LiDAR Project Report

140G0218F0143,
SC East Central 2017 D18

Prepared For:

United State Geological Survey

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Project Report
LiDAR Collection, Processing, and QA/QC

140G0218F0143, SC East Central
2017 D18

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SC East Central 2017 D18

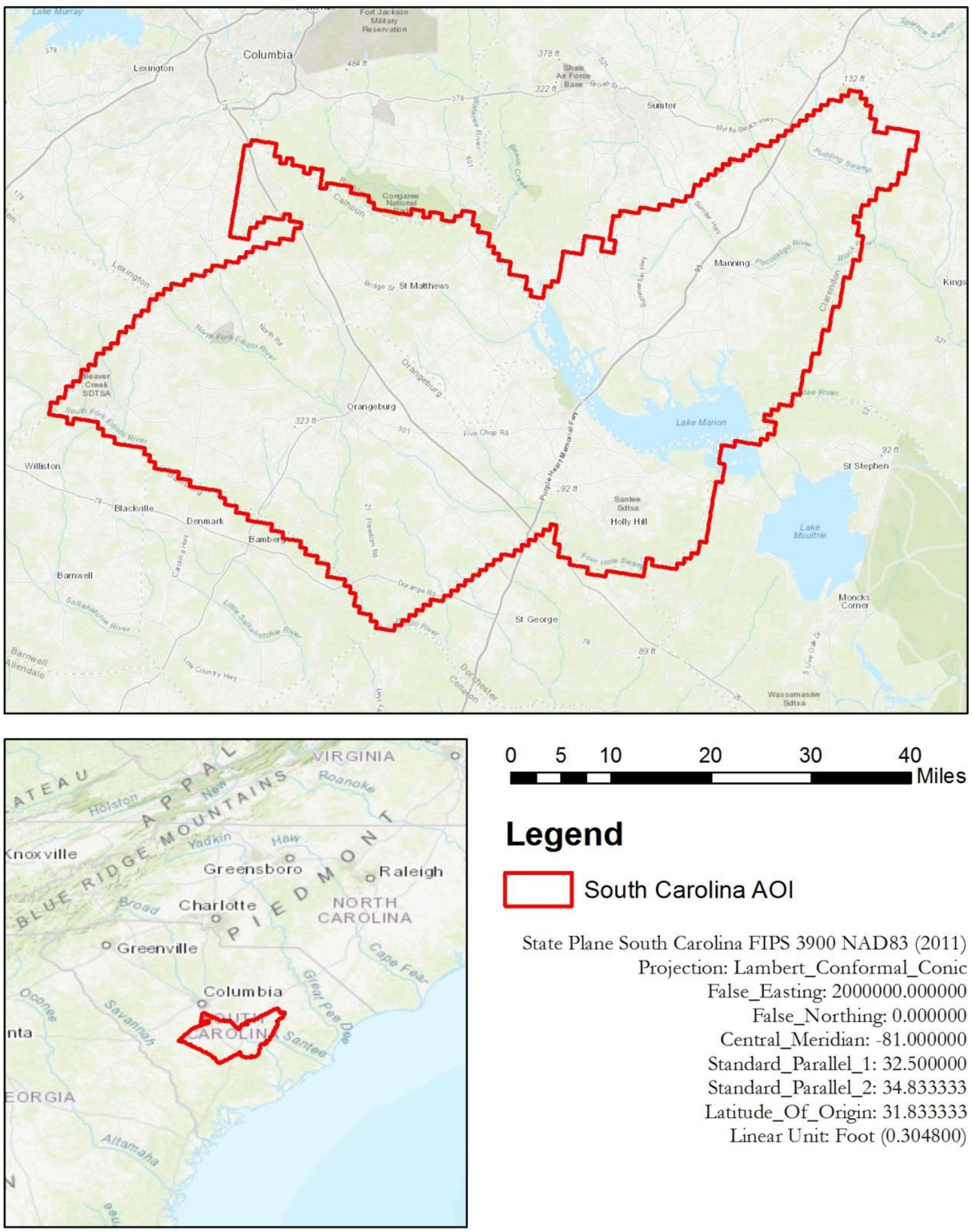

Image 1: SC East Central 2017 D18 LiDAR AOI

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Abbreviations

ANPD – Aggregate Nominal Pulse Density
ASPRS – American Society for Photogrammetry and Remote Sensing
DEM – Digital Elevation Model
DSM – Digital Surface Model
DTM – Digital Terrain Model
GSD – Ground Sample Distance
GNSS - Global Navigation Satellite System
GPS – Global Positioning System
IMU – Inertial Measurement Unit
INS – Inertial Navigation System
NPD − Nominal Pulse Density
NMAS − National Map Accuracy Standard
NPS − Nominal Pulse Spacing
NSSDA − National Standard for Spatial Data Accuracy
NVA − Non-vegetated Vertical Accuracy
PDOP – Airborne GPS positional dilution of precision
PPSM – Points Per Square Meter
QL2 – USGS Quality Level 2
RMSE − root-mean-square-error
RMSEr − the horizontal linear RMSE in the radial direction; includes both x- and y-coordinate errors.
RMSEx − the horizontal linear RMSE in the X direction (Easting)
RMSEy − the horizontal linear RMSE in the Y direction (Northing)
RMSEz − the vertical linear RMSE in the Z direction (Elevation)
RMSDz − root-mean-square-difference in elevation (z)
SBET – Smooth Best Estimate of Trajectory
TIN – Triangulated Irregular Network
USGS – United States Geological Survey
VVA − Vegetated Vertical Accuracy

1 Introduction and Specifications

Digital Aerial Solutions, LLC (DAS) was tasked to collect and process a Light Detection And Ranging (LiDAR) derived elevation dataset for the 140G0218F0143, SC East Central 2017 D18 LiDAR. The area encompasses approximately 2215 square miles Aerial LiDAR data was collected utilizing a Leica ALS80. The ALS80 is a discrete return topographic LiDAR mapping system manufactured by Leica Geosystems. LiDAR data collected for the 140G0218F0143, SC East Central 2017 D18 LiDAR survey has an Aggregate Nominal Pulse (ANPS) spacing of USGS Quality Level 2 (QL2) at 0.71 meters, and includes up to 4 discrete returns per pulse, along with intensity values for each return.

LiDAR datasets were post processed to generate elevation point cloud swaths for each flight line. Deliverables include the point cloud swaths, tiled point clouds classified by land cover type, breaklines to support hydro-flattening of digital elevation models, intensity tiles and bare-earth DEM tiles. The point cloud deliverables are stored in the LAS version 1.4, point data record format 6. The tiling scheme for the NRCS tiled deliverables is a 5000 US Feet x 5000 US Feet grid while for the Albers grid it is 1,000 Meters x 1,000 Meters. Tile number is the appropriate cell number values found in the USNG index. All deliverables were generated in conformance with the U.S. Geological Survey National Geospatial Program Guidelines and Base Specifications, Version 1.3.

2 Spatial Reference System

The spatial reference of the data is as follows:

Horizontal Spatial Reference #1

- Coordinates: State Plane South Carolina FIPS 3900
    - (to 2 decimal places)
- Datum: North American Datum 1983 (2011)
    - US Survey Foot (to 2 decimal places)

Vertical Spatial Reference #1

All datasets are available with orthometric elevation; point cloud datasets are also available with ellipsoid heights.

- Datum: North American Vertical Datum of 1988 (GEOID12B)
    - US Survey Foot (to 2 decimal places)

Horizontal Spatial Reference #2

- Coordinates: Albers Conical Equal Area
    - (to 2 decimal places)
- Datum: North American Datum 1983 (2011)
    - Meters (to 2 decimal places)

Vertical Spatial Reference #2

All datasets are available with orthometric elevation; point cloud datasets are also available with ellipsoid heights.

- Datum: North American Vertical Datum of 1988 (GEOID12B)
    - Meters (to 2 decimal places)

3 LiDAR Acquisition

3.1 Survey Area

The SC East Central 2017 D18 LiDAR survey covers approximately 2215 square miles for the QL2 area covering Calhoun, Clarendon and Orangeburg counties in SC. The flight plan consisted of 201 survey lines and 3 control lines.

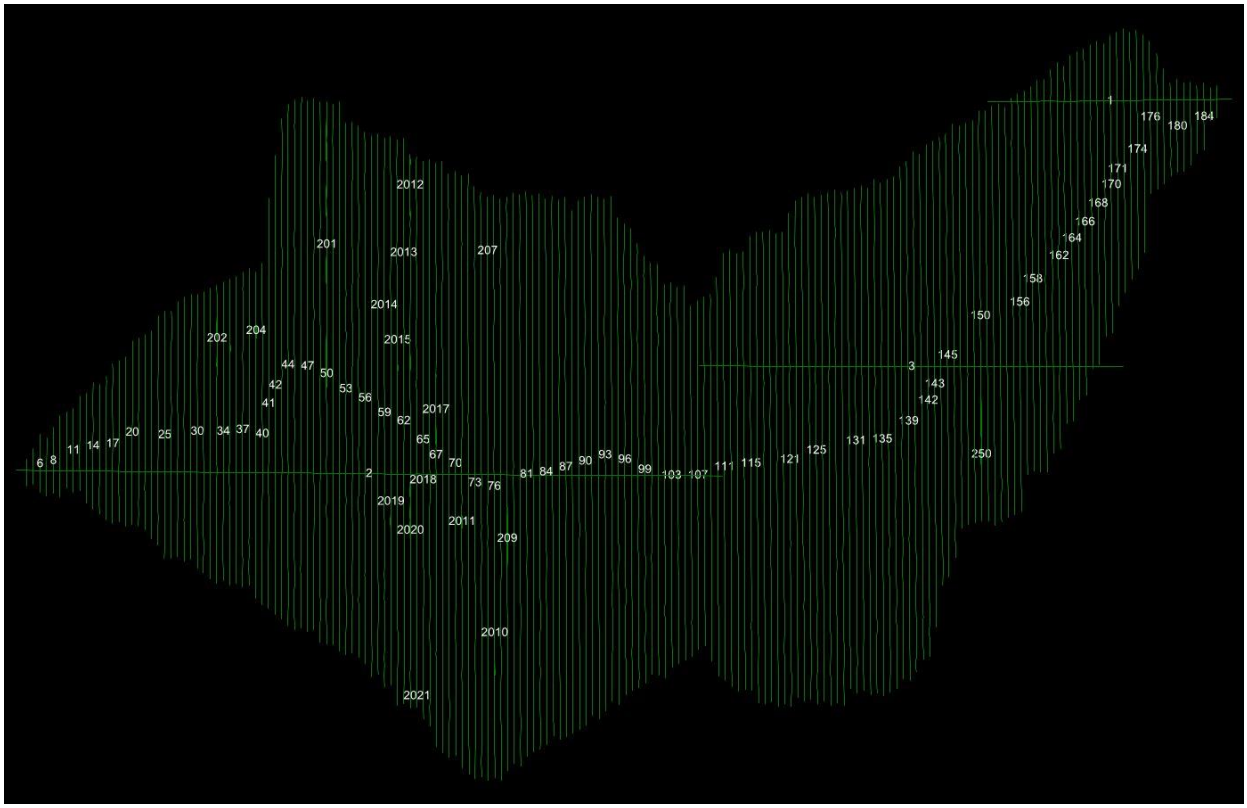

Image 2: SC East Central 2017 D18 LiDAR Flightlines

3.2 Acquisition Parameters

Acquisition parameters include the sensor configuration and the flight plan characteristics, and are selected based on a number of project specific criteria. Criteria reviewed include the required accuracies for the final dataset, the land cover types within the project survey area, and the required nominal pulse spacing. Aggregate Nominal Pulse Density for QL2 Area of Interest is no less than 2ppsm. The project parameters are summarized below.

Parameter	QL2
Flying Height Above Ground Level:	5,430 feet
Nominal Sidelap:	30%
Nominal Speed Over Ground:	155 Knots
Field of View:	38°
Laser Rate:	331.0 kHz
Scan Rate:	53.3 Hz
Maximum Cross Track Spacing:	1.07 meters
Maximum Along Track Spacing:	0.75 meters
Average point Spacing:	0.52 meters

Table 1: Flight Parameters

3.3 Acquisition Mission

The acquisition mission for 140G0218F0143, SC East Central 2017 D18 LiDAR survey was coordinated for optimal collection conditions and was acquired within eight days. Collection began on April 11, 2018 and was completed on April 18, 2018.

3.4 Airborne GPS/IMU

Airborne global positioning system (GPS) and inertial measurement unit (IMU) data were collected on the aircraft during the acquisition mission, providing sensor position and orientation information for geo-referencing the LiDAR data. Airborne GPS observations were collected at a frequency of 2Hz, and IMU observations were collected at a frequency of 200Hz.

Aircraft	Sensor	GPS Lever Arm (m)	IMU Lever Arm (m)
C421-N12RF	ALS80 SN# 8137	X: -0.189, Y: -0.053, Z: -1.367	X: -0.450, Y: 0.164, Z: -0.169
C421-112MJ	ALS80 SN# 8235	X: -0.156, Y: -0.048, Z: -1.376	X: -0.450, Y: 0.164, Z: -0.169

Table 2: Aircraft and Lever Arms

GPS data were collected with ground base stations during the acquisition missions, providing corrections to support differential post-processing of the airborne GPS. Base stations were setup at Orangeburg Municipal Airport SC. Ground GPS observations were collected at a frequency of 2Hz. The use of two base stations was employed to support data acquisition for the project area. The following table's (Table 3) list the positions used in to post-process the airborne GPS.

Name	Latitude	Longitude	Ellipsoid (m)
Orangeburg Municipal Airport, KOGB	33° 27' 54.10259"	-80° 51' 21.30475"	27.495
Orangeburg Municipal Airport, KOGB1	33° 27' 53.96102"	-80° 51' 21.32084"	27.482

Table 3: Base Stations locations

4 LiDAR Processing

4.1 Acquisition Post-Processing

For each mission, airborne GPS were differentially corrected using the ground base station GPS for the corresponding day in Inertial Explorer software. The resulting solution were check to assure an accuracy of +/- 3 cm combined separation for north, east and height position difference between the forward and reverse processing solutions.

Airborne GPS and IMU data were post processed to develop a Smooth Best Estimate of Trajectory (SBET) for each mission, using Leica's Inertial Explorer software. Inertial Explorer applies the reference lever arms for the GPS and IMU measurement system during the processing to determine the trajectory (position and orientation) of the LiDAR sensor during the acquisition mission. The lever arm values were resolved in Inertial Explorer to validate the measurement made during sensor installation in the aircraft.

Raw LiDAR sensor ranging data and the final sensor trajectory from IPAS were processed in Leica's Cloud Pro software to produce the LiDAR elevation point cloud swaths for each flight line, stored in LAS version 1.4 file format. Quality control of the swath point clouds was performed to validate proper function of the sensor systems, full coverage of the project AOI, and point density consistent with the planned nominal pulse spacing.

Swath point clouds were assigned a unique File Source ID within the LAS file format before further processing. Swath files for the 140G0218F0143, SC East Central 2017 D18 LiDAR project were numbered in chronological order of acquisition.

4.2 Geometric Calibration

Geometric and positional accuracy of the LiDAR swath point clouds is highly dependent on accurate calibration of the various subsystems within the LiDAR sensor system. Sensor calibration parameters fall into two categories, one being those parameters proprietary to the manufacturer's sensor design, and the other being parameters common to most commercial airborne LiDAR sensors, the IMU to laser reference system alignment angles (bore sight calibration), and mirror deformation constants (scaling).

The manufacturer specific calibration parameters are applied in Leica's Cloud Pro software for the Leica ALS80 sensor system. Terrasolid's Terramatch software was used to calculate the IMU bore-sight and mirror scale parameters for the 140G0218F0143, SC East Central 2017 D18 LiDAR. Within the TerraMatch software, the Tie- line workflow was used to solve for the parameters. The Tie-line workflow involves automated selection of numerous 'tie-lines', which represent a linear segment fit to the data that should have the same slope, azimuth, position and elevation, within the overlap sections of the survey lines and control lines. The tie-lines provide observations for algorithms within TerraMatch to solve for the bore-sight and mirror scale parameters for the lift.

The Tie-line workflow is dependent upon well distributed tie-lines throughout the swath point clouds to effectively solve for bore-sight and mirror scale parameters with the automated algorithms.

Manual estimation of the bore-sight calibration and mirror scale parameters was performed using the observed tie-lines in overlap areas.

The final step of geometric calibration is to determine elevation (z) offset corrections to be applied to the swath point clouds. The Z values calculated during the course of the acquisition mission can vary at the centimeter level as the GPS satellite constellation observed in the survey area changes with satellites moving through their orbits over the course of the mission. Baseline length from the ground base station GPS to the airborne GPS can also impact the z values calculated for the swath point clouds. The Z offset corrections are calculated in two steps; a relative step, where individual lines are corrected one to another using the adjusted tie-lines from the bore-sight and mirror scale calculation step; and an absolute step, where groups of lines are leveled to project ground control.

For 140G0218F0143, SC East Central 2017 D18 LiDAR project, the control lines were used to determine relative z offset corrections in areas of discernible ground. The ground control points listed below were used to adjust the LiDAR by an average of -0.073 meters.

Point ID	NORTHING (Int. Foot)	EASTING (Int. Foot)	ORTHO (US Survey Foot)
19.GCP.BG	607142.800	1918014.231	225.190
26.GCP.BG	670602.208	2025061.276	335.373
31.GCP.BG	668098.126	2063548.921	315.278
37.GCP.BG	591318.524	2086445.170	160.219
6.GCP.BG	550946.336	2097338.224	140.341
71.GCP.BG	719390.764	2268785.065	79.239
1.GCP.HP	592094.532	2047043.832	192.949
11.GCP.HP	599754.678	2043898.541	198.093
22.GVP.HP	648587.527	1972327.750	292.745
27.GCP.HP	696707.145	1980769.442	389.632
28.GCP.HP	741948.110	1989087.047	249.760
31.GVP.HP	679027.599	2042849.562	339.602
35.GCP.HP	669671.673	2116725.569	167.024
4.GCP.HP	515296.108	2056369.358	121.906
43.GCP.HP	547629.897	2167827.261	98.779
47.GCP.HP	568483.422	2199071.563	111.965
55.GCP.HP	638346.828	2195990.584	115.026
61.GCP.HP	631418.305	2262073.104	126.673
65.GCP.HP	678594.210	2239708.578	126.079
74.GCP.HP	732989.231	2294494.739	101.407
76.GCP.HP	736452.953	2331326.203	94.311
82.GCP.HP	689592.125	2206320.915	154.701
85.GCP.HP	628654.594	2087107.178	179.560
89.GCP.HP	593792.369	2043791.466	195.393
93.GCP.HP	626412.547	2054356.871	301.361

Table 5: Ground Control Points Units: US Feet

The final geometrically calibrated swath point clouds were compared to the bare-earth profile survey data. The data fit the profile surveys within the vertical accuracy tolerance specified for the project. Full documentation of the vertical accuracy checks maybe found in section 5.1.

4.3 Point Cloud Classification

Georeference information was applied to the swath point cloud LAS files. Geometrically calibrated swath point clouds were cut into tiles in 1.4 format for point cloud classification and derived in LAS 1.4 format for product creation.

Tiled point cloud data was processed in Terrasolid's Terrascan software to assign initial classification values. The Terrascan software provides a number of routines to algorithmically detect and assign points to their appropriate class. Points left unclassified by the algorithmic routine remain as Class 1

– Processed, but unclassified. Automated classification routines assigned points to one of the following classes:

```
Class 1 — Processed, but unclassified
Class 2 — Bare-earth ground
Class 7 — Low Noise (low, manually identified, if necessary)
Class 6 — Buildings
Class 9 — Water
Class 17 — Bridge Decks
Class 18 — High Noise (high, manually identified, if necessary)
Class 20 — Ignored Ground (breakline proximity)
Class 21 — Snow (where reliable identifiable)
Class 22 — Temporal Exclusion (typically non-favored data in intertidal zones)
```

Automated classification results were reviewed for each tiled point cloud, and manual edits made where necessary to correct for misclassified points. Points remaining in Class 1 after the automated classification routines were run were left in Class 1. Points falling outside of a 100 meter buffer of the project AOI polygon were excluded from the tiled point clouds.

4.4 Breakline Collection

Manual breakline collection was performed to support the hydro-flattening requirements of the project's DEM deliverables. Breaklines where collected directly from triangulated irregular network (TIN) surface models built from the classified point clouds and intensity raster's. They were then conflated using the LiDAR point cloud. Breaklines were delivered ESRI GDB format.

The data collected for the 140G0218F0143, SC East Central 2017 D18 LiDAR survey maintained significant point density in the water, marsh, and swamp, limiting the usefulness of point density as guiding factor in breakline placement.

5 Quality Control

5.1 Point Clouds

Accuracy and completeness of the LiDAR point clouds directly impacts the quality of all other derived LiDAR derived products. Ensuring a quality LiDAR dataset begins with proper mission planning and execution. Ground GPS base stations are located such that GPS baselines between the ground and airborne receivers do not exceed 30km. For the 140G0218F0143, SC East Central 2017 D18 LiDAR project, two base stations were run to meet this requirement. Static alignment is performed both

before take-off and after landing to allow for GPS integer ambiguity resolution. Sensor operators carefully monitor the LiDAR unit and its various subsystems during the acquisition mission to ensure proper function. Airborne GPS positional dilution of precision (PDOP) estimates are monitored to ensure they remain less than 3.The optical system is monitored to ensure there are no ranging errors encountered during the flight lines.

During acquisition post-processing estimates of the trajectory data accuracy are reviewed to ensure they will support the required accuracies of the point cloud data. The trajectory accuracy is a function of the differentially corrected GPS data and the IMU data.

The raw swath point clouds generated from Leica's Cloud Pro are reviewed as another check for proper sensor function. The point clouds are reviewed for full coverage of the AOI, required point density and nominal pulse spacing, clustering, proper intensity values, full swath coverage within the planned field of view, and planned survey line overlap.

Geometric calibration quality control validates that the positional accuracy requirements of the project are met, and includes relative accuracy assessments for intra-swath (within) and inter-swath (between) accuracy, along with absolute accuracy assessments against project ground control.

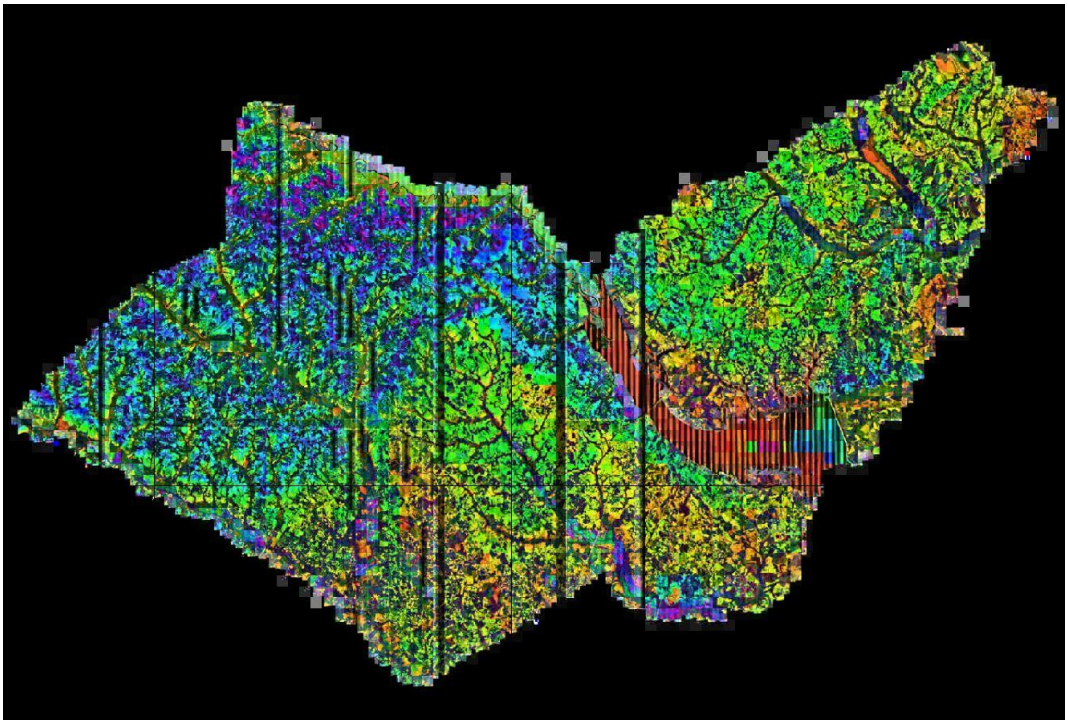

Image 3: SC East Central 2017 D18 LiDAR QL2 Intensity Image

Relative vertical accuracy assessments are normally made using the tie-lines generated in the Terramatch software, as these lines provide positional observations throughout the extent of individual swaths, and between neighboring swaths.

The root mean square error or (RMSE) of the data set was produced to meet ASPRS "Positional Accuracy Standards for Digital Geospatial Data" (2014) for a 0.226 (Meters) RMSEx / RMSEy Horizontal Accuracy Class which equates to Positional Horizontal Accuracy =+/- 0.783 (Meters) at a 95% confidence level.

Estimated LiDAR Horizontal:	(Meters)
Error Per Point ($RMSE_R$)	0.320
Error Per Point ($RMSE_X$/$RMSE_Y$)	0.226
Per Point at 95% confidence level	0.783

Table 6: Estimated LiDAR Horizontal Accuracy

Absolute vertical accuracy assessments for the point cloud data are made against ground check point data. For the 140G0218F0143, SC East Central 2017 D18 LiDAR, ground check point data was collected using Florida Department of Transpiration's real-time kinematic (RTK) network.

Check point locations were collected at 1 – second intervals during the RTK survey. Points collected during the static pre-initialization and post-initialization was removed from the assessment so as not to bias the assessment.

Local TIN models of the elevation points are built around each ground check points. The tin model elevation is sampled at the horizontal position of the ground check point. The TIN model elevation and ground check point survey elevation values were used to calculate the Non-vegetated Vertical Accuracy (NVA) and Vegetated Vertical Accuracy (VVA) of the swath point clouds. The accuracy was calculated in the NRCS State plane coordinate system. In table 9 the meter equivalent in shown. The NVA of the TIN tested RMSEz 0.145 US Feet and 0.291 US Feet at the 95% confidence level in open terrain. NVA of the DEM tested at an RMSEz of 0.180 US Feet and 0.291 US Feet at the 95% confidence level in open terrain. The full calculations for all check points can be found in Appendix B.

Tested Accuracy (US Feet)	$RMSE_Z$	NVA	VVA
Classified LiDAR	0.145	0.284	0.364
Digital Elevation Model	0.180	0.291	0.372

Table 7a: Tested $RMSE_Z$ of NVA, NVA and VVA of LiDAR Point Cloud and DEM in US Feet.

Total #	# NVA	# VVA
135	76	59

Table 8: Number of Survey Points used to calculate accuracy of data.

Tested Accuracy (Meters)	$RMSE_Z$	NVA	VVA
Classified LiDAR	0.044	0.087	0.089
Digital Elevation Model	0.055	0.111	0.113

Table 9: Tested $RMSE_Z$ of NVA, NVA and VVA of LiDAR Point Cloud and DEM in Meters.

The tiled point cloud products were reviewed for full coverage of the AOI and proper classification. As part of the QC process, TINs are built in the Terramodeler software for each tile using the ground class and the hydro-flattening breaklines. The TINs are reviewed for non-ground features, and edited where necessary to remove any remaining non-ground features. Points were also reviewed for absolute elevation, and points falling below the selected orthometric elevation for water were removed from the ground class.

5.2 Breaklines

The final breaklines in ESRI GDB format were reviewed for topological consistency and correct elevation. Breaklines features are tested for monotonicity and vertical variance with LiDAR point cloud as well as not having overlaps or dangles.

5.3 Digital Elevation Models

Digital elevation models (DEMs) were reviewed for conformance with the statement of work and the Base Mapping Specification version 1.3 guidelines. DEM files were loaded in the Global Mapper software and inspected visually for edge matching between tiles, void areas within the project AOI, and proper coding of the NODATA values. DEM file naming was verified for consistency with the USNG index.

Appendix A. Flight Logs

Leica ALS80 Flight Log

Project:	18011_SC_East_Central_QL2										Sensor Operator/s	
											Cynthia Williams	
Date/Julian:	4/10/2018	ALS80 SN# 8137		Disk Drive MM70		Flight Plan(s):					Pilot/s	
Hobbs End	1706.6					18011_SC_East_Central_QL2					Mike Wasielewski	
Hobbs ST	1702.9		LIFT			TARGET AIRSPD (KNTS)		BASE PID:		Base Height:	Aircraft	Airport Idnt:
Flight Time	3.7		A			155		TEMP		1.500	C421-N112MJ	KOGB (Orangeburg, SC)

Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:				MM Space		PDOP	HDOP	
		107	180411_005850	:58	1:08	5327	8°	143	506	18	1.3	0.7	ALS Warning
		108	180411_011211	1:12	1:20	5334	188°	153	502	18	1.3	0.7	
		109	180411_012535	1:25	1:32	5330	8°	143	497	19	1.1	0.6	ALS Warning
		110	180411_013945	1:39	1:49	5358	181°	153	493	20	1.2	0.6	ALS Warning
		111	180411_015348	1:53	2:05	5337	8°	143	488	20	1.1	0.6	
		112	180411_020926	2:09	2:19	5389	181°	155	482	19	1.1	0.6	Range Gate. ALS
		113	180411_022547	2:25	2:33	5297	7°	141	477	18	1.2	0.6	ALS Warning
		114	180411_024149	2:41	2:53	5328	182°	154	471	17	1.3	0.7	ALS Warning
		106	180411_025700	2:57	3:06	5337	8°	146	465	17	1.4	0.7	ALS Warning
		105	180411_031001	3:10	3:18	5343	189°	154	461	17	1.3	0.7	ALS Warning
		104	180411_032359	3:23	3:37	5319	8°	147	456	17	1.2	0.6	
		103	180411_033756	3:37	3:47	5362	189°	153	451	18	1	0.6	ALS Warning
		102	180411_035146	3:51	4:00	5332	8°	145	446	18	1	0.6	

Leica ALS80 Flight Log

Project:	18011_SC_East_Central_QL2						Sensor Operator/s	
							Cynthia Williams	
Date/Julian:	4/11/2018	ALS80 SN# 8137	Disk Drive MM70	Flight Plan(s):			Pilot/s	
Hobbs End	1708.6			18011_SC_East_Central_QL2			Mike Wasielewski	
Hobbs ST	1706.6	LIFT		TARGET AIRSPD (KNTS)	BASE PID:	Base Height:	Aircraft	Airport Idnt:
Flight Time	2	A		155	TEMP	1.500	C421-N112MJ	KOGB (Orangeburg, SC)

Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
		50	180411_131923	13:19	13:32	5380	8°	155	1001	19	1.1	0.7	Clouds last 13 miles. 13 mile Refly.
		40	180411_134012	13:40	13:49	5369	188°	156	993	18	1.3	0.7	
		39	180411_135245	13:52	14:00	5384	8°	153	989	19	1.1	0.6	
		30	180411_140914	14:09	14:17	5446	187°	155	985	20	1	0.6	
		25	180411_142031	14:20	14:26	5447	8°	152	981	19	1.1	0.6	
		24	180411_142958	14:29	14:35	5463	182°	155	978	18	1.2	0.7	
		23	180411_143919	14:39	14:44	5454	9°	157	975	16	1.4	0.8	
		20	180411_144752	14:47	14:57	5459	187°	159	972	16	1.4	0.8	
		19	180411_145556	14:55	15:00	5480	7°	155	970	15	1.5	0.8	

Leica ALS80 Flight Log

Project:	18011_SC_East_Central_QL2									Sensor Operator/s	
										Cynthia Williams	
Date/Julian:	4/12/2018	ALS80 SN# 8137		Disk Drive MM70		Flight Plan(s):				Pilot/s	
Hobbs End	1712.3					18011_SC_East_Central_QL2				Mike Wasielewski	
Hobbs ST	1708.6		LIFT			TARGET AIRSPD (KNTS)	BASE PID:	Base Height:		Aircraft	Airport Idnt:
Flight Time	3.7		A			155	TEMP	1.500		C421-N112MJ	KOGB (Orangeburg, SC)

Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
		49	180412_153759	15:37	15:50	5394	7°	155	695	18	1.2	0.7	Refly NVID Buffer Error. ALS Max Range Gate Erro
		48	180412_155438	15:54	16:07	5403	188°	152	688	19	1.1	0.6	ALS Warning.
		47	180412_161120	16:11	16:24	5358	8°	155	681	17	1.3	0.6	
		46	180412_162809	16:28	16:41	5436	189°	151	674	19	1.3	0.6	Refly 15 Mile.
		51	180412_164441	16:44	16:58	5385	8°	149	667	20	1.3	0.6	ALS Warning.
		52	180412_170210	17:02	17:16	5380	188°	149	660	22	1.1	0.6	Spike in AGL
		53	180412_172024	17:20	17:33	5373	8°	156	652	20	1.2	0.6	ALS Restart.

Leica ALS80 Flight Log

Project:	18011_SC_East_Central_QL2								Sensor Operator/s	
									Cynthia Williams	
Date/Julian:	4/12/2018	ALS80 SN# 8137		Disk Drive MM70		Flight Plan(s):			Pilot/s	
Hobbs End	1712.3					18011_SC_East_Central_QL2			Mike Wasielewski	
Hobbs ST	1708.6		LIFT			TARGET AIRSPD (KNTS)	BASE PID:	Base Height:	Aircraft	Airport Idnt:
Flight Time	3.7		A			155	TEMP	1.500	C421-N112MJ	KOGB (Orangeburg, SC)

Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:				MM Space		PDOP	HDOP	
		54	180412_174950	17:49	18:03	5351	188°	148	645	19	1.8	0.8	ALS High PDOP
		55	180412_180702	18:07	18:20	5381	8°	154	638	19	1.3	0.7	Range Gate High.
		56	180412_182451	18:24	18:38	5337	187°	147	630	21	1.1	0.6	

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Leica ALS80 Flight Log

Project:	18011_SC_East_Central_QL2										Sensor Operator/s	
											Cynthia Williams	
Date/Julian:	4/12/2018	ALS80 SN# 8137		Disk Drive MM70		Flight Plan(s):					Pilot/s	
Hobbs End	1716.2					18011_SC_East_Central_QL2					Mike Wasielewski	
Hobbs ST	1712.3		LIFT			TARGET AIRSPD (KNTS)		BASE PID:		Base Height:	Aircraft	Airport Idnt:
Flight Time	3.9		B			155		TEMP		1.500	C421-N112MJ	KOGB (Orangeburg, SC)

Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
		45	180412_215531	21:55	22:08	5415	5°	151	623	21	1.1	0.6	ALS Warning
		44	180412_221239	22:12	22:27	5390	189°	154	616	21	1.1	0.7	
		43	180412_223009	22:30	22:42	5445	7°	155	608	21	1.2	0.7	ALS Range Gate. Spike in AGL
		42	180412_224659	22:46	22:58	5436	187°	147	602	20	1.2	0.7	
		41	180412_230312	23:03	23:13	5455	9°	153	596	20	1.3	0.8	Spike in AGL
		38	180412_231813	23:18	23:27	5447	187°	148	590	23	1	0.6	
		37	180412_232944	23:29	23:37	5455	8°	156	586	21	1.1	0.6	
		36	180412_234055	23:40	23:48	5445	188°	147	582	22	1	0.6	
		35	180412_235231	23:52	23:59	5446	7°	153	578	21	1.1	0.6	Range Gate ALS
		34	180413_000337	:3	:11	5439	187°	149	574	19	1.2	0.6	
		33	180413_001448	:14	:22	5430	7°	157	570	19	1.2	0.6	
		32	180413_002545	:25	:33	5437	188°	147	566	17	1.4	0.7	
		31	180413_003656	:36	:43	5446	8°	153	562	19	1.3	0.7	
		29	180413_004729	:47	:54	5419	187°	147	558	19	1.3	0.6	
		28	180413_005755	:57	1:04	5439	7°	152	554	19	1.3	0.6	
		27	180413_010808	1:08	1:14	5441	188°	149	551	19	1.3	0.6	
		26	180413_011747	1:17	1:24	5474	5°	152	547	22	1.2	0.6	

Leica ALS80 Flight Log

Project:	18011_SC_East_Central_QL2								Sensor Operator/s	
									Cynthia Williams	
Date/Julian:	4/13/2018	ALS80 SN# 8137		Disk Drive MM70		Flight Plan(s):			Pilot/s	
Hobbs End	1717.2					18011_SC_East_Central_QL2			Mike Wasielewski	
Hobbs ST	1716.2		LIFT			TARGET AIRSPD (KNTS)	BASE PID:	Base Height:	Aircraft	Airport Idnt:
Flight Time	1		A			155	TEMP	1.500	C421-N112MJ	KOGB (Orangeburg, SC)

Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
		22	180413_132846	13:28	13:33	5432	0°	160	544	17	1.6	0.8	
		21	180413_133722	13:37	13:42	5436	188°	147	541	18	1.3	0.7	

Leica ALS80 Flight Log

Project:	18011_SC_East_Central_QL2								Sensor Operator/s	
									Cynthia Williams	
Date/Julian:	4/13/2018	ALS80 SN# 8137		Disk Drive MM70		Flight Plan(s):			Pilot/s	
Hobbs End	1720.8					18011_SC_East_Central_QL2			Mike Wasielewski	
Hobbs ST	1717.2		LIFT			TARGET AIRSPD (KNTS)	BASE PID:	Base Height:	Aircraft	Airport Idnt:
Flight Time	3.6		B			155	TEMP	1.500	C421-N112MJ	KOGB (Orangeburg, SC)

Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:				MM Space		PDOP	HDOP	
		57	180414_001910	:19	:32	5320	7°	155	539	16	1.3	0.7	
		58	180414_003630	:36	:50	5357	187°	144	532	17	1.2	0.6	
		59	180414_005255	:52	1:06	5360	6°	149	524	17	1.2	0.6	ALS Warning
		60	180414_011033	1:10	1:24	5360	187°	151	517	17	1.2	0.6	ALS Warning
		61	180414_012800	1:28	1:41	5374	9°	156	510	19	1	0.6	ALS Warning
		62	180414_014546	1:45	1:59	5358	191°	152	503	18	1.1	0.6	
		63	180414_020304	2:03	2:16	5398	8°	154	495	19	1.1	0.6	Range Gate ALS
		64	180414_022029	2:20	2:34	5390	188°	153	488	19	1.3	0.6	ALS Warning. Spike in AGL
		65	180414_023721	2:37	2:51	5370	6°	155	481	18	1.5	0.7	
		66	180414_025502	2:55	3:08	5359	187°	154	473	16	1.4	0.7	ALS Warning
		67	180414_031226	3:12	3:24	5358	6°	159	466	19	1.2	0.6	ALS Warning
		68	180414_033043	3:30	3:45	5369	188°	148	458	20	1	0.6	

Leica ALS80 Flight Log

Project:	18011_SC_East_Central_QL2								Sensor Operator/s	
									Cynthia Williams	
Date/Julian:	4/14/2018	ALS80 SN# 8137		Disk Drive MM70		Flight Plan(s):			Pilot/s	
Hobbs End	1724.2					18011_SC_East_Central_QL2			Mike Wasielewski	
Hobbs ST	1720.8		LIFT		TARGET AIRSPD (KNTS)	BASE PID:	Base Height:	Aircraft	Airport Idnt:	
Flight Time	3.4		A		155	TEMP	1.500	C421-N112MJ	KOGB (Orangeburg, SC)	

Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
		69	180414_045017	4:50	5:04	5354	7°	155	450	16	1.3	0.7	
		70	180414_050828	5:08	5:23	5333	186°	151	442	17	1.2	0.7	
		71	180414_052548	5:25	5:40	5349	8°	153	434	16	1.4	0.8	
		72	180414_054423	5:44	5:59	5346	187°	150	427	15	1.2	0.8	ALS Warning
		73	180414_060242	6:02	6:17	5352	7°	155	419	14	1.4	0.8	
		74	180414_062112	6:21	6:36	5350	186°	153	411	13	1.8	1	
		75	180414_063928	6:39	6:53	5343	7°	156	404	14	1.4	0.9	IMU Data Missing
		76	180414_065818	6:58	7:12	5348	186°	155	396	14	1.6	0.9	ALS Range Gate
		77	180414_071602	7:16	7:30	5353	6°	153	389	16	1.3	0.8	
		78	180414_073438	7:34	7:48	5324	188°	155	381	16	1.2	0.7	ALS Warning

Leica ALS80 Flight Log

Project:	18011_SC_East_Central_QL2								Sensor Operator/s	
									Hunter Stavnes	
Date/Julian:	4/10/2018	ALS80 SN# 8235		Disk Drive MM70		Flight Plan(s):			Pilot/s	
Hobbs End	3652.4					18011_SC_East_Central_QL2			Keith Morrel	
Hobbs ST	3647.8		LIFT			TARGET AIRSPD (KNTS)	BASE PID:	Base Height:	Aircraft	Airport Idnt:
Flight Time	4.6		A			155	TEMP	1.500	C421-N13RF	KOGB (Orangeburg, SC)

Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
		121	180411_005621	:56	1:08	5295	1°	155	265	18	1.3	0.7	ALS Warning
		120	180411_011245	1:12	1:24	5297	180°	157	259	18	1.3	0.7	ALS Warning
		119	180411_012807	1:28	1:39	5279	1°	153	254	20	1.1	0.6	ALS Warning
		118	180411_014345	1:43	1:55	5290	180°	154	249	21	1	0.6	ALS Warning
		117	180411_015919	1:59	2:11	5314	360°	151	244	20	1.1	0.6	ir Start. Returns did not return to 0 after line end

Leica ALS80 Flight Log

Project:	18011_SC_East_Central_QL2										Sensor Operator/s	
											Hunter Stavnes	
Date/Julian:	4/10/2018	ALS80 SN# 8235		Disk Drive MM70		Flight Plan(s):					Pilot/s	
Hobbs End	3652.4					18011_SC_East_Central_QL2					Keith Morrel	
Hobbs ST	3647.8		LIFT			TARGET AIRSPD (KNTS)		BASE PID:		Base Height:	Aircraft	Airport Idnt:
Flight Time	4.6		A			155		TEMP		1.500	C421-N13RF	KOGB (Orangeburg, SC)

Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:				MM Space		PDOP	HDOP	
		115	180411_023336	2:33	2:44	5317	182°	155	239	18	1.3	0.6	ALS Warning
		116	180411_024831	2:48	3:00	5301	360°	154	234	17	1.5	0.7	ALS Warning
		122	180411_030536	3:05	3:17	5289	181°	157	229	18	1.3	0.7	ALS Warning
		123	180411_032241	3:22	3:35	5269	0°	154	223	18	1.2	0.6	ALS Warning
		124	180411_033926	3:39	3:51	5297	181°	153	218	19	1	0.6	ALS Warning
		125	180411_035636	3:56	4:09	5288	359°	152	213	20	1	0.6	ALS Warning
		126	180411_041313	4:13	4:25	5298	179°	154	207	18	1.2	0.6	ALS Warning
		127	180411_042953	4:29	4:42	5293	360°	151	202	18	1.2	0.6	ALS Warning
		101	180411_044914	4:49	4:59	5340	180°	157	196	17	1.3	0.7	ALS Warning

Leica ALS80 Flight Log

Project:	18011_SC_East_Central_QL2								Sensor Operator/s	
									Hunter Stavnes	
Date/Julian:	4/11/2018	ALS80 SN# 8235		Disk Drive MM70		Flight Plan(s):			Pilot/s	
Hobbs End	3654.4					18011_SC_East_Central_QL2			Keith Morrel	
Hobbs ST	3652.4		LIFT			TARGET AIRSPD (KNTS)	BASE PID:	Base Height:	Aircraft	Airport Idnt:
Flight Time	2		A			155	TEMP	1.500	C421-N13RF	KOGB (Orangeburg, SC)

Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
		4	180411_132345	13:23	13:24	5546	181°	154	519	18	1.4	0.8	
		5	180411_132845	13:28	13:29	5551	1°	155	519	18	1.4	0.7	
		6	180411_133316	13:33	13:34	5550	179°	154	519	18	1.3	0.7	
		7	180411_133906	13:39	13:40	5531	360°	153	518	18	1.3	0.7	
		8	180411_134519	13:45	13:46	5538	181°	155	517	19	1.3	0.7	
		9	180411_135103	13:51	13:53	5531	359°	155	516	19	1.1	0.6	
		10	180411_135659	13:56	13:58	5513	179°	151	516	20	1	0.6	
		11	180411_140249	14:02	14:04	5511	360°	151	515	20	1	0.6	
		12	180411_140840	14:08	14:11	5503	180°	152	514	20	1	0.6	
		13	180411_141522	14:15	14:18	5497	359°	154	513	20	1	0.6	
		14	180411_142159	14:21	14:25	5480	181°	153	511	19	1.1	0.6	
		15	180411_142904	14:29	14:32	5494	359°	153	510	18	1.2	0.7	
		16	180411_143706	14:37	14:40	5498	180°	152	509	16	1.4	0.8	
		17	180411_144442	14:44	14:48	5506	360°	155	507	16	1.4	0.8	
		18	180411_145232	14:52	14:56	5509	180°	153	505	15	1.5	0.8	

Leica ALS80 Flight Log

Project:	18011_SC_East_Central_QL2								Sensor Operator/s	
									Hunter Stavnes	
Date/Julian:	4/11/2018	ALS80 SN# 8235		Disk Drive MM70		Flight Plan(s):			Pilot/s	
Hobbs End	3658.9					18011_SC_East_Central_QL2			Keith Morrel	
Hobbs ST	3654.4		LIFT			TARGET AIRSPD (KNTS)	BASE PID:	Base Height:	Aircraft	Airport Idnt:
Flight Time	4.5		B			155	TEMP	1.500	C421-N13RF	KOGB (Orangeburg, SC)

Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
		3	180411_231923	23:19	23:29	5351	90°	154	503	20	1.4	0.7	ALS Warning
		171	180411_233437	23:34	23:41	5319	0°	152	499	21	1.2	0.6	
		172	180411_234552	23:45	23:52	5290	180°	157	496	23	1	0.6	
		173	180411_235714	23:57	:3	5286	359°	153	493	22	1.1	0.6	
		174	180412_000805	:8	:13	5310	180°	153	490	20	1.1	0.7	
		175	180412_001838	:18	:24	5320	2°	150	487	18	1.3	0.8	
		176	180412_002821	:28	:32	5326	181°	155	485	17	1.4	0.7	
		177	180412_003628	:36	:39	5303	1°	149	483	19	1.3	0.6	
		178	180412_004407	:44	:46	5320	180°	153	482	19	1.2	0.7	
		179	180412_005109	:51	:53	5300	1°	148	480	18	1.3	0.7	
		180	180412_005727	:57	:59	5300	180°	157	479	18	1.3	0.6	
		181	180412_010350	1:03	1:05	5323	1°	156	478	19	1.2	0.6	
		182	180412_010947	1:09	1:11	5311	179°	155	477	18	1.2	0.6	
		183	180412_011613	1:16	1:17	5301	360°	149	476	19	1.2	0.6	
		184	180412_012142	1:21	1:23	5330	181°	159	475	21	1.1	0.6	
		185	180412_012739	1:27	1:28	5321	360°	154	475	24	1.1	0.6	
		186	180412_013210	1:32	1:32	5333	182°	152	474	24	1	0.6	
		1	180412_013746	1:37	1:43	5332	269°	151	474	24	1	0.6	
		170	180412_015209	1:52	1:59	5331	179°	152	471	22	1.1	0.6	
		169	180412_020403	2:04	2:11	5313	359°	154	468	22	1.2	0.6	
		168	180412_021533	2:15	2:23	5309	180°	151	465	21	1.1	0.6	
		167	180412_022803	2:28	2:36	5321	0°	153	461	21	1.2	0.6	
		166	180412_024000	2:40	2:48	5328	180°	154	458	19	1.3	0.6	ALS Warning
		165	180412_025241	2:52	3:01	5313	1°	153	454	18	1.5	0.7	
		100	180412_031500	3:15	3:25	5316	179°	151	450	18	1.2	0.6	ALS Warning

Leica ALS80 Flight Log

Project:	18011_SC_East_Central_QL2								Sensor Operator/s	
									Hunter Stavnes	
Date/Julian:	4/12/2018	ALS80 SN# 8235		Disk Drive MM70		Flight Plan(s):			Pilot/s	
Hobbs End	3663.6					18011_SC_East_Central_QL2			Keith Morrel	
Hobbs ST	3658.9		LIFT			TARGET AIRSPD (KNTS)	BASE PID:	Base Height:	Aircraft	Airport Idnt:
Flight Time	4.7		A			155	TEMP	1.500	C421-N13RF	KOGB (Orangeburg, SC)

Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
		117	180412_153206	15:32	15:43	5304	0°	150	967	18	1.1	0.7	ALS Warning
		164	180412_155605	15:56	16:05	5321	180°	151	962	19	1.1	0.6	
		163	180412_160915	16:09	16:18	5323	360°	153	958	17	1.3	0.6	
		162	180412_162303	16:23	16:32	5304	180°	155	954	19	1.3	0.6	
		158	180412_163655	16:36	16:46	5190	360°	158	950	20	1.3	0.6	
		161	180412_165026	16:50	16:59	5304	181°	153	945	20	1.3	0.6	
		160	180412_170354	17:03	17:13	5303	360°	153	941	22	1.1	0.6	ALS Warning
		150	180412_171823	17:18	17:28	5259	182°	151	937	20	1.1	0.6	Possible Smoke 5 miles from end of line.
		145	180412_173320	17:33	17:44	5300	360°	156	932	20	1.1	0.6	ALS Warning
		144	180412_174824	17:48	17:59	5322	181°	146	928	17	1.9	0.8	ALS Warning
		143	180412_180401	18:04	18:16	5315	1°	157	923	19	1.3	0.7	ALS Warning
		142	180412_182031	18:20	18:33	5259	180°	153	918	21	1.1	0.6	ALS Warning
		141	180412_183724	18:37	18:49	5346	358°	153	913	19	1.2	0.6	ALS Warning
		140	180412_185354	18:53	19:06	5291	182°	155	907	19	1.3	0.6	ALS Warning
		99	180412_191542	19:15	19:26	5351	1°	156	902	21	1.1	0.6	ALS Warning
		98	180412_192955	19:29	19:41	5377	181°	148	897	21	1.1	0.6	

Leica ALS80 Flight Log

Project:	18011_SC_East_Central_QL2								Sensor Operator/s	
									Hunter Stavnes	
Date/Julian:	4/12/2018	ALS80 SN# 8235		Disk Drive MM70		Flight Plan(s):			Pilot/s	
Hobbs End	3668.3					18011_SC_East_Central_QL2			Keith Morrel	
Hobbs ST	3663.6		LIFT			TARGET AIRSPD (KNTS)	BASE PID:	Base Height:	Aircraft	Airport Idnt:
Flight Time	4.7		B			155	TEMP	1.500	C421-N13RF	KOGB (Orangeburg, SC)

Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
		150	180412_214311	21:43	21:46	5323	179°	140	892	19	1.2	0.7	ALS Warning
		159	180412_215020	21:50	22:00	5314	360°	158	890	21	1	0.6	
		157	180412_220344	22:03	22:13	5195	179°	153	886	20	1.2	0.7	
		156	180412_221816	22:18	22:28	5288	0°	150	882	21	1.2	0.7	
		155	180412_223248	22:32	22:43	5261	181°	156	873	20	1.2	0.7	ALS Warning
		154	180412_224705	22:47	22:57	5296	360°	152	872	19	1.5	0.8	
		153	180412_230116	23:01	23:11	5268	181°	149	868	21	1.2	0.8	
		152	180412_231538	23:15	23:26	5292	0°	152	863	22	1.1	0.6	ALS Warning
		151	180412_233012	23:30	23:40	5275	181°	151	858	21	1.2	0.7	ALS Warning
		149	180412_234407	23:44	23:54	5272	360°	150	854	22	1.1	0.6	ALS Warning
		148	180412_235814	23:58	:8	5271	180°	152	850	21	1.2	0.6	ALS Warning
		147	180413_001216	:12	:22	5273	0°	152	845	19	1.2	0.6	ALS Warning
		146	180413_002613	:26	:37	5263	180°	153	841	17	1.5	0.7	ALS Warning
		139	180413_004434	:44	:57	5297	360°	156	836	19	1.3	0.6	ALS Warning
		138	180413_010133	1:01	1:15	5270	179°	152	831	19	1.3	0.6	ALS Warning
		137	180413_011829	1:18	1:31	5280	360°	151	825	22	1.1	0.6	ALS Warning
		136	180413_013504	1:35	1:47	5332	181°	153	820	24	1	0.5	ALS Warning

Leica ALS80 Flight Log

Project:	18011_SC_East_Central_QL2									Sensor Operator/s	
										Hunter Stavnes	
Date/Julian:	4/12/2018	ALS80 SN# 8235		Disk Drive MM70		Flight Plan(s):				Pilot/s	
Hobbs End	3672.1					18011_SC_East_Central_QL2				Keith Morrel	
Hobbs ST	3668.3		LIFT			TARGET AIRSPD (KNTS)	BASE PID:	Base Height:		Aircraft	Airport Idnt:
Flight Time	3.8		C			155	TEMP	1.500		C421-N13RF	KOGB (Orangeburg, SC)

Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
		135	180413_030246	3:02	3:15	5315	359°	155	814	21	1.3	0.7	ALS Warning
		134	180413_031910	3:19	3:32	5287	179°	154	808	20	1.2	0.7	ALS Warning
		133	180413_033552	3:35	3:48	5296	360°	152	803	23	1	0.6	ALS Warning
		132	180413_035223	3:52	4:05	5276	182°	143	797	24	1	0.6	ALS Warning
		131	180413_040833	4:08	4:20	5300	1°	149	792	20	1.3	0.7	ALS Warning
		130	180413_042515	4:25	4:37	5295	179°	146	786	22	1.2	0.6	ALS Warning
		129	180413_044113	4:41	4:53	5315	359°	153	781	20	1.3	0.7	ALS Warning
		128	180413_045718	4:57	5:10	5292	180°	150	776	17	1.3	0.7	ALS Warning
		97	180413_051810	5:18	5:29	5332	360°	152	770	18	1.5	0.8	ALS Warning
		96	180413_053344	5:33	5:45	5337	181°	153	765	17	1.4	0.8	ALS Warning
		95	180413_054924	5:49	6:01	5339	359°	156	759	16	1.2	0.7	ALS Warning
		94	180413_060530	6:05	6:17	5316	181°	152	754	15	1.4	0.8	ALS Warning

Leica ALS80 Flight Log

Project:	18011_SC_East_Central_QL2									Sensor Operator/s	
										Hunter Stavnes	
Date/Julian:	4/13/2018	ALS80 SN# 8235		Disk Drive MM70		Flight Plan(s):				Pilot/s	
Hobbs End	3672.7					18011_SC_East_Central_QL2				Keith Morrel	
Hobbs ST	3672.1		LIFT			TARGET AIRSPD (KNTS)	BASE PID:	Base Height:		Aircraft	Airport Idnt:
Flight Time	0.6		A			155	TEMP	1.500		C421-N13RF	KOGB (Orangeburg, SC)

Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:				MM Space		PDOP	HDOP	
		2	180413_131303	13:13	13:30	5441	271°	152	749	20	1.2	0.7	ALS Warning

Leica ALS80 Flight Log

Project:	18011_SC_East_Central_QL2									Sensor Operator/s	
										Hunter Stavnes	
Date/Julian:	4/17/2018	ALS80 SN# 8235		Disk Drive MM70		Flight Plan(s):				Pilot/s	
Hobbs End	3678.8					18011_SC_East_Central_QL2				Keith Morrel	
Hobbs ST	3678.1		LIFT			TARGET AIRSPD (KNTS)	BASE PID:	Base Height:		Aircraft	Airport Idnt:
Flight Time	0.7		A			155	TEMP	1.500		C421-N13RF	KOGB (Orangeburg, SC)

Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:				MM Space		PDOP	HDOP	
		93	180417_121609	12:16	12:30	5333	359°	139	740	16	1.3	0.7	ALS Warning

Leica ALS80 Flight Log

Project:	18011_SC_East_Central_QL2										Sensor Operator/s	
											Hunter Stavnes	
Date/Julian:	4/18/2018	ALS80 SN# 8235		Disk Drive MM70		Flight Plan(s):					Pilot/s	
Hobbs End	3683.2					18011_SC_East_Central_QL2					Keith Morrel	
Hobbs ST	3678.8		LIFT			TARGET AIRSPD (KNTS)		BASE PID:		Base Height:	Aircraft	Airport Idnt:
Flight Time	4.4		A			155		TEMP		1.500	C421-N13RF	KOGB (Orangeburg, SC)

Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:				MM Space		PDOP	HDOP	
		92	180418_094447	9:44	9:57	5364	0°	150	734	20	1.2	0.6	ALS Warning
		91	180418_100150	10:01	10:14	5363	180°	151	728	19	1.3	0.6	
		90	180418_101824	10:18	10:31	5404	0°	152	722	20	1.2	0.6	ALS Warning
		89	180418_103531	10:35	10:48	5365	180°	153	716	20	1.3	0.6	ALS Warning
		88	180418_105216	10:52	11:05	5409	1°	151	710	21	1.1	0.6	ALS Warning
		87	180418_110844	11:08	11:22	5382	180°	151	705	19	1.1	0.6	ALS Warning
		86	180418_112550	11:25	11:39	5395	359°	155	699	20	1	0.6	
		85	180418_114232	11:42	11:56	5369	180°	152	692	18	1.5	0.8	ALS Warning
		84	180418_115934	11:59	12:13	5402	0°	154	686	18	1.2	0.7	
		83	180418_121644	12:16	12:30	5378	180°	153	680	17	1.3	0.7	ALS Warning
		82	180418_123401	12:34	12:48	5423	1°	153	674	18	1.2	0.7	
		81	180418_125129	12:51	13:05	5386	179°	156	668	19	1	0.6	ALS Warning
		80	180418_130843	13:08	13:22	5392	359°	152	661	18	1.4	0.7	ALS Warning
		79	180418_132616	13:26	13:40	5332	180°	154	655	19	1.1	0.6	ALS Warning

Leica ALS80 Flight Log

Project:	18011_SC_East_Central_QL2										Sensor Operator/s	
											Hunter Stavnes	
Date/Julian:	4/18/2018	ALS80 SN# 8235		Disk Drive MM70		Flight Plan(s):					Pilot/s	
Hobbs End	3685.7					18011_SC_East_Central_QL2					Keith Morrel	
Hobbs ST	3683.2		LIFT			TARGET AIRSPD (KNTS)		BASE PID:		Base Height:	Aircraft	Airport Idnt:
Flight Time	2.5		B			155		TEMP		1.500	C421-N13RF	KOGB (Orangeburg, SC)

Lift	#	Flight Line	Mission Line	UTC time:		GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc.		Comments and Conditions:
				Begin:	End:						PDOP	HDOP	
		R6	180418_144656	14:46	14:47	5512	359°	149	648	18	1.1	0.6	
		R5	180418_145114	14:51	14:52	5517	179°	152	648	18	1.1	0.6	
		R2	180418_145855	14:58	15:00	5499	1°	149	648	18	1.1	0.6	
		R3	180418_150444	15:04	15:05	5500	181°	149	647	18	1.2	0.6	
		R4	180418_151154	15:11	15:12	5561	360°	152	646	19	1.2	0.6	
		R1	180418_152011	15:20	15:27	5392	1°	133	646	21	1.1	0.6	ALS Warning
		R12	180418_153142	15:31	15:33	5376	180°	154	643	21	1.1	0.6	
		R14	180418_153516	15:35	15:36	5505	180°	156	642	20	1.2	0.6	
		R19	180418_154008	15:40	15:41	5488	180°	153	641	20	1.2	0.6	
		R20	180418_154724	15:47	15:49	5388	1°	151	641	19	1.4	0.6	ALS Warning
		R15	180418_155236	15:52	15:54	5509	1°	151	640	20	1.3	0.6	
		R7	180418_160236	16:02	16:04	5425	1°	157	639	20	1.4	0.6	
		R13	180418_160952	16:09	16:10	5521	180°	154	638	20	1.4	0.6	
		R16	180418_161143	16:11	16:13	5526	181°	148	638	21	1.4	0.6	
		R18	180418_161458	16:14	16:17	5494	181°	149	637	21	1.4	0.6	ALS Warning
		R21	180418_162055	16:20	16:21	5396	180°	157	636	21	1.4	0.6	ALS Warning
		R10	180418_162631	16:26	16:28	5408	358°	142	636	22	1.4	0.6	
		R11	180418_163102	16:31	16:31	5475	0°	153	635	22	1.1	0.6	
		R17	180418_163329	16:33	16:35	5446	359°	152	635	21	1.2	0.6	
		R8	180418_164011	16:40	16:41	5454	179°	158	634	20	1.2	0.6	
		R9	180418_164559	16:45	16:47	5477	1°	147	633	20	1.2	0.6	

Appendix B. Vertical Accuracy Calculations

Project Information

Prepared By: Kenneth L. Coffey
Project Name: SC East Central QL2
Sensor Info: Leica ALS80
Required Nominal Pulse Spacing: 0.71
Vendor Name: Digital Aerial Soluitons .LLC
Units: US Survey Feet
Percent of Extent Tolerance: Extents Not Checked
Date of Aquisition: Start: 4/11/2018 Finish: 4/18/2018

Metadata Information

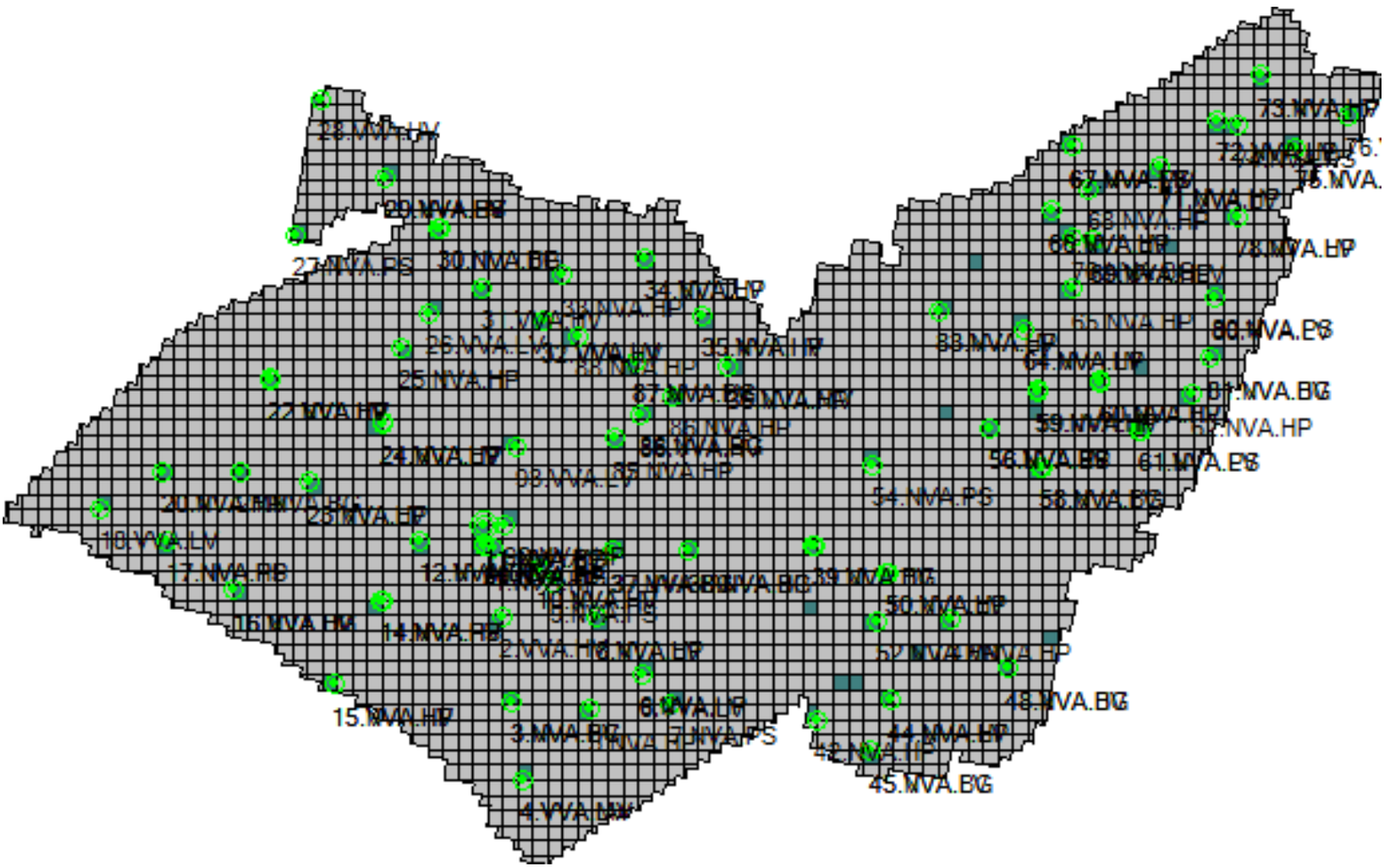
Tile Index:
- Filename: Index_5K_Clip_SPC_Use.shp
- Number of Polys: 0

Intensity:
- Tile Index Attribute: Not Specified
- Data Filename: Not Specified

DEM:
- Tile Index Attribute: NAME
- Data Filename: DEM

LAS:
- Tile Index Attribute: NAME
- Data Filename: LAS

Tiled-Data Area



LiDAR Accuracy Assessment Summary

LC Type	# of Points	NVA	VVA	
LAS				
Bare Ground	17	0.260		
Hard Pavement	47	0.266		
High Vegetation	21		0.448	
Low Vegetation	33		0.305	
Medium Vegetation	5		0.219	
Packed Sand	12	0.372		
Total	135			
DEM				
Bare Ground	17	0.278		
Hard Pavement	47	0.273		
High Vegetation	21		0.477	
Low Vegetation	33		0.273	
Medium Vegetation	5		0.192	
Packed Sand	12	0.365		
Total	135			

Units: US Survey Feet

Coordinates and Offsets of Analyzed Locations

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
1)	☑	**11.NVA.BG**					
			2043983.333	599917.995	204.54	204.49	204.439
					Bare Ground	-0.05	-0.101
2)	☑	**12.NVA.BG**					
			2022390.506	594863.545	272.175	272.135	272.119
					Bare Ground	-0.04	-0.056
3)	☑	**16.NVA.BG**					
			1960388.511	578219.539	221.61	221.26	221.308
					Bare Ground	-0.35	-0.302
4)	☑	**21.NVA.BG**					
			1962506.11	617695.781	340.57	340.426	340.404
					Bare Ground	-0.144	-0.166
5)	☑	**3.NVA.BG**					
			2053059.624	541241.598	148.336	148.434	148.443
					Bare Ground	0.098	0.106
6)	☑	**30.NVA.BG**					
			2028713.127	698896.492	157.434	157.719	157.681
					Bare Ground	0.285	0.247
7)	☑	**37.NVA.BG**					
			2086489.856	591389.333	158.838	158.924	158.919
					Bare Ground	0.086	0.081

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
8)	☑	**38.NVA.BG**					
			2112041.295	591434.976	150.856	150.83	150.858
					Bare Ground	-0.026	0.002
9)	☑	**39.NVA.BG**					
			2153555.169	593271.566	134.468	134.736	134.728
					Bare Ground	0.268	0.26
10)	☑	**45.NVA.BG**					
			2172607.855	524928.983	73.32	73.28	73.28
					Bare Ground	-0.04	-0.04
11)	☑	**48.NVA.BG**					
			2218042.975	552473.874	86.719	86.689	86.749
					Bare Ground	-0.03	0.03
12)	☑	**58.NVA.BG**					
			2229318.879	619448.288	103.487	103.464	103.51
					Bare Ground	-0.023	0.023
13)	☑	**70.NVA.BG**					
			2239834.175	695532.336	111.434	111.445	111.45
					Bare Ground	0.011	0.016
14)	☑	**81.NVA.BG**					
			2285356.559	655550.973	92.385	92.383	92.382
					Bare Ground	-0.002	-0.003

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
15)	☑	**86.NVA.BG**					
			2095940.178	636736.923	180.977	180.992	181.02
					Bare Ground	0.015	0.043
16)	☑	**87.NVA.BG**					
			2093865.326	654525.179	234.15	234.263	234.247
					Bare Ground	0.113	0.097
17)	☑	**91.NVA.BG**					
			2043756.363	593454.303	192.913	192.823	192.829
					Bare Ground	-0.09	-0.084
18)	☑	**1.NVA.HP**					
			2047063.528	591947.925	193.349	193.382	193.369
					Hard Pavement	0.033	0.02
19)	☑	**10.NVA.HP**					
			2061835.659	585582.283	181.374	181.385	181.383
					Hard Pavement	0.011	0.009
20)	☑	**11.NVA.HP**					
			2044008.21	599866.679	204.527	204.416	204.433
					Hard Pavement	-0.111	-0.094
21)	☑	**14.NVA.HP**					
			2009602.391	574783.059	242.513	242.459	242.462
					Hard Pavement	-0.054	-0.051

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
22)	☑	**15.NVA.HP**					
			1993804.943	547076.066	141	141.152	141.146
					Hard Pavement	0.152	0.146
23)	☑	**17.NVA.HP**					
			1938362.362	594744.394	260.383	260.095	260.162
					Hard Pavement	-0.288	-0.221
24)	☑	**20.NVA.HP**					
			1936691.061	617870.715	315.413	315.136	315.128
					Hard Pavement	-0.277	-0.286
25)	☑	**22.NVA.HP**					
			1972303.89	648575.412	291.929	291.877	291.873
					Hard Pavement	-0.052	-0.056
26)	☑	**23.NVA.HP**					
			1985281.908	614231.16	329.635	329.447	329.402
					Hard Pavement	-0.188	-0.233
27)	☑	**24.NVA.HP**					
			2009964.984	633927.333	292.805	292.739	292.675
					Hard Pavement	-0.066	-0.13
28)	☑	**25.NVA.HP**					
			2016015.97	659199.105	364.697	364.925	364.905
					Hard Pavement	0.228	0.208

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
29)	☑	**30.NVA.HP**					
			2028830.561	698867.9	159.636	159.677	159.66
					Hard Pavement	0.041	0.024
30)	☑	**33.NVA.HP**					
			2069799.852	683231.63	282.083	282.362	282.326
					Hard Pavement	0.279	0.243
31)	☑	**34.NVA.HP**					
			2097578.434	688993.667	272.184	272.21	272.206
					Hard Pavement	0.026	0.022
32)	☑	**35.NVA.HP**					
			2116687.531	669642.393	166.804	166.777	166.727
					Hard Pavement	-0.027	-0.077
33)	☑	**36.NVA.HP**					
			2125052.648	652403.376	171.394	171.395	171.385
					Hard Pavement	0.001	-0.009
34)	☑	**38.NVA.HP**					
			2112114.503	591463.054	150.19	150.16	150.161
					Hard Pavement	-0.03	-0.029
35)	☑	**42.NVA.HP**					
			2154573.693	535030.034	80.449	80.338	80.263
					Hard Pavement	-0.111	-0.186

Coordinates and Offsets of Analyzed Locations (Continued)

	ID	Survey X	Survey Y	Z1	Z DEM	Z LAS
				LC Type	ΔZ DEM	ΔZ LAS
36)	**44.NVA.HP**					
		2178976.165	541467.3	100.144	99.962	99.96
				Hard Pavement	-0.182	-0.184
37)	**47.NVA.HP**					
		2199097.806	568509.257	111.138	111.055	111.046
				Hard Pavement	-0.083	-0.092
38)	**5.NVA.HP**					
		2078935.027	538560.61	147.083	147.092	147.118
				Hard Pavement	0.009	0.035
39)	**50.NVA.HP**					
		2177900.424	584028.074	132.7	132.433	132.468
				Hard Pavement	-0.267	-0.232
40)	**52.NVA.HP**					
		2174536.452	568068.297	123.897	123.79	123.777
				Hard Pavement	-0.107	-0.12
41)	**56.NVA.HP**					
		2212149.582	632307.184	123.894	123.697	123.656
				Hard Pavement	-0.197	-0.238
42)	**59.NVA.HP**					
		2228065.283	644808.303	137.549	137.383	137.342
				Hard Pavement	-0.166	-0.207

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
43)	☑	**6.NVA.HP**					
			2096327.412	550227.778	144.698	144.935	144.875
					Hard Pavement	0.237	0.177
44)	☑	**60.NVA.HP**					
			2249042.305	647806.11	132.152	132.066	132.088
					Hard Pavement	-0.086	-0.064
45)	☑	**62.NVA.HP**					
			2279443.395	643268.457	94.583	94.434	94.413
					Hard Pavement	-0.149	-0.17
46)	☑	**64.NVA.HP**					
			2223776.271	665287.902	149.435	149.356	149.36
					Hard Pavement	-0.079	-0.075
47)	☑	**65.NVA.HP**					
			2239765.806	678616.312	125.676	125.656	125.64
					Hard Pavement	-0.02	-0.036
48)	☑	**66.NVA.HP**					
			2232524.211	704458.577	127.647	127.539	127.526
					Hard Pavement	-0.108	-0.121
49)	☑	**68.NVA.HP**					
			2245013.93	711804.98	127.132	126.951	126.974
					Hard Pavement	-0.181	-0.158

Coordinates and Offsets of Analyzed Locations (Continued)

	ID	Survey X	Survey Y	Z1	Z DEM	Z LAS
				LC Type	ΔZ DEM	ΔZ LAS
50)	**69.NVA.HP**					
		2246222.446	694832.716	110.295	110.266	110.251
				Hard Pavement	-0.029	-0.044
51)	**71.NVA.HP**					
		2268731.393	719471.214	85.394	85.303	85.296
				Hard Pavement	-0.091	-0.098
52)	**72.NVA.HP**					
		2287864.184	734831.738	103.432	103.342	103.369
				Hard Pavement	-0.09	-0.063
53)	**73.NVA.HP**					
		2302297.19	749850.373	95.436	95.55	95.575
				Hard Pavement	0.114	0.139
54)	**75.NVA.HP**					
		2313944.084	725737.444	75.413	75.224	75.27
				Hard Pavement	-0.189	-0.143
55)	**78.NVA.HP**					
		2294492.305	702560.175	94.944	95.01	94.94
				Hard Pavement	0.066	-0.004
56)	**8.NVA.HP**					
		2081433.525	568976.912	161.499	161.488	161.509
				Hard Pavement	-0.011	0.01

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
57)	☑	**83.NVA.HP**					
			2195186.253	671179.031	157.828	157.66	157.654
					Hard Pavement	-0.168	-0.174
58)	☑	**85.NVA.HP**					
			2087092.907	628719.481	179.875	179.853	179.841
					Hard Pavement	-0.022	-0.034
59)	☑	**86.NVA.HP**					
			2106251.592	643185.105	188.769	188.611	188.623
					Hard Pavement	-0.158	-0.147
60)	☑	**88.NVA.HP**					
			2074891.018	662734.46	275.928	275.951	275.971
					Hard Pavement	0.023	0.043
61)	☑	**89.NVA.HP**					
			2043769.762	593848.423	195.315	195.218	195.209
					Hard Pavement	-0.097	-0.106
62)	☑	**90.NVA.HP**					
			2043846.795	593749.024	194.147	193.931	193.989
					Hard Pavement	-0.216	-0.158
63)	☑	**91.NVA.HP**					
			2043746.449	593497.976	193.733	193.599	193.63
					Hard Pavement	-0.134	-0.103

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
64)	☑	**92.NVA.HP**					
			2050584.579	600186.236	202.345	202.369	202.406
					Hard Pavement	0.024	0.061
65)	☑	**14.NVA.PS**					
			2009722.531	574792.064	240.413	240.133	240.114
					Packed Sand	-0.28	-0.299
66)	☑	**17.NVA.PS**					
			1938340.106	594730.055	259.192	259.111	259.11
					Packed Sand	-0.081	-0.082
67)	☑	**27.NVA.PS**					
			1980773.514	696762.071	389.52	389.423	389.401
					Packed Sand	-0.097	-0.119
68)	☑	**29.NVA.PS**					
			2010910.022	715623.288	148.051	148.26	148.276
					Packed Sand	0.209	0.225
69)	☑	**54.NVA.PS**					
			2173206.618	620082.928	75.912	75.81	75.856
					Packed Sand	-0.102	-0.056
70)	☑	**56.NVA.PS**					
			2212091.84	632404.307	122.326	122.107	122.074
					Packed Sand	-0.219	-0.252

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
71)	☑	**61.NVA.PS**					
			2262174.182	631436.485	127.319	127.23	127.259
					Packed Sand	-0.089	-0.06
72)	☑	**67.NVA.PS**					
			2239469.74	726090.918	126.122	125.839	125.87
					Packed Sand	-0.283	-0.252
73)	☑	**7.NVA.PS**					
			2105663.305	540377.451	138.149	138.456	138.481
					Packed Sand	0.307	0.332
74)	☑	**74.NVA.PS**					
			2294452.357	732998.715	101.388	101.544	101.527
					Packed Sand	0.156	0.139
75)	☑	**80.NVA.PS**					
			2286869.177	675825.553	77.359	77.295	77.309
					Packed Sand	-0.064	-0.05
76)	☑	**9.NVA.PS**					
			2066257.17	581153.893	174.865	174.956	174.934
					Packed Sand	0.091	0.069
77)	☑	**10.VVA.HV**					
			2061931.882	585552.026	180.364	180.486	180.507
					High Vegetation	0.122	0.143

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
78)	☑	**14.VVA.HV**					
			2009784.768	574790.088	240.711	240.434	240.534
					High Vegetation	-0.277	-0.177
79)	☑	**15.VVA.HV**					
			1993679.425	547095.962	138.97	139.156	139.144
					High Vegetation	0.186	0.174
80)	☑	**16.VVA.HV**					
			1960277.62	578299.077	224.629	224.295	224.356
					High Vegetation	-0.334	-0.273
81)	☑	**2.VVA.HV**					
			2049725.886	569429.115	175.279	175.389	175.434
					High Vegetation	0.11	0.155
82)	☑	**22.VVA.HV**					
			1972340.518	648514.98	291.679	291.693	291.649
					High Vegetation	0.014	-0.03
83)	☑	**24.VVA.HV**					
			2009715.602	634044.032	291.223	291.168	291.173
					High Vegetation	-0.055	-0.05
84)	☑	**28.VVA.HV**					
			1989040.555	741859.017	249.278	249.717	249.696
					High Vegetation	0.439	0.418

Coordinates and Offsets of Analyzed Locations (Continued)

	ID	Survey X	Survey Y	Z1	Z DEM	Z LAS
				LC Type	ΔZ DEM	ΔZ LAS
85)	**29.VVA.HV**					
		2010971.622	715595.907	149.567	149.931	149.927
				High Vegetation	0.364	0.36
86)	**3.VVA.HV**					
		2053055.052	541314.707	148.008	148.38	148.381
				High Vegetation	0.372	0.373
87)	**31.VVA.HV**					
		2042934.086	679069.651	340.554	340.811	340.811
				High Vegetation	0.257	0.257
88)	**32.VVA.HV**					
		2063472.463	668011.426	314.98	315.183	315.175
				High Vegetation	0.203	0.195
89)	**35.VVA.HV**					
		2116684.801	669671.404	166.784	166.753	166.734
				High Vegetation	-0.031	-0.05
90)	**39.VVA.HV**					
		2153457.964	593269.26	134.048	134.564	134.527
				High Vegetation	0.516	0.479
91)	**48.VVA.HV**					
		2217961.995	552406.546	86.896	86.795	86.781
				High Vegetation	-0.101	-0.115

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
92)	☑	**59.VVA.HV**					
			2228112.167	644735.387	136.614	136.663	136.759
					High Vegetation	0.049	0.145
93)	☑	**60.VVA.HV**					
			2249073.382	647788.139	131.109	131.266	131.23
					High Vegetation	0.157	0.121
94)	☑	**69.VVA.HLV**					
			2246177.348	694813.298	109.819	109.839	109.86
					High Vegetation	0.02	0.041
95)	☑	**73.VVA.HV**					
			2302231.013	749868.775	94.941	95.062	95.064
					High Vegetation	0.121	0.123
96)	☑	**81.VVA.HV**					
			2285341.764	655592.408	92.687	92.677	92.673
					High Vegetation	-0.01	-0.014
97)	☑	**86.VVA.HV**					
			2095956.435	636678.858	181.033	180.823	180.876
					High Vegetation	-0.21	-0.157
98)	☑	**11.VVA.LV**					
			2043883.655	599878.321	204.422	204.308	204.346
					Low Vegetation	-0.114	-0.076

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
99)	☑	**12.VVA.LV**					
			2022334.281	594848.128	271.404	271.387	271.392
					Low Vegetation	-0.017	-0.012
100)	☑	**16.VVA.LV**					
			1960393.801	578261.033	221.437	221.065	221.073
					Low Vegetation	-0.372	-0.364
101)	☑	**18.VVA.LV**					
			1916180.133	605480.593	305.695	305.509	305.53
					Low Vegetation	-0.186	-0.165
102)	☑	**22.VVA.LV**					
			1972323.211	648462.172	291.42	291.414	291.328
					Low Vegetation	-0.006	-0.092
103)	☑	**23.VVA.LV**					
			1985307.599	614312.498	329.494	329.222	329.305
					Low Vegetation	-0.272	-0.189
104)	☑	**24.VVA.LV**					
			2009839.661	634051.871	292.46	292.548	292.547
					Low Vegetation	0.088	0.087
105)	☑	**26.VVA.LV**					
			2025038.013	670647.696	334.684	334.914	334.854
					Low Vegetation	0.23	0.17

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
106)	☑	29.VVA.LV					
			2011078.999	715727.446	146.981	147.254	147.292
					Low Vegetation	0.273	0.311
107)	☑	31.VVA.LV					
			2063437.981	668111.081	316.072	316.251	316.266
					Low Vegetation	0.179	0.194
108)	☑	34.VVA.LV					
			2097522.995	689039.884	269.566	269.87	269.871
					Low Vegetation	0.304	0.305
109)	☑	37.VVA.LV					
			2086632.66	591345.386	158.602	158.816	158.78
					Low Vegetation	0.214	0.178
110)	☑	4.VVA.LV					
			2056320.879	515324.279	121.466	121.64	121.668
					Low Vegetation	0.174	0.202
111)	☑	44.VVA.LV					
			2179027.675	541433.084	99.216	99.152	99.163
					Low Vegetation	-0.064	-0.053
112)	☑	45.VVA.LV					
			2172525.033	524909.628	73.674	73.685	73.67
					Low Vegetation	0.011	-0.004

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
113)	☑	**50.VVA.LV**					
			2177976.802	583994.721	130.744	130.653	130.647
					Low Vegetation	-0.091	-0.097
114)	☑	**56.VVA.LV**					
			2212104.1	632300.995	124.567	124.395	124.413
					Low Vegetation	-0.172	-0.154
115)	☑	**58.VVA.LV**					
			2229214.65	619434.741	101.86	101.929	101.917
					Low Vegetation	0.069	0.057
116)	☑	**6.VVA.LV**					
			2096381.708	550220.797	146.056	146.068	146.106
					Low Vegetation	0.012	0.05
117)	☑	**61.VVA.LV**					
			2261989.121	631425.148	125.863	125.638	125.661
					Low Vegetation	-0.225	-0.202
118)	☑	**64.VVA.LV**					
			2223803.755	665224.35	149.531	149.443	149.42
					Low Vegetation	-0.088	-0.111
119)	☑	**66.VVA.LV**					
			2232489.102	704488.047	127.27	127.096	127.137
					Low Vegetation	-0.174	-0.133

Coordinates and Offsets of Analyzed Locations (Continued)

	ID	Survey X	Survey Y	Z1	Z DEM	Z LAS
				LC Type	ΔZ DEM	ΔZ LAS
120)	**67.VVA.LV**					
		2239407.845	726101.21	127.424	127.451	127.496
				Low Vegetation	0.027	0.072
121)	**71.VVA.LV**					
		2268845.989	719348.375	78.041	78.068	78.026
				Low Vegetation	0.027	-0.015
122)	**72.VVA.LV**					
		2287813.103	734768.932	102.706	102.802	102.799
				Low Vegetation	0.096	0.093
123)	**75.VVA.LV**					
		2313890.072	725765.936	75.262	75.213	75.205
				Low Vegetation	-0.049	-0.057
124)	**76.VVA.LV**					
		2331319.705	736494.226	92.962	93.113	93.043
				Low Vegetation	0.151	0.081
125)	**78.VVA.LV**					
		2294477.524	702733.06	96.762	96.623	96.673
				Low Vegetation	-0.139	-0.089
126)	**8.VVA.LV**					
		2081466.52	569029.876	160.718	160.783	160.784
				Low Vegetation	0.065	0.066

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
127)	☑	**80.VVA.LV**					
			2286855.264	675631.085	75.082	74.894	74.914
					Low Vegetation	-0.188	-0.168
128)	☑	**83.VVA.LV**					
			2195193.994	671225.154	157.972	157.845	157.871
					Low Vegetation	-0.127	-0.101
129)	☑	**87.VVA.LV**					
			2093827.954	654527.558	234.347	234.471	234.461
					Low Vegetation	0.124	0.114
130)	☑	**93.VVA.LV**					
			2054402.927	626343.446	298.392	298.335	298.355
					Low Vegetation	-0.057	-0.037
131)	☑	**20.VVA.MV**					
			1936730.809	617878.577	315.941	315.773	315.806
					Medium Vegetation	-0.168	-0.135
132)	☑	**36.VVA.MV**					
			2125036.576	652432.788	171.355	171.414	171.451
					Medium Vegetation	0.059	0.096
133)	☑	**4.VVA.MV**					
			2056313.268	515366.408	121	121.192	121.219
					Medium Vegetation	0.192	0.219

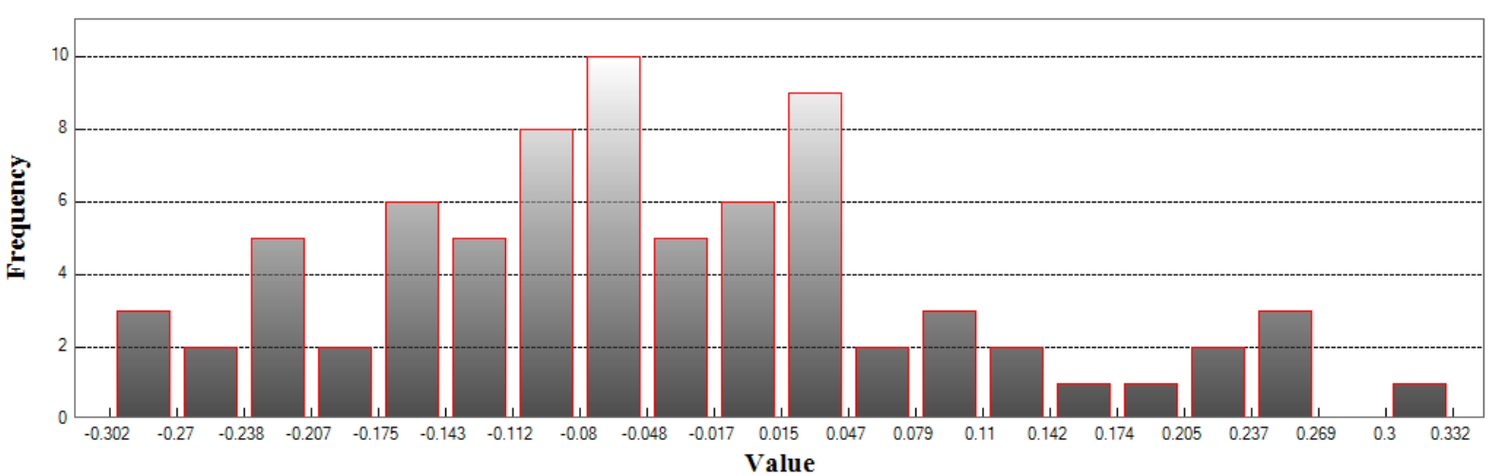
Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	**Survey Y**	**Z1**	**Z DEM**	**Z LAS**
					LC Type	**ΔZ DEM**	**ΔZ LAS**
134)	☑	**52.VVA.MV**					
			2174544.575	568021.334	124.639	124.531	124.532
					Medium Vegetation	-0.108	-0.107
135)	☑	**67.VVA.MV**					
			2239505.452	726052.388	126.604	126.782	126.72
					Medium Vegetation	0.178	0.116

LAS

Nonvegetated Vertical Accuracy
LandCover Type: Bare Ground, Hard Pavement, Packed Sand
Minimum DZ: -0.302
Maximum DZ: 0.332
Mean DZ: -0.043
Mean Magnitude DZ: 0.342
Number Observations: 76
Standard Deviation DZ: 0.139
RMSE Z: 0.145
95% Confidence Level Z: 0.284
Units: US Survey Feet

Histogram



Min: -0.302
Max: 0.332
Number Of Bins: 20
Bin Interval: 0.032

LAS (Continued)

Vegetated Vertical Accuracy

LandCover Type: High Vegetation

Minimum DZ: -0.273

Maximum DZ: 0.479

Mean DZ: 0.101

Mean Magnitude DZ: 0.428

Number Observations: 21

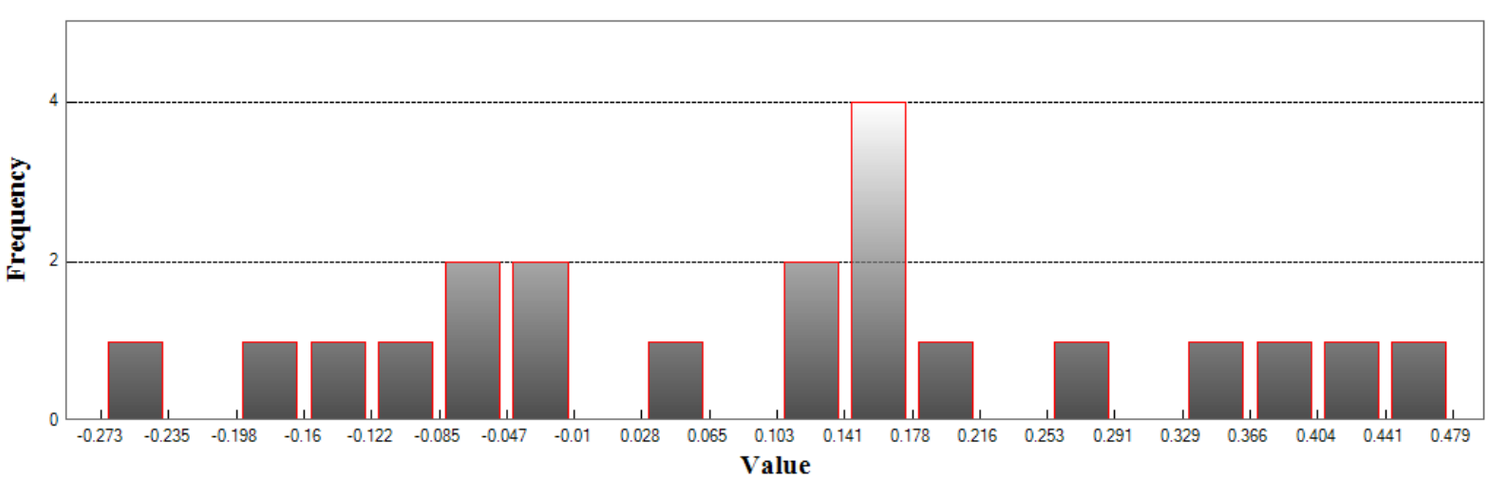
Standard Deviation DZ: 0.205

RMSE Z: 0.224

95th Percentile: 0.448

Units: US Survey Feet

Histogram



Min: -0.273

Max: 0.479

Number Of Bins: 20

Bin Interval: 0.038

LAS (Continued)

Vegetated Vertical Accuracy

LandCover Type: Low Vegetation

Minimum DZ: -0.364

Maximum DZ: 0.311

Mean DZ: -0.004

Mean Magnitude DZ: 0.352

Number Observations: 33

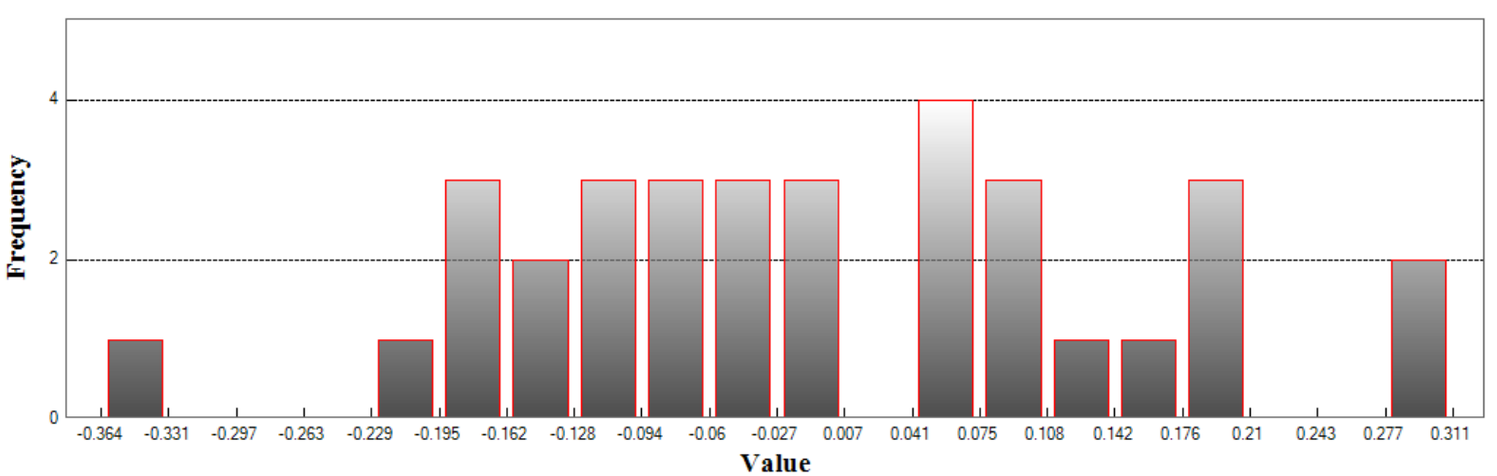
Standard Deviation DZ: 0.153

RMSE Z: 0.151

95th Percentile: 0.305

Units: US Survey Feet

Histogram



Min: -0.364

Max: 0.311

Number Of Bins: 20

Bin Interval: 0.034

LAS (Continued)

Vegetated Vertical Accuracy

LandCover Type: Medium Vegetation

Minimum DZ: -0.135

Maximum DZ: 0.219

Mean DZ: 0.038

Mean Magnitude DZ: 0.367

Number Observations: 5

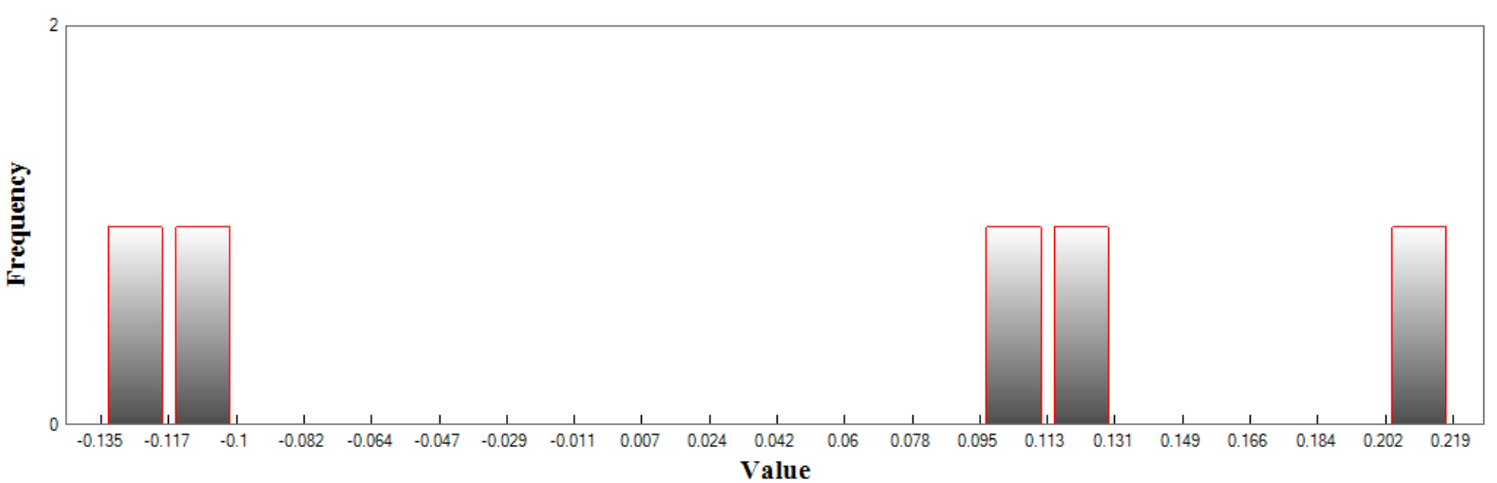
Standard Deviation DZ: 0.153

RMSE Z: 0.142

95th Percentile: 0.219

Units: US Survey Feet

Histogram



Min: -0.135

Max: 0.219

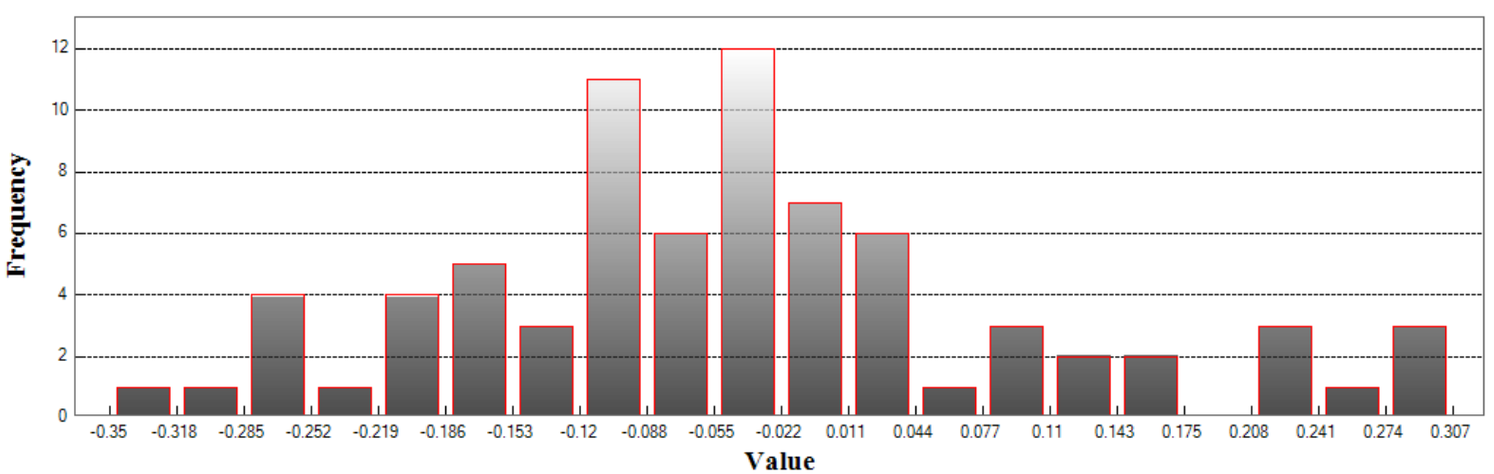
Number Of Bins: 20

Bin Interval: 0.018

DEM

Nonvegetated Vertical Accuracy
LandCover Type: Bare Ground, Hard Pavement, Packed Sand
Minimum DZ: -0.35
Maximum DZ: 0.307
Mean DZ: -0.042
Mean Magnitude DZ: 0.343
Number Observations: 76
Standard Deviation DZ: 0.143
RMSE Z: 0.148
95% Confidence Level Z: 0.291
Units: US Survey Feet

Histogram



Min: -0.35
Max: 0.307
Number Of Bins: 20
Bin Interval: 0.033

DEM (Continued)

Vegetated Vertical Accuracy

LandCover Type: High Vegetation

Minimum DZ: -0.334

Maximum DZ: 0.516

Mean DZ: 0.091

Mean Magnitude DZ: 0.434

Number Observations: 21

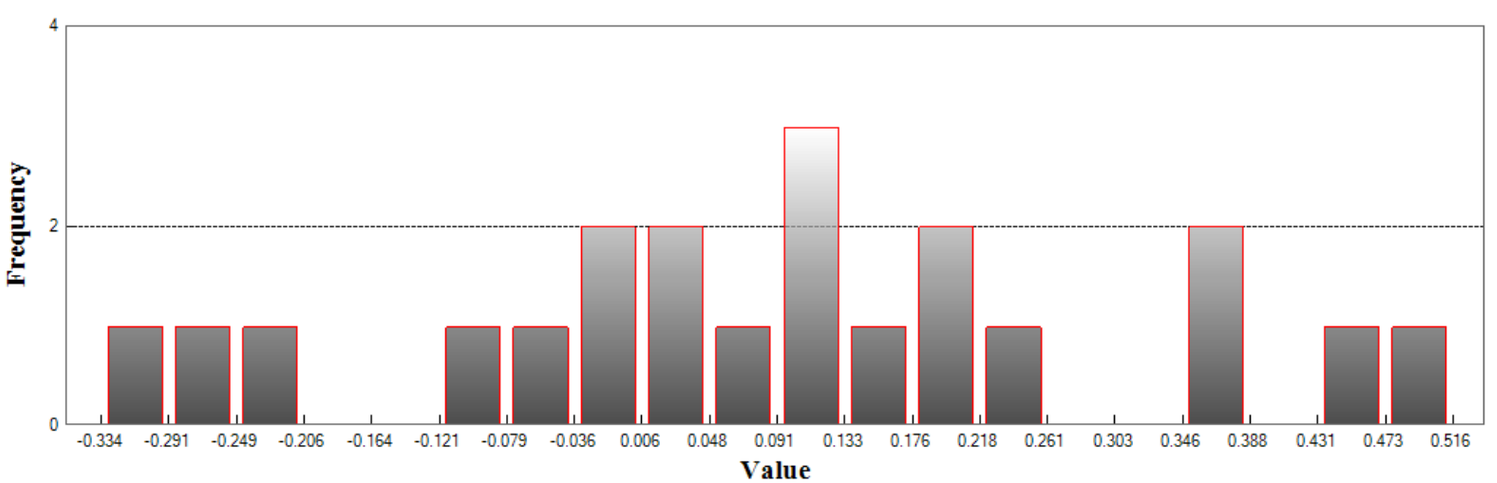
Standard Deviation DZ: 0.225

RMSE Z: 0.238

95th Percentile: 0.477

Units: US Survey Feet

Histogram



Min: -0.334

Max: 0.516

Number Of Bins: 20

Bin Interval: 0.042

DEM (Continued)

Vegetated Vertical Accuracy

LandCover Type: Low Vegetation

Minimum DZ: -0.372

Maximum DZ: 0.304

Mean DZ: -0.009

Mean Magnitude DZ: 0.365

Number Observations: 33

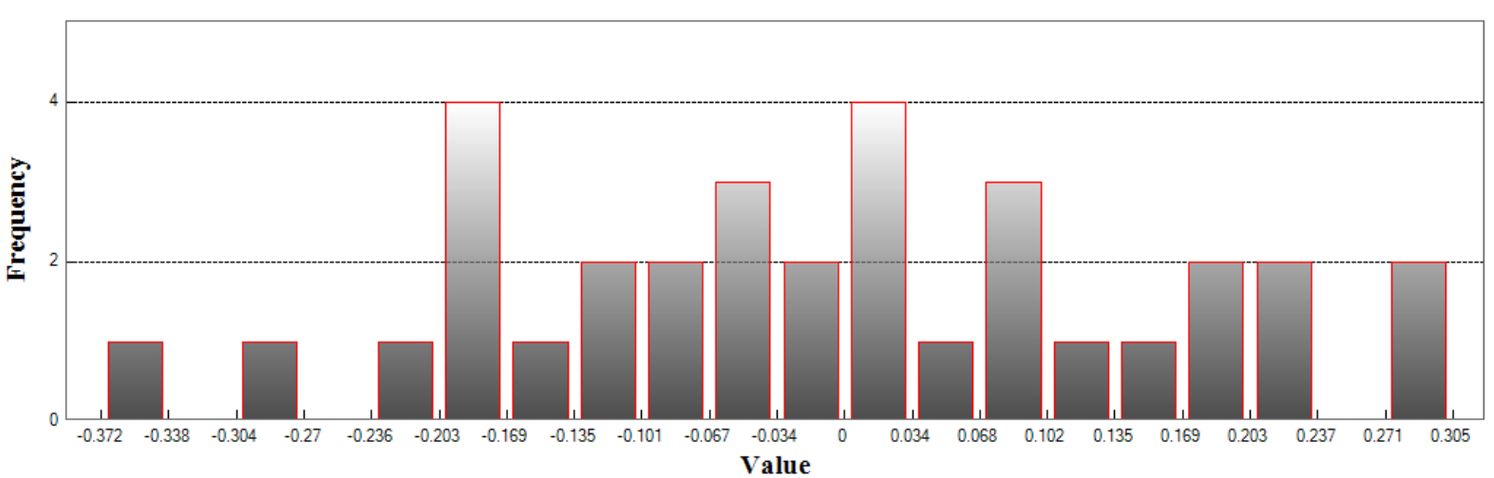
Standard Deviation DZ: 0.164

RMSE Z: 0.162

95th Percentile: 0.273

Units: US Survey Feet

Histogram



Min: -0.372

Max: 0.304

Number Of Bins: 20

Bin Interval: 0.034

DEM (Continued)

Vegetated Vertical Accuracy

LandCover Type: Medium Vegetation

Minimum DZ: -0.168

Maximum DZ: 0.192

Mean DZ: 0.031

Mean Magnitude DZ: 0.376

Number Observations: 5

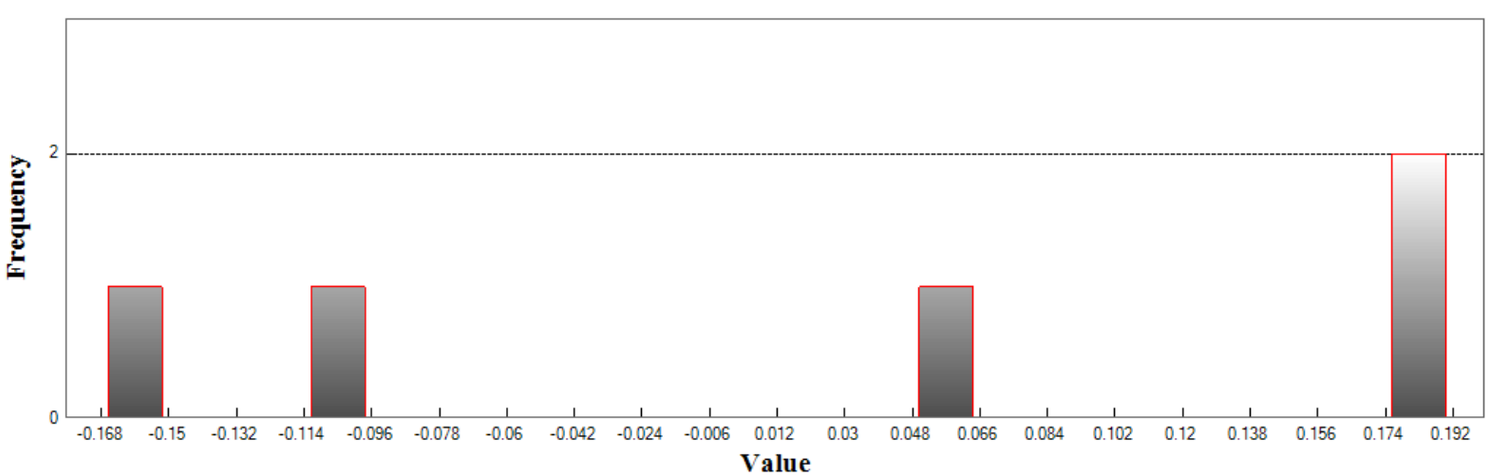
Standard Deviation DZ: 0.164

RMSE Z: 0.15

95th Percentile: 0.192

Units: US Survey Feet

Histogram



Min: -0.168

Max: 0.192

Number Of Bins: 20

Bin Interval: 0.018