Project Report

TASK ORDER NAME: 2018 Kansas QL2 LiDAR
CONTRACT ID: 00000000000000000000039891
EVENT ID: EVT0003259
ATLANTIC PROJECT NUMBER: 18006
PROJECT BLOCK NUMBER: Block 11A

TABLE OF CONTENTS

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 11A encompasses part or all of 7 counties in Southern Kansas and covers approximately 1865 square miles.

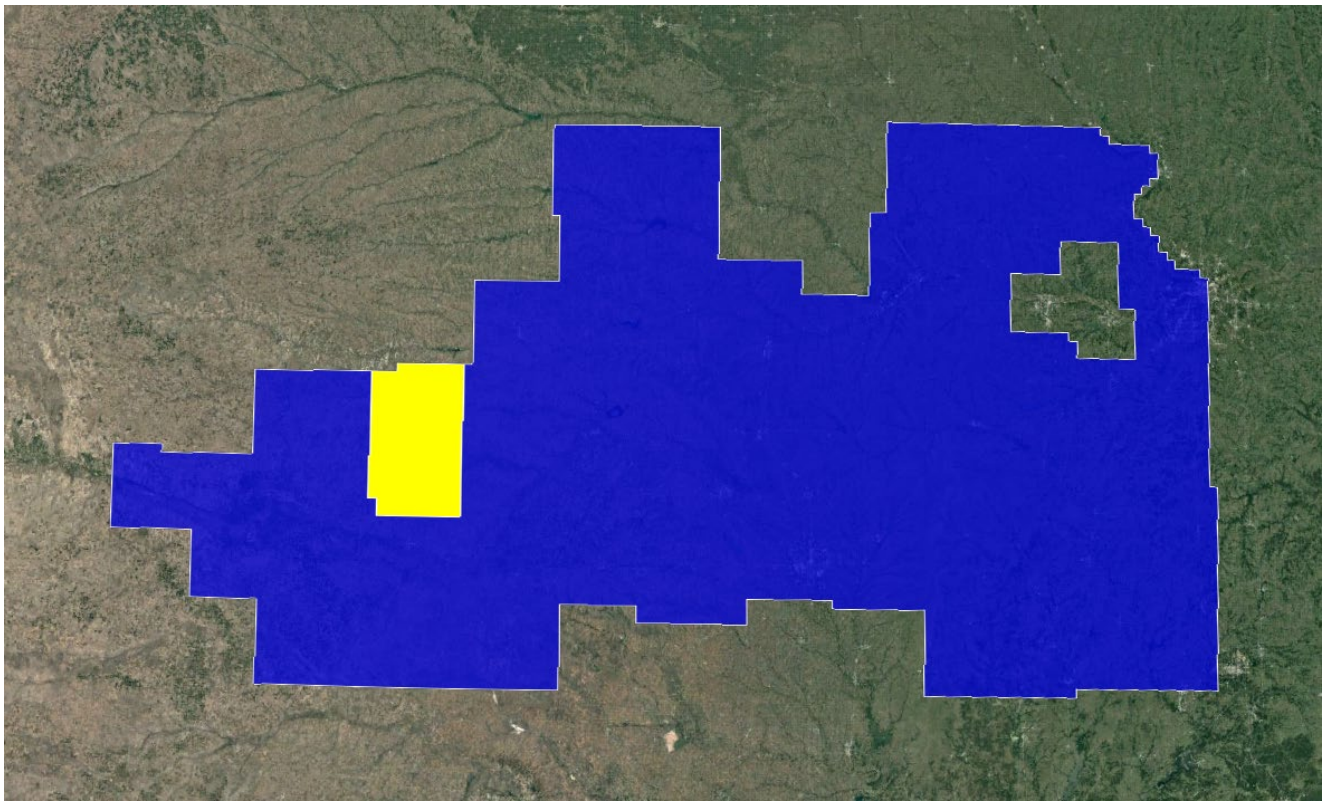


Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) and Associated Areas of Interest (AOIs)

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 5 flight missions conducted between November 24, 2018 and December 11, 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.

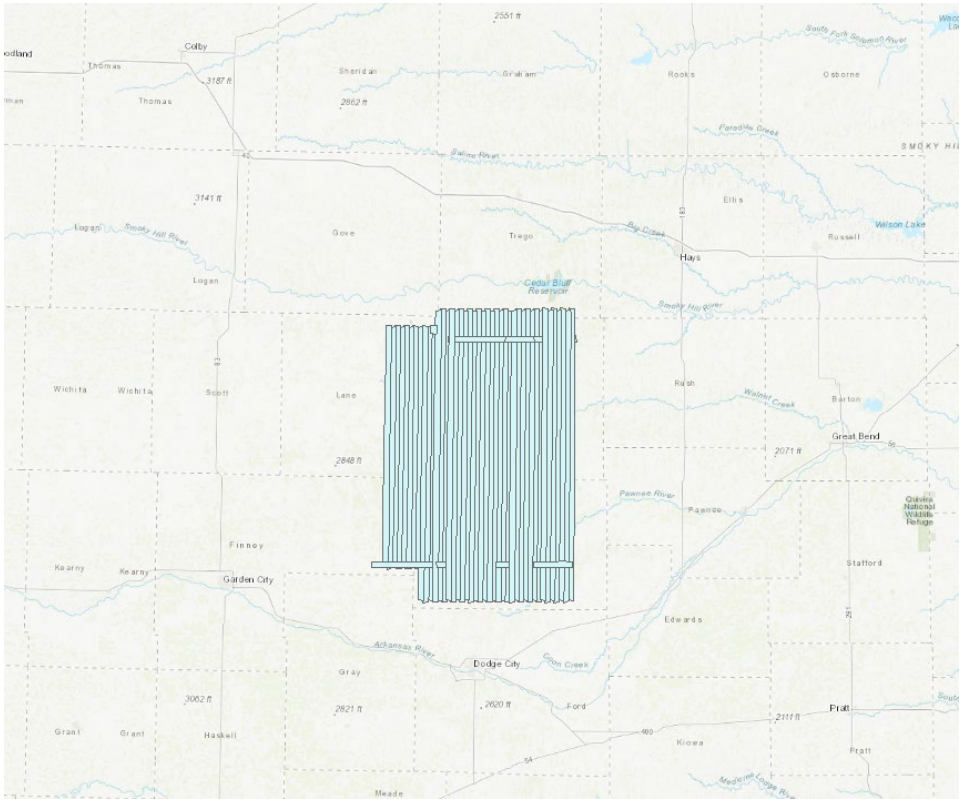


Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

d. GNSS Reference Stations

Eight (8) 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	N37°35'15.79517"	W97°18'32.00080	363.34
ICT3	CORS	ICT3	N37°45'09.33297"	W97°12'58.42230"	401.242
ICT4	CORS	ICT4	N37°37'08.57671"	W97°37'57.00056"	392.172
ICT5	CORS	ICT5	N37°47'12.04062"	W97°37'32.73360"	411.107
KSNC	CORS	KSNC	N38°27'11.84857"	W99°53'41.03840"	672.107
KSJM	CORS	KSJM	N38°04'01.29806"	W99°53'51.42396"	701.458
KSGC	CORS	KSGC	N37°58'08.68605"	W100°53'47.13441"	854.237
KSDT	CORS	KSDT	N38°28'46.22580	W100°28'06.34235"	823.395

Table 5: GNSS Reference Stations

2. Aerial LiDAR Project – Ground Acquisition

a. Ground Control Survey

A total of 81 ground survey points were collected in support of this project, including 21 LiDAR Control Points (LCP), 36 Non-vegetated Vertical Accuracy (NVA) and 24 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
LCP250	434400.569	4252856.631	658.267
LCP259	405894.832	4272411.321	768.091
LCP260	416180.942	4270678.401	756.047
LCP261	430297.223	4270644.626	719.955
LCP285	389635.756	4259785.648	814.805
LCP286	384873.043	4269722.153	814.275
LCP287	380038.511	4268132.755	833.509
LCP375	413030.468	4212558.508	742.236
LCP376	406752.144	4213135.413	742.144
LCP377	400569.892	4230232.134	740.833
LCP378	418887.277	4231263.691	725.609
LCP379	436331.147	4214138.298	664.225
LCP380	435663.791	4225453.429	670.048
LCP381	425261.746	4230390.903	727.659
LCP409	413560.336	4264186.871	711.926
LCP410	402935.749	4243484.051	751.449
LCP411	381057.903	4221298.18	791.59
LCP412	391019.739	4230830.803	775.102
LCP557	412362.441	4230538.975	717.636

ID	Easting	Northing	Elevation
LCP559	426960.875	4212624.307	702.189
LCP576	429794.773	4280314.787	742.218

Table 6: LiDAR Control Point Coordinates

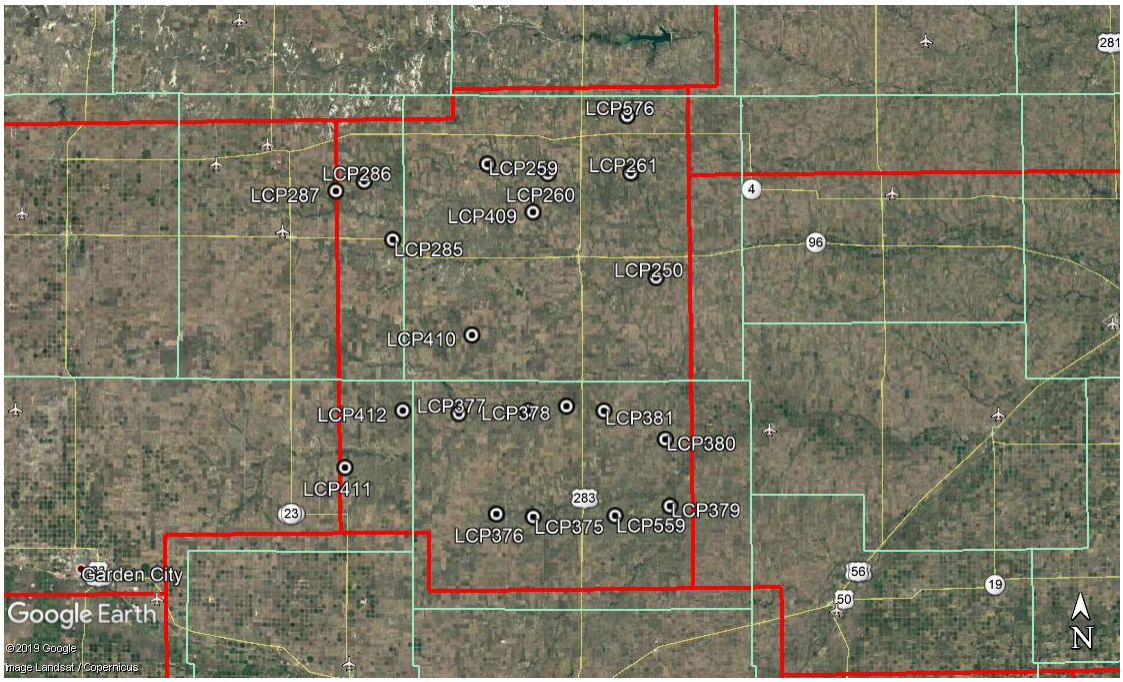


Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
NVA349	380085.091	4268121.448	833.099
NVA350	405867.775	4272422.832	768.12
NVA351	430273.738	4270655.871	719.899
NVA353	389641.976	4259832.031	814.423
NVA354	413550.794	4264194.078	712.144
NVA355	418887.996	4231267.444	725.552
NVA356	402927.894	4243483.714	751.483
NVA357	381065.744	4221294.69	791.615
NVA358	400562.903	4230231.459	740.869
NVA359	413038.033	4212559.384	742.047
NVA360	436313.195	4214136.751	664.371
NVA551	430738.522	4209668.622	723.506
NVA552	400749.546	4217767.507	774.987
NVA553	413537.515	4241796.882	702.117
NVA554	412378.146	4230541.643	717.631
NVA555	424747.758	4240063.642	688.664

ID	Easting	Northing	Elevation
NVA557	396066.844	4248005.271	805.89
NVA558	429648.689	4249635.049	668.423
NVA559	383277.51	4277720.075	829.704
NVA560	410112.586	4256249.259	721.348
NVA561	429822.434	4280337.329	741.993
NVA562	437621.591	4264998.684	684.362
NVA749	422095.674	4215576.077	702.103
NVA750	437140.925	4219745.477	659.905
NVA751	439720.441	4255092.602	647.864
NVA753	396035.242	4256498.002	770.327
NVA754	418937.266	4276677.928	767.608
NVA755	435178.241	4277096.985	737.495
NVA756	421883.821	4256708.374	692.34
NVA757	398194.933	4278092.569	800.582
NVA875	402105.101	4219351.426	777.227
NVA876	429813.945	4201251.817	690.745
NVA882	436010.088	4237634.628	679.31
NVA925	425437.546	4244884.397	685.623
NVA929	429624.557	4265906.026	699.844
NVA935	382696.301	4257952.827	806.871

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

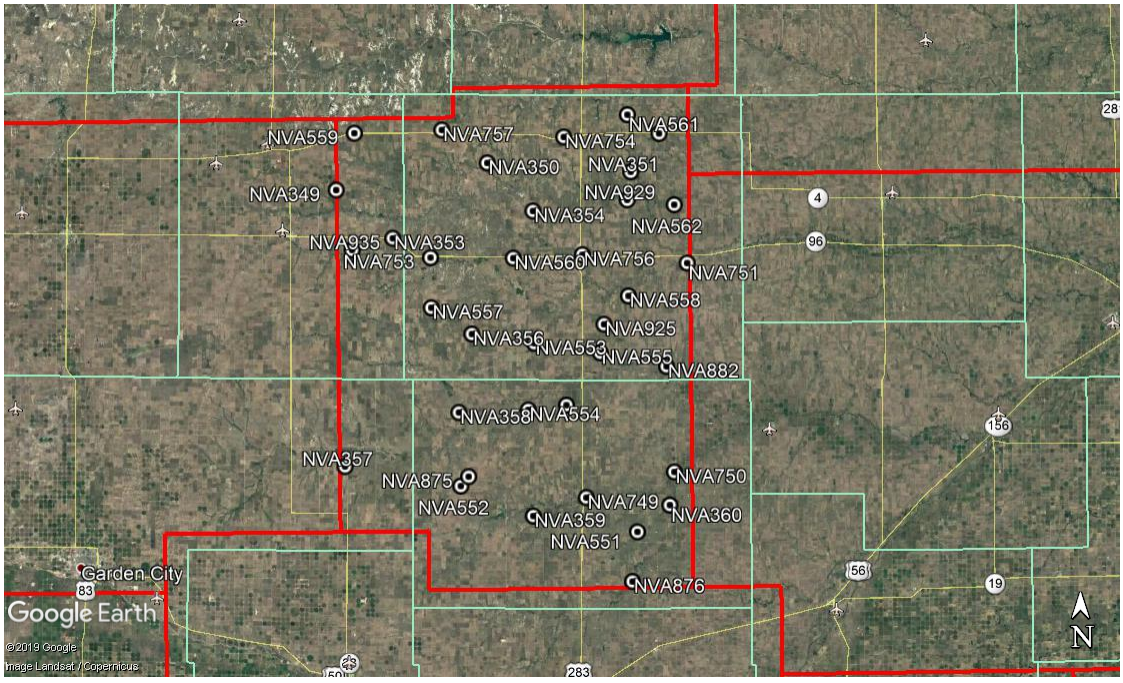


Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
VVA246	384884.917	4269707.318	813.303
VVA247	416200.768	4270687.128	756.693
VVA249	434385.775	4252831.471	657.488
VVA250	391031.674	4230832.037	774.032
VVA251	425249.951	4230384.811	727.744
VVA252	406751.549	4213118.661	741.777
VVA253	435651.732	4225437.486	669.916
VVA380	382664.246	4257977.78	807.02
VVA381	395292.549	4266075.539	764.839
VVA382	429609.156	4265924.614	699.984
VVA384	407103.931	4243396.408	730.597
VVA385	436016.568	4237628.247	679.357
VVA386	415167.177	4222418.364	752.384
VVA459	429821.232	4201257.91	690.848
VVA523	404771.781	4256308.681	730.189
VVA524	382200.288	4245593.434	831.276
VVA525	425396.629	4244888.665	685.325
VVA526	402089.907	4219354.405	777.428
VVA527	426955.223	4212619.565	702.183
VVA608	400754.79	4217784.867	774.941
VVA609	430740.04	4209673.43	723.43
VVA615	424759.992	4240059.358	688.477
VVA663	435170.615	4277121.136	737.088
VVA669	383261.979	4277694.501	829.42

Table 8: Vegetated Vertical Accuracy (VVA) Point Coordinates

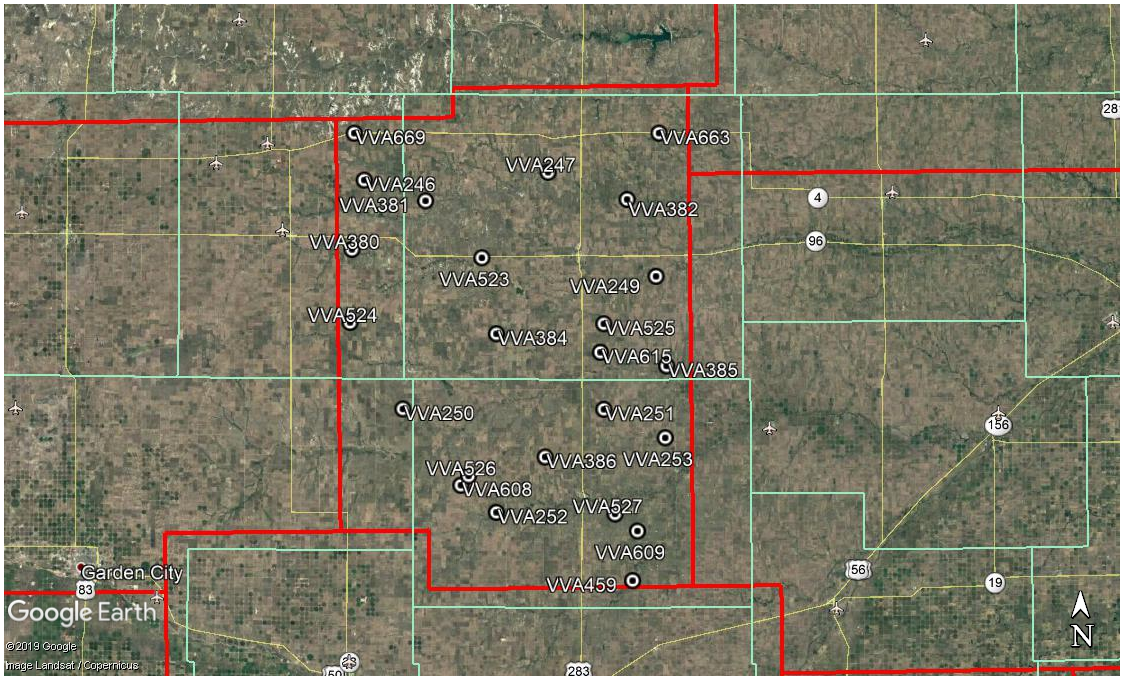


Figure 4: Vegetated Vertical Accuracy (VVA) Point Distribution

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(HARN) (EPSG 3744)
Coordinate System: UTM, 14N
Vertical Datum: NAVD88
Geoid Model: 12B
Units of Reference: Meter

c. LiDAR Point Cloud Statistics

Category	Value
Total Points	12,763,861,817
Nominal Pulse Spacing (m)	0.6861
Nominal Pulse Density (pls/m²)	2.1241
Nominal Pulse Spacing (ft)	2.2511
Nominal Pulse Density (pls/ft²)	0.1973
Aggregate Total Points	12,003,463,367
Aggregate Nominal Pulse Spacing (m)	0.6082
Aggregate Nominal Pulse Density (pls/m²)	2.7034
Aggregate Nominal Pulse Spacing (ft)	1.9954
Aggregate Nominal Pulse Density (pls/ft²)	0.2512

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.

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	# of Points	RMSEz	95% Confidence Level	95th Percentile
NVA of Point Cloud	32	0.0572	0.1121	0.1070
VVA of Point Cloud	20	0.1766	0.3461	0.2023
NVA of DEM	31	0.0540	0.1059	0.0818
VVA of DEM	19	0.0991	0.1941	0.1748

Table 12: NVA/VVA Accuracies

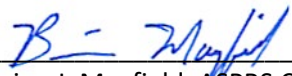
SECTION V: CERTIFICATION STATEMENTS

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
NVA561	429823.180	4280336.587	741.9930	741.9930	OPEN TERRAIN	-
NVA358	400563.654	4230230.725	740.8690	740.8670	OPEN TERRAIN	(0.0020)
NVA558	429649.435	4249634.312	668.4230	668.4210	OPEN TERRAIN	(0.0020)
NVA354	413551.543	4264193.339	712.1440	712.1380	OPEN TERRAIN	(0.0060)
NVA551	430739.269	4209667.892	723.5060	723.4980	OPEN TERRAIN	(0.0080)
NVA350	405868.525	4272422.091	768.1200	768.1110	OPEN TERRAIN	(0.0090)
NVA355	418888.744	4231266.710	725.5520	725.5640	OPEN TERRAIN	0.0120
NVA353	389642.728	4259831.292	814.4230	814.4400	OPEN TERRAIN	0.0170
NVA553	413538.264	4241796.146	702.1170	702.1350	OPEN TERRAIN	0.0180
NVA882	436010.833	4237633.894	679.3100	679.3310	OPEN TERRAIN	0.0210
NVA876	429814.692	4201251.088	690.7450	690.7710	OPEN TERRAIN	0.0260
NVA754	418938.013	4276677.187	767.6080	767.6360	OPEN TERRAIN	0.0280
NVA757	398195.684	4278091.827	800.5820	800.6100	OPEN TERRAIN	0.0280
NVA750	437141.671	4219744.745	659.9050	659.9350	OPEN TERRAIN	0.0300
NVA755	435178.986	4277096.244	737.4950	737.4650	OPEN TERRAIN	(0.0300)
NVA359	413038.783	4212558.653	742.0470	742.0130	OPEN TERRAIN	(0.0340)
NVA351	430274.484	4270655.131	719.8990	719.8600	OPEN TERRAIN	(0.0390)
NVA749	422096.422	4215575.346	702.1030	702.0620	OPEN TERRAIN	(0.0410)
NVA753	396035.993	4256497.264	770.3270	770.2860	OPEN TERRAIN	(0.0410)
NVA925	425438.293	4244883.661	685.6230	685.5770	OPEN TERRAIN	(0.0460)
NVA356	402928.645	4243482.978	751.4830	751.5340	OPEN TERRAIN	0.0510
NVA875	402105.852	4219350.694	777.2270	777.2870	OPEN TERRAIN	0.0600
NVA360	436313.941	4214136.020	664.3710	664.3100	OPEN TERRAIN	(0.0610)
NVA560	410113.335	4256248.521	721.3480	721.2870	OPEN TERRAIN	(0.0610)
NVA751	439721.185	4255091.865	647.8640	647.7980	OPEN TERRAIN	(0.0660)
NVA554	412378.895	4230540.909	717.6310	717.7030	OPEN TERRAIN	0.0720
NVA555	424748.505	4240062.907	688.6640	688.5880	OPEN TERRAIN	(0.0760)
NVA552	400750.298	4217766.775	774.9870	775.0760	OPEN TERRAIN	0.0890
NVA756	421884.568	4256707.636	692.3400	692.2460	OPEN TERRAIN	(0.0940)
NVA929	429625.303	4265905.287	699.8440	699.7480	OPEN TERRAIN	(0.0960)
NVA562	437622.336	4264997.945	684.3620	684.4910	OPEN TERRAIN	0.1290
NVA557	396067.596	4248004.534	805.8900	806.0300	OPEN TERRAIN	0.1400
VVA250	391032.427	4230831.303	774.0320	774.0390	BRUSH	0.0070
VVA249	434386.520	4252830.734	657.4880	657.5010	BRUSH	0.0130
VVA385	436017.313	4237627.513	679.3570	679.3250	BRUSH	(0.0320)

Point ID	Easting	Northing	KnownZ	LaserZ	Description	DeltaZ
VVA459	429821.979	4201257.181	690.8480	690.8080	BRUSH	(0.0400)
VVA608	400755.542	4217784.135	774.9410	774.9820	BRUSH	0.0410
VVA381	395293.300	4266074.799	764.8390	764.8840	BRUSH	0.0450
VVA615	424760.739	4240058.623	688.4770	688.4310	BRUSH	(0.0460)
VVA609	430740.787	4209672.700	723.4300	723.4800	BRUSH	0.0500
VVA523	404772.531	4256307.943	730.1890	730.2440	BRUSH	0.0550
VVA386	415167.926	4222417.632	752.3840	752.3180	BRUSH	(0.0660)
VVA384	407104.681	4243395.672	730.5970	730.6780	BRUSH	0.0810
VVA382	429609.902	4265923.875	699.9840	700.0660	BRUSH	0.0820
VVA251	425250.698	4230384.077	727.7440	727.8330	BRUSH	0.0890
VVA527	426955.970	4212618.834	702.1830	702.2800	BRUSH	0.0970
VVA247	416201.516	4270686.388	756.6930	756.5360	BRUSH	(0.1570)
VVA252	406752.300	4213117.930	741.7770	741.9350	BRUSH	0.1580
VVA526	402090.658	4219353.673	777.4280	777.5900	BRUSH	0.1620
VVA253	435652.478	4225436.753	669.9160	670.0810	BRUSH	0.1650
VVA663	435171.360	4277120.395	737.0880	737.2660	BRUSH	0.1780
VVA246	384885.670	4269706.577	813.3030	813.9660	BRUSH	0.6630

Table 13: Point Cloud Check Point Assessment

b. Digital Elevation Model (DEM) Check Point Assessment

Point ID	Easting	Northing	KnownZ	DEMZ	Description	DeltaZ
NVA350	405868.525	4272422.091	768.1200	768.0895	OPEN TERRAIN	(0.0305)
NVA351	430274.484	4270655.131	719.8990	719.8620	OPEN TERRAIN	(0.0370)
NVA353	389642.728	4259831.292	814.4230	814.4409	OPEN TERRAIN	0.0179
NVA354	413551.543	4264193.339	712.1440	712.1006	OPEN TERRAIN	(0.0434)
NVA355	418888.744	4231266.710	725.5520	725.5566	OPEN TERRAIN	0.0046
NVA356	402928.645	4243482.978	751.4830	751.5219	OPEN TERRAIN	0.0389
NVA358	400563.654	4230230.725	740.8690	740.8440	OPEN TERRAIN	(0.0250)
NVA359	413038.783	4212558.653	742.0470	742.0090	OPEN TERRAIN	(0.0380)
NVA551	430739.269	4209667.892	723.5060	723.5237	OPEN TERRAIN	0.0177
NVA552	400750.298	4217766.775	774.9870	775.0479	OPEN TERRAIN	0.0609
NVA553	413538.264	4241796.146	702.1170	702.1280	OPEN TERRAIN	0.0110
NVA554	412378.895	4230540.909	717.6310	717.7020	OPEN TERRAIN	0.0710
NVA555	424748.505	4240062.907	688.6640	688.5864	OPEN TERRAIN	(0.0776)
NVA557	396067.596	4248004.534	805.8900	806.0229	OPEN TERRAIN	0.1329
NVA558	429649.435	4249634.312	668.4230	668.4189	OPEN TERRAIN	(0.0041)
NVA560	410113.335	4256248.521	721.3480	721.2955	OPEN TERRAIN	(0.0525)
NVA561	429823.180	4280336.587	741.9930	741.9896	OPEN TERRAIN	(0.0034)
NVA562	437622.336	4264997.945	684.3620	684.4546	OPEN TERRAIN	0.0926

Point ID	Easting	Northing	KnownZ	DEMZ	Description	DeltaZ
NVA749	422096.422	4215575.346	702.1030	702.0528	OPEN TERRAIN	(0.0502)
NVA750	437141.671	4219744.745	659.9050	659.9210	OPEN TERRAIN	0.0160
NVA751	439721.185	4255091.865	647.8640	647.8014	OPEN TERRAIN	(0.0626)
NVA753	396035.993	4256497.264	770.3270	770.2303	OPEN TERRAIN	(0.0967)
NVA754	418938.013	4276677.187	767.6080	767.5923	OPEN TERRAIN	(0.0157)
NVA755	435178.986	4277096.244	737.4950	737.4940	OPEN TERRAIN	(0.0010)
NVA756	421884.568	4256707.636	692.3400	692.2398	OPEN TERRAIN	(0.1002)
NVA757	398195.684	4278091.827	800.5820	800.5906	OPEN TERRAIN	0.0086
NVA875	402105.852	4219350.694	777.2270	777.2620	OPEN TERRAIN	0.0350
NVA876	429814.692	4201251.088	690.7450	690.7714	OPEN TERRAIN	0.0264
NVA882	436010.833	4237633.894	679.3100	679.3205	OPEN TERRAIN	0.0105
NVA925	425438.293	4244883.661	685.6230	685.5587	OPEN TERRAIN	(0.0643)
NVA929	429625.303	4265905.287	699.8440	699.7694	OPEN TERRAIN	(0.0746)
VVA247	416201.516	4270686.388	756.6930	756.5215	BRUSH	(0.1715)
VVA249	434386.520	4252830.734	657.4880	657.4838	BRUSH	(0.0042)
VVA250	391032.427	4230831.303	774.0320	774.0370	BRUSH	0.0050
VVA251	425250.698	4230384.077	727.7440	727.8305	BRUSH	0.0865
VVA252	406752.300	4213117.930	741.7770	741.8984	BRUSH	0.1214
VVA253	435652.478	4225436.753	669.9160	670.1013	BRUSH	0.1853
VVA381	395293.300	4266074.799	764.8390	764.8721	BRUSH	0.0331
VVA382	429609.902	4265923.875	699.9840	700.0941	BRUSH	0.1101
VVA384	407104.681	4243395.672	730.5970	730.6579	BRUSH	0.0609
VVA385	436017.313	4237627.513	679.3570	679.3016	BRUSH	(0.0554)
VVA386	415167.926	4222417.632	752.3840	752.3152	BRUSH	(0.0688)
VVA459	429821.979	4201257.181	690.8480	690.8132	BRUSH	(0.0348)
VVA523	404772.531	4256307.943	730.1890	730.2310	BRUSH	0.0420
VVA526	402090.658	4219353.673	777.4280	777.5892	BRUSH	0.1612
VVA527	426955.970	4212618.834	702.1830	702.2805	BRUSH	0.0975
VVA608	400755.542	4217784.135	774.9410	774.9882	BRUSH	0.0472
VVA609	430740.787	4209672.700	723.4300	723.4799	BRUSH	0.0499
VVA615	424760.739	4240058.623	688.4770	688.4288	BRUSH	(0.0482)
VVA663	435171.360	4277120.395	737.0880	737.2617	BRUSH	0.1737

Table 14: DEM Check Point Assessment