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Guy H. Means, *State Geologist and Director*

OPEN-FILE REPORT 112

Text to accompany geologic map of the USGS Cape Canaveral 30 x 60 minute quadrangle, central Florida

By

Jade W. Greene, Christopher P. Williams (P.G. # 2625), Richard C. Green, Crystal L. Hebets, Garrett S. Evans, Michelle M. Ladle, Nickolaus P. Hall, and Brittany M. Duffey

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ABSTRACT

The accompanying 1:100,000 scale geologic map (Open-File Map Series 115, Plate 1) depicts the areal distribution of bedrock and surficial geologic units for the U.S. Geological Survey (USGS) Cape Canaveral 30 x 60 minute quadrangle. The map was constructed using a combination of field mapping (at 1:24,000 scale), compilation of data from existing maps (various scales), core and cuttings analyses and descriptions, and analyses of various Geographic Information System (GIS) data sources. The resulting data were compiled in ESRI® ArcGIS® Pro™ 2.9.5 software for publication as part of the Florida Geological Survey Open-File Map Series. Mapped geologic units range in age from Pliocene to Holocene. Important resources in the mapped area include potable groundwater, sand, fossil shell, and limestone.

The geologic map and accompanying plates produced for this area not only provide a greater understanding of the interaction between the geologic units, associated karst, and ecosystems, but have utility as a land management tool for economic development, mineral and energy production, and environmental protection for Florida. Examples include designing new construction projects, siting new water supply wells, wastewater treatment plants, energy production facilities, waste management and storage facilities, locating sources of mineable resources, and protecting surface and groundwater quality.

Keywords: Florida, geologic map, Avon Park Formation, Ocala Limestone, Hawthorn Group, Arcadia Formation, Peace River Formation, Tertiary/Quaternary undifferentiated shelly sediments, Anastasia Formation, geomorphology, hydrogeology, Floridan aquifer system, Brevard County, Orange County, Osceola County, Merritt Island, Cape Canaveral.

INTRODUCTION

Florida Geological Survey (FGS) Open-File Report (OFR) 112 accompanies Open-File Map Series (OFMS) 115, which is comprised of two plates. Plate 1 depicts the near-surface geology of the USGS Cape Canaveral 30 x 60 minute quadrangle. Plate 2 depicts five geologic cross-sections, a stratigraphic correlation chart, an index geologic map with cross-section lines, and a light detection and ranging (LiDAR) figure depicting beach ridge and dune structures for part of the mapped area.

The study area is in east-central Florida (Figure 1) covering portions of Orange, Brevard, and Osceola counties. It includes the communities of Cape Canaveral, Cocoa Beach, Palm Bay, and Melbourne. The Cape Canaveral quadrangle is bounded to the northwest by the USGS Orlando 30 x 60 minute quadrangle, (Green et al., 2015a; Green et al., 2015b), to the west by the USGS Kissimmee 30 x 60 minute quadrangle (Green et al., 2018a; Green et al., 2018b), to the southwest by the USGS Bartow 30 x 60 minute quadrangle (Green et al., 2019a; Green et al., 2019b), and to the south by the USGS Vero Beach 30 x 60 minute quadrangle (Green et al., 2021a, Green et al., 2021b), all previously mapped under the STATEMAP program. It is bounded to the north by the USGS Titusville 30 x 60 minute quadrangle (currently being mapped by other FGS geologists).

One objective of this report is to provide basic geologic information for the accompanying OFMS 115. Information provided by this report and the plates in OFMS 115 is intended for a diverse audience of professionals in geology, hydrology, engineering, environmental and urban planning, and laypersons, all of whom have varying levels of geologic knowledge. The maps can help users identify and interpret geologic features which impact activities related to groundwater quality and quantity, as well as aid in locating mineral resources, land-use planning, and construction project design. Applied uses of the maps and data in this report include: 1) identifying potential new mineral resources, 2) characterizing zones of geologic hazards, 3) characterizing potential aquifer recharge, discharge, and confinement, 4) surface water, groundwater, and fate and transport modeling, 5) aiding water-management decisions on groundwater usage, 6) providing information on aquifer vulnerability to potential pollution, 7) characterizing ecosystems and wetlands, and 8) engaging in outdoor recreational activities such as hiking, kayaking, caving or bird watching.

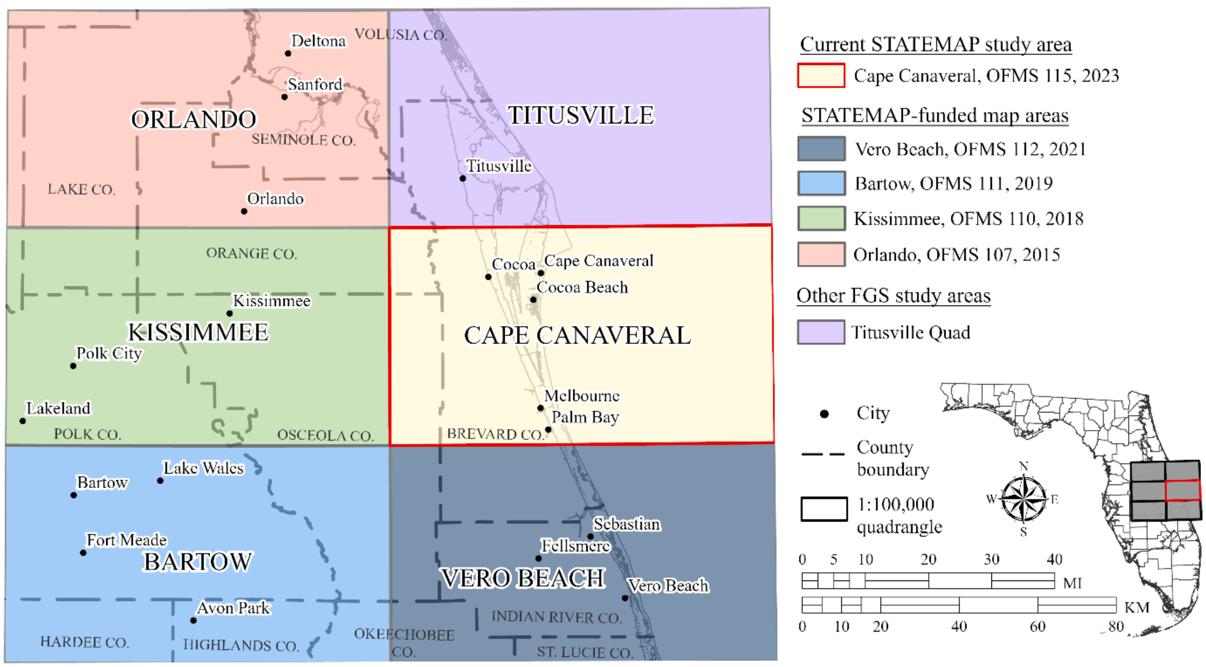

Figure 1. Nearby areas mapped under the FGS STATEMAP Program.

Methods

Mapping efforts consisted of: 1) reviewing and compiling existing geologic literature and data, 2) mapping geologic units in the field at 1:24,000 scale using standard techniques, 3) analyzing existing core and cuttings samples from the FGS Sample Collections Facility, 4) drilling new cores, 5) collecting and describing outcrop samples, and 6) preparing a geologic map, geological cross-sections, and report. Fieldwork, performed during Fall 2021 through Spring 2023, consisted of sampling and describing numerous outcrops, and samples from pit exposures.

Thirteen new geologic samples were added to the FGS surface-sample collection (M-Series) and fifteen cores (762 feet [232.3 meters] total) were drilled. Approximately a dozen outcrops were also examined during this project. In addition to the new M-Series samples collected, 85 historical M-Series samples were examined. All data, including over 177 boreholes from the study area, were compiled and analyzed by the authors. Figure 2 shows the locations of FGS cores, cuttings, outcrops, and M-Series samples within the study area. The map and accompanying plates were developed in ESRI® ArcGIS® Pro™ 2.9.5 software for publication as part of OFMS 115.

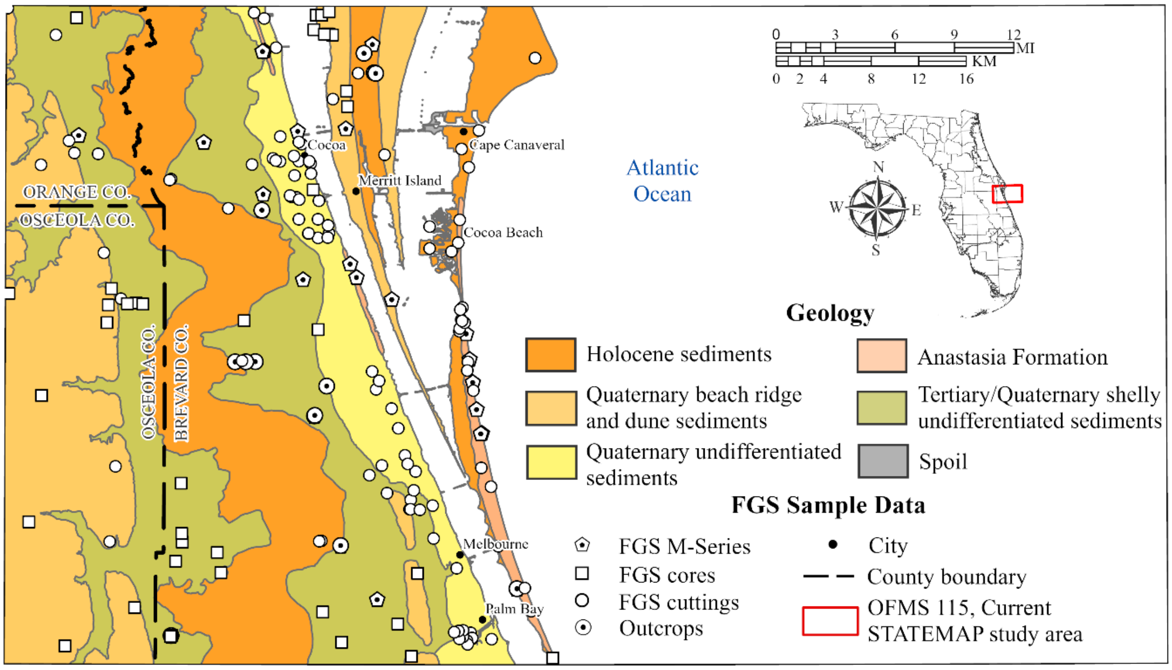

Figure 2. FGS cores, cuttings, outcrops, and M-Series samples used for models.

Four USGS tiles from the 3D Elevation Program (3DEP; U.S. Geological Survey, 2022) were mosaicked together in ArcPro™ 2.9.5 to create the digital elevation model for this study area. These tiles were a combination of LiDAR and topographic-derived digital elevation model (DEM) data. All elevation values are in meters and are referenced to the North American Vertical Datum of 1988 (NAVD 88). This data has a horizontal resolution of 1/3 arc-second (approximately 10 meters), and a vertical resolution of 1 meter.

Top-of-unit rasters were created for several geologic units within the study area using the borehole descriptions completed during this study. In order to produce interpolated top-of-unit rasters, the borehole depth for the top of each unit was first converted from depths below land surface (BLS) into elevations referenced to mean sea-level (MSL). This conversion was performed by taking the elevation value of the borehole location from the hybrid digital elevation model raster and subtracting the depth BLS value, resulting in the MSL elevation for the top-of-unit for each borehole location.

The mean MSL data for each geologic top-of-unit was then used to create a Natural Neighbor (NN) interpolation of the top-of-unit surface. The NN method of interpolation is a simple and exact interpolation method that relies on Voronoi tessellation (a partitioning of a plane into regions based on distances to points) to select a local subset of points and determine a weighted influence at every raster grid cell. This method produces a surface that passes through every data point in the input data set and thus does not attempt to account for errors or outliers. The NN method is particularly useful for visualizing the 'raw' data for problematic areas and extreme outliers prior to building and optimizing the final model.

After examining the initial models created for geologic units, it was evident that some of the predictive errors in the first model were directly attributable to either low data density, local outliers in the borehole data, or both. Outliers are a common occurrence in Florida geologic data for a variety of reasons, both human and natural, including: 1) Hawthorn Group units can be difficult to distinguish even for a trained professional geologist, and therefore some degree of uncertainty may exist in locating contacts, 2) many of the borehole samples are based on cuttings taken at intervals of 10 feet (3.1 meters), which introduces uncertainty in the elevation of the contacts even when the contact is clearly evident, and 3) dissolution in carbonate units can produce significantly different unit elevations in boreholes that are a short distance apart.

In cases where the accuracy metrics of the modeled surfaces indicated large amounts of error due to outliers, an iterative modeling process was used to reduce the average standard error of the interpolated surface. The least-accurate boreholes were then removed from the dataset via cross-validation to improve predictive accuracy. After the removal of outlier data points (generally fewer than ten boreholes per unit), a new interpolated raster was generated.

Figure 3 is a boxplot illustrating the distribution and range of elevation values, relative to MSL, for each geologic unit investigated within the study area. The crossbar within the box represents the median elevation value for each geologic unit. The upper and lower borders of each box correspond to the 25th and 75th percentiles, or the first and third quartiles, respectively; this area is also called the interquartile range and represents the middle 50% of the values in each group. The whiskers that extend from each boxplot reach no further than 150% of the interquartile range. Data that fall beyond the whiskers are considered outlier points and are represented by a dot.

Once the top-of-unit models were completed, they were subtracted from the digital elevation model to produce a raster showing overburden depth between each unit and land surface. The overburden rasters were then used to assist in drawing the final surficial geologic map for the study area.

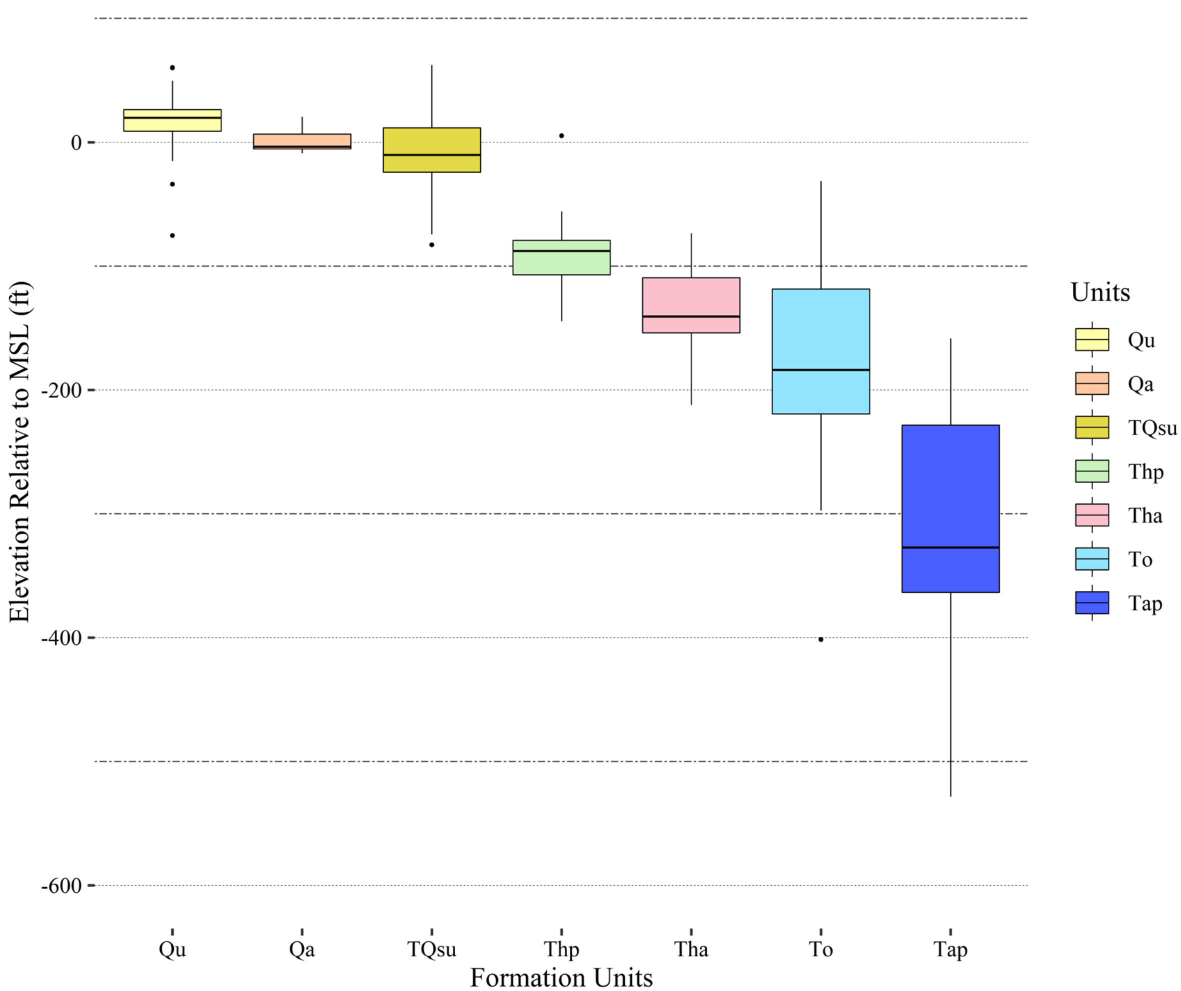

Figure 3. Boxplot of top of lithostratigraphic unit elevation ranges.

Much of the study area is blanketed by a veneer of Quaternary undifferentiated sediments. For this reason, and in keeping with geologic mapping practices developed by Scott et al. (2001), the authors have adopted the procedure of mapping the first named geologic unit within 20 feet (6.1 meters) of the surface. If Quaternary undifferentiated sediments (Qu) have a thickness greater than 20 feet (6.1 meters), they appear as the mapped unit. If these undifferentiated sediments are less than 20 feet (6.1 meters) thick, the underlying lithostratigraphic unit appears on the map. The geologic map (OFMS 115, Plate 1) and the geologic cross-sections (OFMS 115, Plate 2) may appear to disagree slightly when depicting the upper unit due to this convention. This is because geologic cross-section contacts are based on straight-line projection between boreholes, which may lead to apparent unit thicknesses between boreholes not supported by field evidence or other nearby boreholes.

Parts of the region are heavily vegetated, and public access in portions of the mapped area was hindered by the presence of numerous wetlands, mines, farms, ranches, and privately-owned land. Fieldwork access was typically limited to public roads, state-owned lands, and county-owned lands. As such, large sections of the mapped area were inaccessible. In these areas, the authors had to rely on historic core, cuttings, outcrop, and M-Series sample data.

Previous Work

The current study builds on many previous geologic investigations in and around the present map area. Preliminary county geologic maps for Brevard (Scott, 1993a), Orange (Scott,1993b), and Osceola (Scott, 1993c) counties were previously published at a 1:126,720 scale by the FGS. However, each of these OFMS geologic maps were constructed in an average time-frame of two weeks utilizing selected in-house geologic data with little-to-no extra fieldwork. A statewide geologic map (Scott et al., 2001), published by the FGS, provided a framework for the current, more detailed mapping. Although these maps provided a starting point for the detailed geologic mapping undertaken for this project, significant refinement of prior geologic maps was possible because of the additional fieldwork and data generated for this project.

Scott (1988) published detailed descriptions, structure contour maps, and isopach maps for units of the Hawthorn Group. The current study also benefited from the work performed during geologic mapping of the USGS Bartow (Green et al., 2019a; Green et al., 2019b), USGS Kissimmee (Green et al., 2018a; Green et al., 2018b), USGS Orlando (Green et al., 2015a; Green et al., 2015b), and USGS Vero Beach (Green et al., 2021a; Green et al., 2021b) 30 x 60 minute quadrangles. Some of the field relationships and stratigraphic problems were worked out during those projects.

GEOLOGIC SUMMARY

The near-surface geology of the USGS 30 x 60 minute Cape Canaveral quadrangle is composed of a complex mixture of Tertiary to Quaternary carbonate and siliciclastic sediments. A combination of factors, including fluvio-deltaic deposition, marine deposition and erosion of sediments as a result of eustatic changes in sea level, dissolution of underlying carbonates (karstification), and structural features have influenced the geology of the study area.

The oldest unit to crop out in the Cape Canaveral quadrangle is the Tertiary/Quaternary undifferentiated shelly sediments. The unit crops out at various locations and can be seen in numerous pits and quarries along the central and eastern parts of the map area (OFMS 115, Plate 1). The Tertiary/Quaternary undifferentiated shelly sediments overlie the Peace River Formation throughout the mapped area (OFMS 115, Plate 2). The oldest unit investigated for geologic cross-sections is the middle Eocene Avon Park Formation (OFMS 115, Plate 2). Detailed descriptions of the lithology of all units found in the study area begin on page 11 of this publication.

The Cape Canaveral quadrangle encompasses parts of the Upper St. Johns River basin and the Middle East Coast basin (Figure 4; Hydrologic Unit Codes: Basins, 1993). There are no known springs within the study area. Shallow cover-subsidence features present in this area are likely related to dissolution of shells in the underlying undifferentiated Tertiary/Quaternary shelly sediments.

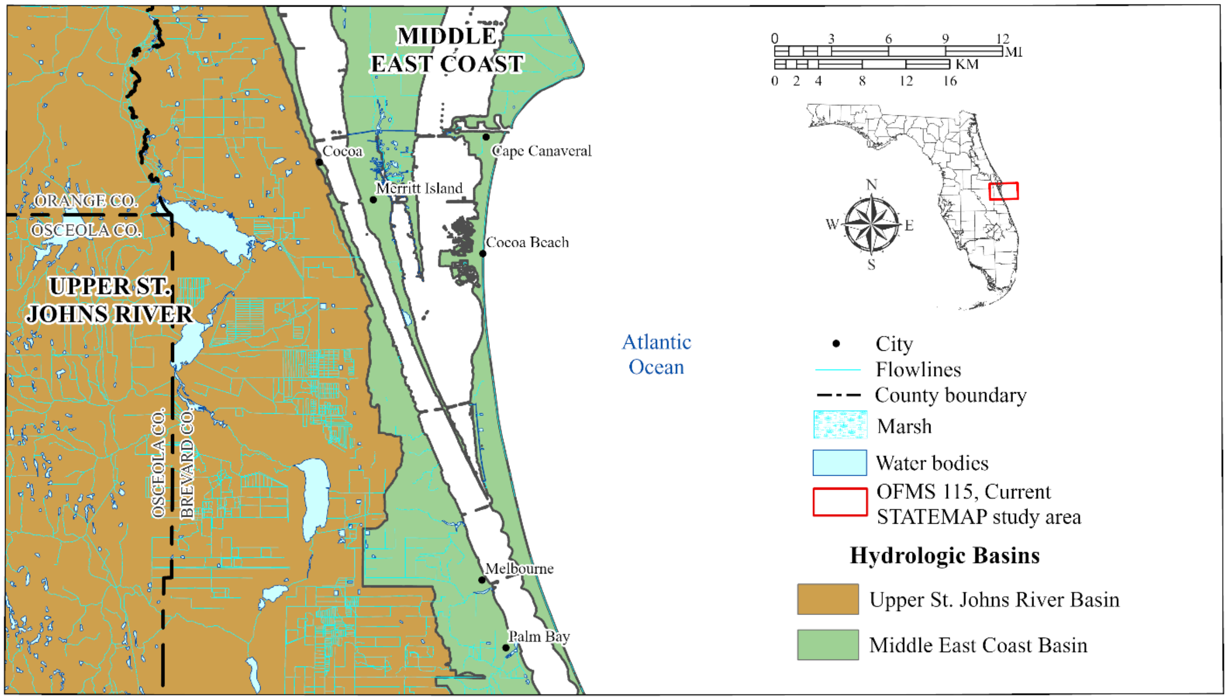

Figure 4. Location of selected river basins and other water bodies within the Cape Canaveral quadrangle.

Structure

Several structural features have affected the geology of the region (Figure 5). The Peninsular Arch has been interpreted by previous authors as a structural arch that deforms pre-Crataceous units, thus laying the framework for Cretaceous to early Cenozoic sedimentation (Applin and Applin, 1944; Applin, 1951; Puri and Vernon, 1964; Williams et al., 1977; Schmidt, 1984; Miller, 1986; Scott, 1997). This feature extends from southeastern Georgia to the vicinity of Lake Okeechobee in southern Florida in a general northwest to southeast trend and is the dominant subsurface feature of the Florida peninsula.

The Ocala Platform is another prominent feature affecting the near-surface units within peninsular Florida. Hopkins (1920) originally named this feature the Ocala Uplift. Vernon (1951) described the Ocala Uplift as a gentle flexure developed in Tertiary sediments with a northwest-southeast trending crest. Because there is continuing uncertainty about the origin of this feature, Scott (1988) used the term Ocala Platform, rather than Ocala Uplift, or Ocala Arch, since it does not have a structural connotation. Although the Ocala Platform does not come into the mapped area, discussion of it is included because of its effects on the regional geology of several map units.

The Brevard Platform, originally described by Riggs (1979), passes through the western edge of the study area (Figure 5). This feature occurs along Florida's east coast from southern Volusia County to St. Lucie County, east of the Peninsular Arch. The Brevard Platform was described by Scott (1988) as a low-relief ridge or platform that gently plunges to the southeast. The Ocala Limestone and Hawthorn Group sediments thin across the Brevard Platform (OFMS 115, Plate 2 cross-sections A-A', B-B' and C-C').

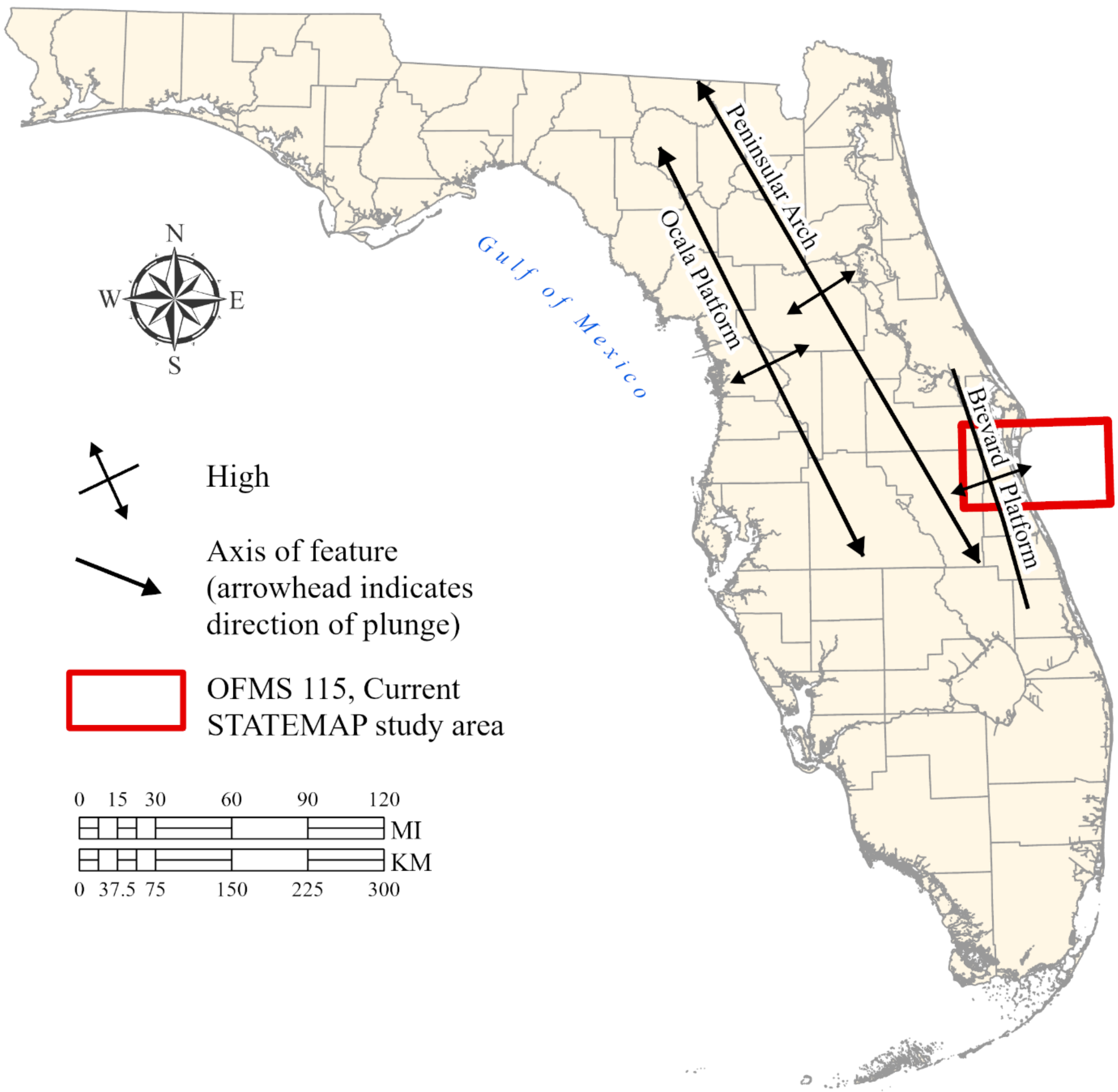

Figure 5. Principal subsurface structures of the Florida peninsula (modified from Scott, 1988).

Geomorphology

The Florida Geological Survey recently published the Florida Geomorphology Atlas (Williams et al., 2022). The atlas synthesized over a century of writings and maps about Florida, along with the addition of new data and new interpretations. These include specific regional discussions of landforms and relationships to the underlying geology and the coastal, fluvial, and karst processes that have affected the evolution of landforms. *The Geomorphology of the Florida Peninsula* (White, 1970), in addition to work by former FGS colleague, Thomas M. Scott, was central to the new statewide map. Recent data and technology, including the addition of significant LiDAR coverages, allowed the FGS to revise nomenclature and refine geomorphic district and province boundaries. In the following section, all geomorphic unit names and most discussions are from Williams et al., (2022).

The new atlas shows the geomorphology by regional units (districts; Figure 6) and sub-regional to local units (provinces; Figure 7). Districts are defined by regional groupings to form map polygons that have landforms which are distinct from adjacent districts. Defining the more localized provinces and their landforms is important for the characterization of the regions within districts. A brief discussion of districts and provinces within the Cape Canaveral quadrangle is listed below.

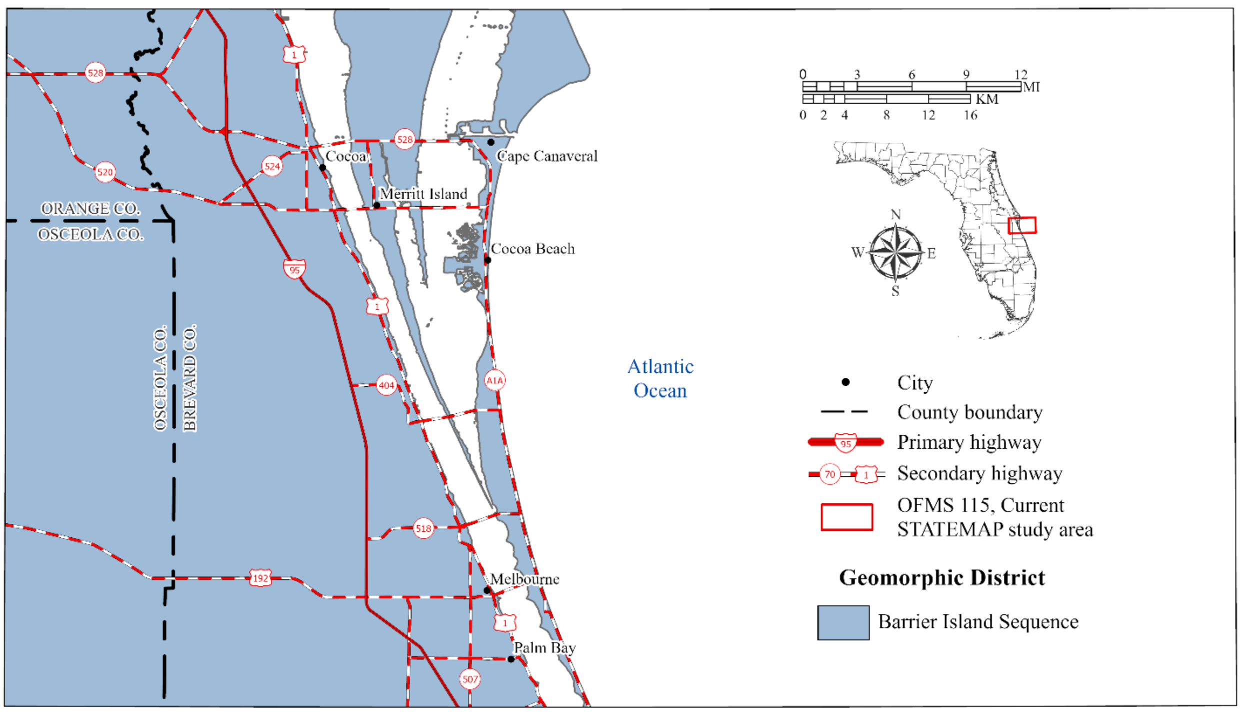

Figure 6. Geomorphic district within the Cape Canaveral quadrangle.

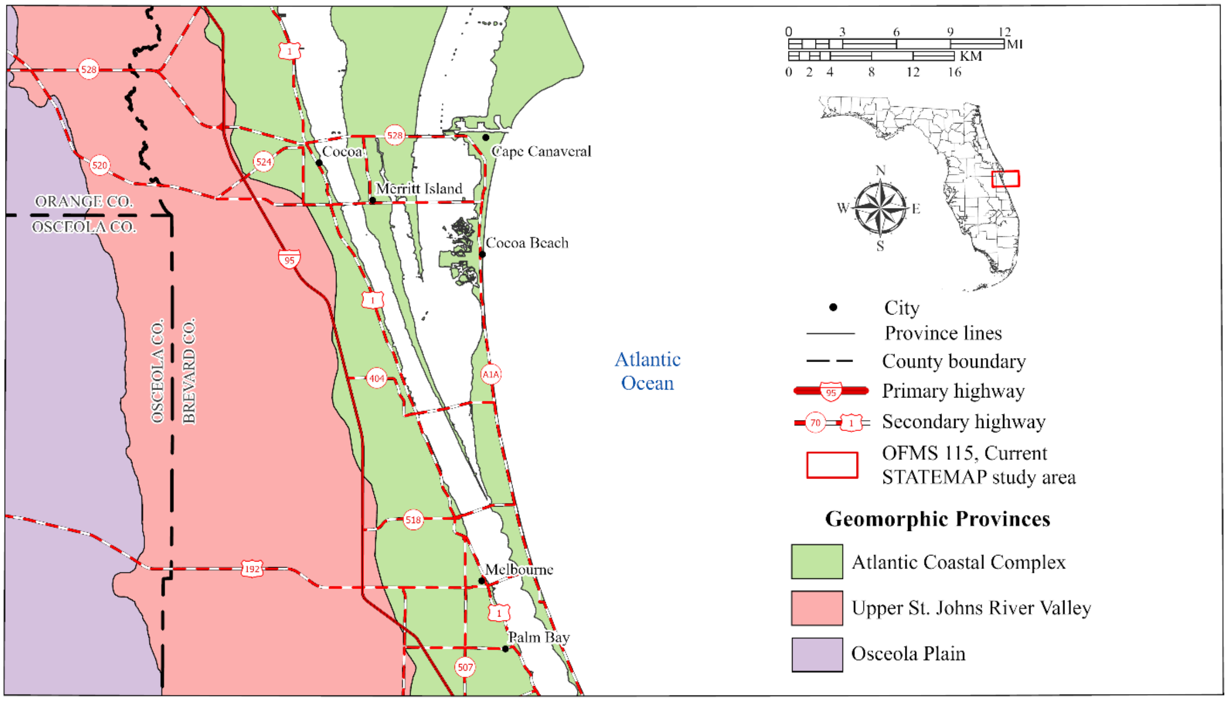

Figure 7. Geomorphic provinces within the Cape Canaveral quadrangle.

Barrier Island Sequence District

The Barrier Island Sequence District, the only geomorphic district in the mapped area, occurs along the Atlantic Coast (Figure 6). It extends from Georgia (Clark and Zisa, 1976) into Florida, and south to the vicinity of Lake Okeechobee (Williams et al., 2022). The eastern boundary of the Barrier Island Sequence District is along the Atlantic Coast. Open lagoons and small embayments, located landward of the barrier islands, are locally termed “rivers” because of their historic uses for navigation. Pliocene-Pleistocene and Holocene coastal processes formed extensive barrier islands, beaches, lagoons, embayments, and shallow-water marine terraces in the district. While modern coastal processes are dominantly erosional along the Atlantic Coast with net longshore transport from north to south, there are many older depositional coastal features in the mapped area. Strand plains and shore-parallel dunes, which represent the preserved depositional features of former shorelines created by beach accretion and/or declining relative sea-levels, are common in the Barrier Island Sequence District. Outstanding examples of strand plains can be seen in the study area on Merritt Island and Cape Canaveral in the Atlantic Coastal Complex Province and the eastern third of the Osceola Plain Province (OFMS 115, Plate 2, Figure 3). Wetlands are commonly coast-parallel and found in the swales between the ridges of the strand plains, tidal marshes, and mangrove swamps landward of the barrier islands. Inland, the broad, relatively flat Osceola Plain Province includes a marine escarpment and strand plain. The Barrier Island Sequence District is subdivided within the mapped area into three provinces: the Osceola Plain, the Upper St. Johns River Valley, and the Atlantic Coastal Complex (Figure 7). Elevations within the Cape Canaveral quadrangle portion of the district range from sea level at the Atlantic Coast in the Atlantic Coastal Complex Province to just over 80 feet (24.4 meters) above MSL in the Osceola Plain Province.

Osceola Plain Province

The Osceola Plain extends from Seminole County in the north, to Martin County in the south (Williams et al., 2022). The Osceola Plain Province has the low and flat topography of a marine terrace (White, 1970). It is a subtle, but complex, geomorphic area that includes most of the Kissimmee River valley in the western two-thirds of the province (Williams et al., 2022) and a strand plain in the eastern third. This strand plain is well developed in eastern Orange and eastern Osceola counties. Drainage in the province includes swale-controlled streams and wetlands that parallel the Atlantic Coast. Several creeks cut across the ridges and flow toward the St. Johns River. Elevations of the Osceola Plain in the study area (Figure 7) range from approximately 20 feet (6.1 meters) above MSL, along the ancient marine escarpment at the boundary with the Upper St. Johns River Valley Province, to over 70 feet (21.3 meters) above MSL along the western edge of the mapped area.

Upper St. Johns River Valley Province

The Upper St. Johns River Valley includes the fluvial/paludal valley from the headwaters of the St. Johns River, near the St. Lucie-Martin County boundary, northward to the outfall of Lake Monroe between Seminole and Volusia counties. The province follows a low-elevation drainage system that was an ancient embayment or lagoon between the Atlantic Coastal Complex Province to the east and the strand plain of the eastern Osceola Plain to the west (Williams et al., 2022). In the study area (Figure 7), the St. Johns River meanders through a large wetland complex with riverine floodplains and lakes. At this point, the river has a distinct river channel, fluvial landforms, and several large lakes. There are many distributaries and oxbows, as is typical of a sediment-choked, low-gradient stream system. Sediment transport in the system is negligible, but wetland development and the lacustrine/paludal sediments influence the presence of distributaries, lakes, and other landforms. Elevations in the Upper St. Johns River Valley in the mapped area range from 5 feet (1.5 meters) to about 35 feet (10.7 meters) above MSL.

Atlantic Coastal Complex Province

The Atlantic Coastal Complex consists of Quaternary barrier islands and related features on, and inland from, the Atlantic Coast. Water bodies and wetlands landward of the barrier islands include lagoons and small embayments. Some of these are locally termed “rivers” because of their historic uses for navigation. Within the study area (Figure 7), tidal regions of the lagoons are dominated by mangrove swamps. The Atlantic Coastal Complex Province extends from the St. Johns River in Duval County to central Palm Beach County (Williams et al., 2022). Most of the Atlantic Coastal Complex is a Pleistocene strand plain, and many of the beach ridges and dunes are coast-parallel. Complex Holocene and Pleistocene beach ridge patterns occur on Cape Canaveral and Merritt Island, respectively. The Anastasia Formation does not create unique rocky coastlines as in some areas to the north and south but does occur near the land surface in parts of the study area. Some small aeolian dunes are also present in the study area. Elevations in the Atlantic Coastal Complex for the study area range from sea level along the Atlantic Coast to about 80 feet (24.4 meters) above MSL along the western boundary of the province.

Cape Canaveral Complex Coastal Geology

The Cape Canaveral Complex along the Atlantic Ocean coastline extends across both the USGS Cape Canaveral and USGS Titusville 30 x 60 minute quadrangles. The Complex is not a formal geomorphological province but, is a region of importance within the study area. The region is the largest cape feature on the Atlantic Coast of Florida. It has a complex coastal geologic history that merits further discussion.

The Pleistocene Anastasia Formation is found in rock ledges at Rockledge, adjacent to the west coast of the Indian River, and in parts of the ridge west of the Indian River. Osmond et al. (1970) report

Th^{230}/U^{234} disequilibrium method dates of approximately 110,000 years before present and elevations of 2 meters and 10 meters, respectively, of these deposits at Rockledge and the ridge west of Indian River.

The sedimentary deposits of Merritt Island range between approximately 125-80 ka, based upon age dates from optically stimulated luminescence studies by Burdette et al. (2009; 2010) and Parkinson et al. (2012), and possibly from about 110-80 ka (pers. comm., Richard Mackenzie). The sediment source and reason for the development of a cape complex is not entirely clear (May, 1972). See Adams et al. (2018) for a discussion on the formation of the Cape Canaveral Complex, including a hypothesis of a potential sediment supply and delta related to a reversal of the St. Johns River.

Southern Merritt Island is mapped as two lobes of Quaternary beach ridge and dune sediments (Qbd), with a region of Holocene undifferentiated sediments (Qh) in the low elevation swale of Sykes Creek between the eastern and western halves of the island (OFMS 115, Plate 1) (see p. 14-16 for lithologic details of mapped Pleistocene/Holocene Series units). Additionally, there are several locations where carbonate rich (mostly calcilutite, shell, and spar) quartz sandstones, and occasionally quartz sandy limestones are found in the shallow subsurface in south-central Merritt Island. Widely scattered coquinoid limestones and carbonate-rich sandstones are found in some of the subsurface of the Qbd and Qh mapped regions. The carbonate-rich, quartz sandstones do not have a coquinoid nature, most common for the Anastasia Formation outcrops in Florida.

The Anastasia Formation is not mapped on southern Merritt Island. This is due to the limited datapoints and the diverse nature of the carbonate-rich rocks on Merritt Island. There may be other localities on Merritt Island with Anastasia Formation at or near the surface. Coastal environments mapping of the Anastasia Formation, however, would require significantly more data than were possible to acquire for the current study.

A recent study by Rodrigues et al. (2022) indicates that the Holocene deposits of Cape Canaveral are not more than 5,700 years old. This region is a strand plain with beach ridge and dune morphology, but is mapped as Qh due to its Holocene age.

LITHOSTRATIGRAPHIC UNITS

Tertiary System

Eocene Series

Avon Park Formation

The middle Eocene Avon Park Formation (Tap), first named by Applin and Applin (1944), is an entirely subsurface unit within the USGS Cape Canaveral 30 x 60 minute quadrangle. It was encountered in many of the boreholes utilized for this study, and efforts were made to include it in the geologic cross-sections where suitable borehole coverages existed (see OFMS 115, Plate 2).

The lithology of the Avon Park Formation can vary between limestone and dolostone. The limestone is cream to light brown to tan, poorly- to well-indurated, variably fossiliferous grainstone and wackestone, with rare mudstone. It is often interbedded with tan to brown, very-poorly to well-indurated, very fine to medium crystalline, fossiliferous (molds and casts), vuggy dolostones. Minor clay beds and organic-rich laminations may occur. Accessory minerals may include pyrite and calcite. Although not common, sedimentary structures may include cross-beds and burrows.

Fossils present in the unit include mollusks, foraminifera (*Spirolina* sp., *Lituonella floridana*, *Fabiana cubensis*, and *Cushmania* [*Dictyoconus*] *americana*), echinoids (*Neolaganum* [*Peronella*] *dalli*), algae, and carbonized plant remains. Porosity in the Avon Park Formation is generally intergranular in the limestone section. Fracture porosity occurs in the more densely recrystallized dolostone, and intercrystalline porosity is characteristic of sucrosic textures. Pinpoint vugs and fossil molds are present to a lesser extent.

Distinguishing between the middle Eocene Avon Park Formation and the unconformably overlying unit, the upper Eocene Ocala Limestone, can at times be difficult in the area. Fossil indicators are only somewhat helpful because the latest deposits of the Avon Park Formation and the earliest deposits of the Ocala Limestone are bank assemblages, consistent with deposition in a shallow-water limestone bank or plateau, not unlike the present-day Bahama Banks (Bryan, 2004). In the mapped area, the contact with the Ocala Limestone and the Avon Park Formation was typically picked based on textural changes from a very light orange grainstone, often containing *Lepidocyclina ocalana* and *Nummulites ocalanus,* to a less chalky, more recrystallized, muddy packstone or wackestone with a color change to yellowish grey, and the appearance of organics. There is also a change in fossil assemblages from common Ocala Limestone benthic foraminifera to the benthic foraminifera *Fallotella* sp. and *Cushmania* [*Dictyoconus*] a*mericana,* found in the Avon Park Formation. Increases in fossil molds and Avon Park Formation fossils, including the echinoid *Neolaganum dalli*, generally become apparent below the contact. Sometimes the *Neolaganum dalli* echinoids (or a hash of similar echinoid fragments) become more common near the top of the unit, often before seeing the index fossils.

The top of the Avon Park Formation ranges from approximately 200 feet (61.0 meters) below MSL in W-13551 (Appendix A) to approximately 390 feet (118.9 meters) below MSL in W-13551 (Appendix A). Due to limited coverage of deeper wells, the total thickness of the Avon Park Formation was not investigated in this study. The Avon Park Formation forms part of the Floridan aquifer system (FAS; Southeastern Geological Society Ad Hoc Committee on Florida Hydrostratigraphic Unit Definition, 1986).

Ocala Limestone

The upper Eocene Ocala Limestone (To), first described by Dall and Harris (1892), is a biogenic marine limestone comprised largely of foraminifera, mollusks, echinoids, and bryozoans. The Ocala Limestone, which sits unconformably on the Avon Park Formation, is recrystallized to varying degrees within the study area.

Based on lithologic differences, the Ocala Limestone, in some areas, can be informally subdivided into an upper and lower unit (Scott, 1991). This subdivision, while often apparent in cores and quarries, is not readily apparent in cuttings. Consequently, the geologic cross-sections do not depict the upper and lower Ocala Limestone. The upper unit is typically a white to cream, fine- to coarse-grained, poorly- to well-indurated, moderately- to well-sorted, very fossiliferous limestone (wackestone, packstone, and grainstone). Common fossils include foraminifera (*Lepidocyclina ocalana* and *Sphaerogypsina globulus*), bryozoans, mollusks, and a rich diversity of echinoids. The lower unit is typically a white to cream, fine- to medium-grained, poorly- to moderately- indurated, moderately- to well-sorted limestone (grainstone to packstone). Fossils include foraminifera (*Amphistegina pinarensis*, *Nummulites* [*Camerina*] *vanderstoki*, and *Nummulites* [*Operculinoides*] *ocalanus*), bryozoans, algae, mollusks, echinoids, and crustaceans. Porosity types in the unit range from intergranular to moldic depending on the lithology.

The Ocala Limestone occurs throughout the study area (OFMS 115, Plate 2). The top of the Ocala Limestone ranges from approximately 80 feet (24.4 meters) below MSL in W-19827, to approximately 400 feet (121.9 meters) below MSL in W-1770 (Appendix A). The thickness of the Ocala Limestone ranges from approximately 20 feet (6.0 meters) in W-13534, to 180 feet (54.9 meters) in W-15172 (Appendix A). The Ocala Limestone forms part of the FAS (Southeastern Geological Society Ad Hoc Committee on Florida Hydrostratigraphic Unit Definition, 1986).

Oligocene-Pliocene Series

Hawthorn Group

Sediments of the lower Oligocene to lower Pliocene Hawthorn Group are thought to have been deposited over the Ocala Platform throughout peninsular Florida, but post-Pliocene erosion and karstification have removed them from the crest of the Ocala Platform (Cooke, 1945; Espenshade and Spencer, 1963; Scott, 1981). Within the mapped area, the Hawthorn Group is composed of sediments from the Arcadia and Peace River formations. Arcadia Formation sediments lie unconformably over the Ocala

Limestone throughout most of the mapped area (OFMS 115, Plate 2, cross-sections). In the northern part of the quadrangle, where the Arcadia Formation is absent, the Peace River Formation may unconformably overlie the Ocala Limestone (OFMS 115, Plate 2, cross-section A-A'). The Peace River Formation lies unconformably over the Arcadia Formation throughout most of the quadrangle. The Hawthorn Group sediments are unconformably overlain by the Tertiary/Quaternary undifferentiated shelly sediments throughout the Cape Canaveral quadrangle. The top of the Hawthorn Group ranges from approximately 55 feet (16.8 meters) below MSL in W-3743 (Appendix A) to 135 feet (41.1 meters) below MSL in W-14737 (Appendix A). The thickness of the Hawthorn Group ranges from approximately 10 feet (3.0 meters) in W-1672 (Appendix A) to 315 feet (96.0 meters) in thickness in W-13551 (Appendix A).

Arcadia Formation

The lower Oligocene to middle Miocene (Brewster-Wingard et al., 1997) Arcadia Formation (Tha) is a yellowish-gray to white, carbonate with variable amounts of quartz sand and phosphorite, interbedded with siliciclastic-dominant sediments. Phosphate content can be highly variable, ranging up to 25 percent, but it is more commonly in the 10 percent range (Scott, 1988). Although limestone is present, dolostone is most common, ranging in grain size from microcrystalline to medium, with the coarser material often having a sucrosic texture. Minor clay and chert beds (some composed of silicified clay) also occur (Upchurch et al., 1982; Scott, 1988). Porosity types can be intergranular and moldic. The Arcadia Formation was identified in most boreholes within the study area based on the presence of sandy, phosphatic carbonate beds (30 feet or more), with occasional presence of bored phosphatic hardgrounds.

The Arcadia Formation ranges from approximately 70 feet (21.3 meters) below MSL (Appendix A; W-10294) to approximately 200 feet (61.0 meters) below MSL (Appendix A; W-13551). The unit ranges from 10 feet (3.1 meters) thick in W-19825 (Appendix A) to approximately 255 feet (77.7 meters) thick in W-1770 (Appendix A). The Arcadia Formation forms part of the intermediate aquifer system/intermediate confining unit (IAS/ICU) in the study area (Southeastern Geological Society Ad Hoc Committee on Florida Hydrostratigraphic Unit Definition, 1986).

Peace River Formation

The middle Miocene to lower Pliocene (Scott, 1988; Covington, 1993) Peace River Formation (Thp) is comprised of yellowish-gray to olive-gray, interbedded quartz sands, clays, and carbonates. Siliciclastics are the predominant component of the unit (Scott, 1988). Phosphatic sand and gravel are most common in the uppermost beds, although they are generally interspersed throughout the unit. The Peace River Formation contains a diverse fossil assemblage of marine and terrestrial fauna. Porosity types in the formation are generally intergranular.

The Peace River Formation unconformably overlies the Arcadia Formation throughout the mapped area (OFMS 115, Plate 2). In areas where the carbonate component of the Peace River Formation is high, or the siliciclastic component of the Arcadia Formation is high, identifying the contact between these formations can be difficult. In such cases, the contact of the Peace River Formation with the Arcadia Formation is best estimated based on the occurrence of sedimentary structures, and where the overall lithologic sequence becomes more carbonate-dominant (Scott, 1988). In most of the study area, the contact is readily recognized at the first occurrence of a light-colored, phosphatic and quartz-sandy dolosilt.

The Peace River Formation ranges from approximately 55 feet (16.8 meters) below MSL in W-3743, to 135 feet (41.1 meters) below MSL in W-14737 (Appendix A). Thicknesses range from approximately 5 feet (1.5 meters) in W-13501, to 130 feet (39.6 meters) in W-13551 (Appendix A). The Peace River Formation sediments comprise a low-permeability confining- to semi-confining facies within the IAS/ICU within the study area (Southeastern Geological Society Ad Hoc Committee on Florida Hydrostratigraphic Unit Definition, 1986).

Tertiary/Quaternary Systems

Pliocene/Pleistocene Series

Tertiary/Quaternary undifferentiated shelly sediments

Tertiary/Quaternary undifferentiated shelly sediments(TQsu) typically consist of fine-to-medium quartz sands and marine mollusk shell beds with variable amounts of micrite, silt, clay, and calcite cement. Colors range from light gray to light-olive gray. Fossil mollusk shells, which may vary from whole to fragments, are often highly weathered and abraded and regularly become the dominant lithology. Porosity is generally intergranular. Other accessory minerals may include calcite, aragonite, mica, heavy minerals, pyrite, and minor phosphate sand and gravel. A basal phosphate lag deposit is occasionally present. In the study area, these undifferentiated Tertiary/Quaternary shelly sediments occur in the form of both unconsolidated sand with varying percentages of shell fragments and calcite-cemented sand and shell fragments, with occasional lithified carbonate beds.

The elevation of the Tertiary/Quaternary shelly sediments is variable throughout the mapped area. The top of the unit is generally less than 40 feet (12.2 meters) above MSL, with most of the unit being less than ten feet (3.0 meters) above MSL (OFMS 115, Plate 2, cross-sections). It is postulated that these occurrences of higher elevation undifferentiated Tertiary/Quaternary shelly sediments are indicative of paleo-shorelines that have been “stranded” due to sea-level fluctuation. Additional studies, with much better core control than was available in this study, are needed to determine the exact nature and relationships of the unit in the region.

These undifferentiated Tertiary/Quaternary shelly sediments are overlain by undifferentiated Quaternary sediments and Quaternary beach ridge and dune sediments in the western portion of the mapped area, and Holocene sediments in the central and eastern portions of the mapped area (OFMS 115, Plate 2). The undifferentiated Tertiary/Quaternary shelly sediments are exposed in several quarries within the study area. In the eastern portion of the quadrangle, the unit is unconformably overlain by Holocene sediments, undifferentiated Quaternary sediments, or the Anastasia Formation. Undifferentiated Tertiary/Quaternary shelly sediments disconformably overlie the Peace River Formation throughout the Cape Canaveral quadrangle.

The top of the undifferentiated Tertiary/Quaternary shelly sediments ranges from approximately 40 feet (12.2 meters) above MSL in W-16388 to 70 feet (21.3 meters) below MSL in W-13745 (Appendix A). The thickness of the undifferentiated Tertiary/Quaternary shelly sediments in the mapped area varies from 5 feet (1.5 meters) in W-3557 to 160 feet (48.8 meters) in W-15961 (Appendix A). Permeable sediments of the Tertiary/Quaternary undifferentiated shelly sediments form part of the surficial aquifer system (SAS; Southeastern Geological Society Ad Hoc Committee on Florida Hydrostratigraphic Unit Definition, 1986).

Pleistocene/Holocene Series

Anastasia Formation

The Anastasia Formation (Qa) is present within a narrow band along the eastern edge of the study area. The formation, named by Sellards (1912), is composed of interbedded coquinoid limestone and quartz sands. It typically occurs as an orangish-brown, poorly- to moderately-indurated coquinoid limestone consisting of whole and broken mollusk shells in a quartz sand matrix. The coquina is commonly cemented by sparry calcite. The sand occurs in beds that are light-gray to tan and orangish-brown, unconsolidated to moderately indurated, and variably fossiliferous. Porosity is intergranular to intercrystalline but may be vuggy and even karstic in more cemented zones. In the study area, the Anastasia Formation occurs predominantly as light-gray-to-tan and orangish-brown, unconsolidated to moderately indurated quartz sand and shells. Coquinoid limestone, sometimes having a micritic or sparry matrix, is common.

The Anastasia Formation can be difficult to distinguish from the undifferentiated Tertiary/Quaternary shelly sediments in some areas due to similarity in lithologic components. Typically, the Anastasia Formation is distinguished based on its fairly uniform fossil content, tendency to contain rounded sand and shell fragments (typical of beach material), orangish-brown color, and lack of clay and silt matrix. In localities where the Anastasia Formation-Tertiary/Quaternary shelly sediments cannot be easily distinguished, undifferentiated Tertiary/Quaternary shelly sediments were picked where the shell fragments become more diverse in taxonomy and texture.

The Anastasia Formation sits on undifferentiated Tertiary/Quaternary shelly sediments (OFMS 115, Plate 2). The top of the unit ranges from approximately 20 feet (6.1 meters) above MSL in W-1680, to 10 feet (3.0 meters) below MSL in W-65 (Appendix A). The thickness of the Anastasia Formation varies from approximately 5 feet (1.5 meters) in W-3702, to 40 feet (12.2 meters) in W-15890 (Appendix A). This formation is considered part of the SAS (Southeastern Geological Society Ad Hoc Committee on Florida Hydrostratigraphic Unit Definition, 1986).

Undifferentiated Quaternary sediments

Quaternary undifferentiated sediments (Qu) include siliciclastic sediments, organics, minor shells, and freshwater carbonates. While not a formally recognized lithostratigraphic unit, the Quaternary undifferentiated sediments are mapped as a discrete unit where these sediments exceed 20 feet thick above formally recognized lithostratigraphic units. The Quaternary undifferentiated sediments in the mapped area may be highly variable in thickness. Quaternary undifferentiated sediments in the study area lie unconformably on Anastasia Formation or Tertiary/Quaternary undifferentiated shelly sediments (OFMS 115, Plate 2).

Generally, undifferentiated Quaternary sediments consist of white-to-gray to orange-to-brown, fine- to coarse-grained, clean-to-clayey (usually) unfossiliferous quartz sand, sandy clays and clays, with variable admixtures of organics. Minor shell fragments are sometimes present in undifferentiated Quaternary sediments near the coast. These characteristics make a distinction between undifferentiated Quaternary sediments and Anastasia Formation difficult at times. The undifferentiated Quaternary sediments form part of the SAS (Southeastern Geological Society Ad Hoc Committee on Florida Hydrostratigraphic Unit Definition, 1986).

Quaternary beach ridge and dune sediments

Quaternary beach ridge and dune sediments (Qbd) are a subdivision of the undifferentiated Quaternary sediments that are mapped on the basis of having a surficial expression of relict beach ridges and dunes. While not a formally recognized lithostratigraphic unit, the unit is mapped following the convention of Scott et al. (2001) in order to facilitate a better understanding of Florida’s geology. The unit unconformably overlies undifferentiated Tertiary/Quaternary shelly sediments in the western part of the study area (OFMS 115; Plate 2).

Beach ridge and dune sediments are comprised of quartz sands with occasional shells and are unconsolidated to poorly consolidated. Organics typically occur as disseminated organic matrix, roots and plant debris, carbonized remains, or charcoal. The unit is considered part of the SAS (Southeastern Geological Society Ad Hoc Committee on Florida Hydrostratigraphic Unit Definition, 1986).

Holocene sediments

Sediments mapped as Holocene (Qh) may include quartz sands, marls, organics, and minor carbonate sands and mud. They occur within the Upper St. Johns River Valley and along the eastern portion of the mapped area and are associated with mangroves and marshes along the coast, in some coastal lowlands, and in modern barrier islands (OFMS 115; Plate 1). Additionally, some areas, especially Cape Canaveral proper, are mapped as Qh due to known age of the deposits (Rodrigues et al., 2022), even though this area has strand plain morphology of beach ridge and dune landforms. These sediments are considered part of the SAS (Southeastern Geological Society Ad Hoc Committee on Florida Hydrostratigraphic Unit Definition, 1986).

SPOIL

The areas marked as spoil on the map are disturbed land created by dredging in the Indian River along navigation channels, Port Canaveral area, and fill for roads and bridges. These are typically a mixture of sand and shells from either the Tertiary/Quaternary undifferentiated shelly sediments, the Anastasia Formation, or Holocene sediments.

HYDROGEOLOGY

Hydrostratigraphic units within the map area, in ascending order, consist of the FAS, the IAS/ICU, and the SAS (Southeastern Geological Society Ad Hoc Committee on Florida Hydrostratigraphic Unit Definition, 1986). A correlation chart of the hydrostratigraphic units, and their relationship to lithostratigraphic units, can be seen on OFMS 115, Plate 2, Figure 2. The FAS, the primary source for drinking water in the region, is generally comprised of carbonate units of the Avon Park Formation and the Ocala Limestone. The sands, silts, clays, and carbonates of the Hawthorn Group comprise the IAS/ICU. The SAS is comprised of Anastasia Formation, undifferentiated Tertiary/Quaternary shelly sediments, undifferentiated Quaternary sediments, Quaternary beach ridge and dune sediments, and Holocene sediments.

DERIVATIVE PRODUCTS

Several derivative products were developed in the process of completing this project. During the mapping efforts, data from 149 boreholes with samples were analyzed and used (Appendix A). Formation picks made on these cores and cutting samples will allow creation of structure contour and isopach maps for the top of several units in the area, as well as future 3-D models. Additional derivative products anticipated to come from this mapping effort include aquifer vulnerability assessment maps. Data derived from prior STATEMAP products have often been used to augment Florida Geological Survey projects involving geologic data such as Florida Aquifer Vulnerability Assessment (FAVA) projects in the state (Arthur et al., 2007; Baker et al., 2007). These geologic maps will also be compiled and published as part of the Statewide Surficial Geologic Map in the next decade.

REFERENCES

Adams, P.N., 2018, Geomorphic origin of Merritt Island-Cape Canaveral, Florida, USA: A paleodelta of the reversed St. Johns River?: Geomorphology, v. 306, p. 102-107, https://doi.org/10.1016/j.geomorph.2018.01.005.

Applin, P., 1951, Possible future petroleum provinces of North America - Florida: American Association of Petroleum Geologists Bulletin, v. 35, p. 405-407.

Applin, P.L., and Applin, E.R., 1944, Regional subsurface stratigraphy and structure of Florida and southern Georgia: American Association of Petroleum Geologists Bulletin, v. 28, p. 1673-1753.

Applin, P.L., and Applin, E.R., 1965, The Comanche Series and associated rocks in the subsurface in central and south Florida: U.S. Geological Survey Professional Paper 447, 84 p.

Arthur, J.D., Wood, H.A.R., Baker, A.E., Cichon, J.R., and Raines, G.L., 2007, Development and implementation of a Bayesian-based aquifer vulnerability assessment in Florida: Natural Resources Research, v. 16, p. 93-107.

Baker, A.E., Wood, H.A.R., and Cichon, J.R., 2007, The Marion County Aquifer Vulnerability Assessment: unpublished report submitted to Marion County Board of County Commissioners in fulfillment of Marion County Project No. SS06-01, March 2007, 42 p.

Brewster-Wingard, G.L., Scott, T.M., Edwards, L.E., Weedman, S.D., and Simmons, K.R., 1997, Reinterpretation of the peninsular Florida Oligocene: an integrated stratigraphic approach: Sedimentary Geology, v. 108, p. 207-228.

Bryan, J.R., 2004, Larger foraminifera: Introduction, biology, ecology, taxonomic and stratigraphic listings and comments on Florida fossil assemblages: Gainesville, Florida Paleontological Society, Florida Fossil Invertebrates, Part 6, 28 p.

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, p. 173-185.

Burdette, K.E., Rink, W.J., Mallinson, D.J., Parham, P.R., and Reinhardt, E.G., 2010, Geologic investigation and optical dating of the Merritt Island sand ridge sequence, eastern Florida, USA: Southeastern Geology, v. 47, p. 175-190.

Clark, W.Z., Jr., and Zisa, A.C., 1976, Physiographic map of Georgia: The Geologic and Water Resources Division, Georgia Department of Natural Resources, scale 1:2,000,000, 1 sheet.

Cooke, C.W., 1945, Geology of Florida: Florida Geological Survey Bulletin 29, 342 p., https://doi.org/10.35256/B29.

Covington, J.M., 1993, Neogene nannofossils of Florida, *in* Zullo, V.A., Harris, W.B., Scott, T.M., and Portell, R.W., eds., The Neogene of Florida and adjacent regions: Florida Geological Survey Special Publication 37, 112 p., https://doi.org/10.35256/SP37 .

Dall, W.H., and Harris, G.D., 1892, Correlation papers, Neocene: U.S. Geological Survey Bulletin 84, 349 p.

Espenshade, G.H., and Spencer, C.W., 1963, Geology of phosphate deposits of northern peninsular Florida: United States Geological Survey Bulletin 1118, 115 p.

Green, R.C., Williams, C.P., Bambach, P.W., Hannon, L.M., Apolinar, B., Campbell, K.M., and Dyer, S.B., 2015a, Geologic map of the USGS 30 x 60 minute Orlando quadrangle, central Florida: Florida Geological Survey Open-File Map Series 107, scale 1:100,000, 3 plates, https://doi.org/10.35256/OFMS107.

Green, R.C., Williams, C.P., Bambach, P.W., Hannon, L.M., Apolinar, B., Campbell, K.M., and Dyer, S.B., 2015b, Text to accompany geologic map of the USGS 30 x 60 minute Orlando quadrangle, central Florida: Florida Geological Survey Open-File Report 105, 31 p., https://doi.org/10.35256/OFR105.

Green, R.C., Williams, C.P., Lamarche, A.G., Albritton, C.K., White, K.M., and Bassett, S.W., 2018a, Geologic map of the USGS Kissimmee 30 x 60 minute quadrangle, central Florida: Florida Geological Survey Open-File Map Series 110, scale 1:100,000, 3 plates, https://doi.org/10.35256/OFMS110.

Green, R.C., Williams, C.P., Lamarche, A.G., Albritton, C.K., White, K.M., and Bassett, S.W., 2018b, Text to accompany geologic map of the USGS Kissimmee 30 x 60 minute quadrangle, central Florida: Florida Geological Survey Open-File Report 107, 42 p., https://doi.org/10.35256/OFR107.

Green, R.C., Williams, C.P., Lamarche, A.G., Hebets, C.L., Albritton, C.K., and Evans, G.S., 2019a, Geologic map of the USGS Bartow 30 x 60 minute quadrangle, central Florida: Florida Geological Survey Open-File Map Series 111, scale 1:100,000, 3 plates, https://doi.org/10.35256/OFMS111.

Green, R.C., Williams, C.P., Lamarche, A.G., Hebets, C.L., Albritton, C.K., and Evans, G.S., 2019b, Text to accompany geologic map of the USGS Bartow 30 x 60 minute quadrangle, central Florida: Florida Geological Survey Open-File Report 108, 38 p., https://doi.org/10.35256/OFR108.

Green, R.C., Lamarche, A.G., Williams, C.P., Hebets, C.L., Evans, G.S., and Albritton, C.A., 2021a, Geologic map of the USGS Vero Beach 30 x 60 minute quadrangle, central Florida, Florida Geological Survey Open-File Map Series 112, scale 1:100,000, 3 plates, https://doi.org/10.35256/OFMS112.

Green, R.C., Lamarche, A.G., Williams, C.P., Hebets, C.L., Evans, G.S., and Albritton, C.A., 2021b, Text to accompany geologic map of the USGS Vero Beach 30 x 60 minute quadrangle, central Florida, Florida Geological Survey Open-File Report 109, 38 p., https://doi.org/10.35256/OFR109.

Hine, A.C., 2013, Geologic history of Florida: major events that formed the Sunshine State: Gainesville, University Press of Florida, 230 pages.

Hopkins, O.B., 1920, Drilling for oil in Florida: U.S. Geological Survey Press Bulletin, April, 1920.

Hydrologic Unit Codes: Basins, 1993: Tallahassee: Florida Department of Environmental Protection, [vector digital data file].

Kromhout, C., Baker, A.E., Albritton, C.K., Scott, T.M., Cichon, J.R., and Miller, S.R., 2017, The Favorability of Florida's Geology to Sinkhole Formation: A report prepared for the Florida Division of Emergency Management, Mitigation Section, 76 p., http://publicfiles.dep.state.fl.us/FGS/FGS_Publications/FGS%20Library%20.

May, J.P., 1972, Age and origin of the Cape Kennedy area: Southeastern Geological Society, Field Conference Guidebook, v. 16, p. 30-34.

Miller, J.A., 1986, Hydrogeologic framework of the Floridan aquifer system in Florida and in parts of Georgia, Alabama, and South Carolina: Regional Aquifer-System Analysis: U.S. Geological Survey Professional Paper 1403-B, 91 p., 33 plates.

Osmond, J.K., May, J.P., and Tanner, W.F., 1970, Age of the Cape Kennedy barrier-and-lagoon complex: Journal of Geophysical Research, v. 75, p. 469-479.

Parkinson, R.W., Huggins, E., and Taylor, D.S., 2012, Sedimentary environments, karstification, and the preservation of a late Pleistocene coastal bone bed: Pine Island Conservation Area, Brevard County, Florida, U.S.A.: Florida Scientist, v. 75, p. 25-40.

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., https://doi.org/10.35256/SP05R.

Riggs, S. R., 1979, Phosphorite sedimentation in Florida-a model phosphogenic system: Economic Geology, v. 74, p. 285-314.

Rodrigues, K, Stapor, F.W., Rink, W.J., Dunbar, J.S., and Doran, G., 2022, A 5700-year-old beach-ridge set at Cape Canaveral, Florida, and its implication for Holocene sea-level history in the southeastern USA: The Holocene, v. 32, p. 40-56. https://doi.org/10.1177/09596836211049975.

Schmidt, W., 1984, Neogene stratigraphy and geologic history of the Apalachicola Embayment: Florida Geological Survey Bulletin 58, 146 p., https://doi.org/10.35256/B58.

Scott, T.M., 1981, The Hawthorn Formation of North Florida: Southeastern Geological Society, Field Conference Guidebook, v. 23, p. 15-23.

_________, 1988, The lithostratigraphy of the Hawthorn Group (Miocene) of Florida: Florida Geological Survey Bulletin 59, 148 p., https://doi.org/10.35256/B59.

_________, 1991, A geological overview, *in* Scott, T.M., Lloyd, J.M., and Maddox, G.L., eds., Florida's ground-water quality monitoring program, hydrogeologic framework: Florida Geological Survey Special Publication 32, 97 p., https://doi.org/10.35256/SP32.

_________, 1993a, Geologic map of Brevard County, Florida: Florida Geological Survey Open-File Map Series 45, Scale 1:126,760, https://doi.org/10.35256/OFMS45.

_________, 1993b, Geologic map of Orange County, Florida: Florida Geological Survey Open-File Map Series 47, Scale 1:126,760, https://doi.org/10.35256/OFMS47.

_________, 1993c, Geologic map of Osceola County, Florida: Florida Geological Survey Open-File Map Series 48, Scale 1:126,760, https://doi.org/10.35256/OFMS48.

_________, 1997, Miocene to Holocene history of Florida, *in* Randazzo, A.F., and Jones, D.S., eds., The Geology of Florida: Gainesville, University Press of Florida, p. 57-67.

Scott, T.M., Campbell, K.M., Rupert, F.R., Arthur, J.A., Green, R.C., Means, G.H., Missimer, T.M., Lloyd, J.M., and Duncan, J.G., 2001, Geologic map of Florida: Florida Geological Survey Map Series 146, scale 1:750,000, https://doi.org/10.35256/MS146.

Scott, T.M., and Wingard, G.L., 1995, Facies, fossils, and time – A discussion of the litho- and biostratigraphic problems in the Plio-Pleistocene sediments in southern Florida, *in* Scott, T.M., 1995, compiler, Stratigraphy and paleontology of the Plio-Pleistocene shell beds, southwest Florida: Southeastern Geological Society Guidebook no. 35, unpaginated.

Sellards, E.H., 1912, The soils and other surface residual material of Florida: Florida Geological Survey Fourth Annual Report, p. 1-79, https://doi.org/10.35256/AR04.

Southeastern Geological Society Ad Hoc Committee on Florida Hydrostratigraphic Unit Definition, 1986, Hydrogeological units of Florida: Florida Geological Survey Special Publication 28, 8 p., https://doi.org/10.35256/SP28.

Upchurch, S.B., Strom, R.N., and Nuckels, M.G., 1982, Silicification of Miocene rocks from central Florida, *in* Scott, T.M., and Upchurch, S.B., eds., Miocene of the southeastern United States: Florida Geological Survey Special Publication 25, p. 251-284. https://doi.org/10.35256/SP25.

U.S. Geological Survey, 2022, 3D Elevation Program 1-Meter Resolution Digital Elevation Mode (published 20221003), https://apps.nationalmap.gov/downloader/ (accessed February, 2023).

Vernon, R.O., 1951, Geology of Citrus and Levy Counties, Florida: Florida Geological Survey Bulletin 33, 256 p., https://doi.org/10.35256/B33

White, W.A., 1970, The geomorphology of the Florida peninsula: Florida Geological Survey Bulletin 51, 164 p., https://doi.org/10.35256/B51

Williams, C.P., Scott, T.M., and Upchurch, S.B., 2022, Florida Geomorphology Atlas: Florida Geological Survey Special Publication 59, 238 p., https://doi.org/10.35256/SP59

Williams, K.E., Nicol, D., and Randazzo, A.F., 1977, The geology of the western part of Alachua County, Florida: Florida Geological Survey Report of Investigation 85, 97 p., https://doi.org/10.35256/RI85.

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APPENDIX A: FLORIDA GEOLOGICAL SURVEY BOREHOLES UTILIZED FOR STUDY

This table lists FGS boreholes within the boundaries of the USGS Cape Canaveral 30 x 60 minute quadrangle utilized for the project. Wells use NAD 1983 HARN projection. Due to graphical constraints, not all boreholes will appear on Plate 1 of OFMS 115. The first 26 boreholes in the table were utilized for geologic cross-sections and appear on Plates 1 and 2 of OFMS 115.

Map ID	Well Label	Data Source	Sample Type	Latitude	Longitude	24K Quad	Elevation (ft.)	Total Depth (ft.)
1	W-9	FGS	Cuttings	28.12083	-80.63167	MELBOURNE WEST	17	511
2	W-65	FGS	Cuttings	28.09000	-80.57528	MELBOURNE EAST	6	309
3	W-719	FGS	Cuttings	28.09417	-80.72722	MELBOURNE WEST	13	79
4	W-846	FGS	Cuttings	28.22251	-80.68366	EAU GALLIE	36	175
5	W-1510	FGS	Cuttings	28.31214	-80.91468	LAKE POINSETT SW	41	279
6	W-3403	FGS	Cuttings	28.38694	-80.67333	COURTENAY	6	90
7	W-3557	FGS	Cuttings	28.36806	-80.85694	LAKE POINSETT	15	553
8	W-3661	FGS	Cuttings	28.37944	-80.78750	SHARPES	24	129
9	W-3663	FGS	Cuttings	28.37862	-80.96923	LAKE POINSETT NW	50	300
10	W-3743	FGS	Cuttings	28.09333	-80.90917	DEER PARK	44	350
11	W-9116	FGS	Cuttings	28.15028	-80.90417	DEER PARK NW	46	290
12	W-10242	FGS	Cuttings	28.46806	-80.76694	SHARPES	22	215
13	W-13489	FGS	Continuous Core	28.25918	-80.91200	LAKE POINSETT SW	43	382
14	W-13490	FGS	Continuous Core	28.26094	-80.79394	LAKE POINSETT	14	230
15	W-13534	FGS	Continuous Core	28.28111	-80.99639	LAKE POINSETT SW	62	392
16	W-14737	FGS	Cuttings	28.26194	-80.60728	COCOA BEACH	6	440
17	W-15334	FGS	Continuous Core	28.49028	-80.93889	LAKE POINSETT NW	15	262
18	W-15961	FGS	Cuttings	28.06957	-80.64460	MELBOURNE WEST	31	2410
19	W-16133	FGS	Cuttings	28.01981	-80.59758	MELBOURNE EAST	16	370
20	W-16299	FGS	Cuttings	28.07333	-80.61111	MELBOURNE EAST	10	1650
21	W-16388	FGS	Cuttings	28.38769	-80.94050	LAKE POINSETT NW	39	370
22	W-16633	FGS	Cuttings	28.32733	-80.72115	COCOA	21	2720
23	W-17550	FGS	Cuttings	28.38240	-80.76697	SHARPES	23	190
24	W-19598	FGS	Continuous Core	28.10795	-80.97861	DEER PARK	60	1480
25	W-19829	FGS	Cuttings	28.40528	-80.59194	CAPE CANAVERAL	9	310
26	W-19967	FGS	Continuous Core	28.08522	-80.81667	DEER PARK SE	18	315
27	W-638	FGS	Cuttings	28.09597	-80.63097	MELBOURNE WEST	23	457
28	W-718	FGS	Cuttings	28.09389	-80.72903	MELBOURNE WEST	13	50
29	W-893	FGS	Cuttings	28.20889	-80.68045	EAU GALLIE	36	143
30	W-1381	FGS	Cuttings	28.35492	-80.75350	LAKE POINSETT	19	190
31	W-1382	FGS	Cuttings	28.42900	-80.71794	COURTENAY	11	325
32	W-1605	FGS	Cuttings	28.32017	-80.60977	COCOA BEACH	5	217
33	W-1606	FGS	Cuttings	28.32017	-80.60977	COCOA BEACH	5	237
34	W-1609	FGS	Cuttings	28.20431	-80.79608	DEER PARK NE	16	270
35	W-1672	FGS	Cuttings	28.34598	-80.80778	LAKE POINSETT	11	180
36	W-1674	FGS	Cuttings	28.36169	-80.75721	LAKE POINSETT	22	58
37	W-1675	FGS	Cuttings	28.36171	-80.74481	COCOA	26	54
38	W-1676	FGS	Cuttings	28.36170	-80.74068	COCOA	26	52
39	W-1677	FGS	Cuttings	28.38001	-80.73684	COURTENAY	7	42
40	W-1680	FGS	Cuttings	28.37256	-80.73667	COCOA	32	49
41	W-1683	FGS	Cuttings	28.36556	-80.74070	COCOA	25	103
42	W-1684	FGS	Cuttings	28.36173	-80.74895	COCOA	23	56

Map ID	Well Label	Data Source	Sample Type	Latitude	Longitude	24K Quad	Elevation (ft.)	Total Depth (ft.)
43	W-1685	FGS	Cuttings	28.35439	-80.74895	COCOA	20	52
44	W-1687	FGS	Cuttings	28.36173	-80.74895	COCOA	23	40
45	W-1688	FGS	Cuttings	28.36171	-80.74481	COCOA	26	54
46	W-1770	FGS	Cuttings	28.27739	-80.89988	LAKE POINSETT SW	28	5856
47	W-1926	FGS	Cuttings	28.21556	-80.67778	EAU GALLIE	33	105
48	W-1944	FGS	Cuttings	28.19444	-80.66694	EAU GALLIE	28	95
49	W-1945	FGS	Cuttings	28.17944	-80.66111	EAU GALLIE	27	85
50	W-1947	FGS	Cuttings	28.15889	-80.65556	EAU GALLIE	20	75
51	W-1959	FGS	Cuttings	28.14667	-80.64639	EAU GALLIE	24	69
52	W-1962	FGS	Cuttings	28.15250	-80.65306	EAU GALLIE	24	63
53	W-2483	FGS	Cuttings	28.25306	-80.60861	COCOA BEACH	5	350
54	W-2867	FGS	Cuttings	28.46036	-80.54344	CAPE CANAVERAL	8	360
55	W-3655	FGS	Cuttings	28.38703	-80.92006	LAKE POINSETT NW	21	184
56	W-3657	FGS	Cuttings	28.38193	-80.74701	COURTENAY	24	115
57	W-3658	FGS	Cuttings	28.38583	-80.75139	SHARPES	30	75
58	W-3659	FGS	Cuttings	28.35583	-80.75472	LAKE POINSETT	19	64
59	W-3660	FGS	Cuttings	28.38084	-80.76644	SHARPES	24	107
60	W-3662	FGS	Cuttings	28.39667	-80.94639	LAKE POINSETT NW	41	390
61	W-3702	FGS	Cuttings	28.14951	-80.58997	TROPIC	8	57
62	W-3909	FGS	Cuttings	28.22972	-80.60139	TROPIC	4	350
63	W-3910	FGS	Cuttings	28.22972	-80.60139	TROPIC	4	350
64	W-3918	FGS	Cuttings	28.37111	-80.75083	LAKE POINSETT	26	78
65	W-3919	FGS	Cuttings	28.32374	-80.73051	COCOA	17	44
66	W-3920	FGS	Cuttings	28.35264	-80.73037	COCOA	26	78
67	W-3921	FGS	Cuttings	28.33791	-80.73041	COCOA	17	58
68	W-3922	FGS	Cuttings	28.32373	-80.74702	COCOA	20	28
69	W-3923	FGS	Cuttings	28.29556	-80.70167	COCOA	19	34
70	W-3924	FGS	Cuttings	28.38176	-80.76336	SHARPES	25	68
71	W-3925	FGS	Cuttings	28.33333	-80.72194	COCOA	30	68
72	W-3927	FGS	Cuttings	28.32167	-80.71472	COCOA	21	68
73	W-3928	FGS	Cuttings	28.32417	-80.72222	COCOA	22	64
74	W-3929	FGS	Cuttings	28.35278	-80.74688	COCOA	19	54
75	W-3934	FGS	Cuttings	28.33833	-80.72028	COCOA	20	34
76	W-3935	FGS	Cuttings	28.33791	-80.73041	COCOA	17	64
77	W-3937	FGS	Cuttings	28.35278	-80.76343	LAKE POINSETT	13	48
78	W-3938	FGS	Cuttings	28.36750	-80.73528	COCOA	34	64
79	W-3940	FGS	Cuttings	28.36750	-80.74692	COCOA	30	78
80	W-3942	FGS	Cuttings	28.39486	-80.74486	COURTENAY	38	54
81	W-3944	FGS	Cuttings	28.39652	-80.74716	COURTENAY	35	68
82	W-3945	FGS	Cuttings	28.38176	-80.76336	SHARPES	25	78
83	W-3947	FGS	Cuttings	28.40056	-80.76306	SHARPES	37	48
84	W-3948	FGS	Cuttings	28.33790	-80.74691	COCOA	23	48
85	W-4420	FGS	Cuttings	28.43444	-80.82639	SHARPES	20	244
86	W-4424	FGS	Cuttings	28.49000	-80.77722	SHARPES	17	74
87	W-4425	FGS	Cuttings	28.15139	-80.67528	EAU GALLIE	28	74
88	W-4430	FGS	Cuttings	28.05837	-80.55257	MELBOURNE EAST	17	54
89	W-4433	FGS	Cuttings	28.49444	-80.78589	SHARPES	30	58
90	W-4437	FGS	Cuttings	28.49583	-80.79417	SHARPES	31	64
91	W-4449	FGS	Cuttings	28.13513	-80.58161	TROPIC	13	48
92	W-4451	FGS	Cuttings	28.43572	-80.68556	COURTENAY	0	68
93	W-4454	FGS	Cuttings	28.14389	-80.68611	EAU GALLIE	26	74
94	W-4767	FGS	Cuttings	28.11806	-80.65139	MELBOURNE WEST	26	50
95	W-6138	FGS	Cuttings	28.25519	-80.60833	COCOA BEACH	5	310

Map ID	Well Label	Data Source	Sample Type	Latitude	Longitude	24K Quad	Elevation (ft.)	Total Depth (ft.)
96	W-6204	FGS	Cuttings	28.35200	-80.72978	COCOA	27	300
97	W-6312	FGS	Cuttings	28.12528	-80.65056	EAU GALLIE	18	80
98	W-6424	FGS	Cuttings	28.20807	-80.59671	TROPIC	8	210
99	W-6455	FGS	Cuttings	28.11806	-80.65083	MELBOURNE WEST	26	120
100	W-6552	FGS	Cuttings	28.13028	-80.67089	EAU GALLIE	26	320
101	W-6553	FGS	Cuttings	28.13028	-80.67089	EAU GALLIE	26	400
102	W-6554	FGS	Cuttings	28.39139	-80.60694	CAPE CANAVERAL	4	323
103	W-6555	FGS	Cuttings	28.39139	-80.60694	CAPE CANAVERAL	4	325
104	W-6569	FGS	Cuttings	28.13250	-80.64783	EAU GALLIE	21	400
105	W-6632	FGS	Cuttings	28.11759	-80.64270	MELBOURNE WEST	21	72
106	W-7062	FGS	Cuttings	28.38194	-80.73806	COURTENAY	7	43
107	W-7063	FGS	Cuttings	28.38194	-80.73806	COURTENAY	7	43
108	W-7069	FGS	Cuttings	28.38194	-80.73806	COURTENAY	7	50
109	W-7248	FGS	Cuttings	28.02446	-80.59895	MELBOURNE EAST	17	105
110	W-7943	FGS	Cuttings	28.31583	-80.63444	COCOA	3	275
111	W-8042	FGS	Cuttings	28.33250	-80.63444	COCOA	0	280
112	W-8866	FGS	Cuttings	28.01961	-80.58083	MELBOURNE EAST	18	100
113	W-8867	FGS	Cuttings	28.02050	-80.59758	MELBOURNE EAST	1	94
114	W-10293	FGS	Cuttings	28.38306	-80.76672	SHARPES	25	202
115	W-10294	FGS	Cuttings	28.38403	-80.76931	SHARPES	25	202
116	W-10295	FGS	Cuttings	28.38403	-80.76931	SHARPES	25	202
117	W-12107	FGS	Cuttings	28.01849	-80.60196	MELBOURNE EAST	21	100
118	W-12108	FGS	Cuttings	28.01580	-80.60161	MELBOURNE EAST	18	100
119	W-12397	FGS	Cuttings	28.02140	-80.60539	MELBOURNE EAST	19	115
120	W-12565	FGS	Cuttings	28.02627	-80.60536	MELBOURNE EAST	15	108
121	W-12650	FGS	Cuttings	28.01984	-80.60849	MELBOURNE EAST	16	109
122	W-12651	FGS	Cuttings	28.25967	-80.60439	COCOA BEACH	13	255
123	W-12652	FGS	Cuttings	28.25967	-80.60439	COCOA BEACH	13	265
124	W-13482	FGS	Continuous Core	28.27417	-80.88694	LAKE POINSETT SW	25	363
125	W-13496	FGS	Continuous Core	28.28501	-80.90811	LAKE POINSETT SW	32	422
126	W-13501	FGS	Continuous Core	28.27333	-80.88111	LAKE POINSETT SW	22	322
127	W-13516	FGS	Continuous Core	28.27358	-80.89447	LAKE POINSETT SW	28	397
128	W-13533	FGS	Continuous Core	28.27250	-80.91089	LAKE POINSETT SW	41	452
129	W-13551	FGS	Continuous Core	28.20389	-80.96806	DEER PARK NW	41	490
130	W-13745	FGS	Continuous Core	28.00531	-80.52841	MELBOURNE EAST	9	328
131	W-13881	FGS	Continuous Core	28.13760	-80.84777	DEER PARK NE	20	322
132	W-14736	FGS	Cuttings	28.26186	-80.60719	COCOA BEACH	5	440
133	W-15172	FGS	Cuttings	28.27114	-80.60622	COCOA BEACH	7	450
134	W-15173	FGS	Cuttings	28.26092	-80.60639	COCOA BEACH	6	425
135	W-15176	FGS	Cuttings	28.22333	-80.60194	TROPIC	8	425
136	W-15177	FGS	Cuttings	28.26956	-80.60783	COCOA BEACH	5	450
137	W-15211	FGS	Cuttings	28.02583	-80.60944	MELBOURNE EAST	10	100
138	W-15830	FGS	Cuttings	28.02487	-80.61311	MELBOURNE EAST	18	101
139	W-15890	FGS	Cuttings	28.04086	-80.54700	MELBOURNE EAST	14	2900
140	W-16226	FGS	Cuttings	28.42342	-80.70527	COURTENAY	7	2510
141	W-16786	FGS	Cuttings	28.37744	-80.60072	CAPE CANAVERAL	10	400
142	W-17572	FGS	Cuttings	28.32694	-80.73889	COCOA	22	180
143	W-17661	FGS	Cuttings	28.32734	-80.73862	COCOA	23	116

Map ID	Well Label	Data Source	Sample Type	Latitude	Longitude	24K Quad	Elevation (ft.)	Total Depth (ft.)
144	W-17663	FGS	Cuttings	28.38237	-80.76697	SHARPES	23	91
145	W-18007	FGS	Cuttings	28.47722	-80.95667	LAKE POINSETT NW	21	61
146	W-18010	FGS	Cuttings	28.39694	-80.94506	LAKE POINSETT NW	40	91
147	W-19004	FGS	Continuous Core	28.47825	-80.72114	COURTENAY	0	35
148	W-19005	FGS	Continuous Core	28.47850	-80.72236	COURTENAY	0	34
149	W-19006	FGS	Continuous Core	28.43500	-80.70616	COURTENAY	5	16
150	W-19007	FGS	Continuous Core	28.48164	-80.73422	COURTENAY	0	24
151	W-19008	FGS	Continuous Core	28.49267	-80.73233	COURTENAY	0	44
152	W-19009	FGS	Continuous Core	28.47819	-80.72375	COURTENAY	0	15
153	W-19010	FGS	Continuous Core	28.47769	-80.71825	COURTENAY	3	50
154	W-19011	FGS	Continuous Core	28.47822	-80.72523	COURTENAY	0	24
155	W-19012	FGS	Continuous Core	28.49267	-80.72761	COURTENAY	1	17
156	W-19013	FGS	Continuous Core	28.49514	-80.72122	COURTENAY	0	16
157	W-18731	FGS	Cuttings	28.36020	-80.73470	COCOA	45	1300
158	W-19592	FGS	Cuttings	28.23060	-80.79577	DEER PARK NE	17	350
159	W-19597	FGS	Continuous Core	28.01398	-80.94725	DEER PARK	60	250
160	W-19823	FGS	Cuttings	28.36750	-80.85833	LAKE POINSETT	14	95
161	W-19825	FGS	Cuttings	28.33744	-80.60839	COCOA BEACH	10	235
162	W-19827	FGS	Cuttings	28.36767	-80.85822	LAKE POINSETT	16	800
163	W-19831	FGS	Cuttings	28.31361	-80.61556	COCOA BEACH	4	340
164	W-19847	FGS	Cuttings	28.44856	-80.69610	COURTENAY	1	235
165	W-19848	FGS	Cuttings	28.49750	-80.99833	LAKE POINSETT NW	43	345
166	W-19921	FGS	Continuous Core	28.03114	-80.66149	MELBOURNE WEST	26	32
167	W-19922	FGS	Continuous Core	28.00658	-80.64983	MELBOURNE WEST	34	44
168	W-19923	FGS	Continuous Core	28.04012	-80.72593	MELBOURNE WEST	20	36
169	W-19924	FGS	Continuous Core	28.01720	-80.70973	MELBOURNE WEST	23	24
170	W-19932	FGS	Continuous Core	28.04316	-80.88759	DEER PARK	45	40
171	W-19933	FGS	Continuous Core	28.07849	-80.85247	DEER PARK SE	21	36
172	W-19934	FGS	Continuous Core	28.06981	-80.81351	DEER PARK SE	17	32
173	W-19936	FGS	Continuous Core	28.02222	-80.85575	DEER PARK SE	23	36
174	W-19937	FGS	Continuous Core	28.02132	-80.85673	DEER PARK SE	26	32
175	W-19962	FGS	Continuous Core	28.09285	-80.84670	DEER PARK SE	20	24
176	W-19963	FGS	Continuous Core	28.09955	-80.84721	DEER PARK SE	19	24
177	W-19964	FGS	Continuous Core	28.10910	-80.83412	DEER PARK SE	20	24
178	W-19965	FGS	Continuous Core	28.12821	-80.83814	DEER PARK SE	20	23
179	W-19966	FGS	Continuous Core	28.25427	-80.73022	COCOA	27	40