



TASK ORDER NAME: 2018 Kansas QL2 LiDAR
CONTRACT ID: 000000000000000000000000039891
EVENT ID: EVT0003259
ATLANTIC PROJECT NUMBER: 18006
PROJECT BLOCK NUMBER: Block 4B

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SECTION I: PROJECT OVERVIEW & PURPOSE

1. Aerial LiDAR Project

a. Project Overview

The State of Kansas Contract 000000000000000000000000039891 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 4B encompasses part or all of 6 counties in Kansas and covers approximately 2624 square miles.

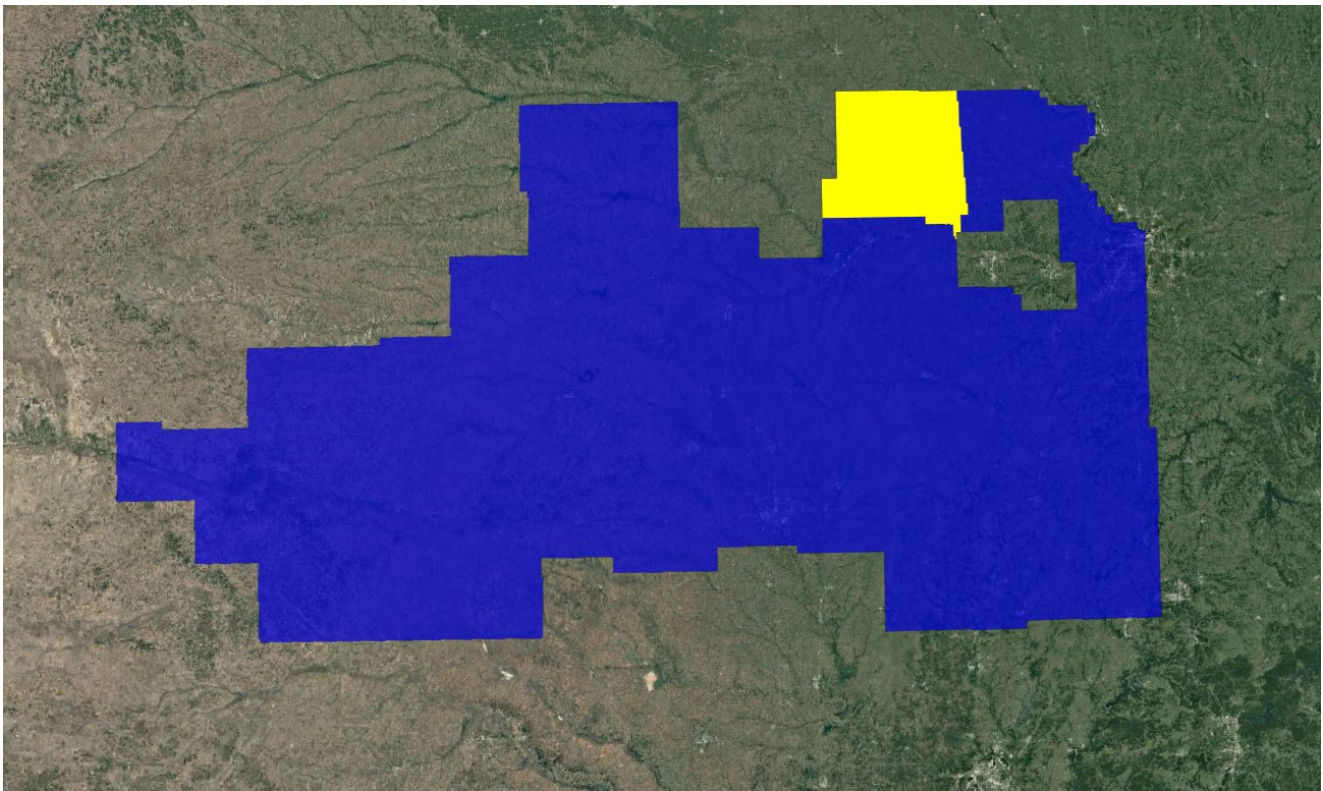


Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) and Associated Areas of Interest (AOIs)

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 130 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 19 flight missions conducted between March 1, 2018 and April 26, 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.

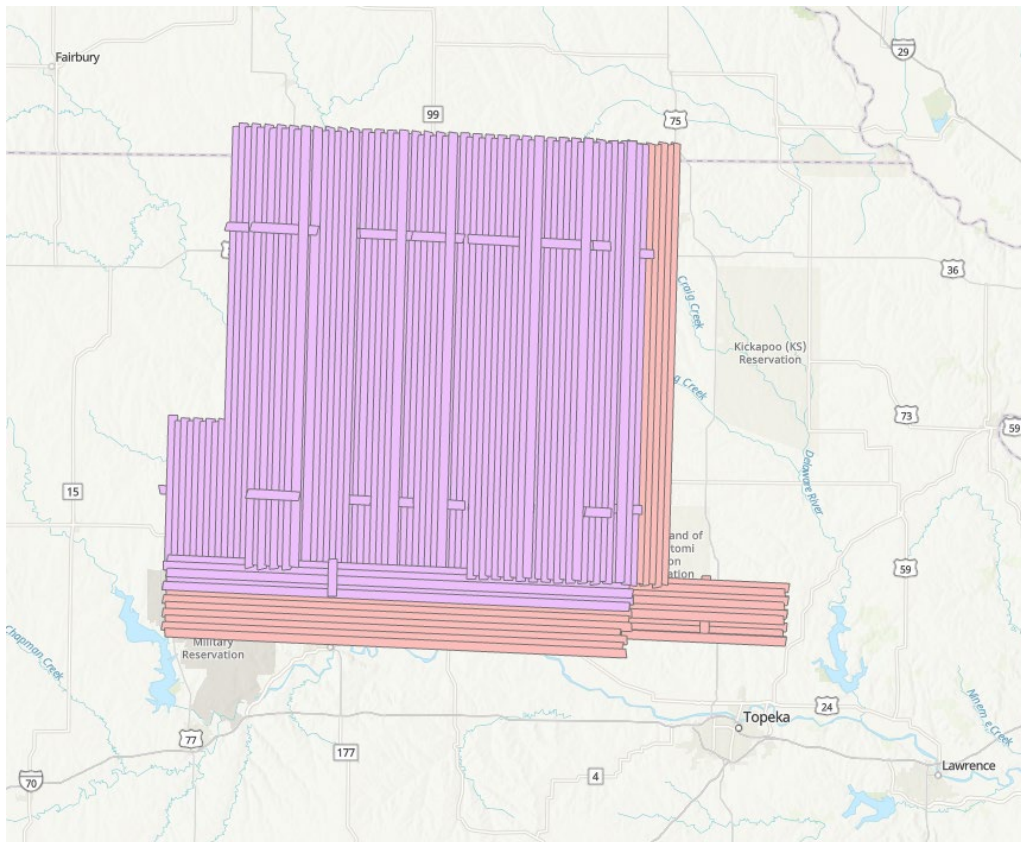


Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

d. GNSS Reference Stations

Twenty-five (25) 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
ICT3	CORS	ICT3	N37°45'09.33290"	W97°12'58.42243"	401.242
KSAY	CORS	KSAY	N37°08'40.33068"	W98°01'49.57453"	383.653
KSBU	CORS	KSBU	N38°11'44.89654"	W95°44'17.09576"	289.926
KSBK	CORS	KSBK	N37°33'03.90852"	W99°38'06.26885"	717.084
KSBR	CORS	KSBR	N39°06'56.69775"	W94°55'43.07246"	251.885
KSCC	CORS	KSCC	N39°22'55.99556"	W97°10'10.61980"	349.885
KSCO	CORS	KSCO	N39°36'37.76224"	W97°39'44.33598"	400.376
KSCP	CORS	KSCP	N38°58'16.54525"	W97°01'11.91593"	320.533
KSCW	CORS	KSCW	N37°16'24.87324"	W99°19'39.34067"	624.848
KSEM	CORS	KSEM	N38°24'14.61668"	W96°10'42.33264"	341.335
KSHW	CORS	KSHW	N39°51'04.21656"	W95°33'34.79184"	324.675
KSKG	CORS	KSKG	N37°39'01.96639"	W98°05'39.96395"	450.922
KSLW	CORS	KSLW	N38°57'44.05427"	W95°14'33.27350"	306.695
KSMH	CORS	KSMH	N39°10'44.46539"	W96°34'25.38239"	290.838
KSOG	CORS	KSOG	N38°38'14.33272"	W95°49'49.98264"	307.468
KSPR	CORS	KSPR	N37°41'26.44138"	W98°44'27.53387"	573.45
KSSN	CORS	KSSN	N39°50'30.90620"	W96°03'19.35788"	314.962
KSTK	CORS	KSTK	N39°05'22.98823"	W95°42'09.76216"	248.525
KSU1	CORS	KSU1	N39°06'02.70007"	W96°36'34.13585"	325.564
MOPL	CORS	MOPL	N39°23'04.09584"	W94°47'00.08368"	211.99
MOSB	CORS	MOSB	N38°49'48.71034"	W94°32'04.48758"	301.135
MOWE	CORS	MOWE	N39°25'19.76974"	W94°53'44.61076"	242.722
NEBE	CORS	NEBE	N40°15'58.00997"	W96°44'41.62308"	365.679
NEHU	CORS	NEHU	N40°10'07.61592"	W95°56'48.84828"	302.862
ZKC1	CORS	ZKC1	N38°52'48.57351"	W94°47'27.00464"	305.466

Table 5: GNSS Reference Stations

2. Aerial LiDAR Project – Ground Acquisition

a. Ground Control Survey

A total of 104 ground survey points were collected in support of this project, including 28 LiDAR Control Points (LCP), 45 Non-vegetated Vertical Accuracy (NVA) and 31 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
LCP601	756504.97	4376762.508	404.896
LCP602	756634.403	4361970.386	364.437
LCP603	754769.852	4404727.461	360.149
LCP604	746478.92	4428622.079	362.138
LCP605	739075.719	4425400.25	377.784
LCP606	735098.963	4421876.59	412.554
LCP608	751234.83	4352925.552	364.859
LCP615	738326.38	4359014.528	314.486
LCP616	740178.814	4362298.311	318.626
LCP617	732799.68	4368555.294	397.985
LCP618	734437.59	4392039.564	400.557
LCP619	738542.61	4397769.782	394.897
LCP620	734675.443	4410591.047	395.933
LCP621	715572.626	4426087.624	423.843
LCP622	716499.931	4431760.809	407.604
LCP623	716438.703	4398735.869	378.507
LCP624	710301.465	4405019.152	392.452
LCP625	692115.283	4428737.298	404.865

ID	Easting	Northing	Elevation
LCP626	708009.9	4384174.061	357.15
LCP627	721842.349	4384383.266	386.126
LCP628	704362.578	4356188.007	333.052
LCP629	694829.79	4383941.701	416.341
LCP631	691543.935	4361136.443	412.688
LCP658	753966.146	4398284.577	405.845
LCP661	730582.42	4387486.482	391.059
LCP662	694253.435	4404719.675	405.984
LCP663	708004.838	4375161.66	430.6
LCP105	247031.473	4344901.254	298.338

Table 6: LiDAR Control Point Coordinates

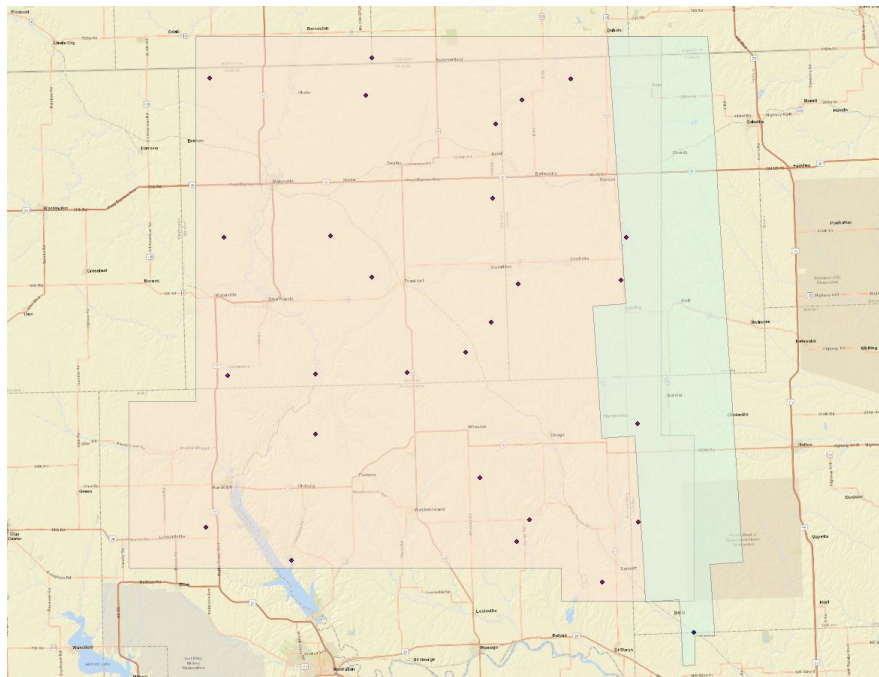


Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
NVA1000	745974.881	4401240.567	397.077
NVA1001	743373.371	4374950.674	342.645
NVA1002	730583.354	4375984.386	459.8
NVA1003	722840.199	4363603.543	363.989
NVA1004	692748.661	4366963.398	375.396
NVA1024	750224.126	4425707.571	319.138
NVA1026	725025.753	4371643.653	424.436

ID	Easting	Northing	Elevation
NVA1027	726990.095	4405511.682	376.255
NVA1028	697151.866	4420240.594	357.709
NVA1029	707014.467	4363836.399	381.281
NVA937	692118.399	4428772.814	404.614
NVA938	704390.45	4356193.988	333.059
NVA939	740198.333	4362253.393	317.11
NVA940	756657.174	4361955.618	364.67
NVA941	721875.725	4384377.811	385.886
NVA942	734463.039	4392017.278	400.967
NVA943	754791.321	4404753.494	358.553
NVA944	746455.045	4428632.907	361.668
NVA945	694811.024	4383915.559	417.048
NVA947	716507.22	4431783.632	406.947
NVA948	734717.376	4410599.594	397.774
NVA949	735116.011	4421844.576	414.442
NVA953	751267.819	4352933.453	364.478
NVA968	711912.059	4421200.744	421.952
NVA969	694273.544	4404702.116	405.564
NVA970	687863.596	4373177.721	379.976
NVA971	740890.975	4383330.387	384.813
NVA972	708057.79	4375185.942	427.834
NVA973	715054.01	4367338.227	429.999
NVA974	734380.949	4366113.342	396.109
NVA975	749724.828	4392652.35	394.334
NVA976	704327.236	4389481.337	359.871
NVA978	750403.357	4422012.697	352.304
NVA992	748826.837	4366267.611	402.479
NVA993	701127.462	4412825.201	352.415
NVA994	705015.305	4426478.014	385.871
NVA995	720942.147	4415455.22	399.03
NVA996	740804.007	4414255.566	399.346
NVA997	750979.566	4414230.517	348.312
NVA998	700840.058	4395053.917	350.646
NVA999	721443.396	4398148.466	351.644
NVA175	251003.176	4393091.138	358.874
NVA259	251699.8	4373823.608	379.077
NVA37	247019.151	4344916.045	298.157
NVA977	242388.225	4382888.112	405.445

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

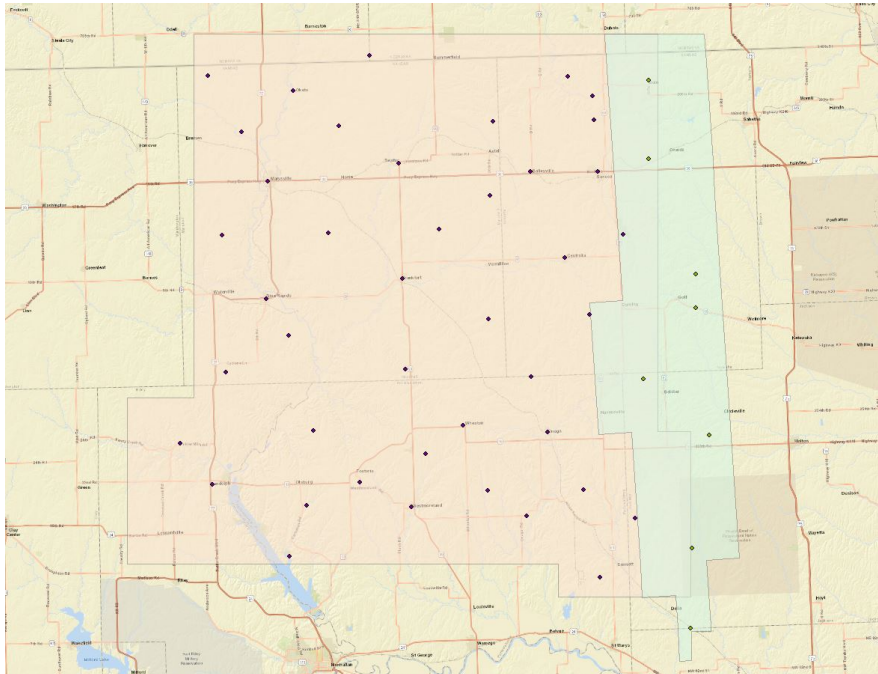


Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
VVA671	708021.13	4384153.084	356.108
VVA672	732763.978	4368632.468	398.016
VVA673	756489.063	4376718.592	407.458
VVA674	715561.766	4426065.083	422.835
VVA675	739093.228	4425368.7	375.103
VVA676	716406.12	4398722.381	378.923
VVA677	738537.829	4397777.762	394.87
VVA678	691520.514	4361149.164	413.21
VVA687	694836.719	4375635.996	393.262
VVA688	745805.694	4410948.726	383.651
VVA689	697181.24	4420289.5	357.222
VVA690	712230.077	4410626.707	399.648
VVA691	726968.101	4405564.925	376.529
VVA692	725071.205	4371650.358	422.378
VVA693	751990.364	4366845.949	398.815
VVA694	743957.445	4391500.983	412.313
VVA699	694418.984	4398213.78	402.242
VVA700	750204.518	4425735.324	319.236
VVA701	703154.926	4429016.797	391.446

ID	Easting	Northing	Elevation
VVA703	730591.769	4387459.297	391.303
VVA704	738155.635	4359016.018	315.567
VVA705	753990.071	4398342.172	408.626
VVA706	725705.919	4411927.955	420.872
VVA708	754465.828	4354707.57	309.739
VVA724	720965.887	4415437.113	397.184
VVA725	701123.821	4412819.862	352.45
VVA726	715049.924	4367286.309	430.45
VVA115	252972.769	4430248.34	403.033
VVA181	245344.087	4416100.265	361.167
VVA59	251684.372	4373769.455	381.56
VVA62	251266.846	4398112.297	369.201

Table 8: Vegetated Vertical Accuracy (VVA) Point Coordinates

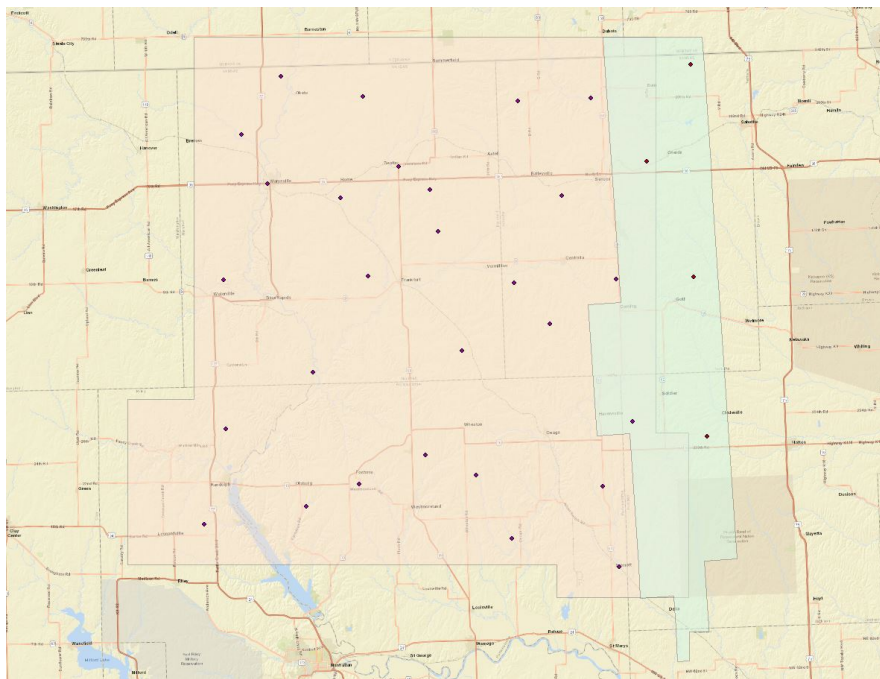


Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

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)	20,840,342,661
Nominal Pulse Spacing (M)	0.6607
Nominal Pulse Density (PLS/M²)	2.2911
Total Points (Aggregate)	20,406,200,876
Aggregate Pulse Spacing (M)	0.6625
Aggregate Pulse Density (PLS/M²)	2.1601

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 1.0-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)	45	0.0773	0.1514	0.1238
NVA (DEM)	45	0.0910	0.1783	0.1614
VVA (Point Cloud)	31	0.1592	0.3120	0.2705
VVA (DEM)	31	0.1966	0.3853	0.1976

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
NVA1000	745974.8810	4401240.5670	397.0770	397.1000	0.0230	NVA
NVA1001	743373.3710	4374950.6740	342.6450	342.7600	0.1150	NVA
NVA1002	730583.3540	4375984.3860	459.8000	459.7700	-0.0300	NVA
NVA1003	722840.1990	4363603.5430	363.9890	363.9800	-0.0090	NVA
NVA1004	692748.6610	4366963.3980	375.3960	375.3100	-0.0860	NVA
NVA1024	750224.1260	4425707.5710	319.1380	319.0900	-0.0480	NVA
NVA1026	725025.7530	4371643.6530	424.4360	424.4900	0.0540	NVA
NVA1027	726990.0950	4405511.6820	376.2550	376.2700	0.0150	NVA
NVA1028	697151.8660	4420240.5940	357.7090	357.6800	-0.0290	NVA
NVA1029	707014.4670	4363836.3990	381.2810	381.3700	0.0890	NVA
NVA175	251003.1759	4393091.1380	358.8740	359.1000	0.2260	NVA
NVA259	251699.8002	4373823.6080	379.0770	378.9400	-0.1370	NVA
NVA37	247019.1513	4344916.0450	298.1570	298.1100	-0.0470	NVA
NVA937	692118.3990	4428772.8140	404.6140	404.5000	-0.1140	NVA
NVA938	704390.4500	4356193.9880	333.0590	333.1100	0.0510	NVA
NVA939	740198.3330	4362253.3930	317.1100	317.1200	0.0100	NVA
NVA940	756657.1740	4361955.6180	364.6700	364.6000	-0.0700	NVA
NVA941	721875.7250	4384377.8110	385.8860	385.8900	0.0040	NVA
NVA942	734463.0390	4392017.2780	400.9670	400.9000	-0.0670	NVA
NVA943	754791.3210	4404753.4940	358.5530	358.5400	-0.0130	NVA
NVA944	746455.0450	4428632.9070	361.6680	361.6700	0.0020	NVA
NVA945	694811.0240	4383915.5590	417.0480	416.9800	-0.0680	NVA
NVA947	716507.2200	4431783.6320	406.9470	407.0300	0.0830	NVA
NVA948	734717.3760	4410599.5940	397.7740	397.7100	-0.0640	NVA
NVA949	735116.0110	4421844.5760	414.4420	414.4200	-0.0220	NVA
NVA953	751267.8190	4352933.4530	364.4780	364.4200	-0.0580	NVA
NVA968	711912.0590	4421200.7440	421.9520	422.0600	0.1080	NVA
NVA969	694273.5440	4404702.1160	405.5640	405.5100	-0.0540	NVA
NVA970	687863.5960	4373177.7210	379.9760	379.8100	-0.1660	NVA
NVA971	740890.9750	4383330.3870	384.8130	384.8500	0.0370	NVA
NVA972	708057.7900	4375185.9420	427.8340	427.9600	0.1260	NVA
NVA973	715054.0100	4367338.2270	429.9990	430.0000	0.0010	NVA
NVA974	734380.9490	4366113.3420	396.1090	396.1900	0.0810	NVA
NVA975	749724.8280	4392652.3500	394.3340	394.3800	0.0460	NVA
NVA976	704327.2360	4389481.3370	359.8710	360.0200	0.1490	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
NVA977	242388.2249	4382888.1120	405.4450	405.3400	-0.1050	NVA
NVA978	750403.3570	4422012.6970	352.3040	352.3600	0.0560	NVA
NVA992	748826.8370	4366267.6110	402.4790	402.4100	-0.0690	NVA
NVA993	701127.4620	4412825.2010	352.4150	352.4100	-0.0050	NVA
NVA994	705015.3050	4426478.0140	385.8710	385.9200	0.0490	NVA
NVA995	720942.1470	4415455.2200	399.0300	399.0600	0.0300	NVA
NVA996	740804.0070	4414255.5660	399.3460	399.3300	-0.0160	NVA
NVA997	750979.5660	4414230.5170	348.3120	348.2600	-0.0520	NVA
NVA998	700840.0580	4395053.9170	350.6460	350.6400	-0.0060	NVA
NVA999	721443.3960	4398148.4660	351.6440	351.6400	-0.0040	NVA
VVA115	252972.7688	4430248.3400	403.0330	403.1300	0.0970	VVA
VVA181	245344.0874	4416100.2650	361.1670	360.8900	-0.2770	VVA
VVA59	251684.3717	4373769.4550	381.5600	381.5100	-0.0500	VVA
VVA62	251266.8464	4398112.2970	369.2010	369.5200	0.3190	VVA
VVA671	708021.1300	4384153.0840	356.1080	356.6200	0.5120	VVA
VVA672	732763.9780	4368632.4680	398.0160	398.2100	0.1940	VVA
VVA673	756489.0630	4376718.5920	407.4580	407.4400	-0.0180	VVA
VVA674	715561.7660	4426065.0830	422.8350	422.9000	0.0650	VVA
VVA675	739093.2280	4425368.7000	375.1030	375.1600	0.0570	VVA
VVA676	716406.1200	4398722.3810	378.9230	378.9200	-0.0030	VVA
VVA677	738537.8290	4397777.7620	394.8700	395.0400	0.1700	VVA
VVA678	691520.5140	4361149.1640	413.2100	413.1300	-0.0800	VVA
VVA687	694836.7190	4375635.9960	393.2620	393.3200	0.0580	VVA
VVA688	745805.6940	4410948.7260	383.6510	383.6800	0.0290	VVA
VVA689	697181.2400	4420289.5000	357.2220	357.4200	0.1980	VVA
VVA690	712230.0770	4410626.7070	399.6480	399.7800	0.1320	VVA
VVA691	726968.1010	4405564.9250	376.5290	376.5400	0.0110	VVA
VVA692	725071.2050	4371650.3580	422.3780	422.6000	0.2220	VVA
VVA693	751990.3640	4366845.9490	398.8150	398.8500	0.0350	VVA
VVA694	743957.4450	4391500.9830	412.3130	412.3400	0.0270	VVA
VVA699	694418.9840	4398213.7800	402.2420	402.1100	-0.1320	VVA
VVA700	750204.5180	4425735.3240	319.2360	319.3800	0.1440	VVA
VVA701	703154.9260	4429016.7970	391.4460	391.6400	0.1940	VVA
VVA703	730591.7690	4387459.2970	391.3030	391.4400	0.1370	VVA
VVA704	738155.6350	4359016.0180	315.5670	315.7400	0.1730	VVA
VVA705	753990.0710	4398342.1720	408.6260	408.5400	-0.0860	VVA
VVA706	725705.9190	4411927.9550	420.8720	420.9200	0.0480	VVA
VVA708	754465.8280	4354707.5700	309.7390	309.7200	-0.0190	VVA
VVA724	720965.8870	4415437.1130	397.1840	397.2500	0.0660	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
VVA725	701123.8210	4412819.8620	352.4500	352.4200	-0.0300	VVA
VVA726	715049.9240	4367286.3090	430.4500	430.4400	-0.0100	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
NVA1000	745974.8810	4401240.5670	397.0770	397.0624	0.0146	NVA
NVA1001	743373.3710	4374950.6740	342.6450	342.7500	-0.1050	NVA
NVA1002	730583.3540	4375984.3860	459.8000	459.7640	0.0360	NVA
NVA1003	722840.1990	4363603.5430	363.9890	364.0342	-0.0452	NVA
NVA1004	692748.6610	4366963.3980	375.3960	375.2167	0.1793	NVA
NVA1024	750224.1260	4425707.5710	319.1380	319.1396	-0.0016	NVA
NVA1026	725025.7530	4371643.6530	424.4360	424.4761	-0.0401	NVA
NVA1027	726990.0950	4405511.6820	376.2550	376.2469	0.0081	NVA
NVA1028	697151.8660	4420240.5940	357.7090	357.7246	-0.0156	NVA
NVA1029	707014.4670	4363836.3990	381.2810	381.2618	0.0192	NVA
NVA175	251003.1759	4393091.1380	358.8740	359.0733	-0.1993	NVA
NVA259	251699.8002	4373823.6080	379.0770	378.8585	0.2185	NVA
NVA37	247019.1513	4344916.0450	298.1570	298.1078	0.0492	NVA
NVA937	692118.3990	4428772.8140	404.6140	404.4349	0.1791	NVA
NVA938	704390.4500	4356193.9880	333.0590	333.1327	-0.0737	NVA
NVA939	740198.3330	4362253.3930	317.1100	317.1368	-0.0268	NVA
NVA940	756657.1740	4361955.6180	364.6700	364.6551	0.0149	NVA
NVA941	721875.7250	4384377.8110	385.8860	385.9030	-0.0170	NVA
NVA942	734463.0390	4392017.2780	400.9670	400.9269	0.0401	NVA
NVA943	754791.3210	4404753.4940	358.5530	358.4960	0.0570	NVA
NVA944	746455.0450	4428632.9070	361.6680	361.5775	0.0905	NVA
NVA945	694811.0240	4383915.5590	417.0480	416.9810	0.0670	NVA
NVA947	716507.2200	4431783.6320	406.9470	407.0269	-0.0799	NVA
NVA948	734717.3760	4410599.5940	397.7740	397.6857	0.0883	NVA
NVA949	735116.0110	4421844.5760	414.4420	414.3844	0.0576	NVA
NVA953	751267.8190	4352933.4530	364.4780	364.4201	0.0579	NVA
NVA968	711912.0590	4421200.7440	421.9520	421.9980	-0.0460	NVA
NVA969	694273.5440	4404702.1160	405.5640	405.5093	0.0547	NVA
NVA970	687863.5960	4373177.7210	379.9760	379.8954	0.0806	NVA
NVA971	740890.9750	4383330.3870	384.8130	384.8228	-0.0098	NVA
NVA972	708057.7900	4375185.9420	427.8340	427.9800	-0.1460	NVA
NVA973	715054.0100	4367338.2270	429.9990	429.9667	0.0323	NVA
NVA974	734380.9490	4366113.3420	396.1090	396.2897	-0.1807	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
NVA975	749724.8280	4392652.3500	394.3340	394.3957	-0.0617	NVA
NVA976	704327.2360	4389481.3370	359.8710	360.0752	-0.2042	NVA
NVA977	242388.2249	4382888.1120	405.4450	405.4014	0.0436	NVA
NVA978	750403.3570	4422012.6970	352.3040	352.4314	-0.1274	NVA
NVA992	748826.8370	4366267.6110	402.4790	402.4457	0.0333	NVA
NVA993	701127.4620	4412825.2010	352.4150	352.3854	0.0296	NVA
NVA994	705015.3050	4426478.0140	385.8710	385.9088	-0.0378	NVA
NVA995	720942.1470	4415455.2200	399.0300	399.1444	-0.1144	NVA
NVA996	740804.0070	4414255.5660	399.3460	399.2728	0.0732	NVA
NVA997	750979.5660	4414230.5170	348.3120	348.2709	0.0411	NVA
NVA998	700840.0580	4395053.9170	350.6460	350.6815	-0.0355	NVA
NVA999	721443.3960	4398148.4660	351.6440	351.6767	-0.0327	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA115	252972.7688	4430248.3400	403.0330	403.1644	-0.1314	VVA
VVA181	245344.0874	4416100.2650	361.1670	360.7424	0.4246	VVA
VVA59	251684.3717	4373769.4550	381.5600	381.4356	0.1244	VVA
VVA62	251266.8464	4398112.2970	369.2010	369.5682	-0.3672	VVA
VVA671	708021.1300	4384153.0840	356.1080	356.6416	-0.5336	VVA
VVA672	732763.9780	4368632.4680	398.0160	398.1209	-0.1049	VVA
VVA673	756489.0630	4376718.5920	407.4580	407.1872	0.2708	VVA
VVA674	715561.7660	4426065.0830	422.8350	422.8835	-0.0485	VVA
VVA675	739093.2280	4425368.7000	375.1030	375.2695	-0.1665	VVA
VVA676	716406.1200	4398722.3810	378.9230	378.8207	0.1023	VVA
VVA677	738537.8290	4397777.7620	394.8700	394.9742	-0.1042	VVA
VVA678	691520.5140	4361149.1640	413.2100	413.1052	0.1048	VVA
VVA687	694836.7190	4375635.9960	393.2620	393.3627	-0.1007	VVA
VVA688	745805.6940	4410948.7260	383.6510	383.6798	-0.0288	VVA
VVA689	697181.2400	4420289.5000	357.2220	357.3436	-0.1216	VVA
VVA690	712230.0770	4410626.7070	399.6480	399.7790	-0.1310	VVA
VVA691	726968.1010	4405564.9250	376.5290	376.5661	-0.0371	VVA
VVA692	725071.2050	4371650.3580	422.3780	422.6031	-0.2251	VVA
VVA693	751990.3640	4366845.9490	398.8150	398.8555	-0.0405	VVA
VVA694	743957.4450	4391500.9830	412.3130	412.3036	0.0094	VVA
VVA699	694418.9840	4398213.7800	402.2420	402.1181	0.1239	VVA
VVA700	750204.5180	4425735.3240	319.2360	319.5231	-0.2871	VVA
VVA701	703154.9260	4429016.7970	391.4460	391.6442	-0.1982	VVA
VVA703	730591.7690	4387459.2970	391.3030	391.4412	-0.1382	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA704	738155.6350	4359016.0180	315.5670	315.9197	-0.3527	VVA
VVA705	753990.0710	4398342.1720	408.6260	408.5356	0.0904	VVA
VVA706	725705.9190	4411927.9550	420.8720	420.7621	0.1099	VVA
VVA708	754465.8280	4354707.5700	309.7390	309.7368	0.0022	VVA
VVA724	720965.8870	4415437.1130	397.1840	397.3086	-0.1246	VVA
VVA725	701123.8210	4412819.8620	352.4500	352.3771	0.0729	VVA
VVA726	715049.9240	4367286.3090	430.4500	430.4312	0.0188	VVA

Table 14: DEM Check Point Assessment