



**TASK ORDER NAME: 2018 Kansas QL2 LiDAR**  
**CONTRACT ID: 000000000000000000000000039891**  
**EVENT ID: EVT0003259**  
**ATLANTIC PROJECT NUMBER: 18006**  
**PROJECT BLOCK NUMBER: Block 8A**

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### c. Client Contact Information

Client Contact Information	
<b>Name of Contact</b>	Tara Lanzrath, CFM
<b>Organization</b>	Kansas Department of Agriculture
<b>Position</b>	Floodplain Mapping Coordinator
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<b>City</b>	Topeka
<b>State or Province</b>	Kansas
<b>Postal Code</b>	66619

Table 1: Aerial LiDAR Client Contact Information

### d. Contract Deliverables

Item	Specification/Format
<b>Metadata</b>	FGDC compliant, xml format
<b>Project Report</b>	.pdf format
<b>Raw Point Cloud</b>	Swaths, LAS 1.4
<b>Classified Point Cloud</b>	LAS 1.4
<b>Bare Earth DEM</b>	ERDAS .IMG format, Hydroflattened
<b>First Return DSM</b>	ERDAS .IMG format
<b>Hydro Polygon Breaklines</b>	.gdb format
<b>Intensity Imagery</b>	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
<b>Model</b>	ALS70-HP
<b>Manufacturer</b>	Leica
<b>Platform</b>	Fixed-Wing
<b>Scan Pattern</b>	Sine, Triangle, Raster
<b>Maximum Scan Rate (Hz)</b>	Sine: 200 Triangle: 158 Raster: 120
<b>Field of View (°)</b>	0 – 75 (Full Angle, User Adjustable)
<b>Maximum Pulse Rate (kHz)</b>	500
<b>Maximum Flying Height (m AGL)</b>	3500
<b>Number of Returns</b>	Unlimited
<b>Number of Intensity Measurements</b>	3 (First, Second, Third)
<b>Roll Stabilization (Automatic Adaptive, °)</b>	75 - Active FOV
<b>Storage Media</b>	Removable 500 GB SSD
<b>Storage Capacity (Hours @ Max Pulse Rate)</b>	6
<b>Size (cm)</b>	Scanner: 37 W x 68 L x 26 H Control Electronics: 45 W x 47 D x 36 H
<b>Weight (kg)</b>	Scanner: 43 Control Electronics: 45
<b>Operation Temperature (°C)</b>	0 – 40
<b>Flight Management</b>	FCMS
<b>Power Consumption</b>	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
<b>System</b>	Leica ALS70-HP
<b>Nominal Pulse Spacing (m)</b>	0.71
<b>Nominal Pulse Density (pls/m<sup>2</sup>)</b>	2.2
<b>Nominal Flight Height (AGL meters)</b>	2000
<b>Nominal Flight Speed (kts)</b>	130
<b>Pass Heading (°)</b>	0
<b>Sensor Scan Angle (°)</b>	45
<b>Scan Frequency (Hz)</b>	33.9
<b>Pulse Rate of Scanner (kHz)</b>	256,400
<b>Line Spacing (m)</b>	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 91 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 9 flight missions conducted between March 3, 2018 and May 9, 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.

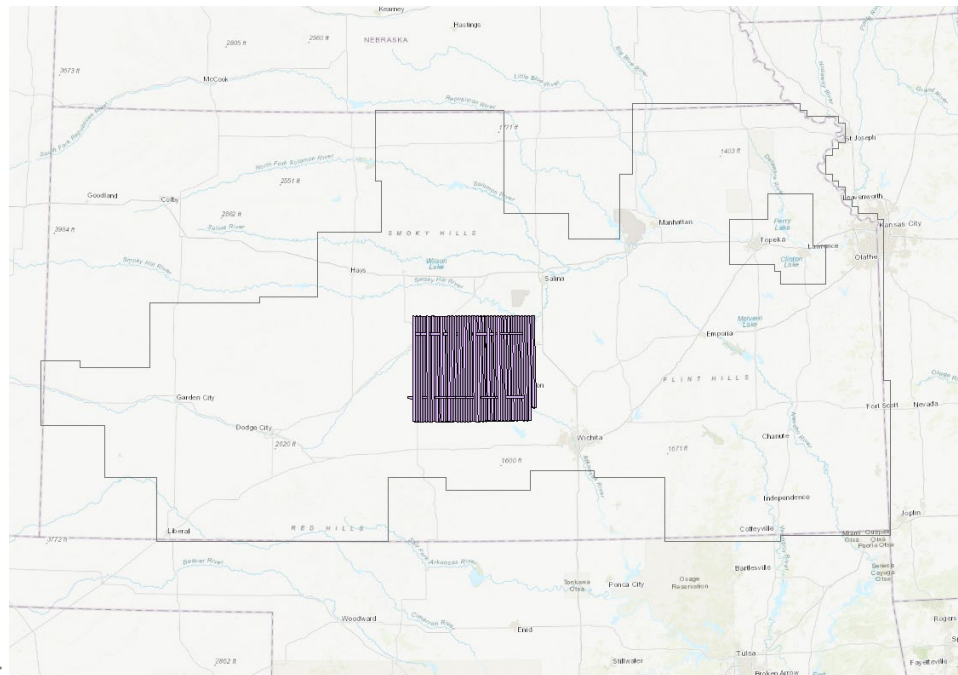


Figure 2:

Figure 3: Orientation of Executed Flight-lines and LiDAR DPA

### d. GNSS Reference Stations

Eleven (11) 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	37°45'09.33297"	97°12'58.42230	401.242m
ICT4	CORS	ICT4	37°37'08.57671"	97°37'57.00056"	392.172m
ICT5	CORS	ICT5	37°47'12.04062"	97°37'32.73360"	411.107m

Designation	Type	PID	Latitude (N)	Longitude (W)	Elevation
<b>KSPR</b>	CORS	KSPR	37°41'26.44138"	98°44'27.53387"	573.45m
<b>KSBK</b>	CORS	KSBK	37°33'03.90852"	99°38'06.26885"	717.084m
<b>KSCW</b>	CORS	KSCW	37°16'24.87324"	99°19'39.34067"	624.848m
<b>KSAY</b>	CORS	KSAY	37°08'40.33068"	98°01'49.57453"	383.653m
<b>KSKY</b>	CORS	KSKY	37°54'40.30614"	99°24'21.76286"	641.963m
<b>KSGB</b>	CORS	KSGB	38°21'16.83108"	98°45'53.40654"	545.627m
<b>KSHU</b>	CORS	KSHU	38°01'52.62370"	97°54'08.45874"	440.099m
<b>OKBF</b>	CORS	OKBF	36°49'40.90146'	99°38'28.88423"	538.779m

*Table 5: GNSS Reference Stations*

## 2. Aerial LiDAR Project – Ground Acquisition

### a. Ground Control Survey

A total of 131 ground survey points were collected in support of this project, including 35 LiDAR Control Points (LCP), 57 Non-vegetated Vertical Accuracy (NVA) and 39 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:

Point ID	Easting	Northing	Elevation
LCP176	607728.3610	4205812.9880	449.7670
LCP213	597180.8040	4241771.3780	481.0050
LCP214	586301.2680	4230357.0600	503.7130
LCP215	592841.1460	4222411.0880	508.7310
LCP216	605455.9910	4235420.7170	469.8120
LCP223	558437.2460	4245626.9080	517.4030
LCP224	587494.4860	4247978.9910	479.4210
LCP225	555864.5830	4255848.5140	524.6230
LCP226	593770.3130	4261101.6740	504.0680
LCP229	534074.5940	4254119.5980	553.9490
LCP232	554548.7270	4233348.3670	518.3410
LCP233	563934.2230	4218687.4960	516.8560
LCP234	573606.2240	4212545.8520	498.7380
LCP235	572146.8010	4204400.1430	500.6250
LCP236	557560.8350	4208140.6460	526.6390
LCP237	517167.9490	4239611.3700	573.2560
LCP238	523671.3260	4234758.0420	570.8040



Point ID	Easting	Northing	Elevation
LCP239	538279.2170	4228355.1480	535.8110
LCP240	545497.8310	4212213.0830	545.4430
LCP241	525336.7510	4219531.9600	573.0490
LCP321	606209.3150	4187083.2360	455.8450
LCP328	590678.8780	4199709.2460	476.5300
LCP329	585626.6180	4196482.3070	459.2420
LCP501	522630.0550	4194515.6800	589.9400
LCP502	528712.2330	4200391.6550	578.2570
LCP504	556342.8180	4197836.9310	526.9120
LCP505	548813.4990	4196164.6780	534.5700
LCP526	606499.1180	4195109.0650	452.6990
LCP530	572198.7250	4194608.7530	486.2170
LCP550	589685.4140	4218997.3160	475.5250
LCP556	590796.7800	4236855.5990	490.2380
LCP558	580982.5620	4256928.9520	496.4960
LCP560	522917.9920	4262106.8910	549.2570
LCP562	543886.1540	4235624.4260	538.5740
LCP595	534012.6840	4186386.8260	571.2540

Table 6: LiDAR Control Point Coordinates

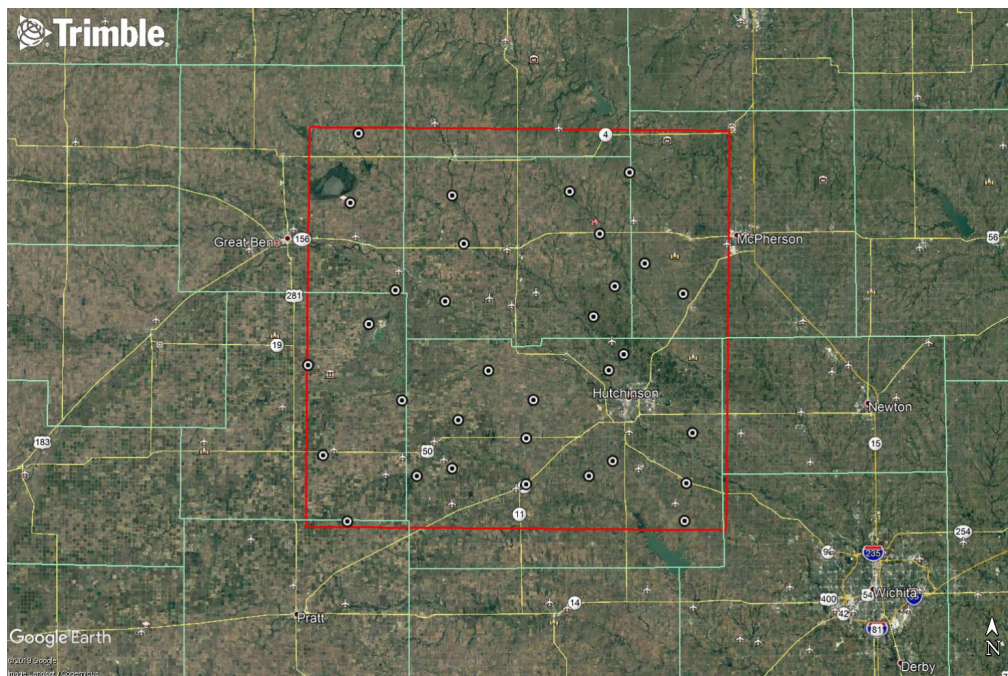


Figure 4: LiDAR Control Point Distribution

Figure 5:

Point ID	Easting	Northing	Elevation
NVA374	534035.5250	4254143.8550	553.9010
NVA375	555897.8460	4255839.2330	524.5750
NVA376	593796.6520	4261056.5820	502.7820
NVA377	523640.3640	4234806.9610	571.3640
NVA378	554570.1750	4233325.8080	518.1480
NVA379	586297.5710	4230326.0740	502.9070
NVA380	545460.4660	4212242.1210	544.4990
NVA381	573620.7720	4212567.8100	499.0050
NVA382	528722.4080	4200393.7010	578.1340
NVA383	548806.6910	4196153.6640	534.7470
NVA384	572173.3110	4204377.7050	499.7080
NVA385	590674.6620	4199710.2820	476.5990
NVA386	597206.3000	4241737.2220	481.2140
NVA391	607725.4720	4205815.7660	449.8470
NVA394	605474.9380	4235404.2170	469.8180
NVA576	522947.4110	4262064.0380	548.9860
NVA577	567109.7930	4216852.7130	513.6210
NVA578	584176.8790	4259352.3630	511.2430
NVA579	561344.6570	4238207.7250	512.0310
NVA580	543871.6870	4235653.9560	538.2820
NVA581	582755.0390	4239050.5200	508.8240
NVA582	530329.0470	4194857.3270	576.6810
NVA583	533308.9410	4227619.3070	561.6440
NVA584	557437.7660	4222871.7940	528.9770
NVA585	589815.0240	4220655.1260	475.5210
NVA586	563306.2710	4196293.1060	513.1330
NVA587	597798.0190	4193385.9860	458.0620
NVA591	607129.4730	4254825.9020	457.0210
NVA595	602302.2370	4191851.6040	479.3910
NVA763	519050.1290	4263217.2150	559.4580
NVA764	516181.7230	4246247.9330	569.1240
NVA766	517746.4340	4225210.6850	583.3940
NVA772	540425.4160	4264123.6350	550.9100
NVA773	536587.8660	4245475.4300	545.0390
NVA774	570011.3410	4244662.6250	514.1120
NVA775	586280.1360	4250482.9240	490.0530
NVA776	569459.3420	4229437.9410	499.9840

Point ID	Easting	Northing	Elevation
NVA777	580527.5850	4222637.4580	485.7560
NVA778	595378.0450	4212732.9670	466.0110
NVA779	596485.1130	4213755.4760	465.3610
NVA780	579739.6800	4202455.4010	489.9860
NVA781	572220.6470	4194612.2940	486.3100
NVA782	560601.2060	4202748.3660	515.2260
NVA783	535226.6020	4201810.3840	565.8350
NVA784	529808.6890	4217616.0420	571.0400
NVA785	573415.0280	4263440.9750	534.6390
NVA788	614930.3120	4247606.4900	452.7050
NVA796	606483.2430	4195127.5140	453.4940
NVA797	608168.7200	4221996.9630	454.2870
NVA861	594716.3780	4202216.4480	467.1860
NVA863	581786.0240	4205880.5820	489.0020
NVA895	530335.8310	4194854.5520	576.9590
NVA916	605945.4950	4241856.8530	463.6790
NVA919	544286.6990	4249332.5550	540.6200
NVA920	568918.3080	4264083.0310	534.7940
NVA922	527792.8850	4236373.3110	567.6980
NVA923	542272.9690	4217824.4270	547.9250

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

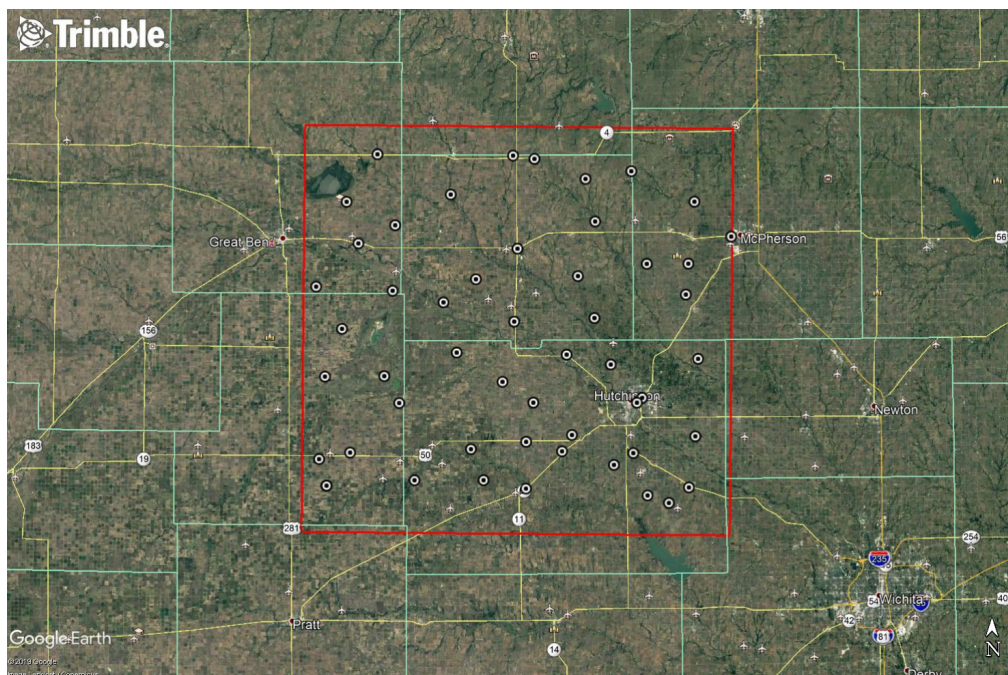


Figure 1: Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

Point ID	Easting	Northing	Elevation
VVA257	517191.3470	4239602.4940	572.9630
VVA263	558366.3930	4245594.9370	517.2440
VVA264	587485.0390	4247956.2050	480.8320
VVA265	525316.5370	4219506.9530	572.9150
VVA266	563940.9870	4218669.4390	516.6560
VVA267	592828.8190	4222377.4240	507.8460
VVA268	522636.2050	4194499.8970	589.8460
VVA269	556340.8040	4197844.2830	527.4140
VVA270	585625.1810	4196499.8970	459.1270
VVA304	606207.9690	4187097.8340	455.6580
VVA305	534021.2110	4186372.0060	571.2790
VVA396	544235.4340	4249359.8640	541.2670
VVA397	568906.0230	4264029.3850	535.2930
VVA399	527757.9470	4236363.9690	566.4750
VVA400	560644.1230	4230110.8260	510.9760
VVA401	589721.1300	4218969.8150	474.9200
VVA402	542255.8170	4217843.6850	548.5580
VVA403	557537.3850	4208158.7500	526.2600
VVA404	581749.7220	4205884.2420	489.4040
VVA408	607788.8680	4193568.9620	453.4240
VVA410	609894.4380	4262855.5750	438.0570
VVA411	606000.8090	4241847.0580	463.4080
VVA536	532300.0180	4254537.1000	550.4110
VVA537	590777.8120	4236862.4040	490.6030
VVA538	538249.0360	4228352.7940	535.9730
VVA539	580974.5720	4256966.9550	496.3580
VVA540	594709.8360	4202179.4650	467.7100
VVA541	564678.7010	4204365.6160	514.5060
VVA542	555753.5090	4257461.8510	525.6990
VVA543	536663.9720	4204924.3830	561.6700
VVA548	607431.5260	4214119.2000	471.9420
VVA594	597789.5700	4193400.3600	458.3600
VVA596	579736.2840	4202462.7900	489.9880
VVA636	529798.0820	4217642.2010	571.2860
VVA651	582712.2390	4239067.8230	509.0800
VVA654	536610.3690	4245437.9480	545.1290
VVA655	573366.9640	4263420.3500	534.6280
VVA656	519040.2960	4263200.4400	559.4440
VVA657	533273.2070	4227574.4590	561.1040

Table 8: Vegetated Vertical Accuracy (VVA) Point Coordinates

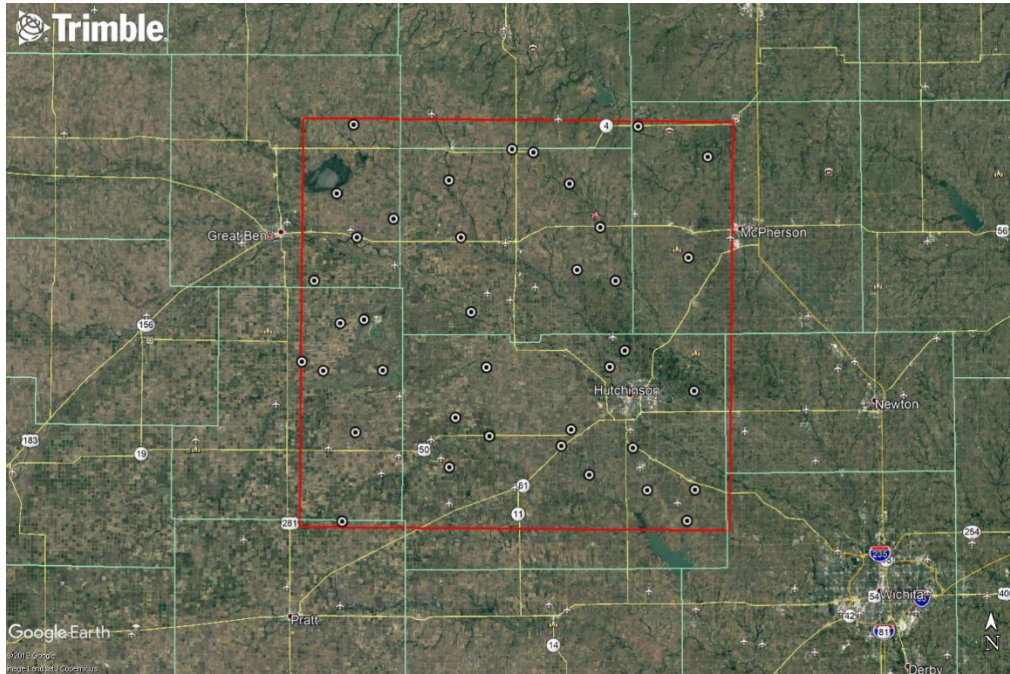


Figure 6: Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

## 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
<b>Total Points</b>	16,900,751,813
<b>Nominal Pulse Spacing (m)</b>	0.6470
<b>Nominal Pulse Density (pls/m<sup>2</sup>)</b>	2.3891
<b>Nominal Pulse Spacing (ft)</b>	2.1226
<b>Nominal Pulse Density (pls/ft<sup>2</sup>)</b>	0.2220
<b>Aggregate Total Points</b>	15,747,366,343
<b>Aggregate Nominal Pulse Spacing (m)</b>	0.5650
<b>Aggregate Nominal Pulse Density (pls/m<sup>2</sup>)</b>	3.1329
<b>Aggregate Nominal Pulse Spacing (ft)</b>	1.8536
<b>Aggregate Nominal Pulse Density (pls/ft<sup>2</sup>)</b>	0.2911

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 <sup>th</sup> 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)	57	0.0687	0.1346	0.1120
NVA (DEM)	57	0.0678	0.1329	0.0865
VVA (Point Cloud)	39	0.1221	0.2393	0.1656
VVA (DEM)	39	0.1239	0.2429	0.1431

Table 12: NVA/VVA Accuracies



## **SECTION V: CERTIFICATION STATEMENTS**

### ***1. Aerial LiDAR Project***

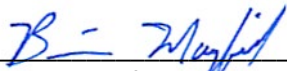
This accuracy assessment confirms that the data may be used for the intended applications stated in Section I of this document. This dataset may also be used as a topographic input for other applications, but the user should be aware that this LiDAR dataset was designed with a specific purpose and was 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
NVA374	534035.5250	4254143.8550	553.9010	553.7970	-0.1040	NVA
NVA375	555897.8460	4255839.2330	524.5750	524.5920	0.0170	NVA
NVA376	593796.6520	4261056.5820	502.7820	502.7270	-0.0550	NVA
NVA377	523640.3640	4234806.9610	571.3640	571.3430	-0.0210	NVA
NVA378	554570.1750	4233325.8080	518.1480	518.1780	0.0300	NVA
NVA379	586297.5710	4230326.0740	502.9070	502.8630	-0.0440	NVA
NVA380	545460.4660	4212242.1210	544.4990	544.4990	0.0000	NVA
NVA381	573620.7720	4212567.8100	499.0050	498.9950	-0.0100	NVA
NVA382	528722.4080	4200393.7010	578.1340	578.0690	-0.0650	NVA
NVA383	548806.6910	4196153.6640	534.7470	534.8830	0.1360	NVA
NVA384	572173.3110	4204377.7050	499.7080	499.7590	0.0510	NVA
NVA385	590674.6620	4199710.2820	476.5990	476.5150	-0.0840	NVA
NVA386	597206.3000	4241737.2220	481.2140	481.2590	0.0450	NVA
NVA391	607725.4720	4205815.7660	449.8470	449.8960	0.0490	NVA
NVA394	605474.9380	4235404.2170	469.8180	469.8440	0.0260	NVA
NVA576	522947.4110	4262064.0380	548.9860	549.0310	0.0450	NVA
NVA577	567109.7930	4216852.7130	513.6210	513.6810	0.0600	NVA
NVA578	584176.8790	4259352.3630	511.2430	511.2540	0.0110	NVA
NVA579	561344.6570	4238207.7250	512.0310	512.0340	0.0030	NVA
NVA580	543871.6870	4235653.9560	538.2820	538.3190	0.0370	NVA
NVA581	582755.0390	4239050.5200	508.8240	508.9000	0.0760	NVA
NVA582	530329.0470	4194857.3270	576.6810	576.7410	0.0600	NVA
NVA583	533308.9410	4227619.3070	561.6440	561.6830	0.0390	NVA
NVA584	557437.7660	4222871.7940	528.9770	528.9580	-0.0190	NVA
NVA585	589815.0240	4220655.1260	475.5210	475.5150	-0.0060	NVA
NVA586	563306.2710	4196293.1060	513.1330	513.1320	-0.0010	NVA
NVA587	597798.0190	4193385.9860	458.0620	458.1710	0.1090	NVA
NVA591	607129.4730	4254825.9020	457.0210	457.0390	0.0180	NVA
NVA595	602302.2370	4191851.6040	479.3910	479.3600	-0.0310	NVA
NVA763	519050.1290	4263217.2150	559.4580	559.5420	0.0840	NVA
NVA764	516181.7230	4246247.9330	569.1240	569.1290	0.0050	NVA
NVA766	517746.4340	4225210.6850	583.3940	583.3500	-0.0440	NVA
NVA772	540425.4160	4264123.6350	550.9100	550.9300	0.0200	NVA
NVA773	536587.8660	4245475.4300	545.0390	545.1030	0.0640	NVA
NVA774	570011.3410	4244662.6250	514.1120	514.2360	0.1240	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
NVA775	586280.1360	4250482.9240	490.0530	490.0360	-0.0170	NVA
NVA776	569459.3420	4229437.9410	499.9840	500.0190	0.0350	NVA
NVA777	580527.5850	4222637.4580	485.7560	485.8320	0.0760	NVA
NVA778	595378.0450	4212732.9670	466.0110	466.0250	0.0140	NVA
NVA779	596485.1130	4213755.4760	465.3610	465.2870	-0.0740	NVA
NVA780	579739.6800	4202455.4010	489.9860	490.0310	0.0450	NVA
NVA781	572220.6470	4194612.2940	486.3100	486.2290	-0.0810	NVA
NVA782	560601.2060	4202748.3660	515.2260	515.1690	-0.0570	NVA
NVA783	535226.6020	4201810.3840	565.8350	565.7670	-0.0680	NVA
NVA784	529808.6890	4217616.0420	571.0400	571.0730	0.0330	NVA
NVA785	573415.0280	4263440.9750	534.6390	534.5510	-0.0880	NVA
NVA788	614930.3120	4247606.4900	452.7050	452.7250	0.0200	NVA
NVA796	606483.2430	4195127.5140	453.4940	453.4000	-0.0940	NVA
NVA797	608168.7200	4221996.9630	454.2870	454.0340	-0.2530	NVA
NVA861	594716.3780	4202216.4480	467.1860	467.3160	0.1300	NVA
NVA863	581786.0240	4205880.5820	489.0020	489.0100	0.0080	NVA
NVA895	530335.8310	4194854.5520	576.9590	576.9400	-0.0190	NVA
NVA916	605945.4950	4241856.8530	463.6790	463.7640	0.0850	NVA
NVA919	544286.6990	4249332.5550	540.6200	540.7270	0.1070	NVA
NVA920	568918.3080	4264083.0310	534.7940	534.7250	-0.0690	NVA
NVA922	527792.8850	4236373.3110	567.6980	567.7330	0.0350	NVA
NVA923	542272.9690	4217824.4270	547.9250	547.9170	-0.0080	NVA
VVA257	517191.3470	4239602.4940	572.9630	573.0580	0.0950	VVA
VVA263	558366.3930	4245594.9370	517.2440	517.6300	0.3860	VVA
VVA264	587485.0390	4247956.2050	480.8320	480.7030	-0.1290	VVA
VVA265	525316.5370	4219506.9530	572.9150	573.0800	0.1650	VVA
VVA266	563940.9870	4218669.4390	516.6560	516.5570	-0.0990	VVA
VVA267	592828.8190	4222377.4240	507.8460	507.7800	-0.0660	VVA
VVA268	522636.2050	4194499.8970	589.8460	589.8730	0.0270	VVA
VVA269	556340.8040	4197844.2830	527.4140	527.4470	0.0330	VVA
VVA270	585625.1810	4196499.8970	459.1270	459.2600	0.1330	VVA
VVA304	606207.9690	4187097.8340	455.6580	455.4080	-0.2500	VVA
VVA305	534021.2110	4186372.0060	571.2790	571.1510	-0.1280	VVA
VVA396	544235.4340	4249359.8640	541.2670	541.2990	0.0320	VVA
VVA397	568906.0230	4264029.3850	535.2930	535.3010	0.0080	VVA
VVA399	527757.9470	4236363.9690	566.4750	566.5650	0.0900	VVA
VVA400	560644.1230	4230110.8260	510.9760	511.0380	0.0620	VVA
VVA401	589721.1300	4218969.8150	474.9200	474.9770	0.0570	VVA
VVA402	542255.8170	4217843.6850	548.5580	548.6890	0.1310	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
VVA403	557537.3850	4208158.7500	526.2600	526.2640	0.0040	VVA
VVA404	581749.7220	4205884.2420	489.4040	489.5380	0.1340	VVA
VVA408	607788.8680	4193568.9620	453.4240	453.5340	0.1100	VVA
VVA410	609894.4380	4262855.5750	438.0570	437.9010	-0.1560	VVA
VVA411	606000.8090	4241847.0580	463.4080	463.5100	0.1020	VVA
VVA536	532300.0180	4254537.1000	550.4110	550.4670	0.0560	VVA
VVA537	590777.8120	4236862.4040	490.6030	490.6580	0.0550	VVA
VVA538	538249.0360	4228352.7940	535.9730	535.7400	-0.2330	VVA
VVA539	580974.5720	4256966.9550	496.3580	496.5290	0.1710	VVA
VVA540	594709.8360	4202179.4650	467.7100	467.8230	0.1130	VVA
VVA541	564678.7010	4204365.6160	514.5060	514.5920	0.0860	VVA
VVA542	555753.5090	4257461.8510	525.6990	525.6790	-0.0200	VVA
VVA543	536663.9720	4204924.3830	561.6700	561.8120	0.1420	VVA
VVA548	607431.5260	4214119.2000	471.9420	471.9920	0.0500	VVA
VVA594	597789.5700	4193400.3600	458.3600	458.4520	0.0920	VVA
VVA596	579736.2840	4202462.7900	489.9880	490.0740	0.0860	VVA
VVA636	529798.0820	4217642.2010	571.2860	571.3140	0.0280	VVA
VVA651	582712.2390	4239067.8230	509.0800	509.1840	0.1040	VVA
VVA654	536610.3690	4245437.9480	545.1290	545.1800	0.0510	VVA
VVA655	573366.9640	4263420.3500	534.6280	534.5900	-0.0380	VVA
VVA656	519040.2960	4263200.4400	559.4440	559.5090	0.0650	VVA
VVA657	533273.2070	4227574.4590	561.1040	561.1100	0.0060	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
NVA374	534035.5250	4254143.8550	553.9010	553.7918	0.1092	NVA
NVA375	555897.8460	4255839.2330	524.5750	524.5902	-0.0152	NVA
NVA376	593796.6520	4261056.5820	502.7820	502.7284	0.0536	NVA
NVA377	523640.3640	4234806.9610	571.3640	571.3599	0.0041	NVA
NVA378	554570.1750	4233325.8080	518.1480	518.1825	-0.0345	NVA
NVA379	586297.5710	4230326.0740	502.9070	502.8519	0.0551	NVA
NVA380	545460.4660	4212242.1210	544.4990	544.5037	-0.0047	NVA
NVA381	573620.7720	4212567.8100	499.0050	499.0104	-0.0054	NVA
NVA382	528722.4080	4200393.7010	578.1340	578.1107	0.0233	NVA
NVA383	548806.6910	4196153.6640	534.7470	534.9108	-0.1638	NVA
NVA384	572173.3110	4204377.7050	499.7080	499.7444	-0.0364	NVA
NVA385	590674.6620	4199710.2820	476.5990	476.5101	0.0889	NVA
NVA386	597206.3000	4241737.2220	481.2140	481.2401	-0.0261	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
NVA391	607725.4720	4205815.7660	449.8470	449.8925	-0.0455	NVA
NVA394	605474.9380	4235404.2170	469.8180	469.8298	-0.0118	NVA
NVA576	522947.4110	4262064.0380	548.9860	549.0278	-0.0418	NVA
NVA577	567109.7930	4216852.7130	513.6210	513.6837	-0.0627	NVA
NVA578	584176.8790	4259352.3630	511.2430	511.2425	0.0005	NVA
NVA579	561344.6570	4238207.7250	512.0310	512.0478	-0.0168	NVA
NVA580	543871.6870	4235653.9560	538.2820	538.3710	-0.0890	NVA
NVA581	582755.0390	4239050.5200	508.8240	508.9135	-0.0895	NVA
NVA582	530329.0470	4194857.3270	576.6810	576.7429	-0.0619	NVA
NVA583	533308.9410	4227619.3070	561.6440	561.6897	-0.0457	NVA
NVA584	557437.7660	4222871.7940	528.9770	528.9583	0.0187	NVA
NVA585	589815.0240	4220655.1260	475.5210	475.5316	-0.0106	NVA
NVA586	563306.2710	4196293.1060	513.1330	513.1267	0.0063	NVA
NVA587	597798.0190	4193385.9860	458.0620	458.1512	-0.0892	NVA
NVA591	607129.4730	4254825.9020	457.0210	457.0816	-0.0606	NVA
NVA595	602302.2370	4191851.6040	479.3910	479.3503	0.0407	NVA
NVA763	519050.1290	4263217.2150	559.4580	559.5308	-0.0728	NVA
NVA764	516181.7230	4246247.9330	569.1240	569.1386	-0.0146	NVA
NVA766	517746.4340	4225210.6850	583.3940	583.3768	0.0172	NVA
NVA772	540425.4160	4264123.6350	550.9100	550.9142	-0.0042	NVA
NVA773	536587.8660	4245475.4300	545.0390	545.1104	-0.0714	NVA
NVA774	570011.3410	4244662.6250	514.1120	514.2175	-0.1055	NVA
NVA775	586280.1360	4250482.9240	490.0530	490.0398	0.0132	NVA
NVA776	569459.3420	4229437.9410	499.9840	499.9993	-0.0153	NVA
NVA777	580527.5850	4222637.4580	485.7560	485.8338	-0.0778	NVA
NVA778	595378.0450	4212732.9670	466.0110	466.0251	-0.0141	NVA
NVA779	596485.1130	4213755.4760	465.3610	465.2971	0.0639	NVA
NVA780	579739.6800	4202455.4010	489.9860	490.0341	-0.0481	NVA
NVA781	572220.6470	4194612.2940	486.3100	486.2696	0.0404	NVA
NVA782	560601.2060	4202748.3660	515.2260	515.1575	0.0685	NVA
NVA783	535226.6020	4201810.3840	565.8350	565.7924	0.0426	NVA
NVA784	529808.6890	4217616.0420	571.0400	571.0934	-0.0534	NVA
NVA785	573415.0280	4263440.9750	534.6390	534.5593	0.0797	NVA
NVA788	614930.3120	4247606.4900	452.7050	452.7345	-0.0295	NVA
NVA796	606483.2430	4195127.5140	453.4940	453.4081	0.0859	NVA
NVA797	608168.7200	4221996.9630	454.2870	454.0332	0.2538	NVA
NVA861	594716.3780	4202216.4480	467.1860	467.2961	-0.1101	NVA
NVA863	581786.0240	4205880.5820	489.0020	489.0179	-0.0159	NVA
NVA895	530335.8310	4194854.5520	576.9590	576.9559	0.0031	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
NVA916	605945.4950	4241856.8530	463.6790	463.7575	-0.0785	NVA
NVA919	544286.6990	4249332.5550	540.6200	540.7176	-0.0976	NVA
NVA920	568918.3080	4264083.0310	534.7940	534.7110	0.0830	NVA
NVA922	527792.8850	4236373.3110	567.6980	567.7307	-0.0327	NVA
NVA923	542272.9690	4217824.4270	547.9250	547.9072	0.0178	NVA
VVA257	517191.3470	4239602.4940	572.9630	573.0488	-0.0858	VVA
VVA263	558366.3930	4245594.9370	517.2440	517.6628	-0.4188	VVA
VVA264	587485.0390	4247956.2050	480.8320	480.7163	0.1157	VVA
VVA265	525316.5370	4219506.9530	572.9150	573.0732	-0.1582	VVA
VVA266	563940.9870	4218669.4390	516.6560	516.5704	0.0856	VVA
VVA267	592828.8190	4222377.4240	507.8460	507.7820	0.0640	VVA
VVA268	522636.2050	4194499.8970	589.8460	589.8981	-0.0521	VVA
VVA269	556340.8040	4197844.2830	527.4140	527.4364	-0.0224	VVA
VVA270	585625.1810	4196499.8970	459.1270	459.2355	-0.1085	VVA
VVA304	606207.9690	4187097.8340	455.6580	455.4243	0.2337	VVA
VVA305	534021.2110	4186372.0060	571.2790	571.1489	0.1301	VVA
VVA396	544235.4340	4249359.8640	541.2670	541.3045	-0.0375	VVA
VVA397	568906.0230	4264029.3850	535.2930	535.2919	0.0011	VVA
VVA399	527757.9470	4236363.9690	566.4750	566.5706	-0.0956	VVA
VVA400	560644.1230	4230110.8260	510.9760	511.0444	-0.0684	VVA
VVA401	589721.1300	4218969.8150	474.9200	474.9738	-0.0538	VVA
VVA402	542255.8170	4217843.6850	548.5580	548.6778	-0.1198	VVA
VVA403	557537.3850	4208158.7500	526.2600	526.2389	0.0211	VVA
VVA404	581749.7220	4205884.2420	489.4040	489.5411	-0.1371	VVA
VVA408	607788.8680	4193568.9620	453.4240	453.5273	-0.1033	VVA
VVA410	609894.4380	4262855.5750	438.0570	437.9239	0.1331	VVA
VVA411	606000.8090	4241847.0580	463.4080	463.5262	-0.1182	VVA
VVA536	532300.0180	4254537.1000	550.4110	550.4565	-0.0455	VVA
VVA537	590777.8120	4236862.4040	490.6030	490.6467	-0.0437	VVA
VVA538	538249.0360	4228352.7940	535.9730	535.7179	0.2551	VVA
VVA539	580974.5720	4256966.9550	496.3580	496.5539	-0.1959	VVA
VVA540	594709.8360	4202179.4650	467.7100	467.8075	-0.0975	VVA
VVA541	564678.7010	4204365.6160	514.5060	514.5987	-0.0927	VVA
VVA542	555753.5090	4257461.8510	525.6990	525.6762	0.0228	VVA
VVA543	536663.9720	4204924.3830	561.6700	561.7981	-0.1281	VVA
VVA548	607431.5260	4214119.2000	471.9420	472.0269	-0.0849	VVA
VVA594	597789.5700	4193400.3600	458.3600	458.4521	-0.0921	VVA
VVA596	579736.2840	4202462.7900	489.9880	490.0723	-0.0843	VVA
VVA636	529798.0820	4217642.2010	571.2860	571.3096	-0.0236	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA651	582712.2390	4239067.8230	509.0800	509.1848	-0.1048	VVA
VVA654	536610.3690	4245437.9480	545.1290	545.1978	-0.0688	VVA
VVA655	573366.9640	4263420.3500	534.6280	534.5822	0.0458	VVA
VVA656	519040.2960	4263200.4400	559.4440	559.4899	-0.0459	VVA
VVA657	533273.2070	4227574.4590	561.1040	561.1042	-0.0002	VVA

Table 14: DEM Check Point Assessment