



Project Report

TASK ORDER NAME: AL_NorthAL_2019_B19

TASK ORDER NUMBER: 140G0219F0286

CONTRACT NUMBER: G16PC00042

ATLANTIC PROJECT NUMBER: 19061

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SECTION 1: PROJECT OVERVIEW AND PURPOSE

1.1 Aerial LiDAR Project

1.1.1 Project Overview

USGS NGTOC task order 140G0219F0286 required Fall 2019/Spring 2020 LiDAR survey to be collected over 1,094 square miles covering part or all 5 counties in Alabama. These counties are Limestone, Madison, Jackson, Morgan, and Marshall. Aerial LiDAR data for this task order was planned, acquired, processed and produced at an aggregate nominal pulse spacing (ANPS) of ≤ 0.5 meters and in compliance with USGS National Geospatial Program LiDAR Base Specification version 1.3.

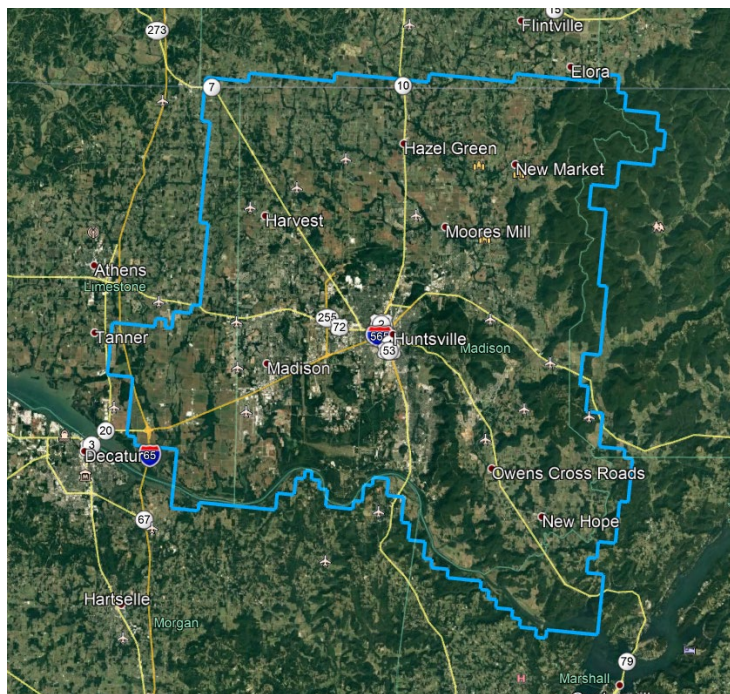


Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA)

1.1.2 Project Purpose

This task order is for planning, acquisition, processing, and derivative products of lidar data to be collected at an aggregate nominal pulse spacing of ≤ 0.5 meters, including overlap and an aggregate nominal pulse density of no less than 2 points per square meter. Lidar data and derivative products produced in compliance with this task order are based on the “National Geospatial Program Lidar Base Specification Version 1.3”. This data will be used to generate Digital Elevation Models (DEMs) for the use in dam safety assessments, engineering design and design reviews, conservation planning, research, delivery, floodplain mapping, and hydrologic modeling utilizing lidar

technology for partners including: the Tennessee Valley Authority, Huntsville Utilities, City of Huntsville, and Madison County Tax Assessor’s Office; it will also support the 3DEP mission.

1.1.3 Contract Deliverables

Item	Specification/Format
Classified Point Cloud	LAS, version 1.4, Point Record Format 6
Bare Earth Surface (Raster DEM) - Hydro	32Bit, floating point, TIF, 1 M cell size
Intensity Imagery	8-bit, 256 color gray scale, TIF, 1 M cell size
Hydro Breaklines	ESRI file geodatabase (polygonZ)
Product Metadata	XML, FGDC compliant
Flight Index	ESRI file geodatabase
Swath Data	ESRI file geodatabase
Project Report	PDF(Acquisition, Survey, Processing, QA/QC)
Tile Scheme	1000 m by 1000 m
Tile Naming	US National Grid Convention

Table 1: Aerial LiDAR Contract Deliverables – Lot 5 & 6

Item	Specification/Format
Classified Point Cloud	LAS, version 1.4, Point Record Format 6
Bare Earth Surface (Raster DEM) - Hydro	32Bit, floating point, TIF, 2.5 FT cell size
Intensity Imagery	8-bit, 256 color gray scale, TIF, 2.5 FT cell size
Hydro Breaklines	ESRI file geodatabase (polygonZ)
Product Metadata	XML, FGDC compliant
Flight Index	ESRI file geodatabase
Swath Data	ESRI file geodatabase
Project Report	PDF(Acquisition, Survey, Processing, QA/QC)
Tile Scheme	1500 ft by 1500 ft (US Survey feet)
Tile Naming	US National Grid Convention

Table 2: Aerial LiDAR Contract Deliverables – Lot 7

SECTION 2: FIELD OPERATIONS

2.1 Aerial LiDAR Project – Aerial Acquisition

2.1.1 Aircraft and Sensor Information

Atlantic operated a PACVX (N750VX) outfitted with an Optech Galaxy Prime LiDAR system during the collection of the project area. The specifications of this system are presented in the following table:

Parameter	Specification
Model	Galaxy Prime
Manufacturer	Optech
Performance Envelope	150 – 4700 m AGL, nominal
Absolute Horizontal Accuracy	1/10,000 x altitude
Absolute Elevation Accuracy	< 0.03 – 0.20 m RMSE from 150 – 4700 m AGL
Topographic Laser	1064-nm near-infrared
Laser Classification	Class IV
Pulse Repetition Frequency (Effective)	Programmable, 50 – 1000 kHz
Beam Divergence	0.25 mrad (1/e)
Laser Range Precision	< 0.008 m
Minimum Target Separation Distance	< 0.7 m (discrete)
Range Capture	Up to 8 range measurements, including last
Intensity Capture	Up to 8 intensity measurements, including last (12-bit)
Scan Angle (Fov)	10 – 60°
Swath Width	10 – 115% of altitude AGL
Scan Frequency	0 – 120 Hz advertised (0 – 240 scan lines/sec)
Scan Product	2000 maximum
Roll Compensation	±5° minimum
Data Storage	Internal solid-state drive (SSD)
Power Requirements	28 V; 300 W
Dimensions and Weight	Sensor: 0.34 x 0.34 x 0.25 m, 27 kg PDU: 0.42 x 0.33 x 0.10 m, 6.5 kg
Operation Temperature	0 to +35°C

Table 3: System Specifications – Galaxy Prime

2.1.2 Sensor Acquisition Information

The following table illustrates project specific system parameters for LiDAR acquisition on this project:

Parameter	Specification
System	Optech Galaxy Prime
Nominal Pulse Spacing (m)	.5
Nominal Pulse Density (pls/m²)	4
Nominal Flight Height (AGL meters)	2500
Nominal Flight Speed (kts)	130
Pass Heading (°)	North/South
Sensor Scan Angle (°)	44
Scan Frequency (Hz)	67
Pulse Rate of Scanner (kHz)	500
Line Spacing (m)	1290
Central Wavelength of Sensor Laser (nm)	1064
Sensor Operated with Multiple Pulses	8
Beam Divergence (mrad)	.25
Nominal Swath Width (m)	1600
Nominal Swath Overlap (%)	20
Scan Pattern	TRIANGLE

Table 4: Aerial LiDAR Sensor Acquisition Parameters

2.1.3 Flight Plan Execution

Atlantic acquired 54 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 5 flight missions conducted between December 4, 2019 and December 30, 2019. Onboard differential Global Navigation Satellite System (GNSS) unit(s) recorded sample aircraft positions at 2 hertz (Hz) or more frequency. LiDAR data was only acquired when a minimum of six (6) satellites were in view.

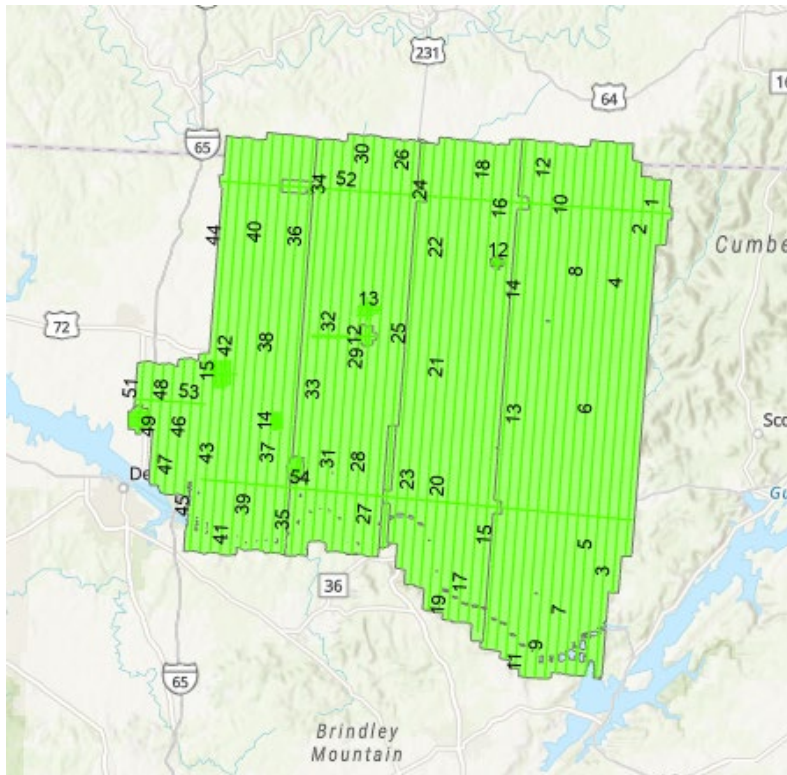


Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

2.1.4 GNSS Reference Stations

Nine (9) 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
ALCN	CORS	ALCN	N34°09'46.97942"	W85°39'31.04959"	164.905
ALCU	CORS	ALCU	N34°10'47.53655"	W86°50'41.56046"	222.816
ALH2	CORS	ALH2	N34°41'56.34036"	W86°36'05.08301"	166.753
ALHL	CORS	ALHL	N33°53'15.29816"	W86°23'52.62564"	330.735
ALNC	CORS	ALNC	N34°40'52.60609"	W87°18'34.02566"	156.77
GTAC	CORS	GTAC	N34°42'39.84929"	W86°39'12.31545"	193.01
TN25	CORS	TN25	N35°22'01.47345"	W86°11'20.80817"	301.315
TN34	CORS	TN34	N35°25'34.74322"	W86°42'43.90764"	229.098
TN39	CORS	TN39	N35°11'29.06987"	W87°00'26.77957"	185.88

Table 5: GNSS Reference Stations

2.2 Aerial LiDAR Project – Ground Acquisition

2.2.1 Ground Control Survey

A total of 161 ground survey points were collected in support of this project, including 32 LiDAR Control Points (LCP), 69 Non-vegetated Vertical Accuracy (NVA) and 60 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 and 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
LCP01	830255.476	1351300.386	246.844
LCP02	836390.422	1363350.361	274.214
LCP03	842469.875	1354844.201	249.71
LCP04	848370.976	1341863.117	217.363
LCP05	841001.758	1346505.028	241.53
LCP06	834058.929	1343831.49	222.123
LCP07	840373.924	1340647.866	232.565
LCP08	850298.395	1354355.09	238.606
LCP09	824157.18	1336109.613	187.797
LCP10	832790.514	1336817.14	192.767
LCP11	841143.456	1366139.208	273.407
LCP12	852628.173	1362801.791	238.442
LCP13	874143.617	1346098.141	232.415
LCP14	863018.224	1333236.601	191.104
LCP15	882986.129	1349526.371	194.111
LCP16	870784.456	1364315.481	240.087

ID	Easting	Northing	Elevation
LCP17	864374.791	1364390.462	248.369
LCP18	859960.753	1355117.997	231.824
LCP19	857089.319	1334379.573	198.208
LCP20	880982.091	1310742.128	186.913
LCP21	880982.089	1310742.128	186.915
LCP22	841519.489	1334559.114	208.805
LCP23	842477.458	1328616.836	174.57
LCP24	853068.269	1331063.836	173.26
LCP25	822387.223	1335997.107	190.601
LCP26	837800.65	1328217.804	186.189
LCP27	830312.79	1330049.975	189.483
LCP28	846126.455	1355141.498	245.891
LCP29	864286.667	1342876.621	202.337
LCP30	870699.696	1358702.941	237.698
LCP31	874228.47	1314587.92	178.544
LCP32	880109.272	1316463.614	193.844

Table 6: LiDAR Control Point Coordinates

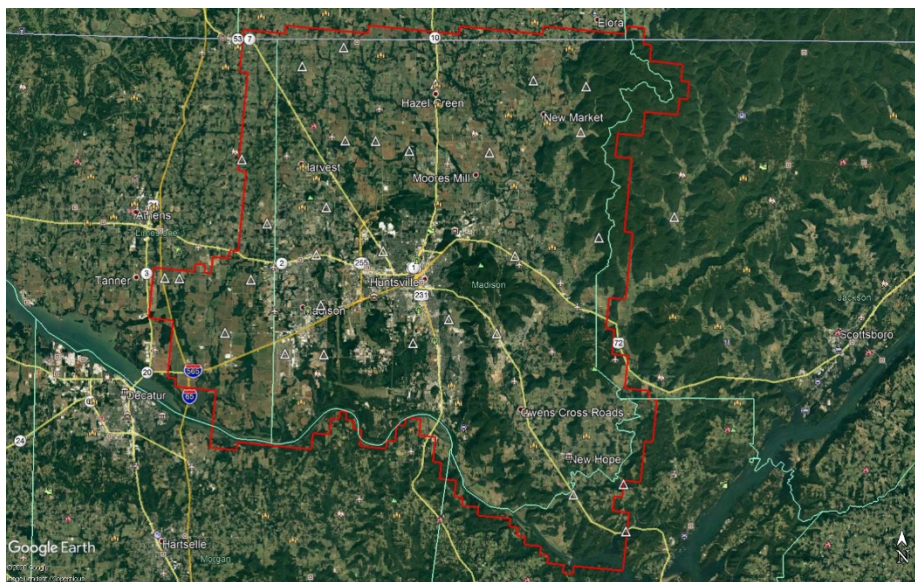


Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
BE01	836390.044	1363365.091	274.162
BE02	843774.379	1360784.885	258.817
BE03	852625.24	1362782.853	238.344
BE04	864366.475	1364384.053	248.347
BE05	870777.322	1364306.059	239.66
BE06	830258.062	1351306.114	247.024
BE07	842472.008	1354833.716	249.769
BE08	850288.077	1354349.325	238.24
BE09	859958.375	1355127.935	231.546
BE10	882996.023	1349521.66	194.076
BE11	834070.864	1343829.691	222.527
BE12	841016.846	1346508.391	241.374
BE13	852852.522	1346298.464	216.682
BE14	863027.723	1333286.455	191.27
BE15	874141.419	1346106.469	232.577
BE16	824166.634	1336106.453	187.829
BE17	832796.393	1336815.383	192.807
BE18	840388.108	1340648.439	232.74
BE19	848365.723	1341859.017	217.298
BE20	833700.017	1359259.619	252.22
BE21	838958.937	1336656.953	232.108
BE22	822862.274	1335963.404	193.878
OT01	857253.709	1349514.874	227.622
OT02	867189.748	1343112.141	193.758
OT03	826991.096	1328078.204	180.58
OT04	833965.962	1330363.278	186.776
OT05	841551.437	1334555.757	209.503
OT06	850058.852	1336507.359	203.372
OT07	857124.571	1334384.197	198.406
OT08	868690.935	1336712.199	184.825
OT09	875052.034	1337841.924	193.722
OT10	833342.371	1322600.821	176.798
OT11	842503.883	1328637.181	175.132
OT12	855501.748	1332244.626	186.263
OT13	859657.386	1329821.343	195.367
OT14	867410.601	1330849.677	182.113

ID	Easting	Northing	Elevation
OT15	875871.055	1332731.145	464.434
OT16	832061.704	1318517.009	176.513
OT17	840034.597	1321550.352	182.917
OT18	855676.877	1323974.873	173.721
OT19	855248.999	1326654.107	174.058
OT20	855637.333	1332255.99	186.741
OT21	841956.636	1321219.742	193.39
OT22	856388.628	1324206.188	178.509
OT23	847670.185	1348746.527	240.48
OT24	872423.093	1350559.68	220.48
UR01	856067.985	1319919.794	184.805
UR02	861433.886	1326235.005	439.193
UR03	872185.747	1326502.804	190.43
UR04	879256.445	1325193.319	181.728
UR05	867161.8	1322516.461	177.227
UR06	875464.687	1322566.703	183.975
UR07	861151.456	1317147.366	191.034
UR08	870419.736	1319306.77	179.664
UR09	880083.967	1316655.477	188.909
UR10	864492.739	1313226.475	175.925
UR11	874454.702	1316394.622	175.773
UR12	870599.183	1311627.207	337.145
UR13	876907.973	1311353.256	189.043
UR14	874304.108	1307788.492	181.513
UR15	880971.541	1310736.143	187.314
UR16	869320.876	1352516.175	213.265
UR17	867588.915	1360291.866	238.467
UR18	856527.583	1356810.362	232.364
UR19	831566.562	1364605.433	261.642
UR20	853211.722	1342603.269	201.625
UR21	872335.449	1319511.353	182.28
UR22	872057.562	1317529.461	177.935
UR23	874635.575	1308861.04	188.61

Table 71: Non-Vegetated Vertical Accuracy (NVA) Point Coordinates

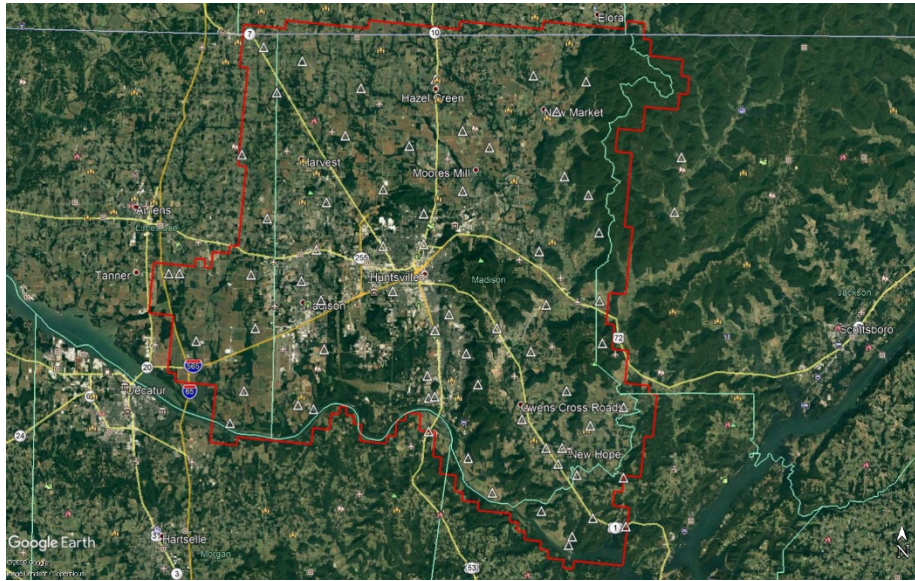


Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
BR01	833720.807	1359255.649	252.591
BR02	841148.289	1366154.555	273.931
BR03	850650.693	1364666.078	241.333
BR04	860222.91	1369813.879	259.288
BR05	872461.623	1371017.1	332.309
BR06	837659.437	1351876.416	255.164
BR07	846117.416	1355144.508	246.318
BR08	859210.804	1360566.615	216.152
BR09	883171.641	1356256.33	200.071
BR10	870711.271	1358697.551	238.911
BR11	847668.366	1348737.282	240.816
BR12	858630.105	1352253.769	208.685
BR13	872422.055	1350570.381	220.364
BR14	836361.566	1342032.607	233.923
BR15	845931.928	1344663.656	227.358
BR16	853218.104	1342613.958	201.724
BR17	843780.539	1360785.699	258.62
BR18	857248.981	1349486.025	227.824
BR19	881439.973	1316239.147	334.098
HG01	864278.587	1342841.089	201.743
HG02	871790.644	1343007.746	194.638
HG03	876937.599	1342698.312	204.698
HG04	822880.971	1335961.635	194.066
HG05	830292.253	1330059.379	192.693
HG06	838964.516	1336667.007	231.519
HG07	845733.496	1334795.725	198.012
HG08	857715.008	1337280.904	347.344
HG09	862817.671	1338052.413	260.195
HG10	872913.91	1337512.92	194.082
HG11	822378.392	1335979.889	190.389
HG12	827161.877	1324825.6	174.099
HG13	837777.627	1328221.529	186.817
HG14	853064.316	1331056.597	173.061
HG15	855650.287	1332238.313	187.342
HG16	863550.345	1332483.914	185.997
HG17	834277.503	1353140.111	246.652

ID	Easting	Northing	Elevation
HG18	841037.701	1346505.813	242.058
HG19	826988.845	1328087.707	181.172
HG20	869303.072	1352527.089	212.195
HG21	875471.202	1322586.414	183.737
TR01	872748.707	1331650.782	212.92
TR02	878175.285	1329735.246	188.214
TR03	834329.606	1320549.751	177.883
TR04	841915.091	1321242.57	192.318
TR05	856407.01	1324200.673	178.17
TR06	857966.357	1324173.725	184.71
TR07	868689.535	1326482.676	192.459
TR08	880980.688	1322792.454	181.496
TR09	861238.7	1321123.819	180.745
TR10	866885.66	1319389.311	183.239
TR11	876893.237	1318660.126	177.267
TR12	869235.87	1316252.167	188.519
TR13	874889.052	1313484.479	176.762
TR14	878353.39	1313829.444	353.134
TR15	874695.707	1308820.912	192.658
TR16	834285.193	1353119.168	247.116
TR17	874271.991	1307847.621	183.217
TR18	853953.23	1333590.002	188.437
TR19	833339.334	1322612.202	176.734
TR20	855491.152	1332218.447	186.512

Table 8: Vegetated Vertical Accuracy (VVA) Point Coordinates

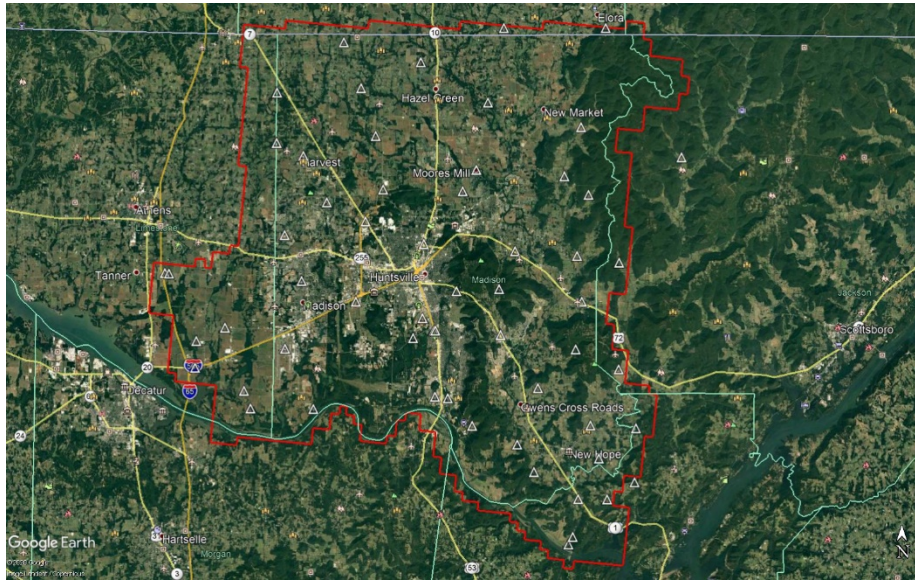


Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

SECTION 3: DATA PRODUCTION

3.1 Aerial LiDAR Project – Calibration/Classification

3.1.1 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.

3.1.2 Coordinate Reference System

Parameter	Specification
Horizontal Datum	NAD83 (2011)
Coordinate System	Albers Conic Equal Area
Vertical Datum	NAVD88
Geoid Model	12B
EPSG Code	6350
Units of Reference	Metric

Table 2: Lots 5 & 6 Coordinate Reference System

Parameter	Specification
Horizontal Datum	NAD83 (2011)
Coordinate System	Alabama East
Vertical Datum	NAVD88
Geoid Model	12B
EPSG Code	NA
Units of Reference	US Survey Feet

Table 10: Lot 7 Coordinate Reference System

3.1.3 LiDAR Point Cloud Statistics

Category	Value
Total Points	16,421,317,234
Nominal Pulse Spacing (m)	0.4350
Nominal Pulse Density (pls/m ²)	5.2847
Aggregate Total Points	16,421,317,234
Aggregate Nominal Pulse Spacing (m)	0.4400
Aggregate Nominal Pulse Density (pls/m ²)	5.1642

Table 11: LiDAR Point Cloud Statistics

3.1.4 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. The following figure depicts a sample of the assessment.

3.1.5 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 $\leq 2\text{cm}$. 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.

3.1.6 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 class 9 (Water).

Code	Description
1	Processed, but unclassified
2	Bare-earth ground
7	Low Noise
9	Water
17	Bridge Decks
18	High Noise
20	Ignored Ground (breakline proximity)

Table 12: LiDAR Point Classification Codes and Descriptions

3.1.7 LiDAR Intensity Imagery

LiDAR intensity imagery was created from the final calibrated and classified lidar point cloud. Intensity images were produced from all classified points and posted to a 1-meter cell size for Lots 5 and 6. For Lot 7 the intensity

imagery was posted at 2.5 feet. Intensity images were cut to match the tile index and its corresponding tile names and delivered in .TIFF format for all Lots.

3.1.8 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.

3.1.9 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. For Lots 5 and 6 DEMs were created with a grid spacing of 1 meter. For Lot 7 the DEMs were created with a grid spacing of 2.5 feet. DEMs for all Lots for this project were cut to match the tile index and its corresponding tile names and delivered in 32-bit floating point .TIFF format.

SECTION 4: ACCURACY ASSESSMENT

4.1 Aerial LiDAR Project – Vertical Accuracy Assessment

4.1.1 Requirements

Per the table below, the Vertical Accuracy Assessment utilized the required parameters for Vertical Data Accuracy Class IV.

Vertical Data Accuracy Class	RMSEz in Non-Vegetated Terrain (cm)	Non-Vegetated Vertical Accuracy (NVA) at 95% Confidence Level (cm)	Vegetated Vertical Accuracy (VVA) at 95th Percentile (cm)
I	1.0	2.0	2.9
II	2.5	4.9	7.4
III	5.0	9.8	14.7
IV	10.0	19.6	29.4
V	12.5	24.5	36.8
VI	20.0	39.2	58.8
VII	33.3	65.3	98.0
VIII	66.7	130.7	196.0
IX	100.0	196.0	294.0
IV	10	19.6	29.4

Table 13: 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).

4.1.2 Results

An overall statistical assessment of the check points can be found in the following two tables (values provided in meters):

Broad Land Cover Type	# of Points	RMSEz	95% Confidence Level	95th Percentile
NVA of Point Cloud	68	0.0323	0.0632	0.0493
NVA of DEM	67	0.0392	0.0768	0.0655
VVA of Point Cloud	53	0.0504	0.0988	0.0804
VVA of DEM	52	0.0586	0.1148	0.1084

Table 3: NVA/VVA Accuracies

PointID	Easting	Northing	KnownZ	LaserZ	Description	DeltaZ
BE10	882996.0230	1349521.6600	194.0760	194.0810	Outside DPA	-
BR19	881439.9730	1316239.1470	334.0980	334.0790	Outside DPA	-

Table 4: Outlier Check Points

SECTION 5: CERTIFICATION STATEMENTS

5.1 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 6: CONTROL POINT ASSESSMENTS

6.1 Aerial LiDAR Project

6.1.1 Point Cloud Check Point Assessment

PointID	Easting	Northing	KnownZ	LaserZ	DeltaZ	Description
BE02	843774.3790	1360784.8850	258.8170	258.8060	-0.0110	NVA
BE03	852625.2400	1362782.8530	238.3440	238.3400	-0.0040	NVA
BE04	864366.4750	1364384.0530	248.3470	248.4030	0.0560	NVA
BE05	870777.3220	1364306.0590	239.6600	239.6810	0.0210	NVA
BE06	830258.0620	1351306.1140	247.0240	247.0210	-0.0030	NVA
BE07	842472.0080	1354833.7160	249.7690	249.7860	0.0170	NVA
BE08	850288.0770	1354349.3250	238.2400	238.2550	0.0150	NVA
BE09	859958.3750	1355127.9350	231.5460	231.5460	0.0000	NVA
BE10	882996.0230	1349521.6600	194.0760	194.0810	0.0050	NVA
BE11	834070.8640	1343829.6910	222.5270	222.5640	0.0370	NVA
BE12	841016.8460	1346508.3910	241.3740	241.4100	0.0360	NVA
BE13	852852.5220	1346298.4640	216.6820	216.6820	0.0000	NVA
BE14	863027.7230	1333286.4550	191.2700	191.2440	-0.0260	NVA
BE15	874141.4190	1346106.4690	232.5770	232.5240	-0.0530	NVA
BE16	824166.6340	1336106.4530	187.8290	187.8410	0.0120	NVA
BE17	832796.3930	1336815.3830	192.8070	192.8040	-0.0030	NVA
BE18	840388.1080	1340648.4390	232.7400	232.7620	0.0220	NVA
BE19	848365.7230	1341859.0170	217.2980	217.2660	-0.0320	NVA
BE20	833700.0170	1359259.6190	252.2200	252.2700	0.0500	NVA
BE21	838958.9370	1336656.9530	232.1080	232.1200	0.0120	NVA
BE22	822862.2740	1335963.4040	193.8780	193.8780	0.0000	NVA
BR02	841148.2890	1366154.5550	273.9310	273.9560	0.0250	VVA
BR03	850650.6930	1364666.0780	241.3330	241.3590	0.0260	VVA
BR04	860222.9100	1369813.8790	259.2880	259.1530	-0.1350	VVA
BR05	872461.6230	1371017.1000	332.3090	332.3410	0.0320	VVA
BR07	846117.4160	1355144.5080	246.3180	246.3130	-0.0050	VVA
BR08	859210.8040	1360566.6150	216.1520	216.2300	0.0780	VVA
BR10	870711.2710	1358697.5510	238.9110	238.8230	-0.0880	VVA
BR11	847668.3660	1348737.2820	240.8160	240.8380	0.0220	VVA
BR12	858630.1050	1352253.7690	208.6850	208.7520	0.0670	VVA
BR13	872422.0550	1350570.3810	220.3640	220.3010	-0.0630	VVA
BR15	845931.9280	1344663.6560	227.3580	227.3590	0.0010	VVA

PointID	Easting	Northing	KnownZ	LaserZ	DeltaZ	Description
BR16	853218.1040	1342613.9580	201.7240	201.7110	-0.0130	VVA
BR17	843780.5390	1360785.6990	258.6200	258.6430	0.0230	VVA
BR18	857248.9810	1349486.0250	227.8240	227.8360	0.0120	VVA
BR19	881439.9730	1316239.1470	334.0980	334.0790	-0.0190	VVA
HG01	864278.5870	1342841.0890	201.7430	201.7400	-0.0030	VVA
HG02	871790.6440	1343007.7460	194.6380	194.6740	0.0360	VVA
HG03	876937.5990	1342698.3120	204.6980	204.6600	-0.0380	VVA
HG04	822880.9710	1335961.6350	194.0660	194.0900	0.0240	VVA
HG05	830292.2530	1330059.3790	192.6930	192.6800	-0.0130	VVA
HG06	838964.5160	1336667.0070	231.5190	231.6140	0.0950	VVA
HG07	845733.4960	1334795.7250	198.0120	197.9980	-0.0140	VVA
HG08	857715.0080	1337280.9040	347.3440	347.3870	0.0430	VVA
HG09	862817.6710	1338052.4130	260.1950	260.2350	0.0400	VVA
HG10	872913.9100	1337512.9200	194.0820	194.0760	-0.0060	VVA
HG11	822378.3920	1335979.8890	190.3890	190.4730	0.0840	VVA
HG12	827161.8770	1324825.6000	174.0990	174.1140	0.0150	VVA
HG13	837777.6270	1328221.5290	186.8170	186.8340	0.0170	VVA
HG14	853064.3160	1331056.5970	173.0610	173.0540	-0.0070	VVA
HG15	855650.2870	1332238.3130	187.3420	187.3440	0.0020	VVA
HG16	863550.3450	1332483.9140	185.9970	186.1110	0.1140	VVA
HG17	834277.5030	1353140.1110	246.6520	246.6800	0.0280	VVA
HG18	841037.7010	1346505.8130	242.0580	242.1240	0.0660	VVA
HG19	826988.8450	1328087.7070	181.1720	181.2090	0.0370	VVA
HG20	869303.0720	1352527.0890	212.1950	212.1990	0.0040	VVA
HG21	875471.2020	1322586.4140	183.7370	183.7280	-0.0090	VVA
OT01	857253.7090	1349514.8740	227.6220	227.6320	0.0100	NVA
OT02	867189.7480	1343112.1410	193.7580	193.7090	-0.0490	NVA
OT03	826991.0960	1328078.2040	180.5800	180.6520	0.0720	NVA
OT04	833965.9620	1330363.2780	186.7760	186.8240	0.0480	NVA
OT05	841551.4370	1334555.7570	209.5030	209.5190	0.0160	NVA
OT06	850058.8520	1336507.3590	203.3720	203.4220	0.0500	NVA
OT07	857124.5710	1334384.1970	198.4060	198.4300	0.0240	NVA
OT08	868690.9350	1336712.1990	184.8250	184.8220	-0.0030	NVA
OT09	875052.0340	1337841.9240	193.7220	193.6940	-0.0280	NVA
OT10	833342.3710	1322600.8210	176.7980	176.8300	0.0320	NVA
OT11	842503.8830	1328637.1810	175.1320	175.1470	0.0150	NVA

PointID	Easting	Northing	KnownZ	LaserZ	DeltaZ	Description
OT12	855501.7480	1332244.6260	186.2630	186.2860	0.0230	NVA
OT13	859657.3860	1329821.3430	195.3670	195.3830	0.0160	NVA
OT14	867410.6010	1330849.6770	182.1130	182.1220	0.0090	NVA
OT15	875871.0550	1332731.1450	464.4340	464.4730	0.0390	NVA
OT16	832061.7040	1318517.0090	176.5130	176.5070	-0.0060	NVA
OT17	840034.5970	1321550.3520	182.9170	182.9320	0.0150	NVA
OT18	855676.8770	1323974.8730	173.7210	173.7300	0.0090	NVA
OT19	855248.9990	1326654.1070	174.0580	174.1030	0.0450	NVA
OT20	855637.3330	1332255.9900	186.7410	186.7590	0.0180	NVA
OT21	841956.6360	1321219.7420	193.3900	193.4000	0.0100	NVA
OT22	856388.6280	1324206.1880	178.5090	178.4890	-0.0200	NVA
OT23	847670.1850	1348746.5270	240.4800	240.4590	-0.0210	NVA
OT24	872423.0930	1350559.6800	220.4800	220.4200	-0.0600	NVA
TR01	872748.7070	1331650.7820	212.9200	212.8360	-0.0840	VVA
TR02	878175.2850	1329735.2460	188.2140	188.1150	-0.0990	VVA
TR03	834329.6060	1320549.7510	177.8830	177.9050	0.0220	VVA
TR04	841915.0910	1321242.5700	192.3180	192.3800	0.0620	VVA
TR05	856407.0100	1324200.6730	178.1700	178.1610	-0.0090	VVA
TR06	857966.3570	1324173.7250	184.7100	184.6960	-0.0140	VVA
TR07	868689.5350	1326482.6760	192.4590	192.4110	-0.0480	VVA
TR08	880980.6880	1322792.4540	181.4960	181.5610	0.0650	VVA
TR09	861238.7000	1321123.8190	180.7450	180.8050	0.0600	VVA
TR10	866885.6600	1319389.3110	183.2390	183.1820	-0.0570	VVA
TR11	876893.2370	1318660.1260	177.2670	177.1920	-0.0750	VVA
TR13	874889.0520	1313484.4790	176.7620	176.6870	-0.0750	VVA
TR15	874695.7070	1308820.9120	192.6580	192.6780	0.0200	VVA
TR16	834285.1930	1353119.1680	247.1160	247.1200	0.0040	VVA
TR17	874271.9910	1307847.6210	183.2170	183.2210	0.0040	VVA
TR18	853953.2300	1333590.0020	188.4370	188.4310	-0.0060	VVA
TR20	855491.1520	1332218.4470	186.5120	186.5080	-0.0040	VVA
UR01	856067.9850	1319919.7940	184.8050	184.8030	-0.0020	NVA
UR02	861433.8860	1326235.0050	439.1930	439.1740	-0.0190	NVA
UR03	872185.7470	1326502.8040	190.4300	190.3930	-0.0370	NVA
UR04	879256.4450	1325193.3190	181.7280	181.6770	-0.0510	NVA
UR05	867161.8000	1322516.4610	177.2270	177.2080	-0.0190	NVA
UR06	875464.6870	1322566.7030	183.9750	183.9440	-0.0310	NVA

PointID	Easting	Northing	KnownZ	LaserZ	DeltaZ	Description
UR07	861151.4560	1317147.3660	191.0340	191.0500	0.0160	NVA
UR08	870419.7360	1319306.7700	179.6640	179.6450	-0.0190	NVA
UR09	880083.9670	1316655.4770	188.9090	188.8670	-0.0420	NVA
UR10	864492.7390	1313226.4750	175.9250	175.8890	-0.0360	NVA
UR11	874454.7020	1316394.6220	175.7730	175.7030	-0.0700	NVA
UR12	870599.1830	1311627.2070	337.1450	337.1300	-0.0150	NVA
UR13	876907.9730	1311353.2560	189.0430	188.9930	-0.0500	NVA
UR14	874304.1080	1307788.4920	181.5130	181.4860	-0.0270	NVA
UR15	880971.5410	1310736.1430	187.3140	187.3050	-0.0090	NVA
UR16	869320.8760	1352516.1750	213.2650	213.2910	0.0260	NVA
UR17	867588.9150	1360291.8660	238.4670	238.4260	-0.0410	NVA
UR18	856527.5830	1356810.3620	232.3640	232.3840	0.0200	NVA
UR19	831566.5620	1364605.4330	261.6420	261.6860	0.0440	NVA
UR20	853211.7220	1342603.2690	201.6250	201.5730	-0.0520	NVA
UR21	872335.4490	1319511.3530	182.2800	182.2820	0.0020	NVA
UR22	872057.5620	1317529.4610	177.9350	177.9060	-0.0290	NVA
UR23	874635.5750	1308861.0400	188.6100	188.5390	-0.0710	NVA

Table 165: Point Cloud Check Point Assessment

6.1.2 Digital Elevation Model (DEM) Check Point Assessment

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BE02	843774.3790	1360784.8850	258.8170	258.8005	0.0165	NVA
BE03	852625.2400	1362782.8530	238.3440	238.3438	0.0002	NVA
BE04	864366.4750	1364384.0530	248.3470	248.3852	-0.0382	NVA
BE05	870777.3220	1364306.0590	239.6600	239.6810	-0.0210	NVA
BE06	830258.0620	1351306.1140	247.0240	247.0227	0.0013	NVA
BE07	842472.0080	1354833.7160	249.7690	249.7748	-0.0058	NVA
BE08	850288.0770	1354349.3250	238.2400	238.2588	-0.0188	NVA
BE09	859958.3750	1355127.9350	231.5460	231.5124	0.0336	NVA
BE11	834070.8640	1343829.6910	222.5270	222.5598	-0.0328	NVA
BE12	841016.8460	1346508.3910	241.3740	241.3861	-0.0121	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BE13	852852.5220	1346298.4640	216.6820	216.6744	0.0076	NVA
BE14	863027.7230	1333286.4550	191.2700	191.2370	0.0330	NVA
BE15	874141.4190	1346106.4690	232.5770	232.5222	0.0548	NVA
BE16	824166.6340	1336106.4530	187.8290	187.8348	-0.0058	NVA
BE17	832796.3930	1336815.3830	192.8070	192.8003	0.0067	NVA
BE18	840388.1080	1340648.4390	232.7400	232.7572	-0.0172	NVA
BE19	848365.7230	1341859.0170	217.2980	217.2407	0.0573	NVA
BE20	833700.0170	1359259.6190	252.2200	252.2571	-0.0371	NVA
BE21	838958.9370	1336656.9530	232.1080	232.0961	0.0119	NVA
BE22	822862.2740	1335963.4040	193.8780	193.8498	0.0282	NVA
OT01	857253.7090	1349514.8740	227.6220	227.6246	-0.0026	NVA
OT02	867189.7480	1343112.1410	193.7580	193.7108	0.0472	NVA
OT03	826991.0960	1328078.2040	180.5800	180.6406	-0.0606	NVA
OT04	833965.9620	1330363.2780	186.7760	186.7967	-0.0207	NVA
OT05	841551.4370	1334555.7570	209.5030	209.5076	-0.0046	NVA
OT06	850058.8520	1336507.3590	203.3720	203.4263	-0.0543	NVA
OT07	857124.5710	1334384.1970	198.4060	198.4035	0.0025	NVA
OT08	868690.9350	1336712.1990	184.8250	184.8161	0.0089	NVA
OT09	875052.0340	1337841.9240	193.7220	193.6836	0.0384	NVA
OT10	833342.3710	1322600.8210	176.7980	176.8258	-0.0278	NVA
OT11	842503.8830	1328637.1810	175.1320	175.1323	-0.0003	NVA
OT12	855501.7480	1332244.6260	186.2630	186.2724	-0.0094	NVA
OT13	859657.3860	1329821.3430	195.3670	195.3494	0.0176	NVA
OT14	867410.6010	1330849.6770	182.1130	182.1086	0.0044	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
OT15	875871.0550	1332731.1450	464.4340	464.4640	-0.0300	NVA
OT16	832061.7040	1318517.0090	176.5130	176.4972	0.0158	NVA
OT17	840034.5970	1321550.3520	182.9170	182.9230	-0.0060	NVA
OT18	855676.8770	1323974.8730	173.7210	173.7113	0.0097	NVA
OT19	855248.9990	1326654.1070	174.0580	174.0905	-0.0325	NVA
OT20	855637.3330	1332255.9900	186.7410	186.7330	0.0080	NVA
OT21	841956.6360	1321219.7420	193.3900	193.3785	0.0115	NVA
OT22	856388.6280	1324206.1880	178.5090	178.4887	0.0203	NVA
OT23	847670.1850	1348746.5270	240.4800	240.4607	0.0193	NVA
OT24	872423.0930	1350559.6800	220.4800	220.4140	0.0660	NVA
UR01	856067.9850	1319919.7940	184.8050	184.7759	0.0291	NVA
UR02	861433.8860	1326235.0050	439.1930	439.1741	0.0189	NVA
UR03	872185.7470	1326502.8040	190.4300	190.3805	0.0495	NVA
UR04	879256.4450	1325193.3190	181.7280	181.6081	0.1199	NVA
UR05	867161.8000	1322516.4610	177.2270	177.1909	0.0361	NVA
UR06	875464.6870	1322566.7030	183.9750	183.9108	0.0642	NVA
UR07	861151.4560	1317147.3660	191.0340	191.0471	-0.0131	NVA
UR08	870419.7360	1319306.7700	179.6640	179.6189	0.0451	NVA
UR09	880083.9670	1316655.4770	188.9090	188.8571	0.0519	NVA
UR10	864492.7390	1313226.4750	175.9250	175.8708	0.0542	NVA
UR11	874454.7020	1316394.6220	175.7730	175.6764	0.0966	NVA
UR12	870599.1830	1311627.2070	337.1450	337.1094	0.0356	NVA
UR13	876907.9730	1311353.2560	189.0430	188.9967	0.0463	NVA
UR14	874304.1080	1307788.4920	181.5130	181.4673	0.0457	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
UR15	880971.5410	1310736.1430	187.3140	187.2594	0.0546	NVA
UR16	869320.8760	1352516.1750	213.2650	213.2506	0.0144	NVA
UR17	867588.9150	1360291.8660	238.4670	238.4362	0.0308	NVA
UR18	856527.5830	1356810.3620	232.3640	232.3777	-0.0137	NVA
UR19	831566.5620	1364605.4330	261.6420	261.6787	-0.0367	NVA
UR20	853211.7220	1342603.2690	201.6250	201.5746	0.0504	NVA
UR21	872335.4490	1319511.3530	182.2800	182.2491	0.0309	NVA
UR22	872057.5620	1317529.4610	177.9350	177.8877	0.0473	NVA
UR23	874635.5750	1308861.0400	188.6100	188.5078	0.1022	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BR02	841148.2890	1366154.5550	273.9310	273.9378	-0.0068	VVA
BR03	850650.6930	1364666.0780	241.3330	241.3434	-0.0104	VVA
BR04	860222.9100	1369813.8790	259.2880	259.1218	0.1662	VVA
BR05	872461.6230	1371017.1000	332.3090	332.3125	-0.0035	VVA
BR07	846117.4160	1355144.5080	246.3180	246.3174	0.0006	VVA
BR08	859210.8040	1360566.6150	216.1520	216.2068	-0.0548	VVA
BR10	870711.2710	1358697.5510	238.9110	238.7422	0.1688	VVA
BR11	847668.3660	1348737.2820	240.8160	240.8328	-0.0168	VVA
BR12	858630.1050	1352253.7690	208.6850	208.7161	-0.0311	VVA
BR13	872422.0550	1350570.3810	220.3640	220.2997	0.0643	VVA
BR15	845931.9280	1344663.6560	227.3580	227.3448	0.0132	VVA
BR16	853218.1040	1342613.9580	201.7240	201.6158	0.1082	VVA
BR17	843780.5390	1360785.6990	258.6200	258.6432	-0.0232	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BR18	857248.9810	1349486.0250	227.8240	227.8218	0.0022	VVA
HG01	864278.5870	1342841.0890	201.7430	201.7182	0.0248	VVA
HG02	871790.6440	1343007.7460	194.6380	194.6499	-0.0119	VVA
HG03	876937.5990	1342698.3120	204.6980	204.6601	0.0379	VVA
HG04	822880.9710	1335961.6350	194.0660	194.0866	-0.0206	VVA
HG05	830292.2530	1330059.3790	192.6930	192.6732	0.0198	VVA
HG06	838964.5160	1336667.0070	231.5190	231.6041	-0.0851	VVA
HG07	845733.4960	1334795.7250	198.0120	198.0042	0.0078	VVA
HG08	857715.0080	1337280.9040	347.3440	347.3604	-0.0164	VVA
HG09	862817.6710	1338052.4130	260.1950	260.2187	-0.0237	VVA
HG10	872913.9100	1337512.9200	194.0820	194.0643	0.0177	VVA
HG11	822378.3920	1335979.8890	190.3890	190.4564	-0.0674	VVA
HG12	827161.8770	1324825.6000	174.0990	174.1002	-0.0012	VVA
HG13	837777.6270	1328221.5290	186.8170	186.8150	0.0020	VVA
HG14	853064.3160	1331056.5970	173.0610	173.0408	0.0202	VVA
HG15	855650.2870	1332238.3130	187.3420	187.3453	-0.0033	VVA
HG16	863550.3450	1332483.9140	185.9970	186.1063	-0.1093	VVA
HG17	834277.5030	1353140.1110	246.6520	246.6725	-0.0205	VVA
HG18	841037.7010	1346505.8130	242.0580	242.1032	-0.0452	VVA
HG19	826988.8450	1328087.7070	181.1720	181.2045	-0.0325	VVA
HG20	869303.0720	1352527.0890	212.1950	212.0869	0.1081	VVA
HG21	875471.2020	1322586.4140	183.7370	183.7124	0.0246	VVA
TR01	872748.7070	1331650.7820	212.9200	212.8501	0.0699	VVA
TR02	878175.2850	1329735.2460	188.2140	188.1055	0.1085	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
TR03	834329.6060	1320549.7510	177.8830	177.8718	0.0112	VVA
TR04	841915.0910	1321242.5700	192.3180	192.2663	0.0517	VVA
TR05	856407.0100	1324200.6730	178.1700	178.1489	0.0211	VVA
TR06	857966.3570	1324173.7250	184.7100	184.7006	0.0094	VVA
TR07	868689.5350	1326482.6760	192.4590	192.3629	0.0961	VVA
TR08	880980.6880	1322792.4540	181.4960	181.5663	-0.0703	VVA
TR09	861238.7000	1321123.8190	180.7450	180.7751	-0.0301	VVA
TR10	866885.6600	1319389.3110	183.2390	183.1769	0.0621	VVA
TR11	876893.2370	1318660.1260	177.2670	177.1805	0.0865	VVA
TR13	874889.0520	1313484.4790	176.7620	176.6828	0.0792	VVA
TR15	874695.7070	1308820.9120	192.6580	192.5967	0.0613	VVA
TR16	834285.1930	1353119.1680	247.1160	247.0925	0.0235	VVA
TR17	874271.9910	1307847.6210	183.2170	183.2101	0.0069	VVA
TR18	853953.2300	1333590.0020	188.4370	188.4463	-0.0093	VVA
TR20	855491.1520	1332218.4470	186.5120	186.5089	0.0031	VVA

Table 17: DEM Check Point Assessment