Project Report

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SECTION 1: PROJECT OVERVIEW AND PURPOSE

1.1 Aerial LiDAR Project

1.1.1 Project Overview

USGS NGTOC task order G17PD00242 required Spring 2017 LiDAR surveys to be collected over 7,931 square miles covering part or all of 22 counties in SW Georgia. These counties are Baker, Bleckley, Crawford, Crisp, Decatur, Dodge, Dooly, Early, Houston, Macon, Meriwether, Miller, Muscogee, Peach, Pulaski, Seminole, Telfair, Terrell, Troup, Turner, Twiggs, and Wilcox. Aerial LiDAR data for this task order was planned, acquired, processed, and produced at an aggregate nominal pulse spacing (ANPS) of 0.7 meters. These data were produced using class 10 for points classified as ignored ground. This is in keeping with the USGS Lidar Base Specification 1.2. The remaining point cloud processing methods are consistent with Lidar Base Specification 2021 rev A. This report is for the GAW block which covers 3,497 square miles.

Isolated gaps in GPS data were identified in several missions covering this project. As both, the IMU data and pulse data, were present across these gaps, using the fixed positions of the GPS on either end, the aircraft velocity across the gaps, and the IMU data, LiDAR calibration staff were able to reach an effective solution to address the GPS voids. Because these gaps were not uniform in size or correction, this extended the iterative LiDAR calibration efforts on this project. Subsequent rigorous data checking confirmed adequate results to meet the required accuracy specs. The USGS QA Team reviewed affected data (blocks) for this project and found no QA/QC discrepancies to report regarding those gaps.

In three missions 123_20190317_1, 123_20190318_1, and 123_20190318_2 there were symptoms of skunk striping present in the collected data. These artifacts are manifested by low noise points at nadir and are believed to have been caused by exhaust from the aircraft during collection. Atlantic isolated the points affected by channel and by intensity and classed them out to noise and flagged them as withheld. We were able to maintain the integrity of the surface and still meet density requirements to meet spec.

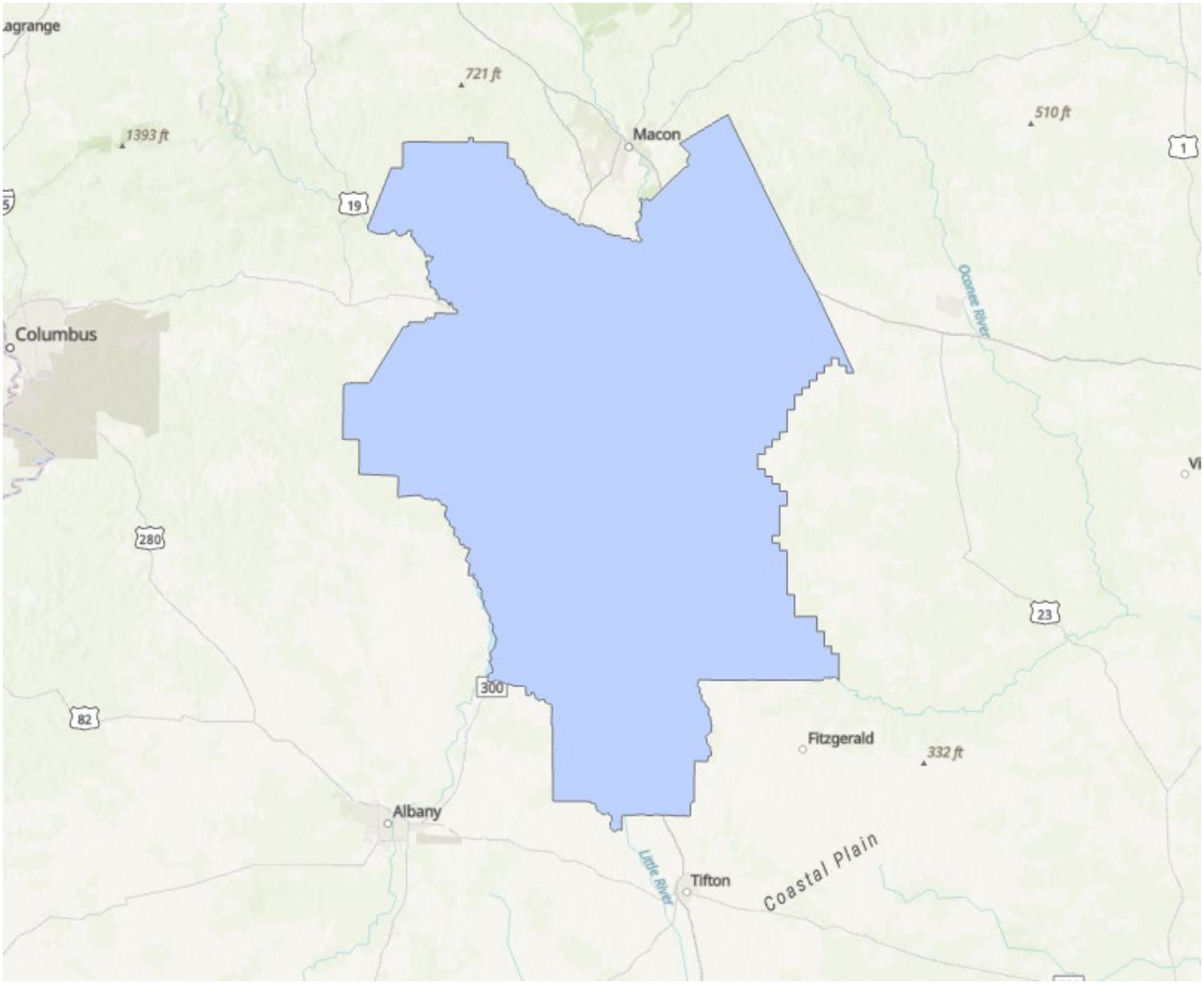

Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) and Associated Areas of Interest

1.1.2 Project Purpose

The produced classified point cloud data, DEMs, and other products derived from this classified point cloud data will aid in planning and management purposes of the participating counties and participants.

1.1.3 Contract Deliverables

Item	Specification/Format
Classified LAS Point Cloud Data	LAS, V1.4, PRF 6,7,8,9 or 10
Bare Earth Surface (Raster DEM)	GIS-compatible, 32-bit floating point raster format (GeoTIFF)
Breaklines	ESRI .gdb
Control	.shp file
Metadata	FGDC compliant, product level
Flight Index	.shp file
Project Report	pdf
Tile Index	.shp file
Intensity Image	8-bit, 256 color gray scale, GeoTIFF

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 Caravan (N167PM) outfitted with an Optech Galaxy T2000 LiDAR system during the collection of the project area. The specifications of this system are presented in the following table:

Parameter	Specification
Model	Galaxy T2000
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
Operation Temperature	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
System	Optech Galaxy T2000
Nominal Pulse Spacing (m)	0.597
Nominal Pulse Density (pls/m²)	2.8
Nominal Flight Height (AGL meters)	2200
Nominal Flight Speed (kts)	150
Pass Heading (°)	Varies
Sensor Scan Angle (°)	40
Scan Frequency (Hz)	64
Pulse Rate of Scanner (kHz)	400
Line Spacing (m)	1260
Central Wavelength of Sensor Laser (nm)	1064
Sensor Operated with Multiple Pulses	7
Beam Divergence (mrad)	0.25
Nominal Swath Width (m)	1588
Nominal Swath Overlap (%)	20
Scan Pattern	Triangle

Table 3: Aerial LiDAR Sensor Acquisition Parameters

2.1.3 Flight Plan Execution

Atlantic acquired 234 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 10 flight missions conducted between January 15, 2021 and January 30, 2021. 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.

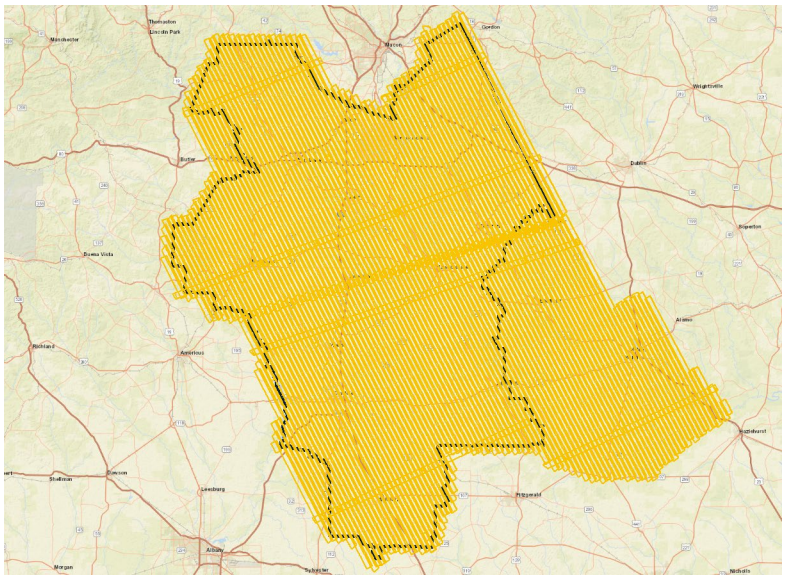

Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

2.1.4 GNSS Reference Stations

16 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.

PID	Latitude (N)	Longitude (W)	Elevation
AL76	N31°52'29.95914"	W85°13'32.48414"	100.108
ALA1	N32°35'55.88599"	W85°30'14.13709"	184.083
ALDO	N31°14'22.17259"	W85°26'24.71391"	79.679
ALLA	N32°55'02.66208"	W85°24'01.80686"	237.157
FL75	N30°36'45.11304"	W83°08'48.07712"	23.029
GAAE	N33°25'38.07520"	W82°04'04.06946"	124.363
GAAY	N31°39'40.91991"	W84°16'29.65382"	55.888
GABY	N31°22'39.31820"	W84°56'06.69141"	63.547
GACC	N33°32'44.73006"	W82°08'01.72612"	98.524
GAHA	N32°11'35.73988"	W83°28'54.37969"	66.192
GAIR	N31°34'51.00271"	W83°05'51.06280"	70.682
GALU	N31°33'48.73821"	W83°50'12.23502"	107.079
GASN	N32°58'54.70716"	W82°48'33.11709"	115.806
TALH	N30°23'47.50413"	W84°21'21.06182"	-7.293
ZJX1	N30°41'55.89383"	W81°54'29.46939"	1.724
ZTL4	N33°22'46.87805"	W84°17'48.21718"	260.680

Table 4: GNSS Reference Stations

2.2 Aerial LiDAR Project – Ground Acquisition

2.2.1 Ground Control Survey

A total of 199 ground survey points were collected in support of this project, including 49 LiDAR Control Points (LCP), 89 Non-vegetated Vertical Accuracy (NVA) and 61 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 [X]	Northing [Y]	Elevation [Z]	Point Type
CTRL01	2380666.982	931055.831	516.834	LCP
CTRL02	2423153.735	964884.137	501.676	LCP
CTRL03	2430264.740	892989.330	322.744	LCP
CTRL04	2469173.181	958922.648	304.383	LCP
CTRL05	2473475.234	942870.534	358.950	LCP
CTRL06	2435609.234	938230.167	451.866	LCP
CTRL07	2549553.191	871736.409	340.558	LCP
CTRL08	2546249.199	841448.343	258.908	LCP
CTRL13	2564310.734	852260.150	382.101	LCP
CTRL14	2512901.245	832182.527	240.200	LCP
CTRL15	2500432.024	773664.220	253.265	LCP
CTRL16	2553273.795	776999.004	217.720	LCP
CTRL21	2470775.233	714207.573	382.274	LCP
CTRL22	2561182.703	725300.510	219.928	LCP
CTRL23	2502040.908	768468.481	272.985	LCP
CTRL24	2525671.701	684660.771	394.759	LCP

Point ID	Easting [X]	Northing [Y]	Elevation [Z]	Point Type
CTRL34	2347529.073	989321.250	438.566	LCP
CTRL35	2417623.261	980232.935	419.505	LCP
CTRL36	2347676.091	926003.151	338.464	LCP
CTRL37	2541472.880	953595.944	479.868	LCP
CTRL38	2523559.117	1036743.917	422.010	LCP
CTRL39	2492075.533	990294.475	417.337	LCP
CTRL40	2499153.425	925289.544	261.127	LCP
CTRL41	2316305.650	886832.142	417.249	LCP
CTRL42	2343063.776	833562.063	335.862	LCP
CTRL43	2366385.635	893634.117	488.066	LCP
CTRL44	2290384.266	861936.713	484.126	LCP
CTRL45	2428644.166	818598.516	385.957	LCP
CTRL46	2408432.044	761416.930	318.085	LCP
CTRL47	2378264.351	800843.211	334.230	LCP
CTRL48	2461709.453	786109.837	341.783	LCP
CTRL49	2418095.720	721695.035	303.328	LCP
CTRL50	2429217.168	667357.352	444.946	LCP
CTRL51	2464426.355	712109.845	382.906	LCP
CTRL55	2507560.112	658230.436	353.364	LCP
CTRL56	2454602.223	618409.167	411.088	LCP
CTRL57	2457014.456	632016.514	412.203	LCP
LCP723	2378235.268	716485.661	249.839	LCP
LCP730	2357251.354	797967.715	329.094	LCP
LCP731	2380622.491	801174.477	307.182	LCP
LCP732	2417265.217	811392.400	378.317	LCP
LCP733	2391442.034	756223.751	327.021	LCP
LCP734	2369530.713	747154.825	295.335	LCP
LCP735	2442918.815	742232.576	365.030	LCP
LCP736	2408775.873	700388.847	288.714	LCP
LCP744	2379256.077	686157.532	276.410	LCP
LCP745	2417684.969	676579.813	325.111	LCP
LCP752	2425793.898	610454.467	403.237	LCP
LCP753	2443917.420	605540.644	378.352	LCP

Point ID	Easting [X]	Northing [Y]	Elevation [Z]	Point Type
BE01	2423777.833	965417.309	493.262	NVA

Point ID	Easting [X]	Northing [Y]	Elevation [Z]	Point Type
BE02	2460556.173	876908.784	279.410	NVA
BE03	2454462.437	911779.226	348.317	NVA
BE04	2435321.817	938755.709	457.837	NVA
BE05	2546648.854	841661.376	259.089	NVA
BE06	2582658.400	936318.436	420.771	NVA
BE10	2539160.565	817752.009	261.905	NVA
BE11	2481590.816	851132.845	373.543	NVA
BE15	2537106.479	760561.581	211.592	NVA
BE16	2525784.123	684288.175	400.192	NVA
BE24	2346694.343	926173.065	347.523	NVA
BE25	2298434.441	1001050.885	486.527	NVA
BE26	2498088.166	925138.234	245.558	NVA
BE27	2548781.797	978710.746	522.584	NVA
BE28	2561222.425	947019.556	469.891	NVA
BE29	2319368.553	813940.717	428.425	NVA
BE30	2373308.633	833517.165	379.175	NVA
BE31	2327894.129	842959.647	293.197	NVA
BE32	2461717.352	786345.142	340.748	NVA
BE33	2361917.652	754129.955	297.201	NVA
BE34	2416380.156	699824.616	309.798	NVA
BE35	2375364.654	675226.268	283.312	NVA
BE39	2456928.075	632252.266	410.604	NVA
BE40	2453849.108	595377.078	346.611	NVA
BE65	2417273.407	811385.218	378.219	NVA
BE69	2391443.717	756236.469	327.398	NVA
BE70	2442911.001	742245.474	364.787	NVA
BE702	2399035.686	783429.336	369.209	NVA
BE705	2412314.141	619914.470	362.463	NVA
BE73	2379243.945	686164.148	276.272	NVA
BE74	2417698.046	676578.191	325.091	NVA
BE79	2425796.208	610466.499	403.024	NVA
OT01	2404218.998	905168.613	435.956	NVA
OT02	2463618.575	848042.570	377.622	NVA
OT03	2468508.382	958889.240	309.363	NVA
OT04	2404082.332	863486.123	515.702	NVA
OT05	2601994.343	896781.605	322.129	NVA

Point ID	Easting [X]	Northing [Y]	Elevation [Z]	Point Type
OT06	2564813.319	851700.703	381.771	NVA
OT10	2553597.112	776514.732	227.233	NVA
OT14	2476206.551	687251.686	372.633	NVA
OT15	2591376.913	674464.075	198.995	NVA
OT16	2502137.360	768026.737	272.517	NVA
OT23	2312642.548	979841.215	359.488	NVA
OT24	2369716.035	1030698.773	490.282	NVA
OT25	2356447.231	957712.679	513.300	NVA
OT26	2541096.120	1018970.172	344.852	NVA
OT27	2520869.632	968969.292	380.962	NVA
OT28	2343482.297	833216.503	337.294	NVA
OT29	2347814.496	885094.801	476.248	NVA
OT30	2366465.069	857409.576	415.474	NVA
OT32	2452441.962	749155.659	428.157	NVA
OT33	2386139.540	780907.350	347.129	NVA
OT34	2375357.853	716033.821	272.772	NVA
OT35	2463656.469	712185.622	401.544	NVA
OT38	2476930.092	581797.837	386.311	NVA
OT39	2414313.069	637387.498	422.088	NVA
OT60	2357243.440	797958.625	328.980	NVA
OT62	2399052.281	783426.849	369.344	NVA
OT66	2416617.752	720623.841	285.374	NVA
UR01	2380576.165	930872.211	516.916	NVA
UR02	2429824.864	892898.659	319.264	NVA
UR03	2473501.969	942449.789	360.294	NVA
UR04	2562425.187	914907.017	423.718	NVA
UR05	2549979.988	871911.564	344.080	NVA
UR09	2500774.063	773524.884	255.710	NVA
UR10	2512524.470	831676.352	232.225	NVA
UR14	2561482.966	725266.714	226.039	NVA
UR15	2516477.082	710026.685	369.018	NVA
UR16	2471099.147	714158.938	377.712	NVA
UR23	2348253.163	989390.143	450.502	NVA
UR24	2416946.493	979779.461	412.943	NVA
UR25	2522062.637	1036759.338	444.128	NVA
UR26	2541685.284	953965.848	485.842	NVA

Point ID	Easting [X]	Northing [Y]	Elevation [Z]	Point Type
UR27	2492384.569	990539.249	413.937	NVA
UR28	2316206.289	887466.834	424.464	NVA
UR29	2289863.144	861887.271	444.680	NVA
UR30	2366023.477	894136.197	494.451	NVA
UR31	2428068.559	818743.999	385.544	NVA
UR32	2409398.950	761097.704	307.894	NVA
UR33	2377908.542	800997.304	339.335	NVA
UR34	2417107.016	721295.356	292.686	NVA
UR35	2428820.258	667152.880	456.708	NVA
UR38	2507400.103	657932.633	350.843	NVA
UR39	2455269.346	618678.817	427.035	NVA
UR61	2389823.364	819710.695	396.470	NVA
UR62	2366514.173	774529.731	305.725	NVA
UR63	2417611.880	767527.631	354.590	NVA
UR68	2383153.977	705391.229	273.337	NVA
UR75	2455430.506	584957.406	374.720	NVA

Point ID	Easting [X]	Northing [Y]	Elevation [Z]	Point Type
BR01	2426086.187	926593.182	401.517	VVA
BR02	2403132.450	840100.531	471.954	VVA
BR03	2476807.145	904773.561	412.040	VVA
BR04	2532066.774	869715.938	332.534	VVA
BR08	2557198.431	795627.013	306.719	VVA
BR11	2506924.233	691547.216	324.805	VVA
BR12	2513431.295	735769.678	284.243	VVA
BR16	2401538.402	972623.740	552.530	VVA
BR17	2541078.481	924134.589	461.127	VVA
BR18	2533052.446	989640.165	547.337	VVA
BR19	2326851.055	861971.345	353.022	VVA
BR20	2318399.231	905195.620	456.501	VVA
BR21	2410811.807	749431.972	339.588	VVA
BR22	2362239.466	804514.357	390.928	VVA
BR23	2393992.671	692737.602	279.090	VVA
BR26	2427881.082	603796.245	376.484	VVA
BR44	2391950.841	728336.933	311.138	VVA
BR49	2412289.675	619929.613	363.539	VVA

Point ID	Easting [X]	Northing [Y]	Elevation [Z]	Point Type
HG01	2476831.178	885006.900	290.734	VVA
HG02	2439280.051	965127.434	470.400	VVA
HG03	2564679.034	890128.643	365.451	VVA
HG07	2495138.411	848930.635	329.874	VVA
HG08	2480366.244	801732.921	342.513	VVA
HG11	2574909.772	702891.050	207.752	VVA
HG12	2483763.952	753612.670	411.445	VVA
HG16	2368423.020	994141.566	557.327	VVA
HG17	2505409.361	951120.576	329.449	VVA
HG18	2501953.872	1014596.618	479.062	VVA
HG19	2341733.394	816413.570	315.273	VVA
HG20	2308606.776	827371.273	427.997	VVA
HG21	2448767.540	779628.828	389.819	VVA
HG22	2386138.863	824989.981	422.596	VVA
HG23	2448593.959	702217.549	377.287	VVA
HG26	2487416.911	627091.981	346.468	VVA
HG40	2327620.905	1018186.163	587.881	VVA
HG43	2401651.235	802202.954	406.486	VVA
HG49	2383339.363	676982.548	279.232	VVA
TR01	2404460.930	955987.755	464.606	VVA
TR02	2464661.758	929206.802	345.567	VVA
TR03	2435638.032	844418.268	392.343	VVA
TR04	2513683.648	895200.313	335.159	VVA
TR07	2511118.926	797735.521	311.125	VVA
TR11	2544678.333	747474.970	205.383	VVA
TR12	2554399.803	691512.304	228.844	VVA
TR15	2388256.808	1007284.098	492.644	VVA
TR16	2333273.412	965694.574	410.009	VVA
TR17	2505180.079	975310.677	389.176	VVA
TR18	2279655.418	844253.396	446.912	VVA
TR19	2385875.419	866758.467	421.125	VVA
TR20	2457557.618	819171.222	350.703	VVA
TR21	2367092.731	740902.461	278.532	VVA
TR22	2369129.849	733658.408	254.631	VVA
TR23	2462502.934	676835.909	346.677	VVA
TR25	2497403.808	596637.674	322.315	VVA

Point ID	Easting [X]	Northing [Y]	Elevation [Z]	Point Type
TR26	2472510.412	659182.162	351.205	VVA
TR46	2380630.687	801215.998	308.783	VVA
TR53	2369482.065	747172.670	293.812	VVA
TR54	2408753.282	700380.416	289.386	VVA
TR65	2443882.360	605578.367	378.280	VVA
TR701	2378206.907	716457.672	251.719	VVA
TR702	2401661.614	802182.378	407.405	VVA

Table 5: LiDAR Control/Check Point Coordinates

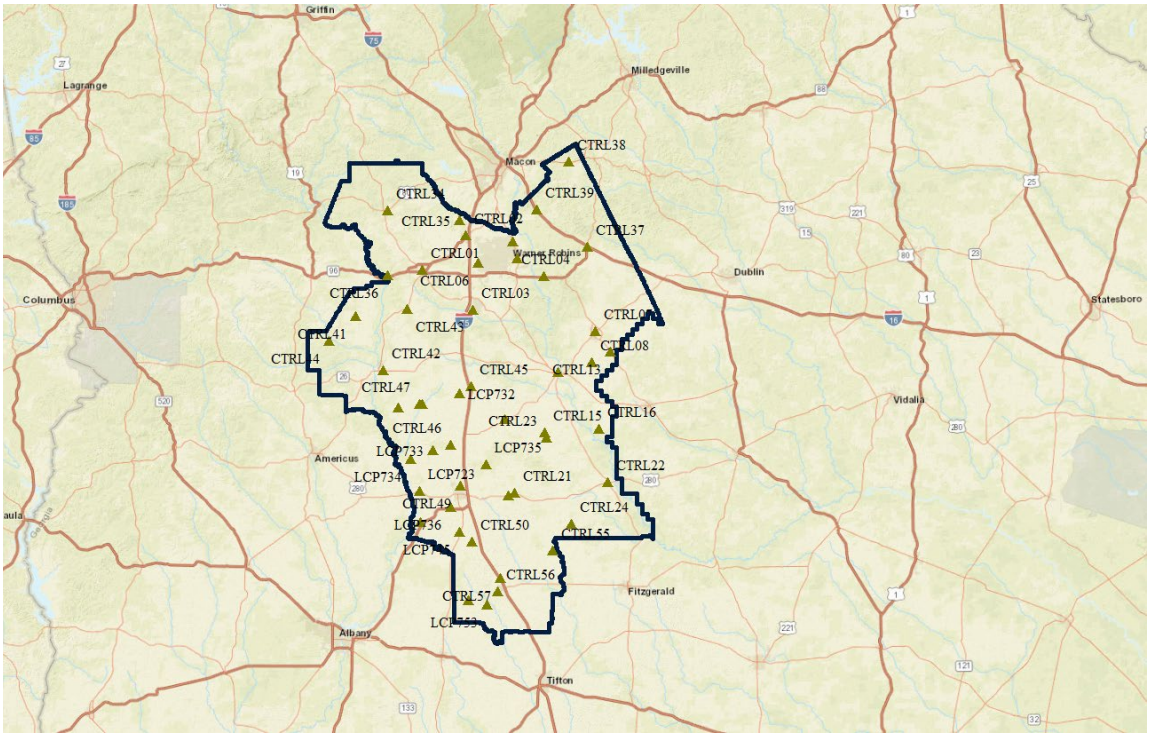

Figure 3: LiDAR Control Point Distribution

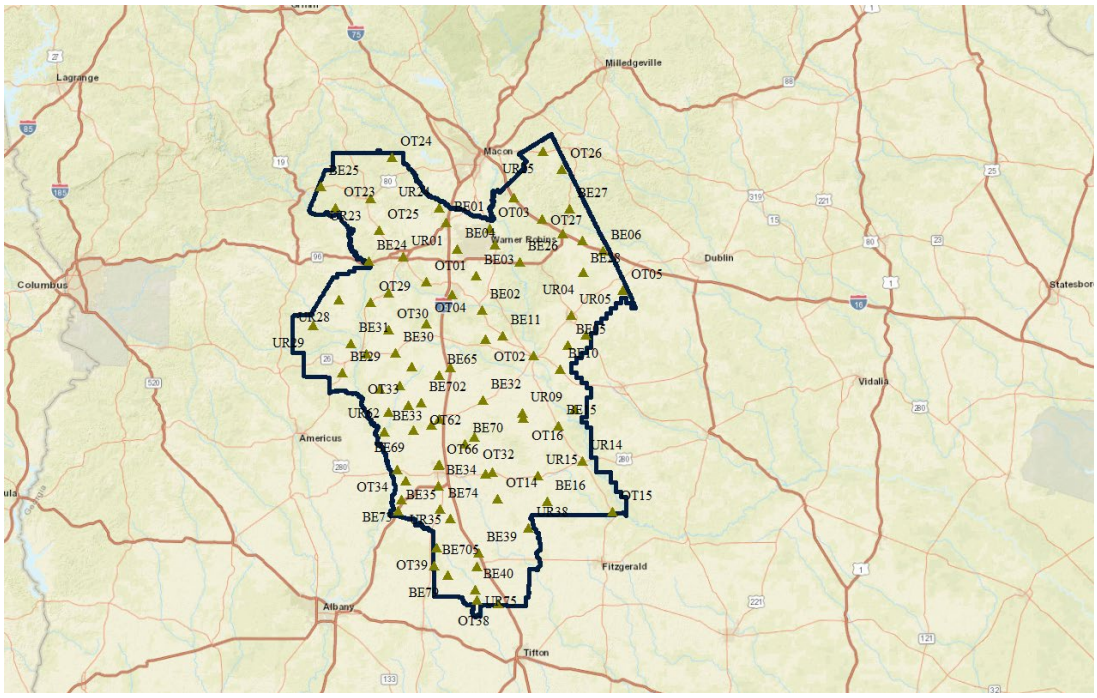

Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

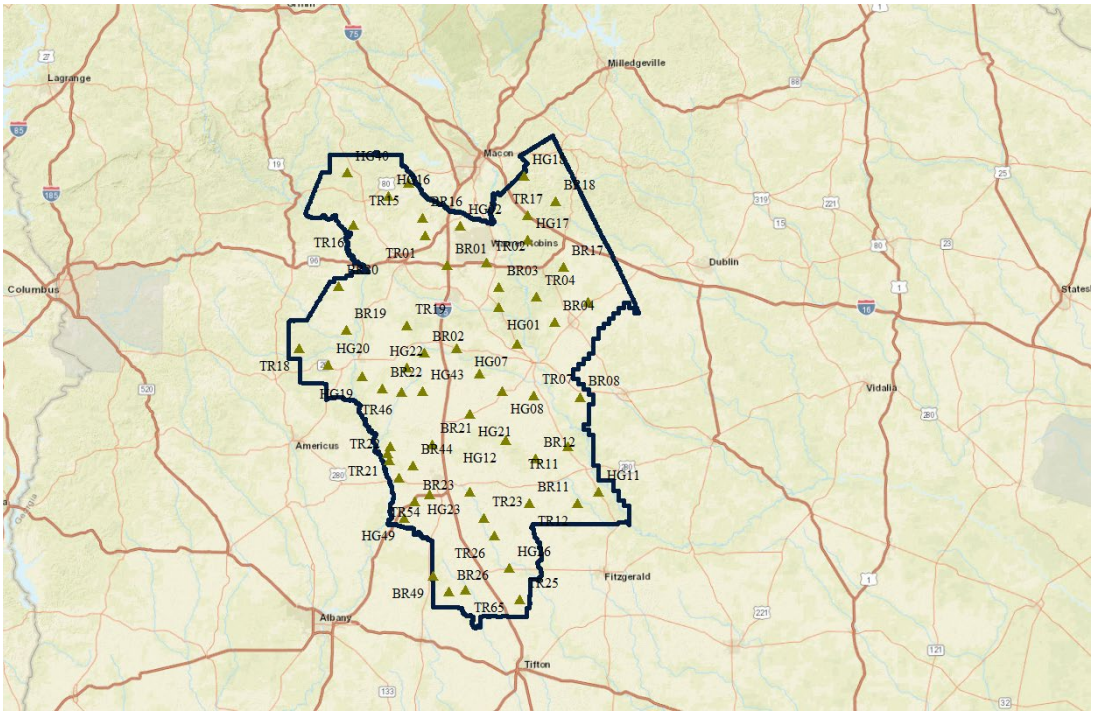

Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

SECTION 3: DATA PRODUCTION

3.1 Aerial LiDAR Project – Calibration/Classification

3.1.1 LiDAR Point Cloud Generation

Atlantic used Optech software products to download the IPAS ABGNSS/IMU data and raw laser scan files from the airborne system. Applanix PosPac 8.5 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	SPCS, GA West
Vertical Datum	NAVD88
Geoid Model	12B
EPSG Code	6447
Units of Reference	Feet (US Survey)

Table 6: Coordinate Reference System

3.1.3 LiDAR Point Cloud Statistics

Category	Value
Total Points (Nominal)	63,718,379,234
Nominal Pulse Spacing (FT)	1.2842
Nominal Pulse Density (PLS/FT^2)	0.6064
Total Points (Aggregate)	63,750,521,165
Aggregate Pulse Spacing (FT)	1.2864
Aggregate Pulse Density (PLS/FT^2)	0.6043

Table 7: 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 ≤2cm. A final analysis of the calibrated lidar is preformed using a TerraMatch tie line report for an overall statistical model of the project area. Individual control point assessments for this project can be found in Section VI of this report.

Upon completion of the data calibration, a complete set of elevation difference intensity rasters (dZ Orthos) are produced. A user-defined color ramp is applied depicting the offsets between overlapping swaths based on project specifications. The dZ orthos provide an opportunity to review the data calibration in a qualitative manner. Atlantic assigns green to all offset values that fall below the required RMSDz requirement of the project. A yellow color is assigned for offsets that fall between the RMSDz value and 1.5x of that value. Finally, red values are assigned to all values that fall beyond 1.5x of the RMSDz requirements of the project.

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
4	Medium Vegetation
5	High Vegetation
7	Low Point (“Low Noise”)
9	Water
10	Ignored ground (Breakline Proximity)
17	Bridge Decks
18	High Noise

Table 8: 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 2.5-feet cell size. The points flagged as withheld have been excluded from the processing of these images, and the valid points left in class 1 were included in the processing of these images as well. 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 2.5 feet. 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 9: 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)	89	0.1829	0.3584	0.3106
NVA (DEM)	89	0.1804	0.3535	0.2285
VVA (Point Cloud)	61	0.5219	1.0229	1.1140
VVA (DEM)	61	0.5188	1.0169	0.2232

Table 10: 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.

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

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
BE01	2423777.8330	965417.3090	493.2620	493.2650	0.0030	NVA
BE02	2460556.1730	876908.7840	279.4100	279.4200	0.0100	NVA
BE03	2454462.4370	911779.2260	348.3170	348.2050	-0.1120	NVA
BE04	2435321.8170	938755.7090	457.8370	458.3310	0.4940	NVA
BE05	2546648.8540	841661.3760	259.0890	258.4180	-0.6710	NVA
BE06	2582658.4000	936318.4360	420.7710	420.8560	0.0850	NVA
BE10	2539160.5650	817752.0090	261.9050	261.9050	0.0000	NVA
BE11	2481590.8160	851132.8450	373.5430	373.5850	0.0420	NVA
BE15	2537106.4790	760561.5810	211.5920	211.5920	0.0000	NVA
BE16	2525784.1230	684288.1750	400.1920	400.2810	0.0890	NVA
BE24	2346694.3430	926173.0650	347.5230	347.6710	0.1480	NVA
BE25	2298434.4410	1001050.8850	486.5270	486.4160	-0.1110	NVA
BE26	2498088.1660	925138.2340	245.5580	245.3390	-0.2190	NVA
BE27	2548781.7970	978710.7460	522.5840	522.7770	0.1930	NVA
BE28	2561222.4250	947019.5560	469.8910	469.7790	-0.1120	NVA
BE29	2319368.5530	813940.7170	428.4250	428.4690	0.0440	NVA
BE30	2373308.6330	833517.1650	379.1750	378.9590	-0.2160	NVA
BE31	2327894.1290	842959.6470	293.1970	293.0900	-0.1070	NVA
BE32	2461717.3520	786345.1420	340.7480	340.7960	0.0480	NVA
BE33	2361917.6520	754129.9550	297.2010	297.3760	0.1750	NVA
BE34	2416380.1560	699824.6160	309.7980	309.8100	0.0120	NVA
BE35	2375364.6540	675226.2680	283.3120	283.4830	0.1710	NVA
BE39	2456928.0750	632252.2660	410.6040	410.7740	0.1700	NVA
BE40	2453849.1080	595377.0780	346.6110	346.3660	-0.2450	NVA
BE65	2417273.4070	811385.2180	378.2190	378.0470	-0.1720	NVA
BE69	2391443.7170	756236.4690	327.3980	327.5450	0.1470	NVA
BE70	2442911.0010	742245.4740	364.7870	364.9970	0.2100	NVA
BE702	2399035.6860	783429.3360	369.2090	369.0850	-0.1240	NVA
BE705	2412314.1410	619914.4700	362.4630	362.7000	0.2370	NVA
BE73	2379243.9450	686164.1480	276.2720	276.5460	0.2740	NVA
BE74	2417698.0460	676578.1910	325.0910	325.3250	0.2340	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
BE79	2425796.2080	610466.4990	403.0240	403.2600	0.2360	NVA
BR01	2426086.1870	926593.1820	401.5170	401.6470	0.1300	VVA
BR02	2403132.4500	840100.5310	471.9540	472.0060	0.0520	VVA
BR03	2476807.1450	904773.5610	412.0400	411.9880	-0.0520	VVA
BR04	2532066.7740	869715.9380	332.5340	331.7200	-0.8140	VVA
BR08	2557198.4310	795627.0130	306.7190	306.7790	0.0600	VVA
BR11	2506924.2330	691547.2160	324.8050	325.1260	0.3210	VVA
BR12	2513431.2950	735769.6780	284.2430	284.4990	0.2560	VVA
BR16	2401538.4020	972623.7400	552.5300	553.0290	0.4990	VVA
BR17	2541078.4810	924134.5890	461.1270	461.2310	0.1040	VVA
BR18	2533052.4460	989640.1650	547.3370	547.5090	0.1720	VVA
BR19	2326851.0550	861971.3450	353.0220	353.3720	0.3500	VVA
BR20	2318399.2310	905195.6200	456.5010	456.8270	0.3260	VVA
BR21	2410811.8070	749431.9720	339.5880	339.9700	0.3820	VVA
BR22	2362239.4660	804514.3570	390.9280	392.2230	1.2950	VVA
BR23	2393992.6710	692737.6020	279.0900	280.3200	1.2300	VVA
BR26	2427881.0820	603796.2450	376.4840	377.5980	1.1140	VVA
BR44	2391950.8410	728336.9330	311.1380	311.5550	0.4170	VVA
BR49	2412289.6750	619929.6130	363.5390	364.4870	0.9480	VVA
HG01	2476831.1780	885006.9000	290.7340	290.9990	0.2650	VVA
HG02	2439280.0510	965127.4340	470.4000	470.3970	-0.0030	VVA
HG03	2564679.0340	890128.6430	365.4510	365.1880	-0.2630	VVA
HG07	2495138.4110	848930.6350	329.8740	330.1110	0.2370	VVA
HG08	2480366.2440	801732.9210	342.5130	342.9560	0.4430	VVA
HG11	2574909.7720	702891.0500	207.7520	208.1580	0.4060	VVA
HG12	2483763.9520	753612.6700	411.4450	411.7680	0.3230	VVA
HG16	2368423.0200	994141.5660	557.3270	557.8650	0.5380	VVA
HG17	2505409.3610	951120.5760	329.4490	329.8570	0.4080	VVA
HG18	2501953.8720	1014596.6180	479.0620	479.1120	0.0500	VVA
HG19	2341733.3940	816413.5700	315.2730	315.8720	0.5990	VVA
HG20	2308606.7760	827371.2730	427.9970	428.3590	0.3620	VVA
HG21	2448767.5400	779628.8280	389.8190	390.1580	0.3390	VVA
HG22	2386138.8630	824989.9810	422.5960	422.5700	-0.0260	VVA
HG23	2448593.9590	702217.5490	377.2870	377.8710	0.5840	VVA
HG26	2487416.9110	627091.9810	346.4680	348.5450	2.0770	VVA
HG40	2327620.9050	1018186.1630	587.8810	588.8640	0.9830	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
HG43	2401651.2350	802202.9540	406.4860	406.4280	-0.0580	VVA
HG49	2383339.3630	676982.5480	279.2320	279.6970	0.4650	VVA
OT01	2404218.9980	905168.6130	435.9560	436.0840	0.1280	NVA
OT02	2463618.5750	848042.5700	377.6220	377.6300	0.0080	NVA
OT03	2468508.3820	958889.2400	309.3630	309.4150	0.0520	NVA
OT04	2404082.3320	863486.1230	515.7020	515.7200	0.0180	NVA
OT05	2601994.3430	896781.6050	322.1290	322.1940	0.0650	NVA
OT06	2564813.3190	851700.7030	381.7710	381.5270	-0.2440	NVA
OT10	2553597.1120	776514.7320	227.2330	227.2460	0.0130	NVA
OT14	2476206.5510	687251.6860	372.6330	372.8580	0.2250	NVA
OT15	2591376.9130	674464.0750	198.9950	199.0560	0.0610	NVA
OT16	2502137.3600	768026.7370	272.5170	272.5200	0.0030	NVA
OT23	2312642.5480	979841.2150	359.4880	359.3480	-0.1400	NVA
OT24	2369716.0350	1030698.7730	490.2820	490.2740	-0.0080	NVA
OT25	2356447.2310	957712.6790	513.3000	513.3640	0.0640	NVA
OT26	2541096.1200	1018970.1720	344.8520	344.9370	0.0850	NVA
OT27	2520869.6320	968969.2920	380.9620	381.0870	0.1250	NVA
OT28	2343482.2970	833216.5030	337.2940	337.0890	-0.2050	NVA
OT29	2347814.4960	885094.8010	476.2480	476.6050	0.3570	NVA
OT30	2366465.0690	857409.5760	415.4740	415.3320	-0.1420	NVA
OT32	2452441.9620	749155.6590	428.1570	428.3000	0.1430	NVA
OT33	2386139.5400	780907.3500	347.1290	347.3280	0.1990	NVA
OT34	2375357.8530	716033.8210	272.7720	273.2950	0.5230	NVA
OT35	2463656.4690	712185.6220	401.5440	401.7280	0.1840	NVA
OT38	2476930.0920	581797.8370	386.3110	386.0850	-0.2260	NVA
OT39	2414313.0690	637387.4980	422.0880	422.4190	0.3310	NVA
OT60	2357243.4400	797958.6250	328.9800	328.8530	-0.1270	NVA
OT62	2399052.2810	783426.8490	369.3440	369.2030	-0.1410	NVA
OT66	2416617.7520	720623.8410	285.3740	285.6470	0.2730	NVA
TR01	2404460.9300	955987.7550	464.6060	464.9600	0.3540	VVA
TR02	2464661.7580	929206.8020	345.5670	345.8960	0.3290	VVA
TR03	2435638.0320	844418.2680	392.3430	392.4160	0.0730	VVA
TR04	2513683.6480	895200.3130	335.1590	335.2200	0.0610	VVA
TR07	2511118.9260	797735.5210	311.1250	311.1740	0.0490	VVA
TR11	2544678.3330	747474.9700	205.3830	205.5730	0.1900	VVA
TR12	2554399.8030	691512.3040	228.8440	229.1460	0.3020	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
TR15	2388256.8080	1007284.0980	492.6440	492.1730	-0.4710	VVA
TR16	2333273.4120	965694.5740	410.0090	410.1430	0.1340	VVA
TR17	2505180.0790	975310.6770	389.1760	389.2020	0.0260	VVA
TR18	2279655.4180	844253.3960	446.9120	446.8080	-0.1040	VVA
TR19	2385875.4190	866758.4670	421.1250	421.2090	0.0840	VVA
TR20	2457557.6180	819171.2220	350.7030	350.9340	0.2310	VVA
TR21	2367092.7310	740902.4610	278.5320	278.9280	0.3960	VVA
TR22	2369129.8490	733658.4080	254.6310	254.9900	0.3590	VVA
TR23	2462502.9340	676835.9090	346.6770	347.0520	0.3750	VVA
TR25	2497403.8080	596637.6740	322.3150	322.5940	0.2790	VVA
TR26	2472510.4120	659182.1620	351.2050	351.4240	0.2190	VVA
TR46	2380630.6870	801215.9980	308.7830	308.7150	-0.0680	VVA
TR53	2369482.0650	747172.6700	293.8120	294.4560	0.6440	VVA
TR54	2408753.2820	700380.4160	289.3860	289.6480	0.2620	VVA
TR65	2443882.3600	605578.3670	378.2800	378.7210	0.4410	VVA
TR701	2378206.9070	716457.6720	251.7190	252.0180	0.2990	VVA
TR702	2401661.6140	802182.3780	407.4050	407.2830	-0.1220	VVA
UR01	2380576.1650	930872.2110	516.9160	516.9010	-0.0150	NVA
UR02	2429824.8640	892898.6590	319.2640	319.2110	-0.0530	NVA
UR03	2473501.9690	942449.7890	360.2940	360.3500	0.0560	NVA
UR04	2562425.1870	914907.0170	423.7180	423.6310	-0.0870	NVA
UR05	2549979.9880	871911.5640	344.0800	343.9560	-0.1240	NVA
UR09	2500774.0630	773524.8840	255.7100	255.7070	-0.0030	NVA
UR10	2512524.4700	831676.3520	232.2250	232.1280	-0.0970	NVA
UR14	2561482.9660	725266.7140	226.0390	226.0460	0.0070	NVA
UR15	2516477.0820	710026.6850	369.0180	368.9960	-0.0220	NVA
UR16	2471099.1470	714158.9380	377.7120	377.8700	0.1580	NVA
UR23	2348253.1630	989390.1430	450.5020	450.7820	0.2800	NVA
UR24	2416946.4930	979779.4610	412.9430	412.8960	-0.0470	NVA
UR25	2522062.6370	1036759.3380	444.1280	444.2370	0.1090	NVA
UR26	2541685.2840	953965.8480	485.8420	485.8800	0.0380	NVA
UR27	2492384.5690	990539.2490	413.9370	413.9000	-0.0370	NVA
UR28	2316206.2890	887466.8340	424.4640	424.6360	0.1720	NVA
UR29	2289863.1440	861887.2710	444.6800	444.4200	-0.2600	NVA
UR30	2366023.4770	894136.1970	494.4510	494.4020	-0.0490	NVA
UR31	2428068.5590	818743.9990	385.5440	385.5200	-0.0240	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
UR32	2409398.9500	761097.7040	307.8940	307.9540	0.0600	NVA
UR33	2377908.5420	800997.3040	339.3350	339.2700	-0.0650	NVA
UR34	2417107.0160	721295.3560	292.6860	292.8040	0.1180	NVA
UR35	2428820.2580	667152.8800	456.7080	456.9800	0.2720	NVA
UR38	2507400.1030	657932.6330	350.8430	350.9270	0.0840	NVA
UR39	2455269.3460	618678.8170	427.0350	427.2330	0.1980	NVA
UR61	2389823.3640	819710.6950	396.4700	396.3640	-0.1060	NVA
UR62	2366514.1730	774529.7310	305.7250	305.8200	0.0950	NVA
UR63	2417611.8800	767527.6310	354.5900	354.6360	0.0460	NVA
UR68	2383153.9770	705391.2290	273.3370	273.6800	0.3430	NVA
UR75	2455430.5060	584957.4060	374.7200	374.7690	0.0490	NVA

Table 11: 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
BE01	2423777.8330	965417.3090	493.2620	493.1759	0.0861	NVA
BE02	2460556.1730	876908.7840	279.4100	279.3373	0.0727	NVA
BE03	2454462.4370	911779.2260	348.3170	348.1923	0.1247	NVA
BE04	2435321.8170	938755.7090	457.8370	458.2448	-0.4078	NVA
BE05	2546648.8540	841661.3760	259.0890	258.4055	0.6835	NVA
BE06	2582658.4000	936318.4360	420.7710	420.8661	-0.0951	NVA
BE10	2539160.5650	817752.0090	261.9050	261.8701	0.0349	NVA
BE11	2481590.8160	851132.8450	373.5430	373.5925	-0.0495	NVA
BE15	2537106.4790	760561.5810	211.5920	211.5748	0.0172	NVA
BE16	2525784.1230	684288.1750	400.1920	400.2493	-0.0573	NVA
BE24	2346694.3430	926173.0650	347.5230	347.5689	-0.0459	NVA
BE25	2298434.4410	1001050.8850	486.5270	486.3583	0.1687	NVA
BE26	2498088.1660	925138.2340	245.5580	245.3445	0.2135	NVA
BE27	2548781.7970	978710.7460	522.5840	522.7034	-0.1194	NVA
BE28	2561222.4250	947019.5560	469.8910	469.7802	0.1108	NVA
BE29	2319368.5530	813940.7170	428.4250	428.4350	-0.0100	NVA
BE30	2373308.6330	833517.1650	379.1750	378.9633	0.2117	NVA
BE31	2327894.1290	842959.6470	293.1970	293.0807	0.1163	NVA
BE32	2461717.3520	786345.1420	340.7480	340.7087	0.0393	NVA
BE33	2361917.6520	754129.9550	297.2010	297.3950	-0.1940	NVA
BE34	2416380.1560	699824.6160	309.7980	309.8097	-0.0117	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BE35	2375364.6540	675226.2680	283.3120	283.4744	-0.1624	NVA
BE39	2456928.0750	632252.2660	410.6040	410.8465	-0.2425	NVA
BE40	2453849.1080	595377.0780	346.6110	346.3484	0.2626	NVA
BE65	2417273.4070	811385.2180	378.2190	378.0413	0.1777	NVA
BE69	2391443.7170	756236.4690	327.3980	327.4934	-0.0954	NVA
BE70	2442911.0010	742245.4740	364.7870	365.0361	-0.2491	NVA
BE702	2399035.6860	783429.3360	369.2090	369.0912	0.1178	NVA
BE705	2412314.1410	619914.4700	362.4630	362.7001	-0.2371	NVA
BE73	2379243.9450	686164.1480	276.2720	276.5486	-0.2766	NVA
BE74	2417698.0460	676578.1910	325.0910	325.2625	-0.1715	NVA
BE79	2425796.2080	610466.4990	403.0240	403.2185	-0.1945	NVA
OT01	2404218.9980	905168.6130	435.9560	435.9974	-0.0414	NVA
OT02	2463618.5750	848042.5700	377.6220	377.5984	0.0236	NVA
OT03	2468508.3820	958889.2400	309.3630	309.3668	-0.0038	NVA
OT04	2404082.3320	863486.1230	515.7020	515.7119	-0.0099	NVA
OT05	2601994.3430	896781.6050	322.1290	322.1424	-0.0134	NVA
OT06	2564813.3190	851700.7030	381.7710	381.5157	0.2553	NVA
OT10	2553597.1120	776514.7320	227.2330	227.2572	-0.0242	NVA
OT14	2476206.5510	687251.6860	372.6330	372.8871	-0.2541	NVA
OT15	2591376.9130	674464.0750	198.9950	199.0190	-0.0240	NVA
OT16	2502137.3600	768026.7370	272.5170	272.4475	0.0695	NVA
OT23	2312642.5480	979841.2150	359.4880	359.3045	0.1835	NVA
OT24	2369716.0350	1030698.7730	490.2820	490.3150	-0.0330	NVA
OT25	2356447.2310	957712.6790	513.3000	513.3891	-0.0891	NVA
OT26	2541096.1200	1018970.1720	344.8520	344.9114	-0.0594	NVA
OT27	2520869.6320	968969.2920	380.9620	381.0663	-0.1043	NVA
OT28	2343482.2970	833216.5030	337.2940	337.0801	0.2139	NVA
OT29	2347814.4960	885094.8010	476.2480	476.5289	-0.2809	NVA
OT30	2366465.0690	857409.5760	415.4740	415.3314	0.1426	NVA
OT32	2452441.9620	749155.6590	428.1570	428.3629	-0.2059	NVA
OT33	2386139.5400	780907.3500	347.1290	347.2966	-0.1676	NVA
OT34	2375357.8530	716033.8210	272.7720	273.3169	-0.5449	NVA
OT35	2463656.4690	712185.6220	401.5440	401.7028	-0.1588	NVA
OT38	2476930.0920	581797.8370	386.3110	386.0991	0.2119	NVA
OT39	2414313.0690	637387.4980	422.0880	422.4016	-0.3136	NVA
OT60	2357243.4400	797958.6250	328.9800	328.8911	0.0889	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
OT62	2399052.2810	783426.8490	369.3440	369.2257	0.1183	NVA
OT66	2416617.7520	720623.8410	285.3740	285.6562	-0.2822	NVA
UR01	2380576.1650	930872.2110	516.9160	516.8635	0.0525	NVA
UR02	2429824.8640	892898.6590	319.2640	319.2454	0.0186	NVA
UR03	2473501.9690	942449.7890	360.2940	360.2526	0.0414	NVA
UR04	2562425.1870	914907.0170	423.7180	423.6089	0.1091	NVA
UR05	2549979.9880	871911.5640	344.0800	343.8419	0.2381	NVA
UR09	2500774.0630	773524.8840	255.7100	255.7087	0.0013	NVA
UR10	2512524.4700	831676.3520	232.2250	232.0702	0.1548	NVA
UR14	2561482.9660	725266.7140	226.0390	226.0367	0.0023	NVA
UR15	2516477.0820	710026.6850	369.0180	368.9961	0.0219	NVA
UR16	2471099.1470	714158.9380	377.7120	377.9265	-0.2145	NVA
UR23	2348253.1630	989390.1430	450.5020	450.7448	-0.2428	NVA
UR24	2416946.4930	979779.4610	412.9430	412.8642	0.0788	NVA
UR25	2522062.6370	1036759.3380	444.1280	444.2257	-0.0977	NVA
UR26	2541685.2840	953965.8480	485.8420	485.8957	-0.0537	NVA
UR27	2492384.5690	990539.2490	413.9370	413.8320	0.1050	NVA
UR28	2316206.2890	887466.8340	424.4640	424.5177	-0.0537	NVA
UR29	2289863.1440	861887.2710	444.6800	444.4062	0.2738	NVA
UR30	2366023.4770	894136.1970	494.4510	494.3930	0.0580	NVA
UR31	2428068.5590	818743.9990	385.5440	385.4724	0.0716	NVA
UR32	2409398.9500	761097.7040	307.8940	307.9134	-0.0194	NVA
UR33	2377908.5420	800997.3040	339.3350	339.2356	0.0994	NVA
UR34	2417107.0160	721295.3560	292.6860	292.7657	-0.0797	NVA
UR35	2428820.2580	667152.8800	456.7080	456.9324	-0.2244	NVA
UR38	2507400.1030	657932.6330	350.8430	350.8136	0.0294	NVA
UR39	2455269.3460	618678.8170	427.0350	427.2572	-0.2222	NVA
UR61	2389823.3640	819710.6950	396.4700	396.3484	0.1216	NVA
UR62	2366514.1730	774529.7310	305.7250	305.7283	-0.0033	NVA
UR63	2417611.8800	767527.6310	354.5900	354.6752	-0.0852	NVA
UR68	2383153.9770	705391.2290	273.3370	273.6680	-0.3310	NVA
UR75	2455430.5060	584957.4060	374.7200	374.7507	-0.0307	NVA
BR01	2426086.1870	926593.1820	401.5170	401.6503	-0.1333	VVA
BR02	2403132.4500	840100.5310	471.9540	471.9816	-0.0276	VVA
BR03	2476807.1450	904773.5610	412.0400	411.8504	0.1896	VVA
BR04	2532066.7740	869715.9380	332.5340	331.2894	1.2446	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BR08	2557198.4310	795627.0130	306.7190	306.7848	-0.0658	VVA
BR11	2506924.2330	691547.2160	324.8050	325.1148	-0.3098	VVA
BR12	2513431.2950	735769.6780	284.2430	284.5276	-0.2846	VVA
BR16	2401538.4020	972623.7400	552.5300	552.9528	-0.4228	VVA
BR17	2541078.4810	924134.5890	461.1270	461.2205	-0.0935	VVA
BR18	2533052.4460	989640.1650	547.3370	547.4967	-0.1597	VVA
BR19	2326851.0550	861971.3450	353.0220	353.2283	-0.2063	VVA
BR20	2318399.2310	905195.6200	456.5010	456.6962	-0.1952	VVA
BR21	2410811.8070	749431.9720	339.5880	339.9705	-0.3825	VVA
BR22	2362239.4660	804514.3570	390.9280	392.5033	-1.5753	VVA
BR23	2393992.6710	692737.6020	279.0900	280.1804	-1.0904	VVA
BR26	2427881.0820	603796.2450	376.4840	377.4606	-0.9766	VVA
BR44	2391950.8410	728336.9330	311.1380	311.5846	-0.4466	VVA
BR49	2412289.6750	619929.6130	363.5390	364.2848	-0.7458	VVA
HG01	2476831.1780	885006.9000	290.7340	290.8858	-0.1518	VVA
HG02	2439280.0510	965127.4340	470.4000	470.2362	0.1638	VVA
HG03	2564679.0340	890128.6430	365.4510	365.1969	0.2541	VVA
HG07	2495138.4110	848930.6350	329.8740	330.0427	-0.1687	VVA
HG08	2480366.2440	801732.9210	342.5130	342.8904	-0.3774	VVA
HG11	2574909.7720	702891.0500	207.7520	208.0774	-0.3254	VVA
HG12	2483763.9520	753612.6700	411.4450	411.7618	-0.3168	VVA
HG16	2368423.0200	994141.5660	557.3270	557.7854	-0.4584	VVA
HG17	2505409.3610	951120.5760	329.4490	330.0853	-0.6363	VVA
HG18	2501953.8720	1014596.6180	479.0620	479.0650	-0.0030	VVA
HG19	2341733.3940	816413.5700	315.2730	315.9252	-0.6522	VVA
HG20	2308606.7760	827371.2730	427.9970	428.4941	-0.4971	VVA
HG21	2448767.5400	779628.8280	389.8190	390.1312	-0.3122	VVA
HG22	2386138.8630	824989.9810	422.5960	422.5295	0.0665	VVA
HG23	2448593.9590	702217.5490	377.2870	377.8609	-0.5739	VVA
HG26	2487416.9110	627091.9810	346.4680	348.4843	-2.0163	VVA
HG40	2327620.9050	1018186.1630	587.8810	588.5171	-0.6361	VVA
HG43	2401651.2350	802202.9540	406.4860	406.4436	0.0424	VVA
HG49	2383339.3630	676982.5480	279.2320	279.5308	-0.2988	VVA
TR01	2404460.9300	955987.7550	464.6060	464.8425	-0.2365	VVA
TR02	2464661.7580	929206.8020	345.5670	345.7021	-0.1351	VVA
TR03	2435638.0320	844418.2680	392.3430	392.4639	-0.1209	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
TR04	2513683.6480	895200.3130	335.1590	335.2001	-0.0411	VVA
TR07	2511118.9260	797735.5210	311.1250	311.1909	-0.0659	VVA
TR11	2544678.3330	747474.9700	205.3830	205.5938	-0.2108	VVA
TR12	2554399.8030	691512.3040	228.8440	229.1339	-0.2899	VVA
TR15	2388256.8080	1007284.0980	492.6440	492.1555	0.4885	VVA
TR16	2333273.4120	965694.5740	410.0090	410.1181	-0.1091	VVA
TR17	2505180.0790	975310.6770	389.1760	389.1929	-0.0169	VVA
TR18	2279655.4180	844253.3960	446.9120	446.8537	0.0583	VVA
TR19	2385875.4190	866758.4670	421.1250	421.2500	-0.1250	VVA
TR20	2457557.6180	819171.2220	350.7030	350.7152	-0.0122	VVA
TR21	2367092.7310	740902.4610	278.5320	278.9272	-0.3952	VVA
TR22	2369129.8490	733658.4080	254.6310	255.1247	-0.4937	VVA
TR23	2462502.9340	676835.9090	346.6770	347.1686	-0.4916	VVA
TR25	2497403.8080	596637.6740	322.3150	322.5886	-0.2736	VVA
TR26	2472510.4120	659182.1620	351.2050	351.4370	-0.2320	VVA
TR46	2380630.6870	801215.9980	308.7830	308.7139	0.0691	VVA
TR53	2369482.0650	747172.6700	293.8120	294.3930	-0.5810	VVA
TR54	2408753.2820	700380.4160	289.3860	289.5866	-0.2006	VVA
TR65	2443882.3600	605578.3670	378.2800	378.7172	-0.4372	VVA
TR701	2378206.9070	716457.6720	251.7190	252.1129	-0.3939	VVA
TR702	2401661.6140	802182.3780	407.4050	407.1818	0.2232	VVA

Table 12: DEM Check Point Assessment