Project Report

TASK ORDER NAME: MS_NRCS_East_2018_B19
TASK ORDER NUMBER: 140G0219F0262
CONTRACT NUMBER: G16PC00042
ATLANTIC PROJECT NUMBER: 19059

TABLE OF CONTENTS

SECTION 1: PROJECT OVERVIEW AND PURPOSE

1.1 Aerial LiDAR Project

1.1.1 Project Overview

USGS NGTOC task order 140G0219F0262 required Fall 2019 / Spring 2020 leaf-off LiDAR surveys to be collected over 6,245 square miles covering parts of Eastern and Central Mississippi. Aerial LiDAR data for this task order was planned, acquired, processed, and produced at an aggregate nominal pulse spacing (ANPS) of ≤ 0.71 meters and in compliance with USGS National Geospatial Program LiDAR Base Specification version 1.3.

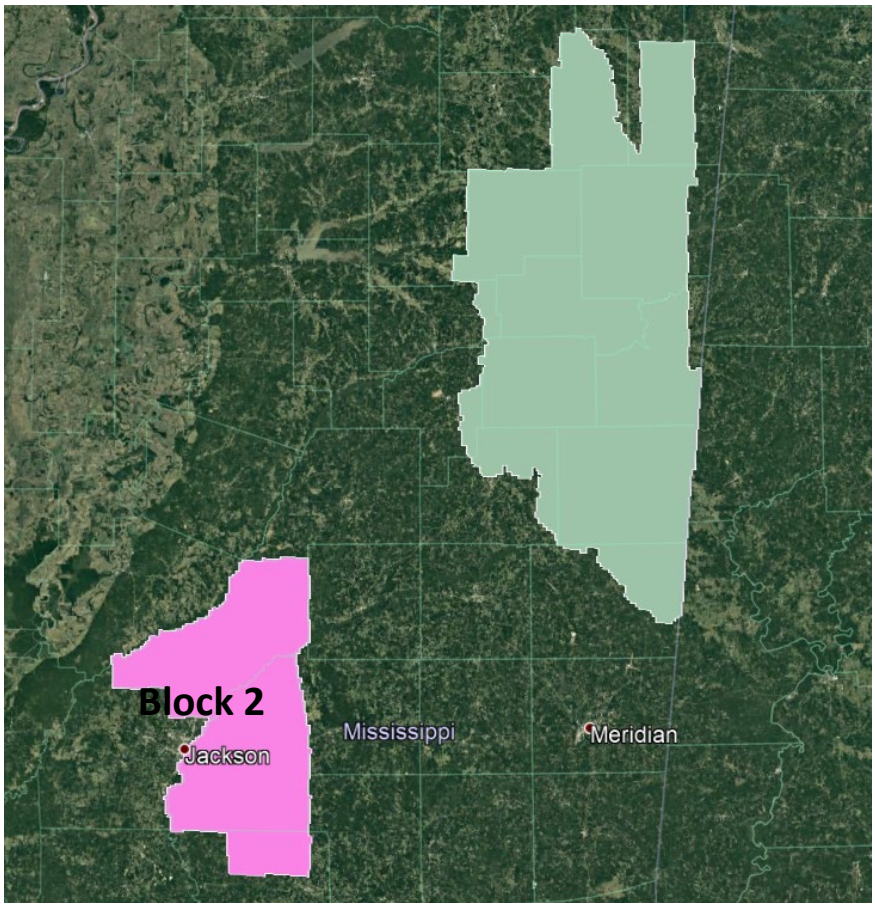

Figure 1: Aerial LiDAR Project Overview – Defined Project Areas (DPA)

1.1.2 Project Purpose

This task order is for planning, acquisition, processing, and derivative products of lidar data to be collected at an aggregate nominal pulse spacing of ≤0.71 meters, including overlap and an aggregate nominal pulse density of no less than 2 points per square meter. Lidar data and derivative products produced in compliance with this task order are based on the *"National Geospatial Program Lidar Base Specification Version 1.3"*. This project will support the 3DEP mission and the Natural Resources Conservation Service (NRCS) high resolution elevation enterprise program.

1.1.3 Contract Deliverables

Item	Specification/Format
Classified Point Cloud	LAS, version 1.4, Point Record Format 6
Bare Earth Surface (Raster DEM) - Hydro	32Bit, floating point, TIF, 1.0M cell size
Hydro Breaklines	ESRI file geodatabase (polylineZ and polygonZ feature classes)
Intensity Image	8-bit, 256 color gray scale, TIF, 1.0 M cell size
Contours	1-foot, smoothed (automated), ESRI file geodatabase
Building Footprints	Automated, ESRI file geodatabase
Delivery Diagram	ESRI shapefile
Product Metadata	XML, FGDC compliant
Flight Index	ESRI file geodatabase
Swath Data	ESRI file geodatabase
Difference Rasters	.TIF, 2.0 M cell size
Dataset Extents	ESRI shapefile
Project Report	PDF (Acquisition, Survey, Processing, QA/QC)
Tile Scheme	UTM Tiling Scheme, 1500M x 1500M
Tile Naming	US National Grid Conventions
Spatial Reference System	Universal Transverse Mercator Zone 15/16 (as appropriate), Meters; NAVD88, Meters, latest Geoid model, EPSG code 6344/6345

Table 1: Aerial LiDAR Contract Deliverables – Lots 6, 7a, 7b, and 8 Deliverables

SECTION 2: FIELD OPERATIONS

2.1 Aerial LiDAR Project – Aerial Acquisition

2.1.1 Aircraft and Sensor Information

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

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

Table 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 Prime
Nominal Pulse Spacing (m)	.65
Nominal Pulse Density (pls/m²)	2.32
Nominal Flight Height (AGL meters)	2118
Nominal Flight Speed (kts)	130
Pass Heading (°)	Cardinals
Sensor Scan Angle (°)	40
Scan Frequency (Hz)	51
Pulse Rate of Scanner (kHz)	250
Line Spacing (m)	1100
Central Wavelength of Sensor Laser (nm)	1064
Sensor Operated with Multiple Pulses	4
Beam Divergence (mrad)	.25
Nominal Swath Width (m)	1439
Nominal Swath Overlap (%)	20
Scan Pattern	Triangle

Table 3: Aerial LiDAR Sensor Acquisition Parameters

2.1.3 Flight Plan Execution

Atlantic acquired 48 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 5 flight missions conducted between January 9, 2020 and February 9, 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 Block 2

2.1.4 GNSS Reference Stations

Twenty-Eight (28) Continuously Operating Reference Stations (CORS) were used to control the LiDAR acquisition for the defined project area. The coordinates provided in the table below are in NAD83 (2011), Geographic Coordinate System, Ellipsoid, Meters.

Designation	Type	PID	Latitude (N)	Longitude (W)	Elevation
1ULM	CORS	1ULM	N32°31'44.52047"	W92°04'33.26902"	15.946
AL23	CORS	AL23	N34°08'54.86892"	W87°57'13.05382"	141.234
AL81	CORS	AL81	N32°34'32.56556"	W88°10'54.32820"	21.105
ALBE	CORS	ALBE	N34°28'31.51982"	W87°51'52.39823"	226.449
ALBU	CORS	ALBU	N32°04'53.91593"	W88°13'59.36284"	16.852
ALFA	CORS	ALFA	N33°41'06.76668"	W87°49'45.54065"	89.166
ARMO	CORS	ARMO	N33°35'40.41810"	W91°48'47.53184"	52.647
MSBN	CORS	MSBN	N31°36'30.35371"	W90°24'34.01893"	125.979
MSBV	CORS	MSBV	N34°39'56.48359"	W88°33'51.51693"	128.612
MSCR	CORS	MSCR	N34°54'23.34342"	W88°32'52.90301"	110.472
MSCT	CORS	MSCT	N32°43'06.65966"	W89°34'17.24910"	85.588
MSEU	CORS	MSEU	N33°32'53.20694"	W89°10'56.99356"	94.83
MSEV	CORS	MSEV	N31°35'42.10104"	W89°12'13.30620"	52.399
MSFL	CORS	MSFL	N34°16'36.56328"	W88°24'55.00177"	75.943
MSGN	CORS	MSGN	N33°20'19.32472"	W91°02'27.47208"	16.295
MSGR	CORS	MSGR	N33°45'50.45050"	W89°49'15.94723"	54.237
MSHS	CORS	MSHS	N34°44'36.31948"	W89°27'12.73029"	153.283
MSJK	CORS	MSJK	N32°19'37.40112"	W90°10'52.80969"	86.498
MSLV	CORS	MSLV	N33°06'27.74211"	W89°04'26.82775"	140.23
MSME	CORS	MSME	N32°22'03.04229"	W88°43'56.81048"	101.878
MSOX	CORS	MSOX	N34°21'50.95182"	W89°31'56.54986"	141.876
MSPE	CORS	MSPE	N33°47'52.35270"	W88°39'30.14101"	75.323
MSPN	CORS	MSPN	N34°14'36.58661"	W89°01'00.68057"	118.394
MSSB	CORS	MSSB	N32°49'46.39663"	W88°29'13.95548"	50.529
MSST	CORS	MSST	N33°27'14.19501"	W88°47'39.13821"	100.103
MSYZ	CORS	MSYZ	N32°50'46.89732"	W90°24'43.10002"	23.04
SIHS	CORS	SIHS	N31°50'36.17712"	W91°39'19.59495"	5.736
TALL	CORS	TALL	N32°24'01.21579"	W91°10'58.84562"	6.074

Table 4: GNSS Reference Stations

2.2 Aerial LiDAR Project – Ground Acquisition

2.2.1 Ground Control Survey

A total of 106 ground survey points were collected in support of this project, including 21 LiDAR Control Points (LCP), 46 Non-vegetated Vertical Accuracy (NVA) and 39 Vegetated Vertical Accuracy (VVA).

Point cloud data accuracy was tested against a Triangulated Irregular Network (TIN) constructed from LiDAR points in clear/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 exceeding ten (10) percent were avoided.

Each land cover type representing ten (10) percent or more of the total project area was 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 tables and figures below outline the coordinate values and distribution of LCP, NVA, and VVA points:

ID	Easting	Northing	Elevation
LCP054	231582.6276	3635006.1442	86.906
LCP055	234736.0238	3621726.3761	94.130
LCP056	225775.1766	3625266.4689	80.066
LCP057	205560.1800	3609398.2533	75.773
LCP058	213564.1630	3619900.6820	79.558
LCP059	221564.4114	3615482.4748	89.429
LCP060	178830.5093	3606107.1520	54.225
LCP061	193997.4324	3613916.5734	58.546
LCP062	189241.6424	3605438.4545	72.213
LCP063	200628.5245	3597548.4009	120.927
LCP064	217626.7024	3606544.9811	76.216
LCP065	208065.0153	3592470.2443	91.152
LCP066	220006.1223	3593092.0137	97.143
LCP067	234809.1469	3606366.6819	92.841
LCP068	235365.2412	3596896.1587	107.138
LCP077	235090.6546	3629073.5365	84.626
LCP078	238456.6759	3627286.3211	103.483
LCP079	206114.7464	3614580.8690	65.028
LCP080	189735.3345	3601725.2916	92.266
LCP081	205027.4006	3595976.9667	103.903
LCP082	235417.2661	3603208.5091	100.439

Table 5: LiDAR Control Point Coordinates

Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
BE041	231590.5843	3635011.1662	86.640
BE042	225776.7741	3625259.5636	80.049
BE043	234732.7604	3621731.7185	94.188
BE044	221561.6318	3615492.3206	89.308
BE045	234819.8353	3606369.7456	92.838
BE046	235371.5708	3596896.6117	107.037
BE047	219992.0150	3593082.5281	96.419
BE048	208071.3673	3592464.7785	91.171
BE049	200612.7660	3597563.3110	120.947
BE050	189249.6326	3605435.5096	71.994
BE051	178834.6790	3606111.3969	54.250
BE052	193988.3476	3613918.7748	58.431
BE053	205560.6899	3609385.2762	75.205
BE054	217609.6327	3606546.9118	76.247
BE055	213570.5449	3619902.0329	79.374
OT043	224695.7250	3639164.0225	73.307
OT044	235062.0485	3629058.1076	81.432
OT045	230776.4006	3621886.3830	73.810
OT046	242881.8010	3620600.4160	122.967
OT048	230099.3281	3600352.1357	113.703
OT049	238480.3589	3592728.2939	108.223
OT050	224424.4059	3591628.1826	107.687
OT052	208866.6720	3604900.8730	87.774
OT055	191480.1827	3611490.7627	60.467
OT056	205910.9031	3618952.4872	61.348
OT057	217452.2869	3615988.7357	81.102
OT058	219654.9436	3627427.7053	68.404
OT066	221363.5012	3611280.2239	82.230
OT067	242345.7133	3627950.6362	118.570

ID	Easting	Northing	Elevation
OT068	195322.5366	3615237.6673	70.316
OT069	185802.9949	3610440.5714	55.577
OT070	217618.1770	3606565.6177	77.321
OT071	235396.3795	3596894.6774	107.122
UR052	189740.8087	3601710.5304	92.137
UR055	185814.7003	3610435.7233	55.466
UR057	205027.8058	3595961.2028	103.785
UR058	208697.3215	3601872.8321	81.157
UR059	212932.6928	3609391.8827	77.148
UR060	214707.9799	3612355.2004	67.698
UR061	219018.9300	3613684.2893	83.746
UR062	211115.1045	3622112.9023	61.044
UR063	220198.4071	3630625.5489	69.600
UR064	221868.7235	3639617.7889	67.576
UR065	243471.8497	3635104.1531	135.246
UR066	232705.3385	3616762.6648	94.321
UR067	237597.3875	3619304.0034	110.190

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

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

ID	Easting	Northing	Elevation
BR034	239214.0998	3638690.5791	102.893
BR035	224833.6812	3633476.0766	97.280
BR036	242337.7598	3627941.1863	118.227
BR037	221371.6295	3611273.2750	82.504
BR038	235413.8100	3603217.3905	100.198
BR039	229535.5117	3593389.8467	112.459
BR040	200288.8554	3603098.7502	99.429
BR041	195038.1832	3607201.1114	83.052
BR042	206100.2074	3614593.2346	64.575
BR043	210225.6614	3616912.0540	69.459

ID	Easting	Northing	Elevation
BR044	218955.7089	3621017.8078	82.969
HG038	226821.9445	3637338.8935	101.685
HG039	237670.5567	3630142.7174	89.759
HG040	227620.1267	3628086.3964	93.148
HG041	237183.0256	3616001.9052	106.377
HG042	236628.6376	3600347.9095	96.866
HG043	225401.1608	3598660.1241	99.080
HG044	210830.7861	3598079.8873	101.815
HG045	195833.9592	3604356.2187	99.835
HG046	177404.6665	3603479.1695	65.034
HG047	195293.6405	3615239.4322	69.763
HG048	215004.1287	3617385.5742	66.935
HG056	200459.5085	3612406.4910	76.588
HG057	232060.9349	3596178.7038	116.295
TR037	235770.7513	3635050.3542	109.390
TR038	238465.8181	3627296.3664	103.667
TR039	234066.0898	3611467.0515	97.569
TR040	232064.1083	3596117.2997	115.523
TR041	225795.3655	3595733.5854	133.978
TR042	220847.9967	3609518.1836	76.720
TR043	214339.6779	3601820.9735	82.388
TR044	197109.9450	3598073.3158	99.386
TR045	183597.0749	3600743.3448	58.941
TR046	200447.2280	3612381.4339	75.987
TR047	204791.6930	3618904.9651	58.740
TR055	224680.5360	3639178.6483	72.691
TR056	243461.1928	3635123.6705	135.057
TR057	195825.0150	3604327.0444	100.686
TR058	208699.2641	3601886.0522	81.442

Table 7: Vegetated Vertical Accuracy (VVA) Point Coordinates

Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

SECTION 3: DATA PRODUCTION

3.1 Aerial LiDAR Project – Calibration/Classification

3.1.1 LiDAR Point Cloud Generation

Atlantic used 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	UTM 16N
Coordinate System	NAD 83 (2011)
Vertical Datum	NAVD88
Geoid Model	12B
EPSG Code	6345
Units of Reference	METER

Table 8: Coordinate Reference System

3.1.3 LiDAR Point Cloud Statistics

Category	Value
Total Points	6,947,572,720
Nominal Pulse Spacing (m)	0.5503
Nominal Pulse Density (pls/m²)	3.3017
Aggregate Total Points	6,947,572,720
Aggregate Nominal Pulse Spacing (m)	0.6318
Aggregate Nominal Pulse Density (pls/m²)	2.5053

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 ≤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	Unclassified
2	Ground
6	Building
7	Low Point (“Low Noise”)
9	Water
17	Bridge Deck
18	High Point (“High Noise”)
20	Breakline Proximity

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 .tif 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 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 (.gdb) for the entire block 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.

3.1.10 Contours

Contours for this project were generated utilizing Model Key Points LiDAR point cloud data. Contours were generated at 1.0 foot intervals, with 1.0 foot contours designated as intermediate and every fifth contour interval as index contours. This product was delivered as an ESRI geodatabase (.gdb) for the entire block area.

3.1.11 Building Footprint Extractions

Building Footprints were derived from lidar points classified as buildings. Building rooftop polygons for features 400 square feet and larger were extracted from automated building classification algorithms performed on the lidar point cloud data. Omission/Commission errors will exist. Rooftop outlines may appear “generalized” or incomplete in certain areas where vegetation or other artifacts are present in the data. This product was delivered as an ESRI geodatabase (.gdb) for the entire block area.

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 11: Vertical Accuracy Standards, Source: ASPRS Positional Accuracy Standards for Digital Geospatial Data v1.0 (2014)

*The terms NVA and VVA are from the American Society for Photogrammetry and Remote Sensing (ASPRS) Positional Accuracy Standards for Digital Geospatial Data v1.0 (2014). The term NVA refers to assessments in clear, open areas (which typically produce only single LiDAR returns); the term VVA refers to assessments in vegetated areas (typically characterized by multiple return LiDAR).

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)	46	0.0445	0.0872	0.0728
NVA (DEM)	46	0.0430	0.0843	0.0710
VVA (Point Cloud)	39	0.0837	0.1640	0.1662
VVA (DEM)	39	0.0824	0.1615	0.1530

Table 12: 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
BE041	231590.5843	3635011.1662	86.6400	86.6230	-0.0170	NVA
BE042	225776.7741	3625259.5636	80.0490	80.0420	-0.0070	NVA
BE043	234732.7604	3621731.7185	94.1880	94.1610	-0.0270	NVA
BE044	221561.6318	3615492.3206	89.3080	89.2540	-0.0540	NVA
BE045	234819.8353	3606369.7456	92.8380	92.7870	-0.0510	NVA
BE046	235371.5708	3596896.6117	107.0370	107.0180	-0.0190	NVA
BE047	219992.0150	3593082.5281	96.4190	96.3660	-0.0530	NVA
BE048	208071.3673	3592464.7785	91.1710	91.1820	0.0110	NVA
BE049	200612.7660	3597563.3110	120.9470	120.9450	-0.0020	NVA
BE050	189249.6326	3605435.5096	71.9940	72.0440	0.0500	NVA
BE051	178834.6790	3606111.3969	54.2500	54.2860	0.0360	NVA
BE052	193988.3476	3613918.7748	58.4310	58.4070	-0.0240	NVA
BE053	205560.6899	3609385.2762	75.2050	75.2060	0.0010	NVA
BE054	217609.6327	3606546.9118	76.2470	76.2430	-0.0040	NVA
BE055	213570.5449	3619902.0329	79.3740	79.3450	-0.0290	NVA
BR034	239214.0998	3638690.5791	102.8930	102.8960	0.0030	VVA
BR035	224833.6812	3633476.0766	97.2800	97.3070	0.0270	VVA
BR036	242337.7598	3627941.1863	118.2270	118.3060	0.0790	VVA
BR037	221371.6295	3611273.2750	82.5040	82.6190	0.1150	VVA
BR038	235413.8100	3603217.3905	100.1980	100.3180	0.1200	VVA
BR039	229535.5117	3593389.8467	112.4590	112.4650	0.0060	VVA
BR040	200288.8554	3603098.7502	99.4290	99.4800	0.0510	VVA
BR041	195038.1832	3607201.1114	83.0520	83.2180	0.1660	VVA
BR042	206100.2074	3614593.2346	64.5750	64.7430	0.1680	VVA
BR043	210225.6614	3616912.0540	69.4590	69.6400	0.1810	VVA
BR044	218955.7089	3621017.8078	82.9690	83.0030	0.0340	VVA
HG038	226821.9445	3637338.8935	101.6850	101.7120	0.0270	VVA
HG039	237670.5567	3630142.7174	89.7590	89.7720	0.0130	VVA
HG040	227620.1267	3628086.3964	93.1480	93.2590	0.1110	VVA
HG041	237183.0256	3616001.9052	106.3770	106.3600	-0.0170	VVA
HG042	236628.6376	3600347.9095	96.8660	96.9670	0.1010	VVA
HG043	225401.1608	3598660.1241	99.0800	99.1890	0.1090	VVA
HG044	210830.7861	3598079.8873	101.8150	101.8770	0.0620	VVA
HG045	195833.9592	3604356.2187	99.8350	99.9430	0.1080	VVA
HG046	177404.6665	3603479.1695	65.0340	65.1090	0.0750	VVA
HG047	195293.6405	3615239.4322	69.7630	69.7840	0.0210	VVA
HG048	215004.1287	3617385.5742	66.9350	66.9490	0.0140	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
HG056	200459.5085	3612406.4910	76.5880	76.7430	0.1550	VVA
HG057	232060.9349	3596178.7038	116.2950	116.3170	0.0220	VVA
OT043	224695.7250	3639164.0225	73.3070	73.2820	-0.0250	NVA
OT044	235062.0485	3629058.1076	81.4320	81.4810	0.0490	NVA
OT045	230776.4006	3621886.3830	73.8100	73.7610	-0.0490	NVA
OT046	242881.8010	3620600.4160	122.9670	122.8880	-0.0790	NVA
OT048	230099.3281	3600352.1357	113.7030	113.7780	0.0750	NVA
OT049	238480.3589	3592728.2939	108.2230	108.1910	-0.0320	NVA
OT050	224424.4059	3591628.1826	107.6870	107.6220	-0.0650	NVA
OT052	208866.6720	3604900.8730	87.7740	87.8510	0.0770	NVA
OT055	191480.1827	3611490.7627	60.4670	60.5010	0.0340	NVA
OT056	205910.9031	3618952.4872	61.3480	61.2980	-0.0500	NVA
OT057	217452.2869	3615988.7357	81.1020	81.2090	0.1070	NVA
OT058	219654.9436	3627427.7053	68.4040	68.4440	0.0400	NVA
OT066	221363.5012	3611280.2239	82.2300	82.2770	0.0470	NVA
OT067	242345.7133	3627950.6362	118.5700	118.5950	0.0250	NVA
OT068	195322.5366	3615237.6673	70.3160	70.3120	-0.0040	NVA
OT069	185802.9949	3610440.5714	55.5770	55.6030	0.0260	NVA
OT070	217618.1770	3606565.6177	77.3210	77.3780	0.0570	NVA
OT071	235396.3795	3596894.6774	107.1220	107.1180	-0.0040	NVA
TR037	235770.7513	3635050.3542	109.3900	109.4180	0.0280	VVA
TR038	238465.8181	3627296.3664	103.6670	103.6510	-0.0160	VVA
TR039	234066.0898	3611467.0515	97.5690	97.6030	0.0340	VVA
TR040	232064.1083	3596117.2997	115.5230	115.6230	0.1000	VVA
TR041	225795.3655	3595733.5854	133.9780	133.9430	-0.0350	VVA
TR042	220847.9967	3609518.1836	76.7200	76.7800	0.0600	VVA
TR043	214339.6779	3601820.9735	82.3880	82.3640	-0.0240	VVA
TR044	197109.9450	3598073.3158	99.3860	99.2790	-0.1070	VVA
TR045	183597.0749	3600743.3448	58.9410	58.8290	-0.1120	VVA
TR046	200447.2280	3612381.4339	75.9870	75.8920	-0.0950	VVA
TR047	204791.6930	3618904.9651	58.7400	58.7120	-0.0280	VVA
TR055	224680.5360	3639178.6483	72.6910	72.7110	0.0200	VVA
TR056	243461.1928	3635123.6705	135.0570	135.1490	0.0920	VVA
TR057	195825.0150	3604327.0444	100.6860	100.7090	0.0230	VVA
TR058	208699.2641	3601886.0522	81.4420	81.5000	0.0580	VVA
UR052	189740.8087	3601710.5304	92.1370	92.1670	0.0300	NVA
UR055	185814.7003	3610435.7233	55.4660	55.4720	0.0060	NVA
UR057	205027.8058	3595961.2028	103.7850	103.8040	0.0190	NVA
UR058	208697.3215	3601872.8321	81.1570	81.2220	0.0650	NVA
UR059	212932.6928	3609391.8827	77.1480	77.1780	0.0300	NVA
UR060	214707.9799	3612355.2004	67.6980	67.7470	0.0490	NVA
UR061	219018.9300	3613684.2893	83.7460	83.7620	0.0160	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
UR062	211115.1045	3622112.9023	61.0440	60.9590	-0.0850	NVA
UR063	220198.4071	3630625.5489	69.6000	69.6660	0.0660	NVA
UR064	221868.7235	3639617.7889	67.5760	67.5590	-0.0170	NVA
UR065	243471.8497	3635104.1531	135.2460	135.2630	0.0170	NVA
UR066	232705.3385	3616762.6648	94.3210	94.2840	-0.0370	NVA
UR067	237597.3875	3619304.0034	110.1900	110.1520	-0.0380	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
BE041	231590.5843	3635011.1662	86.6400	86.6192	-0.0208	NVA
BE042	225776.7741	3625259.5636	80.0490	80.0470	-0.0020	NVA
BE043	234732.7604	3621731.7185	94.1880	94.1651	-0.0229	NVA
BE044	221561.6318	3615492.3206	89.3080	89.2501	-0.0579	NVA
BE045	234819.8353	3606369.7456	92.8380	92.7850	-0.0530	NVA
BE046	235371.5708	3596896.6117	107.0370	107.0217	-0.0153	NVA
BE047	219992.0150	3593082.5281	96.4190	96.3650	-0.0540	NVA
BE048	208071.3673	3592464.7785	91.1710	91.1888	0.0178	NVA
BE049	200612.7660	3597563.3110	120.9470	120.9438	-0.0032	NVA
BE050	189249.6326	3605435.5096	71.9940	72.0420	0.0480	NVA
BE051	178834.6790	3606111.3969	54.2500	54.2839	0.0339	NVA
BE052	193988.3476	3613918.7748	58.4310	58.4070	-0.0240	NVA
BE053	205560.6899	3609385.2762	75.2050	75.2051	0.0001	NVA
BE054	217609.6327	3606546.9118	76.2470	76.2424	-0.0046	NVA
BE055	213570.5449	3619902.0329	79.3740	79.3457	-0.0283	NVA
OT043	224695.7250	3639164.0225	73.3070	73.2873	-0.0197	NVA
OT044	235062.0485	3629058.1076	81.4320	81.4737	0.0417	NVA
OT045	230776.4006	3621886.3830	73.8100	73.7716	-0.0384	NVA
OT046	242881.8010	3620600.4160	122.9670	122.8928	-0.0742	NVA
OT048	230099.3281	3600352.1357	113.7030	113.7837	0.0807	NVA
OT049	238480.3589	3592728.2939	108.2230	108.1890	-0.0340	NVA
OT050	224424.4059	3591628.1826	107.6870	107.6229	-0.0641	NVA
OT052	208866.6720	3604900.8730	87.7740	87.8479	0.0739	NVA
OT055	191480.1827	3611490.7627	60.4670	60.4919	0.0249	NVA
OT056	205910.9031	3618952.4872	61.3480	61.2967	-0.0513	NVA
OT057	217452.2869	3615988.7357	81.1020	81.2045	0.1025	NVA
OT058	219654.9436	3627427.7053	68.4040	68.4459	0.0419	NVA
OT066	221363.5012	3611280.2239	82.2300	82.2719	0.0419	NVA
OT067	242345.7133	3627950.6362	118.5700	118.6051	0.0351	NVA
OT068	195322.5366	3615237.6673	70.3160	70.3091	-0.0069	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
OT069	185802.9949	3610440.5714	55.5770	55.6050	0.0280	NVA
OT070	217618.1770	3606565.6177	77.3210	77.3608	0.0398	NVA
OT071	235396.3795	3596894.6774	107.1220	107.1139	-0.0081	NVA
UR052	189740.8087	3601710.5304	92.1370	92.1657	0.0287	NVA
UR055	185814.7003	3610435.7233	55.4660	55.4639	-0.0021	NVA
UR057	205027.8058	3595961.2028	103.7850	103.8051	0.0201	NVA
UR058	208697.3215	3601872.8321	81.1570	81.2150	0.0580	NVA
UR059	212932.6928	3609391.8827	77.1480	77.1766	0.0286	NVA
UR060	214707.9799	3612355.2004	67.6980	67.7410	0.0430	NVA
UR061	219018.9300	3613684.2893	83.7460	83.7577	0.0117	NVA
UR062	211115.1045	3622112.9023	61.0440	60.9593	-0.0847	NVA
UR063	220198.4071	3630625.5489	69.6000	69.6624	0.0624	NVA
UR064	221868.7235	3639617.7889	67.5760	67.5581	-0.0179	NVA
UR065	243471.8497	3635104.1531	135.2460	135.2548	0.0088	NVA
UR066	232705.3385	3616762.6648	94.3210	94.2768	-0.0442	NVA
UR067	237597.3875	3619304.0034	110.1900	110.1518	-0.0382	NVA

Table 14: DEM NVA Check Point Assessment

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BR034	239214.0998	3638690.5791	102.8930	102.9493	0.0563	VVA
BR035	224833.6812	3633476.0766	97.2800	97.2879	0.0079	VVA
BR036	242337.7598	3627941.1863	118.2270	118.2895	0.0625	VVA
BR037	221371.6295	3611273.2750	82.5040	82.6199	0.1159	VVA
BR038	235413.8100	3603217.3905	100.1980	100.2624	0.0644	VVA
BR039	229535.5117	3593389.8467	112.4590	112.4514	-0.0076	VVA
BR040	200288.8554	3603098.7502	99.4290	99.4999	0.0709	VVA
BR041	195038.1832	3607201.1114	83.0520	83.2209	0.1689	VVA
BR042	206100.2074	3614593.2346	64.5750	64.7262	0.1512	VVA
BR043	210225.6614	3616912.0540	69.4590	69.6640	0.2050	VVA
BR044	218955.7089	3621017.8078	82.9690	82.9968	0.0278	VVA
HG038	226821.9445	3637338.8935	101.6850	101.7169	0.0319	VVA
HG039	237670.5567	3630142.7174	89.7590	89.7700	0.0110	VVA
HG040	227620.1267	3628086.3964	93.1480	93.2476	0.0996	VVA
HG041	237183.0256	3616001.9052	106.3770	106.3573	-0.0197	VVA
HG042	236628.6376	3600347.9095	96.8660	96.9257	0.0597	VVA
HG043	225401.1608	3598660.1241	99.0800	99.1880	0.1080	VVA
HG044	210830.7861	3598079.8873	101.8150	101.8756	0.0606	VVA
HG045	195833.9592	3604356.2187	99.8350	99.9392	0.1042	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
HG046	177404.6665	3603479.1695	65.0340	65.1091	0.0751	VVA
HG047	195293.6405	3615239.4322	69.7630	69.7769	0.0139	VVA
HG048	215004.1287	3617385.5742	66.9350	66.9622	0.0272	VVA
HG056	200459.5085	3612406.4910	76.5880	76.7383	0.1503	VVA
HG057	232060.9349	3596178.7038	116.2950	116.3133	0.0183	VVA
TR037	235770.7513	3635050.3542	109.3900	109.4172	0.0272	VVA
TR038	238465.8181	3627296.3664	103.6670	103.6415	-0.0255	VVA
TR039	234066.0898	3611467.0515	97.5690	97.5871	0.0181	VVA
TR040	232064.1083	3596117.2997	115.5230	115.6133	0.0903	VVA
TR041	225795.3655	3595733.5854	133.9780	133.9439	-0.0341	VVA
TR042	220847.9967	3609518.1836	76.7200	76.7758	0.0558	VVA
TR043	214339.6779	3601820.9735	82.3880	82.3654	-0.0226	VVA
TR044	197109.9450	3598073.3158	99.3860	99.2888	-0.0972	VVA
TR045	183597.0749	3600743.3448	58.9410	58.8272	-0.1138	VVA
TR046	200447.2280	3612381.4339	75.9870	75.8524	-0.1346	VVA
TR047	204791.6930	3618904.9651	58.7400	58.7120	-0.0280	VVA
TR055	224680.5360	3639178.6483	72.6910	72.7012	0.0102	VVA
TR056	243461.1928	3635123.6705	135.0570	135.1524	0.0954	VVA
TR057	195825.0150	3604327.0444	100.6860	100.7035	0.0175	VVA
TR058	208699.2641	3601886.0522	81.4420	81.5099	0.0679	VVA

Table 15: DEM VVA Check Point Assessment