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SECTION I: PROJECT OVERVIEW & PURPOSE

1. Aerial LiDAR Project

a. Project Overview

The State of Kansas Contract 0000000000000000000039891 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 5 encompasses part or all of 7 counties in Southern Kansas and covers 3,088.81 square miles.

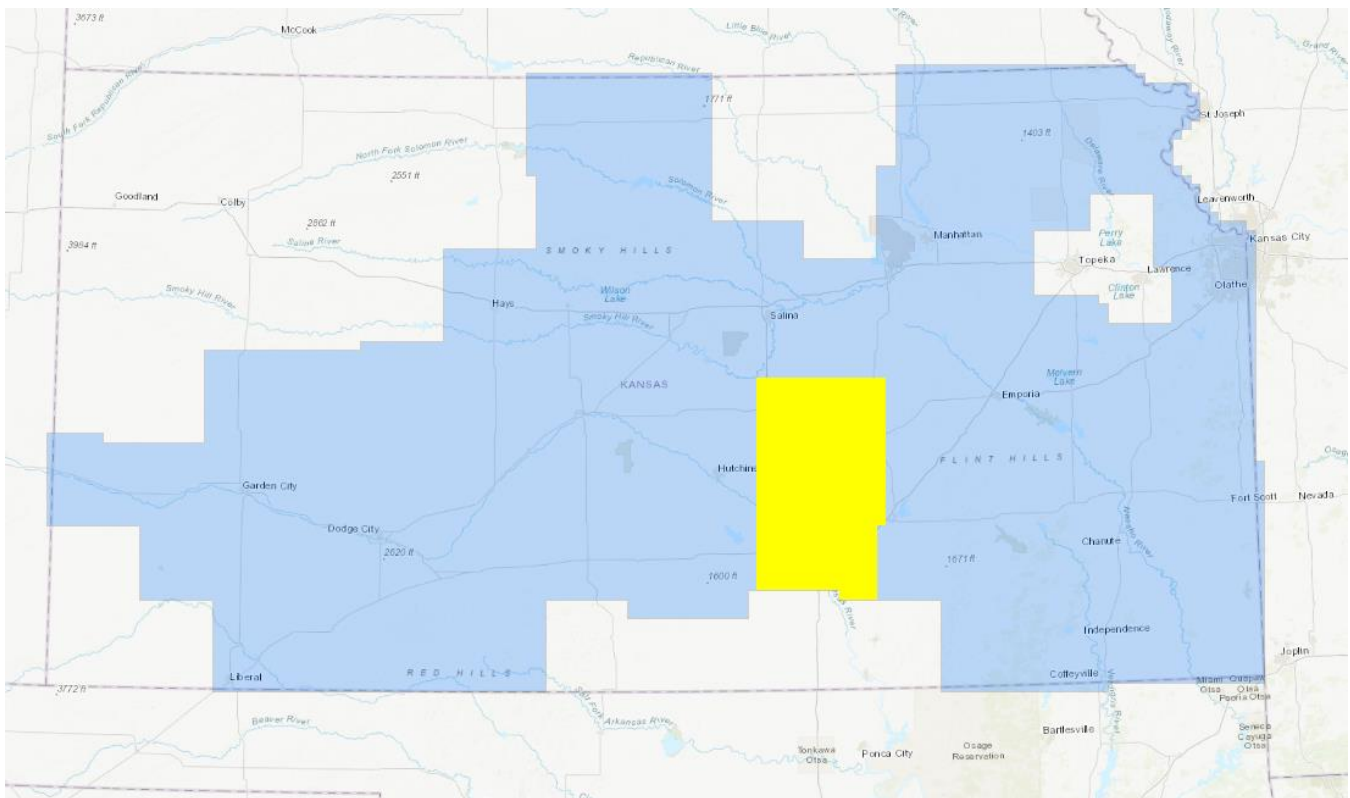


Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) and Associated Areas of Interest (AOIs)

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

Table 3: 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 130 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 10 flight missions conducted between January 18, 2018 and March 2, 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.

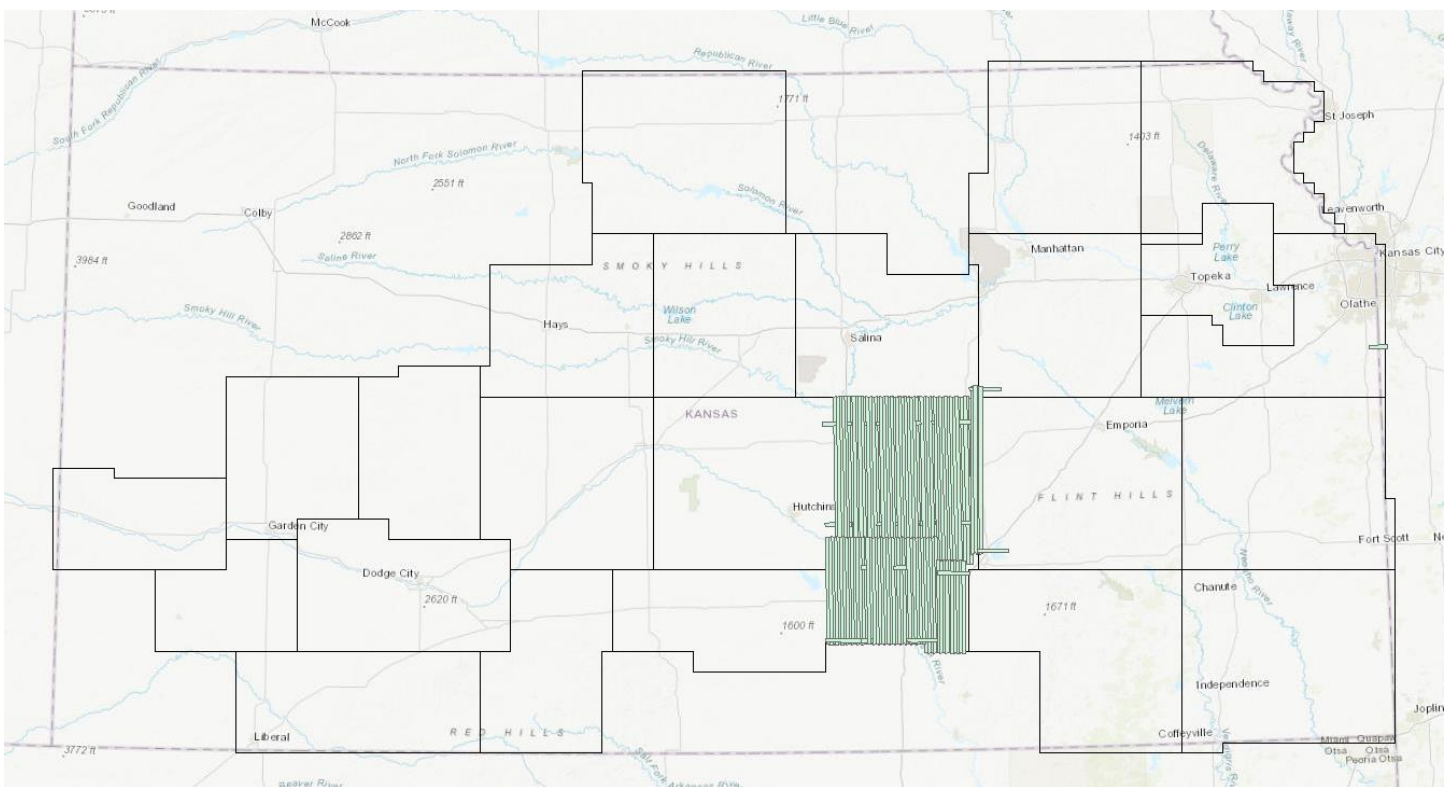


Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

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
ICT1	CORS	ICT1	37°35'15.77364"	97°18'31.95902"	364.421m
ICT3	CORS	ICT3	37°45'09.3125"	97°12'58.38091"	402.344m
ICT4	CORS	ICT4	37°37'08.55554"	97°37'56.95836"	393.243m
ICT5	CORS	ICT5	37°47'12.01942"	97°37'32.69189"	412.188m
KSU1	CORS	KSU1	39°06'02.67728"	96°36'34.09361"	326.637m

Table 5: GNSS Reference Stations

2. Aerial LiDAR Project – Ground Acquisition

a. Ground Control Survey

A total of 115 ground survey points were collected in support of this project, including 38 LiDAR Control Points (LCP), 52 Non-vegetated Vertical Accuracy (NVA) and 25 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
LCP166	659290.541	4193015.43	420.802
LCP169	657430.477	4205620.896	433.872
LCP170	673657.066	4197922.652	415.381
LCP171	668880.973	4196244.635	405.695
LCP172	675612.055	4163223.46	366.668
LCP173	672398.53	4154325.62	365.699
LCP175	682935.841	4206126.597	446.925
LCP177	675132.394	4207606.409	413.261
LCP178	651378.917	4221708.503	458.093
LCP179	676279.112	4228557.085	418.973
LCP180	678560.935	4232642.505	393.776
LCP181	682729.998	4228654.945	435.187
LCP182	664231.968	4212448.608	442.039
LCP192	636656.734	4266502.647	407.247
LCP193	617497.981	4259772.834	460.551
LCP196	666046.89	4262796.192	430.125
LCP197	651678.837	4260113.152	433.44
LCP198	646902.573	4257029.115	464.866

ID	Easting	Northing	Elevation
LCP199	661988.932	4234891.025	436.248
LCP201	651332.015	4233063.605	469.605
LCP202	637154.724	4239145.011	466.323
LCP311	640157.517	4184398.547	409.283
LCP312	627029.734	4194865.227	426.415
LCP313	617328.419	4193344.14	436.855
LCP314	623903.693	4187370.367	429.929
LCP315	626526.849	4176559.183	440.388
LCP316	631187.52	4156686.025	407.263
LCP317	637269.224	4163396.164	397.47
LCP318	616655.662	4237195.933	446.024
LCP319	628763.65	4216445.468	433.04
LCP320	625235.112	4205656.962	435.408
LCP522	620855.703	4183522.896	435.519
LCP523	662780.692	4149197.318	404.33
LCP524	637974.989	4197880.545	419.188
LCP525	670854.666	4164560.19	407.214
LCP531	682033.994	4223812.089	428.846
LCP543	673048.525	4246109.159	398.573
LCP544	635802.671	4245571.809	480.785

Table 63: LiDAR Control Point Coordinates

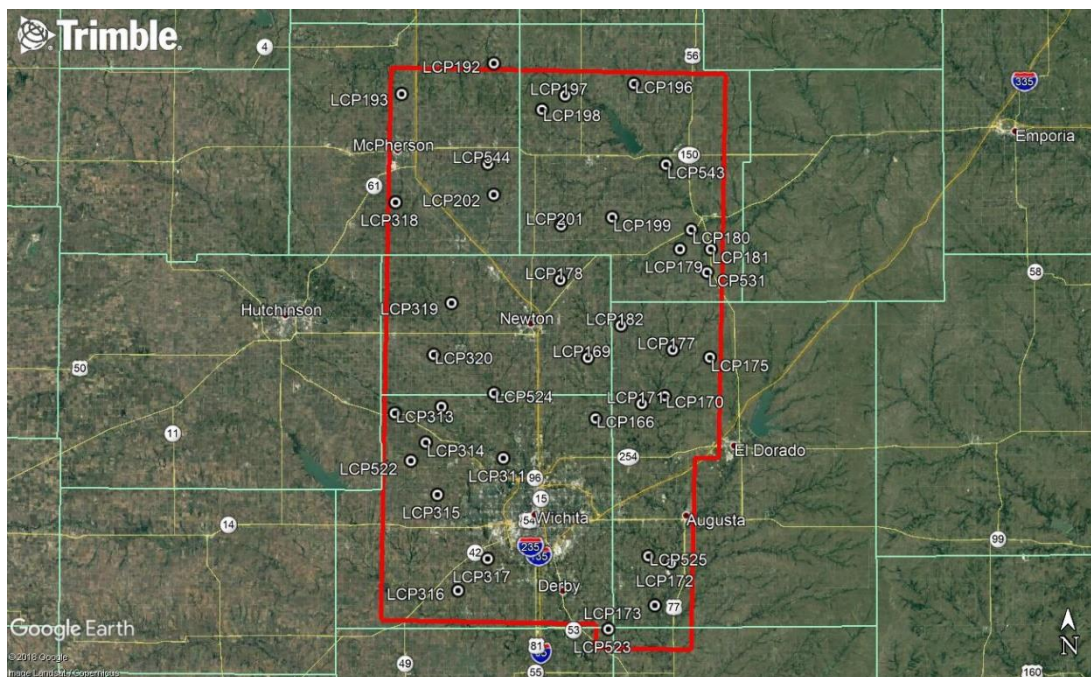


Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
NVA269	626532.275	4176561.459	440.432
NVA270	617334.581	4193326.903	437.068
NVA271	631190.251	4156690.478	407.323
NVA272	662236.425	4163750.082	409.006
NVA387	617475.055	4259780.015	460.134
NVA388	646879.012	4257049.937	464.62
NVA389	666022.599	4262775.823	429.687
NVA390	628775.531	4216428.242	433.559
NVA393	637173.224	4239118.788	465.487
NVA395	668879.865	4196228.589	406.033
NVA396	664239.578	4212412.24	441.791
NVA397	651393.901	4221722.403	458.145
NVA398	678537.926	4232654.204	393.831
NVA405	682749.907	4228654.479	435.761
NVA443	675622.995	4163220.283	366.21
NVA460	633472.371	4189084.126	417.726
NVA461	622182.318	4161295.452	426.319
NVA462	642598.58	4149997.839	383.345
NVA463	662781.914	4149187.086	404.008
NVA467	647723.917	4205033.772	442.336
NVA588	663799.812	4254128.734	415.945
NVA589	619224.496	4229202.377	440.947
NVA590	632600.382	4260031.363	455.29
NVA594	621938.109	4206434.665	436.588
NVA596	618291.397	4237739.402	449.744
NVA597	679212.716	4256079.783	435.585
NVA642	670853.241	4164537.632	407.099
NVA660	659412.469	4174634.554	415.554
NVA661	637982.382	4197881.597	419.202
NVA662	640873.974	4172297.874	398.243
NVA663	620836.56	4183523.203	435.359
NVA664	616352.713	4168761.232	442.339
NVA665	653754.948	4156367.175	384.74
NVA666	619875.921	4149101.749	408.809
NVA786	645403.059	4212528.698	441.685
NVA787	665848.23	4225984.716	417.488
NVA789	629259.705	4229208.038	452.061
NVA790	637344.783	4249691.576	484.182

ID	Easting	Northing	Elevation
VVA277	673661.311	4197917.383	415.513
VVA278	676278.9	4228584.776	418.779
VVA320	624731.506	4155003.648	402.06
VVA321	658576.547	4179809.939	419.515
VVA322	623933.778	4187369.604	430.294
VVA405	623510.526	4215854.539	430.397
VVA406	634621.897	4237494.332	467.328
VVA407	662017.95	4234921.966	435.642
VVA409	634099.282	4255226.207	480.91
VVA445	669446.861	4183290.829	406.93
VVA464	659835.584	4161292.113	407.733
VVA466	656040.847	4195630.066	426.559
VVA544	635778.276	4245580.823	481.181
VVA546	636625.084	4223016.892	451.963
VVA547	616212.355	4258130.955	455.611
VVA593	629251.092	4229206.621	452.113
VVA601	682478.383	4248175.36	439.569
VVA637	659415.46	4174640.508	415.673
VVA638	647700.13	4205039.513	442.019
VVA641	665827.071	4225994.628	417.586

Table 8: Vegetated Vertical Accuracy (VVA) Point Coordinates

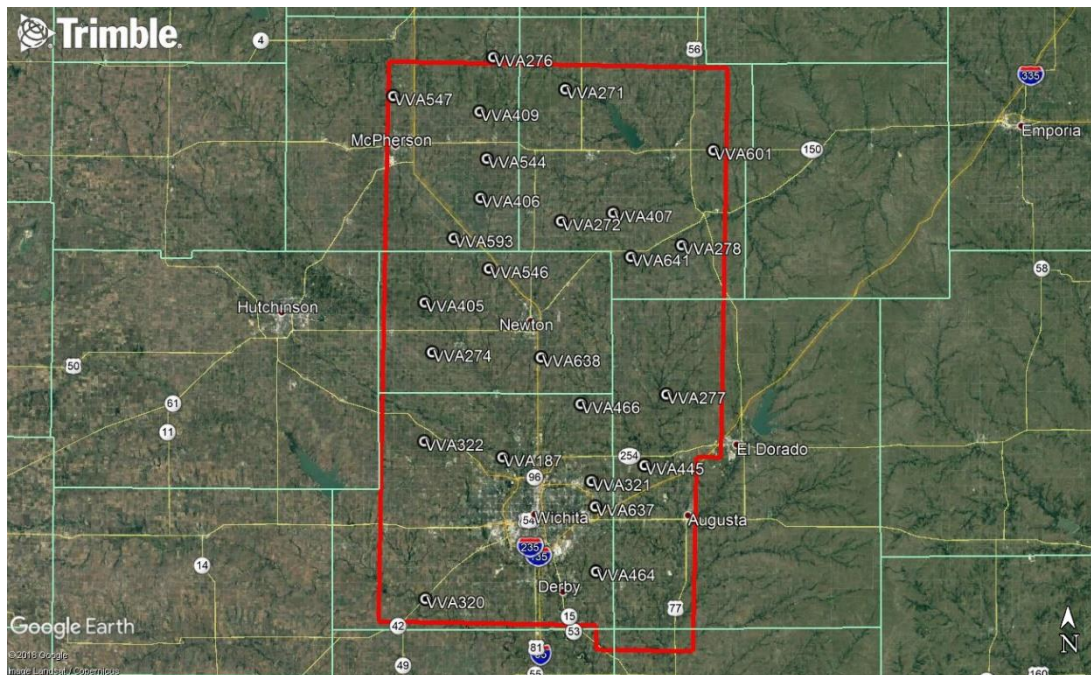


Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

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	29,651,151,201
Nominal Pulse Spacing (m)	0.6211
Nominal Pulse Density (pls/m²)	2.5922
Nominal Pulse Spacing (ft)	2.0378
Nominal Pulse Density (pls/ft²)	0.2408
Aggregate Total Points	26,244,082,827
Aggregate Nominal Pulse Spacing (m)	0.5479
Aggregate Nominal Pulse Density (pls/m²)	3.3310
Aggregate Nominal Pulse Spacing (ft)	1.7976
Aggregate Nominal Pulse Density (pls/ft²)	0.3095

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 ≤ 2 cm. 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 95 th 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	# of Points	RMSEz	95% Confidence Level	95th Percentile
NVA of Point Cloud	51	0.0835	0.1638	0.1205
NVA of DEM	41	0.0795	0.1559	0.0872
VVA of Point Cloud	33	0.1718	0.3367	0.3162
VVA of DEM	27	0.1882	0.3688	0.4015

Table 12: NVA/VVA Accuracies

SECTION V: CERTIFICATION STATEMENTS

1. Aerial LiDAR Project

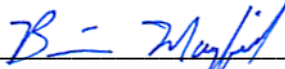
This accuracy assessment confirms that the data may be used for the intended applications stated in Section I of this document. This dataset may also be used as a topographic input for other applications, but the user should be aware that this LiDAR dataset was designed with a specific purpose and was 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	Easting	Northing	KnownZ	LaserZ	Description	DeltaZ
NVA387	617475.0550	4259780.0150	460.1340	460.1340	OPEN TERRAIN	-
NVA588	663799.8120	4254128.7340	415.9450	415.9480	OPEN TERRAIN	0.0030
NVA799	682461.5420	4248165.6010	438.6600	438.6570	OPEN TERRAIN	(0.0030)
NVA443	675622.9950	4163220.2830	366.2100	366.1990	OPEN TERRAIN	(0.0110)
NVA642	670853.2410	4164537.6320	407.0990	407.0790	OPEN TERRAIN	(0.0200)
NVA397	651393.9010	4221722.4030	458.1450	458.1200	OPEN TERRAIN	(0.0250)
NVA666	619875.9210	4149101.7490	408.8090	408.7820	OPEN TERRAIN	(0.0270)
NVA790	637344.7830	4249691.5760	484.1820	484.2110	OPEN TERRAIN	0.0290
NVA663	620836.5600	4183523.2030	435.3590	435.3280	OPEN TERRAIN	(0.0310)
NVA664	616352.7130	4168761.2320	442.3390	442.3060	OPEN TERRAIN	(0.0330)
NVA860	636611.0310	4223019.6720	451.9410	451.9740	OPEN TERRAIN	0.0330
NVA405	682749.9070	4228654.4790	435.7610	435.7270	OPEN TERRAIN	(0.0340)
NVA795	630842.5320	4206723.5460	423.9690	424.0050	OPEN TERRAIN	0.0360
NVA597	679212.7160	4256079.7830	435.5850	435.6220	OPEN TERRAIN	0.0370
NVA786	645403.0590	4212528.6980	441.6850	441.6460	OPEN TERRAIN	(0.0390)
NVA661	637982.3820	4197881.5970	419.2020	419.2420	OPEN TERRAIN	0.0400
NVA272	662236.4250	4163750.0820	409.0060	409.0560	OPEN TERRAIN	0.0500
NVA904	669463.0580	4183305.7650	407.0450	407.0960	OPEN TERRAIN	0.0510
NVA389	666022.5990	4262775.8230	429.6870	429.7410	OPEN TERRAIN	0.0540
NVA662	640873.9740	4172297.8740	398.2430	398.2970	OPEN TERRAIN	0.0540
NVA463	662781.9140	4149187.0860	404.0080	404.0660	OPEN TERRAIN	0.0580
NVA787	665848.2300	4225984.7160	417.4880	417.4300	OPEN TERRAIN	(0.0580)
NVA845	676071.2910	4153340.0060	368.1680	368.1070	OPEN TERRAIN	(0.0610)
NVA271	631190.2510	4156690.4780	407.3230	407.3860	OPEN TERRAIN	0.0630
NVA467	647723.9170	4205033.7720	442.3360	442.3990	OPEN TERRAIN	0.0630
NVA841	675643.4910	4172128.7360	375.9760	375.9100	OPEN TERRAIN	(0.0660)
NVA660	659412.4690	4174634.5540	415.5540	415.6240	OPEN TERRAIN	0.0700
NVA794	673995.7200	4200777.4820	408.8110	408.7410	OPEN TERRAIN	(0.0700)
NVA388	646879.0120	4257049.9370	464.6200	464.6910	OPEN TERRAIN	0.0710
NVA859	640147.9050	4184414.6000	409.6170	409.6890	OPEN TERRAIN	0.0720
NVA462	642598.5800	4149997.8390	383.3450	383.4180	OPEN TERRAIN	0.0730
NVA461	622182.3180	4161295.4520	426.3190	426.4060	OPEN TERRAIN	0.0870
NVA807	684406.1200	4220621.7200	447.8500	447.7630	OPEN TERRAIN	(0.0870)
NVA789	629259.7050	4229208.0380	452.0610	451.9730	OPEN TERRAIN	(0.0880)
NVA906	675132.0140	4207594.4690	413.9180	413.8300	OPEN TERRAIN	(0.0880)

Point ID	Easting	Northing	KnownZ	LaserZ	Description	DeltaZ
NVA792	673040.5070	4246108.1680	398.6180	398.5280	OPEN TERRAIN	(0.0900)
NVA913	634042.7740	4255224.3890	480.1500	480.2450	OPEN TERRAIN	0.0950
NVA460	633472.3710	4189084.1260	417.7260	417.8230	OPEN TERRAIN	0.0970
NVA901	667467.8900	4243000.2320	412.1620	412.2690	OPEN TERRAIN	0.1070
NVA390	628775.5310	4216428.2420	433.5590	433.6690	OPEN TERRAIN	0.1100
NVA393	637173.2240	4239118.7880	465.4870	465.5970	OPEN TERRAIN	0.1100
NVA270	617334.5810	4193326.9030	437.0680	437.1830	OPEN TERRAIN	0.1150
NVA594	621938.1090	4206434.6650	436.5880	436.4720	OPEN TERRAIN	(0.1160)
NVA398	678537.9260	4232654.2040	393.8310	393.7100	OPEN TERRAIN	(0.1210)
NVA596	618291.3970	4237739.4020	449.7440	449.6200	OPEN TERRAIN	(0.1240)
NVA269	626532.2750	4176561.4590	440.4320	440.5580	OPEN TERRAIN	0.1260
NVA396	664239.5780	4212412.2400	441.7910	441.6650	OPEN TERRAIN	(0.1260)
NVA590	632600.3820	4260031.3630	455.2900	455.4440	OPEN TERRAIN	0.1540
NVA665	653754.9480	4156367.1750	384.7400	384.5860	OPEN TERRAIN	(0.1540)
NVA395	668879.8650	4196228.5890	406.0330	406.1970	OPEN TERRAIN	0.1640
NVA912	616235.4200	4258122.1650	455.7590	455.5900	OPEN TERRAIN	(0.1690)
LCP312	627029.7340	4194865.2270	426.4150	426.4130	BRUSH	(0.0020)
LCP170	673657.0660	4197922.6520	415.3810	415.3840	BRUSH	0.0030
LCP202	637154.7240	4239145.0110	466.3230	466.3260	BRUSH	0.0030
LCP178	651378.9170	4221708.5030	458.0930	458.0870	BRUSH	(0.0060)
LCP197	651678.8370	4260113.1520	433.4400	433.4310	BRUSH	(0.0090)
LCP313	617328.4190	4193344.1400	436.8550	436.8460	BRUSH	(0.0090)
LCP173	672398.5300	4154325.6200	365.6990	365.7160	BRUSH	0.0170
VVA187	640137.6770	4184400.9500	408.3310	408.3120	BRUSH	(0.0190)
VVA464	659835.5840	4161292.1130	407.7330	407.7640	BRUSH	0.0310
VVA405	623510.5260	4215854.5390	430.3970	430.3580	BRUSH	(0.0390)
VVA547	616212.3550	4258130.9550	455.6110	455.5720	BRUSH	(0.0390)
VVA546	636625.0840	4223016.8920	451.9630	452.0120	BRUSH	0.0490
VVA406	634621.8970	4237494.3320	467.3280	467.3830	BRUSH	0.0550
VVA445	669446.8610	4183290.8290	406.9300	406.9860	BRUSH	0.0560
VVA322	623933.7780	4187369.6040	430.2940	430.3640	BRUSH	0.0700
VVA638	647700.1300	4205039.5130	442.0190	442.1040	BRUSH	0.0850
VVA641	665827.0710	4225994.6280	417.5860	417.6770	BRUSH	0.0910
VVA407	662017.9500	4234921.9660	435.6420	435.7350	BRUSH	0.0930
NVA589	619224.4960	4229202.3770	440.9470	440.8490	BRUSH	(0.0980)
VVA276	636683.0740	4266497.3540	407.6680	407.8090	BRUSH	0.1410
VVA601	682478.3830	4248175.3600	439.5690	439.7280	BRUSH	0.1590
VVA637	659415.4600	4174640.5080	415.6730	415.8530	BRUSH	0.1800
VVA320	624731.5060	4155003.6480	402.0600	402.2460	BRUSH	0.1860

Point ID	Easting	Northing	KnownZ	LaserZ	Description	DeltaZ
VVA593	629251.0920	4229206.6210	452.1130	452.3030	BRUSH	0.1900
VVA544	635778.2760	4245580.8230	481.1810	480.9790	BRUSH	(0.2020)
VVA409	634099.2820	4255226.2070	480.9100	481.1200	BRUSH	0.2100
VVA272	651327.8390	4233032.1140	469.8860	470.1250	BRUSH	0.2390
VVA466	656040.8470	4195630.0660	426.5590	426.7990	BRUSH	0.2400
VVA274	625244.3220	4205662.3480	435.3130	435.5560	BRUSH	0.2430
VVA278	676278.9000	4228584.7760	418.7790	419.0570	BRUSH	0.2780
VVA277	673661.3110	4197917.3830	415.5130	415.8100	BRUSH	0.2970
VVA271	651686.8080	4260150.4380	432.6040	432.9490	BRUSH	0.3450
VVA321	658576.5470	4179809.9390	419.5150	419.9950	BRUSH	0.4800

Table 13: Point Cloud Check Point Assessment

b. Digital Elevation Model (DEM) Check Point Assessment

Point ID	Easting	Northing	KnownZ	DEMZ	Description	DeltaZ
NVA269	626532.2750	4176561.4590	440.4320	440.4553	OPEN TERRAIN	0.0233
NVA271	631190.2510	4156690.4780	407.3230	407.3759	OPEN TERRAIN	0.0529
NVA272	662236.4250	4163750.0820	409.0060	409.0067	OPEN TERRAIN	0.0007
NVA388	646879.0120	4257049.9370	464.6200	464.6226	OPEN TERRAIN	0.0026
NVA390	628775.5310	4216428.2420	433.5590	433.6462	OPEN TERRAIN	0.0872
NVA393	637173.2240	4239118.7880	465.4870	465.5879	OPEN TERRAIN	0.1009
NVA395	668879.8650	4196228.5890	406.0330	406.1771	OPEN TERRAIN	0.1441
NVA396	664239.5780	4212412.2400	441.7910	441.6224	OPEN TERRAIN	(0.1686)
NVA397	651393.9010	4221722.4030	458.1450	458.0348	OPEN TERRAIN	(0.1102)
NVA398	678537.9260	4232654.2040	393.8310	393.7075	OPEN TERRAIN	(0.1235)
NVA405	682749.9070	4228654.4790	435.7610	435.7180	OPEN TERRAIN	(0.0430)
NVA460	633472.3710	4189084.1260	417.7260	417.7514	OPEN TERRAIN	0.0254
NVA461	622182.3180	4161295.4520	426.3190	426.4015	OPEN TERRAIN	0.0825
NVA462	642598.5800	4149997.8390	383.3450	383.3018	OPEN TERRAIN	(0.0432)
NVA463	662781.9140	4149187.0860	404.0080	404.0192	OPEN TERRAIN	0.0112
NVA467	647723.9170	4205033.7720	442.3360	442.3925	OPEN TERRAIN	0.0565
NVA588	663799.8120	4254128.7340	415.9450	415.9650	OPEN TERRAIN	0.0200
NVA594	621938.1090	4206434.6650	436.5880	436.4851	OPEN TERRAIN	(0.1029)
NVA597	679212.7160	4256079.7830	435.5850	435.6298	OPEN TERRAIN	0.0448
NVA642	670853.2410	4164537.6320	407.0990	407.0586	OPEN TERRAIN	(0.0404)
NVA660	659412.4690	4174634.5540	415.5540	415.6198	OPEN TERRAIN	0.0658
NVA661	637982.3820	4197881.5970	419.2020	419.2509	OPEN TERRAIN	0.0489
NVA662	640873.9740	4172297.8740	398.2430	398.2700	OPEN TERRAIN	0.0270
NVA663	620836.5600	4183523.2030	435.3590	435.2911	OPEN TERRAIN	(0.0679)
NVA664	616352.7130	4168761.2320	442.3390	442.2602	OPEN TERRAIN	(0.0788)

Point ID	Easting	Northing	KnownZ	DEMZ	Description	DeltaZ
NVA665	653754.9480	4156367.1750	384.7400	384.5992	OPEN TERRAIN	(0.1408)
NVA786	645403.0590	4212528.6980	441.6850	441.6100	OPEN TERRAIN	(0.0750)
NVA787	665848.2300	4225984.7160	417.4880	417.4058	OPEN TERRAIN	(0.0822)
NVA789	629259.7050	4229208.0380	452.0610	451.9860	OPEN TERRAIN	(0.0750)
NVA790	637344.7830	4249691.5760	484.1820	484.1933	OPEN TERRAIN	0.0113
NVA792	673040.5070	4246108.1680	398.6180	398.5262	OPEN TERRAIN	(0.0918)
NVA794	673995.7200	4200777.4820	408.8110	408.7331	OPEN TERRAIN	(0.0779)
NVA795	630842.5320	4206723.5460	423.9690	423.9237	OPEN TERRAIN	(0.0453)
NVA799	682461.5420	4248165.6010	438.6600	438.6034	OPEN TERRAIN	(0.0566)
NVA807	684406.1200	4220621.7200	447.8500	447.7424	OPEN TERRAIN	(0.1076)
NVA859	640147.9050	4184414.6000	409.6170	409.6656	OPEN TERRAIN	0.0486
NVA860	636611.0310	4223019.6720	451.9410	451.9601	OPEN TERRAIN	0.0191
NVA901	667467.8900	4243000.2320	412.1620	412.2423	OPEN TERRAIN	0.0803
NVA904	669463.0580	4183305.7650	407.0450	407.0464	OPEN TERRAIN	0.0014
NVA906	675132.0140	4207594.4690	413.9180	413.7326	OPEN TERRAIN	(0.1854)
NVA913	634042.7740	4255224.3890	480.1500	480.1866	OPEN TERRAIN	0.0366
LCP170	673657.0660	4197922.6520	415.3810	415.3682	BRUSH	(0.0128)
LCP173	672398.5300	4154325.6200	365.6990	365.7212	BRUSH	0.0222
LCP178	651378.9170	4221708.5030	458.0930	457.9743	BRUSH	(0.1187)
LCP202	637154.7240	4239145.0110	466.3230	466.3137	BRUSH	(0.0093)
LCP312	627029.7340	4194865.2270	426.4150	426.4214	BRUSH	0.0064
VVA187	640137.6770	4184400.9500	408.3310	408.2586	BRUSH	(0.0724)
VVA272	651327.8390	4233032.1140	469.8860	470.1766	BRUSH	0.2906
VVA274	625244.3220	4205662.3480	435.3130	435.6780	BRUSH	0.3650
VVA277	673661.3110	4197917.3830	415.5130	415.9447	BRUSH	0.4317
VVA278	676278.9000	4228584.7760	418.7790	419.0592	BRUSH	0.2802
VVA320	624731.5060	4155003.6480	402.0600	402.2292	BRUSH	0.1692
VVA321	658576.5470	4179809.9390	419.5150	419.9321	BRUSH	0.4171
VVA322	623933.7780	4187369.6040	430.2940	430.3310	BRUSH	0.0370
VVA405	623510.5260	4215854.5390	430.3970	430.3963	BRUSH	(0.0007)
VVA406	634621.8970	4237494.3320	467.3280	467.3587	BRUSH	0.0307
VVA407	662017.9500	4234921.9660	435.6420	435.7229	BRUSH	0.0809
VVA409	634099.2820	4255226.2070	480.9100	481.0766	BRUSH	0.1666
VVA445	669446.8610	4183290.8290	406.9300	406.9860	BRUSH	0.0560
VVA464	659835.5840	4161292.1130	407.7330	407.7963	BRUSH	0.0633
VVA466	656040.8470	4195630.0660	426.5590	426.8034	BRUSH	0.2444
VVA544	635778.2760	4245580.8230	481.1810	480.9074	BRUSH	(0.2736)
VVA546	636625.0840	4223016.8920	451.9630	451.9609	BRUSH	(0.0021)
VVA593	629251.0920	4229206.6210	452.1130	452.2097	BRUSH	0.0967

Point ID	Easting	Northing	KnownZ	DEMZ	Description	DeltaZ
VVA601	682478.3830	4248175.3600	439.5690	439.7095	BRUSH	0.1405
VVA637	659415.4600	4174640.5080	415.6730	415.8102	BRUSH	0.1372
VVA638	647700.1300	4205039.5130	442.0190	442.1679	BRUSH	0.1489
VVA641	665827.0710	4225994.6280	417.5860	417.6341	BRUSH	0.0481

Table 14: DEM Check Point Assessment