Project Report

TASK ORDER NAME: GA_Statewide_2018_B18
TASK ORDER NUMBER: 140G0218F042
CONTRACT NUMBER: G16PC00042
ATLANTIC PROJECT NUMBER: 18066 – Block 4B

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SECTION 1: PROJECT OVERVIEW AND PURPOSE

1.1 Aerial LiDAR Project

1.1.1 Project Overview

USGS task order 140G0218F042 required Winter, 2018/Spring, 2019 LiDAR surveys to be collected over 32,562 square miles covering part or all of 82 counties in Georgia and 3 partial counties in South Carolina in support of the State of Georgia and the USGS 3DEP program. Aerial LiDAR data for this task order was planned, acquired, processed and produced at an aggregate nominal pulse spacing (ANPS) of ≤0.71 meters and in compliance with USGS National Geospatial Program LiDAR Base Specification version 1.3. The Block 4B area encompasses approximately 1,086 square miles.

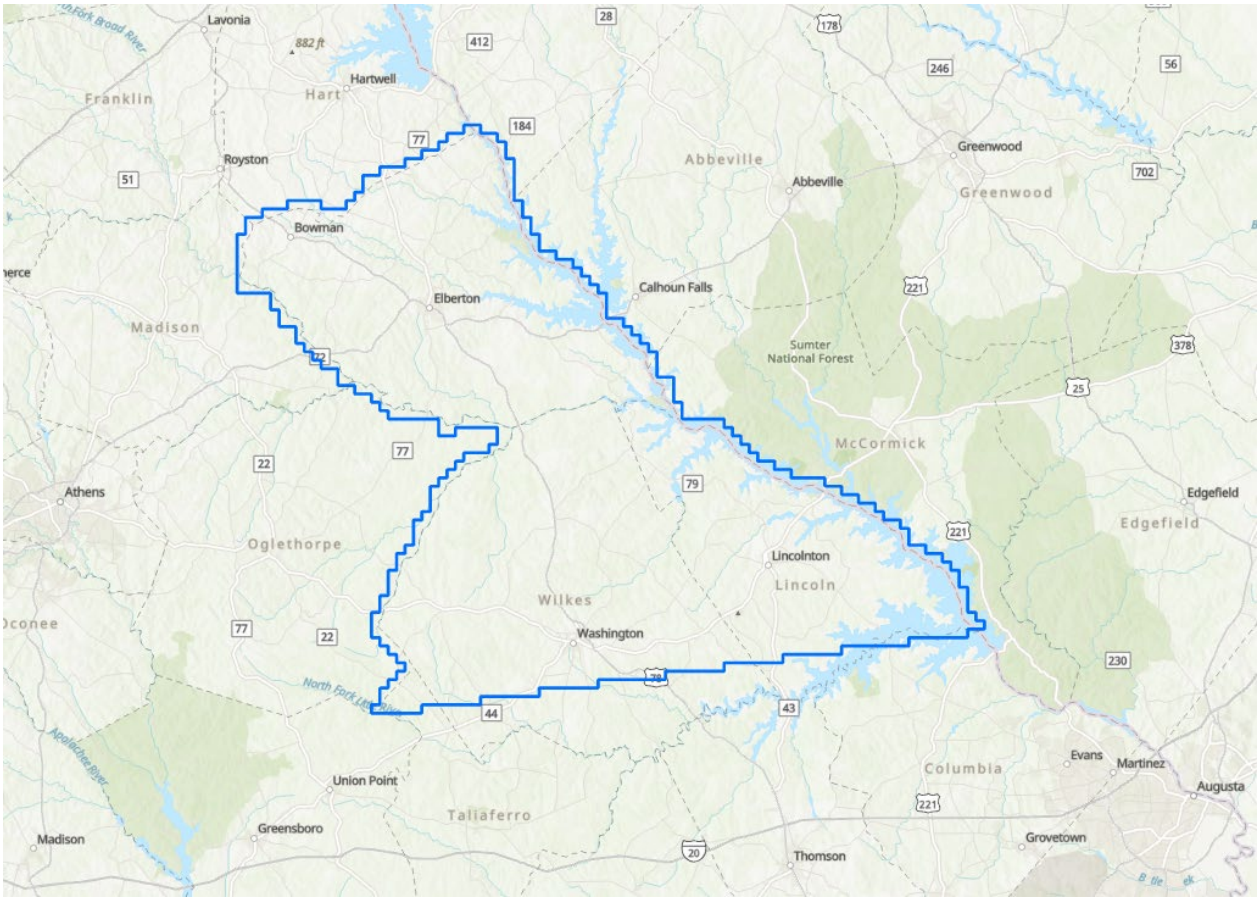

Figure 1: Aerial LiDAR Project Overview

1.1.2 Project Purpose

Aerial lidar was collected to support the mapping efforts of individual counties in the State of Georgia and the USGS 3DEP program.

1.1.3 Contract Deliverables

Item	Specification/Format
Classified Point Cloud	LAS v.14, tiled delivery
Bare Earth Surface	Raster DEM, 1m cell size, hydro flattened, GeoTIFF format
Breaklines	Hydro breaklines to BPA limit, .gdb format
Intensity Imagery	1m cell size, 8-bit, 256 gray scale, GeoTIFF format
Delivery Diagram	.gdb format
Metadata	Per product, FGDC compliant, .xml format
Project Report	Field work procedures, QC procedures and results, overall accuracy, .pdf format

Table 1: Aerial LiDAR Contract Deliverables

SECTION 2: FIELD OPERATIONS

2.1 Aerial LiDAR Project – Aerial Acquisition

2.1.1 Aircraft and Sensor Information

Atlantic operated a Cessna (N732JE) outfitted with a Leica ALS70-HP LiDAR system during the collection of the project area. The specifications of this system are presented in the following table:

Parameter	Specification
Model	ALS70-HP
Manufacturer	Leica
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 Adaptive, °)	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
Operation Temperature (°C)	0 – 40
Flight Management	FCMS
Power Consumption	927 @ 22.0 – 30.3 VDC

Table 2: System Specifications – ALS70-HP

2.1.2 Sensor Acquisition Information

The following table illustrates project specific system parameters for LiDAR acquisition on this project:

Parameter	Specification
System	Leica ALS70-HP
Nominal Pulse Spacing (m)	0.6
Nominal Pulse Density (pls/m²)	2.2
Nominal Flight Height (AGL meters)	2000
Nominal Flight Speed (kts)	130
Pass Heading (°)	Varies
Sensor Scan Angle (°)	45
Scan Frequency (Hz)	35.1
Pulse Rate of Scanner (kHz)	265,000
Line Spacing (m)	1410
Pulse Duration of Scanner (ns)	4
Pulse Width of Scanner (m)	.30
Central Wavelength of Sensor Laser (nm)	1064
Sensor Operated with Multiple Pulses	2
Beam Divergence (mrad)	0.15
Nominal Swath Width (m)	1663
Nominal Swath Overlap (%)	20
Scan Pattern	Triangle

Table 3: Aerial LiDAR Sensor Acquisition Parameters

2.1.3 Flight Plan Execution

Atlantic acquired 108 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 6 flight missions conducted between November 27, 2018 and December 6, 2018. Onboard differential Global Navigation Satellite System (GNSS) unit(s) recorded sample aircraft positions at 2 hertz (Hz) or more frequency. LiDAR data was only acquired when a minimum of six (6) satellites were in view.

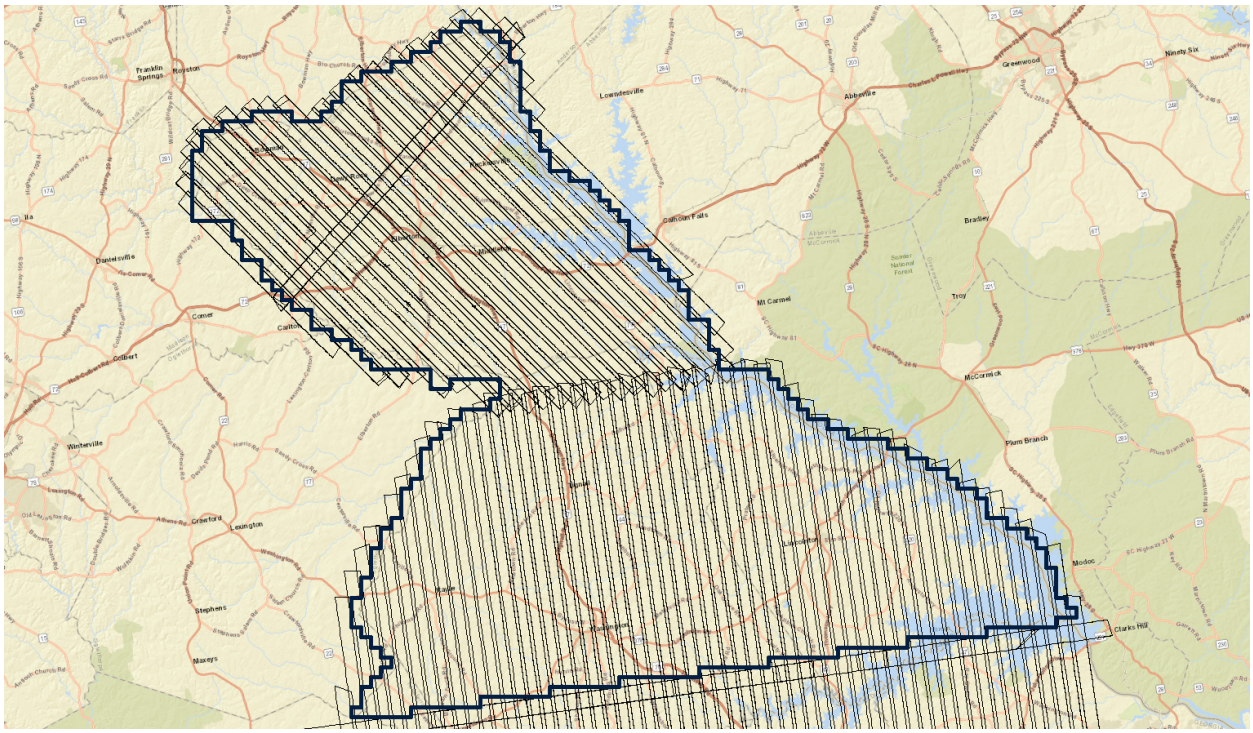

Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

2.1.4 GNSS Reference Stations

Twenty-seven (27) Continuously Operating Reference Stations (CORS) were used to control the LiDAR acquisition for the defined project area. The coordinates provided in below are in NAD83 (2011), Geographic Coordinate System, Ellipsoid, Meters.

PID	Latitude (N)	Longitude (W)	Elevation
ALCN	N34°09'46.97944"	W85°39'31.04923"	164.905
FRKN	N35°11'30.71108"	W83°23'41.77393"	619.545
GAAE	N33°25'38.07637"	W82°04'04.06834"	124.369
GAAU	N33°28'17.14253"	W82°02'01.80804"	113.038
GABN	N34°08'07.10674"	W83°46'38.52666"	277.225
GACC	N33°32'44.73130"	W82°08'01.72538"	98.498
GAGR	N33°34'34.54309"	W83°10'56.32093"	176.567
GAEL	N34°06'58.72063"	W82°52'18.36029"	191.657
GAMV	N33°04'51.82783'	W83°13'34.68699"	84.204
GASM	N33°56'51.12525"	W83°34'46.78349"	243.951
GANW	N33°18'20.82421"	W84°46'02.50935"	259.992
GATH	N33°27'48.60131"	W82°29'57.01780"	133.877
GATN	N32°55'39.31635"	W82°48'09.76227"	121.107
GAWN	N33°05'09.37664"	W82°02'33.89549"	66.118
HAYW	N35°31'35.42154"	W82°55'30.15423"	807.961
NCBC	N35°22'21.58731"	W83°30'23.39886"	564.809
NCHE	N35°21'21.91696"	W82°30'04.02292"	653.121
NCMU	N35°04'06.80197"	W83°57'59.38922"	474.780
NCRB	N35°19'15.71699"	W83°47'48.71728"	605.321
NCSY	N35°20'52.43245"	W83°12'23.41605"	643.773
P779	N35°12'06.98912"	W82°52'20.92954"	878.735
P806	N32°57'47.92265"	W84°13'33.05709"	215.870
SCAI	N33°33'41.96891"	W81°43'11.20118"	135.744
TN17	N35°48'48.18383"	W84°00'17.56371"	279.975
TN21	N35°03'51.76165"	W85°12'25.96384"	196.277
TN29	N35°14'46.29843"	W84°34'06.16388"	198.193
ZTL4	N33°22'46.87792"	W84°17'48.21517"	260.690

Table 4: GNSS Reference Stations

2.2 Aerial LiDAR Project – Ground Acquisition

2.2.1 Ground Control Survey

A total of 35 ground survey points were collected in support of this project, including 11 LiDAR Control Points (LCP), 16 Non-vegetated Vertical Accuracy (NVA) and 8 Vegetated Vertical Accuracy (VVA).

Point cloud data accuracy was tested against a Triangulated Irregular Network (TIN) constructed from LiDAR points in clear and open areas. A clear and open area can be characterized with respect to topographic and ground cover variation such that a minimum of five (5) times the Nominal Pulse Spacing (NPS) exists with less than 1/3 of the RMSEZ deviation from a low-slope plane. Slopes that exceed ten (10) percent were avoided.

Each land cover type representing ten (10) percent or more of the total project area were tested and reported with a VVA. In land cover categories other than dense urban areas, the tested points did not have obstructions forty-five (45) degrees above the horizon to ensure a satisfactory TIN surface. The VVA value is provided as a target. It is understood that in areas of dense vegetation, swamps, or extremely difficult terrain, this value may be exceeded.

The NVA value is a requirement that must be met, regardless of any allowed "busts" in the VVA(s) for individual land cover types within the project. Checkpoints for each assessment (NVA and VVA) are required to be well-distributed throughout the land cover type, for the entire project area.

The following tables and figures outline the coordinate values and distribution of LCP, NVA and VVA points collected in support of this project:

Point ID	Easting [X]	Northing [Y]	Elevation [Z]	Point Type
ELBERT_CP36	1182447.508	1318785.174	239.972	LCP
ELBERT_CP37	1203818.566	1325463.765	207.562	LCP
ELBERT_CP38	1202027.774	1308566.264	200.510	LCP
ELBERT_CP62	1191285.217	1312444.846	207.373	LCP
ELBERT_CP63	1221272.023	1302089.661	115.877	LCP
LINCOLN_CP39	1227860.475	1289740.394	116.820	LCP
LINCOLN_CP40	1240592.123	1279845.640	143.411	LCP
WILKES_CP47	1218876.062	1269587.846	188.637	LCP
WILKES_CP48	1213741.861	1286377.697	181.217	LCP
WILKES_CP49	1199773.874	1273548.794	212.444	LCP
WILKES_CP64	1219254.302	1282181.842	175.953	LCP

Point ID	Easting [X]	Northing [Y]	Elevation [Z]	Point Type
ELBERT_OT37	1198357.893	1315273.367	179.222	NVA
ELBERT_OT38	1199270.264	1299608.835	167.836	NVA
ELBERT_OT39	1224474.256	1304039.225	112.638	NVA

Point ID	Easting [X]	Northing [Y]	Elevation [Z]	Point Type
ELBERT_UA46	1188783.014	1313414.997	217.255	NVA
ELBERT_UA47	1207842.626	1300822.264	156.889	NVA
ELBERT_UA48	1207908.077	1319841.705	151.328	NVA
LINCOLN_OT40	1254877.902	1276399.167	136.078	NVA
LINCOLN_UA58	1232111.029	1290317.376	141.802	NVA
LINCOLN_UA59	1247696.633	1276418.702	136.467	NVA
LINCOLN_UA60	1238915.062	1279616.149	153.721	NVA
WILKES_BE3	1217054.714	1269848.616	184.799	NVA
WILKES_OT49	1223098.396	1280456.017	145.581	NVA
WILKES_OT50	1203317.037	1285400.781	184.674	NVA
WILKES_UA55	1208327.458	1276131.946	203.265	NVA
WILKES_UA56	1218421.207	1269746.362	188.961	NVA
WILKES_UA57	1213312.402	1284649.195	179.815	NVA

Point ID	Easting [X]	Northing [Y]	Elevation [Z]	Point Type
ELBERT_BR4	1197276.194	1312752.732	199.161	VVA
ELBERT_FO44	1182385.211	1314301.360	207.898	VVA
ELBERT_FO45	1198898.767	1304932.509	189.459	VVA
ELBERT_FO46	1206733.532	1319408.313	176.761	VVA
ELBERT_TG3	1201617.970	1316054.248	209.717	VVA
LINCOLN_FO47	1228631.345	1289926.988	133.967	VVA
LINCOLN_FO48	1252757.491	1272130.120	101.175	VVA
WILKES_FO55	1221406.662	1266977.540	165.331	VVA

Table 5: LiDAR Control/Check Point Coordinates

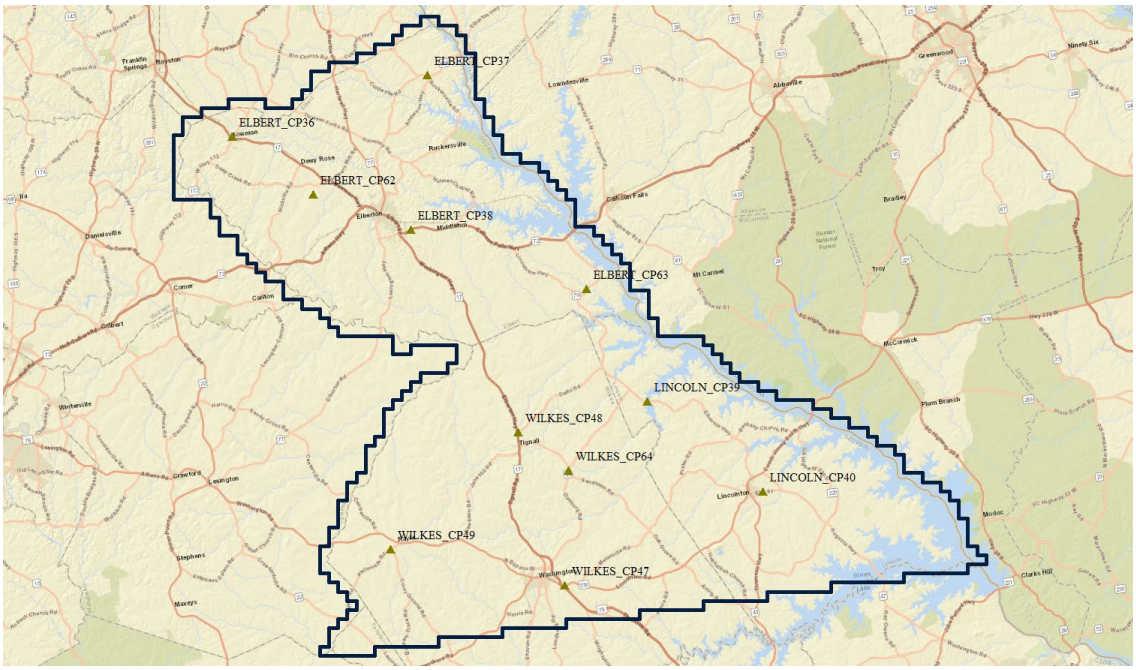

Figure 3: LiDAR Control Point Distribution

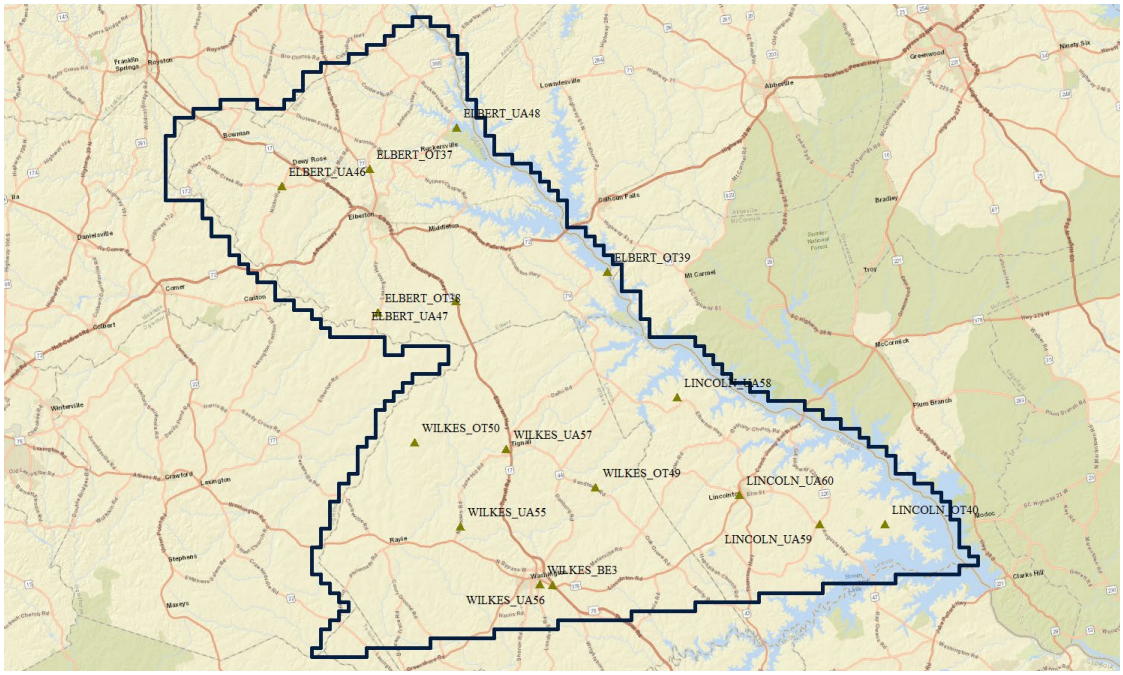

Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

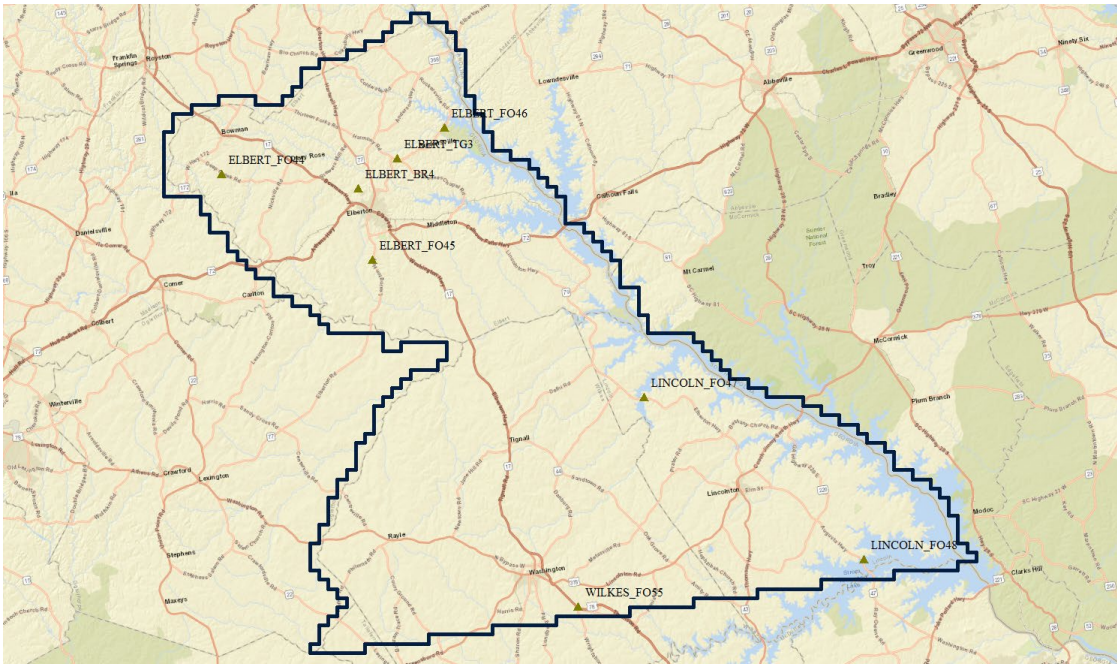

Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

SECTION 3: DATA PRODUCTION

3.1 Aerial LiDAR Project – Calibration/Classification

3.1.1 LiDAR Point Cloud Generation

Atlantic used Leica software products to download the IPAS ABGNSS/IMU data and raw laser scan files from the airborne system. Waypoint Inertial Explorer is used to extract the raw IPAS ABGNSS/IMU data, which is further processed in combination with controlled base stations to provide the final Smoothed Best Estimate Trajectory (SBET) for each mission. The SBETs are combined with the raw laser scan files to export the LiDAR ASCII Standard (*.las) formatted swath point clouds.

3.1.2 Coordinate Reference System

Parameter	Specification
Horizontal Datum	NAD83 (2011)
Coordinate System	Albers Conic
Vertical Datum	NAVD88
Geoid Model	12B
EPSG Code	6350
Units of Reference	Meter

Table 6: Coordinate Reference System

3.1.3 LiDAR Point Cloud Statistics

Category	Value
Total Points (Nominal)	9,666,033,860
Nominal Pulse Spacing (M)	0.6104
Nominal Pulse Density (PLS/M^2)	2.6840
Total Points (Aggregate)	9,666,033,860
Aggregate Pulse Spacing (M)	0.5981
Aggregate Pulse Density (PLS/M^2)	2.7957

Table 7: LiDAR Point Cloud Statistics

3.1.4 Smooth Surface Repeatability (Interswath)

Departures from planarity of first returns within single swaths in non-vegetated areas were assessed at multiple locations with hard surface areas (parking lots or large rooftops) inside the project area. Each area was evaluated using signed difference rasters (maximum elevation – minimum elevation) at a cell size equal to 2 x ANPS, rounded to the next integer.

3.1.5 LiDAR Calibration

Using a combination of GeoCue, TerraScan and TerraMatch; overlapping swath point clouds are corrected for any orientation or linear deviations to obtain the best fit swath-to-swath calibration. Relative calibration was evaluated using advanced plane-matching analysis and parameter corrections derived. This process was repeated

interactively until residual errors between overlapping swaths, across all project missions, was reduced to ≤2cm. A final analysis of the calibrated lidar is preformed using a TerraMatch tie line report for an overall statistical model of the project area. Individual control point assessments for this project can be found in Section VI of this report.

Upon completion of the data calibration, a complete set of elevation difference intensity rasters (dZ Orthos) are produced. A user-defined color ramp is applied depicting the offsets between overlapping swaths based on project specifications. The dZ orthos provide an opportunity to review the data calibration in a qualitative manner. Atlantic assigns green to all offset values that fall below the required RMSDz requirement of the project. A yellow color is assigned for offsets that fall between the RMSDz value and 1.5x of that value. Finally, red values are assigned to all values that fall beyond 1.5x of the RMSDz requirements of the project.

3.1.6 LiDAR Classification

Multiple automated filtering routines are applied to the calibrated LiDAR point cloud identifying and extracting bare-earth and above ground features. GeoCue, TerraScan, and TerraModeler software was used for the initial batch processing, visual inspection and any manual editing of the LiDAR point clouds. Atlantic utilized collected breakline data to preform classification for class 9 (Water).

Code	Description
1	Processed but unclassified
2	Bare-earth ground
3	Low Vegetation (0.5 – 5 feet)
4	Medium Vegetation (5 – 20 feet)
5	High Vegetation (>20 feet)
6	Building footprints
7	Low Noise
9	Water
17	Bridge Decks
18	High Noise
20	Ignored ground (breakline proximity)
21	Snow (where reliable identifiable)
22	Temporal Exclusion (typically non-favored data in intertidal zones)

Table 8: LiDAR Point Classification Codes and Descriptions

3.1.7 LiDAR Intensity Imagery

LiDAR intensity imagery was created from the final calibrated and classified lidar point cloud. Intensity images were produced from all classified points and posted to a 1-meter cell size. Intensity images were cut to match the tile index and its corresponding tile names and delivered in GeoTIFF format.

3.1.8 Hydro-line Collection/Conflation

Hydro breaklines were compiled using LiDAR intensity data and surface terrain models of the entire project area. After the collection, all delineated hydro features were validated for monotonicity and vertical variance. This

procedure ensures that no points were floating above ground. Hydro-lines were then encoded into the LiDAR surface and used to hydro-enforce/flatten all significant water bodies. These final hydro-lines were then used in the production of bare Earth digital models to hydro flatten significant water bodies. This product was delivered as an ESRI geodatabase for the entire project area.

3.1.9 Bare-Earth Surface – Digital Elevation Model (DEM)

Bare earth Digital Elevation Models (DEMs) were derived using the hydro-lines and bare earth (ground) LiDAR points. All DEMs were created with a grid spacing of 1 meter. DEMs for this project were cut to match the tile index and its corresponding tile names and delivered in 32-bit floating point GeoTIFF format.

SECTION 4: ACCURACY ASSESSMENT

4.1 Aerial LiDAR Project – Vertical Accuracy Assessment

4.1.1 Requirements

Per the table below, the Vertical Accuracy Assessment utilized the required parameters for Vertical Data Accuracy Class IV.

Vertical Data Accuracy Class	RMSEz in Non-Vegetated Terrain (cm)	Non-Vegetated Vertical Accuracy (NVA) at 95% Confidence Level (cm)	Vegetated Vertical Accuracy (VVA) at 95th Percentile (cm)
I	1.0	2.0	2.9
II	2.5	4.9	7.4
III	5.0	9.8	14.7
IV	10.0	19.6	29.4
V	12.5	24.5	36.8
VI	20.0	39.2	58.8
VII	33.3	65.3	98.0
VIII	66.7	130.7	196.0
IX	100.0	196.0	294.0
X	333.3	653.3	980.0

Table 9: Vertical Accuracy Standards, Source: ASPRS Positional Accuracy Standards for Digital Geospatial Data v1.0 (2014)

*The terms NVA and VVA are from the American Society for Photogrammetry and Remote Sensing (ASPRS) Positional Accuracy Standards for Digital Geospatial Data v1.0 (2014). The term NVA refers to assessments in clear, open areas (which typically produce only single LiDAR returns); the term VVA refers to assessments in vegetated areas (typically characterized by multiple return LiDAR).

4.1.2 Results

An overall statistical assessment of the check points can be found in the following two tables (values provided in meters):

Broad Land Cover Type	Points (#)	RMSEz	Confidence Level (95%)	Percentile (95th)
NVA (Point Cloud)	15	0.0724	0.1419	0.0201
NVA (DEM)	15	0.0963	0.1888	0.1476
VVA (Point Cloud)	21	0.0682	0.1336	0.0920
VVA (DEM)	21	0.0903	0.1769	0.1740

Table 10: NVA/VVA Accuracies

SECTION 5: CERTIFICATION STATEMENTS

5.1 Aerial LiDAR Project

This accuracy assessment confirms that the data may be used for the intended applications stated in Section I of this document. This dataset may also be used as a topographic input for other applications, but the user should be aware that this LiDAR dataset was designed with a specific purpose and was not intended to meet specifications and/or requirements of users outside of the United States Geological Survey.

It should also be noted that LiDAR points do not represent a continuous surface model. LiDAR points are discrete measurements of the surface and any values derived within a triangle of three LiDAR points are interpolated. As such, the user should not use the resultant LiDAR dataset for vertical placement of a planimetric feature such as a headwall, building footprint or any other planimetric feature unless there is an associated LiDAR point that can be reasonably located on this structure.

Consideration should be given by the end user of this dataset to the fact that this LiDAR dataset was developed differently and separately than previous LiDAR datasets that may be available for this geographic location. It is likely that the data in this project was created using different geodetic control, a different Geoid, newer LiDAR technology and more up-to-date processing techniques. As such, any direct comparative analysis performed between this dataset and previous datasets could result in misleading or inaccurate results. Users are encouraged to proceed with caution while performing this type of comparative analysis and to completely understand the variables that make each of these datasets unique and not corollary.

It is encouraged that the user refers to the full FGDC Metadata and project reports for a complete understanding on the content of this dataset.

I, hereby, certify to the extent of my knowledge that the statements and statistics represented in this document are true and factual.

James C. Cannon, ASPRS Certified Photogrammetrist #R1594CP

SECTION 6: CONTROL POINT ASSESSMENTS

6.1 Aerial LiDAR Project

6.1.1 Point Cloud Check Point Assessment

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
BR01	1189963.1630	1315795.5960	221.3620	221.4300	0.0680	VVA
BR02	1198280.6080	1315401.6460	181.5190	181.5400	0.0210	VVA
BR03	1210367.2520	1307621.1470	167.5220	167.5500	0.0280	VVA
BR04	1215615.9830	1270322.4550	179.5100	179.4600	-0.0500	VVA
ELBERT_BR4	1197276.1940	1312752.7320	199.1610	199.0700	-0.0910	VVA
ELBERT_FO44	1182385.2110	1314301.3600	207.8980	207.9900	0.0920	VVA
ELBERT_FO45	1198898.7670	1304932.5090	189.4590	189.4500	-0.0090	VVA
ELBERT_FO46	1206733.5320	1319408.3130	176.7610	176.9000	0.1390	VVA
ELBERT_OT37	1198357.8930	1315273.3670	179.2220	179.2100	-0.0120	NVA
ELBERT_OT38	1199270.2640	1299608.8350	167.8360	167.8000	-0.0360	NVA
ELBERT_OT39	1224474.2560	1304039.2250	112.6380	112.6500	0.0120	NVA
ELBERT_TG3	1201617.9700	1316054.2480	209.7170	209.6900	-0.0270	VVA
ELBERT_UA46	1188783.0140	1313414.9970	215.2550	215.2200	-0.0350	NVA
ELBERT_UA47	1207842.6260	1300822.2640	156.8890	156.8300	-0.0590	NVA
ELBERT_UA48	1207908.0770	1319841.7050	149.3280	149.2900	-0.0380	NVA
HG01	1196673.0650	1311069.8780	204.1430	204.0500	-0.0930	VVA
HG02	1194356.5620	1323418.4700	226.2280	226.1800	-0.0480	VVA
HG03	1225864.4670	1291238.6270	141.2580	141.2400	-0.0180	VVA
HG04	1238340.3540	1278826.1390	154.3490	154.3400	-0.0090	VVA
LINCOLN_FO47	1228631.3450	1289926.9880	133.9670	133.9700	0.0030	VVA
LINCOLN_FO48	1252757.4910	1272130.1200	101.1750	101.1300	-0.0450	VVA
LINCOLN_OT40	1254877.9020	1276399.1670	136.0780	135.9900	-0.0880	NVA
LINCOLN_UA58	1232111.0290	1290317.3760	141.8020	141.7600	-0.0420	NVA
LINCOLN_UA59	1247696.6330	1276418.7020	136.4670	136.4600	-0.0070	NVA
LINCOLN_UA60	1238915.0620	1279616.1490	153.7210	153.7600	0.0390	NVA
NVA501	1225884.1520	1291243.4500	142.1080	142.0400	-0.0680	NVA
TR01	1183062.3850	1318554.3550	230.4880	230.4500	-0.0380	VVA
TR02	1200472.0840	1309435.5270	206.5640	206.4000	-0.1640	VVA
TR03	1203872.8490	1325294.0160	202.3070	202.3100	0.0030	VVA
TR04	1200693.0490	1274320.7680	205.5380	205.4400	-0.0980	VVA
VVA501	1203854.1760	1325318.3850	202.7050	202.7300	0.0250	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
WILKES_FO55	1221406.6620	1266977.5400	165.3310	165.3100	-0.0210	VVA
WILKES_OT50	1203317.0370	1285400.7810	182.6740	182.5800	-0.0940	NVA
WILKES_UA55	1208327.4580	1276131.9460	201.2650	201.1500	-0.1150	NVA
WILKES_UA56	1218421.2070	1269746.3620	186.9610	186.8000	-0.1610	NVA
WILKES_UA57	1213312.4020	1284649.1950	177.8150	177.7300	-0.0850	NVA

Table 11: Point Cloud Check Point Assessment

6.1.2 Digital Elevation Model (DEM) Check Point Assessment

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
ELBERT_OT37	1198357.8930	1315273.3670	179.2220	179.1900	0.0320	NVA
ELBERT_OT38	1199270.2640	1299608.8350	167.8360	167.7200	0.1160	NVA
ELBERT_OT39	1224474.2560	1304039.2250	112.6380	112.6290	0.0090	NVA
ELBERT_UA46	1188783.0140	1313414.9970	215.2550	215.1300	0.1250	NVA
ELBERT_UA47	1207842.6260	1300822.2640	156.8890	156.8300	0.0590	NVA
ELBERT_UA48	1207908.0770	1319841.7050	149.3280	149.2200	0.1080	NVA
LINCOLN_OT40	1254877.9020	1276399.1670	136.0780	135.9400	0.1380	NVA
LINCOLN_UA58	1232111.0290	1290317.3760	141.8020	141.7160	0.0860	NVA
LINCOLN_UA59	1247696.6330	1276418.7020	136.4670	136.4400	0.0270	NVA
LINCOLN_UA60	1238915.0620	1279616.1490	153.7210	153.7240	-0.0030	NVA
NVA501	1225884.1520	1291243.4500	142.1080	142.0180	0.0900	NVA
WILKES_OT50	1203317.0370	1285400.7810	182.6740	182.5780	0.0960	NVA
WILKES_UA55	1208327.4580	1276131.9460	201.2650	201.1500	0.1150	NVA
WILKES_UA56	1218421.2070	1269746.3620	186.9610	186.7910	0.1700	NVA
WILKES_UA57	1213312.4020	1284649.1950	177.8150	177.7300	0.0850	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BR01	1189963.1630	1315795.5960	221.3620	221.3810	-0.0190	VVA
BR02	1198280.6080	1315401.6460	181.5190	181.5100	0.0090	VVA
BR03	1210367.2520	1307621.1470	167.5220	167.5200	0.0020	VVA
BR04	1215615.9830	1270322.4550	179.5100	179.4800	0.0300	VVA
ELBERT_BR4	1197276.1940	1312752.7320	199.1610	198.9620	0.1990	VVA
ELBERT_FO44	1182385.2110	1314301.3600	207.8980	207.9930	-0.0950	VVA
ELBERT_FO45	1198898.7670	1304932.5090	189.4590	189.4400	0.0190	VVA
ELBERT_FO46	1206733.5320	1319408.3130	176.7610	176.8450	-0.0840	VVA
ELBERT_TG3	1201617.9700	1316054.2480	209.7170	209.6400	0.0770	VVA
HG01	1196673.0650	1311069.8780	204.1430	203.9900	0.1530	VVA
HG02	1194356.5620	1323418.4700	226.2280	226.1590	0.0690	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
HG03	1225864.4670	1291238.6270	141.2580	141.1760	0.0820	VVA
HG04	1238340.3540	1278826.1390	154.3490	154.3200	0.0290	VVA
LINCOLN_FO47	1228631.3450	1289926.9880	133.9670	133.9600	0.0070	VVA
LINCOLN_FO48	1252757.4910	1272130.1200	101.1750	101.1300	0.0450	VVA
TR01	1183062.3850	1318554.3550	230.4880	230.4000	0.0880	VVA
TR02	1200472.0840	1309435.5270	206.5640	206.3900	0.1740	VVA
TR03	1203872.8490	1325294.0160	202.3070	202.3120	-0.0050	VVA
TR04	1200693.0490	1274320.7680	205.5380	205.4100	0.1280	VVA
VVA501	1203854.1760	1325318.3850	202.7050	202.6200	0.0850	VVA
WILKES_FO55	1221406.6620	1266977.5400	165.3310	165.2400	0.0910	VVA

Table 12: DEM Check Point Assessment