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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 9A encompasses part or all of 6 counties in Kansas and covers approximately 2625 square miles.

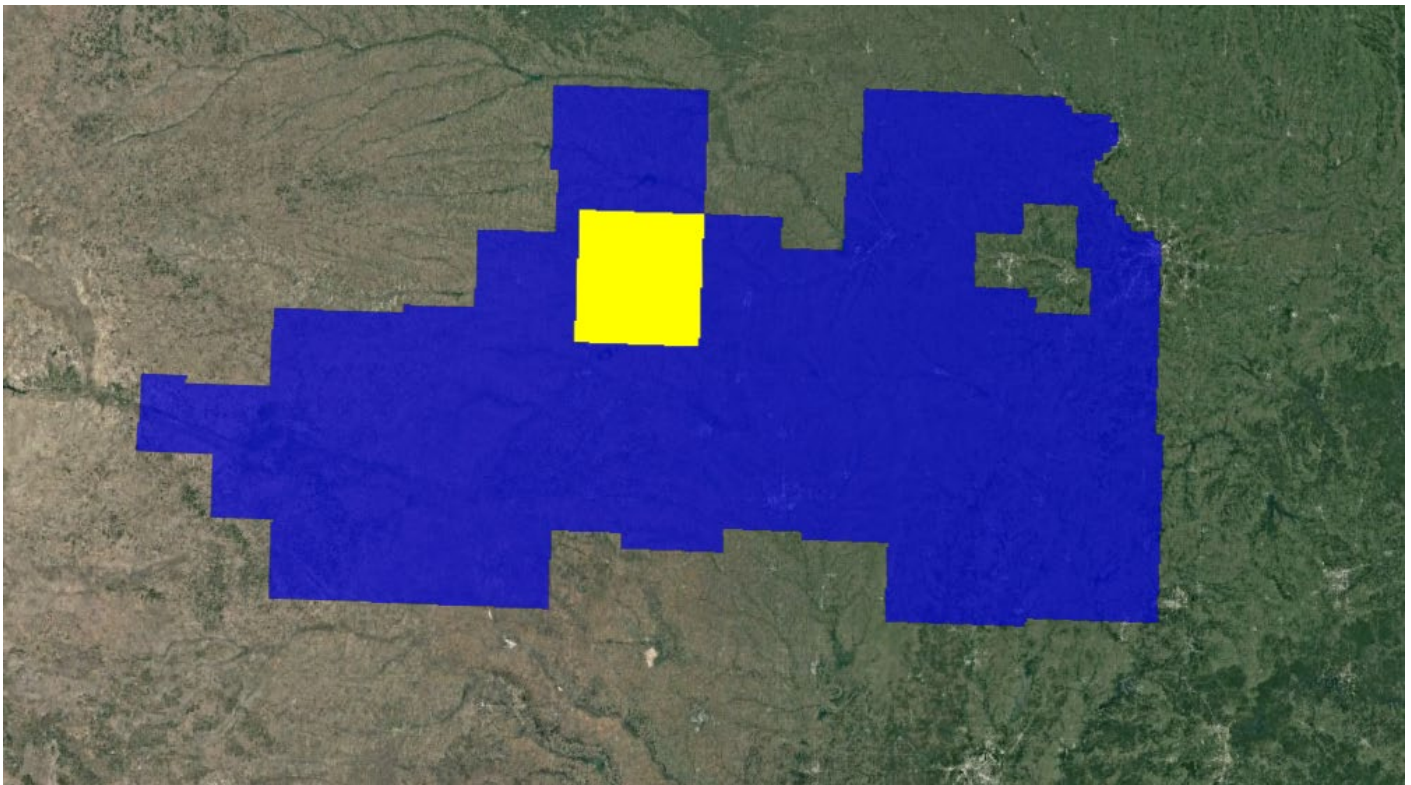


Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) and Associated Areas of Interest (AOIs)

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 86 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 13 flight missions conducted between May 11, 2018 and March 20, 2019. 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.

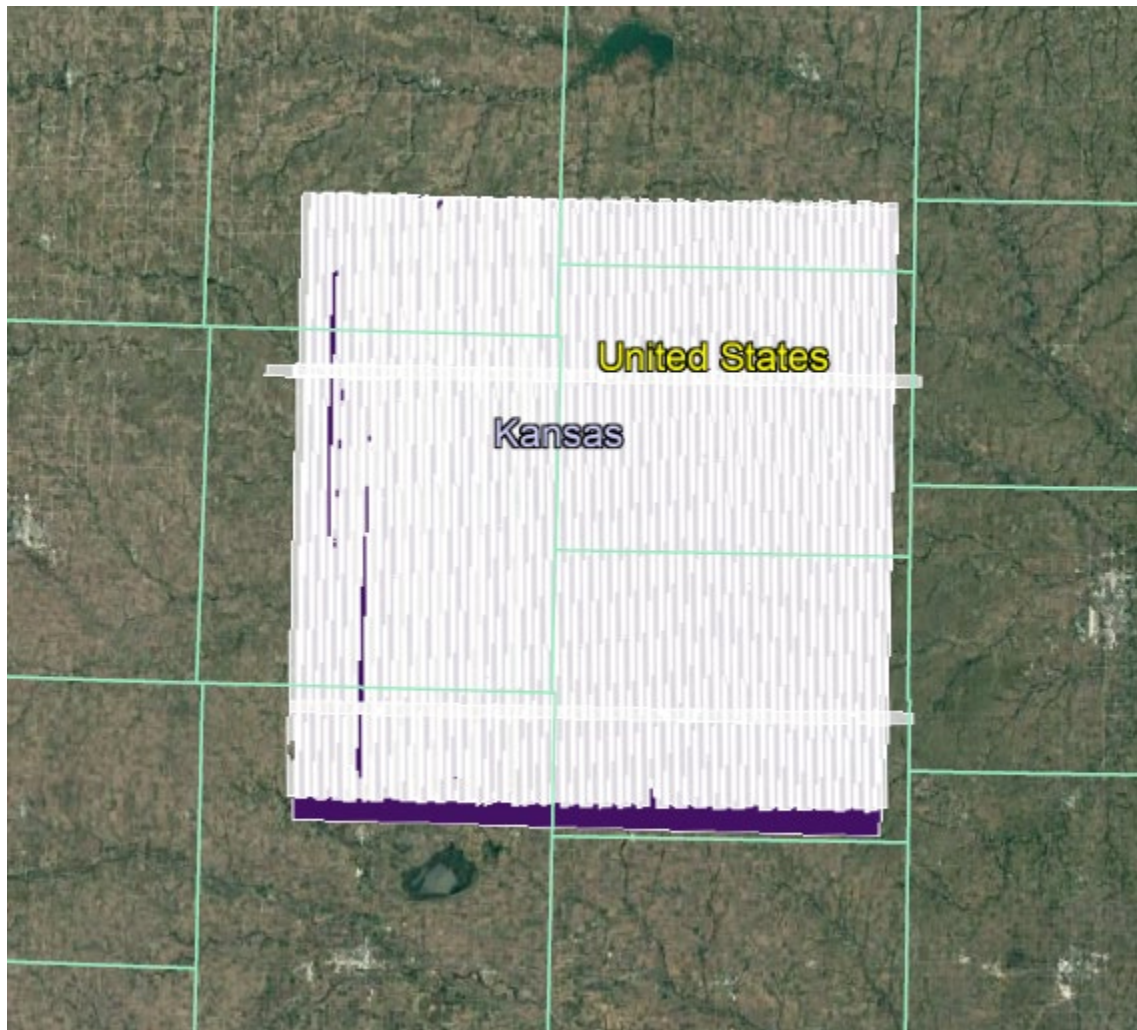


Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

d. GNSS Reference Stations

Seventeen (17) 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
ICT5	CORS	ICT5	N37°47'12.04059"	W97°37'32.73375"	411.106M
KSCC	CORS	KSCC	N39°22'56.01790"	W97°10'10.66420"	348.866M
KSCO	CORS	KSCO	N39°36'37.78447"	W97°39'44.38104"	399.371M
KSCP	CORS	KSCP	N38°58'16.54517"	W97°01'11.91640"	320.534M
KSGB	CORS	KSGB	N38°21'16.86581"	W98°45'53.44305"	548.782M
KSHR	CORS	KSHR	N38°35'32.77532"	W98°24'51.93486"	532.181M
KSHU	CORS	KSHU	N38°01'52.62370"	W97°54'08.45874"	440.099M
KSJM	CORS	KSJM	N38°04'01.31691"	W99°53'51.41926"	706.353M
KSLC	CORS	KSLC	N38°31'55.09282"	W99°18'19.68107"	608.942M
KSPR	CORS	KSPR	N37°41'26.44138"	W98°44'27.53387"	573.45M
KSMA	CORS	KSMA	N38°21'35.65314"	W97°00'42.65212"	381.282M
KSMP	CORS	KSMP	N38°20'46.93949"	W97°40'11.75275"	434.95M
KSSL	CORS	KSSL	N38°47'59.78191"	W97°38'12.80326"	358.168M
KSWK	CORS	KSWK	N39°01'03.70267"	W99°52'05.27379"	728.846M
NEBU	CORS	NEBU	N40°20'07.58797"	W97°34'30.15678"	464.174M
NEFR	CORS	NEFR	N40°08'53.37718"	W97°10'14.46878"	412.528M
NERC	CORS	NERC	N40°04'32.27635"	W98°31'05.31765"	494.048M

Table 5: GNSS Reference Stations

2. Aerial LiDAR Project – Ground Acquisition

a. Ground Control Survey

A total of 114 ground survey points were collected in support of this project, including 29 LiDAR Control Points (LCP), 47 Non-vegetated Vertical Accuracy (NVA) and 38 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
LCP217	560249.823	4315544.588	463.423
LCP218	549355.17	4312976.155	466.957
LCP219	545283.242	4308408.978	509.036
LCP220	560594.513	4297855.896	515.785
LCP221	564002.458	4297181.287	545.933
LCP222	578264.637	4285060.245	497.868
LCP227	566249.672	4276881.559	525.137
LCP228	535693.515	4268900.185	561.062
LCP230	535692.346	4275518.49	585.461
LCP270	532684.061	4293694.121	515.618
LCP271	531808.878	4288737.644	535.87
LCP272	534243.422	4286455.39	566.231
LCP273	518949.72	4286023.341	573.561
LCP274	513390.851	4287993.181	583.486
LCP275	513393.739	4312150.015	491.234
LCP276	512695.038	4326667.476	508.254
LCP433	512897.877	4312178.252	495.351
LCP434	540902.437	4323309.63	454.033

ID	Easting	Northing	Elevation
LCP447	577317.448	4329376.261	446.995
LCP448	577877.93	4336590.976	426.908
LCP457	516236.325	4347902.783	537.836
LCP458	526226.957	4342824.117	590.036
LCP459	518341.036	4335375.735	535.329
LCP460	544080.672	4331630.49	502.755
LCP473	573035.123	4341456.778	456.128
LCP552	577026.372	4310859.976	430.68
LCP554	575022.621	4285028.238	478.728
LCP580	542979.299	4292581.078	507.093
LCP582	530242.146	4327356.006	466.007

Table 6: LiDAR Control Point Coordinates

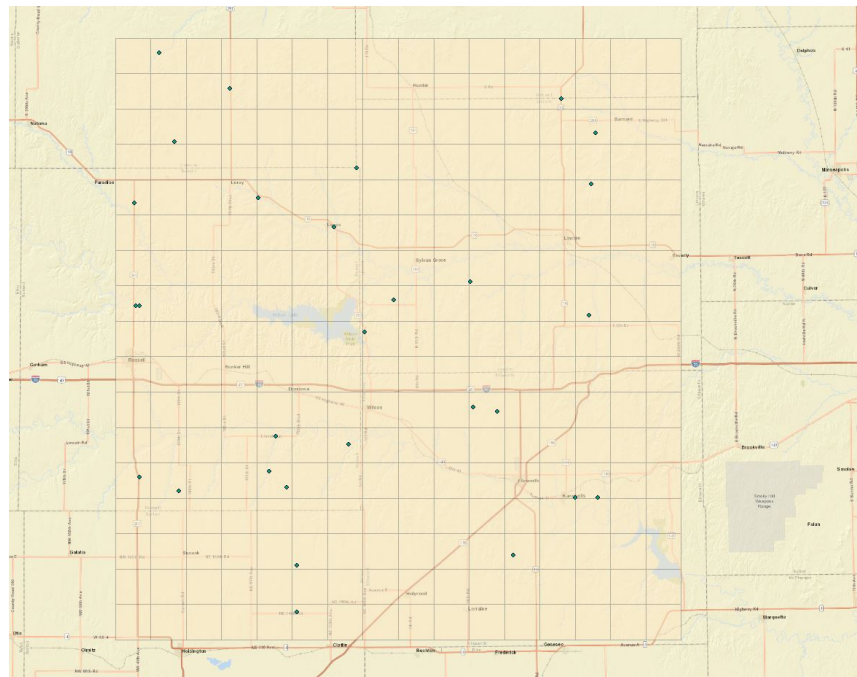


Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
NVA299	516229.669	4347928.916	537.819
NVA301	518357.21	4335381.35	534.554
NVA307	513383.258	4312158.421	491.52
NVA311	513359.401	4287967.986	583.923
NVA312	577862.729	4336600.209	427.278
NVA313	544057.273	4331595.858	502.883



ID	Easting	Northing	Elevation
NVA314	549393.692	4312996.465	468.499
NVA315	526215.988	4342832.203	589.307
NVA316	534250.342	4286425.64	565.977
NVA317	535609.46	4275528.435	585.301
NVA318	566235.443	4276913.039	523.282
NVA319	564021.806	4297156.644	546.333
NVA321	582536.37	4349221.291	436.352
NVA322	578225.205	4285084.992	498.02
NVA495	517471.347	4328289.505	524.964
NVA496	513364.339	4278163.219	593.063
NVA505	573055.574	4342294.648	452.379
NVA506	531622.542	4338327.753	527.613
NVA507	589469.36	4329716.766	427.081
NVA509	585116.371	4301373.452	467.61
NVA510	559376.979	4299458.971	523.378
NVA511	528635.281	4294526.513	520.232
NVA512	542042.757	4279965.958	569.115
NVA513	565064.031	4334418.59	471.036
NVA514	541355.512	4314213.688	493.312
NVA515	561863.239	4312353.722	480.876
NVA516	575034.222	4285004.672	478.375
NVA517	530195.422	4317137.125	527.627
NVA700	511709.059	4305967.776	558.514
NVA702	517443.672	4329898.166	521.321
NVA703	517436.909	4330193.208	525.09
NVA706	535820.946	4300132.787	528.939
NVA707	551381.21	4271218.645	549.896
NVA708	529009.692	4276921.372	586.747
NVA709	567006.973	4288003.112	482.96
NVA710	574038.607	4321794.599	432.725
NVA711	552174.906	4343031.483	488.594
NVA712	582311.517	4338179.974	402.366
NVA713	552640.337	4318448.776	449.717
NVA716	588202.456	4277291.916	463.911
NVA717	585530.092	4309435.517	436.78
NVA917	581706.483	4305553.546	474.801
NVA918	561380.733	4286582.833	488.535
NVA921	528452.209	4275063.214	581.134
NVA927	514417.606	4304741.957	557.747

ID	Easting	Northing	Elevation
NVA931	546208.622	4297246.394	513.13
NVA932	512138.495	4323419.34	527.139

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

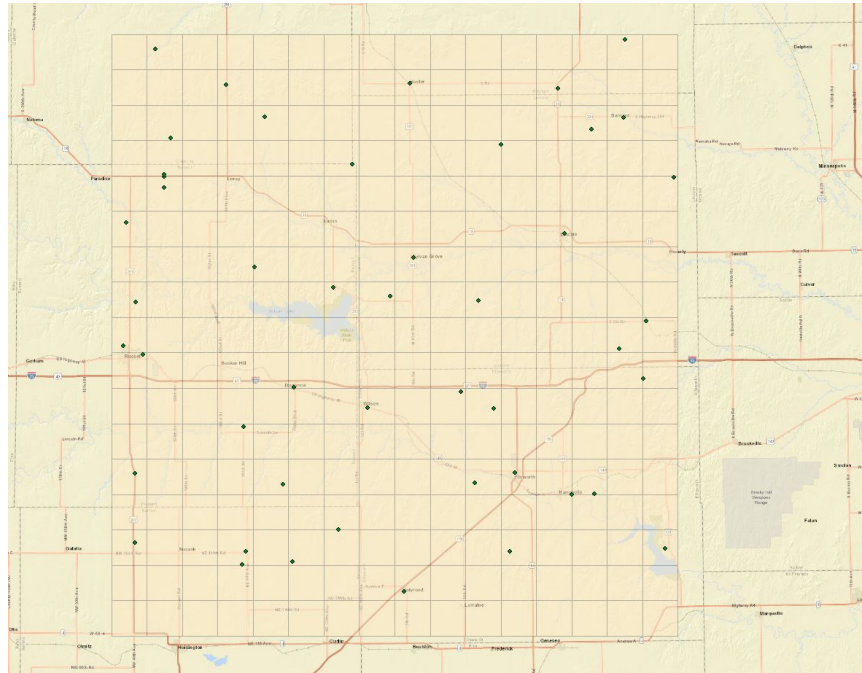


Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
VVA199	532705.47	4293667.452	516.387
VVA207	512707.253	4326681.582	509.034
VVA213	518937.642	4285987.682	572.381
VVA214	512899.497	4312162.548	495.267
VVA215	577333.232	4329407.752	446.991
VVA216	545268.819	4308429.248	508.729
VVA219	573042.388	4341433.144	454.857
VVA220	560621.658	4297867.627	515.785
VVA221	560277.288	4315535.848	463.055
VVA262	535700.394	4268876.557	560.98
VVA342	515019.888	4281444.857	573.427
VVA343	513983.143	4291167.546	564.649
VVA345	512160.135	4323434.281	526.992
VVA348	546224.196	4297259.693	513.024
VVA349	529862.971	4342832.538	539.905

ID	Easting	Northing	Elevation
VVA350	527045.04	4320227.751	531.268
VVA351	528414.626	4275041.345	581.421
VVA352	576998.961	4310834.566	430.647
VVA353	581675.313	4305573.036	473.795
VVA354	585931.244	4335084.744	403.170
VVA456	533411.453	4309793.581	465.199
VVA483	514384.989	4304746.567	557.637
VVA484	516926.955	4348480.654	541.679
VVA486	515884.802	4344523.757	592.13
VVA491	543014.28	4292586.261	504.698
VVA492	561412.208	4286569.736	488.403
VVA493	538575.983	4344077.383	541.704
VVA494	540531.259	4323700.67	457.766
VVA495	565521.389	4344926.898	431.174
VVA496	577968.503	4275443.959	478.524
VVA497	531799.989	4288779.81	532.586
VVA498	531572.699	4327492.054	465.025
VVA499	530224.37	4327385.182	467.006
VVA500	573053.73	4336906.46	466.171
VVA652	585550.491	4309447.19	435.961
VVA653	585096.015	4301338.761	467.779
VVA665	528621.403	4294483.521	520.379
VVA666	517427.23	4328321.215	525.631

Table 8: Vegetated Vertical Accuracy (VVA) Point Coordinates

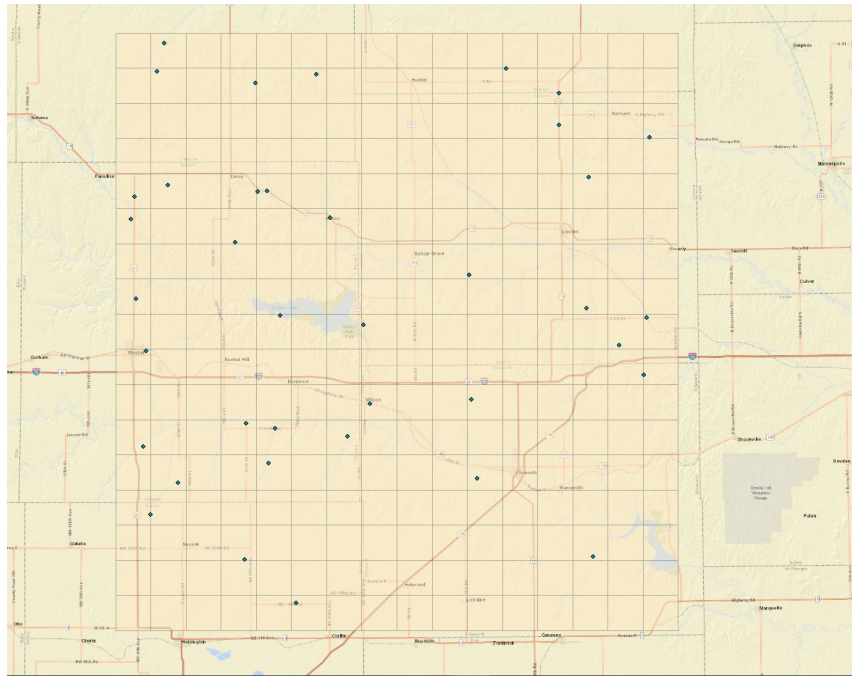


Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

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

c. LiDAR Point Cloud Statistics

Category	Value
Total Points (Nominal)	15,774,457,327
Nominal Pulse Spacing (M)	0.6602
Nominal Pulse Density (PLS/M²)	2.2944
Total Points (Aggregate)	20,325,092,971
Aggregate Pulse Spacing (M)	0.5821
Aggregate Pulse Density (PLS/M²)	2.9517

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 performed 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 1-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	Points (#)	RMSEz	Confidence Level (95%)	Percentile (95th)
NVA (Point Cloud)	46	0.0942	0.1846	0.1618
NVA (DEM)	46	0.0972	0.1904	0.1540
VVA (Point Cloud)	37	0.1456	0.2855	0.2628
VVA (DEM)	37	0.1478	0.2897	0.1654

Table 12: NVA/VVA Accuracies

SECTION V: CERTIFICATION STATEMENTS

1. Aerial LiDAR Project

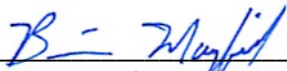
This accuracy assessment confirms that the data may be used for the intended applications stated in Section I of this document. This dataset may also be used as a topographic input for other applications, but the user should be aware that this LiDAR dataset was designed with a specific purpose and was 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
NVA299	516229.6690	4347928.9160	537.8190	537.7980	-0.0210	NVA
NVA301	518357.2100	4335381.3500	534.5540	534.4900	-0.0640	NVA
NVA307	513383.2580	4312158.4210	491.5200	491.5200	0.0000	NVA
NVA311	513359.4010	4287967.9860	583.9230	583.9040	-0.0190	NVA
NVA312	577862.7290	4336600.2090	427.2780	427.3630	0.0850	NVA
NVA314	549393.6920	4312996.4650	468.4990	468.3410	-0.1580	NVA
NVA315	526215.9880	4342832.2030	589.3070	589.5290	0.2220	NVA
NVA316	534250.3420	4286425.6400	565.9770	566.0760	0.0990	NVA
NVA317	535609.4600	4275528.4350	585.3010	585.3360	0.0350	NVA
NVA318	566235.4430	4276913.0390	523.2820	523.2670	-0.0150	NVA
NVA319	564021.8060	4297156.6440	546.3330	546.2350	-0.0980	NVA
NVA321	582536.3700	4349221.2910	436.3520	436.3800	0.0280	NVA
NVA322	578225.2050	4285084.9920	498.0200	498.1280	0.1080	NVA
NVA495	517471.3470	4328289.5050	524.9640	524.8770	-0.0870	NVA
NVA496	513364.3390	4278163.2190	593.0630	593.0670	0.0040	NVA
NVA505	573055.5740	4342294.6480	452.3790	452.3880	0.0090	NVA
NVA506	531622.5420	4338327.7530	527.6130	527.5700	-0.0430	NVA
NVA507	589469.3600	4329716.7660	427.0810	426.9290	-0.1520	NVA
NVA509	585116.3710	4301373.4520	467.6100	467.5450	-0.0650	NVA
NVA510	559376.9790	4299458.9710	523.3780	523.4720	0.0940	NVA
NVA511	528635.2810	4294526.5130	520.2320	520.3420	0.1100	NVA
NVA512	542042.7570	4279965.9580	569.1150	569.0010	-0.1140	NVA
NVA513	565064.0310	4334418.5900	471.0360	471.0130	-0.0230	NVA
NVA514	541355.5120	4314213.6880	493.3120	493.2140	-0.0980	NVA
NVA515	561863.2390	4312353.7220	480.8760	480.8710	-0.0050	NVA
NVA516	575034.2220	4285004.6720	478.3750	478.3520	-0.0230	NVA
NVA517	530195.4220	4317137.1250	527.6270	527.6680	0.0410	NVA
NVA700	511709.0590	4305967.7760	558.5140	558.2660	-0.2480	NVA
NVA702	517443.6720	4329898.1660	521.3210	521.3030	-0.0180	NVA
NVA703	517436.9090	4330193.2080	525.0900	524.9310	-0.1590	NVA
NVA706	535820.9460	4300132.7870	528.9390	528.9670	0.0280	NVA
NVA707	551381.2100	4271218.6450	549.8960	549.9650	0.0690	NVA
NVA708	529009.6920	4276921.3720	586.7470	586.6730	-0.0740	NVA
NVA709	567006.9730	4288003.1120	482.9600	482.9460	-0.0140	NVA
NVA710	574038.6070	4321794.5990	432.7250	432.7150	-0.0100	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
NVA711	552174.9060	4343031.4830	488.5940	488.5630	-0.0310	NVA
NVA712	582311.5170	4338179.9740	402.3660	402.3510	-0.0150	NVA
NVA713	552640.3370	4318448.7760	449.7170	449.6780	-0.0390	NVA
NVA716	588202.4560	4277291.9160	463.9110	464.0140	0.1030	NVA
NVA717	585530.0920	4309435.5170	436.7800	436.6630	-0.1170	NVA
NVA917	581706.4830	4305553.5460	474.8010	474.8490	0.0480	NVA
NVA918	561380.7330	4286582.8330	488.5350	488.6120	0.0770	NVA
NVA921	528452.2090	4275063.2140	581.1340	581.3130	0.1790	NVA
NVA927	514417.6060	4304741.9570	557.7470	557.6950	-0.0520	NVA
NVA932	512138.4950	4323419.3400	527.1390	527.3300	0.1910	NVA
VVA199	532705.4700	4293667.4520	516.3870	516.3990	0.0120	NVA
VVA207	512707.2530	4326681.5820	509.0340	509.1270	0.0930	VVA
VVA213	518937.6420	4285987.6820	572.3810	572.3700	-0.0110	VVA
VVA214	512899.4970	4312162.5480	495.2670	495.2610	-0.0060	VVA
VVA215	577333.2320	4329407.7520	446.9910	447.1220	0.1310	VVA
VVA216	545268.8190	4308429.2480	508.7290	508.8420	0.1130	VVA
VVA219	573042.3880	4341433.1440	454.8570	454.9700	0.1130	VVA
VVA220	560621.6580	4297867.6270	515.7850	515.7990	0.0140	VVA
VVA221	560277.2880	4315535.8480	463.0550	463.2790	0.2240	VVA
VVA262	535700.3940	4268876.5570	560.9800	560.9070	-0.0730	VVA
VVA342	515019.8880	4281444.8570	573.4270	573.3990	-0.0280	VVA
VVA343	513983.1430	4291167.5460	564.6490	564.5730	-0.0760	VVA
VVA345	512160.1350	4323434.2810	526.9920	526.9020	-0.0900	VVA
VVA348	546224.1960	4297259.6930	513.0240	513.4340	0.4100	VVA
VVA349	529862.9710	4342832.5380	539.9050	540.0110	0.1060	VVA
VVA350	527045.0400	4320227.7510	531.2680	531.4020	0.1340	VVA
VVA351	528414.6260	4275041.3450	581.4210	581.5140	0.0930	VVA
VVA352	576998.9610	4310834.5660	430.6470	430.8440	0.1970	VVA
VVA353	581675.3130	4305573.0360	473.7950	473.8680	0.0730	VVA
VVA354	585931.2440	4335084.7440	403.1700	403.1490	-0.0210	VVA
VVA456	533411.4530	4309793.5810	465.1990	465.2990	0.1000	VVA
VVA483	514384.9890	4304746.5670	557.6370	557.4780	-0.1590	VVA
VVA484	516926.9550	4348480.6540	541.6790	541.7430	0.0640	VVA
VVA486	515884.8020	4344523.7570	592.1300	592.3880	0.2580	VVA
VVA491	543014.2800	4292586.2610	504.6980	504.4940	-0.2040	VVA
VVA492	561412.2080	4286569.7360	488.4030	488.4930	0.0900	VVA
VVA493	538575.9830	4344077.3830	541.7040	541.9860	0.2820	VVA
VVA494	540531.2590	4323700.6700	457.7660	457.7050	-0.0610	VVA
VVA495	565521.3890	4344926.8980	431.1740	431.1290	-0.0450	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
VVA496	577968.5030	4275443.9590	478.5240	478.6620	0.1380	VVA
VVA497	531799.9890	4288779.8100	532.5860	532.8400	0.2540	VVA
VVA498	531572.6990	4327492.0540	465.0250	465.0410	0.0160	VVA
VVA499	530224.3700	4327385.1820	467.0060	466.7840	-0.2220	VVA
VVA500	573053.7300	4336906.4600	466.1710	466.1960	0.0250	VVA
VVA652	585550.4910	4309447.1900	435.9610	435.9400	-0.0210	VVA
VVA653	585096.0150	4301338.7610	467.7790	467.7550	-0.0240	VVA
VVA665	528621.4030	4294483.5210	520.3790	520.5680	0.1890	VVA
VVA666	517427.2300	4328321.2150	525.6310	525.5990	-0.0320	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
NVA299	516229.6690	4347928.9160	537.8190	537.7810	0.0380	NVA
NVA301	518357.2100	4335381.3500	534.5540	534.4950	0.0590	NVA
NVA307	513383.2580	4312158.4210	491.5200	491.5130	0.0070	NVA
NVA311	513359.4010	4287967.9860	583.9230	583.8980	0.0250	NVA
NVA312	577862.7290	4336600.2090	427.2780	427.3600	-0.0820	NVA
NVA314	549393.6920	4312996.4650	468.4990	468.3420	0.1570	NVA
NVA315	526215.9880	4342832.2030	589.3070	589.5090	-0.2020	NVA
NVA316	534250.3420	4286425.6400	565.9770	566.0770	-0.1000	NVA
NVA317	535609.4600	4275528.4350	585.3010	585.3390	-0.0380	NVA
NVA318	566235.4430	4276913.0390	523.2820	523.2500	0.0320	NVA
NVA319	564021.8060	4297156.6440	546.3330	546.2370	0.0960	NVA
NVA321	582536.3700	4349221.2910	436.3520	436.4120	-0.0600	NVA
NVA322	578225.2050	4285084.9920	498.0200	498.1580	-0.1380	NVA
NVA495	517471.3470	4328289.5050	524.9640	524.8760	0.0880	NVA
NVA496	513364.3390	4278163.2190	593.0630	593.0810	-0.0180	NVA
NVA505	573055.5740	4342294.6480	452.3790	452.3980	-0.0190	NVA
NVA506	531622.5420	4338327.7530	527.6130	527.5570	0.0560	NVA
NVA507	589469.3600	4329716.7660	427.0810	426.9360	0.1450	NVA
NVA509	585116.3710	4301373.4520	467.6100	467.5480	0.0620	NVA
NVA510	559376.9790	4299458.9710	523.3780	523.4790	-0.1010	NVA
NVA511	528635.2810	4294526.5130	520.2320	520.3530	-0.1210	NVA
NVA512	542042.7570	4279965.9580	569.1150	568.9920	0.1230	NVA
NVA513	565064.0310	4334418.5900	471.0360	470.9960	0.0400	NVA
NVA514	541355.5120	4314213.6880	493.3120	493.2260	0.0860	NVA
NVA515	561863.2390	4312353.7220	480.8760	480.8820	-0.0060	NVA
NVA516	575034.2220	4285004.6720	478.3750	478.3490	0.0260	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
NVA517	530195.4220	4317137.1250	527.6270	527.6580	-0.0310	NVA
NVA700	511709.0590	4305967.7760	558.5140	558.2400	0.2740	NVA
NVA702	517443.6720	4329898.1660	521.3210	521.2950	0.0260	NVA
NVA703	517436.9090	4330193.2080	525.0900	524.9240	0.1660	NVA
NVA706	535820.9460	4300132.7870	528.9390	528.9830	-0.0440	NVA
NVA707	551381.2100	4271218.6450	549.8960	549.9680	-0.0720	NVA
NVA708	529009.6920	4276921.3720	586.7470	586.6710	0.0760	NVA
NVA709	567006.9730	4288003.1120	482.9600	482.9250	0.0350	NVA
NVA710	574038.6070	4321794.5990	432.7250	432.7040	0.0210	NVA
NVA711	552174.9060	4343031.4830	488.5940	488.5690	0.0250	NVA
NVA712	582311.5170	4338179.9740	402.3660	402.3600	0.0060	NVA
NVA713	552640.3370	4318448.7760	449.7170	449.6420	0.0750	NVA
NVA716	588202.4560	4277291.9160	463.9110	464.0290	-0.1180	NVA
NVA717	585530.0920	4309435.5170	436.7800	436.6630	0.1170	NVA
NVA917	581706.4830	4305553.5460	474.8010	474.8480	-0.0470	NVA
NVA918	561380.7330	4286582.8330	488.5350	488.6030	-0.0680	NVA
NVA921	528452.2090	4275063.2140	581.1340	581.3180	-0.1840	NVA
NVA927	514417.6060	4304741.9570	557.7470	557.6820	0.0650	NVA
NVA932	512138.4950	4323419.3400	527.1390	527.3070	-0.1680	NVA
VVA199	532705.4700	4293667.4520	516.3870	516.3960	-0.0090	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA207	512707.2530	4326681.5820	509.0340	509.1170	-0.0830	VVA
VVA213	518937.6420	4285987.6820	572.3810	572.3610	0.0200	VVA
VVA214	512899.4970	4312162.5480	495.2670	495.2850	-0.0180	VVA
VVA215	577333.2320	4329407.7520	446.9910	447.1510	-0.1600	VVA
VVA216	545268.8190	4308429.2480	508.7290	508.8210	-0.0920	VVA
VVA219	573042.3880	4341433.1440	454.8570	454.9930	-0.1360	VVA
VVA220	560621.6580	4297867.6270	515.7850	515.8070	-0.0220	VVA
VVA221	560277.2880	4315535.8480	463.0550	463.2500	-0.1950	VVA
VVA262	535700.3940	4268876.5570	560.9800	560.9190	0.0610	VVA
VVA342	515019.8880	4281444.8570	573.4270	573.4190	0.0080	VVA
VVA343	513983.1430	4291167.5460	564.6490	564.5680	0.0810	VVA
VVA345	512160.1350	4323434.2810	526.9920	526.9510	0.0410	VVA
VVA348	546224.1960	4297259.6930	513.0240	513.4300	-0.4060	VVA
VVA349	529862.9710	4342832.5380	539.9050	540.0190	-0.1140	VVA
VVA350	527045.0400	4320227.7510	531.2680	531.4180	-0.1500	VVA
VVA351	528414.6260	4275041.3450	581.4210	581.5560	-0.1350	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA352	576998.9610	4310834.5660	430.6470	430.8460	-0.1990	VVA
VVA353	581675.3130	4305573.0360	473.7950	473.8580	-0.0630	VVA
VVA354	585931.2440	4335084.7440	403.1700	403.1330	0.0370	VVA
VVA456	533411.4530	4309793.5810	465.1990	465.2650	-0.0660	VVA
VVA483	514384.9890	4304746.5670	557.6370	557.4820	0.1550	VVA
VVA484	516926.9550	4348480.6540	541.6790	541.7390	-0.0600	VVA
VVA486	515884.8020	4344523.7570	592.1300	592.3910	-0.2610	VVA
VVA491	543014.2800	4292586.2610	504.6980	504.4910	0.2070	VVA
VVA492	561412.2080	4286569.7360	488.4030	488.4610	-0.0580	VVA
VVA493	538575.9830	4344077.3830	541.7040	542.0280	-0.3240	VVA
VVA494	540531.2590	4323700.6700	457.7660	457.7310	0.0350	VVA
VVA495	565521.3890	4344926.8980	431.1740	431.1290	0.0450	VVA
VVA496	577968.5030	4275443.9590	478.5240	478.6580	-0.1340	VVA
VVA497	531799.9890	4288779.8100	532.5860	532.8290	-0.2430	VVA
VVA498	531572.6990	4327492.0540	465.0250	465.0300	-0.0050	VVA
VVA499	530224.3700	4327385.1820	467.0060	466.7550	0.2510	VVA
VVA500	573053.7300	4336906.4600	466.1710	466.2030	-0.0320	VVA
VVA652	585550.4910	4309447.1900	435.9610	435.9450	0.0160	VVA
VVA653	585096.0150	4301338.7610	467.7790	467.7780	0.0010	VVA
VVA665	528621.4030	4294483.5210	520.3790	520.5720	-0.1930	VVA
VVA666	517427.2300	4328321.2150	525.6310	525.6010	0.0300	VVA

Table 14: DEM Check Point Assessment