Dewberry Consultants LLC
1000 N. Ashley Drive, Suite 801
Tampa, FL 33602-3718
813.225.1325
813.225.1385 fax
www.dewberry.com

South Carolina LiDAR Acquisition – Spartanburg County

Report Produced for South Carolina Department of Natural Resources

Project Number: P24-N143-MJ

Report Date: 04/18/2014

SUBMITTED BY:

Dewberry
1000 North Ashley Drive Suite 801
Tampa, FL 33602
813.225.1325

SUBMITTED TO:

SC Dept of Natural Resources
1000 Assembly Street, Suite 125
Columbia, SC 29201
803.734.9494

Table of Contents

Executive Summary

The primary purpose of this project was to develop a consistent and accurate surface elevation dataset derived from high-accuracy Light Detection and Ranging (LiDAR) technology for the South Carolina Department of Natural Resources (SCDNR) Spartanburg County, SC Project Area.

The LiDAR data were processed to a bare-earth digital terrain model and a hydro-flattened digital terrain model. Detailed breaklines and bare-earth Digital Elevation Models (DEMs) were produced for the project area. Data was formatted according to tiles with each tile covering an area of 5,000 ft by 5,000 ft following the SCGS tiling and naming system (State provided). A total of 1,019 tiles were produced for the project encompassing an area of approximately 840 sq. miles.

THE PROJECT TEAM

Dewberry served as the prime contractor for the project. In addition to project management, Dewberry was responsible for LAS classification, all LiDAR products, breakline production, Digital Elevation Model (DEM) production, and quality assurance.

The Atlantic Group completed LiDAR data acquisition and data calibration for the project area.

SURVEY AREA

The project area addressed by this report falls within Spartanburg County in South Carolina.

DATE OF SURVEY

The LiDAR aerial acquisition was conducted from February 21, 2013 (julian day 052) thru March 17, 2013 (julian day 076).

DATUM REFERENCE

Data produced for the project were delivered in the following reference system.

> **Horizontal Datum:** The horizontal datum for the project is North American Datum of 1983 (NAD 83) NSRS 2007
> **Vertical Datum:** The Vertical datum for the project is North American Vertical Datum of 1988 (NAVD88)
> **Coordinate System:** State Plane South Carolina FIPS 3900
> **Units:** Horizontal units are in International Feet, Vertical units are in US Survey Feet.
> **Geiod Model:** Geoid09

LIDAR VERTICAL ACCURACY

SCDNR will conduct additional, independent quality assurance/quality control and accuracy assessment studies of the elevation data produced by Dewberry.

PROJECT DELIVERABLES

The deliverables for the project are listed below.

1. Classified Point Cloud Data (Tiled)
2. Bare Earth Surface (Raster DEM – 10 ft ESRI GRID format)
3. Intensity Images (8-bit gray scale, tiled, GeoTIFF format)
4. Breakline Data (File GDB)
5. Hydro-Flattened Terrain (File GDB)
6. Metadata
7. Dewberry project report (acquisition, processing, QC)
8. LiDAR acquisition report (provided by The Atlantic Group)
9. Project extents, including a shapefile derived from the LiDAR deliverables

PROJECT TILING FOOTPRINT

One thousand and nineteen (1,019) tiles intersect the project boundary and are part of this delivery. The extent of each tile is 5,000 feet by 5,000 feet (see Appendix A for a complete listing of delivered tiles).

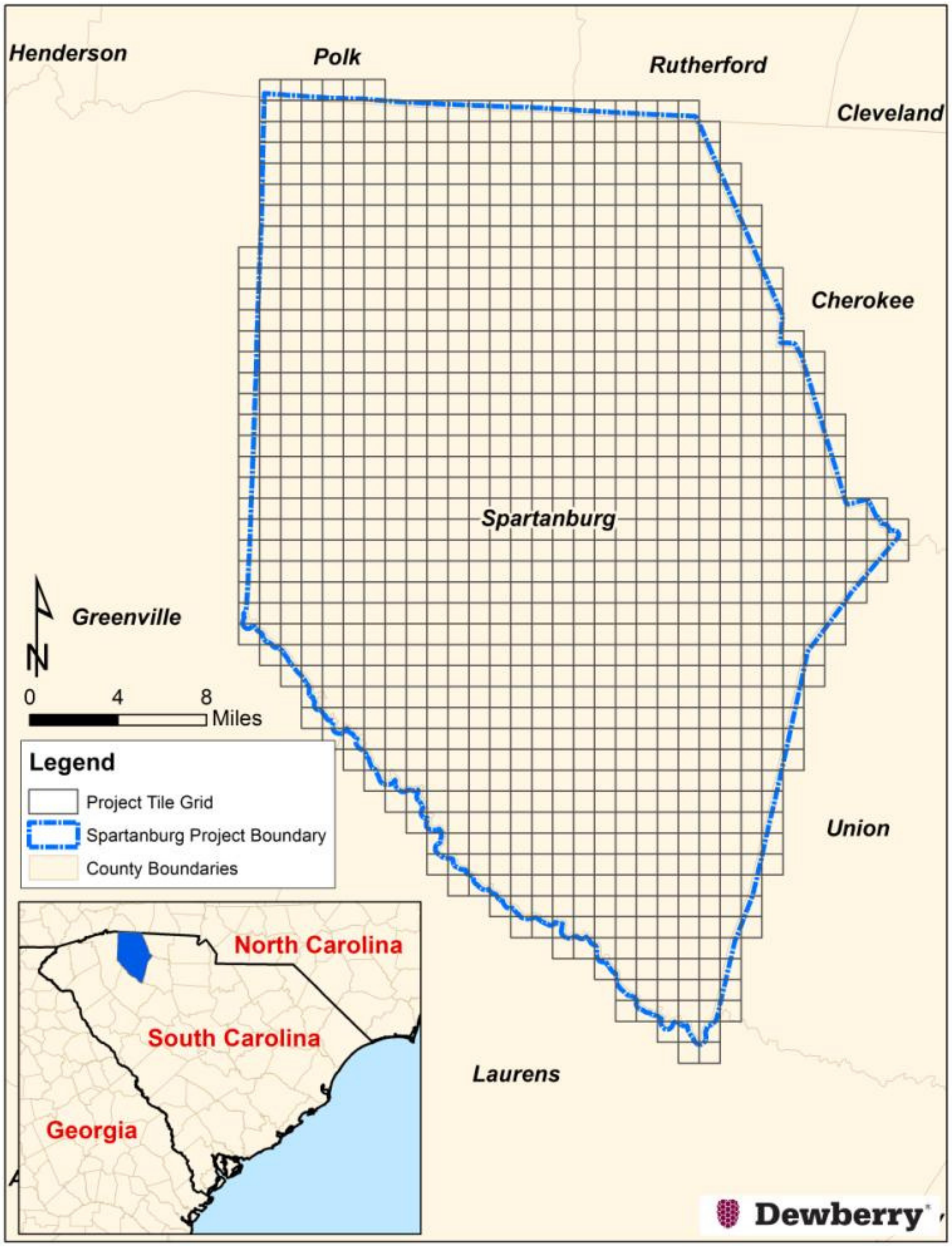


Figure 1: Project Map

LiDAR Acquisition Report

The Atlantic Group provided high accuracy, calibrated multiple return LiDAR for roughly 1,510 square miles around Greenville County, SC and Spartanburg County, SC. A separate LiDAR acquisition report has been provided in addition to this project report. The separate acquisition report provides more detailed flight logs and GPS/IMU post processing reports in addition to the information found below.

LIDAR ACQUISITION DETAILS

LIDAR acquisition began on February 21, 2013 (julian day 052) and was completed on March 17, 2013 (julian day 076). Two hundred and twenty-six (226) passes were planned for Spartanburg and Spartanburg Counties in South Carolina as a series of parallel flight lines with cross flight lines for the purposes of quality control. The flight plan included a zigzag flight line collection as a result of the inherent IMU drift associated with all IMU systems. In order to reduce any margin for error in the flight plan, Atlantic Group followed FEMA's Appendix A "guidelines" for flight planning and, at a minimum, includes the following criteria:

- A digital flight line layout using LEICA MISSION PRO flight design software for direct integration into the aircraft flight navigation system.
- Planned flight lines; flight line numbers; and coverage area.
- LiDAR coverage extended by a predetermined margin beyond all project borders to ensure necessary over-edge coverage appropriate for specific task order deliverables.
- Local restrictions related to air space and any controlled areas have been investigated so that required permissions can be obtained in a timely manner with respect to schedule. Additionally, Atlantic Group will file our flight plans as required by local Air Traffic Control (ATC) prior to each mission.

Atlantic Group monitored weather and atmospheric conditions and conducted LiDAR missions only when no conditions exist below the sensor that will affect the collection of data. These conditions include leaf-off for hardwoods, no snow, rain, fog, smoke, mist and low clouds. LiDAR systems are active sensors, not requiring light, thus missions may be conducted during night hours when weather restrictions do not prevent collection. Atlantic Group accesses reliable weather sites and indicators (webcams) to establish the highest probability for successful collection in order to position our sensor to maximize successful data acquisition.

Within 72-hours prior to the planned day(s) of acquisition, Atlantic Group closely monitored the weather, checking all sources for forecasts at least twice daily. As soon as weather conditions were conducive to acquisition, our aircraft mobilized to the project site to begin data collection. Once on site, the acquisition team took responsibility for weather analysis.

Atlantic Group LiDAR sensors are calibrated at a designated site located at the Lawrence County Airport in Courtland, Alabama and are periodically checked and adjusted to minimize corrections at project sites.

FLIGHT PLAN

Atlantic Group operated the collection aircraft; a Cessna T-210 (Tail # N732JE) outfitted with a LEICA ALS70-HP LiDAR system from Atlantic Group's facilities in Courtland. The LiDAR was completed over twenty lifts.

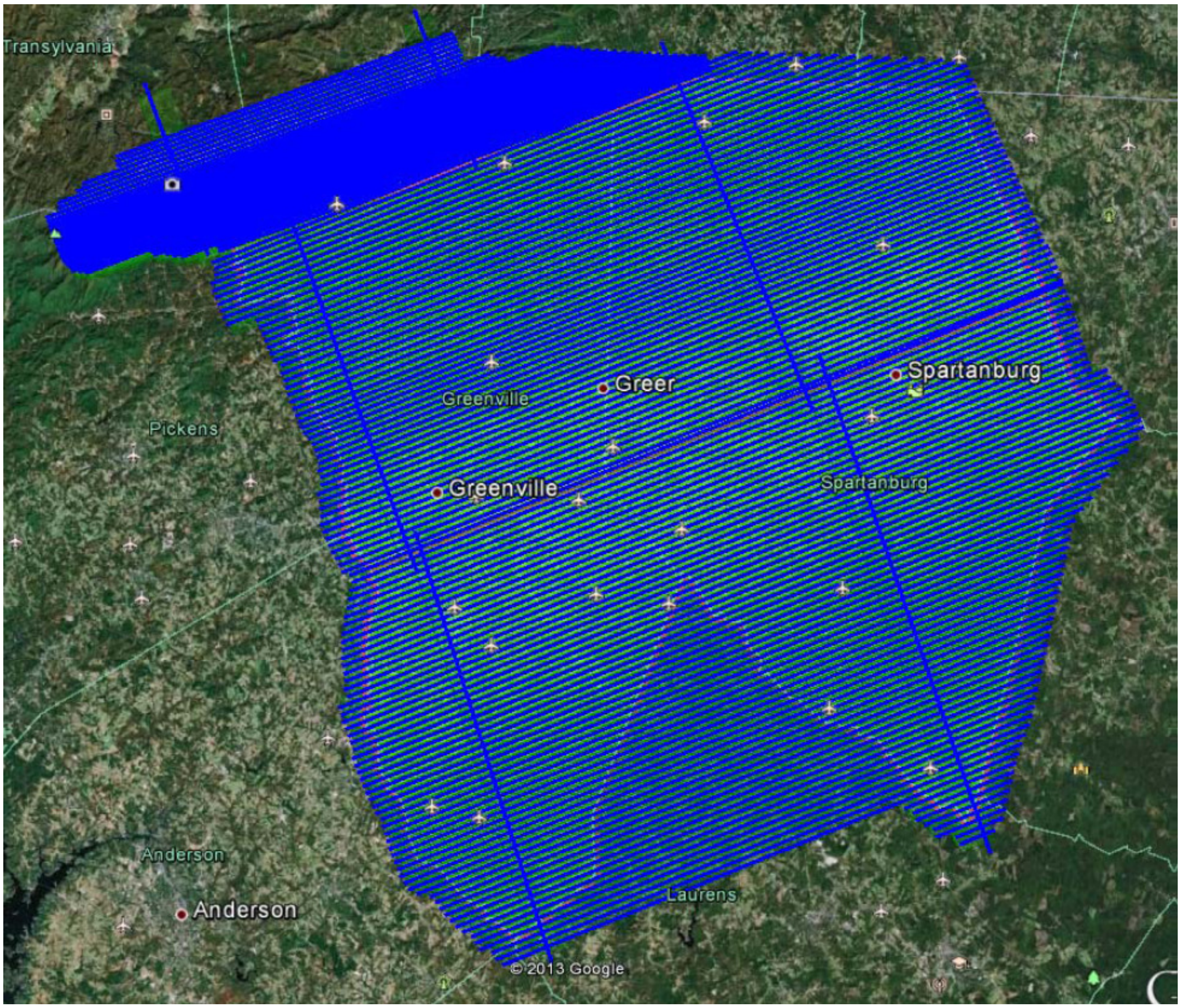


Figure 2: Flight Layout

Item	Chosen Parameter
System	Lecia ASL 70HP
Active Flight Lines	226
Total Flight Line Length (km)	9038
Total Flight Time (h)	53.8
Total Laser Time (h)	35
Approximate Area (km^2)	3912.69
Altitude (AGL meters)	1249
Approx. Ground Speed (kts)	140
Laser Fireing Rate (kHz)	167.6
Scan Frequency (hz)	24.3
Swath width (m)	1164
Swath Overlap (%)	50
Line Spacing (m)	450
Pass heading (degree)	68
Field of View (degree)	40
Computed Down Track spacing (m)	1.03
Computed Cross Track Spacing (m)	1.03
Average point spacing (m)	0.7
Point Density at Nadir	1.9
Points per meter^2 (m)	2.1
Gain up/Down	3
Scan Pattern	Triangle
MPiA	OFF

Table 1: Atlantic Group's LiDAR pre-flight system parameters

Leica ALS70-HP		
Manufacturer	Leica	
Model	ALS70 - HP	
Platform	Fixed-wing	
Scan Pattern	sine, triangle, raster	
Maximum Scan rate (Hz)	sine	200
	triangle	158
	raster	120
Field of view (°)	0 - 75 (full angle, user adjustable)	
Maximum Pulse rate (kHz)	500	
Maximum Flying height (m AGL)	3500	
Number of returns	unlimited	
Number of intensity measurements	3 (first, second, third)	
Roll stabilization (automatic adative, °)	75 - active FOV	
Storage media	removable 500 GB SSD	
Storage capacity (hours @ max pulse rate)	6	
size (cm)	Scanner	37 W x 68 L x 26 H
	Control Electronics	45 W x 47 D x 36 H
Weight (kg)	Scanner	43
	Control Electronics	45
Operating Temperature	0 - 40 °C	
Flight Management	FCMS	
Power Consumption	927 W @ 22.0 - 30.3 VDC	

Table 2: Scanner Specifications

FLIGHT LOGS AND TRAJECTORIES

Upon notification to proceed, the flight crew loaded the flight plans and validated the flight parameters. The Acquisition Manager contacted air traffic control and coordinated flight pattern requirements. LiDAR acquisition began immediately upon notification that control base stations were in place. During flight operations, the flight crew monitored weather and atmospheric conditions. LiDAR missions were flown only when no condition existed below the sensor that would affect the collection of data. The pilot constantly monitored the aircraft course, position, pitch, roll, and yaw of the aircraft. The sensor operator monitored the sensor, the status of PDOPs, and performed the first Q/C review during acquisition. The flight crew constantly reviewed weather and cloud locations. Any flight lines impacted by unfavorable conditions were marked as invalid and re-flown immediately or at an optimal time. Appendix A in the separate LiDAR acquisition report provided by the Atlantic Group details the actual flight logs.

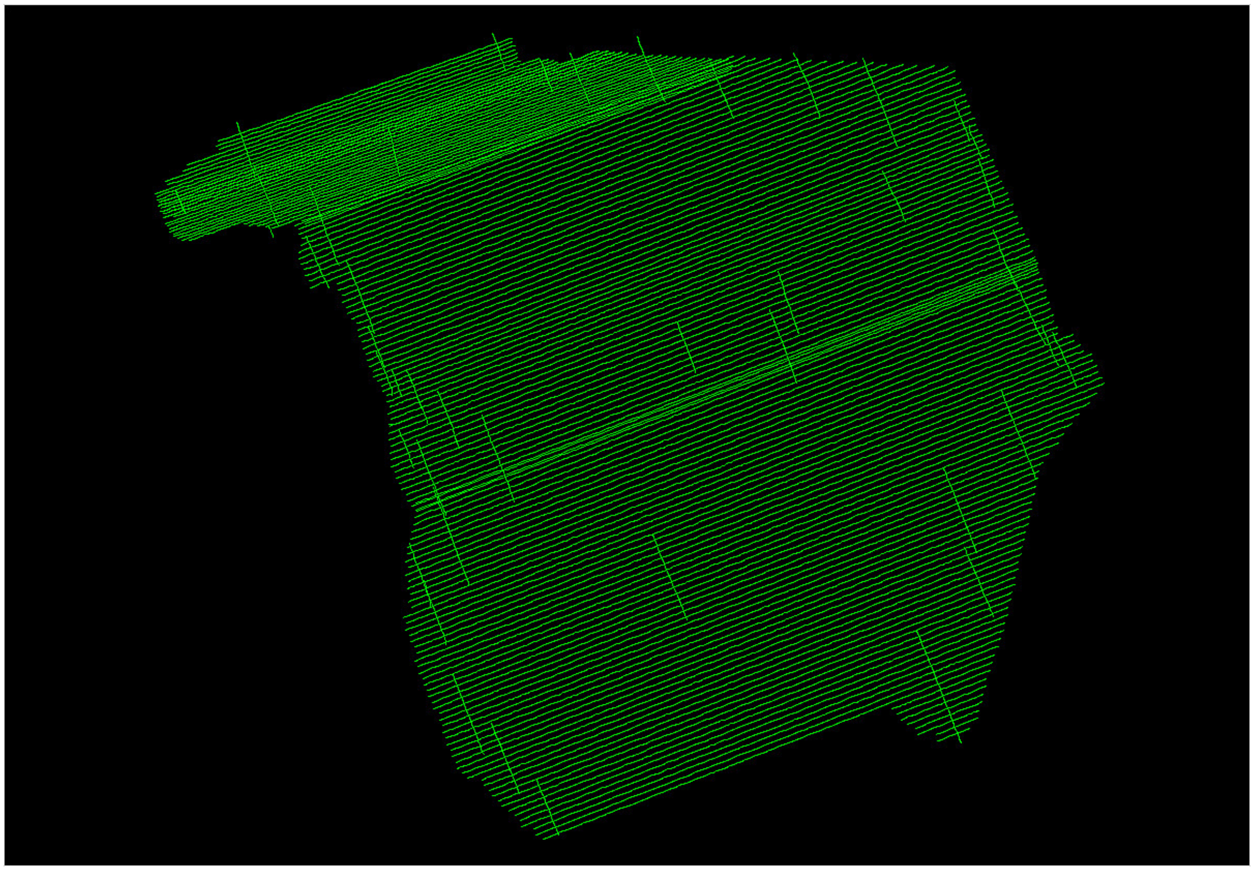


Figure 3: Final trajectories as flown

BASE STATIONS

All surveys were performed to Federal Geodetic Control Subcommittee (FGCS) guidelines. Atlantic Group maximized existing NGS control and the ALDOT CORS stations to provide the control network, designed with proper redundancies, session occupation times, and time between sessions according to the applicable NOS technical standards. GPS observations were conducted using Federal Geodetic Control Committee (FGCC) approved dual frequency GPS receivers. A minimum of two fixed-height tripods were used as ground base stations running at a one (1.0) second epoch collection rate during every mission, typically at a minimum of four hours. The control locations are planned to ensure a 28km baseline distance from the furthest flight line distance. Also, the KP index is considered prior to mission collection and no collection occurred when the KP index was at or above 4. During acquisition the following ground control points were used. Appendix B in the separate LiDAR acquisition report from the Atlantic Group shows an OPUS solution for each ground point used.

Station	Latitude	Longitude	Northing	Easting	Elevation	PID
ARP	34 53 45.70955	82 13 3.71266	340316.720	498298.749	256.197m	ED0110
GSP_A	34 54 12.39485	82 12 41.37989	341132.362	498875.389	258.816m	AE3549
KLUX	34 30 25.95188	81 56 55.68701	296928.778	522480.003	179.236m	
GSP (Set PID)	34 53 45.42515	82 13 3.06388	340307.762	498315.117	255.105m	

Table 3: Base Stations used to control LiDAR acquisition

Station	Julian Day	Receiver Model	Antenna Model	Height (m)	Start Date/Time	Stop Date/Time
GSP_A	52	LEICA	SR530	1.585	2/21/13 14:30	2/21/13 19:47
GSP	52	LEICA	SR530	1.418	2/21/13 15:00	2/21/13 19:55
GSP_A	52	LEICA	SR530	1.585	2/21/13 22:30	2/21/13 1:40
GSP	52	LEICA	SR530	1.418	2/21/13 22:25	2/21/13 1:35
ARP	55	LEICA	SR530	1.498	2/24/13 15:25	2/24/13 23:00
GSP_A	55	LEICA	SR530	1.586	2/24/13 15:15	2/24/13 23:00
ARP	56	LEICA	SR530	1.498	2/25/13 13:15	2/25/13 19:45
GSP_A	56	LEICA	SR530	1.586	2/25/13 13:15	2/25/13 19:55
ARP	58	LEICA	SR530	1.498	2/27/13 13:10	2/27/13 16:00
GSP_A	58	LEICA	SR530	1.586	2/27/13 13:05	2/27/13 16:15
ARP	58	LEICA	SR530	1.498	2/27/13 21:15	2/27/13 25:05
GSP_A	58	LEICA	SR530	1.586	2/27/13 21:00	2/27/13 25:00
ARP	60	LEICA	SR530	1.498	3/1/13 11:30	3/1/13 15:00
GSP_A	60	LEICA	SR530	1.586	3/1/13 11:40	3/1/13 15:15
ARP	62	LEICA	SR530	1.498	3/3/13 13:00	3/3/13 21:00
GSP_A	62	LEICA	SR530	1.586	3/3/13 13:00	3/3/13 22:00
ARP	63	LEICA	SR530	1.498	3/4/13 13:00	3/4/13 17:30
GSP_A	63	LEICA	SR530	1.586	3/4/13 13:15	3/4/13 17:35
ARP	63	LEICA	SR530	1.498	3/4/13 20:00	3/4/13 22:00
GSP_A	63	LEICA	SR530	1.586	3/4/13 20:00	3/4/13 22:00
ARP	66	LEICA	SR530	1.498	3/7/13 13:00	3/7/13 17:30
GSP_A	66	LEICA	SR530	1.586	3/7/13 20:00	3/7/13 22:00
ARP	67	LEICA	SR530	1.498	3/8/13 13:00	3/8/13 17:30
GSP_A	67	LEICA	SR530	1.586	3/8/13 20:00	3/8/13 22:00
ARP	68	LEICA	SR530	1.498	3/9/13 13:00	3/9/13 17:30
GSP_A	68	LEICA	SR530	1.586	3/9/13 20:00	3/9/13 22:00
KLUX	74	TOPCON	SR530	1.378	3/15/13 7:55	3/15/13 18:22
KLUX	75	TOPCON	SR530	1.378	3/16/13 7:55	3/16/13 18:22
KLUX	76	TOPCON	SR530	1.353	3/17/13 9:37	3/17/13 16:22

Table 4: Site Observations

LIDAR SURVEY COVERAGE CHECK

Data was checked after each mission and after all flown missions to verify complete coverage.

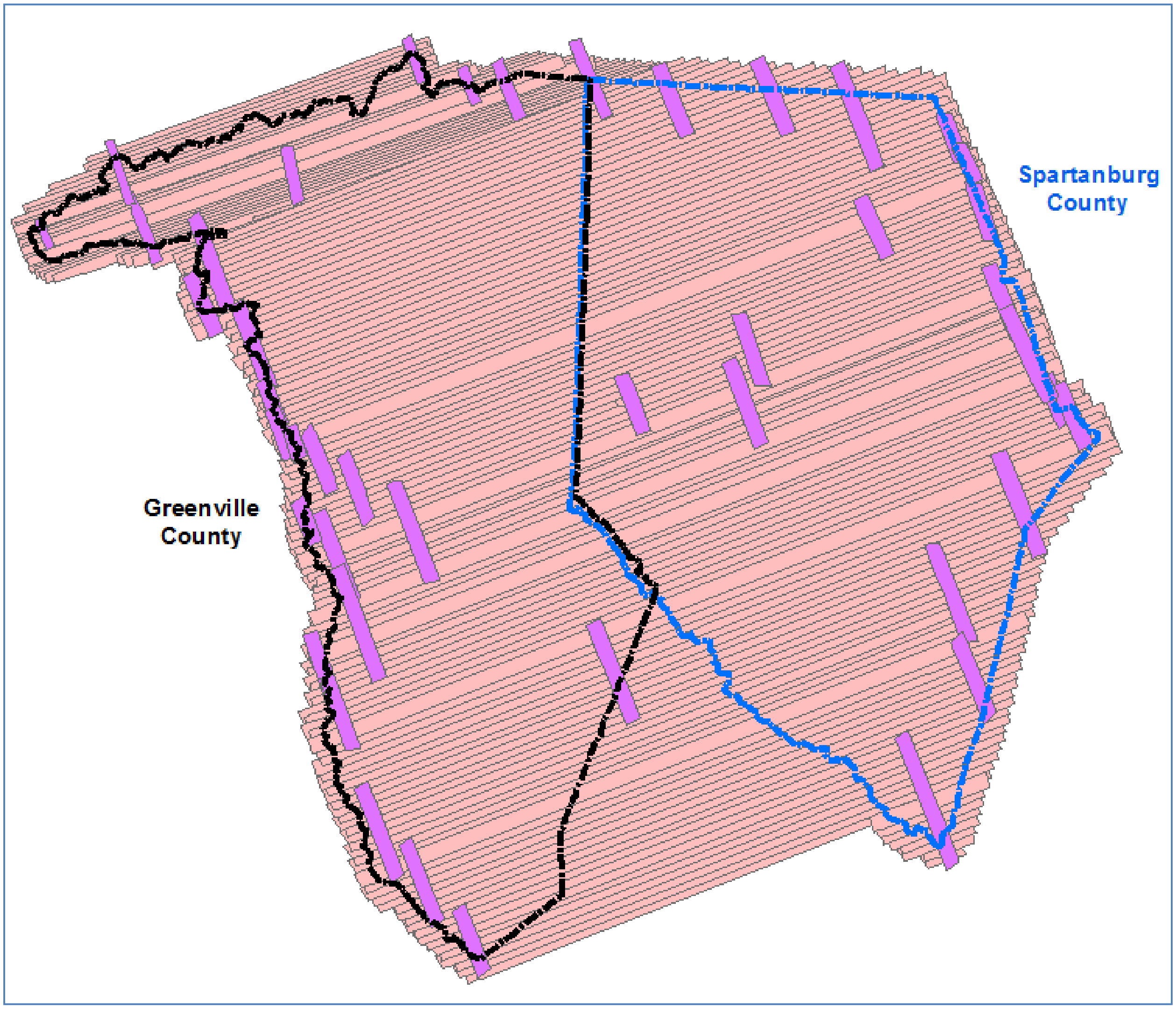


Figure 4: LiDAR swath output (pink and purple) showing complete coverage over both counties. Cross swaths used for calibration purposes only are shown in purple. These calibration swaths were not used to populate the final tiled LAS.

CALIBRATION

Atlantic Group utilized a combination of software tools to calibrate each flight line to each other as well as to control points. LEICA ALS post processing software was used to extract each individual flight line with initial settings for heading, roll, pitch, and scale. Once these lines are extracted they're then imported into Terra Scan to find the final heading, roll, pitch, and scale adjustments. Distance measurements are taken from flight line to flight line as well as known or established control points. These measurements are then applied to the flight lines through the terra scan software. The lines are then extracted with the calibration corrections and imported into the GeoCue software for classification. Utilizing GeoCue LiDAR ortho raster checklist, final calibration QC is performed to verify relative accuracy of <= 7cm $RMSE_{(z)}$ within individual swaths. Upon completion of QC the final LAS swaths are exported through Terra Scan based on client parameters and specifications. For both Greenville and Spartanburg Counties the data was exported in LAS version 1.2 with the horizontal datum referenced to NAD_1983_NSRS 2007 State Plane South Carolina FIPS 3900 in International Feet and vertically to NAVD88 – Geoid 09 in U.S. Survey Feet.

GPS/IMU PROCESSING

LEICA IPAS TC was used to post process the airborne solutions for the mission. IGS08 (EPOCH:2013.1011) coordinates from the OPUS solutions was used in the post processing. The solution for JD13060_1 was split into two parts A and B. Part B contains a solution for one line within mission JD13060_1 that was processed separately for a better solution. Output reports for each mission can be found in the separate LiDAR acquisition report provided by the Atlantic Group.

LiDAR Processing & Qualitative Assessment

DATA CLASSIFICATION AND EDITING

LiDAR mass points were produced to LAS 1.2 specifications, including the following LAS classification codes:

- Class 1 = Unclassified, used for all other features that do not fit into remaining classes
- Class 2 = Bare-Earth Ground
- Class 7 = Noise, isolated low and high points
- Class 8 = Model Key Points (thinned bare-earth ground)
- Class 9 = Water, points located within collected breaklines
- Class 10 = Ignored Ground due to breakline proximity
- Class 11 = Withheld, Points with scan angles exceeding +/- 20 degrees
- Class 13 = Bridges and Large Box Culverts

Please note that the model key point class is a thinned ground dataset. To view the full ground dataset, classes 2 and 8 are both required.

The data was processed using GeoCue and TerraScan software. The initial step is the setup of the GeoCue project, which is done by importing a project defined tile boundary index encompassing the entire project area. The acquired 3D laser point clouds, in LAS binary format, were imported into the GeoCue project and tiled according to the project tile grid. Once tiled, the laser points were classified using a proprietary routine in TerraScan. This routine classifies any obvious outliers in the dataset to class 7 and points with scan angles exceeding +/- 20 degrees to class 11. After points that could negatively affect the ground are removed from class 1, the ground layer is extracted from this remaining point cloud. The ground extraction process encompassed in this routine takes place by building an iterative surface model.

This surface model is generated using three main parameters: building size, iteration angle and iteration distance. The initial model is based on low points being selected by a "roaming window" with the assumption that these are the ground points. The size of this roaming window is determined by the building size parameter. The low points are triangulated and the remaining points are evaluated and subsequently added to the model if they meet the iteration angle and distance constraints. This process is repeated until no additional points are added within iterations. A second critical parameter is the maximum terrain angle constraint, which determines the maximum terrain angle allowed within the classification model.

The following fields within the LAS files are populated to the following precision: GPS Time (0.000001 second precision), Easting (0.001 feet precision), Northing (0.001 feet precision), Elevation (0.001 feet precision), Intensity (integer value - 12 bit dynamic range), Number of Returns (integer - range of 1-4), Return number (integer range of 1-4), Scan Direction Flag (integer - range 0-1), Classification (integer), Scan Angle Rank (integer), Edge of flight line (integer, range 0-1), User bit field (integer - flight line information encoded). The LAS file also contains a variable length record in the file header that defines the projection, datums, and units.

Once the initial ground routine has been performed on the data, Dewberry creates Delta Z (DZ) orthos to check the relative accuracy of the LiDAR data. These orthos compare the elevations of LiDAR points from overlapping flight lines on a 6 feet pixel cell size basis. If the elevations of points within each pixel are within 10 cm (0.328 ft) of each other, the pixel is colored green. If the elevations of points within each pixel are between 10 cm and 15 cm (0.492 ft) of each other, the pixel is colored yellow, and if the elevations of points within each pixel are greater than 15 cm in difference, the pixel is colored red. Pixels that do not contain points from overlapping flight lines are colored according to their intensity values. DZ orthos can be created using the full point cloud or ground only points and are used to review and verify the calibration of the data is acceptable. Some areas are expected to show sections or portions of red, including terrain variations, slope changes, and vegetated areas or buildings if the full point cloud is used. However, large or continuous sections of yellow or red pixels can indicate the data was not calibrated correctly or that there were issues during acquisition that could affect the usability of the data. The DZ orthos for Spartanburg County showed that the data was calibrated correctly with no issues that would affect its usability. The figure below shows an example of the DZ orthos.

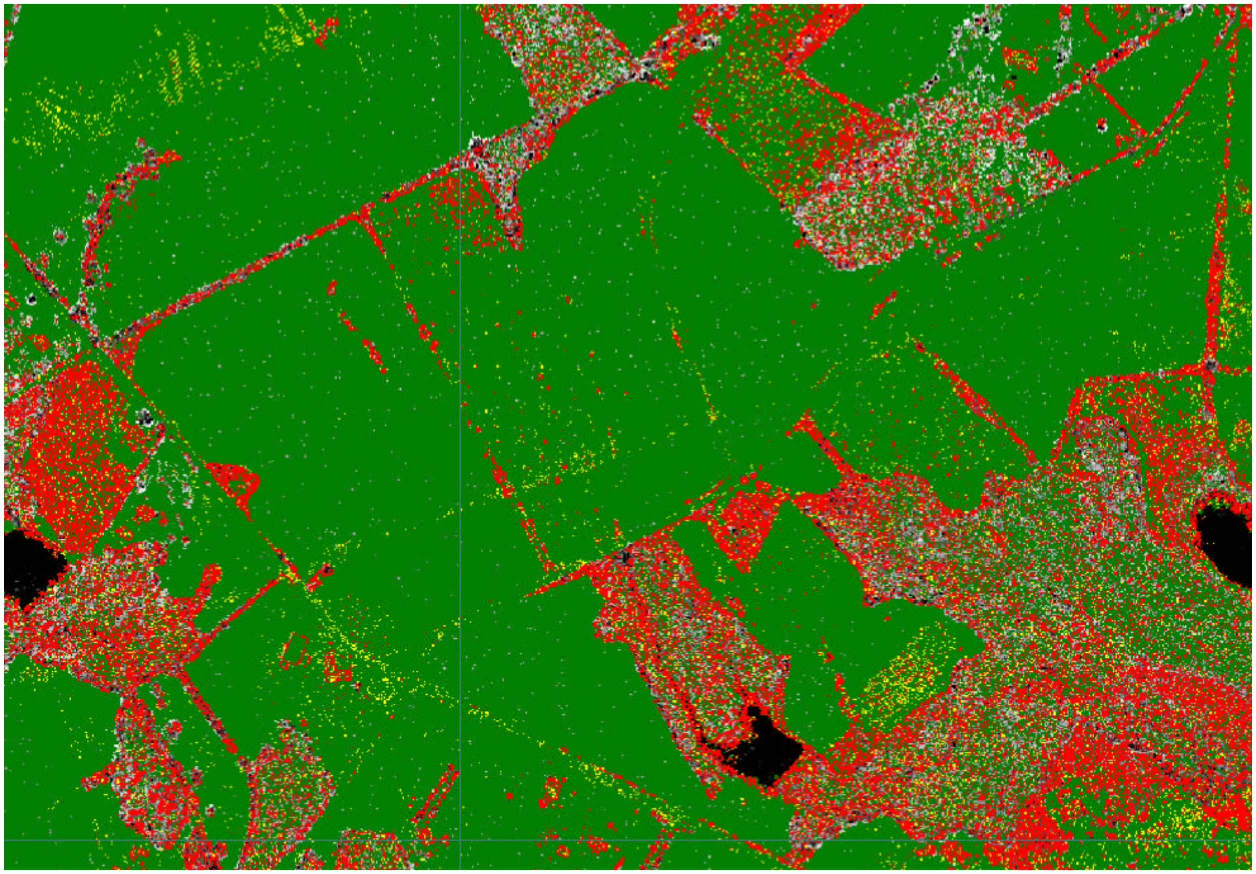


Figure 5: DZ orthos created from the full point cloud. Some red pixels are visible along embankments, sloped terrain, and in vegetated land cover, as expected. Open, flat areas are green indicating the calibration and relative accuracy of the data is acceptable.

Once the calibration and relative accuracy of the data was confirmed, Dewberry utilized a variety of software suites for data processing. The LAS dataset was imported into GeoCue task management software for processing in Terrascan. Each tile was imported into Terrascan and a surface model was created to examine the ground classification. Dewberry analysts visually reviewed the ground surface model and corrected errors in the ground classification such as vegetation, buildings, and bridges that were present following the initial processing conducted by Dewberry. Bridge points and large culverts were classified as class 13 during this stage. Dewberry analysts employ 3D visualization techniques to view the point cloud at multiple angles and in profile to ensure that non-ground points are removed from the ground classification. After the ground classification corrections were completed, the dataset was processed through a water classification routine that utilizes breaklines compiled by Dewberry to automatically classify hydro features. The water classification routine selects ground points within the breakline polygons and automatically classifies them as class 9, water. The final classification routine applied to the dataset selects ground points within a specified distance of the water breaklines and classifies them as class 10, ignored ground due to breakline proximity. Lastly, a routine is used to classify select ground points from class 2 to class 8, model key points. Model key points are a thinned ground class. While less dense, model key points contain enough points at the necessary locations to create a somewhat generalized surface model, suitable for contours and other processes. In order to view or use the full ground data, both classes 2 and 8 are required.

QUALITATIVE ASSESSMENT

For the Spartanburg County LiDAR project, Dewberry is responsible for internal quality assurance/quality control for edgematching along flightlines, data voids, automated and manual feature extraction, and other visual and automated QA steps. SCDNR will conduct independent quality assurance/quality control and accuracy assessment studies of the elevation data produced by Dewberry, including survey checkpoints.

ANALYSIS

Dewberry utilizes GeoCue software as the primary geospatial process management system. GeoCue is a three tier, multi-user architecture that uses .NET technology from Microsoft. .NET technology provides the real-time notification system that updates users with real-time project status, regardless of who makes changes to project entities. GeoCue uses database technology for sorting project metadata. Dewberry uses Microsoft SQL Server as the database of choice. Specific analysis is conducted in Terrascan and QT Modeler environments.

Following the completion of LiDAR point classification, the Dewberry qualitative assessment process flow for the Spartanburg County LiDAR project incorporated the following reviews:

1. *Format:* The LAS files are verified to meet project specifications. The LAS files for the Spartanburg County LiDAR project conform to the specifications outlined below.

- Format, Echos, Intensity
  - LAS format 1.2
  - Point data record format 1
  - Multiple returns (echos) per pulse
  - Intensity values populated for each point
- ASPRS classification scheme
  - Class 1 – Unclassified
  - Class 2 – Bare-earth ground
  - Class 7 – Noise
  - Class 8 – Model Key Points (thinned bare-earth ground)
  - Class 9 – Water
  - Class 10 – Ignored Ground due to breakline proximity
  - Class 11 – Withheld due to scan angles exceeding +/- 20 degrees
  - Class 13 – Bridges and Culverts
- Projection
  - Datum – North American Datum 1983, NSRS 2007
  - Projected Coordinate System – State Plane South Carolina FIPS 3900
  - Linear Units – International Feet
  - Vertical Datum – North American Vertical Datum 1988, Geoid 09
  - Vertical Units – US Survey Feet
- LAS header information:
  - Class (Integer)
  - Adjusted GPS Time (0.000001 seconds)
  - Easting (0.001 feet)
  - Northing (0.001 feet)

- Elevation (0.001 feet)
- Echo Number (Integer 1 to 4)
- Echo (Integer 1 to 4)
- Intensity (8 bit integer)
- Flight Line (Integer)
- Scan Angle (Integer degree)

2. *Data density, data voids:* The LAS files are used to produce Digital Elevation Models using the commercial software package “QT Modeler” which creates a 3-dimensional data model derived from Class 2 (ground points) in the LAS files. Grid spacing is based on the project density deliverable requirement for un-obscured areas. For the Spartanburg Coutny LiDAR project, it is stipulated that the nominal pulse spacing (NPS) be 1.4 meters.

   a. Acceptable voids (areas with no LiDAR returns in the LAS files) that are present in the majority of LiDAR projects include voids caused by bodies of water. These are considered to be acceptable voids. No unacceptable voids are present in the Spartanburg County LiDAR project.

3. *Bare earth quality:* Dewberry reviewed the cleanliness of the bare earth to ensure the ground has correct definition, meets the project requirements, there is correct classification of points, and there are less than 5% residual artifacts.

   a. *Artifacts:* Artifacts are caused by the misclassification of ground points and usually represent vegetation and/or manmade structures. The artifacts identified are usually low lying structures, such as porches or low vegetation used as landscaping in neighborhoods and other developed areas. These low lying features are extremely difficult for the automated algorithms to detect as non-ground and must be removed manually. The vast majority of these features have been removed but a small number of these features are still in the ground classification. The limited numbers of features remaining in the ground are usually 1 foot or less above the actual ground surface, and should not negatively impact the usability of the dataset.

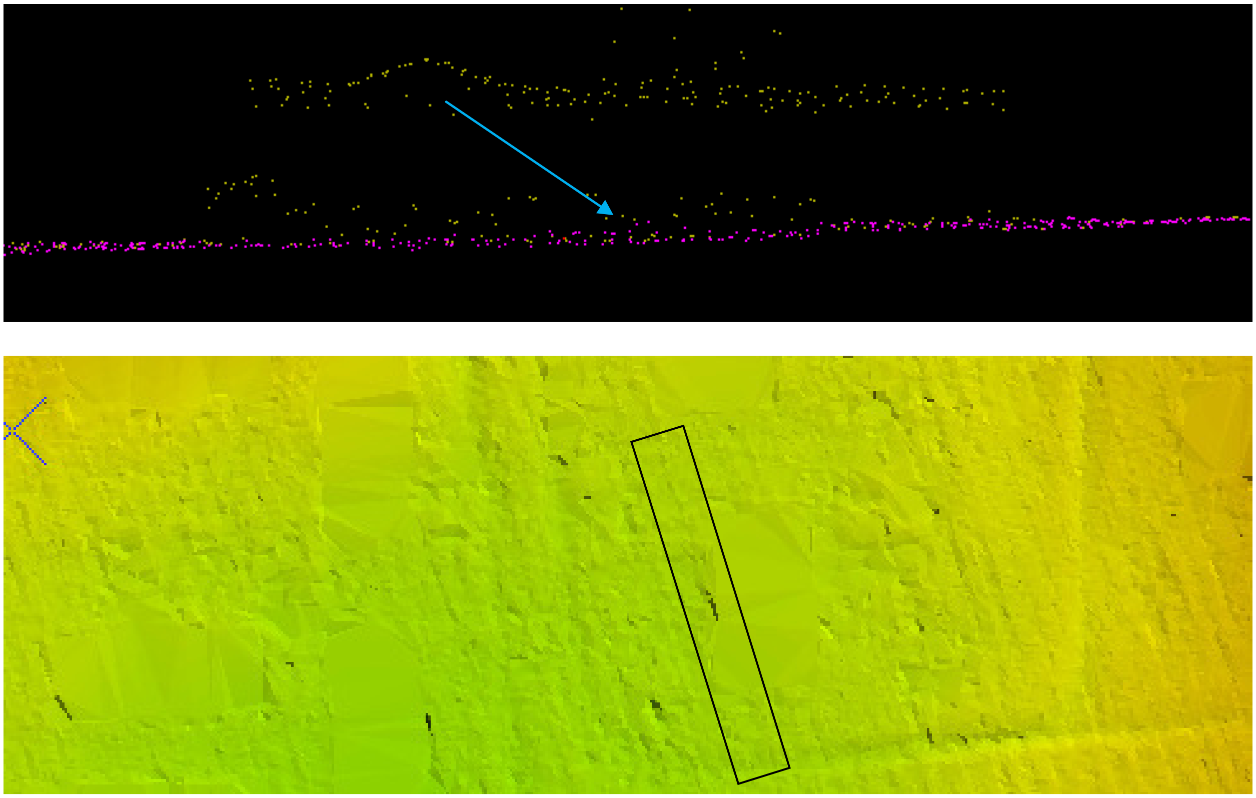
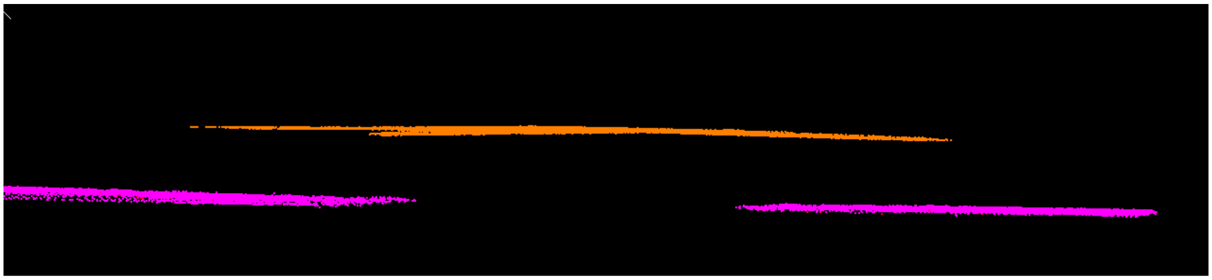


Figure 6 – Tile number 6183-01. Profile with points colored by class (class 1=yellow, class 2 and 8=pink) is shown in the top view and a TIN of the surface is shown in the bottom view. The arrow identifies low vegetation points. A limited number of these small features are still classified as ground but do not impact the usability of the dataset.

b. *Bridge Removal Artifacts:* The DEM surface models are created from TINs or Terrains. TIN and Terrain models create continuous surfaces from the inputs. Because a continuous surface is being created, the TIN or Terrain will use interpolation to triangulate across a bridge opening from legitimate ground points on either side of the actual bridge. This can cause visual artifacts or "saddles." These "artifacts" are only visual and do not exist in the LiDAR points or breaklines.



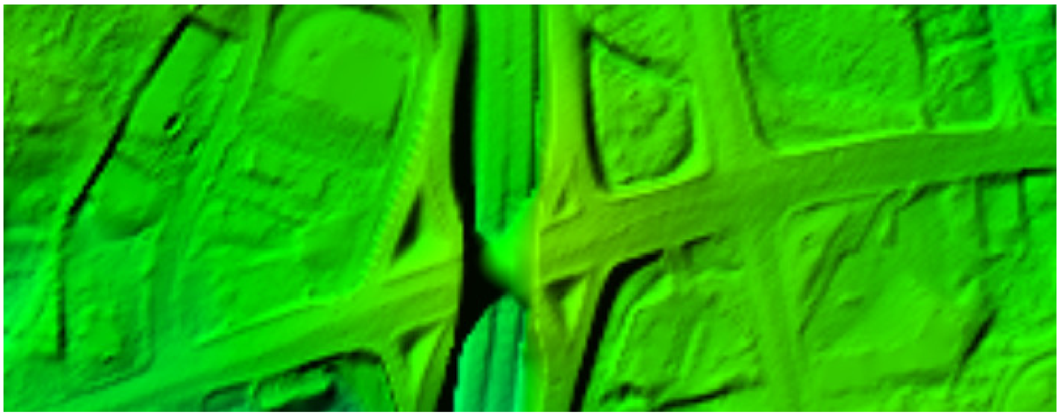


Figure 7 – The DEM in the bottom view shows a visual artifact because the surface model is interpolated from the ground points on the slope leading to the bridge to the lower ground points on either side of the bridge. The surface model must make a continuous model and in order to do so, points are connected through interpolation. This can cause visual artifacts when there are features with large elevation differences. The profile in the top view shows the LiDAR points of this particular feature colored by class. All bridge points have been removed from ground (pink) and reclassified to bridge (orange). There are no ground points that can be modified to correct this visual artifact.

c. *Culverts and Bridges:* Bridges have been removed from the bare earth surface and have been reclassified to class 13. Large box culverts have also been classified to class 13. Smaller culverts that are mainly composed of legitimate ground points remain in the bare earth surface. Below are examples of culvert and bridges that have been reclassified or remain in the ground.

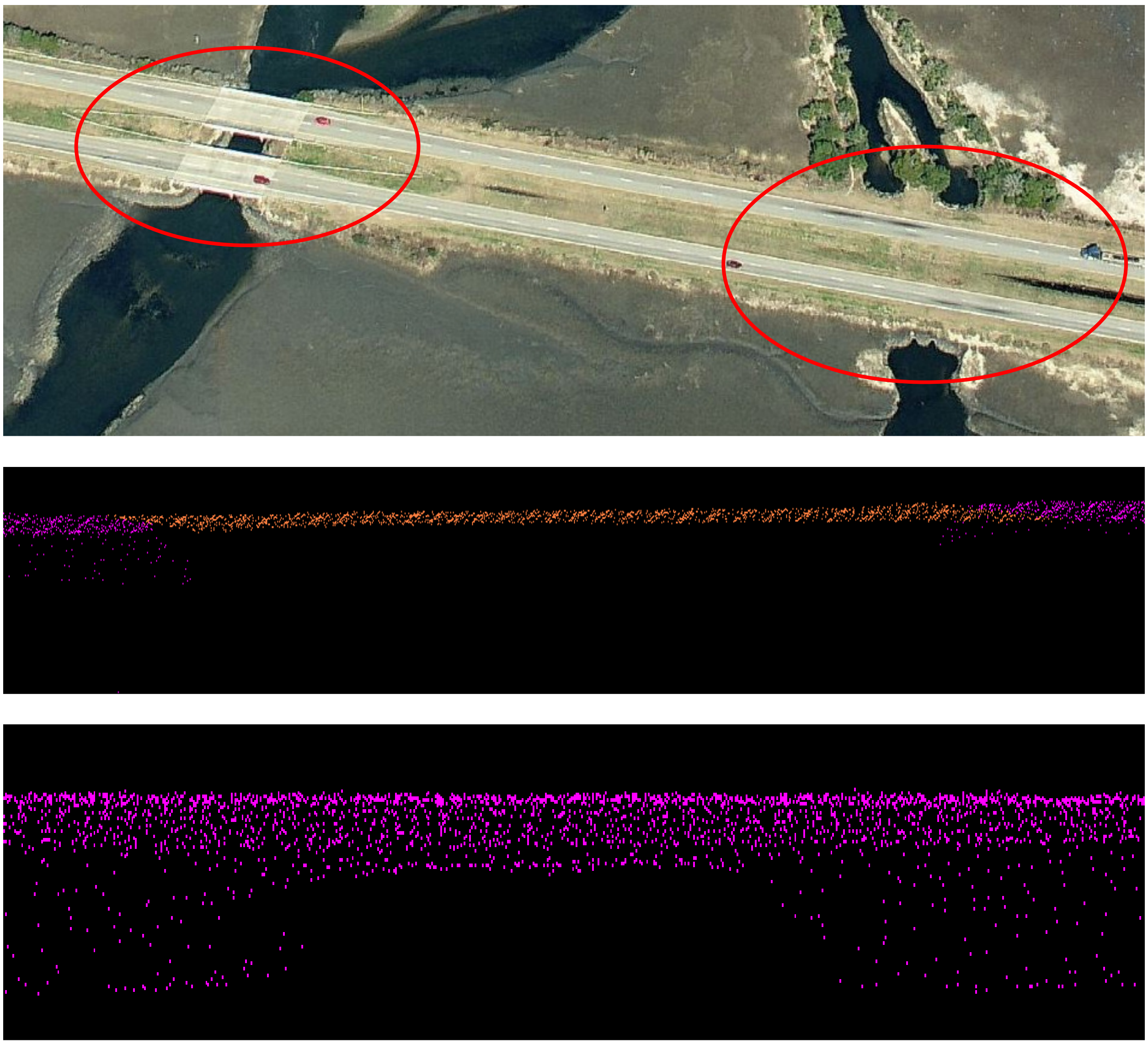


Figure 8 –Top: Area showing a bridge and culvert along a road. Middle: Profile with points colored by class (class 13=orange, class 2=pink) shows bridge moved to class 13. Bottom: Profile with points all in ground (pink). This small culvert remains in the bare earth surface.

d. *Concrete Railroad Tunnels:* Tunnels are generally included in the final ground model. An example of a railroad tunnel left in ground is shown below.

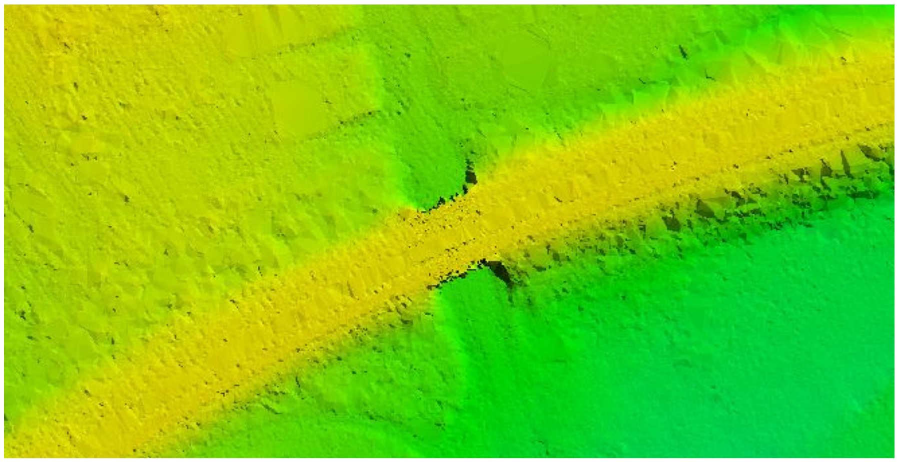


Figure 9: Tile# 7124-03. These types of rail tunnels are found throughout the project area and have been left in the ground model.

LiDAR Vertical Accuracy

SCDNR will contract for an independent quality review and accuracy assessment study of the elevation data and products generated for this project.

Breakline Production & Qualitative Assessment Report

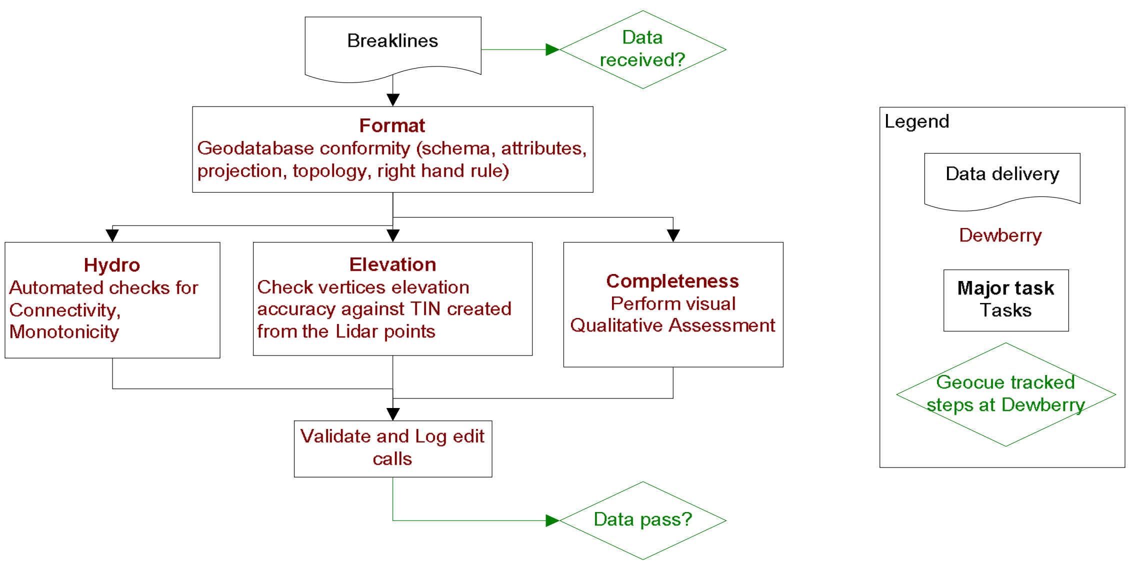
BREAKLINE PRODUCTION METHODOLOGY

Dewberry used GeoCue software to develop LiDAR stereo models of the Spartanburg County LiDAR Project area so the LiDAR derived data could be viewed in 3-D stereo using Socet Set softcopy photogrammetric software. Using LiDARgrammetry procedures with LiDAR intensity imagery, Dewberry used the stereo models developed by Dewberry to stereo-compile the three types of hard breaklines in accordance with the project's Data Dictionary.

All drainage breaklines are monotonically enforced to show downhill flow. Exceptions may exist in tidally influenced areas. Water bodies are reviewed in stereo and the lowest elevation is applied to the entire waterbody.

BREAKLINE QUALITATIVE ASSESSMENT

Dewberry completed breakline qualitative assessments according to a defined workflow. The following workflow diagram represents the steps taken by Dewberry to provide a thorough qualitative assessment of the breakline data.



BREAKLINE TOPOLOGY RULES

Automated checks are applied on hydro features to validate the 3D connectivity of the feature and the monotonicity of the hydrographic breaklines. Dewberry's major concern was that the hydrographic breaklines have a continuous flow downhill and that breaklines do not undulate. Error points are generated at each vertex not complying with the tested rules and these potential edit calls are then visually validated during the visual evaluation of the data. This step also helped validate that breakline vertices did not have excessive minimum or maximum elevations and that elevations are consistent with adjacent vertex elevations.

The next step is to compare the elevation of the breakline vertices against the elevation extracted from the ESRI Terrain built from the LiDAR ground points, keeping in mind that a discrepancy is expected because of the hydro-enforcement applied to the breaklines and because of the interpolated imagery used to acquire the breaklines. A given tolerance is used to validate if the elevations differ too much from the LiDAR.

Dewberry's final check for the breaklines was to perform a full qualitative analysis. Dewberry compared the breaklines against LiDAR intensity images to ensure breaklines were captured in the required locations. The quality control steps taken by Dewberry are outlined in the QA Checklist below.

BREAKLINE QA/QC CHECKLIST

Project Number/Description: DNR Project #P24-N143-MJ
Spartanburg County LiDAR

Date: 04/01/2014

Overview

☒ All Feature Classes are present in GDB

☒ All features have been loaded into the geodatabase correctly. Ensure feature classes with subtypes are domained correctly.

☒ The breakline topology inside of the geodatabase has been validated. See Data Dictionary for specific rules

☒ Projection/coordinate system of GDB is accurate with project specifications

Perform Completeness check on breaklines using either intensity or ortho imagery

☒ Check entire dataset for missing features that were not captured, but should be to meet baseline specifications or for consistency (See Data Dictionary for specific collection rules). Features should be collected consistently across tile bounds within a dataset as well as be collected consistently between datasets.

☒ Check to make sure breaklines are compiled to correct tile grid boundary and there is full coverage without overlap

☒ Check to make sure breaklines are correctly edge-matched to adjoining datasets if applicable. Ensure breaklines from one dataset join breaklines from another dataset that are coded the same and all connecting vertices between the two datasets match in X,Y, and Z (elevation). There should be no breaklines abruptly ending at dataset boundaries and no discrepancies of Z-elevation in overlapping vertices between datasets.

Compare Breakline Z elevations to LiDAR elevations

☒ Using a terrain created from LiDAR ground points and water points, drape breaklines on terrain to compare Z values. Breakline elevations should be at or below the elevations of the immediately surrounding terrain. This should be performed before other breakline checks are completed.

Perform automated data checks using ESRI's Data Reviewer

The following data checks are performed utilizing ESRI's Data Reviewer extension. These checks allow automated validation of 100% of the data. Error records can either be written to a table for future correction, or browsed for immediate correction. Data Reviewer checks should always be performed on the full dataset.

☒ Perform "adjacent vertex elevation change check" on the Inland Ponds and Lakes feature class (Elevation Difference Tolerance=.001 feet). This check will return waterbodies whose vertices are not all identical. This tool is found under "Z Value Checks."

☒ Perform "unnecessary polygon boundaries check" on Inland Ponds and Lakes and Tidal Waters feature classes. This tool is found under "Topology Checks."

☒ Perform "different Z-Value at intersection check" (Inland Streams and Rivers to Inland Streams and Rivers), (Ponds and Lakes to Ponds and Lakes), (Streams and Rivers to Ponds and Lakes), Elevation Difference Tolerance= .01 feet Minimum, 600 feet Maximum, Touches. This tool is found under "Z Value Checks."

☒ Perform "duplicate geometry check" on (Connectors to Connectors), (Centerlines to Conterlines), (Inland Streams and Rivers to Inland Streams and Rivers), (Inland Ponds and Lakes to Inland Ponds and Lakes), and (Inland Streams and Rivers to Inland Ponds and Lakes). Attributes do not need to be checked during this tool. This tool is found under "Duplicate Geometry Checks."

☒ Perform "geometry on geometry check" (Inland Streams and Rivers to Inland Ponds and Lakes), (Inland Streams and Rivers to Inland Streams and Rivers), and (Inland Ponds and Lakes to Inland Ponds and Lakes). Spatial relationship is crosses, attributes do not need to be checked. This tool is found under "Feature on Feature Checks."

☒ Perform "geometry on geometry check" (Inland Streams and Rivers to Inland Ponds and Lakes), (Inland Streams and Rivers to Inland Streams and Rivers), and (Inland Ponds and Lakes to Inland Ponds and Lakes). Spatial relationship is intersect, attributes do not need to be checked. This tool is found under "Feature on Feature Checks."

☒ Perform "polygon overlap/gap is sliver check" on (Inland Ponds and Lakes to Inland Ponds and Lakes). Maximum Polygon Area is not required. This tool is found under "Feature on Feature Checks."

Perform Dewberry Proprietary Tool Checks

☒ Perform monotonicity check on (Inland Streams and Rivers), (Single Line Drains), and (Connectors) using "A3_checkMonotonicityStreamLines." This tool looks at line direction as well as elevation. Features in the output shapefile attributed with a "d" are correct monotonically, but were compiled from low elevation to high elevation. These features are ok and can be ignored. Features in the output shapefile attributed with an "m" are not correct monotonically and need elevations to be corrected. Input features for this tool need to be in a geodatabase and must be a line. If features are a polygon they will need to be converted to a line feature. Z tolerance is 0.01 feet.

☒ Perform connectivity check between (Inland Streams and Rivers to Inland Streams and Rivers), (Ponds and Lakes to Ponds and Lakes), (Streams and Rivers to Ponds and Lakes), and (Single Line Drains to Connectors) using the tool "07_CheckConnectivityForHydro." The input for this tool needs to be in a geodatabase. The output is a shapefile showing the location of overlapping vertices from the polygon features and polyline features that are at different Z-elevation.

Metadata

☒ Each XML file (1 per feature class) is error free as determined by the USGS MP tool

☒ Metadata content contains sufficient detail and all pertinent information regarding source materials, projections, datums, processing steps, etc. Content should be consistent across all feature classes.

Completion Comments: Complete – Approved

Data Dictionary

HORIZONTAL AND VERTICAL DATUM

The horizontal datum shall be North American Datum of 1983 NSRS2007, units in International Feet. The vertical datum shall be referenced to the North American Vertical Datum of 1988 (NAVD 88), units in US Survey Feet. Geoid09 shall be used to convert ellipsoidal heights to orthometric heights.

COORDINATE SYSTEM AND PROJECTION

All data shall be projected to horizontal State Plane South Carolina FIPS 3900, NAD 83, NSRS 2007, International Feet, vertical NAVD 88 (Geoid 09), US Survey Feet.

DUAL LINE DRAINS (INLAND STREAMS AND RIVERS)

Feature Dataset: BREAKLINES
Feature Type: Polygon
Contains Z Values: Yes
XY Resolution: Accept Default Setting
XY Tolerance: 0.003

Feature Class: STREAMS_AND_RIVERS
Contains M Values: No
Annotation Subclass: None
Z Resolution: Accept Default Setting
Z Tolerance: 0.001

Description

This polygon feature class will depict linear hydrographic features with a width greater than 40 feet.

Table Definition

Field Name	Data Type	Allow Null Values	Default Value	Domain	Precision	Scale	Length	Responsibility
OBJECTID	Object ID							Assigned by Software
SHAPE	Geometry							Assigned by Software
SHAPE_LENGTH	Double	Yes			0	0		Calculated by Software
SHAPE_AREA	Double	Yes			0	0		Calculated by Software

Feature Definition

Description	Criteria
Dual Line Drains (Streams and Rivers)	Linear hydrographic features such as streams, rivers, canals, etc. with an average width greater than 40 feet. In the case of embankments, if the feature forms a natural dual line channel, then capture it consistent with the capture rules. Other natural or manmade embankments will not qualify for this project. Features will be collected while maintaining montonicity and connectivity between adjacent features. Features will be flat from bank to bank. Islands: The double line stream shall be captured around an island if the island is greater than 1/2 acre. In this case a segmented polygon shall be used around the island in order to allow for the island feature to remain as a "hole" in the feature.

SINGLE LINE DRAINS (INLAND STREAMS AND RIVERS)

Feature Dataset: BREAKLINES
Feature Type: Polyline
Contains Z Values: Yes
XY Resolution: Accept Default Setting
XY Tolerance: 0.003

Feature Class: SINGLE LINE DRAINS
Contains M Values: No
Annotation Subclass: None
Z Resolution: Accept Default Setting
Z Tolerance: 0.001

Description

This polygon feature class will depict linear hydrographic features with a width less than 40 feet.

Table Definition

Field Name	Data Type	Allow Null Values	Default Value	Domain	Precision	Scale	Length	Responsibility
OBJECTID	Object ID							Assigned by Software
SHAPE	Geometry							Assigned by Software
SHAPE_LENGTH	Double	Yes			0	0		Calculated by Software

Feature Definition

Description	Criteria
Single Line Drains (Streams and Rivers)	Linear hydrographic features such as streams, rivers, canals, etc. with an average width less than 40 feet in width. In the case of embankments, if the feature forms a natural dual line channel, then capture it consistent with the capture rules. Features will be collected while maintaining montonicity and connectivity between adjacent features.

INLAND PONDS AND LAKES

Feature Dataset: BREAKLINES
Feature Type: Polygon
Contains Z Values: Yes
XY Resolution: Accept Default Setting
XY Tolerance: 0.003

Feature Class: PONDS_AND_LAKES
Contains M Values: No
Annotation Subclass: None
Z Resolution: Accept Default Setting
Z Tolerance: 0.001

Description

This polygon feature class will depict closed water body features that are at a constant elevation.

Table Definition

Field Name	Data Type	Allow Null Values	Default Value	Domain	Precision	Scale	Length	Responsibility
OBJECTID	Object ID							Assigned by Software
SHAPE	Geometry							Assigned by Software
SHAPE_LENGTH	Double	Yes			0	0		Calculated by Software
SHAPE_AREA	Double	Yes			0	0		Calculated by Software

Feature Definition

Description	Criteria
Ponds and Lakes	Land/Water boundaries of constant elevation water bodies such as lakes, reservoirs, ponds, etc. Features shall be defined as closed polygons and contain an elevation value that reflects the best estimate of the water elevation at the time of data capture. Water body features will be captured for features 1 acre in size or greater. "Donuts" will exist where there are islands within a closed water body feature. An Island within a Closed Water Body Feature that is 1/2 acre in size or greater will also have a "donut polygon" compiled. Water bodies shall be captured as closed polygons with the water feature to the right. <u>The compiler shall take care to ensure that the z-value remains consistent for all vertices placed on the water body.</u> Breaklines must be captured at or just below the elevations of the immediately surrounding terrain. Under no circumstances should a feature be elevated above the surrounding LiDAR points. Acceptable variance in the negative direction will be defined for each project individually.

STREAM CENTERLINES

Feature Dataset: BREAKLINES
Feature Type: Polyline
Contains Z Values: Yes
XY Resolution: Accept Default Setting
XY Tolerance: 0.003

Feature Class: STREAM CENTERLINE
Contains M Values: No
Annotation Subclass: None
Z Resolution: Accept Default Setting
Z Tolerance: 0.001

Description

This polyline feature class approximates the center of water features to ensure connectivity of hydro network.

Table Definition

Field Name	Data Type	Allow Null Values	Default Value	Domain	Precision	Scale	Length	Responsibility
OBJECTID	Object ID							Assigned by Software
SHAPE	Geometry							Assigned by Software
SHAPE_LENGTH	Double	Yes			0	0		Calculated by Software

Feature Definition

Description	Criteria
Stream Centerlines	Stream Centerlines will be collected at the approximate center of dual line drains and inland ponds and lakes as appropriate to maintain connectivity of the stream network

CONNECTORS

Feature Dataset: BREAKLINES
Feature Type: Polyline
Contains Z Values: Yes
XY Resolution: Accept Default Setting
XY Tolerance: 0.003

Feature Class: STREAM CONNECTOR
Contains M Values: No
Annotation Subclass: None
Z Resolution: Accept Default Setting
Z Tolerance: 0.001

Description

This polyline feature class connects water bodies where culverts are present to maintain drainage network connectivity.

Table Definition

Field Name	Data Type	Allow Null Values	Default Value	Domain	Precision	Scale	Length	Responsibility
OBJECTID	Object ID							Assigned by Software
SHAPE	Geometry							Assigned by Software
SHAPE_LENGTH	Double	Yes			0	0		Calculated by Software

Feature Definition

Description	Criteria
Stream Connectors	Stream Connectors will be collected in areas where culverts are present or as needed to maintain connectivity of the drainage network.

DEM Production & Qualitative Assessment

DEM PRODUCTION METHODOLOGY

Dewberry utilized ESRI software and Global Mapper for the DEM production and QC process. ArcGIS software is used to generate the products and the QC is performed in both ArcGIS and Global Mapper.

1. Classify Water Points: LAS points falling within hydrographic breaklines shall be classified to ASPRS class 9 (water) using TerraScan. Breaklines must be prepared correctly prior to performing this task.
2. Classify Ignored Ground Points: Classify points within 1 foot to the breaklines from Ground to class 10 (ignored ground).
3. Terrain Processing: A bare earth terrain will be generated using the LAS data that has been imported into Arc as a Multipoint File.
4. Convert Terrain to Raster: Convert terrain to 10 ft ESRI GRID raster in Arc, using floating point for output cell values and natural neighbors interpolation.
5. Perform QAQC: During the QA process anomalies will be identified and corrective polygons will be created.
6. Split DEM: DEM will be split to reduce file size to max 1.5GB as per specifications.

DEM QUALITATIVE ASSESSMENT

Dewberry performed a comprehensive qualitative assessment of the bare earth DEM deliverables to ensure that all tiled DEM products were delivered with the proper extents, were free of processing artifacts, and contained the proper referencing information. This process was performed in ArcGIS software with the use of a tool set Dewberry has developed to verify that the raster extents match those of the tile grid and contain the correct projection information. The DEM data was reviewed at a scale of 1:5000 to review for artifacts caused by the DEM generation process. All corrections are completed using Dewberry's proprietary correction workflow. Upon completion of the corrections, the DEM data is loaded into Global Mapper for its second review and to verify corrections.

The image below show an example of a bare earth DEM.

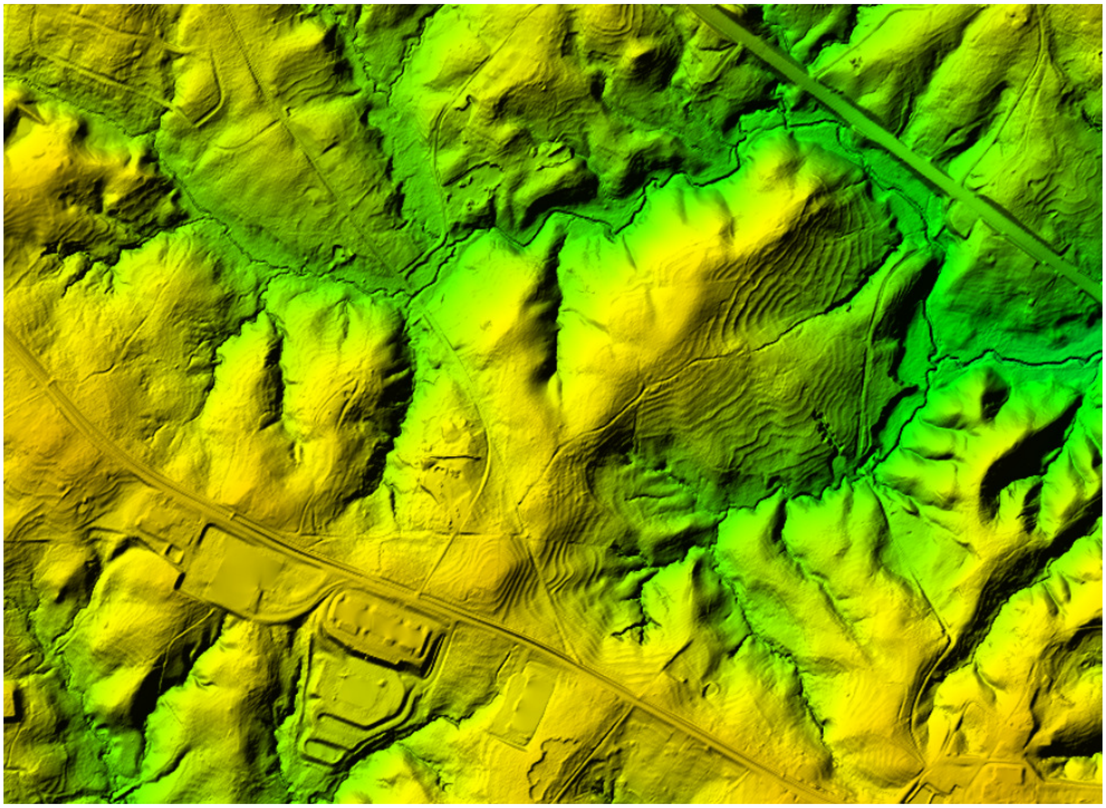


Figure 10 – An example of the bare earth DEM.

Because the bare earth DEM does not include hydroflattening, artifacts in the water will be present. The image below shows an example of water artifacts along a river breakline that was not hydroflattened.

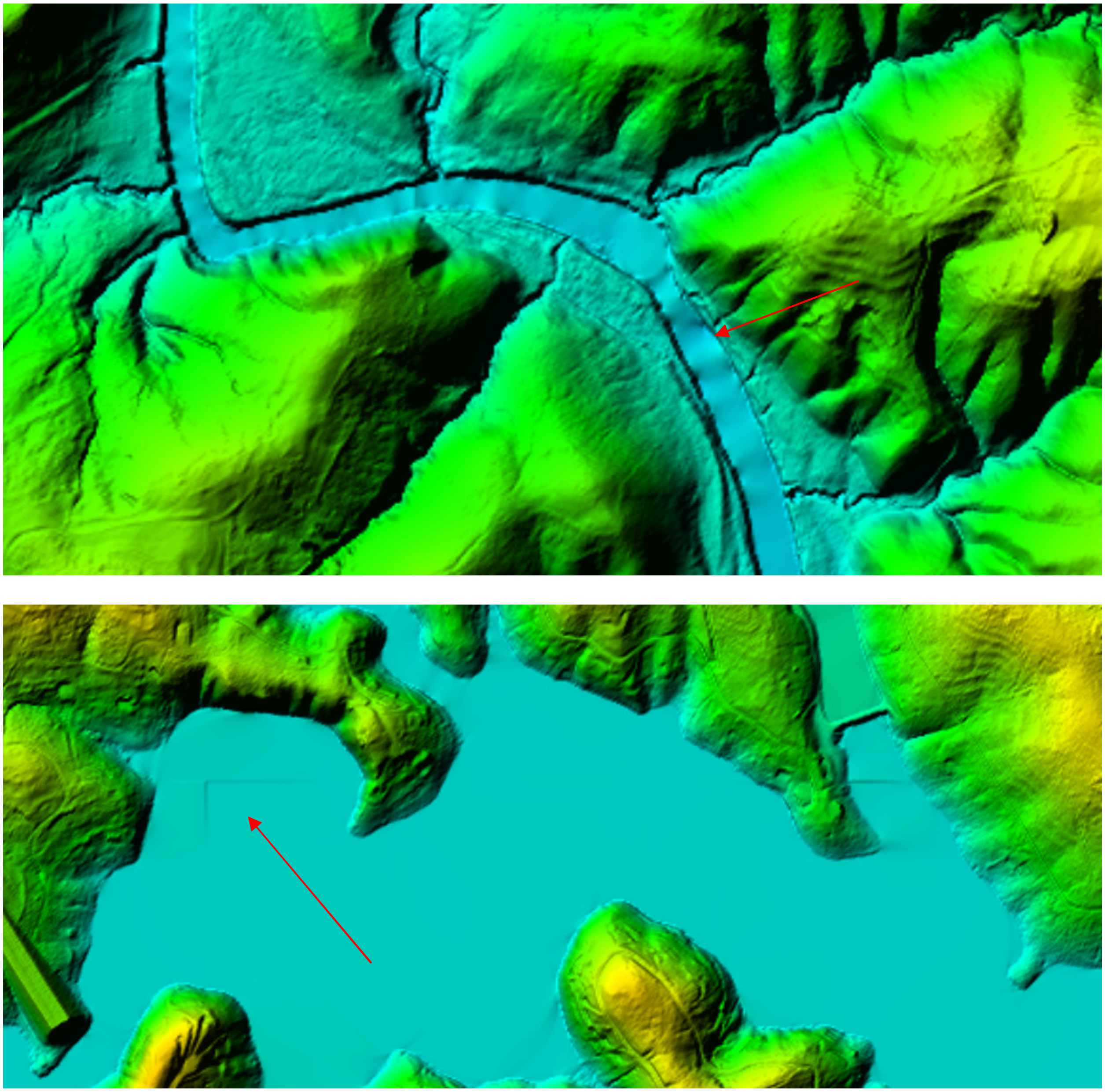


Figure 11 - The bare earth DEM showing water artifacts within a river breakline (top) and a nearby lake (bottom).

DEM QA/QC CHECKLIST

Project Number/Description: Project#P24-N143-MJ Spartanburg County LiDAR
Date: 04/17/2014

Overview

- ☒ Correct number of files is delivered and all files are in ESRI GRID format
- ☒ Verify Raster Extents
- ☒ Verify Projection/Coordinate System

Review

- ☒ Manually review bare-earth DEMs in Arc and Global Mapper
- ☒ DEM cell size is 10 feet
- ☒ Perform all necessary corrections in Arc using Dewberry's proprietary correction workflow.
- ☒ Review all corrections in Global Mapper

Metadata

- ☒ Project level DEM metadata XML file is error free as determined by the USGS MP tool
- ☒ Metadata content contains sufficient detail and all pertinent information regarding source materials, projections, datums, processing steps, etc.

Completion Comments: Complete - Approved

Appendix A: Complete List of Delivered Tiles

6039-01	6069-04	6087-04	6130-03	6141-01	6151-01	6161-01
6039-02	6074-02	6088-01	6130-04	6141-02	6151-02	6161-02
6039-04	6074-04	6088-02	6131-01	6141-03	6151-03	6161-03
6047-02	6075-01	6088-03	6131-02	6141-04	6151-04	6161-04
6048-01	6075-02	6088-04	6131-03	6142-01	6152-01	6162-01
6048-02	6075-03	6089-01	6131-04	6142-02	6152-02	6162-02
6048-04	6075-04	6089-02	6132-01	6142-03	6152-03	6162-03
6049-01	6076-01	6089-03	6132-02	6142-04	6152-04	6162-04
6049-02	6076-02	6089-04	6132-03	6143-01	6153-01	6163-01
6049-03	6076-03	6092-02	6132-04	6143-02	6153-02	6163-02
6049-04	6076-04	6093-01	6133-01	6143-03	6153-03	6163-03
6056-02	6077-01	6093-02	6133-02	6143-04	6153-04	6163-04
6057-01	6077-02	6093-03	6133-03	6144-01	6154-01	6164-01
6057-02	6077-03	6093-04	6133-04	6144-02	6154-02	6164-02
6057-03	6077-04	6094-01	6134-01	6144-03	6154-03	6164-03
6057-04	6078-01	6094-02	6134-02	6144-04	6154-04	6164-04
6058-01	6078-02	6094-03	6134-03	6145-01	6155-01	6165-01
6058-02	6078-03	6094-04	6134-04	6145-02	6155-02	6165-02
6058-03	6078-04	6095-01	6135-01	6145-03	6155-03	6165-03
6058-04	6079-01	6095-02	6135-02	6145-04	6155-04	6165-04
6059-01	6079-02	6095-03	6135-03	6146-01	6156-01	6166-01
6059-02	6079-03	6095-04	6135-04	6146-02	6156-02	6166-02
6059-03	6079-04	6096-01	6136-01	6146-03	6156-03	6166-03
6059-04	6083-01	6096-02	6136-02	6146-04	6156-04	6166-04
6065-02	6083-02	6096-03	6136-03	6147-01	6157-01	6167-01
6066-01	6084-01	6096-04	6136-04	6147-02	6157-02	6167-02
6066-02	6084-02	6097-01	6137-01	6147-03	6157-03	6167-03
6066-03	6084-03	6097-02	6137-02	6147-04	6157-04	6167-04
6066-04	6084-04	6097-03	6137-03	6148-01	6158-01	6168-01
6067-01	6085-01	6097-04	6137-04	6148-02	6158-02	6168-02
6067-02	6085-02	6098-01	6138-01	6148-03	6158-03	6168-03
6067-03	6085-03	6098-02	6138-02	6148-04	6158-04	6168-04
6067-04	6085-04	6098-03	6138-03	6149-01	6159-01	6169-01
6068-01	6086-01	6098-04	6138-04	6149-02	6159-02	6169-02
6068-02	6086-02	6099-01	6139-02	6149-03	6159-03	6169-03
6068-03	6086-03	6099-02	6139-04	6149-04	6159-04	6169-04
6068-04	6086-04	6099-03	6140-01	6150-01	6160-01	6170-01
6069-01	6087-01	6099-04	6140-02	6150-02	6160-02	6170-02
6069-02	6087-02	6130-01	6140-03	6150-03	6160-03	6170-03
6069-03	6087-03	6130-02	6140-04	6150-04	6160-04	6170-04

6171-01	6181-03	6192-01	6241-01	6280-02	7008-01	7020-02
6171-02	6181-04	6192-02	6241-02	6280-03	7008-02	7021-01
6171-03	6182-01	6192-03	6241-03	6280-04	7008-03	7021-02
6171-04	6182-02	6192-04	6241-04	6281-01	7008-04	7021-03
6172-01	6182-03	6193-01	6242-01	6281-02	7009-01	7021-04
6172-02	6182-04	6193-02	6242-02	6281-03	7009-02	7022-01
6172-03	6183-01	6193-03	6242-03	6281-04	7009-03	7022-02
6172-04	6183-02	6193-04	6242-04	6282-03	7009-04	7022-03
6173-01	6183-03	6194-01	6250-01	6282-04	7011-02	7022-04
6173-02	6183-04	6194-02	6250-02	6290-01	7012-01	7023-01
6173-03	6184-01	6194-03	6250-03	6290-02	7012-02	7023-02
6173-04	6184-02	6194-04	6250-04	6290-03	7012-03	7023-03
6174-01	6184-03	6195-01	6251-01	6290-04	7012-04	7023-04
6174-02	6184-04	6195-02	6251-02	6291-01	7013-01	7024-01
6174-03	6185-01	6195-03	6251-03	6291-02	7013-02	7024-02
6174-04	6185-02	6195-04	6251-04	6291-03	7013-03	7024-03
6175-01	6185-03	6196-01	6252-01	6291-04	7013-04	7024-04
6175-02	6185-04	6196-02	6252-02	6292-03	7014-01	7025-01
6175-03	6186-01	6196-03	6252-03	6292-04	7014-02	7025-02
6175-04	6186-02	6196-04	6252-04	7002-01	7014-03	7025-03
6176-01	6186-03	6197-01	6260-01	7002-02	7014-04	7025-04
6176-02	6186-04	6197-02	6260-02	7002-04	7015-01	7026-01
6176-03	6187-01	6197-03	6260-03	7003-01	7015-02	7026-02
6176-04	6187-02	6197-04	6260-04	7003-02	7015-03	7026-03
6177-01	6187-03	6198-01	6261-01	7003-03	7015-04	7026-04
6177-02	6187-04	6198-02	6261-02	7003-04	7016-01	7027-01
6177-03	6188-01	6198-03	6261-03	7004-01	7016-02	7027-02
6177-04	6188-02	6198-04	6261-04	7004-02	7016-03	7027-03
6178-01	6188-03	6199-01	6262-01	7004-03	7016-04	7027-04
6178-02	6188-04	6199-02	6262-03	7004-04	7017-01	7028-01
6178-03	6189-01	6199-03	6262-04	7005-01	7017-02	7028-02
6178-04	6189-02	6199-04	6270-01	7005-02	7017-03	7028-03
6179-01	6189-03	6230-02	6270-02	7005-03	7017-04	7028-04
6179-02	6189-04	6230-04	6270-03	7005-04	7018-01	7029-01
6179-03	6190-01	6231-02	6270-04	7006-01	7018-02	7029-02
6179-04	6190-02	6231-04	6271-01	7006-02	7018-03	7029-03
6180-01	6190-03	6232-02	6271-02	7006-03	7018-04	7029-04
6180-02	6190-04	6232-04	6271-03	7006-04	7019-01	7030-01
6180-03	6191-01	6240-01	6271-04	7007-01	7019-02	7030-02
6180-04	6191-02	6240-02	6272-03	7007-02	7019-03	7030-03
6181-01	6191-03	6240-03	6272-04	7007-03	7019-04	7030-04
6181-02	6191-04	6240-04	6280-01	7007-04	7020-01	7031-01

7031-02	7042-01	7055-04	7103-03	7114-01	7124-03	7135-01
7031-03	7042-02	7056-01	7103-04	7114-02	7124-04	7135-02
7031-04	7042-03	7056-02	7104-01	7114-03	7125-01	7135-03
7032-01	7042-04	7056-03	7104-02	7114-04	7125-02	7135-04
7032-02	7043-01	7056-04	7104-03	7115-01	7125-03	7136-01
7032-03	7043-02	7057-01	7104-04	7115-02	7125-04	7136-02
7032-04	7043-03	7057-02	7105-01	7115-03	7126-01	7136-03
7033-01	7043-04	7057-03	7105-02	7115-04	7126-02	7136-04
7033-02	7044-01	7057-04	7105-03	7116-01	7126-03	7137-01
7033-03	7044-02	7058-01	7105-04	7116-02	7126-04	7137-02
7033-04	7044-03	7058-02	7106-01	7116-03	7127-01	7137-03
7034-01	7044-04	7058-03	7106-02	7116-04	7127-02	7137-04
7034-02	7045-01	7058-04	7106-03	7117-01	7127-03	7138-01
7034-03	7045-02	7059-01	7106-04	7117-02	7127-04	7138-02
7034-04	7045-03	7059-02	7107-01	7117-03	7128-01	7138-03
7035-01	7045-04	7059-03	7107-02	7117-04	7128-02	7138-04
7035-02	7046-01	7059-04	7107-03	7118-01	7128-03	7139-01
7035-03	7046-02	7066-01	7107-04	7118-02	7128-04	7139-02
7035-04	7046-03	7067-01	7108-01	7118-03	7129-01	7139-03
7036-01	7046-04	7067-03	7108-02	7118-04	7129-02	7139-04
7036-02	7047-01	7068-01	7108-03	7119-01	7129-03	7140-01
7036-03	7047-02	7068-02	7108-04	7119-02	7129-04	7140-02
7036-04	7047-03	7068-03	7109-01	7119-03	7130-01	7140-03
7037-01	7047-04	7069-01	7109-02	7119-04	7130-02	7140-04
7037-02	7048-01	7069-02	7109-03	7120-01	7130-03	7141-01
7037-03	7048-02	7069-03	7109-04	7120-02	7130-04	7141-02
7037-04	7048-03	7069-04	7110-01	7120-03	7131-01	7141-03
7038-01	7048-04	7079-01	7110-02	7120-04	7131-02	7141-04
7038-02	7049-01	7100-01	7110-03	7121-01	7131-03	7142-01
7038-03	7049-02	7100-02	7110-04	7121-02	7131-04	7142-02
7038-04	7049-03	7100-03	7111-01	7121-03	7132-01	7142-03
7039-01	7049-04	7100-04	7111-02	7121-04	7132-02	7142-04
7039-02	7052-01	7101-01	7111-03	7122-01	7132-03	7143-01
7039-03	7053-01	7101-02	7111-04	7122-02	7132-04	7143-02
7039-04	7053-03	7101-03	7112-01	7122-03	7133-01	7143-03
7040-01	7054-01	7101-04	7112-02	7122-04	7133-02	7143-04
7040-02	7054-02	7102-01	7112-03	7123-01	7133-03	7144-01
7040-03	7054-03	7102-02	7112-04	7123-02	7133-04	7144-02
7041-01	7054-04	7102-03	7113-01	7123-03	7134-01	7144-03
7041-02	7055-01	7102-04	7113-02	7123-04	7134-02	7144-04
7041-03	7055-02	7103-01	7113-03	7124-01	7134-03	7145-01
7041-04	7055-03	7103-02	7113-04	7124-02	7134-04	7145-02

7145-03	7151-01	7156-03	7162-04	7171-04	7201-04	7222-04
7145-04	7151-02	7156-04	7163-01	7172-01	7202-03	7230-01
7146-01	7151-03	7157-01	7163-02	7172-02	7202-04	7230-02
7146-02	7151-04	7157-02	7163-03	7172-03	7210-01	7230-03
7146-03	7152-01	7157-03	7163-04	7172-04	7210-02	7230-04
7146-04	7152-02	7157-04	7164-01	7173-01	7210-03	7231-01
7147-01	7152-03	7158-01	7164-02	7173-03	7210-04	7231-02
7147-02	7152-04	7158-03	7164-03	7174-01	7211-01	7231-03
7147-03	7153-01	7158-04	7164-04	7174-03	7211-02	7231-04
7147-04	7153-02	7159-01	7165-01	7181-01	7211-03	7232-03
7148-01	7153-03	7159-03	7165-02	7181-02	7211-04	7232-04
7148-02	7153-04	7160-01	7165-03	7181-03	7212-03	7240-01
7148-03	7154-01	7160-02	7165-04	7182-01	7212-04	7240-02
7148-04	7154-02	7160-03	7166-01	7182-03	7220-01	7240-03
7149-01	7154-03	7160-04	7166-03	7182-04	7220-02	7240-04
7149-02	7154-04	7161-01	7166-04	7200-01	7220-03	7241-01
7149-03	7155-01	7161-02	7170-01	7200-02	7220-04	7241-03
7149-04	7155-02	7161-03	7170-02	7200-03	7221-01	7939-02
7150-01	7155-03	7161-04	7170-03	7200-04	7221-02	7949-01
7150-02	7155-04	7162-01	7171-01	7201-01	7221-03	
7150-03	7156-01	7162-02	7171-02	7201-02	7221-04	
7150-04	7156-02	7162-03	7171-03	7201-03	7222-03	