



atlantic

Project Report

TASK ORDER NAME: 2018 Kansas QL2 LiDAR
CONTRACT ID: 000000000000000000000000039891
EVENT ID: EVT0003259
ATLANTIC PROJECT NUMBER: 18006
PROJECT BLOCK NUMBER: Block 10

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SECTION I: PROJECT OVERVIEW & PURPOSE

1. Aerial LiDAR Project

a. Project Overview

The State of Kansas Contract 00000000000000000000000039891 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 10 encompasses part or all of 6 counties in Kansas and covers approximately 3041 square miles.

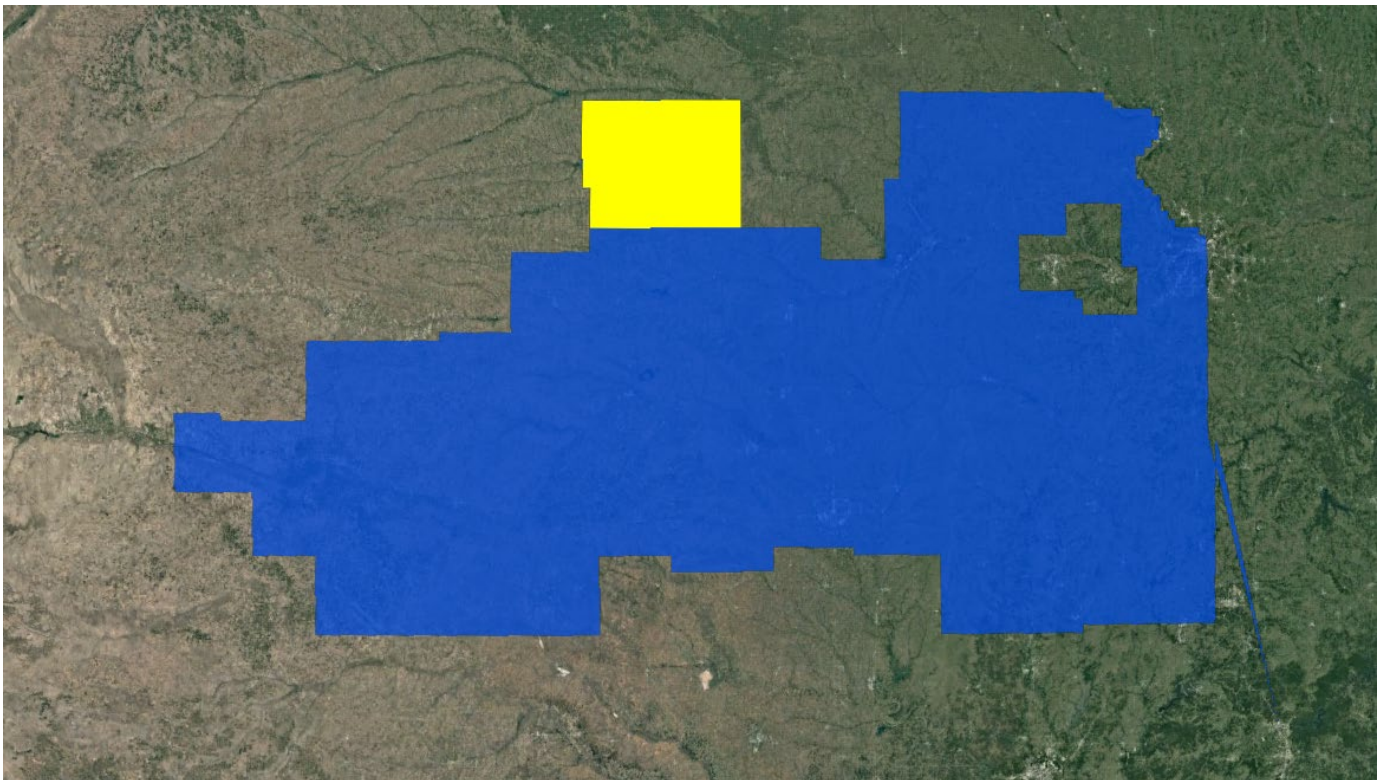


Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) and Associated Areas of Interest (AOIs)

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 99 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 8 flight missions conducted between March 15, 2018 and December 21, 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.

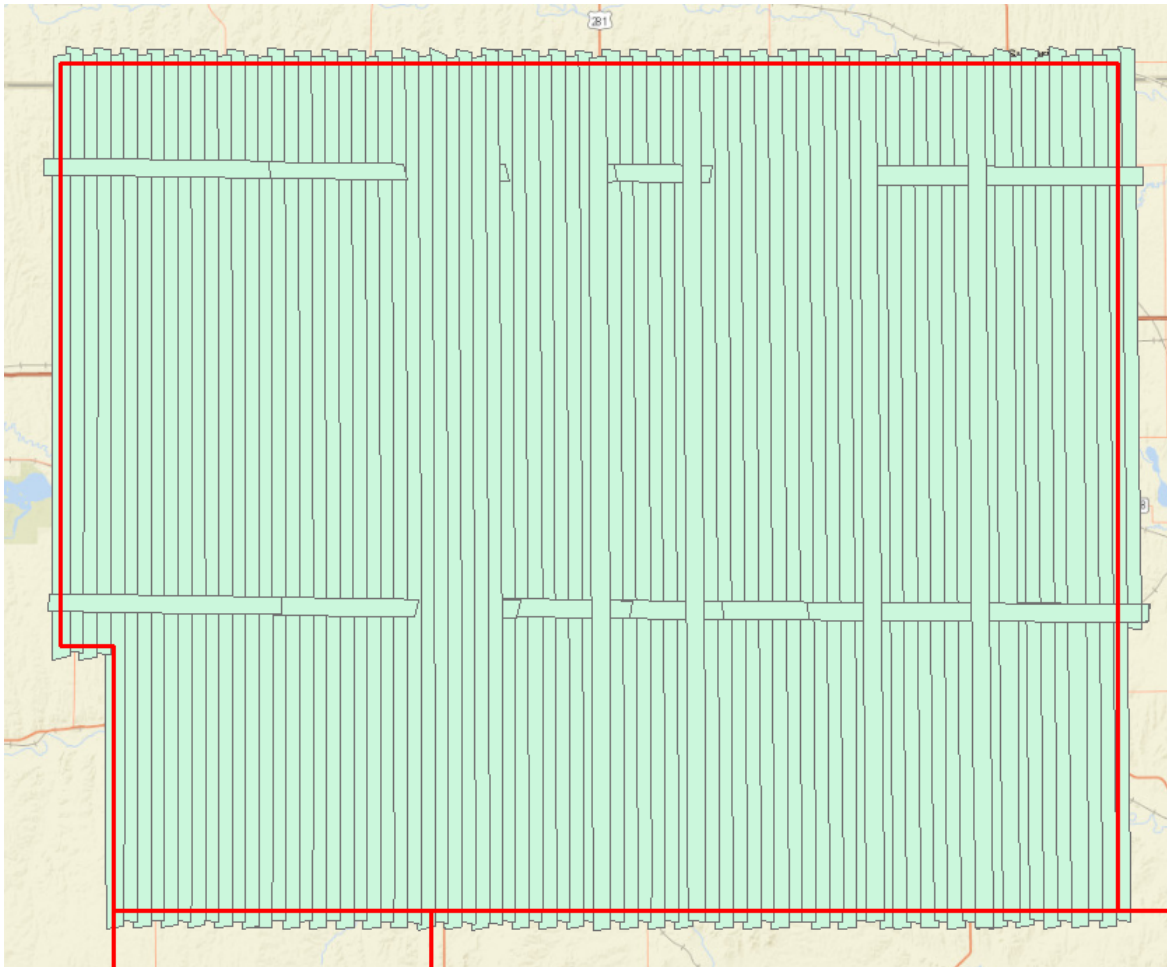


Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

d. GNSS Reference Stations

Seven (7) 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
KSCO	CORS	KSCO	39°36'37.78446"	97°39'44.38109"	399.372 m
KSCP	CORS	KSCP	38°58'16.54517"	97°01'11.91640"	320.534 m
KSHR	CORS	KSHR	38°35'32.79659	98°24'51.97977"	531.162 m
KSSL	CORS	KSSL	38°47'59.78190"	97°38'12.80331"	358.168 m
NEBU	CORS	NEBU	40°20'07.58797"	97°34'30.15678"	464.174 m
NEFR	CORS	NEFR	40°08'53.37718"	97°10'14.46878"	412.528 m
NERC	CORS	NERC	40°04'32.27634"	98°31'05.31771"	494.048 m

Table 5: GNSS Reference Stations

2. Aerial LiDAR Project – Ground Acquisition

a. Ground Control Survey

A total of 181 ground survey points were collected in support of this project, including 48 LiDAR Control Points (LCP), 83 Non-vegetated Vertical Accuracy (NVA) and 50 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
LCP290	587178.461	4376764.675	474.761
LCP291	551943.083	4377532.605	459.438
LCP292	553179.185	4375100.804	447.95
LCP293	559292.235	4360678.664	493.447
LCP294	559382.477	4418594.565	547.069
LCP295	544086.638	4413657.749	545.508
LCP296	548028.616	4418501.908	574.895
LCP297	572544.37	4402379.28	504.593
LCP298	572050.401	4422777.74	527.982
LCP299	576893.133	4427336.165	494.067
LCP300	587080.429	4413544.529	470.846
LCP301	586446.575	4416681.532	488.591
LCP302	566876.25	4406303.947	566.038
LCP303	567936.043	4426674.609	541.287
LCP304	572193.727	4409401.481	539.902
LCP305	553737.934	4424978.073	572.258
LCP306	556004.589	4420181.125	549.995
LCP435	497509.289	4399728.136	529.826
LCP436	513126.529	4388270.942	486.161

ID	Easting	Northing	Elevation
LCP437	557620.546	4426529.074	553.686
LCP438	524778.346	4404078.326	557.985
LCP439	528470.852	4403935.223	552.011
LCP440	533450.062	4395897.836	517.09
LCP441	541670.229	4395976.134	525.165
LCP442	536619.262	4389445.902	514.033
LCP443	534401.341	4384701.007	510.674
LCP444	519853.71	4384064.917	481.984
LCP445	560979.113	4413116.613	517.265
LCP446	579318.834	4359218.208	442.403
LCP449	541541.859	4365426.517	456.55
LCP450	540735.505	4354138.502	516.948
LCP451	534354.215	4350117.721	571.653
LCP452	531104.255	4357341.05	485.497
LCP453	505677.373	4364750.189	547.617
LCP455	516700.603	4354927.983	578.938
LCP456	520783.088	4352548.387	513.24
LCP461	519948.823	4410864.956	559.17
LCP462	506077.472	4414376.121	595.467
LCP463	510305.337	4421634.049	629.349
LCP464	512979.429	4424498.809	623.571
LCP465	530402.88	4422875.898	601.634
LCP466	534317.657	4419176.525	571.929
LCP467	559471.917	4389628.178	475.206
LCP468	551131.329	4391177.128	482.223
LCP469	564093.403	4391273.324	532.54
LCP470	585010.296	4383391.489	450.238
LCP471	561556.34	4355869.209	453.926
LCP472	560590.395	4352236.759	459.619

Table 6: LiDAR Control Point Coordinates

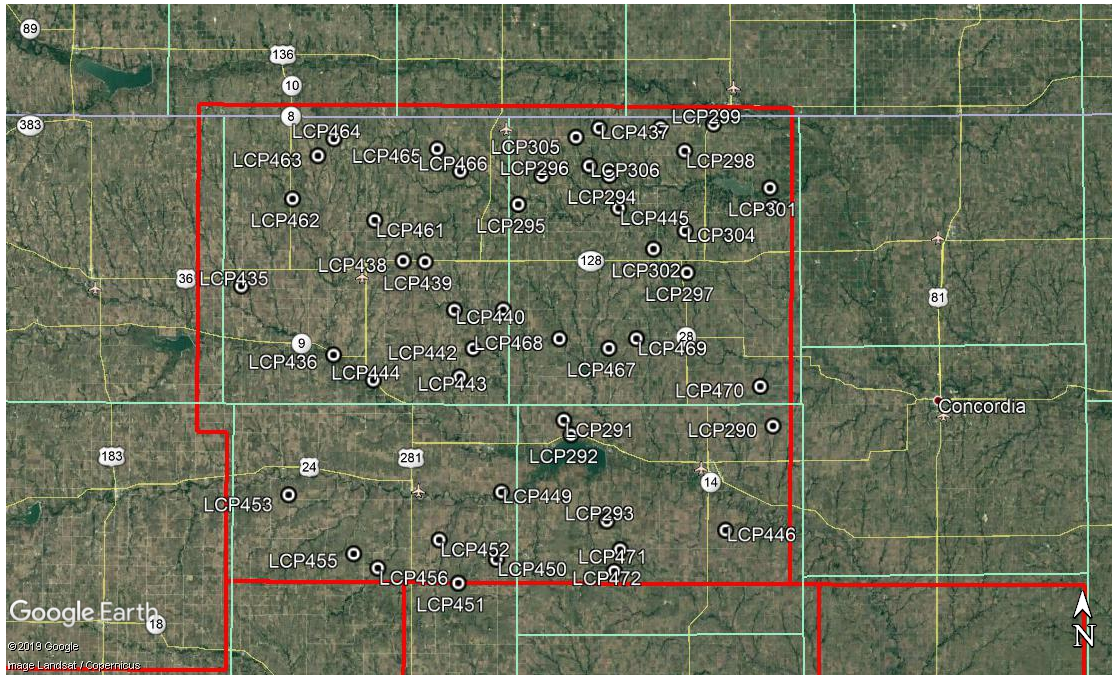


Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
NVA273	510325.373	4421627.809	629.382
NVA274	520083.93	4410920.529	562.673
NVA275	497506.606	4399689.494	532.151
NVA276	505690.07	4364743.759	547.749
NVA277	516682.783	4354941.573	578.964
NVA278	566863.966	4406301.341	565.959
NVA279	579319.932	4359223.142	442.569
NVA280	541537.688	4365413.755	455.526
NVA281	531117.7	4357354.167	484.987
NVA282	559475.769	4389640.718	474.903
NVA283	536637.237	4389491.757	510.418
NVA284	524780.646	4402452.256	562.832
NVA285	530563.54	4423226.641	596.897
NVA286	556004.274	4420205.379	551.72
NVA287	544124.633	4413652.655	544.886
NVA288	572196.017	4409425.199	539.547
NVA289	576903.787	4427325.894	494.389
NVA290	552055.255	4352610	560.319
NVA291	553182.239	4375118.555	447.371
NVA292	534419.935	4350428.269	564.38
NVA293	520774.05	4352538.634	513.204
NVA294	534394.624	4384698.531	510.677



ID	Easting	Northing	Elevation
NVA295	533450.904	4395900.341	517.069
NVA296	519838.519	4426081.124	614.006
NVA297	548019.727	4418480.543	574.829
NVA298	559383.491	4418583.655	547.115
NVA464	512112.511	4378319.635	552.815
NVA465	500715.923	4414117.232	598.667
NVA466	511881.415	4411941.473	560.182
NVA468	497492.345	4390481.331	506.821
NVA469	563282.822	4362289.31	474.211
NVA471	585604	4374430.835	463.655
NVA472	581951.647	4395862.091	462.782
NVA473	564630.613	4417041.958	496.618
NVA474	527978.586	4412791.809	611.493
NVA475	561291.656	4413121.774	531.091
NVA476	539088.752	4372652.365	452.471
NVA477	549434.05	4395970.724	493.676
NVA478	565853.313	4396580.397	542.521
NVA479	555913.498	4379931.911	448.557
NVA480	573494.043	4380057.362	476.283
NVA481	570889.077	4361184.491	451.102
NVA482	580425.533	4382542.798	475.393
NVA483	574656.549	4397758.219	489.967
NVA484	566981.607	4413799.366	542.249
NVA485	564002.779	4424575.909	552.177
NVA486	550242.185	4424551.34	566.594
NVA487	527952.273	4412373.264	609.853
NVA488	545705.501	4408818.024	582.14
NVA489	532745.147	4366937.984	477.477
NVA490	578585.748	4356027.885	460.551
NVA491	575004.704	4375366.484	459.456
NVA492	559505.291	4386392.908	487.839
NVA493	557779.88	4394512.887	496.979
NVA667	518426.65	4403958.06	551.801
NVA668	508149.931	4402307.577	559.839
NVA669	497318.164	4402750.81	543.452
NVA670	513115.175	4388253.486	485.9
NVA671	504534.798	4368781.282	502.578
NVA672	567735.844	4404407.588	538.994
NVA673	578152.69	4404236.367	502.298
NVA674	572483.939	4391455.534	475.41

ID	Easting	Northing	Elevation
NVA675	576627.604	4368442.148	431.665
NVA676	545786.269	4354263.25	484.644
NVA677	549089.604	4372929.333	455.756
NVA678	526112.923	4365281.929	472.299
NVA679	559362.986	4413589.382	505.825
NVA680	538069.233	4406817.058	563.097
NVA681	582220.884	4420894.724	505.87
NVA682	525544.81	4379840.01	470.153
NVA683	523943.419	4424755.195	581.98
NVA684	567412.084	4403821.029	524.886
NVA685	586222.632	4403831.493	466.343
NVA686	572469.286	4391835.901	474.674
NVA687	574999.128	4368939.237	430.399
NVA688	540784.441	4354302.804	510.605
NVA689	539184.675	4372879.153	452.421
NVA690	526295.543	4365477.176	473.344
NVA691	548289.209	4408210.248	562.38
NVA692	538060.443	4406831.442	563.377
NVA693	582620.684	4421037.79	514.21
NVA694	526506.424	4379075.838	468.022
NVA695	524707.851	4424815.707	592.157

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

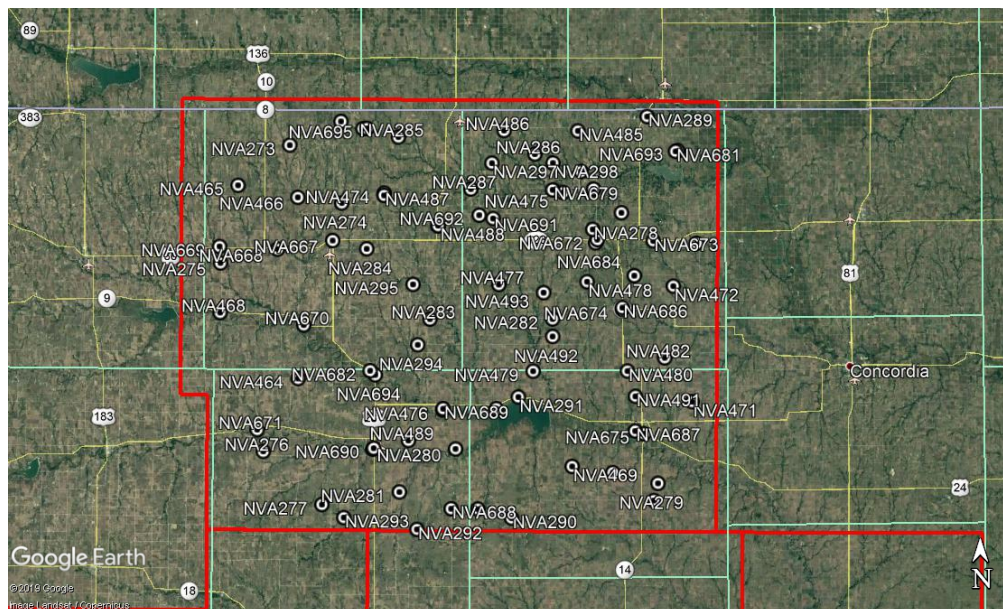


Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
VVA190	506062.753	4414395.044	597.415

ID	Easting	Northing	Elevation
VVA191	517071.71	4395859.267	518.773
VVA192	557611.648	4426530.897	553.241
VVA193	572548.705	4402398.854	504.757
VVA194	542136.728	4395941.131	525.987
VVA195	524768.407	4404075.186	557.392
VVA196	587204.079	4376811.274	474.946
VVA197	551979.808	4377523.035	459.987
VVA198	561554.541	4355878.737	452.395
VVA200	564088.341	4391259.134	531.727
VVA201	519896.071	4384013.48	481.331
VVA202	528494.426	4403943.575	551.949
VVA203	568021.229	4426737.861	537.202
VVA204	560579.076	4352244.202	459.034
VVA205	551140.449	4391167.463	481.835
VVA206	557201.436	4360653.189	478.936
VVA323	507886.05	4369314.148	495.185
VVA324	502309.938	4397428.146	-468.91
VVA325	512967.876	4424493.404	622.549
VVA326	559519.403	4383267.003	473.659
VVA327	560982.535	4413929.073	508.195
VVA328	529629.643	4376663.128	463.152
VVA329	540755.062	4354137.336	515.724
VVA330	542899.519	4408813.756	-531.38
VVA331	583102.631	4401026.124	454.441
VVA332	524605.478	4425541.684	-525.18
VVA333	558591.561	4394437.979	-433.904
VVA334	559202.791	4376746.618	440.196
VVA335	559531.095	4408937.718	-496.053
VVA336	547422.827	4360590.293	457.587
VVA337	574895.107	4351084.162	-398.231
VVA338	536135.961	4395894.436	501.138
VVA339	581755.783	4407398.218	-428.465
VVA340	523361.17	4424866.872	582.933
VVA467	501207.89	4420000.717	624.07
VVA468	518382.846	4376959.549	501.288
VVA469	506212.762	4353452.159	543.379
VVA470	577909.807	4417878.919	483.744
VVA471	550890.348	4413731.2	529.409
VVA472	557806.599	4394049.239	489.303
VVA473	526484.51	4386228.944	521.395

ID	Easting	Northing	Elevation
VVA474	535221.912	4364184.315	464.282
VVA475	579131.408	4388145.65	454.051
VVA476	570823.89	4417016.928	491.252
VVA477	534327.446	4419176.139	571.603
VVA478	560070.81	4363910.523	457.337
VVA479	531301.552	4386703.149	504.157
VVA480	535274.949	4364212.203	462.139
VVA481	580307.988	4364668.962	416.593
VVA482	580261.886	4388167.188	443.302

Table 8: Vegetated Vertical Accuracy (VVA) Point Coordinates

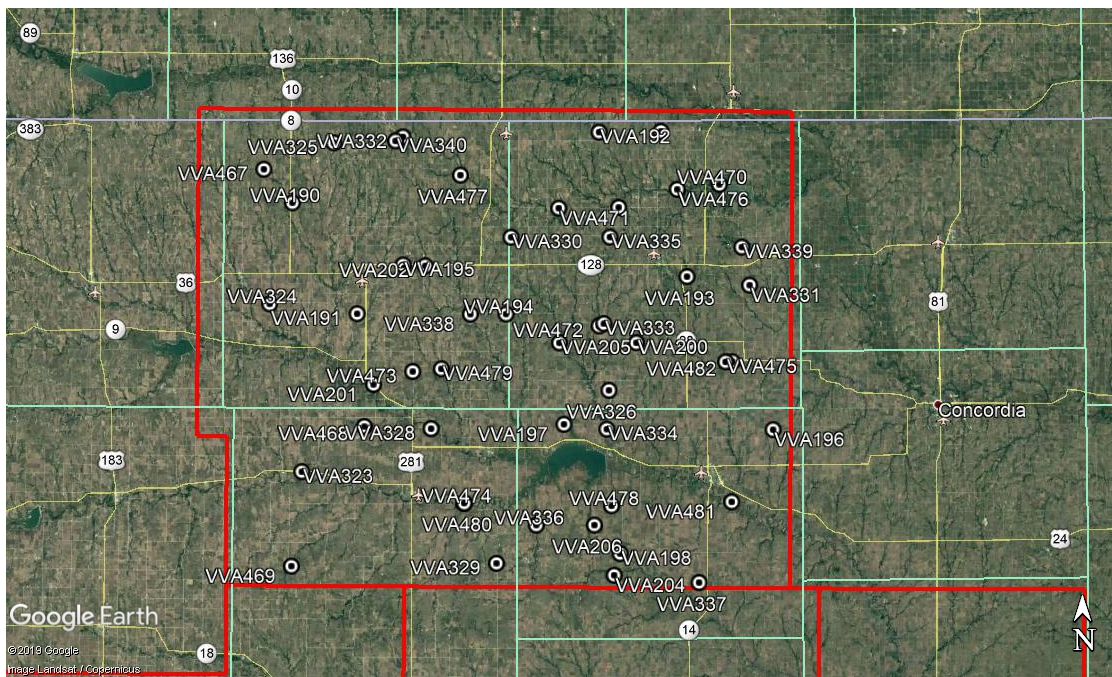


Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

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)	14,774,848,922
Nominal Pulse Spacing (M)	0.6571
Nominal Pulse Density (PLS/M²)	2.3159
Total Points (Aggregate)	22,671,677,624
Aggregate Pulse Spacing (M)	0.5869
Aggregate Pulse Density (PLS/M²)	2.9030

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 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)	79	0.0734	0.1438	0.1248
NVA (DEM)	79	0.0724	0.1419	0.0966
VVA (Point Cloud)	43	0.1651	0.3235	0.2746
VVA (DEM)	43	0.1479	0.2898	0.1387

Table 12: NVA/VVA Accuracies

SECTION V: CERTIFICATION STATEMENTS

1. Aerial LiDAR Project

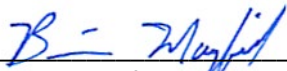
This accuracy assessment confirms that the data may be used for the intended applications stated in Section I of this document. This dataset may also be used as a topographic input for other applications, but the user should be aware that this LiDAR dataset was designed with a specific purpose and was 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
NVA273	510326.1040	4421627.0460	629.3820	629.3160	-0.0660	NVA
NVA274	520084.6590	4410919.7680	562.6730	562.6150	-0.0580	NVA
NVA276	505690.8020	4364743.0050	547.7490	547.8320	0.0830	NVA
NVA277	516683.5130	4354940.8210	578.9640	578.9830	0.0190	NVA
NVA279	579320.6520	4359222.3900	442.5690	442.6180	0.0490	NVA
NVA280	541538.4140	4365413.0020	455.5260	455.5510	0.0250	NVA
NVA281	531118.4280	4357353.4150	484.9870	485.0070	0.0200	NVA
NVA282	559476.4920	4389639.9610	474.9030	475.0500	0.1470	NVA
NVA283	536637.9640	4389491.0000	510.4180	510.4590	0.0410	NVA
NVA284	524781.3750	4402451.4960	562.8320	562.8210	-0.0110	NVA
NVA285	530564.2670	4423225.8780	596.8970	597.0090	0.1120	NVA
NVA286	556004.9970	4420204.6170	551.7200	551.6490	-0.0710	NVA
NVA287	544125.3580	4413651.8940	544.8860	544.8720	-0.0140	NVA
NVA288	572196.7380	4409424.4390	539.5470	539.6790	0.1320	NVA
NVA289	576904.5070	4427325.1310	494.3890	494.4190	0.0300	NVA
NVA290	552055.9800	4352609.2490	560.3190	560.3330	0.0140	NVA
NVA291	553182.9630	4375117.8000	447.3710	447.3880	0.0170	NVA
NVA292	534420.6630	4350427.5180	564.3800	564.4150	0.0350	NVA
NVA293	520774.7800	4352537.8820	513.2040	513.2130	0.0090	NVA
NVA294	534395.3510	4384697.7740	510.6770	510.7590	0.0820	NVA
NVA295	533451.6310	4395899.5830	517.0690	517.0500	-0.0190	NVA
NVA296	519839.2480	4426080.3610	614.0060	613.8890	-0.1170	NVA
NVA297	548020.4520	4418479.7810	574.8290	574.8540	0.0250	NVA
NVA298	559384.2140	4418582.8930	547.1150	547.1290	0.0140	NVA
NVA321	582537.0900	4349220.5410	436.3520	436.3520	0.0000	NVA
NVA464	512113.2420	4378318.8790	552.8150	552.8090	-0.0060	NVA
NVA465	500716.6550	4414116.4700	598.6670	598.3410	-0.3260	NVA
NVA466	511882.1450	4411940.7120	560.1820	560.1610	-0.0210	NVA
NVA469	563283.5450	4362288.5570	474.2110	474.2870	0.0760	NVA
NVA471	585604.7190	4374430.0810	463.6550	463.6670	0.0120	NVA
NVA472	581952.3670	4395861.3330	462.7820	462.7690	-0.0130	NVA
NVA473	564631.3350	4417041.1970	496.6180	496.6080	-0.0100	NVA
NVA474	527979.3140	4412791.0480	611.4930	611.4380	-0.0550	NVA
NVA475	561292.3790	4413121.0130	531.0910	531.2390	0.1480	NVA
NVA476	539089.4790	4372651.6100	452.4710	452.4340	-0.0370	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
NVA477	549434.7750	4395969.9660	493.6760	493.7730	0.0970	NVA
NVA478	565854.0350	4396579.6390	542.5210	542.4810	-0.0400	NVA
NVA479	555914.2220	4379931.1550	448.5570	448.5120	-0.0450	NVA
NVA480	573494.7640	4380056.6070	476.2830	476.4150	0.1320	NVA
NVA481	570889.7990	4361183.7390	451.1020	451.0850	-0.0170	NVA
NVA482	580426.2530	4382542.0420	475.3930	475.3730	-0.0200	NVA
NVA483	574657.2700	4397757.4610	489.9670	490.0910	0.1240	NVA
NVA484	566982.3290	4413798.6050	542.2490	542.2170	-0.0320	NVA
NVA485	564003.5010	4424575.1470	552.1770	552.1230	-0.0540	NVA
NVA486	550242.9090	4424550.5770	566.5940	566.6090	0.0150	NVA
NVA487	527953.0010	4412372.5030	609.8530	609.9090	0.0560	NVA
NVA488	545706.2260	4408817.2640	582.1400	582.2240	0.0840	NVA
NVA489	532745.8750	4366937.2300	477.4770	477.4520	-0.0250	NVA
NVA490	578586.4690	4356027.1340	460.5510	460.5930	0.0420	NVA
NVA491	575005.4250	4375365.7290	459.4560	459.5180	0.0620	NVA
NVA492	559506.0140	4386392.1510	487.8390	487.9170	0.0780	NVA
NVA493	557780.6030	4394512.1290	496.9790	496.9760	-0.0030	NVA
NVA667	518427.3800	4403957.3000	551.8010	551.7780	-0.0230	NVA
NVA668	508150.6620	4402306.8170	559.8390	559.8900	0.0510	NVA
NVA670	513115.9060	4388252.7290	485.9000	485.8940	-0.0060	NVA
NVA671	504535.5300	4368780.5280	502.5780	502.5410	-0.0370	NVA
NVA672	567736.5660	4404406.8290	538.9940	538.9480	-0.0460	NVA
NVA674	572484.6600	4391454.7770	475.4100	475.4880	0.0780	NVA
NVA675	576628.3250	4368441.3950	431.6650	431.7230	0.0580	NVA
NVA676	545786.9950	4354262.4980	484.6440	484.6660	0.0220	NVA
NVA677	549090.3290	4372928.5790	455.7560	455.7920	0.0360	NVA
NVA678	526113.6520	4365281.1750	472.2990	472.3920	0.0930	NVA
NVA679	559363.7090	4413588.6210	505.8250	505.8790	0.0540	NVA
NVA680	538069.9590	4406816.2980	563.0970	563.0510	-0.0460	NVA
NVA681	582221.6030	4420893.9620	505.8700	505.9130	0.0430	NVA
NVA682	525545.5390	4379839.2540	470.1530	470.1540	0.0010	NVA
NVA683	523944.1470	4424754.4320	581.9800	582.0990	0.1190	NVA
NVA684	567412.8060	4403820.2700	524.8860	524.8520	-0.0340	NVA
NVA685	586223.3510	4403830.7340	466.3430	466.3300	-0.0130	NVA
NVA686	572470.0070	4391835.1440	474.6740	474.7250	0.0510	NVA
NVA687	574999.8490	4368938.4830	430.3990	430.4960	0.0970	NVA
NVA688	540785.1680	4354302.0520	510.6050	510.4400	-0.1650	NVA
NVA689	539185.4020	4372878.3980	452.4210	452.3740	-0.0470	NVA
NVA690	526296.2720	4365476.4220	473.3440	473.4320	0.0880	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
NVA691	548289.9340	4408209.4880	562.3800	562.3990	0.0190	NVA
NVA692	538061.1690	4406830.6820	563.3770	563.3900	0.0130	NVA
NVA693	582621.4030	4421037.0280	514.2100	514.2330	0.0230	NVA
NVA694	526507.1530	4379075.0820	468.0220	468.0780	0.0560	NVA
NVA695	524708.5790	4424814.9440	592.1570	592.2460	0.0890	NVA
VVA190	506063.4840	4414394.2820	597.4150	597.3770	-0.0380	NVA
VVA191	517072.4400	4395858.5080	518.7730	518.9790	0.2060	VVA
VVA192	557612.3710	4426530.1340	553.2410	553.4100	0.1690	VVA
VVA193	572549.4260	4402398.0950	504.7570	504.7410	-0.0160	VVA
VVA194	542137.4540	4395940.3730	525.9870	526.1760	0.1890	VVA
VVA195	524769.1360	4404074.4260	557.3920	557.4900	0.0980	VVA
VVA196	587204.7980	4376810.5190	474.9460	475.3280	0.3820	VVA
VVA197	551980.5330	4377522.2800	459.9870	460.2580	0.2710	VVA
VVA198	561555.2640	4355877.9850	452.3950	452.6640	0.2690	VVA
VVA200	564089.0630	4391258.3770	531.7270	531.6540	-0.0730	VVA
VVA201	519896.8010	4384012.7230	481.3310	481.5920	0.2610	VVA
VVA202	528495.1540	4403942.8150	551.9490	552.0250	0.0760	VVA
VVA203	568021.9500	4426737.0980	537.2020	537.5260	0.3240	VVA
VVA204	560579.8000	4352243.4510	459.0340	459.1750	0.1410	VVA
VVA205	551141.1740	4391166.7060	481.8350	481.8630	0.0280	VVA
VVA206	557202.1600	4360652.4370	478.9360	479.0790	0.1430	VVA
VVA323	507886.7820	4369313.3940	495.1850	495.3290	0.1440	VVA
VVA324	502310.6700	4397427.3870	520.5380	520.3860	-0.1520	VVA
VVA325	512968.6060	4424492.6410	622.5490	622.5610	0.0120	VVA
VVA326	559520.1260	4383266.2470	473.6590	473.8130	0.1540	VVA
VVA327	560983.2580	4413928.3120	508.1950	508.3520	0.1570	VVA
VVA328	529630.3710	4376662.3730	463.1520	463.0990	-0.0530	VVA
VVA329	540755.7890	4354136.5840	515.7240	515.6090	-0.1150	VVA
VVA330	542900.2450	4408812.9960	583.2560	583.4790	0.2230	VVA
VVA331	583103.3500	4401025.3650	454.4410	454.5740	0.1330	VVA
VVA332	524606.2060	4425540.9210	576.8040	576.8470	0.0430	VVA
VVA333	558592.2840	4394437.2210	486.3920	486.4880	0.0960	VVA
VVA334	559203.5140	4376745.8630	440.1960	440.2230	0.0270	VVA
VVA335	559531.8180	4408936.9580	548.2250	548.1700	-0.0550	VVA
VVA336	547423.5530	4360589.5400	457.5870	457.6550	0.0680	VVA
VVA337	574895.8280	4351083.4110	452.0990	452.3200	0.2210	VVA
VVA338	536136.6880	4395893.6780	501.1380	501.2970	0.1590	VVA
VVA339	581756.5020	4407397.4580	480.9340	481.0200	0.0860	VVA
VVA340	523361.8980	4424866.1090	582.9330	583.0650	0.1320	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
VVA467	501208.6220	4419999.9540	624.0700	623.8320	-0.2380	VVA
VVA468	518383.5760	4376958.7930	501.2880	501.3420	0.0540	VVA
VVA469	506213.4940	4353451.4070	543.3790	543.5210	0.1420	VVA
VVA473	526485.2380	4386228.1870	521.3950	521.5780	0.1830	VVA
VVA476	570824.6110	4417016.1670	491.2520	491.5270	0.2750	VVA
VVA477	534328.1730	4419175.3770	571.6030	571.6660	0.0630	VVA
VVA478	560071.5330	4363909.7700	457.3370	457.5250	0.1880	VVA
VVA479	531302.2800	4386702.3920	504.1570	504.2070	0.0500	VVA
VVA481	580308.7080	4364668.2090	416.5930	416.6650	0.0720	VVA
VVA482	580262.6060	4388166.4310	443.3020	443.3900	0.0880	VVA
VVA484	516927.6860	4348479.9030	541.6790	541.7270	0.0480	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
NVA273	510326.1040	4421627.0460	629.3820	629.3080	0.0740	NVA
NVA274	520084.6590	4410919.7680	562.6730	562.6010	0.0720	NVA
NVA276	505690.8020	4364743.0050	547.7490	547.8260	-0.0770	NVA
NVA277	516683.5130	4354940.8210	578.9640	578.9640	0.0000	NVA
NVA279	579320.6520	4359222.3900	442.5690	442.6080	-0.0390	NVA
NVA280	541538.4140	4365413.0020	455.5260	455.5400	-0.0140	NVA
NVA281	531118.4280	4357353.4150	484.9870	484.9960	-0.0090	NVA
NVA282	559476.4920	4389639.9610	474.9030	474.9970	-0.0940	NVA
NVA283	536637.9640	4389491.0000	510.4180	510.3930	0.0250	NVA
NVA284	524781.3750	4402451.4960	562.8320	562.8270	0.0050	NVA
NVA285	530564.2670	4423225.8780	596.8970	597.0090	-0.1120	NVA
NVA286	556004.9970	4420204.6170	551.7200	551.6590	0.0610	NVA
NVA287	544125.3580	4413651.8940	544.8860	544.8910	-0.0050	NVA
NVA288	572196.7380	4409424.4390	539.5470	539.6660	-0.1190	NVA
NVA289	576904.5070	4427325.1310	494.3890	494.4220	-0.0330	NVA
NVA290	552055.9800	4352609.2490	560.3190	560.3210	-0.0020	NVA
NVA291	553182.9630	4375117.8000	447.3710	447.4170	-0.0460	NVA
NVA292	534420.6630	4350427.5180	564.3800	564.4050	-0.0250	NVA
NVA293	520774.7800	4352537.8820	513.2040	513.2130	-0.0090	NVA
NVA294	534395.3510	4384697.7740	510.6770	510.7420	-0.0650	NVA
NVA295	533451.6310	4395899.5830	517.0690	517.0490	0.0200	NVA
NVA296	519839.2480	4426080.3610	614.0060	613.9040	0.1020	NVA
NVA297	548020.4520	4418479.7810	574.8290	574.8550	-0.0260	NVA
NVA298	559384.2140	4418582.8930	547.1150	547.1320	-0.0170	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
NVA464	512113.2420	4378318.8790	552.8150	552.8010	0.0140	NVA
NVA465	500716.6550	4414116.4700	598.6670	598.3550	0.3120	NVA
NVA466	511882.1450	4411940.7120	560.1820	560.1230	0.0590	NVA
NVA469	563283.5450	4362288.5570	474.2110	474.2900	-0.0790	NVA
NVA471	585604.7190	4374430.0810	463.6550	463.6660	-0.0110	NVA
NVA472	581952.3670	4395861.3330	462.7820	462.7650	0.0170	NVA
NVA473	564631.3350	4417041.1970	496.6180	496.6120	0.0060	NVA
NVA474	527979.3140	4412791.0480	611.4930	611.4360	0.0570	NVA
NVA475	561292.3790	4413121.0130	531.0910	531.2450	-0.1540	NVA
NVA476	539089.4790	4372651.6100	452.4710	452.4400	0.0310	NVA
NVA477	549434.7750	4395969.9660	493.6760	493.7850	-0.1090	NVA
NVA478	565854.0350	4396579.6390	542.5210	542.5000	0.0210	NVA
NVA479	555914.2220	4379931.1550	448.5570	448.5300	0.0270	NVA
NVA480	573494.7640	4380056.6070	476.2830	476.4170	-0.1340	NVA
NVA481	570889.7990	4361183.7390	451.1020	451.0900	0.0120	NVA
NVA482	580426.2530	4382542.0420	475.3930	475.3900	0.0030	NVA
NVA483	574657.2700	4397757.4610	489.9670	490.1010	-0.1340	NVA
NVA484	566982.3290	4413798.6050	542.2490	542.2450	0.0040	NVA
NVA485	564003.5010	4424575.1470	552.1770	552.1290	0.0480	NVA
NVA486	550242.9090	4424550.5770	566.5940	566.6120	-0.0180	NVA
NVA487	527953.0010	4412372.5030	609.8530	609.8870	-0.0340	NVA
NVA488	545706.2260	4408817.2640	582.1400	582.2160	-0.0760	NVA
NVA489	532745.8750	4366937.2300	477.4770	477.4350	0.0420	NVA
NVA490	578586.4690	4356027.1340	460.5510	460.5960	-0.0450	NVA
NVA491	575005.4250	4375365.7290	459.4560	459.5140	-0.0580	NVA
NVA492	559506.0140	4386392.1510	487.8390	487.8900	-0.0510	NVA
NVA493	557780.6030	4394512.1290	496.9790	496.9740	0.0050	NVA
NVA667	518427.3800	4403957.3000	551.8010	551.7740	0.0270	NVA
NVA668	508150.6620	4402306.8170	559.8390	559.8850	-0.0460	NVA
NVA670	513115.9060	4388252.7290	485.9000	485.8830	0.0170	NVA
NVA671	504535.5300	4368780.5280	502.5780	502.4820	0.0960	NVA
NVA672	567736.5660	4404406.8290	538.9940	538.8770	0.1170	NVA
NVA674	572484.6600	4391454.7770	475.4100	475.4750	-0.0650	NVA
NVA675	576628.3250	4368441.3950	431.6650	431.7060	-0.0410	NVA
NVA676	545786.9950	4354262.4980	484.6440	484.6310	0.0130	NVA
NVA677	549090.3290	4372928.5790	455.7560	455.8120	-0.0560	NVA
NVA678	526113.6520	4365281.1750	472.2990	472.3380	-0.0390	NVA
NVA679	559363.7090	4413588.6210	505.8250	505.8730	-0.0480	NVA
NVA680	538069.9590	4406816.2980	563.0970	563.0500	0.0470	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
NVA681	582221.6030	4420893.9620	505.8700	505.8950	-0.0250	NVA
NVA682	525545.5390	4379839.2540	470.1530	470.1360	0.0170	NVA
NVA683	523944.1470	4424754.4320	581.9800	582.0890	-0.1090	NVA
NVA684	567412.8060	4403820.2700	524.8860	524.8540	0.0320	NVA
NVA685	586223.3510	4403830.7340	466.3430	466.3250	0.0180	NVA
NVA686	572470.0070	4391835.1440	474.6740	474.7380	-0.0640	NVA
NVA687	574999.8490	4368938.4830	430.3990	430.5230	-0.1240	NVA
NVA688	540785.1680	4354302.0520	510.6050	510.4200	0.1850	NVA
NVA689	539185.4020	4372878.3980	452.4210	452.3480	0.0730	NVA
NVA690	526296.2720	4365476.4220	473.3440	473.4310	-0.0870	NVA
NVA691	548289.9340	4408209.4880	562.3800	562.3880	-0.0080	NVA
NVA692	538061.1690	4406830.6820	563.3770	563.3810	-0.0040	NVA
NVA693	582621.4030	4421037.0280	514.2100	514.2220	-0.0120	NVA
NVA694	526507.1530	4379075.0820	468.0220	468.0860	-0.0640	NVA
NVA695	524708.5790	4424814.9440	592.1570	592.2290	-0.0720	NVA
VVA190	506063.4840	4414394.2820	597.4150	597.3990	0.0160	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA191	517072.4400	4395858.5080	518.7730	518.9730	-0.2000	VVA
VVA192	557612.3710	4426530.1340	553.2410	553.3940	-0.1530	VVA
VVA193	572549.4260	4402398.0950	504.7570	504.7630	-0.0060	VVA
VVA194	542137.4540	4395940.3730	525.9870	526.1440	-0.1570	VVA
VVA195	524769.1360	4404074.4260	557.3920	557.4960	-0.1040	VVA
VVA196	587204.7980	4376810.5190	474.9460	475.3240	-0.3780	VVA
VVA197	551980.5330	4377522.2800	459.9870	460.1390	-0.1520	VVA
VVA198	561555.2640	4355877.9850	452.3950	452.6440	-0.2490	VVA
VVA200	564089.0630	4391258.3770	531.7270	531.6360	0.0910	VVA
VVA201	519896.8010	4384012.7230	481.3310	481.5560	-0.2250	VVA
VVA202	528495.1540	4403942.8150	551.9490	552.0380	-0.0890	VVA
VVA203	568021.9500	4426737.0980	537.2020	537.3350	-0.1330	VVA
VVA204	560579.8000	4352243.4510	459.0340	459.1990	-0.1650	VVA
VVA205	551141.1740	4391166.7060	481.8350	481.9290	-0.0940	VVA
VVA206	557202.1600	4360652.4370	478.9360	479.0340	-0.0980	VVA
VVA323	507886.7820	4369313.3940	495.1850	495.3270	-0.1420	VVA
VVA324	502310.6700	4397427.3870	520.5380	520.3850	0.1530	VVA
VVA325	512968.6060	4424492.6410	622.5490	622.5740	-0.0250	VVA
VVA326	559520.1260	4383266.2470	473.6590	473.7820	-0.1230	VVA
VVA327	560983.2580	4413928.3120	508.1950	508.3220	-0.1270	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA328	529630.3710	4376662.3730	463.1520	463.1040	0.0480	VVA
VVA329	540755.7890	4354136.5840	515.7240	515.5800	0.1440	VVA
VVA330	542900.2450	4408812.9960	583.2560	583.4140	-0.1580	VVA
VVA331	583103.3500	4401025.3650	454.4410	454.5950	-0.1540	VVA
VVA332	524606.2060	4425540.9210	576.8040	576.8410	-0.0370	VVA
VVA333	558592.2840	4394437.2210	486.3920	486.4870	-0.0950	VVA
VVA334	559203.5140	4376745.8630	440.1960	440.2240	-0.0280	VVA
VVA335	559531.8180	4408936.9580	548.2250	548.2050	0.0200	VVA
VVA336	547423.5530	4360589.5400	457.5870	457.6560	-0.0690	VVA
VVA337	574895.8280	4351083.4110	452.0990	452.3160	-0.2170	VVA
VVA338	536136.6880	4395893.6780	501.1380	501.3200	-0.1820	VVA
VVA339	581756.5020	4407397.4580	480.9340	481.0180	-0.0840	VVA
VVA340	523361.8980	4424866.1090	582.9330	583.0460	-0.1130	VVA
VVA467	501208.6220	4419999.9540	624.0700	623.8380	0.2320	VVA
VVA468	518383.5760	4376958.7930	501.2880	501.3420	-0.0540	VVA
VVA469	506213.4940	4353451.4070	543.3790	543.5120	-0.1330	VVA
VVA473	526485.2380	4386228.1870	521.3950	521.5690	-0.1740	VVA
VVA476	570824.6110	4417016.1670	491.2520	491.5000	-0.2480	VVA
VVA477	534328.1730	4419175.3770	571.6030	571.6910	-0.0880	VVA
VVA478	560071.5330	4363909.7700	457.3370	457.5130	-0.1760	VVA
VVA479	531302.2800	4386702.3920	504.1570	504.2250	-0.0680	VVA
VVA481	580308.7080	4364668.2090	416.5930	416.6630	-0.0700	VVA
VVA482	580262.6060	4388166.4310	443.3020	443.3730	-0.0710	VVA

Table 14: DEM Check Point Assessment