt marsh and facilitate inundation and drainage of the marshland. They are mapped by delineating the high tide mark identified on the true color aerial imagery. If the image was taken at low tide, the area shown as mud was delineated as tidal creek to represent the highest point of inundation. The Intracoastal Waterway was partially delineated as tidal creek because there were no historic photographs prior to dredging and it was, at times, unclear what was previously natural versus dredged. Evidence based on the natural shape of the Matanzas River and lack of dredged spoil north of the State Road 206 bridge indicate it is largely a natural tidal creek in spite of modern dredging. However; while historic maps indicate continuation of the Matanzas River southward to the vicinity of Palm Coast, the portion of Matanzas River from the southern study area boundary northward to the State Route 206 bridge is almost entirely lined on the west side by dredged spoil and reveals significant anthropogenic impacts upon the modern configuration of the Matanzas River.

Intertidal/Subtidal Map Units

Qb - Bioherms (Recent)

Bioherms are comprised of oyster beds located in tidal flat and tidal creek environments and have highly variable shapes and sizes. Bioherms were mapped by grouping concentrated oyster beds into one feature. If large enough, bioherms were mapped on their own by digitizing the characteristic brown outer rim of the oyster beds.

Qcl - Channel levee (Recent)

These are more anthropogenic than natural in origin, consisting of oyster shells deposited along tidal creeks partially by natural wave action, but primarily from boat wakes. Channel levees form a ridge that separates the tidal creek from the salt marsh. These map units appear as bright white linear features in the true color imagery.

Qtf - Tidal flat (Recent)

Non-vegetated, shallow-water habitats situated between low and high tide limits. Substrate is soft to semi-soft sand or mud. Tidal flats are found where sediment accumulates and is usually bordered landward by *Spartina alterniflora* marshes and seaward by tidal creeks.

Subtidal Map Units

Qetd - Ebb tide delta (Recent)

Mapped to include the extent of sandy sediment shoals formed seaward of a tidal inlet due to currents associated with the outgoing tide.

Qftd - Flood tide delta (Recent)

Mapped to include the extent of sandy sediment shoals formed landward of a tidal inlet due to currents associated with the incoming tide.

Qic - Inlet channel (Recent)

Features that connect the Atlantic Ocean with the Matanzas and Tolomato rivers through the barrier islands within the study area. The seaward extent of the inlet channel was delineated based upon the location of the deeper water distributaries of the ebb tidal delta. The channel inland is mapped to the ends of the flood tidal delta and the points where loss of sand beach environments on the river shorelines occur. St. Augustine Inlet and Matanzas Inlet are the two inlet channels in the study area.

Coastal-Riverine Map Units

Qfw - Freshwater wetland (Recent)

Freshwater wetland tends to be an open expanse of grasses, sedges, rushes and other types of non-salt tolerant herbaceous plants or shrub vegetation. They are located west of the salt marsh in the study area. Land use data developed by the St. Johns River Water Management District (SJRWMD) were used to aid in the identification of freshwater wetlands. LiDAR elevation data further enhanced mapping efforts and the delineation of the wetland polygons.

Qol - Oxbow lakes (Recent)

These features form when the meander of a tidal creek is cut off to form a lake. Many oxbow lakes rapidly transform into salt marsh due to deposition of muddy sediments into these low relief and shallow depressions once cut off from the energy of tidal scouring.

Qpn - Pond (natural) (Recent)

Natural freshwater ponds are located west of the salt marsh in the upland environments of the study area.

Qs - Swamp (Recent)

Swamps represent wetlands that are dominated by hardwood tree species and rare instances of Pond Pine, *Pinus serotina*. They are located west of the salt marsh in the study area. Land use data developed by the St. Johns River Water Management District (SJRWMD) was used to aid in the identification of swamps. LiDAR elevation data further enhanced mapping efforts and the delineation of the swamp polygons.

Anthropogenic Map Units

Qdm - Dams (Recent)

This unit depicts the earthen dams constructed to contain water for the impoundments located mostly in and adjacent to St. Augustine.

Qdma - Docks/Marinas/Anchorage (Recent)

Docks represent large commercial entities that comprise a large area for storing boats along the tidal creeks in the study area. They are mapped by including all boats, boat slips and decks that encompass the dock area. This may include part of the tidal creek, Intracoastal Waterway or dredged channel.

Qdc - Dredged channels (Recent)

Dredged channels are anthropogenic channels in tidal creek marsh systems. They include canals and ditches used to drain the salt marsh, and the straightening of tidal creeks and areas near docks. Historical imagery dating back to the 1930s was used to verify dredged channels.

Qds - Dredged spoil (Recent)

Dredged Spoil (spoil islands) are usually seen as bright white mounds on the true color imagery. Older spoil islands may be partially or mostly covered by vegetation representative of salt marsh to dune environments. An example of the latter is northern Rattlesnake Island in Fort Matanzas National Monument. Regardless of the amount of vegetation, spoil islands are always mapped as dredged spoil rather than by the vegetative communities that may now inhabit them. Historical imagery dating to the 1930s aided in identifying dredged spoil and its extent.

Qf - Fill (Recent)

Fill represents the anthropogenic placement of sediment in wetland areas. Fill was delineated wherever it was clear that it has been used for development. Types of development may include roads, bridges, airports and residential or commercial buildings.

Qg - Groins (Recent)

Structures laid perpendicular to the shoreline used to trap sand are found at the boat ramp at Fort Matanzas and along the beach in the southern portion of the study area at Marineland. They are mapped by enclosing the visible portion of their rock structures.

Qhs - Historic structures (Recent)

These include buildings that have an historical significance, such as, forts and lighthouses. They are mapped by including their property extent.

Qi - Impoundments (Recent)

Water bodies formed by damming of creeks and small waterways. Several are located in and adjacent to St. Augustine.

Qj - Jetties (Recent)

Jetties occur as pairs adjacent to inlets in the study area. They are mapped by enclosing the visible extent of their rock structures.

Qmd - Mosquito ditches (Recent)

Occur on Rattlesnake Island. They are delineated by enclosing their dredged channels.

Qp - Piers (Recent)

This map unit represents the pier located on Anastasia Island at St. Augustine Beach.

Qqbp - Quarry/Borrow Pit (Recent)

Extraction of sand, shell and coquina is common along the western portion of the study area. Quarries/ borrow pits are rectangular- (or irregular-) shaped pits containing water. Pits are flooded due to the high water table. An active pit may be identified by blue, milky water while an abandoned (or inactive) pit would contain black water on the true color imagery. Borrow pits are frequently found along roads which required fill during roadway construction.

Qrr - Rip rap (Recent)

A layer of large rocks used to harden the shoreline by bridges and houses and other structures along waterways located in the study area. They are mapped by enclosing the visible extent of the rocks.

Qsp - Stormwater ponds (Recent)

Anthropogenic water features that usually appear black in true color imagery. They are easily identified by their rectangular or irregular shapes. The vast majority of stormwater ponds are found in urbanized areas. These are common in residential or commercial developed land as opposed to the quarry/borrow pit features that are typically more isolated from development sites.

GRI Digital Geologic Map of Castillo de San Marcos NMON and Fort Matanzas NMON

Geologic Map Unit List

The geologic units present in the GRI Digital Geologic Map of Castillo de San Marcos National Monument and Fort Matanzas National Monument are listed below. Units are listed with their assigned unit symbol and unit name (e.g., Qh - Undifferentiated sediments). Units are listed from youngest to oldest. No description for water is provided. Information about each geologic unit is also presented in this dataset's Geologic Unit Information (CAFOUNIT) table included with the GRI geologic-GIS digital data.

Cenozoic Era

Holocene Epoch

[Qh](#) - Undifferentiated sediments

Pleistocene Epoch

[Qbd](#) - Beach ridge and dune

Late Pleistocene Epoch

[Qa](#) - Anastasia Formation

Pleistocene and Pliocene Epochs

[QTsu](#) - Shelly sediments of Pliocene and Pleistocene *

Middle Miocene Epoch

[Thc](#) - Coosawhatchie Formation *

Lower Miocene Epoch

[Thmh](#) - Marks Head Formation *

[Thpf](#) - Penney Farms Formation *

Upper Eocene Epoch

[To](#) - Ocala Limestone *

**unit is only present in cross section (see unit description for additional information).*

Geologic Map Unit Descriptions

Descriptions of all geologic units were provided by the source map. ([EGS Geologic Map](#); GRI Source Map ID 75749).

Qh - Undifferentiated sediments (Holocene)

Undifferentiated Holocene sediments are interpreted to have been deposited during the Holocene. While these may include areas along rivers in other Florida localities, in the current study area, these are mostly confined to the salt marshes adjacent to the Matanzas, Tolomato and Guana rivers and the

Intracoastal Waterway and portions of the barrier islands in which the Anastasia Formation is not interpreted to be within 20 feet of the surface. They are typically noted at elevations less than 5 ft (1.5 m) above modern sea level. Lithology may include carbonate sands, quartz sands, carbonate and siliciclastic muds and organics (Scott 2001). The 20 foot depth is used in Florida geologic mapping due to the fact that in most areas of the state a thin sand or clay sediment covering lies above the bedrock. It is important to note where the underlying bedrock is near the surface due to concerns for surface pollution entering the aquifers where sediment cover is thin.

Qbd - Beach ridge and dune (Pleistocene)

Significant portions of the study area are mantled with quartz sands which may at times include clay and organics. In coastal St. Johns and Flagler counties, these deposits have been identified as Quaternary beach ridge and dune due to the strong regional component of ridge and swale development in the overall geomorphology. These deposits are interpreted to be Pleistocene. The Florida Geological Survey attempts to apply quasi-geomorphological designations of the undifferentiated Quaternary units for the benefit of constituent readers in order to provide more information about the nature of their deposition. Without these designations, all the undifferentiated sediments would be labeled Qu. The beach ridge and dune complex strongly influences the patterns of uplands and wetlands in the region as well as the development of distinct trellis drainage.

Sediments of Qu or Qbd in cuttings and cores are lithologically similar, if not the same. They consist of quartz sand that may, at times, have clay and organics present. In the study area, these range in colors from pinkish grey to moderate dark grey, very light orange to greyish orange to light yellowish orange, and brownish grey to greyish brown to dark yellowish brown, and even black humate-cemented sands. Quartz sand grain size may range from very fine to gravel because these are beach ridges and dunes that were dominated by coastal transport and deposition, and not simply aeolian. Grain size is also related to the source material which includes deposits of widely variable grain size, such as the Cypresshead Formation.

Qa - Anastasia Formation (Late Pleistocene)

The Late Pleistocene Anastasia Formation crops out locally along the Atlantic coast of Florida from the vicinity of St. Augustine in the north to Boca Raton in the south. The formation was first named by Sellards (1912), but has had further discussion and description by subsequent workers, including Cooke (1945), Puri and Vernon (1964) and Scott (2001). Cooke (1945) describes the Qa as coquina or coquinoid limestone, a deposit of whole or broken shells, dominated by mollusks, that range from unconsolidated to well indurated. The dominant cement is sparry calcite, but iron oxide is, at times, another common binding material. The Qa also consists of quartz sands, largely fine- to medium grained. These quartz sands may have shell material reduced to sand-sized grains or may be the sole constituent with no carbonate material present. The Qa may also have trace components of heavy minerals, echinoids, mica, even phosphate and phosphatized shell material. The Qa has been hypothesized to have been deposited during marine isotope stage 5 sea level high stands. Recent optically stimulated luminescence dating by Burdette et al. (2009) provided further evidence that several of the cemented outcrops of the formation were deposited during sea level stand from near modern sea level to 26.2 ft (8 m) above modern sea level between approximately 83 ka to 112 ka.

The more distinctive, well indurated outcrops of the Qa are found in the present study area along the

Atlantic shoreline from Washington Oaks Gardens State Park northward nearly continuously to Marineland, as well as in, and just south of Matanzas Inlet. Other exposures have been noted along the Intracoastal Waterway in northern Flagler County and in the Summer Haven area on the south side of Matanzas Inlet. The latter is known to have been a source of coquina for the building of Fort Matanzas in the middle eighteenth century (Deagan 1976; U.S. Department of the Interior 1981). Exposures are also found just east of the Intracoastal Waterway in dug drainage ditches and canals in the south-central portion of Anastasia Island and in the Old Spanish Quarries at Anastasia State Park. The most inland outcrops in the study area are a series of quarries that roughly parallel the trend of Holmes Boulevard on the west side of St. Augustine.

In cores and cuttings, identification of the Qa can be complicated by the fact that the quartz sands and mollusk shells that comprise the formation are also found as part of the undifferentiated Quaternary sediments, Quaternary beach ridge and dune, and the shelly sediments of Pliocene and Pleistocene. In some localities, the Qa is well indurated in the subsurface or may have intercalated beds of indurated shell and quartz sand with unconsolidated sediments dominated by quartz sand with some to no shell material. At other localities, only unconsolidated quartz sands with limited to no shell material are present. Most often, where no coquina deposits were found in association with a set of samples, the interval in the core or cuttings was identified as undifferentiated Quaternary sediments. In some cases, evidence related to stratigraphic position, dominance of clay in the unit and much darker colored shell material, moderate light grey to moderate dark grey, assisted with tentative distinction between the Qa and shelly sediments of Pliocene and Pleistocene deposits. Many areas exist in St. Johns County where the Qa is not recognized in cores and cuttings, but instead there are a series of sand and clayey sand units ranging from brown to black, the latter being humate-cemented quartz sand. It is hypothesized that portions of the Qa in this area were eroded and reworked since original Late Pleistocene deposition of the unit. This may have been due to surficial erosion and development of paleovalleys for surface drainage during the intervening lowered sea levels, as well as inlet migration during relatively high sea levels.

QTsu - Shelly sediments of Pliocene and Pleistocene (Pliocene/Pleistocene)

The shelly sediments of Pliocene and Pleistocene are undifferentiated and have varying amounts of sand and clay, sometimes dominated by molluscan shell material. In southern Florida, these units are among the most abundant and diverse fossil molluscan faunas in the world (Scott 2001). There have been various attempts to divide formations out of these deposits, but most of the work has been centered on biostratigraphy, particularly molluscan (Scott and Wingard 1995). Formational units for geologic mapping center on the dominance of lithostratigraphy in distinguishing rocks of different formations. Therefore, even though formation names such as the Caloosahatchee, Bermont, Fort Thompson or Nashua, the latter in northern Florida, have been applied to these units, they are not distinct in lithology, only in paleontology. These are complex sedimentary deposits that are typically unconsolidated with varying calcareous and fossiliferous components in quartz sand with clays and muscovite typically present. Toward the base of the QTsu, sand and pebble phosphate are sometimes reworked from the underlying Hawthorn Group sediments. Scott (2001) notes that the QTsu deposits may also consist of well indurated, sandy, fossiliferous limestones. These are rare in the study area with most of the limestones and dolostones at the transition to the Coosawhatchie Formation of the Hawthorn Group.

****unit (QTsu) only present in cross section**.** The GRI adopts a common standard that unit time symbols (e.g., Q and T) are listed with the younger time symbol, in this case Q, being listed first. The

FGS presents unit time symbols with the older time symbol, in this case T, being listed first. The FGS unit symbol for this unit was changed from TQsu to QTsu, however, the cross section graphics still present the unit as TQsu.

Thc - Coosawhatchie Formation (Middle Miocene)

The Hawthorn Group has complex lithology and high variability regionally in Florida. In northern peninsular Florida within the current study area, there are three distinct, though not altogether dissimilar, formations that are recognized. All of the Hawthorn Group deposits in this region are Miocene.

The Middle Miocene Coosawhatchie Formation does not crop out in the study area, but does in northern Florida. Within the study area, the upper portion of the Thc typically consists of quartz sands with dolostone matrix, occasionally being well indurated. The carbonates are too sandy to be considered part of the Charlton Member. The sands typically contain phosphatic sands and sometimes gravels. The lower portion of the Thc becomes darker in color and clay becomes more dominant than carbonate. Colors range from light olive grey to olive grey to greenish grey. The section of Thc in cores and cuttings was recognized by the occasionally well indurated upper section and dolomitic sands and sandy dolostones that transition with depth to more clays and sands, darker in color than the upper portions of the unit. All samples typically contained phosphate. The contact with the Marks Head Formation was defined where the lithology changed to more clays and dolostones, typically finer grained and lighter in color than the overlying Thc.

unit (Thc) only present in cross section

Thmh - Marks Head Formation (Lower Miocene)

The Hawthorn Group has complex lithology and high variability regionally in Florida. In northern peninsular Florida within the current study area, there are three distinct, though not altogether dissimilar, formations that are recognized. All of the Hawthorn Group deposits in this region are Miocene.

The Lower Miocene Marks Head Formation, like the Penney Farms Formation, does not crop out in the study area. It is a subsurface unit encountered only in cores and cuttings. It is a variably quartz sandy, clayey, dolomitic unit and is the most lithologically variable of the formations in the Hawthorn Group in northern Florida (Scott 1988). The clayey and dolomitic beds in the Thmh typically also contain quartz sand. Colors are lighter than the Penney Farms Formation or the lower portion of the overlying Coosawhatchie Formation. Colors typically range in the greenish grey to olive grey to pale olive. Phosphatic sands are common in much of the unit.

unit (Thmh) only present in cross section

Thpf - Penney Farms Formation (Lower Miocene)

The Hawthorn Group has complex lithology and high variability regionally in Florida. In northern

peninsular Florida within the current study area, there are three distinct, though not altogether dissimilar, formations that are recognized. All of the Hawthorn Group deposits in this region are Miocene.

The Lower Miocene Penney Farms Formation, is the basal stratigraphic formation in the Hawthorn Group in northeastern Florida. Near the Georgia border it interfingers and grades northward into the Lower Miocene Parachucla Formation (Huddlestun 1988). This formation does not crop out at the surface so all instances of it are in cores and cuttings. The upper portion of the Thpf is predominantly siliciclastic with scattered carbonate beds (Scott 1988). These have variable amounts of sand, clay, phosphate and dolostone, and tend toward olive grey and grayish olive green colors. The lower portion of the Thpf is predominantly carbonate with some interbedded sands and clays (Scott 1988). In the study area, the base of the Thpf consists of well indurated dolostone, often with intraclasts having phosphatized rims. The Oligocene section is missing in this area such that the lower contact is with the Upper Eocene Ocala Limestone.

unit (Thpf) only present in cross section

To - Ocala Limestone (Upper Eocene)

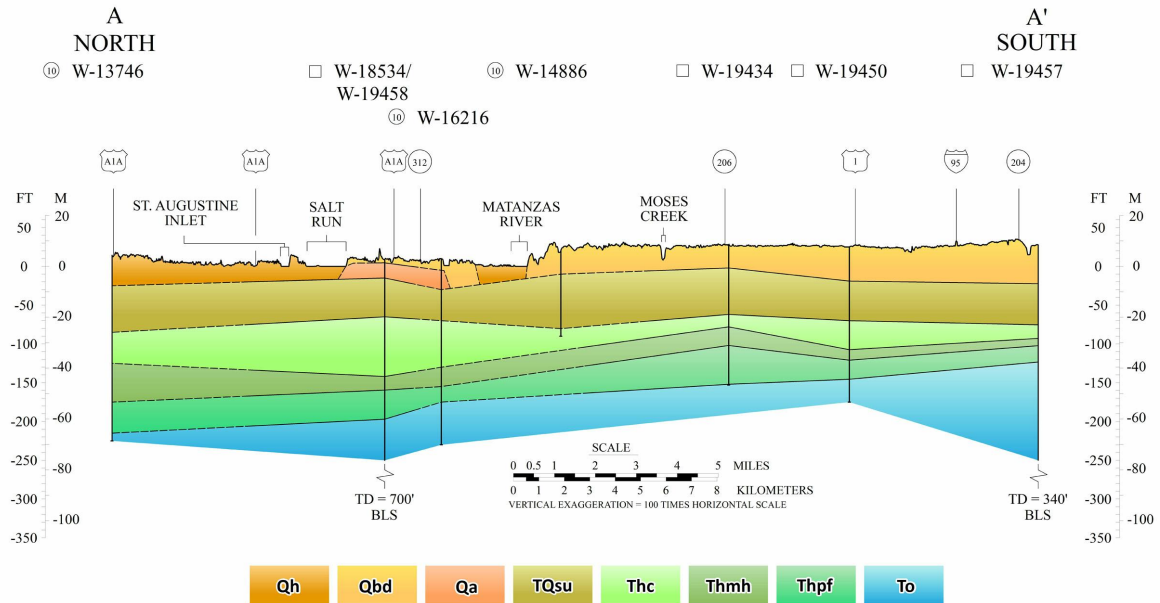
The Upper Eocene Ocala Limestone consists of nearly pure limestone with occasional dolostone (Scott 2001). It is typically grainstone, packstone or wackestone and fossiliferous with benthic foraminifera, echinoids, bryozoans and mollusks or mollusk molds commonly present. In the study area, this is the deepest unit at the base of the cross-sections. Depth below land surface to the top of the Ocala Limestone in the study area varies from 134 feet to 265 feet (40.8 meters to 80.8 meters).

unit (To) only present in cross section

Geologic Cross Sections

The geologic cross sections present in the GRI Digital Geologic Map of Castillo de San Marcos National Monument and Fort Matanzas National Monument are presented below. The cross section graphics were scanned at a high resolution and can be viewed in more detail by zooming in (when viewing the digital format of this document).

Geologic Cross Section A-A'



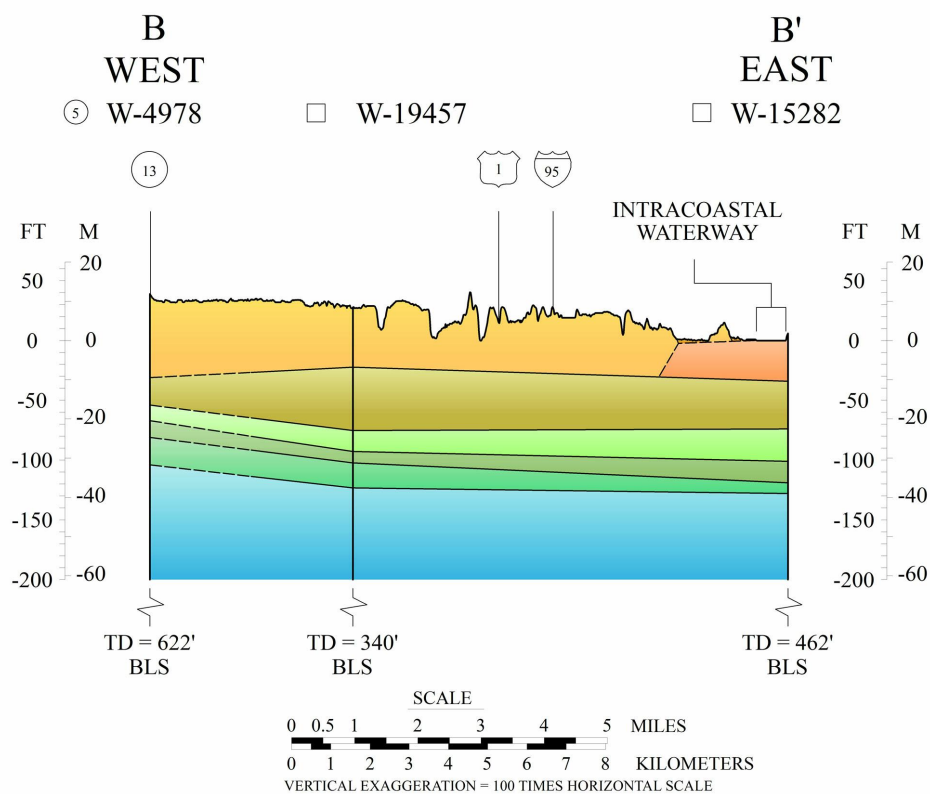
* Vertical exaggeration x 100. Full A-A' cross section graphic.

** Wells shown in cross section are present in the GRI digital GIS data.

*** The unit symbol for the Shelly sediments of Pliocene and Pleistocene age unit is represented as QTsu in the GRI digital map products, however, the cross section graphic still presents the unit as TQsu, as per the FGS source data, and the FGS unit age symbol listing convention.

Extracted from: [\(FGS Geologic Map\)](#)

Geologic Cross Section B-B'



* Vertical exaggeration x 100. Full B-B' cross section graphic.

** Wells shown in cross section are present in the GRI digital GIS data.

*** The unit symbol for the Shelly sediments of Pliocene and Pleistocene age unit is represented as QTsu in the GRI digital map products, however, the cross section graphic still presents the unit as TQsu, as per the FGS source data, and the FGS unit age symbol listing convention.

Extracted from: ([FGS Geologic Map](#)).

FGS Source Map Information, References and Acknowledgements

The Florida Geological Survey (FGS) provided brief descriptions of how geomorphic and geologic features were mapped and the GIS data produced. The FGS also provided use constraints, references, credits and acknowledgements relevant to both the geomorphic and geologic digital data.

FGS Description of Mapping and Digital Data Production

Geologic units were mapped by using well core and cutting samples from the FGS repository, outcrops found in the field, and historic geologic maps. Formations were delineated from the cores and cuttings descriptions. Using these formation picks, outcrops found in the field, and historic geologic maps, initial geologic units were placed on the map. The geologic units were further enhanced by looking at trends in the data and refining the polygon boundaries.

The geology cross section lines represent north-south and west-east cross section profile lines through wells with formation picks. Field Points consist of outcrop or float identified in the field but not sampled. Mseries points (other fields points) consist of outcrop samples found, collected, and identified in the field. Well locations were used to assist in the construction of geologic map units.

**FGS catalogue ID numbers and USGS 30'x60' quadrangle sample ID numbers are presented in the geologic observation localities data layer. Of note, sample ID numbers begin with SA, an abbreviation for the Saint Augustine 30'x60' quadrangle.*

Geomorphic units were mapped as area (polygon) features by using the five, seven and a half minute (7.5') quadrangles of interest: St. Augustine, St. Augustine Beach, St. Augustine Beach OE East, Dinner Island NE, and Matanzas Inlet. One foot true color 2010 aerial images were collected from the Florida Department of Transportation and mosaicked together to create one seamless image. It was then classified using the supervised classification method in PCI Geomatica (remote sensing software package) to identify water and wetland features. Supervised classification uses training points (pixels that represent a feature) to categorize features of interest. This created a raster which was converted into water and wetland polygons using ArcGIS 10.0. These polygons were then smoothed in ArcMap by using a geoprocessing tool. To further enhance the geomorphic feature boundaries the 2010 true color aerial imagery was used as an aerial interpretation reference and manual digitizing was performed.

LiDAR (2008 St. Johns) was used to identify dune and ridge features as well as delineation of wetland boundaries. Details of these features as delineated are described within each coded value. These varied from simple interpretation and heads up digitizing of features to complex digital data filtering and combination. Topology was created and used to identify all errors in the feature class. All gaps and overlaps were then corrected to make the final feature class.

The data were completed as a component of the National Park Service (NPS) Geologic Resources Inventory (GRI) program, a NPS Inventory and Monitoring Division (I&MD) funded program that is administered by the NPS Geologic Resources Division (GRD).

***The above text was summarized from metadata text associated with each feature class in the FGS digital data (geodatabase), and from a document supplied by the FGS that pertained to how the geomorphic data was produced.*

FGS Use Constraints

Not for use at scale greater than 1:24,000 (source map scale). These geologic data were developed by the Florida Department of Environmental Protection (FDEP) - Florida Geological Survey (FGS) to carry out agency responsibilities related to management, protection, and development of Florida's natural resources. Although efforts have been made to make the information accurate and useful, the FDEP/FGS assumes no responsibility for errors in the information and does not guarantee that the data are free from errors or inaccuracies. Similarly, FDEP/FGS assumes no responsibility for the consequences of inappropriate uses or interpretations of the data. As such, these digital data are distributed on "as is" basis and the user assumes all risk as to their quality, the results obtained from their use, and the performance of the data. FDEP/FGS bears no responsibility to inform users of any subsequent changes made to these data. Anyone using this data is advised that precision implied by the data may far exceed actual precision. Comments on these data are invited and FDEP/FGS would appreciate that documented errors be brought to staff attention. The development of these data sets represents a major investment of staff time and effort. As a professional responsibility, we expect that the FDEP/FGS will receive proper credit when you utilize these data sets. Further, since part of these data were developed and collected with U.S. Government or State of Florida funding, no proprietary rights may be attached to it in whole or in part, nor may it be sold to the U.S. Government or the Florida State Government as part of any procurement of products or services.

FGS References

- Burdette, K.E., Rink, W.J., Means, G.H. and Portell, R.W., 2009, Optical dating of the Anastasia Formation northeastern Florida, USA: *Southeastern Geology*, v. 46, n. 4, p. 173-185.
- Cooke, C.W., 1945, *Geology of Florida*: Florida Geological Survey Bulletin 29, 339 p.
- Deagan, K., 1976, *Archaeological investigations at Fort Matanzas National Monument*: Florida State University, 124 p.
- Huddleston, P.F., 1988, A revision of the lithostratigraphic units of the coastal plain of Georgia: The Miocene through Holocene: *Georgia Geologic Survey Bulletin* 104, 162 p.
- Puri, H.S. and Vernon, R.O., 1964, *Summary of the geology of Florida and a guidebook to the classic exposures*: Florida Geological Survey Special Publication 5, revised, 312 p.
- Scott, T. M., 1988, *The lithostratigraphy of the Hawthorn Group (Miocene) of Florida*: Florida Geological Survey Bulletin 59, 148 p.
- Scott, T. M., 2001, *Text to accompany the geologic map of Florida*: Florida Geological Survey Open-File Report 80, 29 p.
- Scott, T.M. and Wingard, G.L., 1995, Facies, fossils and time—A discussion of the litho- and biostratigraphic problems of the Plio-Pleistocene sediments in southern Florida: in Scott, T.M. ed., *Stratigraphy and paleontology of the Plio-Pleistocene shell beds, southwest Florida*: Southeastern Geological Society Guidebook 35, unpaginated.
- Sellards, E.H., 1912, *The soils and other surface residual materials of Florida*: Florida Geological Survey Fourth Annual Report, p. 1-79.

U.S. Department of the Interior, 1981, Environmental assessment, general management plan, development concept plan, Fort Matanzas National Monument, Florida: Denver Service Center, National Park Service, unpublished report, 118 p.

FGS Credits

Credits provided by the Florida Geological Survey.

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GRI Digital Data Credits

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GRI finalization by Stephanie O'Meara.

GRI program coordination and scoping provided by Bruce Heise and Tim Connors (NPS GRD, Lakewood, Colorado).