Project Report

TASK ORDER NAME: 2018 Kansas QL2 LiDAR
CONTRACT ID: 00000000000000000000039891
EVENT ID: EVT0003259
ATLANTIC PROJECT NUMBER: 18006
PROJECT BLOCK NUMBER: Block 13

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SECTION I: PROJECT OVERVIEW & PURPOSE

1. Aerial LiDAR Project

a. Project Overview

The State of Kansas Contract 00000000000000000000039891 required Leaf-off 2018 QL 2 LiDAR surveys to be collected over 54,663 square miles covering part or all of 86 counties in Kansas in support of the Kansas Department of Agriculture and Kansas Data Access and Support Center. 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 1.2. Project Block 13 encompasses part or all of 4 counties in Kansas and covers approximately 1152 square miles.

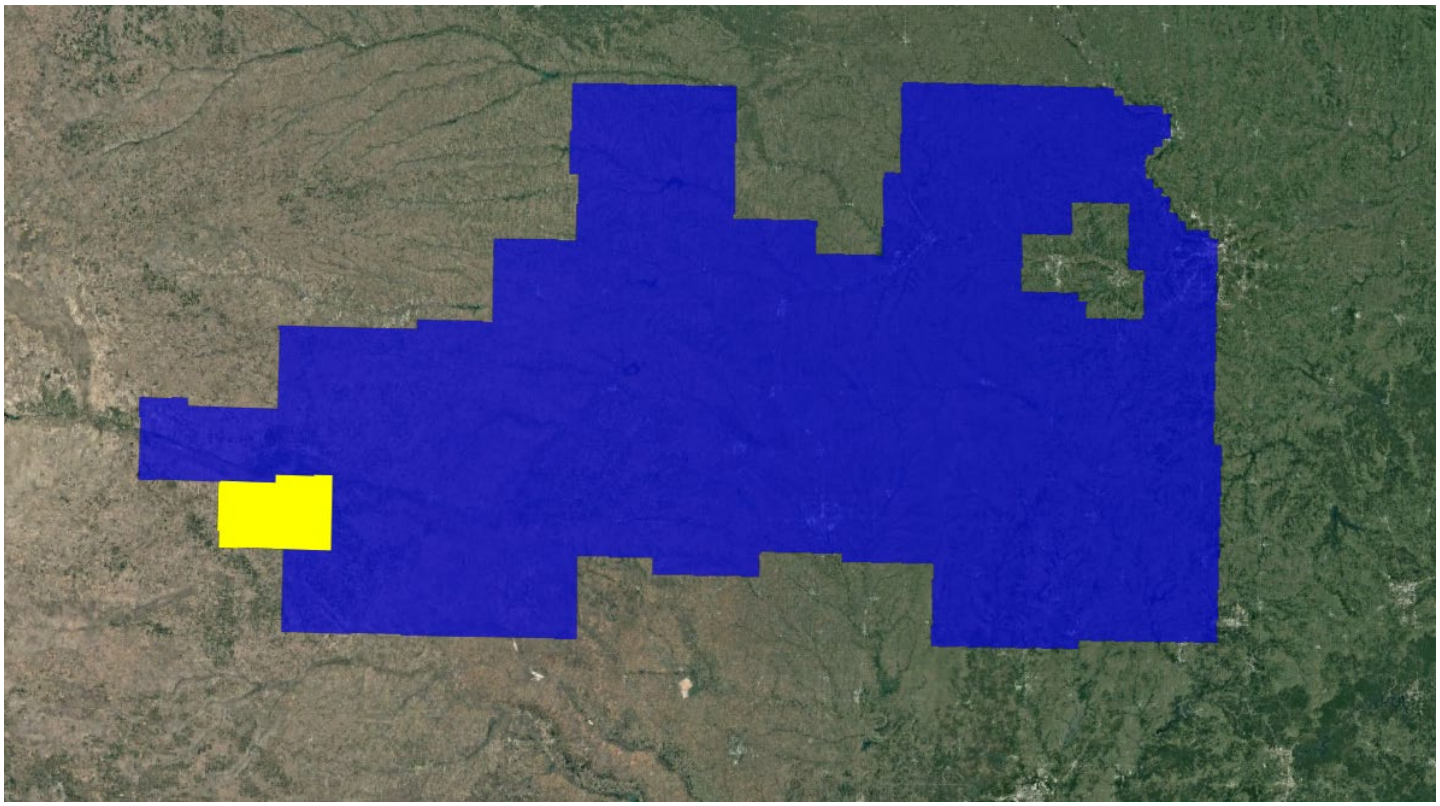


Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) and Associated Areas of Interest (AOIs)

b. Project Purpose

The State of Kansas, on behalf of the Kansas Department of Agriculture and Kansas Data Access and Support Center, has contracted with Atlantic for professional services related to the development of Light Detection and Ranging (LiDAR). Additional partners include the USDA Natural Resource Conservation Service, the U.S. Geological Survey, the Kansas GIS Policy Board, the Kansas Department of Transportation and the Kansas Water Office. These LiDAR elevation data will be used for conservation planning, design, research, floodplain mapping, wetlands identification, dam safety assessments, hydrologic modeling, and subsidence monitoring.

c. Client Contact Information

Client Contact Information	
Name of Contact	Tara Lanzrath, CFM
Organization	Kansas Department of Agriculture
Position	Floodplain Mapping Coordinator
Telephone	785-296-2513
E-Mail Address	Tara.Lanzrath@ks.gov
Mailing Address	6531 SE Forbes Ave., Suite B
City	Topeka
State or Province	Kansas
Postal Code	66619

Table 1: Aerial LiDAR Client Contact Information

d. Contract Deliverables

Item	Specification/Format
Metadata	FGDC compliant, xml format
Project Report	.pdf format
Raw Point Cloud	Swaths, LAS 1.4
Classified Point Cloud	LAS 1.4
Bare Earth DEM	ERDAS .IMG format, Hydroflattened
First Return DSM	ERDAS .IMG format
Hydro Polygon Breaklines	.gdb format
Intensity Imagery	ERDAS .IMG format

Table 2: Aerial LiDAR Contract Deliverables

SECTION II: FIELD OPERATIONS

1. Aerial LiDAR Project – Aerial Acquisition

a. Aircraft & 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

Table3: System Specifications – ALS70-HP

b. 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)	0.69
Nominal Pulse Density (pls/m²)	2.1
Nominal Flight Height (AGL meters)	2000
Nominal Flight Speed (kts)	130
Pass Heading (°)	Varies
Sensor Scan Angle (°)	45
Scan Frequency (Hz)	33.9
Pulse Rate of Scanner (kHz)	256,400
Line Spacing (m)	1,171

Parameter	Specification
Pulse Duration of Scanner (ns)	4
Pulse Width of Scanner (m)	.35
Central Wavelength of Sensor Laser (nm)	1064
Sensor Operated with Multiple Pulses	2
Beam Divergence (mrad)	.15
Nominal Swath Width (m)	1,740
Nominal Swath Overlap (%)	20
Scan Pattern	TRIANGLE

Table 4: Aerial LiDAR Sensor Acquisition Parameters

c. Flight Plan Execution

Atlantic acquired 42 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 3 flight missions conducted between December 15, 2018 and December 16, 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

d. GNSS Reference Stations

Three (3) 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.

Designation	Type	PID	Latitude (N)	Longitude (W)	Elevation
KSSY	CORS	KSSY	37°58'43.11413'	101°45'18.18781"	964.95
KSGC	CORS	KSGC	37°58'08.68605"	100°53'47.13441"	854.237
KSMD	CORS	KSMD	37°17'06.43096"	100°21'31.02753"	747.069

Table 5: GNSS Reference Stations

2. Aerial LiDAR Project – Ground Acquisition

a. Ground Control Survey

A total of 59 ground survey points were collected in support of this project, including 17 LiDAR Control Points (LCP), 23 Non-vegetated Vertical Accuracy (NVA) and 19 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 & 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:

ID	Easting	Northing	Elevation
LCP419	350210.482	4168270.613	870.906
LCP388	302405.59	4154727.581	928.003
LCP417	323206.401	4183387.934	893.86
LCP418	328737.527	4179969.6	899.468
LCP420	323473.714	4164676.026	916.698
LCP421	318847.3	4169682.54	929.598
LCP422	285213.406	4172460.299	944.047
LCP423	286934.504	4178961.06	938.939
LCP424	312560.59	4176254.912	922.739
LCP474	335365.061	4188561.598	879.955
LCP475	333841.774	4190181.769	883.968
LCP516	329796.695	4152359.152	898.471
LCP517	302448.286	4152263.332	904.124
LCP518	291921.362	4154977.852	920.52
LCP577	322905.459	4197673.195	891.655
LCP579	291358.356	4162059.024	931.835
LCP585	335136.577	4168606.211	894.787

Table 6: LiDAR Control Point Coordinates

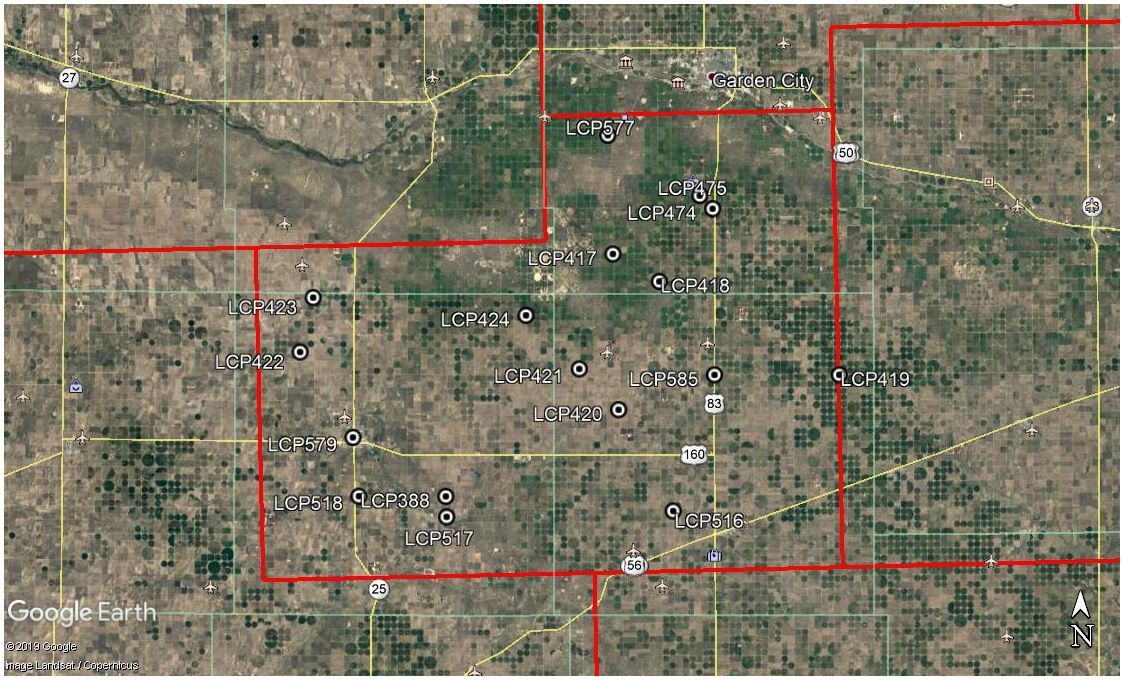


Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
NVA413	333843.404	4190195.99	883.892
NVA414	285205.419	4172461.524	944.051
NVA415	323206.379	4183377.377	893.892
NVA416	302409.619	4154718.132	927.801
NVA417	323474.023	4164670.333	916.678
NVA418	350193.873	4168282.661	871.441
NVA609	322927.74	4197678.321	891.808
NVA610	345096.856	4186106.821	866.815
NVA611	293063.3	4168141.692	938.742
NVA612	314885.469	4172198.995	927.234
NVA613	335168.749	4168590.708	894.195
NVA614	286389.581	4152631.961	953.514
NVA615	323343.125	4154524.495	901.905
NVA812	289363.188	4184079.015	959.392
NVA814	338734.548	4174948.544	877.075
NVA815	291364.513	4162047.549	931.74
NVA816	334775.411	4158889.942	897.797
NVA817	337095.626	4149608.819	887.574
NVA820	310549.541	4159286.873	923.085
NVA881	344545.962	4148997.715	877.632
NVA885	318437.493	4188846.608	905.867

ID	Easting	Northing	Elevation
NVA886	299535.298	4167535.523	948.95
NVA899	310537.13	4159293.747	922.49

Table 7: Non-Vegetated Vertical Accuracy (NVA) Point Coordinates

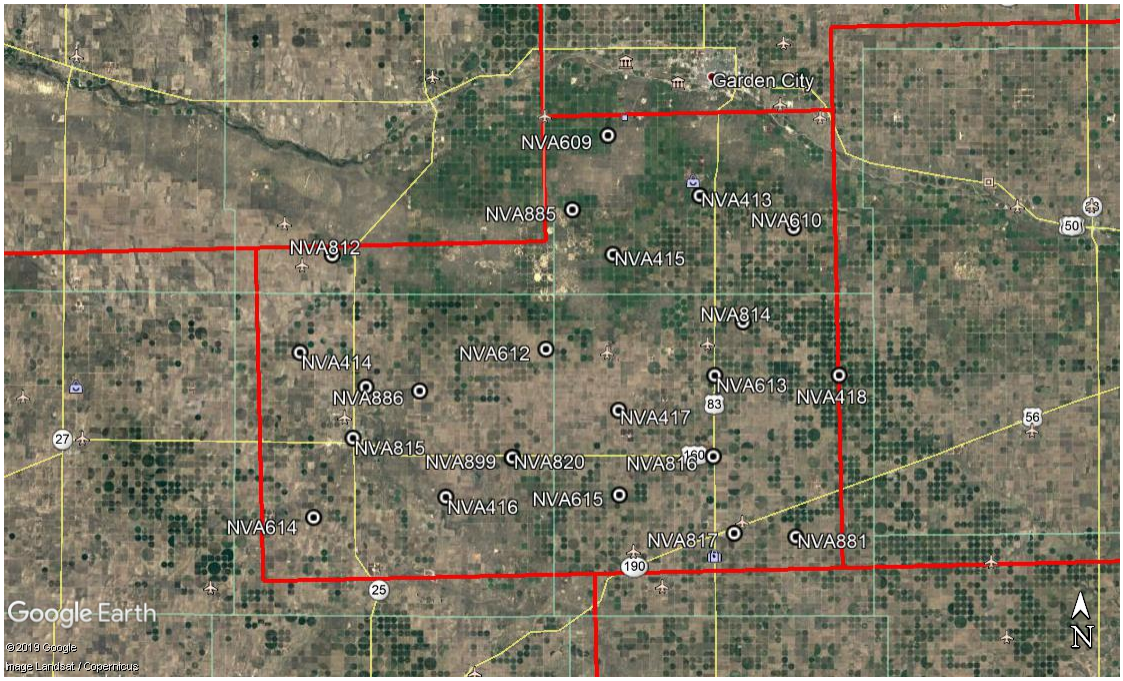


Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
VVA288	312547.558	4176259.619	922.548
VVA289	318426.501	4188849.85	906.252
VVA290	286917.024	4178964.351	939.622
VVA291	318861.291	4169674.34	929.603
VVA292	302445.608	4152272.192	904.423
VVA421	301593.416	4184587.29	924.182
VVA422	328721.207	4179974.222	899.44
VVA423	291926.984	4154991.503	919.364
VVA424	328351.892	4162459.712	905.819
VVA425	329806.807	4152356.095	897.943
VVA559	335363.517	4188573.218	879.785
VVA560	299541.287	4167521.5	949.06
VVA561	338198.207	4171824.252	881.881
VVA562	313721.169	4153957.232	926.972
VVA563	313697.846	4154104.136	926.693
VVA564	344536.348	4149009.137	877.4
VVA614	337083.093	4149598.252	887.436

ID	Easting	Northing	Elevation
VVA618	345130.425	4186107.687	867.063
VVA622	334829.748	4158875.08	896.448

Table 8: Vegetated Vertical Accuracy (VVA) Point Coordinates

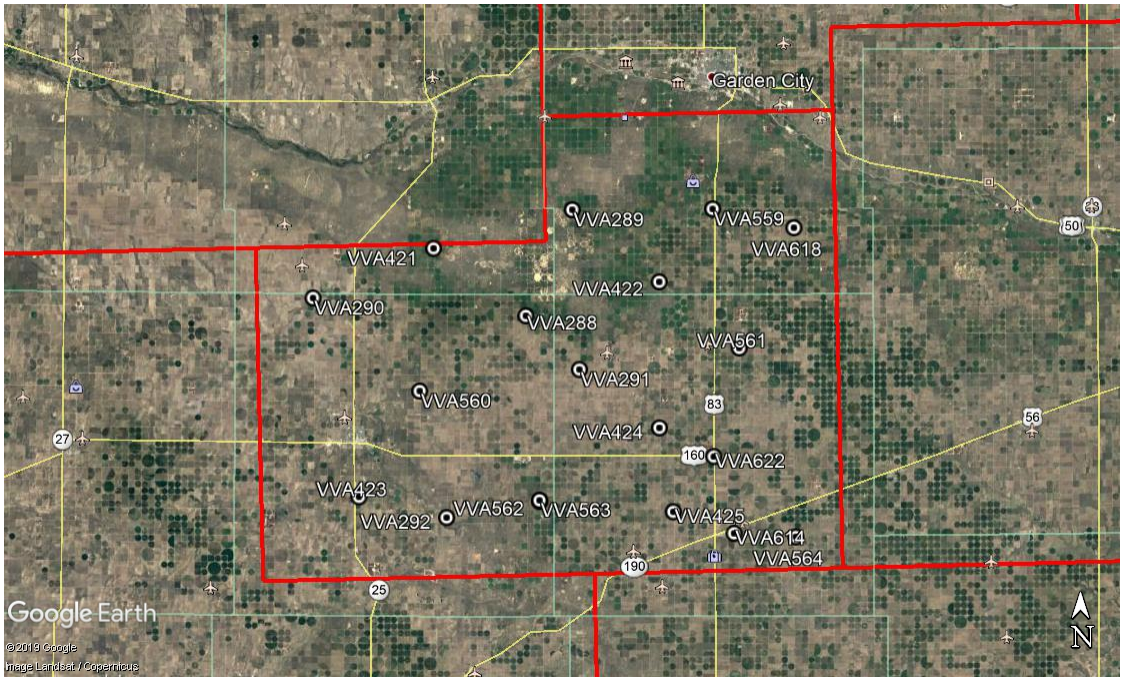


Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

SECTION III: DATA PRODUCTION

3. Aerial LiDAR Project – Calibration/Classification

a. 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.

b. Coordinate Reference System

Horizontal Datum: NAD83(ITRF96)
Coordinate System: UTM, 14N
Vertical Datum: NAVD88
Geoid Model: 12B
Units of Reference: Meter

c. LiDAR Point Cloud Statistics

Category	Value
Total Points	10,123,344,128
Nominal Pulse Spacing (m)	0.8886
Nominal Pulse Density (pls/m²)	1.2665
Aggregate Total Points	10,123,344,128
Aggregate Nominal Pulse Spacing (m)	0.6039
Aggregate Nominal Pulse Density (pls/m²)	2.7419

Table 9: LiDAR Point Cloud Statistics

d. 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. The following figure depicts a sample of the assessment.

e. 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.

f. 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 classes 9 (Water) and 10 (Ignored Ground).

Code	Description
1	Unclassified
2	Ground
7	Low point (noise)
9	Water
10	Ignored ground (breakline proximity)
17	Bridge
18	High point (noise)

Table 10: LiDAR Point Classification Codes and Descriptions

g. 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 0.5-meter cell size. Intensity images were cut to match the tile index and its corresponding tile names and delivered in .img format.

h. 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.

i. 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 .img format.

j. Surface-Digital Elevation Model (DSM)

Surface digital elevation models (DSMs) were derived using all first return LiDAR points, excluding LiDAR points classified as high or low noise. All DSMs were created with a grid spacing of 1 meter. DSMs for this project were cut to match the tile index and its corresponding tile names and delivered in 32-bit floating point .img format.

SECTION IV: ACCURACY ASSESSMENT

1. Aerial LiDAR Project – Vertical Accuracy Assessment

a. 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 11: 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).

b. 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)	19	0.0717	0.1405	0.1347
NVA (DEM)	18	0.0747	0.1465	0.1335
VVA (Point Cloud)	16	0.1082	0.2120	0.1968
VVA (DEM)	16	0.1104	0.2163	0.1926

Table 12: NVA/VVA Accuracies

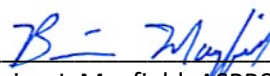
SECTION V: CERTIFICATION STATEMENTS

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.



Brian J. Mayfield, ASPRS Certified Photogrammetrist #R1276

SECTION VI: CONTROL POINT ASSESSMENTS

1. Aerial LiDAR Project

a. Point Cloud Check Point Assessment

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
NVA414	285206.1900	4172460.7970	944.0510	943.8880	-0.1630	NVA
NVA415	323207.1440	4183376.6490	893.8920	893.9070	0.0150	NVA
NVA416	302410.3880	4154717.4080	927.8010	927.9330	0.1320	NVA
NVA417	323474.7880	4164669.6080	916.6780	916.5920	-0.0860	NVA
NVA418	350194.6340	4168281.9360	871.4410	871.4940	0.0530	NVA
NVA611	293064.0700	4168140.9660	938.7420	938.7090	-0.0330	NVA
NVA612	314886.2350	4172198.2690	927.2340	927.2960	0.0620	NVA
NVA613	335169.5120	4168589.9830	894.1950	894.2110	0.0160	NVA
NVA614	286390.3530	4152631.2370	953.5140	953.5280	0.0140	NVA
NVA615	323343.8910	4154523.7720	901.9050	902.0640	0.1590	NVA
NVA812	289363.9580	4184078.2860	959.3920	959.3470	-0.0450	NVA
NVA814	338735.3110	4174947.8180	877.0750	877.0420	-0.0330	NVA
NVA815	291365.2840	4162046.8240	931.7400	931.7300	-0.0100	NVA
NVA816	334776.1750	4158889.2180	897.7970	897.7320	-0.0650	NVA
NVA817	337096.3890	4149608.0970	887.5740	887.5970	0.0230	NVA
NVA820	310550.3080	4159286.1490	923.0850	923.0230	-0.0620	NVA
NVA881	344546.7240	4148996.9930	877.6320	877.6410	0.0090	NVA
NVA886	299536.0670	4167534.7970	948.9500	948.9440	-0.0060	NVA
NVA899	310537.8980	4159293.0230	922.4900	922.5150	0.0250	NVA
VVA288	312548.3250	4176258.8920	922.5480	922.6260	0.0780	VVA
VVA290	286917.7950	4178963.6230	939.6220	939.6960	0.0740	VVA
VVA291	318862.0570	4169673.6140	929.6030	929.7430	0.1400	VVA
VVA292	302446.3770	4152271.4690	904.4230	904.6220	0.1990	VVA
VVA421	301594.1840	4184586.5610	924.1820	924.1450	-0.0370	VVA
VVA422	328721.9710	4179973.4950	899.4400	899.3980	-0.0420	VVA
VVA423	291927.7550	4154990.7790	919.3640	919.5600	0.1960	VVA
VVA424	328352.6570	4162458.9880	905.8190	905.9920	0.1730	VVA
VVA425	329807.5720	4152355.3720	897.9430	898.0120	0.0690	VVA
VVA560	299542.0560	4167520.7740	949.0600	949.1710	0.1110	VVA
VVA561	338198.9700	4171823.5260	881.8810	881.8180	-0.0630	VVA
VVA562	313721.9360	4153956.5090	926.9720	927.0230	0.0510	VVA
VVA563	313698.6130	4154103.4130	926.6930	926.7240	0.0310	VVA
VVA564	344537.1100	4149008.4150	877.4000	877.4670	0.0670	VVA
VVA614	337083.8560	4149597.5300	887.4360	887.5620	0.1260	VVA
VVA622	334830.5120	4158874.3560	896.4480	896.4510	0.0030	VVA

Table 13: Point Cloud Check Point Assessment

b. Digital Elevation Model (DEM) Check Point Assessment

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
NVA414	285206.1900	4172460.7970	944.0510	943.8774	-0.1736	NVA
NVA415	323207.1440	4183376.6490	893.8920	893.9373	0.0453	NVA
NVA416	302410.3880	4154717.4080	927.8010	927.9327	0.1317	NVA
NVA417	323474.7880	4164669.6080	916.6780	916.5737	-0.1043	NVA
NVA611	293064.0700	4168140.9660	938.7420	938.7479	0.0059	NVA
NVA612	314886.2350	4172198.2690	927.2340	927.3022	0.0682	NVA
NVA613	335169.5120	4168589.9830	894.1950	894.2156	0.0206	NVA
NVA614	286390.3530	4152631.2370	953.5140	953.5332	0.0192	NVA
NVA615	323343.8910	4154523.7720	901.9050	902.0492	0.1442	NVA
NVA812	289363.9580	4184078.2860	959.3920	959.3526	-0.0395	NVA
NVA814	338735.3110	4174947.8180	877.0750	877.0826	0.0076	NVA
NVA815	291365.2840	4162046.8240	931.7400	931.7138	-0.0262	NVA
NVA816	334776.1750	4158889.2180	897.7970	897.7317	-0.0653	NVA
NVA817	337096.3890	4149608.0970	887.5740	887.6013	0.0274	NVA
NVA820	310550.3080	4159286.1490	923.0850	923.0827	-0.0023	NVA
NVA881	344546.7240	4148996.9930	877.6320	877.6349	0.0029	NVA
NVA886	299536.0670	4167534.7970	948.9500	948.8939	-0.0561	NVA
NVA899	310537.8980	4159293.0230	922.4900	922.5483	0.0583	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA288	312548.3250	4176258.8920	922.5480	922.6073	0.0593	VVA
VVA290	286917.7950	4178963.6230	939.6220	939.6994	0.0774	VVA
VVA291	318862.0570	4169673.6140	929.6030	929.7405	0.1375	VVA
VVA292	302446.3770	4152271.4690	904.4230	904.6206	0.1976	VVA
VVA421	301594.1840	4184586.5610	924.1820	924.1611	-0.0209	VVA
VVA422	328721.9710	4179973.4950	899.4400	899.4138	-0.0262	VVA
VVA423	291927.7550	4154990.7790	919.3640	919.5500	0.1860	VVA
VVA424	328352.6570	4162458.9880	905.8190	906.0099	0.1910	VVA
VVA425	329807.5720	4152355.3720	897.9430	897.9859	0.0429	VVA
VVA560	299542.0560	4167520.7740	949.0600	949.1774	0.1174	VVA
VVA561	338198.9700	4171823.5260	881.8810	881.7996	-0.0814	VVA
VVA562	313721.9360	4153956.5090	926.9720	927.0489	0.0769	VVA
VVA563	313698.6130	4154103.4130	926.6930	926.7380	0.0450	VVA
VVA564	344537.1100	4149008.4150	877.4000	877.4564	0.0564	VVA
VVA614	337083.8560	4149597.5300	887.4360	887.5826	0.1467	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA622	334830.5120	4158874.3560	896.4480	896.4270	-0.0210	VVA

Table 14: DEM Check Point Assessment