GEOLOGY REPORT

GEOLOGIC MAPPING OF CUMBERLAND ISLAND NATIONAL SEASHORE GEORGIA, U.S.A.

Prepared for:
Geologic Resources Division
National Park Service
Denver, Colorado

By:
Randall W. Parkinson
RWParkinson Consulting
rwparkinson@cfl.rr.com

and
Mary Latiolias
MDA Information Systems
Mary.Latiolais@mdaus.com

Through:
Gerry Horak
Dynamac Corporation
ghorak@dynamac.com

September 28, 2011
(Date of submittal)
Table of Contents

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Introduction</td>
<td>1</td>
</tr>
<tr>
<td>II. CUIS Geology Map</td>
<td>2</td>
</tr>
<tr>
<td>A. Background</td>
<td>2</td>
</tr>
<tr>
<td>1. Geologic Framework</td>
<td>2</td>
</tr>
<tr>
<td>2. Boundaries of Mapping Area</td>
<td></td>
</tr>
<tr>
<td>3. Subsurface geology</td>
<td>4</td>
</tr>
<tr>
<td>4. Base map imagery</td>
<td>5</td>
</tr>
<tr>
<td>5. Metadata</td>
<td>5</td>
</tr>
<tr>
<td>6. Coordinates and Datum</td>
<td>5</td>
</tr>
<tr>
<td>7. Site visits</td>
<td>5</td>
</tr>
<tr>
<td>8. QA/QC</td>
<td>6</td>
</tr>
<tr>
<td>9. Errors and Omissions</td>
<td>6</td>
</tr>
<tr>
<td>10. Acknowledgements</td>
<td>8</td>
</tr>
<tr>
<td>11. Bibliography</td>
<td>8</td>
</tr>
<tr>
<td>B. Geology Map</td>
<td>9</td>
</tr>
<tr>
<td>1. Morphogenetic units</td>
<td>9</td>
</tr>
<tr>
<td>2. Geologic cross-section</td>
<td>11</td>
</tr>
<tr>
<td>3. Special Features</td>
<td>11</td>
</tr>
<tr>
<td>4. Anthropogenic Features</td>
<td>11</td>
</tr>
<tr>
<td>C. Digital Addenda</td>
<td>12</td>
</tr>
<tr>
<td>1. Imagery</td>
<td></td>
</tr>
<tr>
<td>2. Shoreline – historical</td>
<td></td>
</tr>
<tr>
<td>3. Elevation</td>
<td></td>
</tr>
<tr>
<td>4. Vegetation</td>
<td></td>
</tr>
</tbody>
</table>
# List of Exhibits

<table>
<thead>
<tr>
<th>Caption</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1 - Regional location map</td>
<td>1</td>
</tr>
<tr>
<td>Figure 2 - Georgia physiographic provinces</td>
<td>2</td>
</tr>
<tr>
<td>Figure 1 - Cross-section of Georgia’s lower coastal plain</td>
<td>3</td>
</tr>
<tr>
<td>Figure 2 - Cenozoic geology in project area</td>
<td>3</td>
</tr>
<tr>
<td>Figure 3 - Location of transects illustrating subsurface geology</td>
<td>4</td>
</tr>
<tr>
<td>Table 1 - Summary of QA/QC survey</td>
<td>7</td>
</tr>
</tbody>
</table>
I. Introduction

This report describes the efforts and resulting products created by MDA Information Systems Inc. and RWParkinson Consulting, Inc. to characterize the geology of Cumberland Island National Park, Georgia (CUIS; Fig. 1) using the Coastal Geology Mapping Protocols developed by the National Park Service (NPS) Geological Resources Inventory Program (GRI) for Atlantic and Gulf National Park Units (NPS-D-2269).

The map(s) were constructed at 1:24000 scale using baseline information acquired from existing files (i.e., elevation data used to construct contour lines), newly acquired field data (i.e., personal observations of intermittent springs), and data derived from the interpretation of these data (i.e. relict beach ridges). All data have been compiled into a digital geo-database and digital maps using ArcGIS 10. To the extent possible, the CUIS geology map complies with Part I Section D (Geologic Map Products) of the USGS STATEMAP Program (see Announcement No. 09HQPA0003).

The geological features or map units were delineated using elevation (i.e., topography), land cover (i.e., vegetation), and a knowledge of geological processes operating within this segment of the US Atlantic Coast. The suite of “morphogenetic” units mapped during this project correspond to distinct landforms (i.e., linear ridge) generated by a distinct geological process (i.e., wave action).

In the following text, the morphogenetic units shown on the CUIS geology map are described. The addenda to this report contain supplemental and/or supporting information.

Figure 1- Regional location map of CUIS project area illustrating major physiographic provinces of eastern North America (from Geology of Florida 1997).
II. CUIS Geology Map

A. Background

1. Geologic Framework

   The state of Georgia is divided into five major physiographic provinces (Fig. 2). The boundary between the very old crustal rocks of the Piedmont and much younger sediments of the Coastal Plain is marked by the fall line, a historic point where riverboat navigation was impeded by outcropping rocks and non-navigable rapids.

   The fall line represents the inland edge of the Coastal Plain, where sediments of the Cretaceous period were deposited more than 100 million years ago. The lower half of the Coastal Plain extends inland approximately sixty-five miles and includes antecedent topography reflecting the presence of six progressively higher and older shorelines (Fig. 3):

   - Holocene/Silver Bluff Formation
   - Princess Anne Formation
   - Pamlico Formation
   - Talbot Formation
   - Penholoway Formation
   - Wicomico Formation

   These features are geologically and morphologically similar to Georgia’s modern barrier island and coastal system. They are all thus interpreted to have formed under similar coastal conditions during Pleistocene sea level highstands.

Cumberland Island is one of eight major islands or island groups located between the Savannah and St. Marys Rivers. Each was formed during the most recent Pleistocene sea level highstand. In addition to Cumberland/Little Cumberland Island, these include Jekyll, St. Simons/Sea Island/Little St. Simons, Sapelo/Blackbeard, St. Catherines, Ossabaw, Wassaw, and Tybee/Little Tybee. Six of these islands are composite barriers consisting of a Pleistocene core (i.e., the Silver Bluff Formation) surrounded by much younger Holocene deposits.
which accumulated around the core under conditions of relatively stable sea level during the past 6,000 years (Fig. 4).

Cumberland Island is separated from the Georgia mainland by a backbarrier estuary (Cumberland Sound). This estuary formed as rising Holocene sea level flooded low lying areas of the Georgia coastal plain. The town of St Marys, like many coastal municipalities that rim the seaward edge of Georgia mainland, was built on high ground associated with the Princess Anne Formation; the second of six relict barrier complexes (Fig. 3) which formed when Pleistocene sea level was at or above its present elevation.

Figure 3 - Cross-section of Georgia’s lower coastal plain illustrating relationship between antecedent topography and relict coastal features (D. Thieme, Valdosta State University).

Figure 4 - Cenozoic geology in project area (green polygon) includes three shoreline complexes; Holocene, Silver Bluff, and Princess Anne. Cumberland Island is a composite barrier because it consists of both Holocene and Pleistocene (Silver Bluff) age deposits (McLemore et al. 1981).
2. Boundaries of Mapping Area
The project area lies within the boundaries of six 7.5’ USGS quadrangles: Cumberland Island North, Cumberland Island South, Kingsland Island NE, Harriett’s Bluff, Fernandina Beach, and Saint Marys. Only Cumberland Island North and South lie entirely within the mapping area. The mapping boundary for Kingsland NE and Harriett’s Bluff is truncated at longitude 81°31’30”W. St Mary’s and Fernandina Beach boundaries extend beyond the Georgia/Florida state line to latitude 30°41’15”N.

3. Subsurface geology
A cross-section illustrating the subsurface geology of Cumberland Island was constructed using the data of McLemore et al. (1981). These data included core borings, lithologic logs, sediment testing, and seismic surveys which were ultimately synthesized into six cross-sections; five perpendicular to the island’s Atlantic Ocean shoreline and one parallel to its long axis (Fig. 5).

Figure 5 - Location of transects illustrating Cumberland Island subsurface geology. Line B - B’ was selected for use in the CUIS geology map (Adapted from McLemore 1981).
A review of these data indicated the subsurface geology was similar along each transect with respect to sedimentology, lithology, stratigraphy, elevation, and age. Therefore, the subsurface geology of CUIS could be accurately illustrated by one cross section. In this investigation, the geologic data acquired along line B – B’ was chosen to represent the subsurface geology of the project area (Fig. 5).

4. Base map imagery
In general, features were digitized on screen and edited at a view scale of at least 1:10,000 using National Agriculture Imagery Program (NAIP) 2010 true-color hires imagery (1:40:000) or a LiDAR Digital Elevation Model (DEM) with a spatial resolution of 2 m.

Waterbody features of the National Hydrography Dataset (NHD) were merged with the boundary quadrangle polygons to create the initial configuration of segmented morphogenetic units. In the upland areas, the Swamp/Marsh class of the Waterbody feature was categorized as wetland. These were then edited to better correspond to the wetland polygons of Coastal Change Analysis Program (C-CAP) 2006 and Bozeman 19751. Lake/Pond and Reservoir classes from the Waterbody feature were also extracted as the foundation for the Open Water category in the upland areas, but these polygons were then edited to match the NAIP 2010 imagery. Elevation trends and vegetation transitions were used to constrain the boundaries of each morphogenetic unit.

5. Metadata
Metadata have been created for all spatial data produced and therefore unique to this project, as well as those files either downloaded from another source or provided by NPS and subsequently altered as required to achieve one or more project objective. Most alterations only include clipping datasets to the project boundaries. The metadata are stored amongst other elements of geology map’s digital database and are FGDC (Federal Geographic Data Committee) compliant.

6. Coordinates and Datum
The horizontal coordinate system for this project is NAD1983/UTM Zone 17N. Georgia LiDAR was acquired in 2010 using NAVD 88 as the vertical datum (Keith McFadden, USGS; personal communication 2010). Florida LiDAR was acquired in 2007; however the western portion of St Marys Quadrangle is missing. The Florida vertical datum is also NAVD88. All elevations are expressed in meters.

7. Site visits
Two site visits were conducted during construction of the geology map. The initial visit (December 2010) was designed to meet with park staff to discuss management issues which the map might help to resolve and identify specific issues. One visit was then conducted to verify the mapped geology.

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1 The vegetation map attributed to Boseman or Boseman et al 1975 is widely used by CUIS staff. Its correct citation is Hillestad et al. 1975. A recent digitization of this map was provided by Lisa M. Kruse (Botanist, Georgia Department of Natural Resources) as completed by NatureServe in 2006.
landscape features which might otherwise not be considered as relevant to the project (i.e., intermittent freshwater springs).

The second visit (July 2011) was designed with the following objectives:

- Assess map accuracy
- Inspect units or contacts already mapped to affirm decisions to date
- Inspect landscape features which have not yet been classified and mapped because their origin cannot been confirmed using desktop database
- Inspect other features of interest to park staff

All objectives were successfully achieved. The accuracy assessment is discussed in the following section (QA/QC).

8. QA/QC
To assure the accuracy of mapping, two 7.5’ quads were haphazardly selected: one of the mainland (St Marys) and one of the island (Cumberland Island North). In each, as many as nine geographic points were haphazardly identified by GPS coordinates. During the second site visit (July 2011) an attempt was made to reach the location of each GPS coordinate and there classify the morphogenetic unit(s) which best represented the landscape. Upon return from the site visit, these field classifications were compared to those on the CUIS geology map to determine their agreement. The results of this assessment are summarized in Table 1.

Of the sites successfully accessed all but two were not in agreement with the CUIS geology map. In the field, both of these sites were described as a tidal creek (aka estuarine intertidal) within the Silver Bluff formation. On the CUIS map, both sites were initially classified as Silver Bluff. Upon inspection of other island tidal creeks a similar “error” was noted. Tidal creek areas above +4 ft were re-classified as either open water, wetland, or as Silver Bluff (default unit).

9. Errors and Omissions
This mapping of morphogenetic units is based primarily upon interpretation of elevation and landcover data, review of literature, discussion with local experts, and a comprehensive understanding of coastal geology. Select locations in the project area were visited to confirm accuracy (c.f. QA/QC section above); however the vast majority of polygons and contacts have not been verified. This map is therefore intended to be a reasonable facsimile of CUIS geology; upgrades and additions are expected over time and with use.
<table>
<thead>
<tr>
<th>Point #</th>
<th>Lat</th>
<th>Long</th>
<th>Description</th>
<th>Map Unit</th>
<th>Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>009</td>
<td>30.76</td>
<td>-81.52</td>
<td>In parking lot at edge of pine flatwoods of mainland at Cumberland Harbors.</td>
<td>Mpa</td>
<td>Y</td>
</tr>
<tr>
<td>010</td>
<td>30.76</td>
<td>-81.51</td>
<td>Entrance to Cumberland Harbor gated community; center of road. Mainland disturbed. Elevation 2 or 3 meters above water table.</td>
<td>Mpa</td>
<td>Y</td>
</tr>
<tr>
<td>011</td>
<td>30.76</td>
<td>-81.52</td>
<td>Contact between disturbed mainland and one of many intertidal creeks draining into estuary.</td>
<td>Ei</td>
<td>Y</td>
</tr>
<tr>
<td>012</td>
<td>30.76</td>
<td>-81.54</td>
<td>In turn around along south side of mainland access road to Cumberland Harbor.</td>
<td>Outside</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>boundary</td>
<td>Outside</td>
<td>NA</td>
</tr>
<tr>
<td>013</td>
<td>30.76</td>
<td>-81.54</td>
<td>Mainland at shoreline of open water (spoil pond). Elevation of upland about 3 meters above water level.</td>
<td>Ei</td>
<td>Y</td>
</tr>
<tr>
<td>014</td>
<td>30.72</td>
<td>-81.55</td>
<td>St. Marys shoreline; mainland disturbed, estuary is narrow band of wetland with open water to the south.</td>
<td>Mpa</td>
<td>Y</td>
</tr>
<tr>
<td>015</td>
<td>30.72</td>
<td>-81.55</td>
<td>On seawall and contact between mainland spoil and estuary wetland/intertidal.</td>
<td>Mpa</td>
<td>Y</td>
</tr>
<tr>
<td>016</td>
<td>30.72</td>
<td>-81.56</td>
<td>On disturbed mainland, a few meters north of shoreline and estuary intertidal (wetlands) unit.</td>
<td>Ei</td>
<td>Y</td>
</tr>
<tr>
<td>017</td>
<td>30.72</td>
<td>-81.56</td>
<td>At south end of dock and above estuary intertidal (wetland).</td>
<td>Ei</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ci-North</td>
<td></td>
<td></td>
</tr>
<tr>
<td>018</td>
<td>30.87</td>
<td>-81.44</td>
<td>GPS at mouth or point of discharge onto surface. Depression contains numerous fallen trees along margin created by expanding size and/or relief. Spring in Silver Bluff unit. Intermittant freshwater spring is new unit.</td>
<td>On map, red circle with label Bis</td>
<td>Y</td>
</tr>
<tr>
<td>019</td>
<td></td>
<td></td>
<td>No data acquired.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>020</td>
<td></td>
<td></td>
<td>No data acquired.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>021</td>
<td>30.88</td>
<td>-81.44</td>
<td>Centered over tidal creek on bridge. Landscape appears to be Silver Bluff.</td>
<td>Blsb</td>
<td>N</td>
</tr>
<tr>
<td>022</td>
<td>30.93</td>
<td>-81.45</td>
<td>Terrapin Point. Point at edge of bluff and about 30 meters above estuary. GPS point obtained at edge of upland (Silver Bluff); apparent offset on image suggests active bluff erosion/retreat.</td>
<td>Blsb</td>
<td>Y</td>
</tr>
<tr>
<td>023</td>
<td>30.93</td>
<td>-81.45</td>
<td>Possible shell midden along edge of bluff and within Silver Bluff.</td>
<td>Blsb</td>
<td>Y</td>
</tr>
<tr>
<td>024</td>
<td>30.93</td>
<td>-81.45</td>
<td>Southern limit of bluff. Evidence of midden on trail and at top of bluff scarp where oyster is observed overlying clean quartz sand. Three photographs (GPS024 a - c). Silver Bluff.</td>
<td>Blsb</td>
<td>Y</td>
</tr>
<tr>
<td>025</td>
<td>30.91</td>
<td>-81.45</td>
<td>Centered over tidal creek on bridge. Landscape is Silver Bluff.</td>
<td>Blsb</td>
<td>N</td>
</tr>
<tr>
<td>026</td>
<td>30.74</td>
<td>30.74</td>
<td>Contact between relic(?) sand (beach?) ridge and Silver Bluff.</td>
<td>Blsb</td>
<td>Y</td>
</tr>
</tbody>
</table>
10. Acknowledgements
The investigators thank Chester Jackson Jr. (Georgia Southern University) for sharing ideas on the region’s geology, participating in a site visit, and reviewing a draft version of the CUIS geologic map. We sincerely appreciate the dedication and assistance of John Fry (Resource Management Chief, Cumberland Island National Park) who provided logistical support during site visits, made available important and often elusive background reference materials, and who took the time necessary to explain relevant management issues and map elements relevant to this project. Finally, Keith McFadden (USGS Geospatial Liaison for Georgia and Tennessee) is gratefully acknowledged for providing the Georgia LiDAR 2010 data as soon as it was approved for distribution.

11. Bibliography


Jackson Jr., C. 2006. Historical back-barrier shoreline changes along Cumberland Island, Georgia 1857 to 2002. Department of Geology, University of Georgia. 54 pgs plus attachments.


National Park Service 2011. Draft soil survey, Cumberland Island National Seashore, Georgia. Natural Resource Program Center, Geologic Resources Division, Soil Resources Inventory. 35 pgs.
B. Geology Map
1. Morphogenetic units
   Morphogenetic units identify geologic features by categories related to form (structure) and development (origin). A three level hierarchy describes the morphogenetic units used in this mapping project. Each unit is mapped using distinct colors and a 3-4 digit letter code as described in NPS publication NPS-D-2269, Coastal Geology Mapping Protocols for the Atlantic and Gulf National Park Units.
   a. Mainland – The emergent margin of the North American tectonic plate regionally referenced as the Atlantic Coastal Plain. Composed primarily of unconsolidated fluvial and marine sediments which have accumulated over the last 100 million years.
      1) Wetland – Non-cultivated vegetated zone wherein the substrate is inundated or saturated for a significant part of the year.
      2) Princess Anne – The second in a series of late Pleistocene paleo-shoreline features identified along the coast of Georgia. The complex is located along the mainland shoreline; landward of the Silver Bluff shoreline.
      3) Open water - Standing water features like lakes, ponds and reservoirs.
   b. Estuary - A coastal embayment wherein the salinity of seawater is measurably diluted by the influx of freshwater and where tidal effects are evident.
      1) Open water – Typically channel features with depths greater than – 4 ft MLLW.
      2) Intertidal - Zones within or along the margin of the estuary wherein the substrate is permanently wet and/or intermittently water-covered; may be vegetated or barren. When barren, substrate typically sandy mud with local oyster bioherms and/or wetland peat outcrops.
      3) Spoil – Anthropogenic feature created by mechanical deposition of dredged material (generally sand, shell and mud).
      4) Relict sand bar – Emergent depositional feature consisting predominantly of coarse-grained shell and quartz sand created by waves and tides. Environment of deposition no longer present at site.
   c. Barrier Complex – Part of barrier island system consisting of composite island or complex seaward of mainland and estuary. Associated with stable or slowly rising sea level, moderate to high wave energy, micro-tides, and abundant sediment supply.
      1) Coastal – Features formed or modified by the effects of physical, biological, or chemical processes associated with the Atlantic Ocean shoreline.
         a) Beach - Gently sloping surface of unconsolidated sediments (e.g., sand and gravel) accumulating in high-energy zone of breaking waves at the land-sea interface and extending from low tide to toe of coastal dunes, sea cliffs, or other distinct change in slope or physiography.
         b) Dunes - Low mound, ridge, bank, or hill of loose, windblown, granular material (generally fine sand), either bare or covered by vegetation,
that is capable of movement from place to place but always
maintaining a characteristic shape determined by the relative
importance of sediment supply, vegetation, and wind.

c) Sand spit – Continuous linear accumulation of sand or gravel
deposited from longshore drift and having one end attached to the
mainland or beach and the other termination adjacent to open water.
Linear morphology deviates to “curving” or at high angle to the
general trend of the coastline when currents of tidal inlet or creek
encountered.

2) Relict – Landform made by environmental processes no longer operating
at location.

a) Dunes – Mound of fine grained sediment exhibiting features similar to
modern or active dunes, but in region where processes necessary to
generate landform do not presently operate.

b) Beach – Deposit of sand and gravel with features similar to modern
beach (i.e., orientation generally parallel to Atlantic Ocean shoreline)
but in a region where coastal processes necessary to generate this
landform do not presently operate.

c) Beach ridges - Essentially continuous linear mound(s) of sand and
gravel material trending parallel to the modern coast, but located
landward of the present limit of storm surge and wave action.
Morphological and sedimentological similarity to active beach ridges
evident. However, located in region where processes necessary to
generate beach ridges do not presently operate.

d) Sand ridges - Essentially continuous linear mound(s) of coarse-grained
material located landward of and generally parallel to the Atlantic
Ocean. Morphological and sedimentological characteristics no
sufficient to determine whether landform constructed by storm surge,
wave action, or aeolian processes; none of which are presently
operating at landform location.

e) Sand spit - Essentially continuous linear mound(s) of coarse-grained
material generally parallel to the Atlantic Ocean with terminus curved
towards mainland (west). Geomorphology indicates landform
constructed by interaction of wave action, longshore currents, and
tides, but landform in region where these processes are no longer
operating.

3) Island core – Portion of island complex formed during preceding late
Pleistocene sea level highstand and subsequently modified by subaerial
processes of weathering and erosion.

a) Silver Bluff – The youngest late Pleistocene relict shoreline complex.
Frequently found along landward margin of “composite” barrier
islands.

b) Wetland – Non-cultivated vegetated zone wherein the substrate is
inundated or saturated for a significant part of the year.

c) Open water – Includes lakes, ponds, and reservoirs.
d. Atlantic Ocean - Second largest and geologically youngest major ocean basin that initiated about 180 million years ago.
   1) Coastal – Margin of ocean basin extending from mean low water to fair weather wave base.

2. Geologic cross-section
   A cross-section illustrating the subsurface geology of Cumberland Island was constructed based primarily upon transect B-B’ (Figure 5) of McLemore et al. (1981). Chronostratigraphic contact between Holocene shoreline and Pleistocene island complex mapped as a ravinement surface during this study. All other contacts are based upon McLemore et al (1981). Paucity of subsurface data recognized during this study and as such all stratigraphic contacts are illustrated using a dashed line.

3. Special Features
   Special Features refer to map elements other than morphogenetic or identified by park staff as a landscape feature of potential importance when formulating a long-term management strategy.
   a. Intermittent freshwater spring – Identified by John Fry. Freshwater flow was not active during two site visits, but features like vegetation, channel or runnel, and soil moisture suggest intermittent flow.
   b. Core locations – Identify location of McLemore et al. (1081) three core borings used to construct subsurface geologic cross-section B-B’.
   c. Ridge axis – Myriad sand ridges are present at the northern and southern end of Cumberland Island and parallel to the Atlantic Ocean shoreline. The ridges are attributed to wave and wind action and are present in both relict and active geomorphic units. However, at a contour interval of 5 m, many of the individual ridges are illustrated in the CUIS geology map because their local relief is less than the contour interval. These features represent one or more significant events which took place during the evolution of the island complex in response to changing geologic, oceanographic, and meteorological conditions. To ensure recognition, the axes of the more prominent ridges and including those with a local relief less than 5 m are highlighted.
   d. Contours – Contours or lines of constant elevation are mapped using LiDAR data acquired in 2010 (Georgia) and 2007 (Florida). Interval selected to maximize utility of elevation data without interfering with geologic information illustrated on map.
   e. Wilderness Area - Wilderness Area Boundary for Cumberland Island National Seashore as delineated by NPS.

4. Anthropogenic Features – Specific human elements of the project area were mapped at the request of NPS or to facilitate utility by providing a geographic frame of reference.
   a. Water quality stations – Digital file provided by NPS staff (wq_station.shp); description not available.
b. HUC boundary – Digital file provided by NPS staff (catalog unit); description not available.
c. CUIS visitor center – Digital file provided by NPS staff from (visitor_center.shp); description not available.
d. CUIS parkhead – Digital file provided by NPS staff (parkhead.shp); description not available.
e. Railroad – Includes mainline, spur, or yard as provided by US Census Bureau as TIGER/Line shapefiles.
f. Trail – Digital file provided by NPS staff (trail.shp); description not available.
g. Secondary roads - Includes main arteries, usually a U.S. Highway, State Highway or County Highway; local road, neighborhood road, rural road, city street as provided by US Census Bureau as TIGER/Line shapefiles.
h. Private road – Includes private road for service vehicles (logging, oil fields, ranches, etc.) as provided by US Census Bureau as TIGER/Line shapefiles.
i. 4WD- Includes vehicular trail as provided by US Census Bureau as TIGER/Line shapefiles.

C. Digital Addenda (files posted on MDA FTP site on or about September 28, 2011, to facilitate transfer to NPS)
1. Imagery
2. Shoreline – historical
3. Elevation
4. Vegetation