Project Report

TASK ORDER NAME: 2018 Kansas QL2 LiDAR
CONTRACT ID: 00000000000000000000039891
EVENT ID: EVT0003259
ATLANTIC PROJECT NUMBER: 18006
PROJECT BLOCK NUMBER: Block 12

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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 12 encompasses part or all of 2 counties in Southern Kansas and covers approximately 1535 square miles.

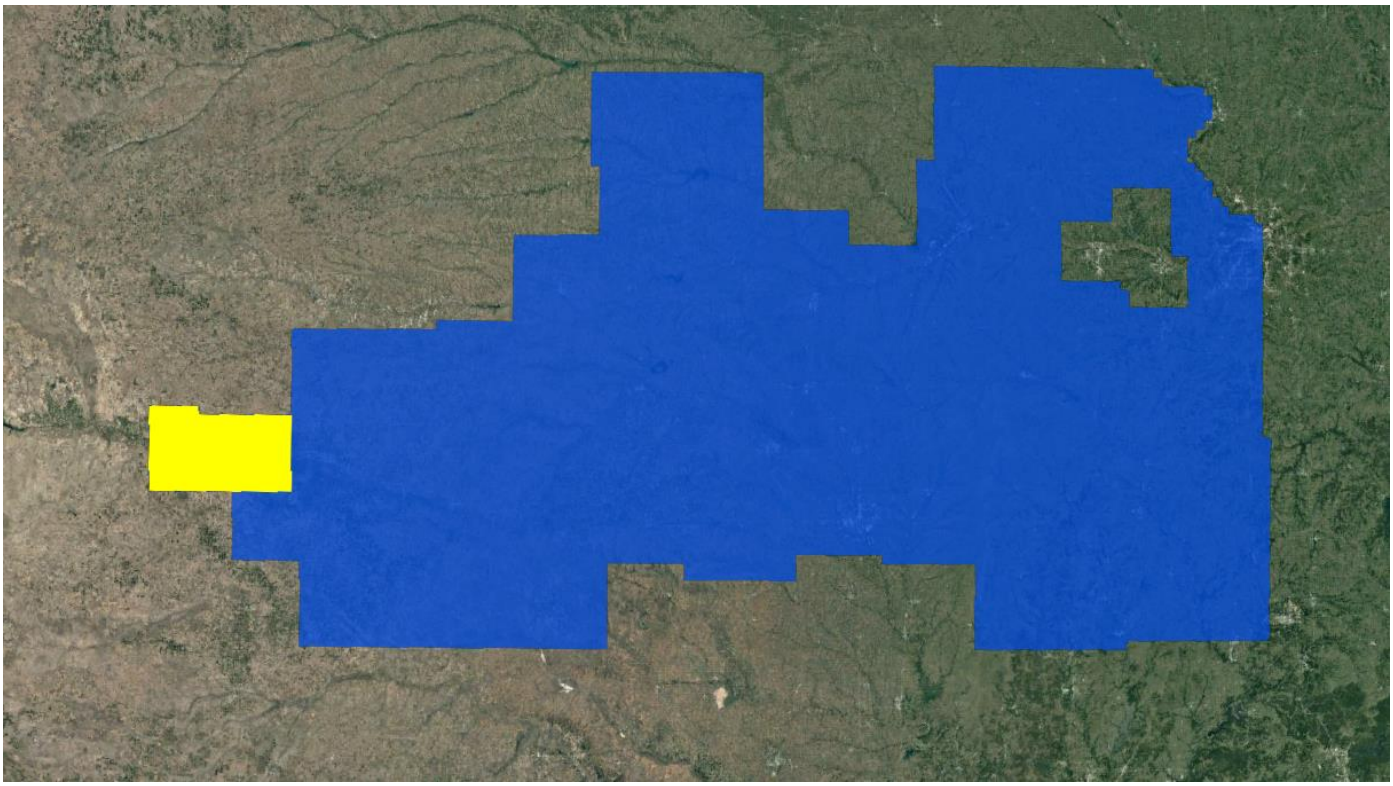


Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) and Associated Areas of Interest (AOIs)

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)	0.71
Nominal Pulse Density (pls/m²)	2.2
Nominal Flight Height (AGL meters)	2000
Nominal Flight Speed (kts)	130
Pass Heading (°)	0
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 52 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 6 flight missions conducted between November 26, 2018 and December 15, 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.

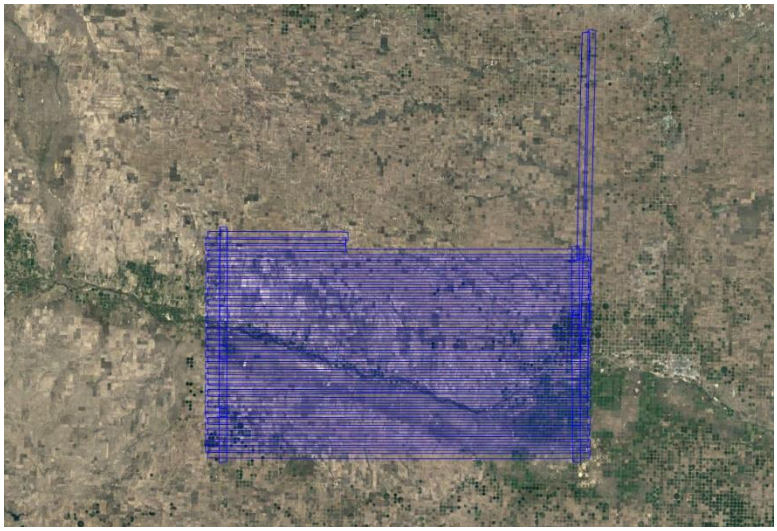


Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

d. GNSS Reference Stations

Five (5) 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
KSDT	CORS	KSDT	38°28'46.22580"	100°28'06.34232"	823.395
KSGC	CORS	KSGC	37°58'08.68605"	100°53'47.13440"	854.237
KSMD	CORS	KSMD	37°17'06.43096"	100°21'31.02751	747.069
KSSY	CORS	KSSY	37°58'43.11413"	101°45'18.18780"	964.95
KSTB	CORS	KSTB	38°28'05.28179"	101°45'08.09433"	1083.673

Table 5: GNSS Reference Stations

2. Aerial LiDAR Project – Ground Acquisition

a. Ground Control Survey

A total of 65 ground survey points were collected in support of this project, including 19 LiDAR Control Points (LCP), 27 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
LCP288	237128.108	4227834.266	1129.293
LCP289	243239.726	4218027.907	1065.97
LCP425	308793.743	4189009.225	914.599
LCP426	306665.433	4205197.525	920.354
LCP427	283236.947	4198208.512	949.043
LCP428	236669.449	4212371.882	1016.855
LCP429	247339.724	4194524.926	1099.908
LCP430	267089.23	4189916.806	1043.013
LCP431	277598.283	4189604.279	1001.326
LCP508	299272.479	4211841.541	986.777
LCP509	296037.3	4226412.985	990.326
LCP510	283738.517	4226673.133	1025.812
LCP511	272000.234	4214055.448	1027.243
LCP512	283168.41	4204905.194	1001.506
LCP513	286494.565	4208895.479	1009.154
LCP514	262175.423	4219078.334	1041.413
LCP581	258660.637	4208491.347	1008.089
LCP590	251673.648	4231465.699	1116.284
LCP598	286757.196	4218701.968	1010.943

Table 6: LiDAR Control Point Coordinates

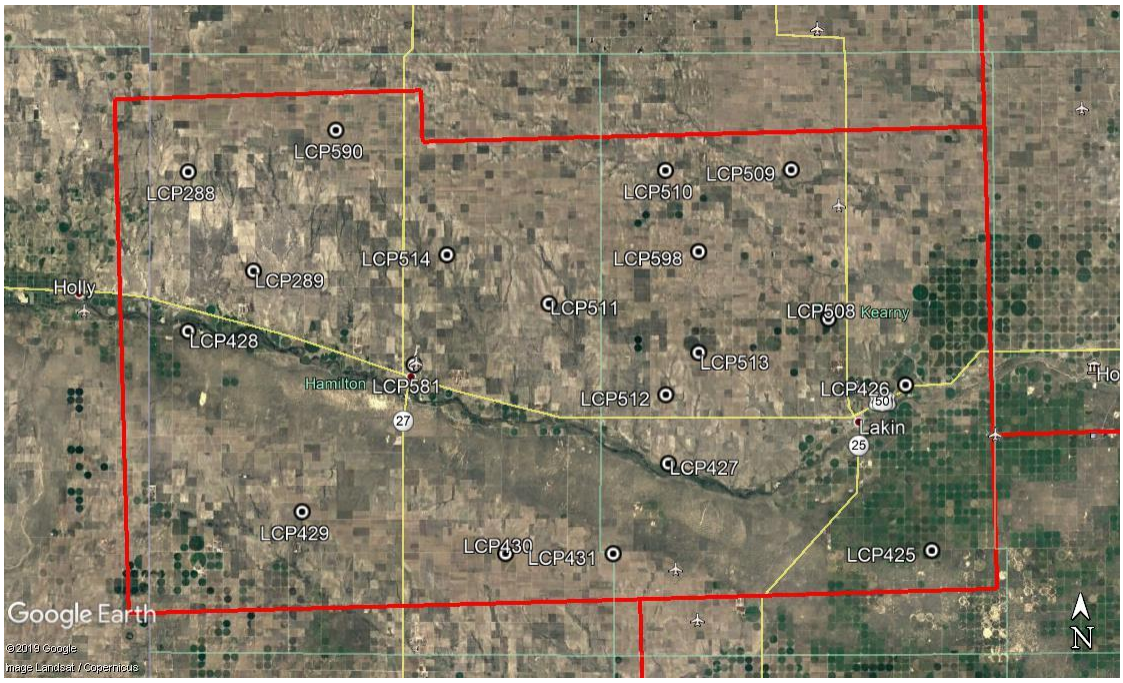


Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
NVA341	286502.757	4208888.886	1009.193
NVA343	283743.821	4226662.719	1025.87
NVA344	243205.376	4218009.665	1066.14
NVA345	247328.519	4194522.712	1099.796
NVA346	271997.64	4214064.562	1026.92
NVA347	267080.77	4189919.723	1043.054
NVA348	236669.306	4212373.578	1016.82
NVA411	283235.377	4198212.296	949.197
NVA412	308793.217	4189004.563	914.61
NVA538	305952.147	4216524.239	949.228
NVA541	286746.489	4218702.836	1010.435
NVA546	263095.346	4184648.91	1035.458
NVA547	248451.391	4230150.871	1127.439
NVA548	241080.564	4198210.334	1120.932
NVA549	264067.305	4209375.044	1019.293
NVA550	251410.949	4224254.151	1108.36
NVA737	312301.386	4205595.043	898.618
NVA742	299264.971	4211838.365	986.885
NVA744	272501.926	4228527.115	1051.776
NVA745	276191.727	4201444.073	956.674
NVA746	252310.728	4213093.628	1022.357

ID	Easting	Northing	Elevation
NVA747	246590.993	4190515.378	1048.817
NVA748	258647.327	4208491.175	1008.193
NVA811	300654.62	4201651.216	920.333
NVA887	291523.697	4195682.581	933.106
NVA898	286676.404	4215337.093	1016.022
NVA936	252281.542	4213074.582	1022.28

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

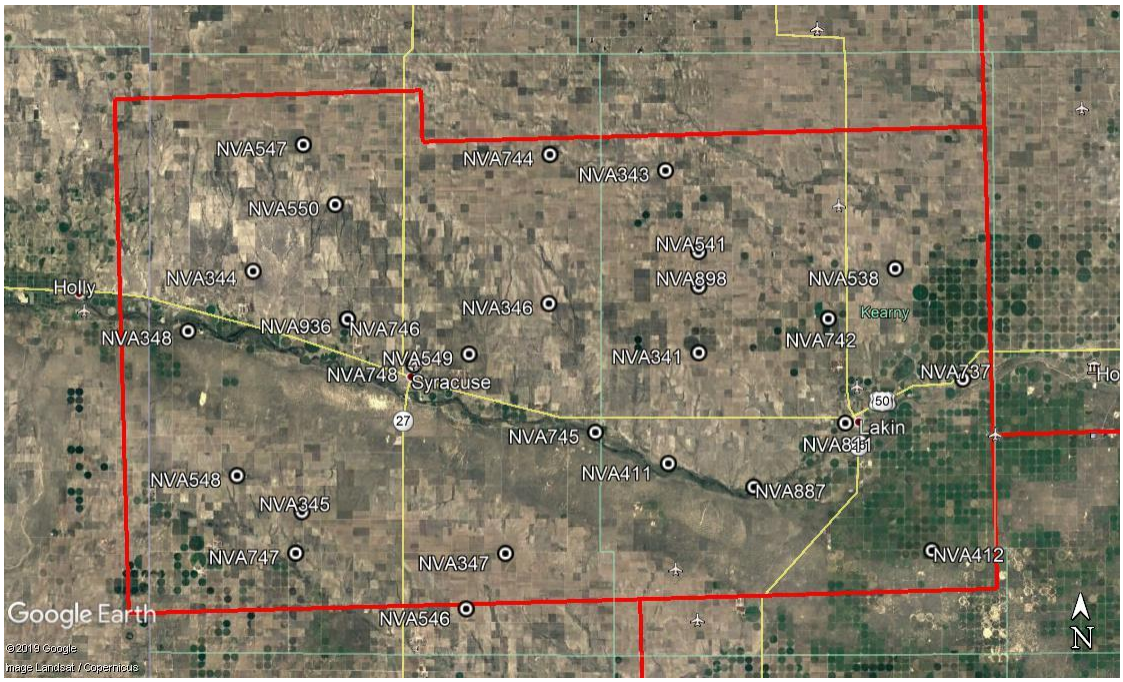


Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
VVA236	283187.526	4204891.208	1000.961
VVA237	296026.284	4226425.41	990.231
VVA243	237133.962	4227827.439	1128.979
VVA244	277582.201	4189598.102	1001.27
VVA245	265955.692	4223831.736	1071.373
VVA370	312348.633	4216535.917	920.646
VVA373	286677.226	4215318.066	1015.725
VVA377	262172.984	4196506.971	1007.066
VVA378	251658.823	4231451.023	1116.291
VVA379	238538.328	4190706.56	1060.39
VVA515	306665.066	4205206.262	920.381
VVA520	233592.389	4200598.324	1090.033
VVA521	262171.019	4219087.992	1040.725
VVA558	291525.708	4195690.467	932.631

ID	Easting	Northing	Elevation
VVA619	300691.751	4201682.119	920.872
VVA620	276164.503	4201418.152	956.032
VVA633	312340.435	4216531.425	920.605
VVA634	264067.009	4209339.82	1019.004
VVA670	251404.022	4224197.482	1107.125

Table 8: Vegetated Vertical Accuracy (VVA) Point Coordinates

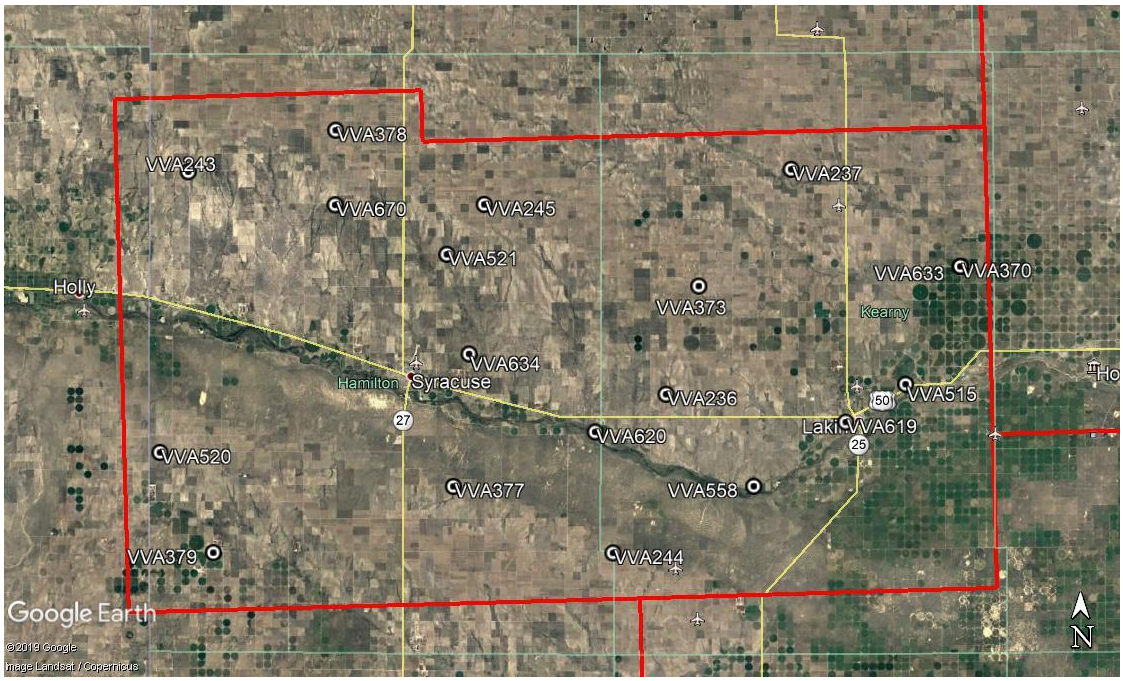


Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

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 (Nominal)	12,167,181,842
Nominal Pulse Spacing (M)	0.6758
Nominal Pulse Density (PLS/M^2)	2.1895
Total Points (Aggregate)	11,716,663,803
Aggregate Pulse Spacing (M)	0.5923
Aggregate Pulse Density (PLS/M^2)	2.8502

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)	26	0.0535	0.1049	0.0688
NVA (DEM)	26	0.0526	0.1031	0.0698
VVA (Point Cloud)	19	0.0572	0.1121	0.1192
VVA (DEM)	19	0.0611	0.1198	0.1246

Table 12: NVA/VVA Accuracies

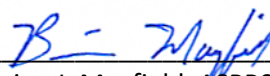
SECTION V: CERTIFICATION STATEMENTS

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
NVA341	286502.7570	4208888.8860	1009.1930	1009.1660	-0.0270	NVA
NVA343	283743.8210	4226662.7190	1025.8700	1025.8380	-0.0320	NVA
NVA344	243205.3760	4218009.6650	1066.1400	1066.1010	-0.0390	NVA
NVA345	247328.5190	4194522.7120	1099.7960	1099.7700	-0.0260	NVA
NVA346	271997.6400	4214064.5620	1026.9200	1026.9310	0.0110	NVA
NVA347	267080.7700	4189919.7230	1043.0540	1043.0300	-0.0240	NVA
NVA348	236669.3060	4212373.5780	1016.8200	1016.8260	0.0064	NVA
NVA411	283235.3770	4198212.2960	949.1970	949.1410	-0.0570	NVA
NVA412	308793.2170	4189004.5630	914.6100	914.6360	0.0260	NVA
NVA538	305952.1470	4216524.2390	949.2280	949.3750	0.1470	NVA
NVA541	286746.4890	4218702.8360	1010.4350	1010.4390	0.0035	NVA
NVA547	248451.3910	4230150.8710	1127.4390	1127.4050	-0.0340	NVA
NVA548	241080.5640	4198210.3340	1120.9320	1120.9240	-0.0077	NVA
NVA549	264067.3050	4209375.0440	1019.2930	1019.2780	-0.0150	NVA
NVA550	251410.9490	4224254.1510	1108.3600	1108.3700	0.0096	NVA
NVA737	312301.3860	4205595.0430	898.6180	898.5550	-0.0630	NVA
NVA742	299264.9710	4211838.3650	986.8850	986.9140	0.0290	NVA
NVA744	272501.9260	4228527.1150	1051.7760	1051.6940	-0.0820	NVA
NVA745	276191.7270	4201444.0730	956.6740	956.5650	-0.1090	NVA
NVA746	252310.7280	4213093.6280	1022.3570	1022.3420	-0.0150	NVA
NVA747	246590.9930	4190515.3780	1048.8170	1048.7640	-0.0530	NVA
NVA748	258647.3270	4208491.1750	1008.1930	1008.1520	-0.0410	NVA
NVA811	300654.6200	4201651.2160	920.3330	920.3360	0.0034	NVA
NVA887	291523.6970	4195682.5810	933.1060	933.0270	-0.0790	NVA
NVA898	286676.4040	4215337.0930	1016.0220	1016.1040	0.0820	NVA
NVA936	252281.5420	4213074.5820	1022.2800	1022.2400	-0.0400	NVA
VVA236	283187.5260	4204891.2080	1000.9610	1001.0490	0.0880	VVA
VVA237	296026.2840	4226425.4100	990.2310	990.2890	0.0580	VVA
VVA243	237133.9620	4227827.4390	1128.9790	1128.9340	-0.0450	VVA
VVA244	277582.2010	4189598.1020	1001.2700	1001.3890	0.1190	VVA
VVA245	265955.6920	4223831.7360	1071.3730	1071.3820	0.0085	VVA
VVA370	312348.6330	4216535.9170	920.6460	920.6470	0.0007	VVA
VVA373	286677.2260	4215318.0660	1015.7250	1015.7420	0.0170	VVA
VVA377	262172.9840	4196506.9710	1007.0660	1007.0240	-0.0420	VVA
VVA378	251658.8230	4231451.0230	1116.2910	1116.2720	-0.0190	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
VVA379	238538.3280	4190706.5600	1060.3900	1060.4100	0.0200	VVA
VVA515	306665.0660	4205206.2620	920.3810	920.4040	0.0230	VVA
VVA520	233592.3890	4200598.3240	1090.0330	1090.1200	0.0870	VVA
VVA521	262171.0190	4219087.9920	1040.7250	1040.7470	0.0220	VVA
VVA558	291525.7080	4195690.4670	932.6310	932.5890	-0.0420	VVA
VVA619	300691.7510	4201682.1190	920.8720	920.9010	0.0290	VVA
VVA620	276164.5030	4201418.1520	956.0320	956.0210	-0.0110	VVA
VVA633	312340.4350	4216531.4250	920.6050	920.7260	0.1210	VVA
VVA634	264067.0090	4209339.8200	1019.0040	1019.0570	0.0530	VVA
VVA670	251404.0220	4224197.4820	1107.1250	1107.1820	0.0570	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
NVA341	286502.7570	4208888.8860	1009.1930	1009.1644	-0.0286	NVA
NVA343	283743.8210	4226662.7190	1025.8700	1025.8503	-0.0197	NVA
NVA344	243205.3760	4218009.6650	1066.1400	1066.1033	-0.0367	NVA
NVA345	247328.5190	4194522.7120	1099.7960	1099.7765	-0.0195	NVA
NVA346	271997.6400	4214064.5620	1026.9200	1026.9341	0.0141	NVA
NVA347	267080.7700	4189919.7230	1043.0540	1043.0288	-0.0252	NVA
NVA348	236669.3060	4212373.5780	1016.8200	1016.8228	0.0028	NVA
NVA411	283235.3770	4198212.2960	949.1970	949.1367	-0.0603	NVA
NVA412	308793.2170	4189004.5630	914.6100	914.6403	0.0303	NVA
NVA538	305952.1470	4216524.2390	949.2280	949.3728	0.1448	NVA
NVA541	286746.4890	4218702.8360	1010.4350	1010.4323	-0.0027	NVA
NVA547	248451.3910	4230150.8710	1127.4390	1127.3982	-0.0408	NVA
NVA548	241080.5640	4198210.3340	1120.9320	1120.9126	-0.0194	NVA
NVA549	264067.3050	4209375.0440	1019.2930	1019.3089	0.0159	NVA
NVA550	251410.9490	4224254.1510	1108.3600	1108.3748	0.0148	NVA
NVA737	312301.3860	4205595.0430	898.6180	898.5598	-0.0582	NVA
NVA742	299264.9710	4211838.3650	986.8850	986.9106	0.0256	NVA
NVA744	272501.9260	4228527.1150	1051.7760	1051.6946	-0.0814	NVA
NVA745	276191.7270	4201444.0730	956.6740	956.5778	-0.0962	NVA
NVA746	252310.7280	4213093.6280	1022.3570	1022.3433	-0.0137	NVA
NVA747	246590.9930	4190515.3780	1048.8170	1048.7543	-0.0627	NVA
NVA748	258647.3270	4208491.1750	1008.1930	1008.1610	-0.0320	NVA
NVA811	300654.6200	4201651.2160	920.3330	920.3332	0.0002	NVA
NVA887	291523.6970	4195682.5810	933.1060	933.0356	-0.0704	NVA
NVA898	286676.4040	4215337.0930	1016.0220	1016.1049	0.0829	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
NVA936	252281.5420	4213074.5820	1022.2800	1022.2229	-0.0571	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA236	283187.5260	4204891.2080	1000.9610	1001.0603	0.0993	VVA
VVA237	296026.2840	4226425.4100	990.2310	990.2780	0.0470	VVA
VVA243	237133.9620	4227827.4390	1128.9790	1128.9190	-0.0600	VVA
VVA244	277582.2010	4189598.1020	1001.2700	1001.3934	0.1234	VVA
VVA245	265955.6920	4223831.7360	1071.3730	1071.3839	0.0109	VVA
VVA370	312348.6330	4216535.9170	920.6460	920.6632	0.0172	VVA
VVA373	286677.2260	4215318.0660	1015.7250	1015.7457	0.0207	VVA
VVA377	262172.9840	4196506.9710	1007.0660	1007.0331	-0.0329	VVA
VVA378	251658.8230	4231451.0230	1116.2910	1116.2556	-0.0354	VVA
VVA379	238538.3280	4190706.5600	1060.3900	1060.4156	0.0256	VVA
VVA515	306665.0660	4205206.2620	920.3810	920.4023	0.0213	VVA
VVA520	233592.3890	4200598.3240	1090.0330	1090.1233	0.0903	VVA
VVA521	262171.0190	4219087.9920	1040.7250	1040.7576	0.0326	VVA
VVA558	291525.7080	4195690.4670	932.6310	932.5901	-0.0409	VVA
VVA619	300691.7510	4201682.1190	920.8720	920.9096	0.0376	VVA
VVA620	276164.5030	4201418.1520	956.0320	956.0176	-0.0144	VVA
VVA633	312340.4350	4216531.4250	920.6050	920.7402	0.1352	VVA
VVA634	264067.0090	4209339.8200	1019.0040	1019.0447	0.0407	VVA
VVA670	251404.0220	4224197.4820	1107.1250	1107.1825	0.0575	VVA

Table 14: DEM Check Point Assessment