



## **Project Report**

**TASK ORDER NAME: GA\_Central\_2019\_B19**

**TASK ORDER NUMBER: 140G0219F0277**

**CONTRACT NUMBER: G16PC00042**

**ATLANTIC PROJECT NUMBER: 19064**

**USGS WORK UNIT ID: ID183179\_GA\_Central\_3\_2018**

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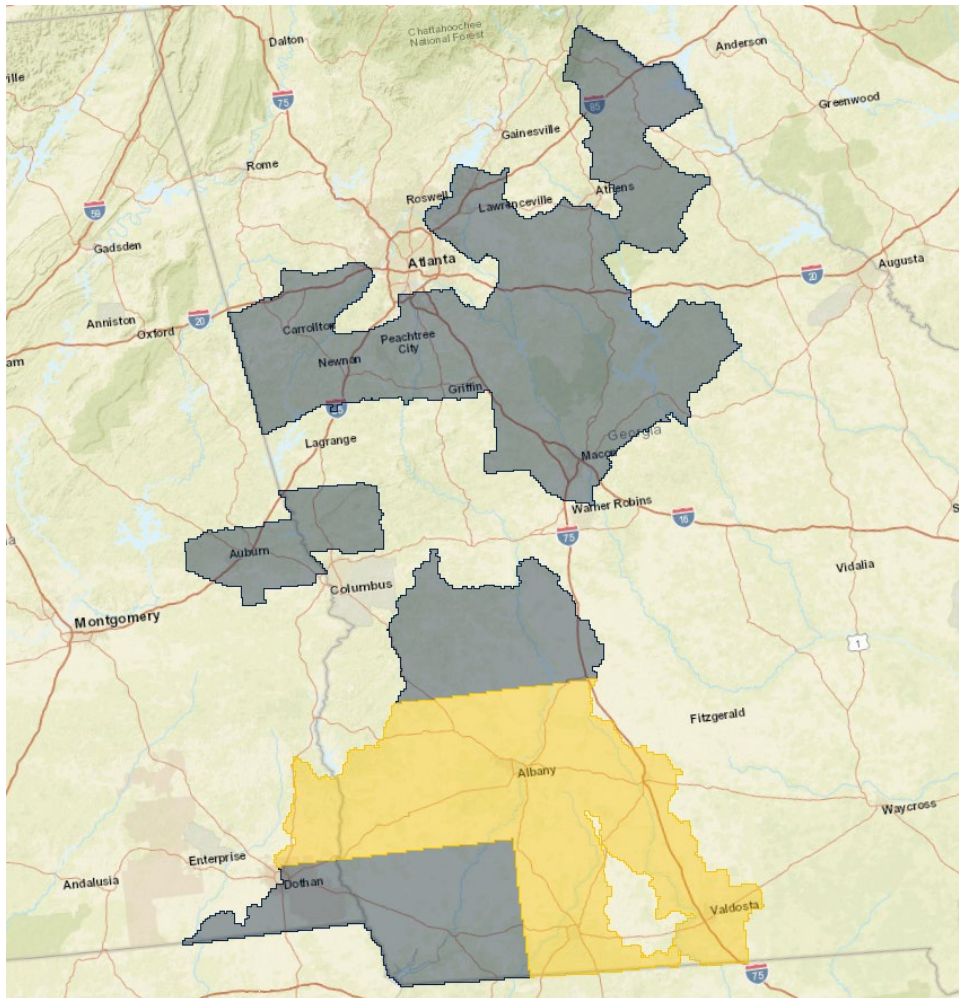
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## SECTION 1: PROJECT OVERVIEW AND PURPOSE

### 1.1 Aerial LiDAR Project

#### 1.1.1 Project Overview

USGS task order 140G0219F0277 required Winter 2019/Spring 2020 LiDAR surveys to be collected over 20,320 square miles covering part or all of 60 counties in Georgia and 6 counties in Alabama in support of the USGS 3DEP Program. Aerial LiDAR data for this task order was planned, acquired, processed, and produced at an aggregate nominal pulse spacing (ANPS) of  $\leq 0.71$  meters and in compliance with USGS National Geospatial Program LiDAR Base Specification version 1.3. The GA Central 3 2018 Work Unit encompasses approximately 6,360 square miles.



### 1.1.2 Project Purpose

Aerial lidar was collected to support the mapping efforts of individual counties in the State of Georgia and Alabama and the USGS 3DEP program.

### 1.1.3 Contract Deliverables

Item	Specification/Format
<b>Classified Point Cloud</b>	LAS v.14, tiled delivery
<b>Bare Earth Surface</b>	Raster DEM, 1m cell size, hydro flattened, GeoTIFF format
<b>Breaklines</b>	Hydro breaklines to BPA limit, .gdb format
<b>Intensity Imagery</b>	1m cell size, 8-bit, 256 gray scale, GeoTIFF format
<b>Delivery Diagram</b>	.gdb format
<b>Metadata</b>	Per product, FGDC compliant, .xml format
<b>Project Report</b>	Field work procedures, QC procedures and results, overall accuracy, .pdf format

*Table 1: Aerial LiDAR Contract Deliverables*

## SECTION 2: FIELD OPERATIONS

### 2.1 Aerial LiDAR Project – Aerial Acquisition

#### 2.1.1 Aircraft and Sensor Information

Atlantic operated a PACDV (N750DV) 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
<b>Model</b>	Galaxy Prime
<b>Manufacturer</b>	Optech
<b>Performance Envelope</b>	150 – 4700 m AGL, nominal
<b>Absolute Horizontal Accuracy</b>	1/10,000 x altitude
<b>Absolute Elevation Accuracy</b>	< 0.03 – 0.20 m RMSE from 150 – 4700 m AGL
<b>Topographic Laser</b>	1064-nm near-infrared
<b>Laser Classification</b>	Class IV
<b>Pulse Repetition Frequency (Effective)</b>	Programmable, 50 – 1000 kHz
<b>Beam Divergence</b>	0.25 mrad (1/e)
<b>Laser Range Precision</b>	< 0.008 m
<b>Minimum Target Separation Distance</b>	< 0.7 m (discrete)
<b>Range Capture</b>	Up to 8 range measurements, including last
<b>Intensity Capture</b>	Up to 8 intensity measurements, including last (12-bit)
<b>Scan Angle (Fov)</b>	10 – 60°
<b>Swath Width</b>	10 – 115% of altitude AGL
<b>Scan Frequency</b>	0 – 120 Hz advertised (0 – 240 scan lines/sec)
<b>Scan Product</b>	2000 maximum
<b>Roll Compensation</b>	±5° minimum
<b>Data Storage</b>	Internal solid-state drive (SSD)
<b>Power Requirements</b>	28 V; 300 W
<b>Dimensions and Weight</b>	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
<b>Operation Temperature</b>	0 to +35°C

Table 2: 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
<b>System</b>	Optech Galaxy Prime
<b>Nominal Pulse Spacing (m)</b>	.64
<b>Nominal Pulse Density (pls/m<sup>2</sup>)</b>	2.44
<b>Nominal Flight Height (AGL meters)</b>	2000
<b>Nominal Flight Speed (kts)</b>	150
<b>Pass Heading (°)</b>	Varied
<b>Sensor Scan Angle (°)</b>	45
<b>Scan Frequency (Hz)</b>	60
<b>Pulse Rate of Scanner (kHz)</b>	350
<b>Line Spacing (m)</b>	1325.48
<b>Pulse Width of Scanner (m)</b>	1664
<b>Central Wavelength of Sensor Laser (nm)</b>	1064
<b>Sensor Operated with Multiple Pulses</b>	6
<b>Beam Divergence (mrad)</b>	.25
<b>Nominal Swath Width (m)</b>	1657
<b>Nominal Swath Overlap (%)</b>	20
<b>Scan Pattern</b>	TRIANGLE

*Table 3: Aerial LiDAR Sensor Acquisition Parameters*

## 2.1.3 Flight Plan Execution

Atlantic acquired 311 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 44 flight missions conducted between February 2, 2020 and March 27, 2020. 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.

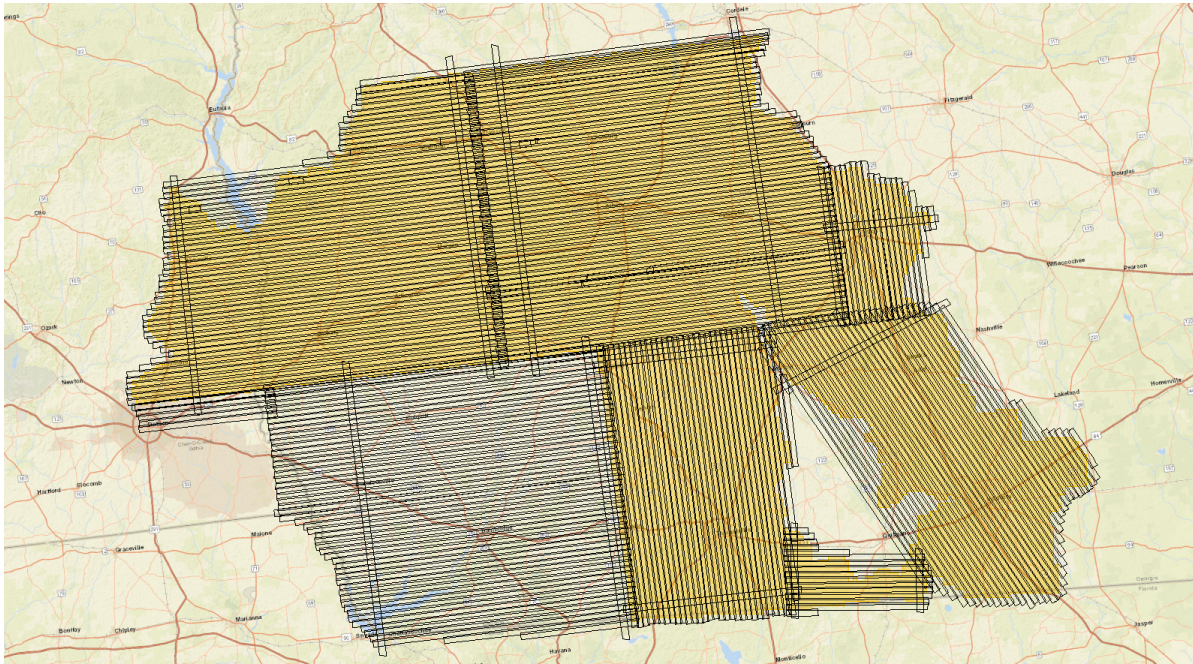


Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

## 2.1.4 GNSS Reference Stations

Forty-five (45) 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
AL60	CORS	AL60	N32°24'40.94501"	W86°16'13.97625"	44.676
AL62	CORS	AL62	N32°08'53.36427"	W85°41'12.37925"	140.811
AL76	CORS	AL76	N31°52'29.95916"	W85°13'32.48370"	100.108
ALA1	CORS	ALA1	N32°35'55.88602"	W85°30'14.13663"	184.083
ALAN	CORS	ALAN	N31°18'26.56972"	W86°29'02.25647"	85.248
ALDO	CORS	ALDO	N31°14'22.17261"	W85°26'24.71346"	79.679
ALHD	CORS	ALHD	N31°21'30.70339"	W85°15'43.45150"	71.838
ALLA	CORS	ALLA	N32°55'02.66210"	W85°24'01.80640"	237.158
ALLO	CORS	ALLO	N31°46'20.37200"	W85°30'06.79661"	117.211
ALNB	CORS	ALNB	N31°22'38.98303"	W85°54'57.77490"	106.888
ALRE	CORS	ALRE	N31°24'40.68451"	W87°14'03.29774"	85.24
ALSE	CORS	ALSE	N32°26'50.71020"	W87°00'42.40656"	29.745

Designation	Type	PID	Latitude (N)	Longitude (W)	Elevation
ALTU	CORS	ALTU	N31°48'00.73672"	W85°57'15.53867"	141.125
DUNN	CORS	DUNN	N29°03'43.76395"	W82°22'15.35407"	-7.86
FL75	CORS	FL75	N30°36'45.11268"	W83°08'48.07610"	23.15
FLCB	CORS	FLCB	N29°50'33.38184"	W84°41'42.55870"	-21.079
FLMN	CORS	FLMN	N30°27'48.94548"	W83°24'46.53918"	21.051
FLTE	CORS	FLTE	N30°25'31.35486"	W84°15'01.38582"	61.588
FRKN	CORS	FRKN	N35°11'30.71115"	W83°23'41.77455"	619.541
GAAE	CORS	GAAE	N33°25'38.07517"	W82°04'04.06813"	124.356
GAAY	CORS	GAAY	N31°39'40.91991"	W84°16'29.65338"	55.889
GABR	CORS	GABR	N31°20'26.96122"	W83°16'11.38598"	60.19
GABY	CORS	GABY	N31°22'39.31821"	W84°56'06.69097"	63.548
GACC	CORS	GACC	N33°32'44.73033"	W82°08'01.72591"	98.476
GACG	CORS	GACG	N30°39'23.51713"	W83°06'01.04606"	15.588
GACL	CORS	GACL	N30°52'20.86185"	W84°23'55.88567"	56.406
GACU	CORS	GACU	N32°27'51.70118"	W84°59'11.19604"	53.14
GACV	CORS	GACV	N33°33'14.67672"	W84°00'36.20356"	213.82
GADO	CORS	GADO	N31°18'57.63577"	W83°51'40.87879"	86.392
GAED	CORS	GAED	N31°36'01.14065"	W84°51'42.39845"	103.784
GAGR	CORS	GAGR	N33°34'35.76001"	W83°10'58.96946"	172.93
GALC	CORS	GALC	N31°14'37.74051"	W84°55'13.36666"	38.465
GAMO	CORS	GAMO	N31°08'37.61920"	W83°42'50.80405"	62.983
GAMV	CORS	GAMV	N33°05'56.63939"	W83°14'47.49447"	91.103
GARA	CORS	GARA	N32°12'58.40828"	W83°51'11.16996"	91.464
GASA	CORS	GASA	N31°42'35.50980"	W84°22'08.78398"	68.854
GAVA	CORS	GAVA	N30°50'35.11375"	W83°16'18.44500"	45.412
GAWD	CORS	GAWD	N31°02'51.98948"	W84°12'16.58539"	82.181
GAWE	CORS	GAWE	N32°00'31.56770"	W84°33'33.38027"	128.759
GNVL	CORS	GNVL	N29°41'11.57797"	W82°16'36.75907"	22.438
P805	CORS	P805	N32°57'47.65078"	W84°13'32.99336"	215.735
TALH	CORS	TALH	N30°23'47.50413"	W84°21'21.06142"	-7.292
XCTY	CORS	XCTY	N29°37'51.63332"	W83°06'29.36131"	-15.299
ZJX1	CORS	ZJX1	N30°41'55.89366"	W81°54'29.46878"	1.677
ZTL4	CORS	ZTL4	N33°22'46.87805"	W84°17'48.21671"	260.681

Table 4: GNSS Reference Stations



## 2.2 Aerial LiDAR Project – Ground Acquisition

### 2.2.1 Ground Control Survey

A total of 282 ground survey points were collected in support of this project, including 74 LiDAR Control Points (LCP), 121 Non-vegetated Vertical Accuracy (NVA) and 87 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:

Point ID	Easting	Northing	Elevation
LCP737	1097922.075	1049140.669	104.841
LCP738	1101751.102	1035802.685	90.729
LCP739	1086778.123	1019340.137	86.977
LCP740	1106534.962	1029627.575	76.357
LCP741	1109274.239	1050048.139	92.811
LCP742	1112751.263	1045394.418	87.435
LCP743	1121668.648	1050858.573	84.720
LCP744	1136422.002	1051558.118	84.250
LCP745	1148357.453	1050100.917	99.094
LCP746	1117187.692	1036428.083	78.654
LCP747	1090071.159	1002523.155	65.363
LCP748	1104899.009	993640.523	56.507
LCP749	1107273.462	981612.696	51.262
LCP750	1120843.138	1006054.983	56.632
LCP751	1124875.777	1030792.936	78.904
LCP752	1153325.073	1030320.369	122.907

Point ID	Easting	Northing	Elevation
LCP753	1158970.999	1029514.251	115.322
LCP754	1176836.029	1016948.892	117.041
LCP755	1188956.862	1011154.875	101.442
LCP756	1184111.860	1006405.834	93.922
LCP757	1172999.778	1009658.073	93.742
LCP758	1156416.586	1016744.411	109.517
LCP759	1132060.158	1023455.008	72.198
LCP760	1148522.899	1012819.825	122.028
LCP761	1164627.866	1005333.299	107.367
LCP762	1142486.711	1005787.227	126.256
LCP763	1134395.801	984482.022	109.445
LCP764	1201905.505	933779.733	66.974
LCP765	1197772.905	932468.048	59.235
LCP766	1200399.041	948899.234	47.469
LCP767	1187443.663	950098.341	63.415
LCP768	1184493.016	966637.912	74.444
LCP769	1174457.170	966586.487	71.701
LCP770	1162640.934	983915.659	104.507
LCP771	1176661.330	987335.932	87.999
LCP772	1183551.881	985226.612	74.771
LCP773	1192425.832	974950.259	68.633
LCP774	1202058.034	966170.558	71.704
LCP775	1211645.586	933351.426	59.193
LCP776	1218189.241	939131.400	52.006
LCP777	1221022.699	949477.020	62.295
LCP778	1148241.586	962529.910	79.688
LCP779	1123274.162	962032.842	97.653
LCP780	1135878.034	960731.364	84.096
LCP781	1128347.922	951045.605	84.200
LCP782	1140278.308	944899.126	51.402
LCP783	1185453.879	923452.636	42.490
LCP784	1169257.043	925034.499	61.504
LCP785	1134656.716	925465.357	85.712
LCP786	1128143.316	927251.990	41.990
LCP787	1155155.228	929939.907	56.819
LCP788	1165713.653	933260.459	64.170

Point ID	Easting	Northing	Elevation
LCP906	1075154.769	977676.785	60.735
LCP907	1048325.588	974943.331	72.209
LCP908	1074953.367	1022822.434	107.240
LCP909	1061172.713	1022468.373	123.116
LCP910	1056624.773	1028604.337	135.982
LCP911	1063635.234	1034772.197	138.758
LCP912	1080775.169	1031566.656	104.158
LCP913	1058887.570	1000120.130	88.730
LCP914	1038252.434	1005342.159	113.203
LCP915	1069225.650	1014290.381	95.065
LCP916	1031631.518	995987.941	65.937
LCP917	1015895.221	1010175.638	100.866
LCP918	1040174.948	977226.569	70.133
LCP919	1029666.473	972179.257	40.213
LCP920	1008459.837	969154.385	93.181
LCP921	1015959.292	979795.083	98.696
LCP922	1012079.844	986686.825	107.115
LCP923	1049084.307	983044.329	62.706
LCP924	1061930.793	1034600.390	141.143
LCP925	1038137.421	1003947.000	112.327
LCP926	1030715.372	972168.397	64.226
LCP927	1009193.571	974369.090	101.660

Table 5: LiDAR Control Point Coordinates

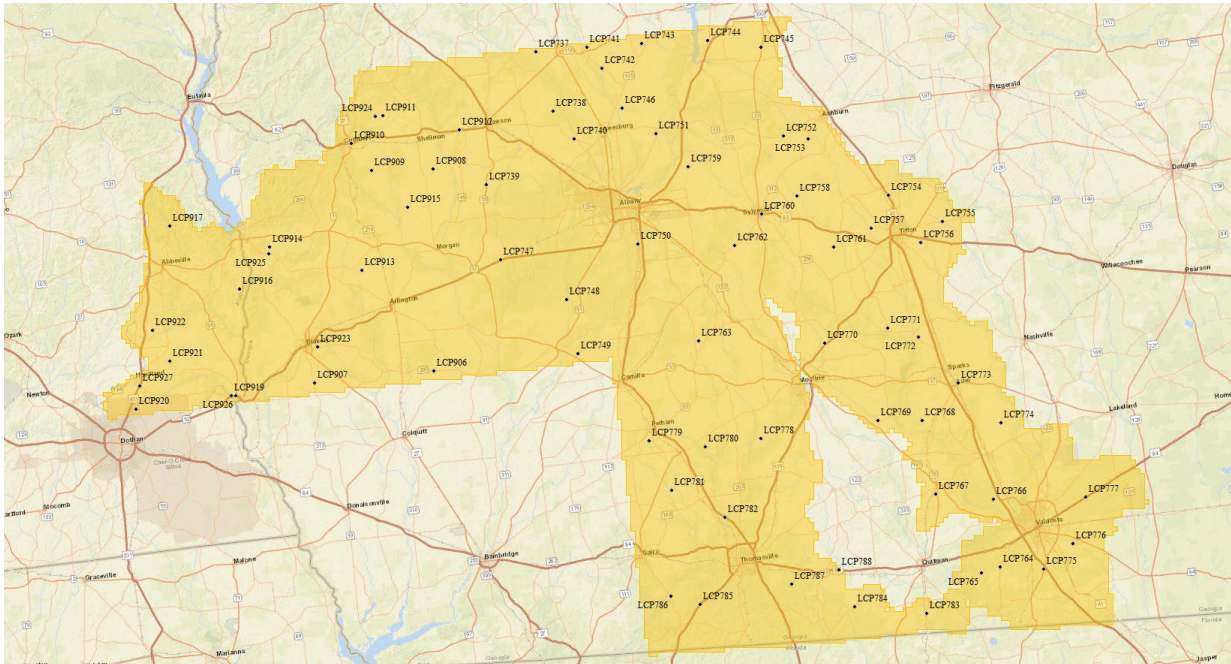


Figure 3: LiDAR Control Point Distribution

Point ID	Easting	Northing	Elevation
BE100	1123270.694	962032.986	97.666
BE112	1140290.326	944908.141	51.283
BE115	1128141.425	927248.576	41.910
BE116	1155152.800	929936.095	56.961
BE117	1185449.772	923452.514	42.481
BE118	1187442.936	950094.443	63.382
BE119	1221024.656	949473.828	62.272
BE120	1211641.847	933351.666	59.170
BE66	1142487.460	1005790.868	126.301
BE703	1087239.331	1026082.120	89.961
BE704	1140465.358	1041759.434	86.159
BE705	1148904.244	1032683.555	110.479
BE706	1172738.718	992068.036	84.251
BE72	1109271.165	1050052.590	92.800
BE73	1136418.098	1051559.670	84.208
BE74	1148361.452	1050100.919	99.088
BE75	1056556.701	1028658.685	134.087
BE76	1080246.057	1030536.116	101.944

Point ID	Easting	Northing	Elevation
BE77	1106535.629	1029630.552	76.349
BE78	1124871.941	1030791.802	78.847
BE79	1153325.309	1030324.111	122.842
BE80	1015866.753	1012144.812	114.507
BE81	1012159.734	986681.696	107.630
BE82	1031641.492	995992.260	66.061
BE83	1058893.430	1000107.199	88.151
BE84	1090067.876	1002526.948	65.241
BE85	1120842.905	1006059.274	56.615
BE87	1172994.046	1009657.368	93.756
BE88	1188957.724	1011150.459	101.458
BE89	1029308.205	972432.219	37.654
BE91	1048332.628	974943.237	72.231
BE92	1075147.272	977650.098	60.092
BE93	1107277.521	981611.815	51.298
BE94	1134393.664	984478.975	109.393
BE95	1162638.136	983919.998	104.524
BE96	1183548.637	985226.604	74.759
BE97	1202062.903	966170.973	71.630
BE98	1174460.537	966588.532	71.696
BE99	1148245.613	962528.128	79.752
OT100	1146032.972	931261.404	80.370
OT104	1090295.042	984277.940	51.584
OT105	1075881.263	1003703.543	69.893
OT106	1122866.177	988190.143	67.150
OT107	1142360.996	1017675.636	111.404
OT108	1108465.015	1019218.524	75.815
OT109	1082796.865	1043850.649	131.697
OT111	1164508.804	1013711.395	112.139
OT112	1172732.806	992065.277	84.428
OT113	1192424.079	974957.250	68.656
OT114	1195762.959	953107.189	71.680
OT115	1221708.191	927851.463	48.523
OT116	1058020.721	1011084.345	113.152
OT67	1069516.604	1038670.837	139.512
OT68	1092262.826	1042088.946	113.544

Point ID	Easting	Northing	Elevation
OT69	1121141.871	1042421.443	93.993
OT70	1140461.736	1041765.996	86.211
OT702	1097672.811	999878.004	55.775
OT703	1130128.142	920766.923	83.648
OT71	1016656.659	1002582.537	129.627
OT72	1043875.576	1010794.735	118.953
OT73	1068162.280	1015663.778	105.122
OT74	1093879.652	1015890.473	73.108
OT75	1125731.544	1017908.163	66.376
OT76	1151736.317	1020131.233	131.238
OT77	1024203.003	984427.146	92.087
OT78	1045143.245	988563.399	91.192
OT79	1073946.545	990912.852	71.563
OT80	1104898.222	993643.626	56.537
OT81	1130251.049	995309.994	90.135
OT82	1158964.539	1002629.354	103.423
OT83	1179933.299	1000532.180	94.405
OT88	1121378.553	971987.809	64.403
OT89	1148954.137	973916.853	100.160
OT90	1172626.362	976420.568	77.605
OT901	1012256.393	986463.374	105.902
OT902	1060517.597	980350.544	60.823
OT91	1190459.227	966324.615	74.101
OT92	1209233.420	952932.041	52.779
OT94	1153441.747	952871.085	70.568
OT99	1124779.156	935709.999	82.550
UR100	1037923.052	984579.178	99.086
UR105	1017520.752	972614.001	85.459
UR106	1022561.159	992394.122	79.563
UR107	1008468.126	969155.793	92.916
UR109	1131887.789	1008480.789	79.198
UR110	1116563.517	1025554.268	73.621
UR111	1094545.172	1025531.512	92.026
UR112	1053303.140	983561.626	68.961
UR113	1135715.933	971754.972	92.416
UR114	1095421.069	990744.185	55.350

Point ID	Easting	Northing	Elevation
UR115	1047954.123	1018106.098	130.873
UR116	1077760.885	1013916.036	73.266
UR120	1151256.285	939838.301	77.303
UR69	1106854.871	1042796.282	89.700
UR70	1091791.755	1032877.846	107.946
UR701	1195753.277	953106.505	71.862
UR702	1140814.100	976983.226	102.120
UR71	1086774.084	1019340.268	86.870
UR72	1067884.665	1028792.898	128.155
UR73	1131032.749	1036739.361	69.281
UR74	1141480.589	1028852.231	88.955
UR75	1163225.430	1023699.331	114.215
UR76	1176831.155	1016947.816	117.232
UR77	1156873.455	1007851.970	120.482
UR78	1169086.334	998891.749	91.757
UR79	1166633.866	976291.242	79.376
UR80	1181432.856	974537.912	75.857
UR81	1191062.177	982798.837	75.264
UR82	1201015.519	955711.629	71.873
UR83	1210442.597	943127.757	68.695
UR84	1208933.904	924279.222	42.767
UR85	1169259.208	925031.498	61.516
UR86	1144909.587	919911.503	52.447
UR904	1032679.961	1007153.870	75.699
UR905	1014326.765	1001480.611	137.523
UR93	1121119.416	947206.109	96.738
UR95	1135879.494	960727.762	84.057
UR96	1141456.504	994528.708	116.805
UR97	1108357.421	1005113.154	57.226
UR98	1064230.262	988245.986	64.787
UR99	1047593.205	1000571.709	91.121

*Table 6: Non-Vegetated Vertical Accuracy (NVA) Point Coordinates*

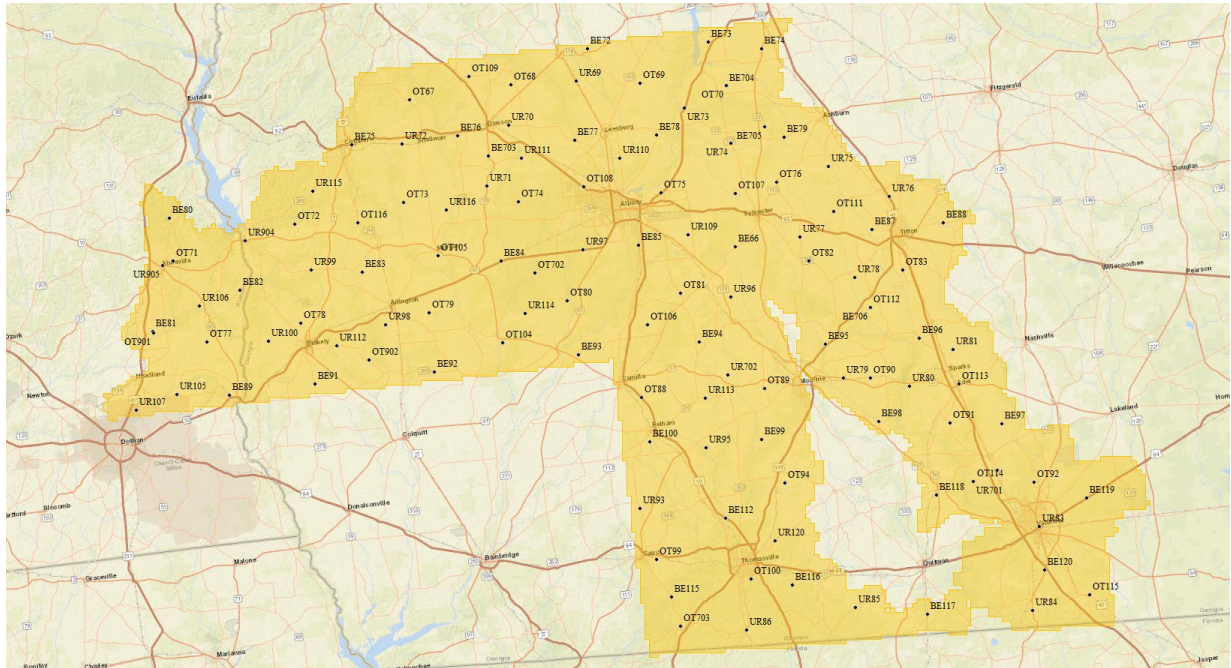


Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

Point ID	Easting	Northing	Elevation
BR45	1076235.603	1037037.834	122.848
BR46	1062731.119	1045154.559	163.335
BR48	1133403.536	1044112.939	83.611
BR49	1148896.298	1032687.229	110.807
BR50	1148507.499	1012819.734	121.651
BR51	1152486.155	1000138.536	100.382
BR52	1134613.557	1002021.400	96.340
BR53	1109085.175	998362.689	55.053
BR55	1084368.565	990944.358	55.583
BR56	1040958.161	995293.217	83.859
BR57	1024500.491	1004026.995	130.962
BR58	1014166.272	994014.511	125.530
BR59	1034827.985	981503.985	80.149
BR60	1055488.148	993239.244	77.597
BR61	1079868.408	984355.263	62.979
BR62	1100854.103	982807.989	51.881
BR63	1115643.484	980639.320	53.101
BR64	1147136.693	981904.575	100.637



Point ID	Easting	Northing	Elevation
BR65	1142619.832	966463.883	90.962
BR66	1130861.406	938805.298	75.490
BR702	1106858.852	1042785.075	89.206
BR73	1130117.397	920781.111	83.798
BR74	1140832.231	933985.718	78.822
BR75	1220090.454	944331.572	56.008
BR76	1212291.110	959202.134	67.212
BR82	1059929.262	980018.875	58.610
BR83	1097223.028	1007975.807	59.304
BR901	1023014.440	1006774.611	143.942
BR902	1013143.054	987592.380	110.119
BR955	1067799.725	1000097.813	76.082
HG46	1071144.039	1044582.221	145.402
HG47	1112745.595	1045399.979	87.862
HG49	1138001.381	1048924.672	85.110
HG50	1139077.614	1033671.566	84.607
HG51	1125104.361	1036612.696	81.723
HG52	1107731.503	1026083.991	76.957
HG53	1102610.512	1008962.530	59.112
HG54	1134837.886	1013948.677	83.673
HG55	1127292.757	1002038.470	77.349
HG56	1138599.036	987453.716	114.877
HG57	1125691.558	979273.881	75.721
HG64	1136396.394	954979.389	73.419
HG65	1140824.009	976989.420	101.961
HG66	1162859.383	992706.305	85.339
HG67	1187781.536	957328.711	58.558
HG68	1199815.446	979145.737	73.797
HG69	1181863.788	1016000.031	93.893
HG701	1092272.546	1042076.258	113.570
HG702	1096690.387	996950.615	53.370
HG703	1164500.367	1013699.621	112.393
HG704	1135724.256	971773.385	92.146
HG76	1163466.611	918380.695	31.961
HG77	1146333.490	949041.744	64.174
HG78	1064523.168	1007287.674	90.577

Point ID	Easting	Northing	Elevation
HG79	1116840.980	1013855.275	58.357
HG80	1086357.203	1008285.203	64.673
HG81	1228264.467	954211.444	57.946
HG82	1207946.871	941451.852	59.706
HG83	1087237.774	1026075.078	90.052
TR55	1121612.160	1050877.883	86.537
TR57	1097916.197	1049136.998	104.851
TR59	1063644.728	1034759.636	139.118
TR60	1061181.113	1022479.426	122.821
TR61	1074940.288	1022841.062	107.559
TR62	1101741.582	1035795.992	90.298
TR63	1117177.872	1036431.768	78.359
TR64	1132051.207	1023458.711	72.099
TR65	1158958.998	1029524.380	115.300
TR66	1156493.323	1016765.591	109.677
TR67	1164630.281	1005337.964	107.378
TR68	1184124.331	1006398.166	93.430
TR69	1176665.804	987336.289	88.195
TR70	1184503.011	966642.640	74.451
TR703	1181459.754	974536.109	74.984
TR704	1124781.719	935702.836	82.825
TR72	1201912.438	933779.180	67.321
TR73	1218185.171	939140.764	51.538
TR74	1165735.858	933251.468	65.217
TR75	1134671.234	925473.831	85.582
TR76	1128350.650	951026.253	83.981
TR79	1200386.370	948905.973	47.750
TR80	1040406.189	975652.088	75.660
TR81	1038230.891	1005340.410	112.801
TR82	1016748.364	979322.086	86.931
TR901	1085895.464	1032073.525	102.979
TR902	1046982.604	1007855.719	121.643
TR93	1197761.534	932466.521	59.070

Table 7: Vegetated Vertical Accuracy (VVA) Point Coordinates



## 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	Albers Equal Area
Coordinate System	NAD83 2011
Vertical Datum	NAVD88
Geoid Model	12B
EPSG Code	6350
Units of Reference	Meter

Table 8: Coordinate Reference System

#### 3.1.3 LiDAR Point Cloud Statistics

Category	Value
Total Points (Nominal)	59,871,650,676
Nominal Pulse Spacing (M)	0.5424
Nominal Pulse Density (PLS/M <sup>2</sup> )	3.3987
Total Points (Aggregate)	56,353,654,915
Aggregate Pulse Spacing (M)	0.5597
Aggregate Pulse Density (PLS/M <sup>2</sup> )	3.1917

Table 9: 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.

#### 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
3	Low Vegetation (0.5 – 5 feet)
4	Medium Vegetation (5 – 20 feet)
5	High Vegetation (>20 feet)
6	Buildings
7	Low Noise
9	Water
17	Bridge Decks
18	High Noise
20	Ignored Ground (breakline proximity)
21	Snow (where reliable identifiable)
22	Temporal Exclusion (typically non-favored data in intertidal zones)

*Table 10: 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 1.0-meter cell size. Intensity images were cut to match the tile index and its corresponding tile names and delivered in GeoTIFF format.

### 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. 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 GeoTIFF 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
X	333.3	653.3	980.0

*Table 1: 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	Points (#)	RMSEz	Confidence Level (95%)	Percentile (95th)
NVA (Point Cloud)	117	0.0715	0.1401	0.1414
NVA (DEM)	117	0.0707	0.1386	0.1086
VVA (Point Cloud)	87	0.1456	0.2854	0.2651
VVA (DEM)	87	0.1373	0.2692	0.0938

*Table 2: NVA/VVA Accuracies*

## SECTION 5: CERTIFICATION STATEMENTS

### 5.1 Aerial LiDAR Project

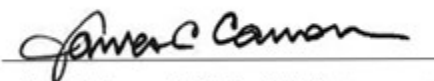
This accuracy assessment confirms that the data may be used for the intended applications stated in Section I of this document. This dataset may also be used as a topographic input for other applications, but the user should be aware that this LiDAR dataset was designed with a specific purpose and was 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.



James C. Cannon, ASPRS Certified Photogrammetrist #R1594CP





## SECTION 6: CONTROL POINT ASSESSMENTS

### 6.1 Aerial LiDAR Project

#### 6.1.1 Point Cloud Check Point Assessment

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
BE100	1123270.6940	962032.9860	97.6660	97.6320	-0.0340	NVA
BE112	1140290.3260	944908.1410	51.2830	51.1850	-0.0980	NVA
BE115	1128141.4250	927248.5760	41.9100	41.9790	0.0690	NVA
BE116	1155152.8000	929936.0950	56.9610	56.8950	-0.0660	NVA
BE117	1185449.7720	923452.5140	42.4810	42.5250	0.0440	NVA
BE118	1187442.9360	950094.4430	63.3820	63.4130	0.0310	NVA
BE119	1221024.6560	949473.8280	62.2720	62.2150	-0.0570	NVA
BE120	1211641.8470	933351.6660	59.1700	59.1870	0.0170	NVA
BE66	1142487.4600	1005790.8680	126.3010	126.2590	-0.0420	NVA
BE703	1087239.3310	1026082.1200	89.9610	90.0140	0.0530	NVA
BE704	1140465.3580	1041759.4340	86.1590	86.3210	0.1620	NVA
BE705	1148904.2440	1032683.5550	110.4790	110.5180	0.0390	NVA
BE706	1172738.7180	992068.0360	84.2510	84.2790	0.0280	NVA
BE72	1109271.1650	1050052.5900	92.8000	92.7580	-0.0420	NVA
BE73	1136418.0980	1051559.6700	84.2080	84.2670	0.0590	NVA
BE74	1148361.4520	1050100.9190	99.0880	99.1310	0.0430	NVA
BE75	1056556.7010	1028658.6850	134.0870	134.0530	-0.0340	NVA
BE76	1080246.0570	1030536.1160	101.9440	101.9620	0.0180	NVA
BE77	1106535.6290	1029630.5520	76.3490	76.2910	-0.0580	NVA
BE78	1124871.9410	1030791.8020	78.8470	78.9720	0.1250	NVA
BE79	1153325.3090	1030324.1110	122.8420	122.8590	0.0170	NVA
BE80	1015866.7530	1012144.8120	114.5070	114.5450	0.0380	NVA
BE81	1012159.7340	986681.6960	107.6300	107.6380	0.0080	NVA
BE82	1031641.4920	995992.2600	66.0610	66.0720	0.0110	NVA
BE83	1058893.4300	1000107.1990	88.1510	88.1410	-0.0100	NVA
BE85	1120842.9050	1006059.2740	56.6150	56.7410	0.1260	NVA
BE87	1172994.0460	1009657.3680	93.7560	93.9320	0.1760	NVA
BE88	1188957.7240	1011150.4590	101.4580	101.5380	0.0800	NVA
BE89	1029308.2050	972432.2190	37.6540	37.6450	-0.0090	NVA
BE91	1048332.6280	974943.2370	72.2310	72.2080	-0.0230	NVA
BE92	1075147.2720	977650.0980	60.0920	60.1230	0.0310	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
BE93	1107277.5210	981611.8150	51.2980	51.4050	0.1070	NVA
BE94	1134393.6640	984478.9750	109.3930	109.3910	-0.0020	NVA
BE95	1162638.1360	983919.9980	104.5240	104.5950	0.0710	NVA
BE96	1183548.6370	985226.6040	74.7590	74.8610	0.1020	NVA
BE97	1202062.9030	966170.9730	71.6300	71.6900	0.0600	NVA
BE98	1174460.5370	966588.5320	71.6960	71.7400	0.0440	NVA
BE99	1148245.6130	962528.1280	79.7520	79.6960	-0.0560	NVA
BR45	1076235.6030	1037037.8340	122.8480	122.8450	-0.0030	VVA
BR46	1062731.1190	1045154.5590	163.3350	163.4320	0.0970	VVA
BR48	1133403.5360	1044112.9390	83.6110	83.6990	0.0880	VVA
BR49	1148896.2980	1032687.2290	110.8070	110.9800	0.1730	VVA
BR50	1148507.4990	1012819.7340	121.6510	121.6630	0.0120	VVA
BR51	1152486.1550	1000138.5360	100.3820	100.5730	0.1910	VVA
BR52	1134613.5570	1002021.4000	96.3400	96.5720	0.2320	VVA
BR53	1109085.1750	998362.6890	55.0530	55.2950	0.2420	VVA
BR55	1084368.5650	990944.3580	55.5830	55.7210	0.1380	VVA
BR56	1040958.1610	995293.2170	83.8590	83.9010	0.0420	VVA
BR57	1024500.4910	1004026.9950	130.9620	131.0500	0.0880	VVA
BR58	1014166.2720	994014.5110	125.5300	125.5010	-0.0290	VVA
BR59	1034827.9850	981503.9850	80.1490	80.0960	-0.0530	VVA
BR60	1055488.1480	993239.2440	77.5970	77.9000	0.3030	VVA
BR61	1079868.4080	984355.2630	62.9790	63.2160	0.2370	VVA
BR62	1100854.1030	982807.9890	51.8810	52.2410	0.3600	VVA
BR63	1115643.4840	980639.3200	53.1010	53.2270	0.1260	VVA
BR64	1147136.6930	981904.5750	100.6370	100.6370	0.0000	VVA
BR65	1142619.8320	966463.8830	90.9620	91.0080	0.0460	VVA
BR66	1130861.4060	938805.2980	75.4900	75.6680	0.1780	VVA
BR702	1106858.8520	1042785.0750	89.2060	89.4220	0.2160	VVA
BR73	1130117.3970	920781.1110	83.7980	84.0410	0.2430	VVA
BR74	1140832.2310	933985.7180	78.8220	78.9240	0.1020	VVA
BR75	1220090.4540	944331.5720	56.0080	55.8240	-0.1840	VVA
BR76	1212291.1100	959202.1340	67.2120	67.2740	0.0620	VVA
BR82	1059929.2620	980018.8750	58.6100	58.6620	0.0520	VVA
BR83	1097223.0280	1007975.8070	59.3040	59.4670	0.1630	VVA
BR901	1023014.4400	1006774.6110	143.9420	143.9260	-0.0160	VVA
BR902	1013143.0540	987592.3800	110.1190	110.1510	0.0320	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
BR955	1067799.7250	1000097.8130	76.0820	76.1050	0.0230	VVA
HG46	1071144.0390	1044582.2210	145.4020	145.4880	0.0860	VVA
HG47	1112745.5950	1045399.9790	87.8620	88.0560	0.1940	VVA
HG49	1138001.3810	1048924.6720	85.1100	85.1730	0.0630	VVA
HG50	1139077.6140	1033671.5660	84.6070	84.7280	0.1210	VVA
HG51	1125104.3610	1036612.6960	81.7230	81.9430	0.2200	VVA
HG52	1107731.5030	1026083.9910	76.9570	77.1850	0.2280	VVA
HG53	1102610.5120	1008962.5300	59.1120	59.2260	0.1140	VVA
HG54	1134837.8860	1013948.6770	83.6730	83.8820	0.2090	VVA
HG55	1127292.7570	1002038.4700	77.3490	77.6180	0.2690	VVA
HG56	1138599.0360	987453.7160	114.8770	115.1400	0.2630	VVA
HG57	1125691.5580	979273.8810	75.7210	75.8080	0.0870	VVA
HG64	1136396.3940	954979.3890	73.4190	73.5380	0.1190	VVA
HG65	1140824.0090	976989.4200	101.9610	101.9580	-0.0030	VVA
HG66	1162859.3830	992706.3050	85.3390	85.3060	-0.0330	VVA
HG67	1187781.5360	957328.7110	58.5580	58.6440	0.0860	VVA
HG68	1199815.4460	979145.7370	73.7970	74.1230	0.3260	VVA
HG69	1181863.7880	1016000.0310	93.8930	94.0220	0.1290	VVA
HG701	1092272.5460	1042076.2580	113.5700	113.5520	-0.0180	VVA
HG702	1096690.3870	996950.6150	53.3700	53.6180	0.2480	VVA
HG703	1164500.3670	1013699.6210	112.3930	112.5890	0.1960	VVA
HG704	1135724.2560	971773.3850	92.1460	92.2560	0.1100	VVA
HG76	1163466.6110	918380.6950	31.9610	32.1020	0.1410	VVA
HG77	1146333.4900	949041.7440	64.1740	64.2570	0.0830	VVA
HG78	1064523.1680	1007287.6740	90.5770	90.5400	-0.0370	VVA
HG79	1116840.9800	1013855.2750	58.3570	58.6230	0.2660	VVA
HG80	1086357.2030	1008285.2030	64.6730	64.6720	-0.0010	VVA
HG81	1228264.4670	954211.4440	57.9460	57.9630	0.0170	VVA
HG82	1207946.8710	941451.8520	59.7060	59.7930	0.0870	VVA
HG83	1087237.7740	1026075.0780	90.0520	90.1760	0.1240	VVA
OT100	1146032.9720	931261.4040	80.3700	80.2540	-0.1160	NVA
OT105	1075881.2630	1003703.5430	69.8930	69.9940	0.1010	NVA
OT106	1122866.1770	988190.1430	67.1500	67.2050	0.0550	NVA
OT107	1142360.9960	1017675.6360	111.4040	111.3190	-0.0850	NVA
OT108	1108465.0150	1019218.5240	75.8150	75.9480	0.1330	NVA
OT109	1082796.8650	1043850.6490	131.6970	131.6970	0.0000	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
OT111	1164508.8040	1013711.3950	112.1390	112.1750	0.0360	NVA
OT112	1172732.8060	992065.2770	84.4280	84.4580	0.0300	NVA
OT113	1192424.0790	974957.2500	68.6560	68.7960	0.1400	NVA
OT114	1195762.9590	953107.1890	71.6800	71.7280	0.0480	NVA
OT115	1221708.1910	927851.4630	48.5230	48.6060	0.0830	NVA
OT116	1058020.7210	1011084.3450	113.1520	113.1790	0.0270	NVA
OT67	1069516.6040	1038670.8370	139.5120	139.5190	0.0070	NVA
OT68	1092262.8260	1042088.9460	113.5440	113.5200	-0.0240	NVA
OT69	1121141.8710	1042421.4430	93.9930	94.0060	0.0130	NVA
OT70	1140461.7360	1041765.9960	86.2110	86.3420	0.1310	NVA
OT702	1097672.8110	999878.0040	55.7750	55.8830	0.1080	NVA
OT703	1130128.1420	920766.9230	83.6480	83.7050	0.0570	NVA
OT71	1016656.6590	1002582.5370	129.6270	129.6440	0.0170	NVA
OT72	1043875.5760	1010794.7350	118.9530	118.9030	-0.0500	NVA
OT73	1068162.2800	1015663.7780	105.1220	105.0780	-0.0440	NVA
OT74	1093879.6520	1015890.4730	73.1080	73.2250	0.1170	NVA
OT75	1125731.5440	1017908.1630	66.3760	66.5040	0.1280	NVA
OT76	1151736.3170	1020131.2330	131.2380	131.2170	-0.0210	NVA
OT77	1024203.0030	984427.1460	92.0870	92.1130	0.0260	NVA
OT78	1045143.2450	988563.3990	91.1920	91.2240	0.0320	NVA
OT79	1073946.5450	990912.8520	71.5630	71.6890	0.1260	NVA
OT80	1104898.2220	993643.6260	56.5370	56.6910	0.1540	NVA
OT81	1130251.0490	995309.9940	90.1350	90.0870	-0.0480	NVA
OT82	1158964.5390	1002629.3540	103.4230	103.4030	-0.0200	NVA
OT83	1179933.2990	1000532.1800	94.4050	94.5950	0.1900	NVA
OT88	1121378.5530	971987.8090	64.4030	64.4110	0.0080	NVA
OT89	1148954.1370	973916.8530	100.1600	100.0950	-0.0650	NVA
OT90	1172626.3620	976420.5680	77.6050	77.6720	0.0670	NVA
OT901	1012256.3930	986463.3740	105.9020	105.9080	0.0060	NVA
OT902	1060517.5970	980350.5440	60.8230	60.9510	0.1280	NVA
OT91	1190459.2270	966324.6150	74.1010	74.1090	0.0080	NVA
OT92	1209233.4200	952932.0410	52.7790	52.7830	0.0040	NVA
OT94	1153441.7470	952871.0850	70.5680	70.6010	0.0330	NVA
OT99	1124779.1560	935709.9990	82.5500	82.5700	0.0200	NVA
TR55	1121612.1600	1050877.8830	86.5370	86.6830	0.1460	VVA
TR57	1097916.1970	1049136.9980	104.8510	104.9920	0.1410	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
TR59	1063644.7280	1034759.6360	139.1180	139.0080	-0.1100	VVA
TR60	1061181.1130	1022479.4260	122.8210	122.8010	-0.0200	VVA
TR61	1074940.2880	1022841.0620	107.5590	107.6320	0.0730	VVA
TR62	1101741.5820	1035795.9920	90.2980	90.3760	0.0780	VVA
TR63	1117177.8720	1036431.7680	78.3590	78.3060	-0.0530	VVA
TR64	1132051.2070	1023458.7110	72.0990	72.2920	0.1930	VVA
TR65	1158958.9980	1029524.3800	115.3000	115.3790	0.0790	VVA
TR66	1156493.3230	1016765.5910	109.6770	109.8200	0.1430	VVA
TR67	1164630.2810	1005337.9640	107.3780	107.4460	0.0680	VVA
TR68	1184124.3310	1006398.1660	93.4300	93.5720	0.1420	VVA
TR69	1176665.8040	987336.2890	88.1950	88.2410	0.0460	VVA
TR70	1184503.0110	966642.6400	74.4510	74.4810	0.0300	VVA
TR703	1181459.7540	974536.1090	74.9840	75.0700	0.0860	VVA
TR704	1124781.7190	935702.8360	82.8250	82.5750	-0.2500	VVA
TR72	1201912.4380	933779.1800	67.3210	67.3320	0.0110	VVA
TR73	1218185.1710	939140.7640	51.5380	51.5570	0.0190	VVA
TR74	1165735.8580	933251.4680	65.2170	64.9360	-0.2810	VVA
TR75	1134671.2340	925473.8310	85.5820	85.6180	0.0360	VVA
TR76	1128350.6500	951026.2530	83.9810	84.0120	0.0310	VVA
TR79	1200386.3700	948905.9730	47.7500	47.8700	0.1200	VVA
TR80	1040406.1890	975652.0880	75.6600	75.6600	0.0000	VVA
TR81	1038230.8910	1005340.4100	112.8010	112.7770	-0.0240	VVA
TR82	1016748.3640	979322.0860	86.9310	86.9440	0.0130	VVA
TR902	1046982.6040	1007855.7190	121.6430	121.6100	-0.0330	VVA
TR93	1197761.5340	932466.5210	59.0700	59.1810	0.1110	VVA
UR100	1037923.0520	984579.1780	99.0860	99.1080	0.0220	NVA
UR105	1017520.7520	972614.0010	85.4590	85.4380	-0.0210	NVA
UR106	1022561.1590	992394.1220	79.5630	79.5500	-0.0130	NVA
UR107	1008468.1260	969155.7930	92.9160	92.9870	0.0710	NVA
UR109	1131887.7890	1008480.7890	79.1980	79.3450	0.1470	NVA
UR110	1116563.5170	1025554.2680	73.6210	73.6830	0.0620	NVA
UR111	1094545.1720	1025531.5120	92.0260	92.1200	0.0940	NVA
UR112	1053303.1400	983561.6260	68.9610	68.9540	-0.0070	NVA
UR113	1135715.9330	971754.9720	92.4160	92.3330	-0.0830	NVA
UR114	1095421.0690	990744.1850	55.3500	55.3720	0.0220	NVA
UR115	1047954.1230	1018106.0980	130.8730	130.7940	-0.0790	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
UR120	1151256.2850	939838.3010	77.3030	77.2410	-0.0620	NVA
UR69	1106854.8710	1042796.2820	89.7000	89.7690	0.0690	NVA
UR70	1091791.7550	1032877.8460	107.9460	107.9090	-0.0370	NVA
UR701	1195753.2770	953106.5050	71.8620	71.9230	0.0610	NVA
UR702	1140814.1000	976983.2260	102.1200	102.0340	-0.0860	NVA
UR71	1086774.0840	1019340.2680	86.8700	86.8320	-0.0380	NVA
UR72	1067884.6650	1028792.8980	128.1550	128.1850	0.0300	NVA
UR73	1131032.7490	1036739.3610	69.2810	69.3940	0.1130	NVA
UR74	1141480.5890	1028852.2310	88.9550	89.0110	0.0560	NVA
UR75	1163225.4300	1023699.3310	114.2150	114.2360	0.0210	NVA
UR76	1176831.1550	1016947.8160	117.2320	117.2980	0.0660	NVA
UR77	1156873.4550	1007851.9700	120.4820	120.4030	-0.0790	NVA
UR78	1169086.3340	998891.7490	91.7570	91.8480	0.0910	NVA
UR79	1166633.8660	976291.2420	79.3760	79.4350	0.0590	NVA
UR80	1181432.8560	974537.9120	75.8570	75.9280	0.0710	NVA
UR81	1191062.1770	982798.8370	75.2640	75.3850	0.1210	VVA
UR82	1201015.5190	955711.6290	71.8730	71.8410	-0.0320	NVA
UR83	1210442.5970	943127.7570	68.6950	68.6990	0.0040	NVA
UR84	1208933.9040	924279.2220	42.7670	42.7880	0.0210	NVA
UR85	1169259.2080	925031.4980	61.5160	61.5400	0.0240	NVA
UR86	1144909.5870	919911.5030	52.4470	52.3830	-0.0640	NVA
UR904	1032679.9610	1007153.8700	75.6990	75.6820	-0.0170	NVA
UR905	1014326.7650	1001480.6110	137.5230	137.5260	0.0030	NVA
UR93	1121119.4160	947206.1090	96.7380	96.7980	0.0600	NVA
UR95	1135879.4940	960727.7620	84.0570	84.0310	-0.0260	NVA
UR96	1141456.5040	994528.7080	116.8050	116.8400	0.0350	NVA
UR97	1108357.4210	1005113.1540	57.2260	57.3780	0.1520	NVA
UR98	1064230.2620	988245.9860	64.7870	64.8110	0.0240	NVA
UR99	1047593.2050	1000571.7090	91.1210	91.0680	-0.0530	NVA

*Table 13: 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
BE100	1123270.6940	962032.9860	97.6660	97.6040	0.0620	NVA
BE112	1140290.3260	944908.1410	51.2830	51.1780	0.1050	NVA
BE115	1128141.4250	927248.5760	41.9100	41.9360	-0.0260	NVA
BE116	1155152.8000	929936.0950	56.9610	56.8240	0.1370	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BE117	1185449.7720	923452.5140	42.4810	42.4950	-0.0140	NVA
BE118	1187442.9360	950094.4430	63.3820	63.4180	-0.0360	NVA
BE119	1221024.6560	949473.8280	62.2720	62.1000	0.1720	NVA
BE120	1211641.8470	933351.6660	59.1700	59.1660	0.0040	NVA
BE66	1142487.4600	1005790.8680	126.3010	126.2710	0.0300	NVA
BE703	1087239.3310	1026082.1200	89.9610	90.0690	-0.1080	NVA
BE704	1140465.3580	1041759.4340	86.1590	86.3200	-0.1610	NVA
BE705	1148904.2440	1032683.5550	110.4790	110.4860	-0.0070	NVA
BE706	1172738.7180	992068.0360	84.2510	84.1570	0.0940	NVA
BE72	1109271.1650	1050052.5900	92.8000	92.7500	0.0500	NVA
BE73	1136418.0980	1051559.6700	84.2080	84.2700	-0.0620	NVA
BE74	1148361.4520	1050100.9190	99.0880	99.1290	-0.0410	NVA
BE75	1056556.7010	1028658.6850	134.0870	134.0590	0.0280	NVA
BE76	1080246.0570	1030536.1160	101.9440	101.9840	-0.0400	NVA
BE77	1106535.6290	1029630.5520	76.3490	76.3060	0.0430	NVA
BE78	1124871.9410	1030791.8020	78.8470	78.9530	-0.1060	NVA
BE79	1153325.3090	1030324.1110	122.8420	122.8410	0.0010	NVA
BE80	1015866.7530	1012144.8120	114.5070	114.5240	-0.0170	NVA
BE81	1012159.7340	986681.6960	107.6300	107.6190	0.0110	NVA
BE82	1031641.4920	995992.2600	66.0610	66.0580	0.0030	NVA
BE83	1058893.4300	1000107.1990	88.1510	88.1340	0.0170	NVA
BE85	1120842.9050	1006059.2740	56.6150	56.7310	-0.1160	NVA
BE87	1172994.0460	1009657.3680	93.7560	93.8620	-0.1060	NVA
BE88	1188957.7240	1011150.4590	101.4580	101.5300	-0.0720	NVA
BE89	1029308.2050	972432.2190	37.6540	37.6350	0.0190	NVA
BE91	1048332.6280	974943.2370	72.2310	72.1660	0.0650	NVA
BE92	1075147.2720	977650.0980	60.0920	60.1180	-0.0260	NVA
BE93	1107277.5210	981611.8150	51.2980	51.4030	-0.1050	NVA
BE94	1134393.6640	984478.9750	109.3930	109.3530	0.0400	NVA
BE95	1162638.1360	983919.9980	104.5240	104.5480	-0.0240	NVA
BE96	1183548.6370	985226.6040	74.7590	74.8550	-0.0960	NVA
BE97	1202062.9030	966170.9730	71.6300	71.6990	-0.0690	NVA
BE98	1174460.5370	966588.5320	71.6960	71.7230	-0.0270	NVA
BE99	1148245.6130	962528.1280	79.7520	79.6980	0.0540	NVA
OT100	1146032.9720	931261.4040	80.3700	80.2490	0.1210	NVA
OT105	1075881.2630	1003703.5430	69.8930	69.9880	-0.0950	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
OT106	1122866.1770	988190.1430	67.1500	67.2110	-0.0610	NVA
OT107	1142360.9960	1017675.6360	111.4040	111.3620	0.0420	NVA
OT108	1108465.0150	1019218.5240	75.8150	75.9590	-0.1440	NVA
OT109	1082796.8650	1043850.6490	131.6970	131.7050	-0.0080	NVA
OT111	1164508.8040	1013711.3950	112.1390	112.1480	-0.0090	NVA
OT112	1172732.8060	992065.2770	84.4280	84.3450	0.0830	NVA
OT113	1192424.0790	974957.2500	68.6560	68.7420	-0.0860	NVA
OT114	1195762.9590	953107.1890	71.6800	71.7020	-0.0220	NVA
OT115	1221708.1910	927851.4630	48.5230	48.6040	-0.0810	NVA
OT116	1058020.7210	1011084.3450	113.1520	113.1530	-0.0010	NVA
OT67	1069516.6040	1038670.8370	139.5120	139.5150	-0.0030	NVA
OT68	1092262.8260	1042088.9460	113.5440	113.5060	0.0380	NVA
OT69	1121141.8710	1042421.4430	93.9930	93.9870	0.0060	NVA
OT70	1140461.7360	1041765.9960	86.2110	86.3170	-0.1060	NVA
OT702	1097672.8110	999878.0040	55.7750	55.8370	-0.0620	NVA
OT703	1130128.1420	920766.9230	83.6480	83.6870	-0.0390	NVA
OT71	1016656.6590	1002582.5370	129.6270	129.6420	-0.0150	NVA
OT72	1043875.5760	1010794.7350	118.9530	118.8980	0.0550	NVA
OT73	1068162.2800	1015663.7780	105.1220	105.0290	0.0930	NVA
OT74	1093879.6520	1015890.4730	73.1080	73.1880	-0.0800	NVA
OT75	1125731.5440	1017908.1630	66.3760	66.4700	-0.0940	NVA
OT76	1151736.3170	1020131.2330	131.2380	131.1810	0.0570	NVA
OT77	1024203.0030	984427.1460	92.0870	91.9360	0.1510	NVA
OT78	1045143.2450	988563.3990	91.1920	91.1210	0.0710	NVA
OT79	1073946.5450	990912.8520	71.5630	71.6720	-0.1090	NVA
OT80	1104898.2220	993643.6260	56.5370	56.6250	-0.0880	NVA
OT81	1130251.0490	995309.9940	90.1350	90.0640	0.0710	NVA
OT82	1158964.5390	1002629.3540	103.4230	103.3660	0.0570	NVA
OT83	1179933.2990	1000532.1800	94.4050	94.5410	-0.1360	NVA
OT88	1121378.5530	971987.8090	64.4030	64.4200	-0.0170	NVA
OT89	1148954.1370	973916.8530	100.1600	100.1010	0.0590	NVA
OT90	1172626.3620	976420.5680	77.6050	77.6100	-0.0050	NVA
OT901	1012256.3930	986463.3740	105.9020	105.9090	-0.0070	NVA
OT902	1060517.5970	980350.5440	60.8230	60.9660	-0.1430	NVA
OT91	1190459.2270	966324.6150	74.1010	74.0790	0.0220	NVA
OT92	1209233.4200	952932.0410	52.7790	52.8080	-0.0290	NVA



Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
OT94	1153441.7470	952871.0850	70.5680	70.6290	-0.0610	NVA
OT99	1124779.1560	935709.9990	82.5500	82.5850	-0.0350	NVA
UR100	1037923.0520	984579.1780	99.0860	99.0980	-0.0120	NVA
UR105	1017520.7520	972614.0010	85.4590	85.4730	-0.0140	NVA
UR106	1022561.1590	992394.1220	79.5630	79.5270	0.0360	NVA
UR107	1008468.1260	969155.7930	92.9160	92.9810	-0.0650	NVA
UR109	1131887.7890	1008480.7890	79.1980	79.2940	-0.0960	NVA
UR110	1116563.5170	1025554.2680	73.6210	73.6660	-0.0450	NVA
UR111	1094545.1720	1025531.5120	92.0260	92.0680	-0.0420	NVA
UR112	1053303.1400	983561.6260	68.9610	68.9830	-0.0220	NVA
UR113	1135715.9330	971754.9720	92.4160	92.2840	0.1320	NVA
UR114	1095421.0690	990744.1850	55.3500	55.3080	0.0420	NVA
UR115	1047954.1230	1018106.0980	130.8730	130.8020	0.0710	NVA
UR120	1151256.2850	939838.3010	77.3030	77.2400	0.0630	NVA
UR69	1106854.8710	1042796.2820	89.7000	89.7270	-0.0270	NVA
UR70	1091791.7550	1032877.8460	107.9460	107.9210	0.0250	NVA
UR701	1195753.2770	953106.5050	71.8620	71.8800	-0.0180	NVA
UR702	1140814.1000	976983.2260	102.1200	102.0340	0.0860	NVA
UR71	1086774.0840	1019340.2680	86.8700	86.7510	0.1190	NVA
UR72	1067884.6650	1028792.8980	128.1550	128.1650	-0.0100	NVA
UR73	1131032.7490	1036739.3610	69.2810	69.3560	-0.0750	NVA
UR74	1141480.5890	1028852.2310	88.9550	88.9990	-0.0440	NVA
UR75	1163225.4300	1023699.3310	114.2150	114.1920	0.0230	NVA
UR76	1176831.1550	1016947.8160	117.2320	117.2530	-0.0210	NVA
UR77	1156873.4550	1007851.9700	120.4820	120.4020	0.0800	NVA
UR78	1169086.3340	998891.7490	91.7570	91.8040	-0.0470	NVA
UR79	1166633.8660	976291.2420	79.3760	79.4020	-0.0260	NVA
UR80	1181432.8560	974537.9120	75.8570	75.8770	-0.0200	NVA
UR82	1201015.5190	955711.6290	71.8730	71.7980	0.0750	NVA
UR83	1210442.5970	943127.7570	68.6950	68.7140	-0.0190	NVA
UR84	1208933.9040	924279.2220	42.7670	42.7560	0.0110	NVA
UR85	1169259.2080	925031.4980	61.5160	61.5320	-0.0160	NVA
UR86	1144909.5870	919911.5030	52.4470	52.3640	0.0830	NVA
UR904	1032679.9610	1007153.8700	75.6990	75.6580	0.0410	NVA
UR905	1014326.7650	1001480.6110	137.5230	137.5520	-0.0290	NVA
UR93	1121119.4160	947206.1090	96.7380	96.7990	-0.0610	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
UR95	1135879.4940	960727.7620	84.0570	84.0130	0.0440	NVA
UR96	1141456.5040	994528.7080	116.8050	116.8350	-0.0300	NVA
UR97	1108357.4210	1005113.1540	57.2260	57.4110	-0.1850	NVA
UR98	1064230.2620	988245.9860	64.7870	64.8100	-0.0230	NVA
UR99	1047593.2050	1000571.7090	91.1210	91.0150	0.1060	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BR45	1076235.6030	1037037.8340	122.8480	122.7500	0.0980	VVA
BR46	1062731.1190	1045154.5590	163.3350	163.4130	-0.0780	VVA
BR48	1133403.5360	1044112.9390	83.6110	83.6850	-0.0740	VVA
BR49	1148896.2980	1032687.2290	110.8070	110.7760	0.0310	VVA
BR50	1148507.4990	1012819.7340	121.6510	121.6730	-0.0220	VVA
BR51	1152486.1550	1000138.5360	100.3820	100.5530	-0.1710	VVA
BR52	1134613.5570	1002021.4000	96.3400	96.5040	-0.1640	VVA
BR53	1109085.1750	998362.6890	55.0530	55.3580	-0.3050	VVA
BR55	1084368.5650	990944.3580	55.5830	55.7710	-0.1880	VVA
BR56	1040958.1610	995293.2170	83.8590	83.8650	-0.0060	VVA
BR57	1024500.4910	1004026.9950	130.9620	131.0810	-0.1190	VVA
BR58	1014166.2720	994014.5110	125.5300	125.4990	0.0310	VVA
BR59	1034827.9850	981503.9850	80.1490	80.0020	0.1470	VVA
BR60	1055488.1480	993239.2440	77.5970	77.9150	-0.3180	VVA
BR61	1079868.4080	984355.2630	62.9790	63.3360	-0.3570	VVA
BR62	1100854.1030	982807.9890	51.8810	52.1600	-0.2790	VVA
BR63	1115643.4840	980639.3200	53.1010	53.2320	-0.1310	VVA
BR64	1147136.6930	981904.5750	100.6370	100.6800	-0.0430	VVA
BR65	1142619.8320	966463.8830	90.9620	90.9910	-0.0290	VVA
BR66	1130861.4060	938805.2980	75.4900	75.6860	-0.1960	VVA
BR702	1106858.8520	1042785.0750	89.2060	89.4740	-0.2680	VVA
BR73	1130117.3970	920781.1110	83.7980	84.0000	-0.2020	VVA
BR74	1140832.2310	933985.7180	78.8220	78.8930	-0.0710	VVA
BR75	1220090.4540	944331.5720	56.0080	56.1030	-0.0950	VVA
BR76	1212291.1100	959202.1340	67.2120	67.4020	-0.1900	VVA
BR82	1059929.2620	980018.8750	58.6100	58.6750	-0.0650	VVA
BR83	1097223.0280	1007975.8070	59.3040	59.3930	-0.0890	VVA
BR901	1023014.4400	1006774.6110	143.9420	143.9140	0.0280	VVA
BR902	1013143.0540	987592.3800	110.1190	110.1780	-0.0590	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BR955	1067799.7250	1000097.8130	76.0820	76.0740	0.0080	VVA
HG46	1071144.0390	1044582.2210	145.4020	145.4940	-0.0920	VVA
HG47	1112745.5950	1045399.9790	87.8620	88.0670	-0.2050	VVA
HG49	1138001.3810	1048924.6720	85.1100	85.1620	-0.0520	VVA
HG50	1139077.6140	1033671.5660	84.6070	84.6450	-0.0380	VVA
HG51	1125104.3610	1036612.6960	81.7230	81.8840	-0.1610	VVA
HG52	1107731.5030	1026083.9910	76.9570	77.1030	-0.1460	VVA
HG53	1102610.5120	1008962.5300	59.1120	59.2310	-0.1190	VVA
HG54	1134837.8860	1013948.6770	83.6730	83.7410	-0.0680	VVA
HG55	1127292.7570	1002038.4700	77.3490	77.5470	-0.1980	VVA
HG56	1138599.0360	987453.7160	114.8770	114.8940	-0.0170	VVA
HG57	1125691.5580	979273.8810	75.7210	75.8320	-0.1110	VVA
HG64	1136396.3940	954979.3890	73.4190	73.4410	-0.0220	VVA
HG65	1140824.0090	976989.4200	101.9610	101.8920	0.0690	VVA
HG66	1162859.3830	992706.3050	85.3390	85.2670	0.0720	VVA
HG67	1187781.5360	957328.7110	58.5580	58.7370	-0.1790	VVA
HG68	1199815.4460	979145.7370	73.7970	74.1410	-0.3440	VVA
HG69	1181863.7880	1016000.0310	93.8930	93.8790	0.0140	VVA
HG701	1092272.5460	1042076.2580	113.5700	113.5370	0.0330	VVA
HG702	1096690.3870	996950.6150	53.3700	53.5550	-0.1850	VVA
HG703	1164500.3670	1013699.6210	112.3930	112.4510	-0.0580	VVA
HG704	1135724.2560	971773.3850	92.1460	92.1900	-0.0440	VVA
HG76	1163466.6110	918380.6950	31.9610	32.0200	-0.0590	VVA
HG77	1146333.4900	949041.7440	64.1740	64.2500	-0.0760	VVA
HG78	1064523.1680	1007287.6740	90.5770	90.4930	0.0840	VVA
HG79	1116840.9800	1013855.2750	58.3570	58.5610	-0.2040	VVA
HG80	1086357.2030	1008285.2030	64.6730	64.6560	0.0170	VVA
HG81	1228264.4670	954211.4440	57.9460	57.8630	0.0830	VVA
HG82	1207946.8710	941451.8520	59.7060	59.7750	-0.0690	VVA
HG83	1087237.7740	1026075.0780	90.0520	90.1410	-0.0890	VVA
TR55	1121612.1600	1050877.8830	86.5370	86.6780	-0.1410	VVA
TR57	1097916.1970	1049136.9980	104.8510	105.0250	-0.1740	VVA
TR59	1063644.7280	1034759.6360	139.1180	139.0200	0.0980	VVA
TR60	1061181.1130	1022479.4260	122.8210	122.7900	0.0310	VVA
TR61	1074940.2880	1022841.0620	107.5590	107.6520	-0.0930	VVA
TR62	1101741.5820	1035795.9920	90.2980	90.3430	-0.0450	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
TR63	1117177.8720	1036431.7680	78.3590	78.2800	0.0790	VVA
TR64	1132051.2070	1023458.7110	72.0990	72.0570	0.0420	VVA
TR65	1158958.9980	1029524.3800	115.3000	115.3840	-0.0840	VVA
TR66	1156493.3230	1016765.5910	109.6770	109.8240	-0.1470	VVA
TR67	1164630.2810	1005337.9640	107.3780	107.4610	-0.0830	VVA
TR68	1184124.3310	1006398.1660	93.4300	93.4570	-0.0270	VVA
TR69	1176665.8040	987336.2890	88.1950	88.2220	-0.0270	VVA
TR70	1184503.0110	966642.6400	74.4510	74.4570	-0.0060	VVA
TR703	1181459.7540	974536.1090	74.9840	75.0170	-0.0330	VVA
TR704	1124781.7190	935702.8360	82.8250	82.4460	0.3790	VVA
TR72	1201912.4380	933779.1800	67.3210	67.2640	0.0570	VVA
TR73	1218185.1710	939140.7640	51.5380	51.5590	-0.0210	VVA
TR74	1165735.8580	933251.4680	65.2170	64.9550	0.2620	VVA
TR75	1134671.2340	925473.8310	85.5820	85.6030	-0.0210	VVA
TR76	1128350.6500	951026.2530	83.9810	84.0210	-0.0400	VVA
TR79	1200386.3700	948905.9730	47.7500	47.8430	-0.0930	VVA
TR80	1040406.1890	975652.0880	75.6600	75.5980	0.0620	VVA
TR81	1038230.8910	1005340.4100	112.8010	112.7770	0.0240	VVA
TR82	1016748.3640	979322.0860	86.9310	86.9290	0.0020	VVA
TR902	1046982.6040	1007855.7190	121.6430	121.6690	-0.0260	VVA
TR93	1197761.5340	932466.5210	59.0700	59.2910	-0.2210	VVA
UR81	1191062.1770	982798.8370	75.2640	75.3210	-0.0570	VVA

Table 14: DEM Check Point Assessment

## SECTION 7: ADDENDUM

### 7.1 Low Confidence Polygons

Low confidence polygons have been delivered with this dataset. These polygons represent areas where heavy vegetation or inundated areas greatly diminish penetration of the lidar pulse, resulting in a bare earth surface that is potentially less accurate due to the lack of lidar returns from the ground beneath the vegetation or surface water. Low confidence polygons delineate areas where conformance to VVA standards may not be met. The low confidence polygons created for this dataset were delineated according to the criteria and assumptions outlined in the ASPRS Positional Accuracy Standards for Digital Geospatial Data (2014). Low confidence areas are identified using a ground density raster. All areas with a Nominal Ground Point Density less than the threshold of 0.5 pts/m<sup>2</sup> are identified as low confidence cells in the ground density raster. The low confidence cells are exported to polygons and aggregated into larger shapes. Areas of expected low density in the ground, such as water or where buildings/structures have been removed, are deleted from the aggregated low confidence polygons. The size of all polygons is then calculated and polygons below the minimum size threshold of 5 acres are removed from the final low confidence polygon dataset.