
LiDAR Project Report

G14PD01081, FEMA Region
6 – Upper Clear Fork Brazos,
TX QL2 LiDAR

Prepared For:

United States Geological Survey



Prepared By:

Digital Aerial Solutions, LLC



CONTRACT: #G10PC00093

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TASK ORDER: # G14PD01081

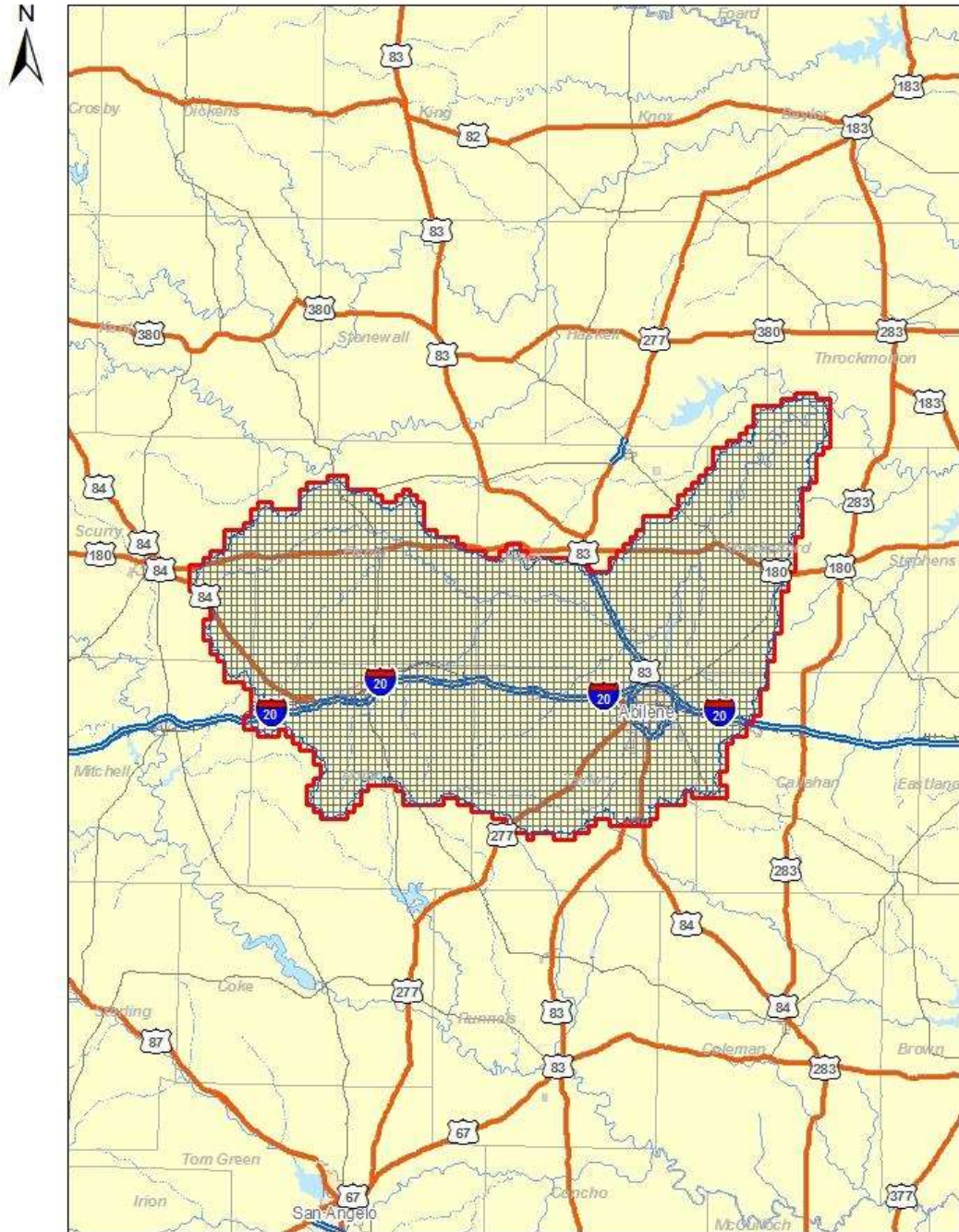
Project Report
LiDAR Collection, Processing, and QA/QC

G14PD01081, FEMA Region 6 –
Upper Clear Fork Brazos, TX QL2
LiDAR

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Upper Clear Fork Brazos Watershed TX QL2 LiDAR



QL2 LiDAR AOI

UpperClearForkBrazos_LidarExtent

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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 G14PD01081, FEMA Region 6 – Upper Clear Fork Brazos QL2 LiDAR. The area encompasses approximately 2983 square miles. Aerial LiDAR data was collected utilizing an ALS70 and ALS80. The ALS70 is a discrete return topographic LiDAR mapping system manufactured by Leica Geosystems.

LiDAR data collected for the G14PD01081, FEMA Region 6 – Upper Clear Fork Brazos QL2 LiDAR Lidar survey has a nominal pulse spacing of 0.7 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 (DEM)s, intensity tiles, and bare-earth DEM tiles. Point cloud deliverables are stored in the LAS version 1.2 formats. The tiling scheme for tiled deliverables is a 1500 meters x 1500 meter grid. 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 1.0*.

2 Spatial Reference System

The spatial reference of the data is as follows.

Horizontal Spatial Reference

- Datum: NAVD88, Meters (to 3 decimal places)
- Coordinates: UTM Zone 14, NAD83, Meters (to 2 decimal places);

Vertical Spatial Reference

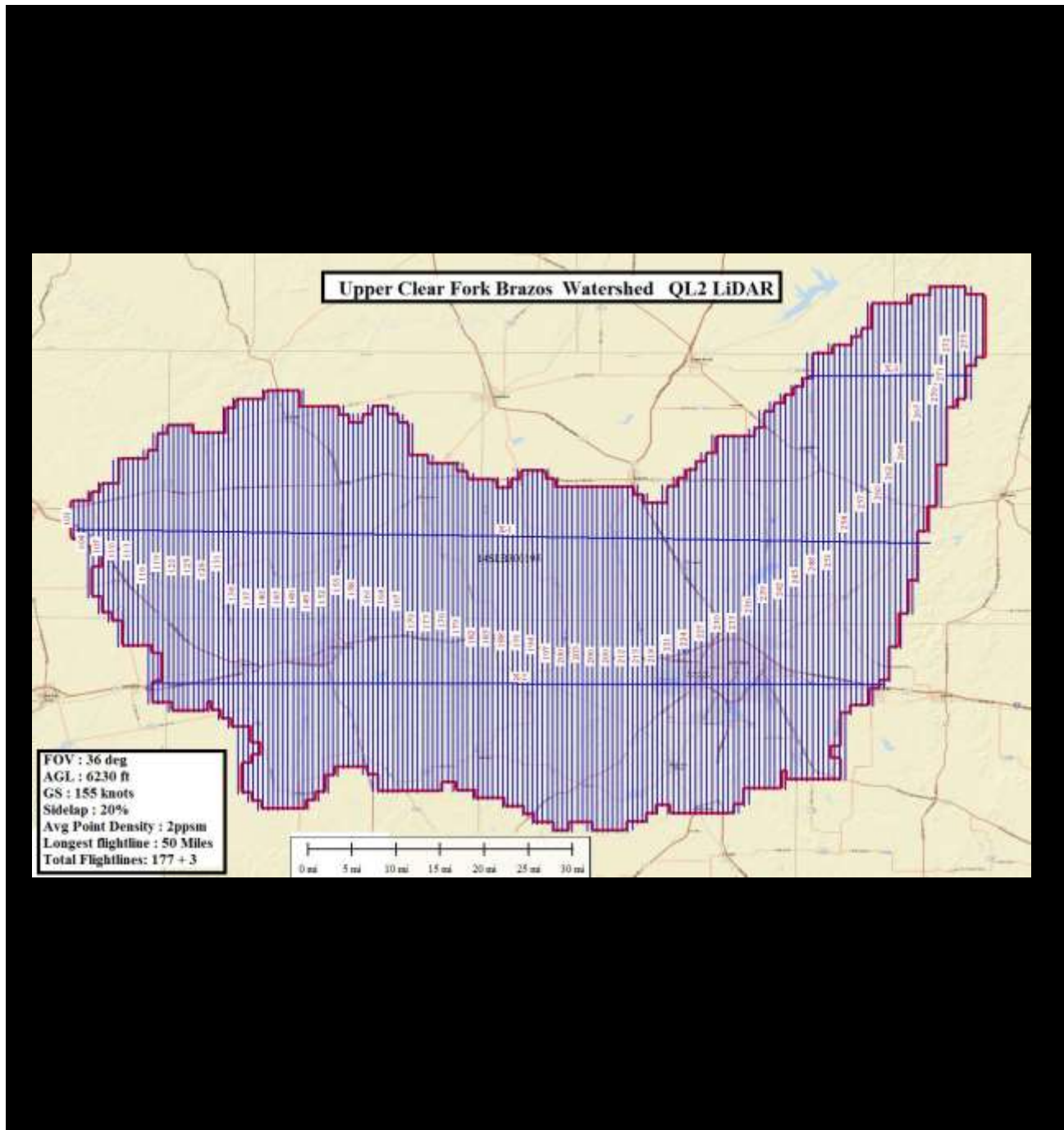
All datasets are available with orthometric elevation; point cloud datasets are also available with ellipsoid heights

- Datum: North American Vertical Datum of 1983

3 LiDAR Acquisition

3.1 Survey Area

The G14PD01081, FEMA Region 6 – Upper Clear Fork Brazos QL2 Lidar survey covers approximately 2983 square miles covering all of Haskell, Throckmorton, Scurry, Fisher, Jones, Shackelford, Mitchell, Nolan, Taylor and Callahan Counties. The flight plan consisted of 177 survey lines and 3 control lines.



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. Acquisition parameters selected for the Upper Clear Fork Brazos TX, 2ppsm Lidar project are summarized below.

Parameter	Value
Flying Height Above Ground Level	6230 feet
Nominal Sidelap	30%
Nominal Speed Over Ground	155 knots
Field of View	36°
Laser Rate	132 kHz
Scan Rate	66.2 hz
Maximum Cross Track Spacing	0.78 meters
Maximum Along Track Spacing	0.82 meters
Average Spacing	0.7 meters

3.3 Acquisition Mission

The acquisition mission for G14PD01081, FEMA Region 6 –Upper Clear Fork Brazos QL2 LiDAR survey was coordinated to be acquired in 2 weeks. Collection began on December 12th 2014 and was completed on December 22nd , 2014.

3.4 Airborne GPS/IMU

Airborne global positioning system (GPS) and inertial measurement unit (IMU) data was 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 are collected at a frequency of 200Hz.

Aircraft	Sensor	GPS Lever Arm (m)	IMU Lever Arm (m)
C421 – N112MJ	ALS70 – SN1132	x: -0.210, y: -0.060, z: -1.370	x: -0.450, y: -0.159, z: -0.169

In addition, GPS data was collected with ground base stations during the acquisition mission, providing corrections to support differential post-processing of the airborne GPS. One ground base station was setup at an NGS Benchmark (Keyport) as the base of operation. The additional ground base station were selected and place threw the project to ensure complete coverage. Ground GPS observations were collected at a frequency of 2Hz.

4 LiDAR Processing

4.1 Acquisition Post-Processing

Once the acquisition was completed, initial post-processing was performed to generate geo-referenced LiDAR elevation point clouds.

The airborne GPS dataset was differentially corrected using the ground base station GPS datasets collected by DAS in Leica's IPAS software. IPAS computes the GPS dataset corrections in both forward and reverse chronological sequence, obtaining two solutions for the GPS trajectory. The differences between these two solutions were reviewed to ensure a consistent result, and agree within +/- 3cm. The forward and reverse solutions also show good fit between the two different base stations used in the post-processing.

Differentially corrected airborne GPS data was merged with the airborne IMU dataset in Leica's IPAS software through Kalman filtering techniques. IPAS applies the reference lever arms for the GPS and IMU measurement systems during processing to determine the trajectory (position and orientation) of the LiDAR sensor during the acquisition mission. Estimated lever arm values reported posteriori validate the measurements made during sensor installation in the aircraft.

Raw LiDAR sensor ranging data and the final sensor trajectory from IPAS were processed in Leica's ALSPP software to produce the LiDAR elevation point cloud swaths for each flightline, stored in LAS version 1.2 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 G14PDO1081, FEMA Region 6 – Upper Clear Fork Brazos QL2 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-site), and mirror deformation constants (scaling).

The manufacturer specific calibration parameters are applied in Leica's Cloud Pro software for the ALS80 sensor system. Terrasolid's Terramatch software was used to calculate the IMU bore-site and mirror scale parameters for the G14PDO1081, FEMA Region 6 – Upper Clear Fork Brazos QL2 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-site 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-site and mirror scale parameters with the automated algorithms.

survey and control lines. Manual estimation of the bore-site 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. 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. 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-site and mirror scale calculation step; and an absolute step, where groups of lines are leveled to project ground control.

For the G14PD01081, FEMA Region 6 – Upper Clear Fork Brazos QL2 LiDAR project, the control lines were used to determine relative z offset corrections in areas of discernible ground. The base station operated by DAS in the survey area provided for minimal baseline lengths, resulting in generally good z agreement between the survey lines and control lines.

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 USNG index, 1500 meter x 1500 meter LAS 1.2 format tiles for point cloud classification and derived 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 – Noise (low or high, manually identified, if needed)
- Class 9 – Water
- Class 10 – Ignored Ground (Breakline Proximity)

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 were collected directly from the classified point clouds and from triangulated irregular network (TIN) surface models built from the classified point clouds, in Terrasolids's Terrascan and Terramodeler software. Breakline features were collected as design file elements in Bentley's Microstation software. Breaklines were converted to ESRI 3D shapefile format for the breakline deliverable, and tiled to USNG index.

The data collected for the G14PD01081, FEMA Region 6 – Upper Clear Fork Brazos QL2 LiDAR survey maintained significant point density in the water, limiting the usefulness of point density as guiding factor in breakline placement.

Points classified as Class 2 – Bare-earth ground, falling within a one meter buffer of the collected breaklines, were reassigned to Class 10 – Ignored Ground. These points are excluded from the surface model during DEM generation to preserve the hydro-flattening characteristics of the breaklines.

4.5 DEM Generation

The final classified point clouds and collected breaklines were reviewed for completeness and conformance to the task order scope of work. Within the Terramodeler software, points in Class 2 – Bare-earth ground and the breaklines were combined to generate TIN elevation models for each tile, from which the bare-earth DEM tiles were interpolated and exported as 32 bit raster IMG format.

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 G14PD01081, FEMA Region 6 – Upper Clear Fork Brazos QL2 LiDAR project, two base stations were run to meet this requirement, one at the field operations airport and one within the survey area. 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 CloudPro 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.

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.

There is not a systematic method of testing when testing horizontal accuracy in LiDAR. The estimated Horizontal accuracy at one sigma based on the flying height for the project, is between 10cm and 20cm according to manufacturer specifications.

Absolute vertical accuracy assessments for the point cloud data are made against ground check point data. For the G14PD01081, FEMA Region 6 – Upper Clear Fork Brazos QL2 LiDAR, ground check point data consisted of the ground GPS base station, and real-time kinematic (RTK) GPS techniques.

Check point locations were collected at 1 – second intervals during the RTK survey. Points collected during the static pre-initialization and post-initialization were 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 fundamental vertical accuracy (FVA) of the swath point clouds. The NVA of the TIN tested RMSE_z 0.067 meters and 0.131 meters at the 95% confidence level in open terrain. NVA of the DEM tested at an RMSE_z of 0.067 meters and 0.130 meters at the 95% confidence level in open terrain. The full calculations for all check points can be found in Appendix A.

FVA of TIN

RMSE _z =	0.067	meters
NSSDA =	0.131	meters

FVA of DEM

RMSE _z =	0.067	meters
NSSDA =	0.130	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 3D shapefile format were reviewed for topological consistency and correct elevation. Breaklines features are continuous and do not have overlaps or dangles.

5.3 Digital Elevation Models

Digital elevation models (DEMs) were reviewed for conformance with the SOW and the Base Mapping Specification version 1.0 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.

Appendices

Appendix A. Vertical Accuracy Calculations



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Project Information

Prepared By: Joshua Helton
Project Name: TX Upper Clear Brazos
Sensor Info: ALS80
Required Nominal Pulse Spacing: 0.7
Vendor Name: USGS
Units: Meters
Percent of Extent Tolerance: Extents Not Checked
Date of Aquisition: Start: 1/19/2016 Finish: 1/19/2016

Metadata Information

Tile Index:

Path: Q:\G14PD01081 Fort Brazos\Index\LiDAR_Index.shp

Number of Polys: 0

Intensity:

Tile Index Attribute: Not Specified

Path to Data: Not Specified

DEM:

Tile Index Attribute: USNG

Path to Data: Q:\G14PD01081 Fort Brazos\BE_DEM

LAS:

Tile Index Attribute: USNG

Path to Data: Q:\G14PD01081 Fort Brazos\Classified_PointCloud



Tiled-Data Area





LiDAR Accuracy Assessment Summary

LC Type	# of Points	FVA	SVA	CVA
LAS				
ALL	258			0.213
Brushland	36		0.262	
Forested	36		0.192	
TallWeeds	62		0.194	
Bare Earth	63	0.131		
Urban	61		0.153	
Total	258			
DEM				
ALL	251			0.170
Brushland	36		0.204	
Forested	35		0.180	
TallWeeds	60		0.170	
Bare Earth	61	0.130		
Urban	59		0.128	
Total	251			

Units: Meters



Coordinates and Offsets of Analyzed Locations

	ID					
		Survey X	Survey Y	Z1	Z DEM	Z LAS
				LC Type	ΔZ DEM	ΔZ LAS
1)	<input checked="" type="checkbox"/>	BL_01				
		424096.71	3589102.365	529.958	529.758	529.749
				Brushland	-0.2	-0.209
2)	<input checked="" type="checkbox"/>	BL_04				
		406859.443	3568698.009	663.9	663.911	663.903
				Brushland	0.011	0.003
3)	<input checked="" type="checkbox"/>	BL_05				
		416288.46	3578897.344	585.459	585.706	585.739
				Brushland	0.247	0.28
4)	<input checked="" type="checkbox"/>	BL_06				
		440870.247	3598246.743	526.968	527.081	527.099
				Brushland	0.113	0.131
5)	<input checked="" type="checkbox"/>	BL_10				
		404131.088	3592477.125	571.94	572.014	571.968
				Brushland	0.074	0.028
6)	<input checked="" type="checkbox"/>	BL_12				
		426756.06	3579496.548	557.134	557.219	557.244
				Brushland	0.085	0.11
7)	<input checked="" type="checkbox"/>	BL_13				
		450540.369	3586619.279	616.224	616.243	616.234
				Brushland	0.019	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	
8)	<input checked="" type="checkbox"/>	BL_15					
		370653.558	3623231.086	596.582	596.691	596.815	
				Brushland	0.109	0.233	
9)	<input checked="" type="checkbox"/>	BL_16					
		429861.632	3585508.45	536.078	536.295	536.34	
				Brushland	0.217	0.262	
10)	<input checked="" type="checkbox"/>	BL_17					
		406916.29	3620743.308	556.262	556.355	556.336	
				Brushland	0.093	0.074	
11)	<input checked="" type="checkbox"/>	BL_18					
		424953.255	3604414.673	504.319	504.334	504.31	
				Brushland	0.015	-0.009	
12)	<input checked="" type="checkbox"/>	BL_19					
		444589.092	3625495.319	493.814	493.961	493.981	
				Brushland	0.147	0.167	
13)	<input checked="" type="checkbox"/>	BL_20					
		370654.375	3612106.354	611.227	611.246	611.458	
				Brushland	0.019	0.231	
14)	<input checked="" type="checkbox"/>	BL_21					
		384053.997	3595281.775	604.233	604.224	604.401	
				Brushland	-0.009	0.168	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
15)	<input checked="" type="checkbox"/>	BL_22					
		359788.987	3570881.074	782.481	782.524	782.673	
				Brushland	0.043	0.192	
16)	<input checked="" type="checkbox"/>	BL_28					
		453155.63	3606863.617	576.502	576.591	576.577	
				Brushland	0.089	0.075	
17)	<input checked="" type="checkbox"/>	BL_30					
		386237.845	3615998.363	566.336	566.273	566.599	
				Brushland	-0.063	0.263	
18)	<input checked="" type="checkbox"/>	BL_31					
		396513.342	3606618.241	565.777	565.888	565.876	
				Brushland	0.111	0.099	
19)	<input checked="" type="checkbox"/>	BL_33					
		436457.153	3605654.369	504.846	504.965	505.058	
				Brushland	0.119	0.212	
20)	<input checked="" type="checkbox"/>	BL_34					
		448602.831	3615231.47	538.195	538.281	538.384	
				Brushland	0.086	0.189	
21)	<input checked="" type="checkbox"/>	BL_35					
		437790.59	3617114.213	473.043	473.206	473.212	
				Brushland	0.163	0.169	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
22)	<input checked="" type="checkbox"/>	BL_36					
		370703.483	3583234.943	691.41	691.445	691.456	
				Brushland	0.035	0.046	
23)	<input checked="" type="checkbox"/>	BL_37					
		443909.554	3640157.299	472.918	473.045	473.158	
				Brushland	0.127	0.24	
24)	<input checked="" type="checkbox"/>	BL_38					
		437314.542	3632601.491	482.326	482.37	482.371	
				Brushland	0.044	0.045	
25)	<input checked="" type="checkbox"/>	BL_40					
		404569.663	3583163.129	585.872	585.974	585.914	
				Brushland	0.102	0.042	
26)	<input checked="" type="checkbox"/>	BL_41					
		357019.071	3623464.633	632.015	632.205	632.203	
				Brushland	0.19	0.188	
27)	<input checked="" type="checkbox"/>	BL_44					
		409610.804	3609359.506	536.301	536.305	536.356	
				Brushland	0.004	0.055	
28)	<input checked="" type="checkbox"/>	BL_46					
		370448.147	3574700.037	783.851	783.766	783.887	
				Brushland	-0.085	0.036	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
29)	<input checked="" type="checkbox"/>	BL_47					
		395337.301	3584203.564	638.115	638.156	638.229	
				Brushland	0.041	0.114	
30)	<input checked="" type="checkbox"/>	BL_49					
		413340.475	3589655.658	553.181	553.347	553.326	
				Brushland	0.166	0.145	
31)	<input checked="" type="checkbox"/>	BL_50					
		429774.914	3613724.355	517.292	517.345	517.354	
				Brushland	0.053	0.062	
32)	<input checked="" type="checkbox"/>	BL_51					
		452792.272	3595546.101	617.342	617.493	617.517	
				Brushland	0.151	0.175	
33)	<input checked="" type="checkbox"/>	BL_53					
		418927.395	3594819.097	546.206	546.2	546.345	
				Brushland	-0.006	0.139	
34)	<input checked="" type="checkbox"/>	BL_58					
		387007.502	3605144.158	579.762	579.792	579.869	
				Brushland	0.03	0.107	
35)	<input checked="" type="checkbox"/>	BL_61					
		424046.585	3590553.217	524.056	523.976	524.161	
				Brushland	-0.08	0.105	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
36)	<input checked="" type="checkbox"/>	BL_62					
		459920.262	3635470.513	527.514	527.642	527.658	
				Brushland	0.128	0.144	
37)	<input checked="" type="checkbox"/>	FRST_01					
		424144.115	3589151.383	529.627	529.292	529.452	
				Forested	-0.335	-0.175	
38)	<input checked="" type="checkbox"/>	FRST_02					
		443367.948	3571333.252	629.105	629.097	629.331	
				Forested	-0.008	0.226	
39)	<input checked="" type="checkbox"/>	FRST_03					
		438086.777	3577449.916	556.086	556.035	556.03	
				Forested	-0.051	-0.056	
40)	<input checked="" type="checkbox"/>	FRST_04					
		406838.547	3568709.862	664.554	664.589	664.629	
				Forested	0.035	0.075	
41)	<input checked="" type="checkbox"/>	FRST_05					
		416358.848	3578850.167	587.353	587.394	587.451	
				Forested	0.041	0.098	
42)	<input checked="" type="checkbox"/>	FRST_09					
		393357.374	3595474.516	587.081	587.223	587.219	
				Forested	0.142	0.138	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
43)	<input checked="" type="checkbox"/>	FRST_10					
		404192.899	3592354.415	572.004	571.999	572.007	
				Forested	-0.005	0.003	
44)	<input checked="" type="checkbox"/>	FRST_11					
		426733.732	3579507.898	557.286	557.286	557.293	
				Forested	0	0.007	
45)	<input checked="" type="checkbox"/>	FRST_12					
		450827.057	3586633.056	617.482	617.478	617.471	
				Forested	-0.004	-0.011	
46)	<input checked="" type="checkbox"/>	FRST_15					
		429792.988	3585555.262	536.11	536.127	536.13	
				Forested	0.017	0.02	
47)	<input checked="" type="checkbox"/>	FRST_19					
		453992.699	3620966.946	559.152	559.319	559.316	
				Forested	0.167	0.164	
48)	<input checked="" type="checkbox"/>	FRST_26					
		425233.168	3623924.768	530.771	NaN	530.666	
				Forested	NaN	-0.105	
49)	<input checked="" type="checkbox"/>	FRST_28					
		453159.77	3606867.949	576.403	576.503	576.488	
				Forested	0.1	0.085	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
50)	<input checked="" type="checkbox"/>	FRST_29					
		411172.399	3601334.585	549.031	549.045	549.07	
				Forested	0.014	0.039	
51)	<input checked="" type="checkbox"/>	FRST_30					
		386252.974	3615988.106	566.406	566.44	566.47	
				Forested	0.034	0.064	
52)	<input checked="" type="checkbox"/>	FRST_31					
		396489.553	3606611.604	566.057	566.118	565.983	
				Forested	0.061	-0.074	
53)	<input checked="" type="checkbox"/>	FRST_32					
		419010.854	3616228.873	538.538	538.506	538.502	
				Forested	-0.032	-0.036	
54)	<input checked="" type="checkbox"/>	FRST_33					
		436508.973	3605672.23	505.972	506.073	506.09	
				Forested	0.101	0.118	
55)	<input checked="" type="checkbox"/>	FRST_34					
		448551.623	3615210.59	538.296	538.299	538.543	
				Forested	0.003	0.247	
56)	<input checked="" type="checkbox"/>	FRST_35					
		437805.792	3617097.904	473.018	473.096	473.07	
				Forested	0.078	0.052	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
57)	<input checked="" type="checkbox"/>	FRST_36					
		443896.266	3640147.684	472.523	472.49	472.519	
				Forested	-0.033	-0.004	
58)	<input checked="" type="checkbox"/>	FRST_37					
		437354.105	3632537.201	481.283	481.363	481.354	
				Forested	0.08	0.071	
59)	<input checked="" type="checkbox"/>	FRST_39					
		404585.096	3583165.134	585.544	585.543	585.482	
				Forested	-0.001	-0.062	
60)	<input checked="" type="checkbox"/>	FRST_42					
		394268.928	3614689.187	547.017	547.026	546.985	
				Forested	0.009	-0.032	
61)	<input checked="" type="checkbox"/>	FRST_44					
		409620.764	3609353.539	536.393	536.369	536.443	
				Forested	-0.024	0.05	
62)	<input checked="" type="checkbox"/>	FRST_46					
		370499.582	3574736.834	783.494	783.359	783.438	
				Forested	-0.135	-0.056	
63)	<input checked="" type="checkbox"/>	FRST_47					
		395373.557	3584229.885	638.051	638.127	638.149	
				Forested	0.076	0.098	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
64)	<input checked="" type="checkbox"/>	FRST_48					
		377264.596	3604240.341	638.704	638.655	638.673	
				Forested	-0.049	-0.031	
65)	<input checked="" type="checkbox"/>	FRST_49					
		413362.655	3589678.423	552.58	552.61	552.625	
				Forested	0.03	0.045	
66)	<input checked="" type="checkbox"/>	FRST_52					
		428276.501	3565684.664	602.138	602.103	602.093	
				Forested	-0.035	-0.045	
67)	<input checked="" type="checkbox"/>	FRST_53					
		419022.803	3594862.182	544.759	544.738	544.769	
				Forested	-0.021	0.01	
68)	<input checked="" type="checkbox"/>	FRST_55					
		417371.174	3568043.588	607.796	607.789	607.796	
				Forested	-0.007	0	
69)	<input checked="" type="checkbox"/>	FRST_56					
		357760.254	3579819.12	769.749	769.873	769.908	
				Forested	0.124	0.159	
70)	<input checked="" type="checkbox"/>	FRST_58					
		387011.241	3605154.153	579.85	579.831	579.974	
				Forested	-0.019	0.124	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
71)	<input checked="" type="checkbox"/>	FRST_59					
		339231.122	3614785.67	722.54	722.596	722.589	
				Forested	0.056	0.049	
72)	<input checked="" type="checkbox"/>	FRST_62					
		459926.143	3635445.916	527.489	527.698	527.669	
				Forested	0.209	0.18	
73)	<input checked="" type="checkbox"/>	TW_01					
		424113.935	3589142.917	529.779	529.581	529.553	
				TallWeeds	-0.198	-0.226	
74)	<input checked="" type="checkbox"/>	TW_02					
		443331.456	3571318.13	627.053	627.066	627.064	
				TallWeeds	0.013	0.011	
75)	<input checked="" type="checkbox"/>	TW_03					
		438038.206	3577518.077	555.445	555.532	555.526	
				TallWeeds	0.087	0.081	
76)	<input checked="" type="checkbox"/>	TW_04					
		406819.917	3568697.313	664.178	664.177	664.313	
				TallWeeds	-0.001	0.135	
77)	<input checked="" type="checkbox"/>	TW_05					
		416306.673	3578906.167	586.204	586.281	586.274	
				TallWeeds	0.077	0.07	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
78)	<input checked="" type="checkbox"/>	TW_06					
		440844.62	3598184.4	527.763	527.771	527.795	
				TallWeeds	0.008	0.032	
79)	<input checked="" type="checkbox"/>	TW_07					
		355080.665	3589834.912	728.126	728.255	728.258	
				TallWeeds	0.129	0.132	
80)	<input checked="" type="checkbox"/>	TW_08					
		367630.564	3594925.619	643.064	643.233	643.231	
				TallWeeds	0.169	0.167	
81)	<input checked="" type="checkbox"/>	TW_09					
		393408.104	3595557.918	586.806	586.852	586.856	
				TallWeeds	0.046	0.05	
82)	<input checked="" type="checkbox"/>	TW_10					
		404123.135	3592473.156	571.903	571.932	571.999	
				TallWeeds	0.029	0.096	
83)	<input checked="" type="checkbox"/>	TW_11					
		431099.034	3594169.192	516.628	516.671	516.673	
				TallWeeds	0.043	0.045	
84)	<input checked="" type="checkbox"/>	TW_12					
		450836.728	3586625.661	617.321	617.37	617.39	
				TallWeeds	0.049	0.069	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
85)	<input checked="" type="checkbox"/>	TW_13					
		367531.468	3595714.546	645.667	645.743	645.747	
				TallWeeds	0.076	0.08	
86)	<input checked="" type="checkbox"/>	TW_14					
		370650.325	3623249.161	596.592	596.758	596.75	
				TallWeeds	0.166	0.158	
87)	<input checked="" type="checkbox"/>	TW_15					
		429865.052	3585537.453	536.009	536.061	536.038	
				TallWeeds	0.052	0.029	
88)	<input checked="" type="checkbox"/>	TW_16					
		406950.995	3620763.572	556.323	556.358	556.381	
				TallWeeds	0.035	0.058	
89)	<input checked="" type="checkbox"/>	TW_17					
		424962.922	3604410.265	504.008	503.954	503.955	
				TallWeeds	-0.054	-0.053	
90)	<input checked="" type="checkbox"/>	TW_18					
		444574.093	3625482.545	493.664	493.628	493.629	
				TallWeeds	-0.036	-0.035	
91)	<input checked="" type="checkbox"/>	TW_19					
		453961.506	3620983.198	559.019	559.147	559.138	
				TallWeeds	0.128	0.119	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
92)	<input checked="" type="checkbox"/>	TW_20					
		370673.525	3612114.949	611.631	611.781	611.782	
				TallWeeds	0.15	0.151	
93)	<input checked="" type="checkbox"/>	TW_21					
		384041.822	3595310.215	603.178	603.143	603.206	
				TallWeeds	-0.035	0.028	
94)	<input checked="" type="checkbox"/>	TW_22					
		359784.111	3570879.294	782.376	782.419	782.42	
				TallWeeds	0.043	0.044	
95)	<input checked="" type="checkbox"/>	TW_23					
		383078.289	3571459.646	761.3	761.43	761.411	
				TallWeeds	0.13	0.111	
96)	<input checked="" type="checkbox"/>	TW_24					
		393319.789	3574104.042	754.624	754.755	754.742	
				TallWeeds	0.131	0.118	
97)	<input checked="" type="checkbox"/>	TW_25					
		342329.472	3622631.115	687.874	688.062	688.048	
				TallWeeds	0.188	0.174	
98)	<input checked="" type="checkbox"/>	TW_26					
		425261.661	3623901.06	530.695	NaN	530.705	
				TallWeeds	NaN	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	
99)	<input checked="" type="checkbox"/>	TW_27					
		336779.191	3607209.178	731.487	731.481	731.466	
				TallWeeds	-0.006	-0.021	
100)	<input checked="" type="checkbox"/>	TW_28					
		453142.065	3606871.232	576.883	576.991	576.992	
				TallWeeds	0.108	0.109	
101)	<input checked="" type="checkbox"/>	TW_29					
		411124.886	3601362.81	548.809	548.872	548.89	
				TallWeeds	0.063	0.081	
102)	<input checked="" type="checkbox"/>	TW_30					
		386225.865	3616000.834	566.146	566.202	566.262	
				TallWeeds	0.056	0.116	
103)	<input checked="" type="checkbox"/>	TW_31					
		396501.014	3606618.904	566.017	566.017	566.036	
				TallWeeds	0	0.019	
104)	<input checked="" type="checkbox"/>	TW_32					
		419030.739	3616224.943	538.071	538.072	538.088	
				TallWeeds	0.001	0.017	
105)	<input checked="" type="checkbox"/>	TW_33					
		436503.414	3605659.5	506.195	506.309	506.306	
				TallWeeds	0.114	0.111	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
106)	<input checked="" type="checkbox"/>	TW_34					
		448569.548	3615219.328	538.292	538.374	538.45	
				TallWeeds	0.082	0.158	
107)	<input checked="" type="checkbox"/>	TW_35					
		437731.269	3617138.414	473.623	473.688	473.699	
				TallWeeds	0.065	0.076	
108)	<input checked="" type="checkbox"/>	TW_36					
		370699.48	3583078.823	697.357	697.368	697.389	
				TallWeeds	0.011	0.032	
109)	<input checked="" type="checkbox"/>	TW_37					
		443909.909	3640172.535	472.955	472.958	472.967	
				TallWeeds	0.003	0.012	
110)	<input checked="" type="checkbox"/>	TW_38					
		437340.417	3632563.801	481.917	481.981	482.001	
				TallWeeds	0.064	0.084	
111)	<input checked="" type="checkbox"/>	TW_39					
		386158.943	3584389.613	768.259	768.224	768.259	
				TallWeeds	-0.035	0	
112)	<input checked="" type="checkbox"/>	TW_40					
		404503.344	3583163.758	586.848	586.873	586.906	
				TallWeeds	0.025	0.058	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
113)	<input checked="" type="checkbox"/>	TW_41					
		356964.121	3623461.203	634.335	634.402	634.455	
				TallWeeds	0.067	0.12	
114)	<input checked="" type="checkbox"/>	TW_42					
		344564.429	3597191.904	723.422	723.612	723.648	
				TallWeeds	0.19	0.226	
115)	<input checked="" type="checkbox"/>	TW_43					
		394266.5	3614696.301	547.075	547.129	547.145	
				TallWeeds	0.054	0.07	
116)	<input checked="" type="checkbox"/>	TW_44					
		361544.492	3602446.442	677.51	677.575	677.633	
				TallWeeds	0.065	0.123	
117)	<input checked="" type="checkbox"/>	TW_45					
		409615.097	3609357.441	536.437	536.371	536.405	
				TallWeeds	-0.066	-0.032	
118)	<input checked="" type="checkbox"/>	TW_46					
		350210.476	3631305.671	645.338	645.33	645.322	
				TallWeeds	-0.008	-0.016	
119)	<input checked="" type="checkbox"/>	TW_47					
		370501.939	3574711.524	784.173	784.158	784.199	
				TallWeeds	-0.015	0.026	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
120)	<input checked="" type="checkbox"/>	TW_48					
		395339.685	3584181.367	637.797	637.808	637.961	
				TallWeeds	0.011	0.164	
121)	<input checked="" type="checkbox"/>	TW_49					
		377274.026	3604218.617	638.534	638.584	638.561	
				TallWeeds	0.05	0.027	
122)	<input checked="" type="checkbox"/>	TW_50					
		413346.183	3589660.577	552.957	553.102	553.152	
				TallWeeds	0.145	0.195	
123)	<input checked="" type="checkbox"/>	TW_51					
		429807.61	3613692.468	516.533	516.532	516.534	
				TallWeeds	-0.001	0.001	
124)	<input checked="" type="checkbox"/>	TW_52					
		452708.588	3595557.316	617.79	617.844	617.842	
				TallWeeds	0.054	0.052	
125)	<input checked="" type="checkbox"/>	TW_53					
		428277.16	3565672.24	602.44	602.523	602.5	
				TallWeeds	0.083	0.06	
126)	<input checked="" type="checkbox"/>	TW_54					
		418947.699	3594837.803	545.774	545.936	545.947	
				TallWeeds	0.162	0.173	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
127)	<input checked="" type="checkbox"/>	TW_55					
		450692.539	3648731.836	492.65	NaN	492.911	
				TallWeeds	NaN	0.261	
128)	<input checked="" type="checkbox"/>	TW_56					
		417363.703	3568020.589	607.479	607.555	607.567	
				TallWeeds	0.076	0.088	
129)	<input checked="" type="checkbox"/>	TW_57					
		357784.714	3579818.161	769.749	769.827	769.851	
				TallWeeds	0.078	0.102	
130)	<input checked="" type="checkbox"/>	TW_58					
		362079.18	3615771.107	633.932	634.055	634.047	
				TallWeeds	0.123	0.115	
131)	<input checked="" type="checkbox"/>	TW_59					
		387018.401	3605191.202	580.258	580.306	580.318	
				TallWeeds	0.048	0.06	
132)	<input checked="" type="checkbox"/>	TW_61					
		370986.615	3624079.741	597.565	597.616	597.605	
				TallWeeds	0.051	0.04	
133)	<input checked="" type="checkbox"/>	TW_62					
		424036.352	3590571.871	524.343	524.264	524.261	
				TallWeeds	-0.079	-0.082	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
134)	<input checked="" type="checkbox"/>	TW_63					
		459920.566	3635447.767	527.617	527.738	527.764	
				TallWeeds	0.121	0.147	
135)	<input checked="" type="checkbox"/>	BECHK_01					
		424086.956	3589133.184	529.809	529.639	529.677	
				Bare Earth	-0.17	-0.132	
136)	<input checked="" type="checkbox"/>	BECHK_02					
		443318.688	3571346.916	626.784	626.7	626.715	
				Bare Earth	-0.084	-0.069	
137)	<input checked="" type="checkbox"/>	BECHK_03					
		438074.767	3577469.543	556.067	556.06	556.062	
				Bare Earth	-0.007	-0.005	
138)	<input checked="" type="checkbox"/>	BECHK_04					
		406828.196	3568727.84	665.72	665.724	665.679	
				Bare Earth	0.004	-0.041	
139)	<input checked="" type="checkbox"/>	BECHK_05					
		416329.525	3578818.048	587.029	587.023	587.027	
				Bare Earth	-0.006	-0.002	
140)	<input checked="" type="checkbox"/>	BECHK_06					
		440829.061	3598192.758	527.915	527.92	527.916	
				Bare Earth	0.005	0.001	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
141)	<input checked="" type="checkbox"/>	BECHK_07					
		355067.226	3589838.687	728.18	728.24	728.261	
				Bare Earth	0.06	0.081	
142)	<input checked="" type="checkbox"/>	BECHK_08					
		367897.173	3594951.121	650.666	650.674	650.704	
				Bare Earth	0.008	0.038	
143)	<input checked="" type="checkbox"/>	BECHK_09					
		393490.678	3595852.827	585.318	585.349	585.376	
				Bare Earth	0.031	0.058	
144)	<input checked="" type="checkbox"/>	BECHK_10					
		404112.426	3592463.792	572.024	572.016	571.983	
				Bare Earth	-0.008	-0.041	
145)	<input checked="" type="checkbox"/>	BECHK_11					
		431137.75	3593723.971	518.141	518.211	518.212	
				Bare Earth	0.07	0.071	
146)	<input checked="" type="checkbox"/>	BECHK_12					
		426879.198	3579653.136	558.458	558.424	558.431	
				Bare Earth	-0.034	-0.027	
147)	<input checked="" type="checkbox"/>	BECHK_13					
		450781.508	3586613.977	616.761	616.713	616.714	
				Bare Earth	-0.048	-0.047	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
148)	<input checked="" type="checkbox"/>	BECHK_14					
		367589.06	3594992.485	640.543	640.591	640.586	
				Bare Earth	0.048	0.043	
149)	<input checked="" type="checkbox"/>	BECHK_15					
		370658.594	3623357.265	596.359	596.409	596.392	
				Bare Earth	0.05	0.033	
150)	<input checked="" type="checkbox"/>	BECHK_16					
		429783.123	3585469.769	536.384	536.375	536.373	
				Bare Earth	-0.009	-0.011	
151)	<input checked="" type="checkbox"/>	BECHK_17					
		406924.884	3620784.64	555.825	555.862	555.824	
				Bare Earth	0.037	-0.001	
152)	<input checked="" type="checkbox"/>	BECHK_18					
		424955.332	3604392.225	503.9	503.739	503.742	
				Bare Earth	-0.161	-0.158	
153)	<input checked="" type="checkbox"/>	BECHK_19					
		444576.928	3625522.367	495.306	495.295	495.278	
				Bare Earth	-0.011	-0.028	
154)	<input checked="" type="checkbox"/>	BECHK_20					
		453953.025	3620947.047	559.508	559.641	559.655	
				Bare Earth	0.133	0.147	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
155)	<input checked="" type="checkbox"/>	BECHK_21					
		370676.832	3612097.403	611.385	611.365	611.363	
				Bare Earth	-0.02	-0.022	
156)	<input checked="" type="checkbox"/>	BECHK_22					
		384050.005	3595296.928	603.589	603.657	603.662	
				Bare Earth	0.068	0.073	
157)	<input checked="" type="checkbox"/>	BECHK_23					
		359777.037	3570893.331	782.635	782.594	782.591	
				Bare Earth	-0.041	-0.044	
158)	<input checked="" type="checkbox"/>	BECHK_24					
		383156.921	3571454.951	762.303	762.246	762.296	
				Bare Earth	-0.057	-0.007	
159)	<input checked="" type="checkbox"/>	BECHK_25					
		393311.256	3574077.352	753.764	753.858	753.852	
				Bare Earth	0.094	0.088	
160)	<input checked="" type="checkbox"/>	BECHK_26					
		342349.073	3622653.818	689.476	689.617	689.607	
				Bare Earth	0.141	0.131	
161)	<input checked="" type="checkbox"/>	BECHK_27					
		425244.825	3623907.987	530.949	NaN	530.808	
				Bare Earth	NaN	-0.141	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
162)	<input checked="" type="checkbox"/>	BECHK_28					
		336950.063	3606829.123	727.678	727.615	727.649	
				Bare Earth	-0.063	-0.029	
163)	<input checked="" type="checkbox"/>	BECHK_29					
		453139.836	3606850.066	576.599	576.667	576.677	
				Bare Earth	0.068	0.078	
164)	<input checked="" type="checkbox"/>	BECHK_30					
		386236.265	3616032.876	564.609	564.62	564.663	
				Bare Earth	0.011	0.054	
165)	<input checked="" type="checkbox"/>	BECHK_31					
		396546.239	3606595.755	565.928	565.982	565.991	
				Bare Earth	0.054	0.063	
166)	<input checked="" type="checkbox"/>	BECHK_32					
		419048.708	3616242.411	538.488	538.531	538.54	
				Bare Earth	0.043	0.052	
167)	<input checked="" type="checkbox"/>	BECHK_33					
		436502.916	3605639.724	506.506	506.552	506.544	
				Bare Earth	0.046	0.038	
168)	<input checked="" type="checkbox"/>	BECHK_34					
		448591.669	3615239.106	538.383	538.423	538.403	
				Bare Earth	0.04	0.02	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
169)	<input checked="" type="checkbox"/>	BECHK_35					
		437767.685	3617142.306	473.7	473.712	473.708	
				Bare Earth	0.012	0.008	
170)	<input checked="" type="checkbox"/>	BECHK_36					
		370702.28	3583074.024	697.619	697.611	697.631	
				Bare Earth	-0.008	0.012	
171)	<input checked="" type="checkbox"/>	BECHK_37					
		443922.892	3640152.763	473.604	473.559	473.55	
				Bare Earth	-0.045	-0.054	
172)	<input checked="" type="checkbox"/>	BECHK_38					
		437373.038	3632565.268	481.76	481.83	481.807	
				Bare Earth	0.07	0.047	
173)	<input checked="" type="checkbox"/>	BECHK_39					
		386143.436	3584375.757	768.806	768.734	768.792	
				Bare Earth	-0.072	-0.014	
174)	<input checked="" type="checkbox"/>	BECHK_40					
		404529.528	3583182.737	586.206	586.232	586.218	
				Bare Earth	0.026	0.012	
175)	<input checked="" type="checkbox"/>	BECHK_41					
		356990.238	3623445.465	633.891	633.962	634.003	
				Bare Earth	0.071	0.112	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
	Survey X	Survey Y	LC Type				
				ΔZ DEM	ΔZ LAS		
176)	<input checked="" type="checkbox"/>	BECHK_42					
		344525.721	3597061.595	721.753	721.823	721.878	
				Bare Earth	0.07	0.125	
177)	<input checked="" type="checkbox"/>	BECHK_43					
		394267.371	3614675.322	546.557	546.569	546.458	
				Bare Earth	0.012	-0.099	
178)	<input checked="" type="checkbox"/>	BECHK_44					
		361515.345	3602465.58	677.888	677.885	677.92	
				Bare Earth	-0.003	0.032	
179)	<input checked="" type="checkbox"/>	BECHK_45					
		409612.387	3609390.846	536.477	536.489	536.495	
				Bare Earth	0.012	0.018	
180)	<input checked="" type="checkbox"/>	BECHK_46					
		350198.64	3631250.354	645.446	645.534	645.516	
				Bare Earth	0.088	0.07	
181)	<input checked="" type="checkbox"/>	BECHK_47					
		370513.374	3574707.72	784.447	784.402	784.439	
				Bare Earth	-0.045	-0.008	
182)	<input checked="" type="checkbox"/>	BECHK_48					
		395350.529	3584219.559	638.353	638.308	638.313	
				Bare Earth	-0.045	-0.04	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
183)	<input checked="" type="checkbox"/>	BECHK_49					
		377230.51	3604222.986	637.423	637.416	637.425	
				Bare Earth	-0.007	0.002	
184)	<input checked="" type="checkbox"/>	BECHK_50					
		413386.198	3589652.701	553.046	553.07	553.106	
				Bare Earth	0.024	0.06	
185)	<input checked="" type="checkbox"/>	BECHK_51					
		429844.155	3613662.227	516.804	516.765	516.763	
				Bare Earth	-0.039	-0.041	
186)	<input checked="" type="checkbox"/>	BECHK_52					
		452724.982	3595520.707	618.017	618.049	618.046	
				Bare Earth	0.032	0.029	
187)	<input checked="" type="checkbox"/>	BECHK_53					
		428312.074	3565673.789	603.288	603.225	603.2	
				Bare Earth	-0.063	-0.088	
188)	<input checked="" type="checkbox"/>	BECHK_54					
		418951.345	3594867.837	545.681	545.652	545.635	
				Bare Earth	-0.029	-0.046	
189)	<input checked="" type="checkbox"/>	BECHK_55					
		450711.05	3648712.789	493.496	NaN	493.47	
				Bare Earth	NaN	-0.026	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID			Z1	Z DEM	Z LAS	
		Survey X	Survey Y				
				LC Type	ΔZ DEM	ΔZ LAS	
190)	<input checked="" type="checkbox"/>	BECHK_56					
		417394.6	3568072.18	608.318	608.282	608.305	
				Bare Earth	-0.036	-0.013	
191)	<input checked="" type="checkbox"/>	BECHK_57					
		357775.164	3579851.929	769.983	769.947	769.94	
				Bare Earth	-0.036	-0.043	
192)	<input checked="" type="checkbox"/>	BECHK_58					
		362051.412	3615773.144	634.163	634.179	634.173	
				Bare Earth	0.016	0.01	
193)	<input checked="" type="checkbox"/>	BECHK_59					
		386980.828	3605123.735	579.587	579.562	579.53	
				Bare Earth	-0.025	-0.057	
194)	<input checked="" type="checkbox"/>	BECHK_60					
		339198.813	3614793.15	723.117	723.136	723.139	
				Bare Earth	0.019	0.022	
195)	<input checked="" type="checkbox"/>	BECHK_61					
		370987.423	3624115.678	597.041	597.084	597.057	
				Bare Earth	0.043	0.016	
196)	<input checked="" type="checkbox"/>	BECHK_62					
		423948.946	3590586.311	525.567	525.345	525.382	
				Bare Earth	-0.222	-0.185	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
197)	<input checked="" type="checkbox"/>	BECHK_63					
		459896.093	3635454.4	527.95	528.079	528.04	
				Bare Earth	0.129	0.09	
198)	<input checked="" type="checkbox"/>	URBNCHK_01					
		424101.149	3589149.274	529.707	529.506	529.485	
				Urban	-0.201	-0.222	
199)	<input checked="" type="checkbox"/>	URBNCHK_02					
		443256.98	3571407.292	624.473	624.398	624.41	
				Urban	-0.075	-0.063	
200)	<input checked="" type="checkbox"/>	URBNCHK_03					
		438068.42	3577495.155	556.115	556.055	556.055	
				Urban	-0.06	-0.06	
201)	<input checked="" type="checkbox"/>	URBNCHK_04					
		406806.036	3568692.227	664.857	664.856	664.858	
				Urban	-0.001	0.001	
202)	<input checked="" type="checkbox"/>	URBNCHK_05					
		416347.264	3578842.448	587.318	587.335	587.36	
				Urban	0.017	0.042	
203)	<input checked="" type="checkbox"/>	URBNCHK_07					
		355071.101	3589820.216	728.22	728.29	728.294	
				Urban	0.07	0.074	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
204)	<input checked="" type="checkbox"/>	URBNCHK_08					
		367804.922	3594885.22	646.96	647.059	647.036	
				Urban	0.099	0.076	
205)	<input checked="" type="checkbox"/>	URBNCHK_09					
		393499.93	3595842.922	585.313	585.365	585.323	
				Urban	0.052	0.01	
206)	<input checked="" type="checkbox"/>	URBNCHK_10					
		404139.331	3592378.661	572.391	572.408	572.408	
				Urban	0.017	0.017	
207)	<input checked="" type="checkbox"/>	URBNCHK_11					
		431123.963	3593757.409	518.904	518.962	518.929	
				Urban	0.058	0.025	
208)	<input checked="" type="checkbox"/>	URBNCHK_12					
		426881.745	3579635.426	558.524	558.517	558.513	
				Urban	-0.007	-0.011	
209)	<input checked="" type="checkbox"/>	URBNCHK_13					
		450800.452	3586611.221	617.339	617.331	617.336	
				Urban	-0.008	-0.003	
210)	<input checked="" type="checkbox"/>	URBNCHK_14					
		363685.907	3636021.268	602.734	602.825	602.834	
				Urban	0.091	0.1	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
211)	<input checked="" type="checkbox"/>	URBNCHK_15					
		370657.254	3623368.332	596.355	596.394	596.373	
				Urban	0.039	0.018	
212)	<input checked="" type="checkbox"/>	URBNCHK_16					
		429799.029	3585470.225	536.333	536.352	536.359	
				Urban	0.019	0.026	
213)	<input checked="" type="checkbox"/>	URBNCHK_17					
		406933.266	3620783.167	555.933	555.94	555.896	
				Urban	0.007	-0.037	
214)	<input checked="" type="checkbox"/>	URBNCHK_18					
		425026.45	3604413.643	503.581	503.507	503.481	
				Urban	-0.074	-0.1	
215)	<input checked="" type="checkbox"/>	URBNCHK_19					
		444556.788	3625519.731	495.349	495.331	495.344	
				Urban	-0.018	-0.005	
216)	<input checked="" type="checkbox"/>	URBNCHK_20					
		453932.995	3620960.82	559.399	559.486	559.469	
				Urban	0.087	0.07	
217)	<input checked="" type="checkbox"/>	URBNCHK_22					
		384061.852	3595338.541	602.649	602.698	602.705	
				Urban	0.049	0.056	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
218)	<input checked="" type="checkbox"/>	URBNCHK_23					
		359762.881	3570852.306	782.058	782.035	782.032	
				Urban	-0.023	-0.026	
219)	<input checked="" type="checkbox"/>	URBNCHK_24					
		383150.991	3571497.242	763.563	763.562	763.565	
				Urban	-0.001	0.002	
220)	<input checked="" type="checkbox"/>	URBNCHK_25					
		393308.362	3574079.075	753.8	753.913	753.903	
				Urban	0.113	0.103	
221)	<input checked="" type="checkbox"/>	URBNCHK_26					
		342279.074	3622973.161	686.312	686.465	686.454	
				Urban	0.153	0.142	
222)	<input checked="" type="checkbox"/>	URBNCHK_27					
		425243.58	3623849.004	530.962	NaN	530.796	
				Urban	NaN	-0.166	
223)	<input checked="" type="checkbox"/>	URBNCHK_28					
		336947.843	3606812.605	727.735	727.827	727.836	
				Urban	0.092	0.101	
224)	<input checked="" type="checkbox"/>	URBNCHK_29					
		453113.615	3606889.739	578.426	578.484	578.479	
				Urban	0.058	0.053	



Coordinates and Offsets of Analyzed Locations (Continued)

ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS
				LC Type	ΔZ DEM	ΔZ LAS
225)	<input checked="" type="checkbox"/> URBNCHK_30					
		411138.382	3601389.335	549.233	549.281	549.262
				Urban	0.048	0.029
226)	<input checked="" type="checkbox"/> URBNCHK_31					
		385392.963	3624701.32	573.276	573.265	573.327
				Urban	-0.011	0.051
227)	<input checked="" type="checkbox"/> URBNCHK_32					
		386218.22	3616027.886	565.047	565.034	565.074
				Urban	-0.013	0.027
228)	<input checked="" type="checkbox"/> URBNCHK_33					
		396536.939	3606638.03	565.799	565.78	565.781
				Urban	-0.019	-0.018
229)	<input checked="" type="checkbox"/> URBNCHK_35					
		436471.15	3605671.614	505.154	505.209	505.197
				Urban	0.055	0.043
230)	<input checked="" type="checkbox"/> URBNCHK_36					
		448580.604	3615209.799	538.25	538.263	538.281
				Urban	0.013	0.031
231)	<input checked="" type="checkbox"/> URBNCHK_37					
		437786.686	3617134.916	473.589	473.59	473.603
				Urban	0.001	0.014



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
232)	<input checked="" type="checkbox"/>	URBNCHK_38					
		370765.673	3583020.94	703.715	703.627	703.592	
				Urban	-0.088	-0.123	
233)	<input checked="" type="checkbox"/>	URBNCHK_39					
		443923.718	3640137.81	473.697	473.698	473.716	
				Urban	0.001	0.019	
234)	<input checked="" type="checkbox"/>	URBNCHK_40					
		437361.12	3632585.728	481.961	482.012	482.023	
				Urban	0.051	0.062	
235)	<input checked="" type="checkbox"/>	URBNCHK_41					
		386149.981	3584377.895	768.825	768.734	768.744	
				Urban	-0.091	-0.081	
236)	<input checked="" type="checkbox"/>	URBNCHK_42					
		404525.726	3583195.338	586.038	586.047	586.11	
				Urban	0.009	0.072	
237)	<input checked="" type="checkbox"/>	URBNCHK_43					
		356993.165	3623459.706	633.544	633.61	633.609	
				Urban	0.066	0.065	
238)	<input checked="" type="checkbox"/>	URBNCHK_44					
		344575.422	3597211.376	724.541	724.665	724.694	
				Urban	0.124	0.153	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
239)	<input checked="" type="checkbox"/>	URBNCHK_45					
		394215.804	3614664.119	546.535	546.539	546.563	
				Urban	0.004	0.028	
240)	<input checked="" type="checkbox"/>	URBNCHK_46					
		361492.169	3602468.793	677.753	677.68	677.748	
				Urban	-0.073	-0.005	
241)	<input checked="" type="checkbox"/>	URBNCHK_47					
		409612.927	3609394.008	536.414	536.441	536.488	
				Urban	0.027	0.074	
242)	<input checked="" type="checkbox"/>	URBNCHK_48					
		350189.145	3631294.946	645.564	645.608	645.616	
				Urban	0.044	0.052	
243)	<input checked="" type="checkbox"/>	URBNCHK_49					
		370473.036	3574690.151	784.798	784.776	784.734	
				Urban	-0.022	-0.064	
244)	<input checked="" type="checkbox"/>	URBNCHK_50					
		395394.643	3584179.896	637.739	637.693	637.818	
				Urban	-0.046	0.079	
245)	<input checked="" type="checkbox"/>	URBNCHK_51					
		377247.005	3604231.785	637.739	637.716	637.703	
				Urban	-0.023	-0.036	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
246)	<input checked="" type="checkbox"/>	URBNCHK_52					
		413330.623	3589634.731	553.572	553.562	553.606	
				Urban	-0.01	0.034	
247)	<input checked="" type="checkbox"/>	URBNCHK_53					
		429833.341	3613659.331	516.915	516.862	516.863	
				Urban	-0.053	-0.052	
248)	<input checked="" type="checkbox"/>	URBNCHK_54					
		452726.456	3595540.725	617.953	617.995	617.987	
				Urban	0.042	0.034	
249)	<input checked="" type="checkbox"/>	URBNCHK_55					
		428308.266	3565634.598	604.181	604.167	604.136	
				Urban	-0.014	-0.045	
250)	<input checked="" type="checkbox"/>	URBNCHK_56					
		418966.961	3594825.373	546.129	546.144	546.117	
				Urban	0.015	-0.012	
251)	<input checked="" type="checkbox"/>	URBNCHK_57					
		450725.07	3648712.696	493.783	NaN	493.772	
				Urban	NaN	-0.011	
252)	<input checked="" type="checkbox"/>	URBNCHK_58					
		417401.035	3568050.062	608.19	608.089	608.078	
				Urban	-0.101	-0.112	



Coordinates and Offsets of Analyzed Locations (Continued)

	ID						
		Survey X	Survey Y	Z1	Z DEM	Z LAS	
				LC Type	ΔZ DEM	ΔZ LAS	
253)	<input checked="" type="checkbox"/>	URBNCHK_59					
		357820.579	3579862.237	770.202	770.224	770.225	
				Urban	0.022	0.023	
254)	<input checked="" type="checkbox"/>	URBNCHK_60					
		386948.044	3605135.979	579.946	579.911	579.917	
				Urban	-0.035	-0.029	
255)	<input checked="" type="checkbox"/>	URBNCHK_61					
		339126.354	3615102.006	722.172	722.222	722.194	
				Urban	0.05	0.022	
256)	<input checked="" type="checkbox"/>	URBNCHK_62					
		370933.6	3624114.685	597.405	597.434	597.469	
				Urban	0.029	0.064	
257)	<input checked="" type="checkbox"/>	URBNCHK_63					
		423932.347	3590618.804	525.898	525.662	525.672	
				Urban	-0.236	-0.226	
258)	<input checked="" type="checkbox"/>	URBNCHK_64					
		459884.032	3635467.384	528.307	528.432	528.428	
				Urban	0.125	0.121	

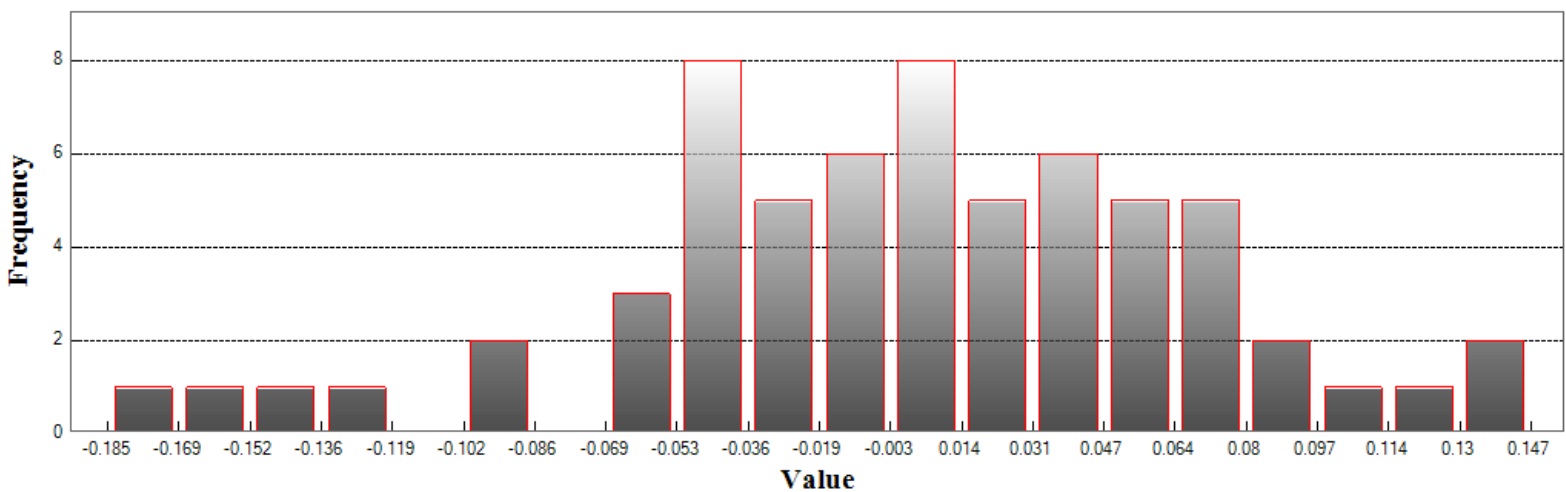


LAS

Fundamental Vertical Accuracy

LandCover Type: Bare Earth
Minimum DZ: -0.185
Maximum DZ: 0.147
Mean DZ: 0.003
Mean Magnitude DZ: 0.227
Number Observations: 63
Standard Deviation DZ: 0.067
RMSE Z: 0.067
95% Confidence Level Z: 0.131
Units: Meters

Histogram



Min: -0.185
Max: 0.147
Number Of Bins: 20
Bin Interval: 0.017



LAS (Continued)

Supplemental Vertical Accuracy

LandCover Type: Brushland

Minimum DZ: -0.209

Maximum DZ: 0.28

Mean DZ: 0.12

Mean Magnitude DZ: 0.364

Number Observations: 36

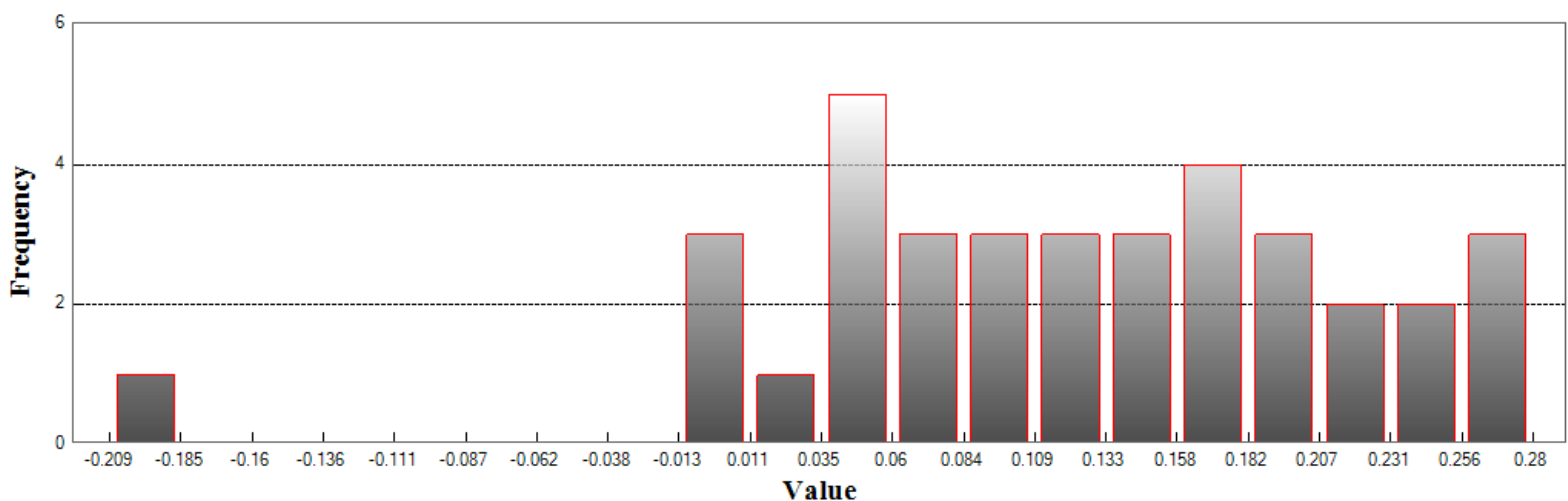
Standard Deviation DZ: 0.098

RMSE Z: 0.154

95th Percentile: 0.262

Units: Meters

Histogram



Min: -0.209

Max: 0.28

Number Of Bins: 20

Bin Interval: 0.024



LAS (Continued)

Supplemental Vertical Accuracy

LandCover Type: Forested

Minimum DZ: -0.175

Maximum DZ: 0.247

Mean DZ: 0.04

Mean Magnitude DZ: 0.279

Number Observations: 36

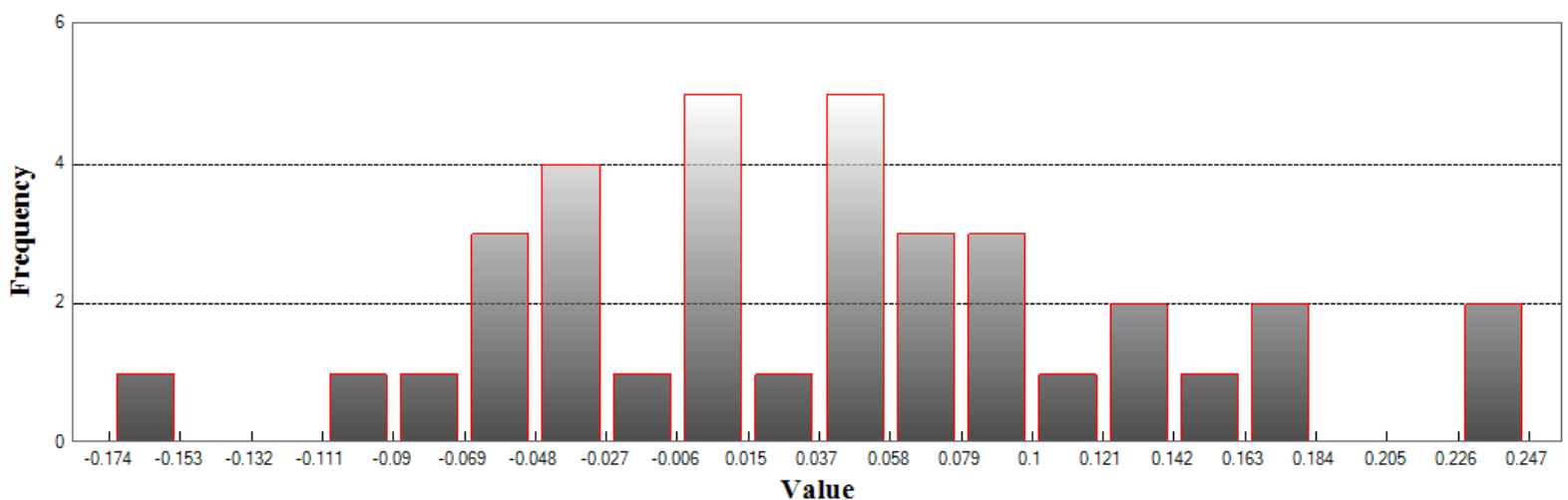
Standard Deviation DZ: 0.093

RMSE Z: 0.1

95th Percentile: 0.192

Units: Meters

Histogram



Min: -0.175

Max: 0.247

Number Of Bins: 20

Bin Interval: 0.021



LAS (Continued)

Supplemental Vertical Accuracy

LandCover Type: TallWeeds

Minimum DZ: -0.226

Maximum DZ: 0.261

Mean DZ: 0.071

Mean Magnitude DZ: 0.294

Number Observations: 62

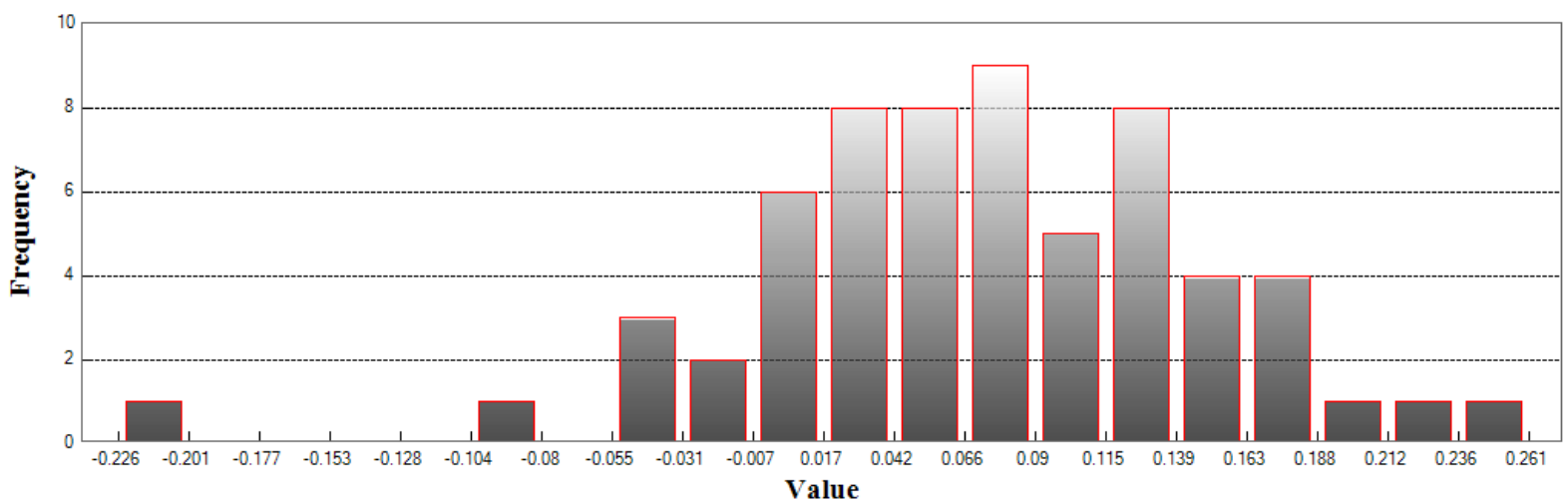
Standard Deviation DZ: 0.078

RMSE Z: 0.106

95th Percentile: 0.194

Units: Meters

Histogram



Min: -0.226

Max: 0.261

Number Of Bins: 20

Bin Interval: 0.024



LAS (Continued)

Supplemental Vertical Accuracy

LandCover Type: Urban

Minimum DZ: -0.226

Maximum DZ: 0.153

Mean DZ: 0.008

Mean Magnitude DZ: 0.24

Number Observations: 61

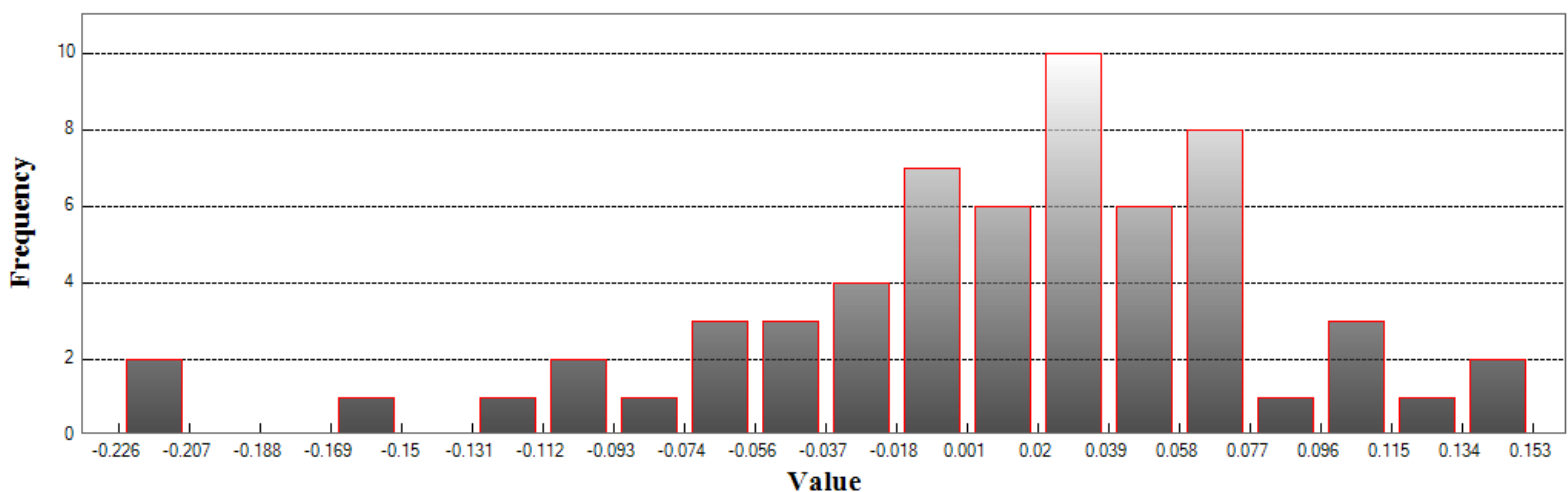
Standard Deviation DZ: 0.076

RMSE Z: 0.076

95th Percentile: 0.153

Units: Meters

Histogram



Min: -0.226

Max: 0.153

Number Of Bins: 20

Bin Interval: 0.019

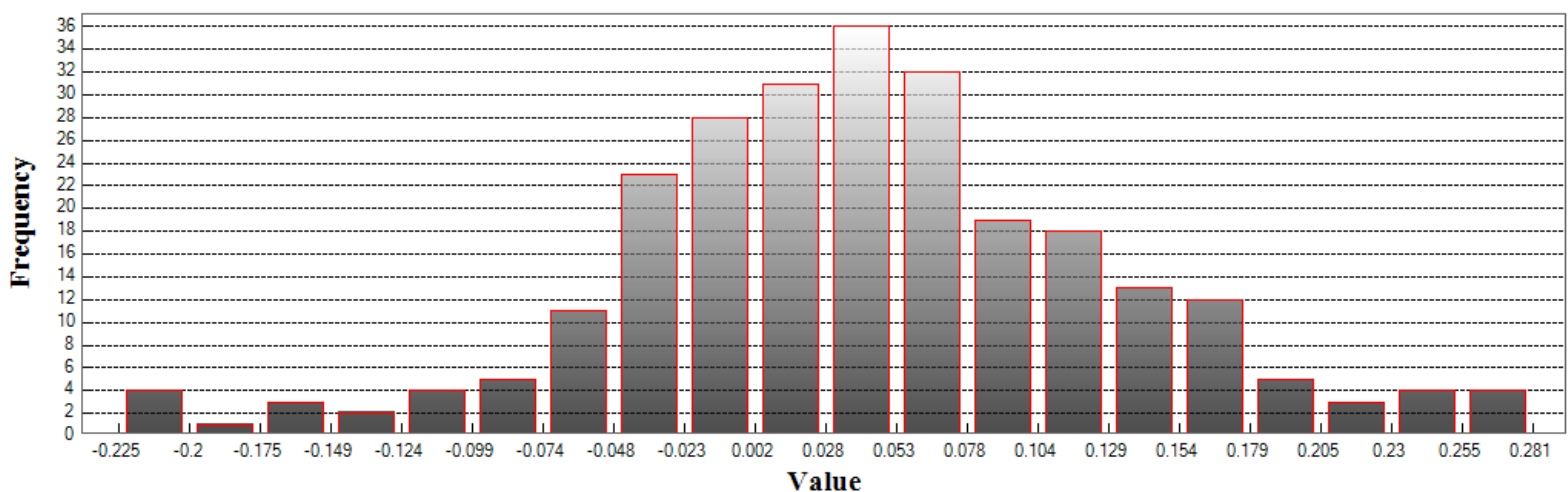


LAS (Continued)

Consolidated Vertical Accuracy

LandCover Type: ALL
Minimum DZ: -0.226
Maximum DZ: 0.28
Mean DZ: 0.042
Mean Magnitude DZ: 0.276
Number Observations: 258
Standard Deviation DZ: 0.09
RMSE Z: 0.099
95th Percentile: 0.213
Units: Meters

Histogram



Min: -0.226

Max: 0.28

Number Of Bins: 20

Bin Interval: 0.025



DEM

Fundamental Vertical Accuracy

LandCover Type: Bare Earth

Minimum DZ: -0.222

Maximum DZ: 0.141

Mean DZ: 0.004

Mean Magnitude DZ: 0.223

Number Observations: 61

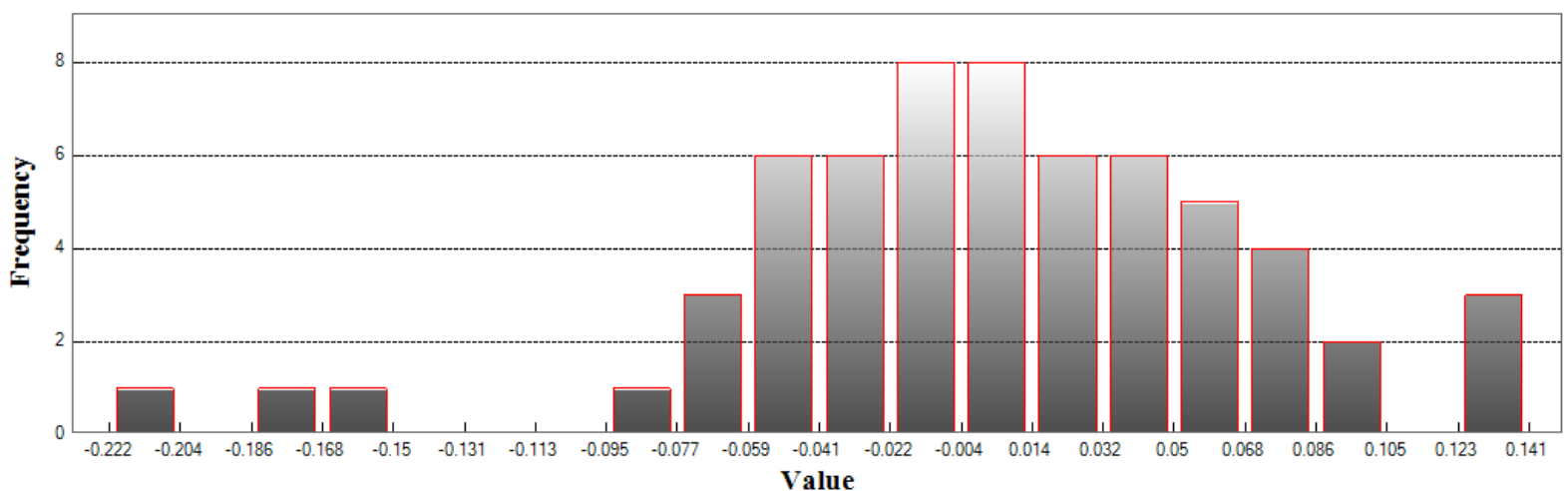
Standard Deviation DZ: 0.067

RMSE Z: 0.067

95% Confidence Level Z: 0.13

Units: Meters

Histogram



Min: -0.222

Max: 0.141

Number Of Bins: 20

Bin Interval: 0.018



DEM (Continued)

Supplemental Vertical Accuracy

LandCover Type: Brushland

Minimum DZ: -0.2

Maximum DZ: 0.247

Mean DZ: 0.066

Mean Magnitude DZ: 0.302

Number Observations: 36

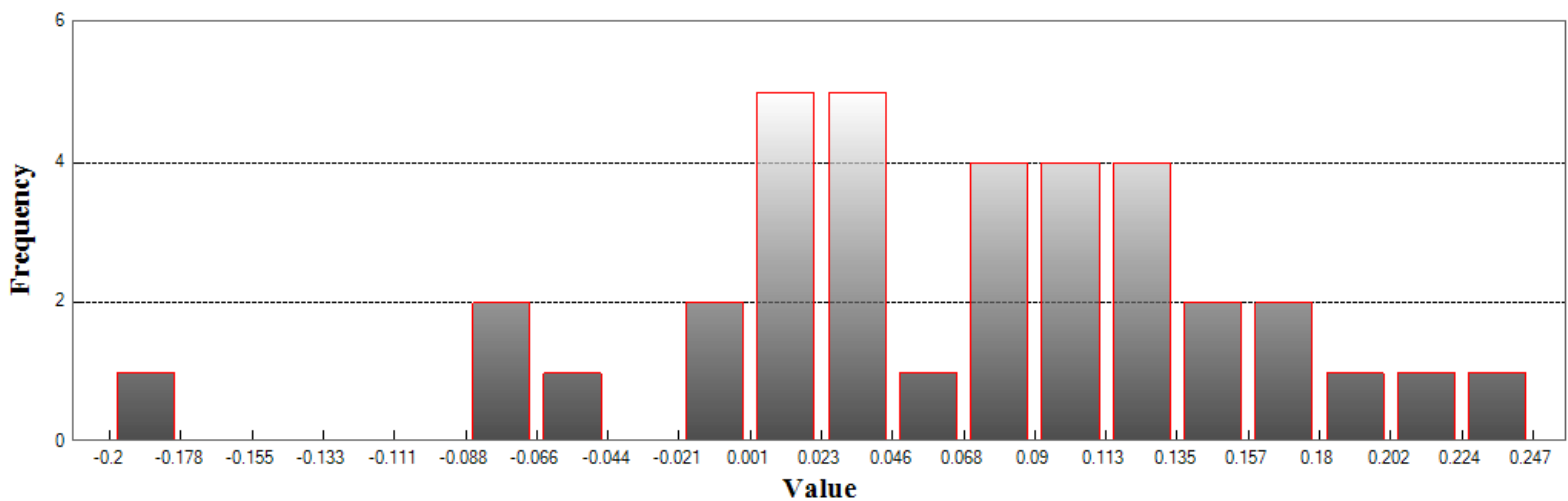
Standard Deviation DZ: 0.09

RMSE Z: 0.111

95th Percentile: 0.204

Units: Meters

Histogram



Min: -0.2

Max: 0.247

Number Of Bins: 20

Bin Interval: 0.022



DEM (Continued)

Supplemental Vertical Accuracy

LandCover Type: Forested

Minimum DZ: -0.335

Maximum DZ: 0.209

Mean DZ: 0.018

Mean Magnitude DZ: 0.247

Number Observations: 35

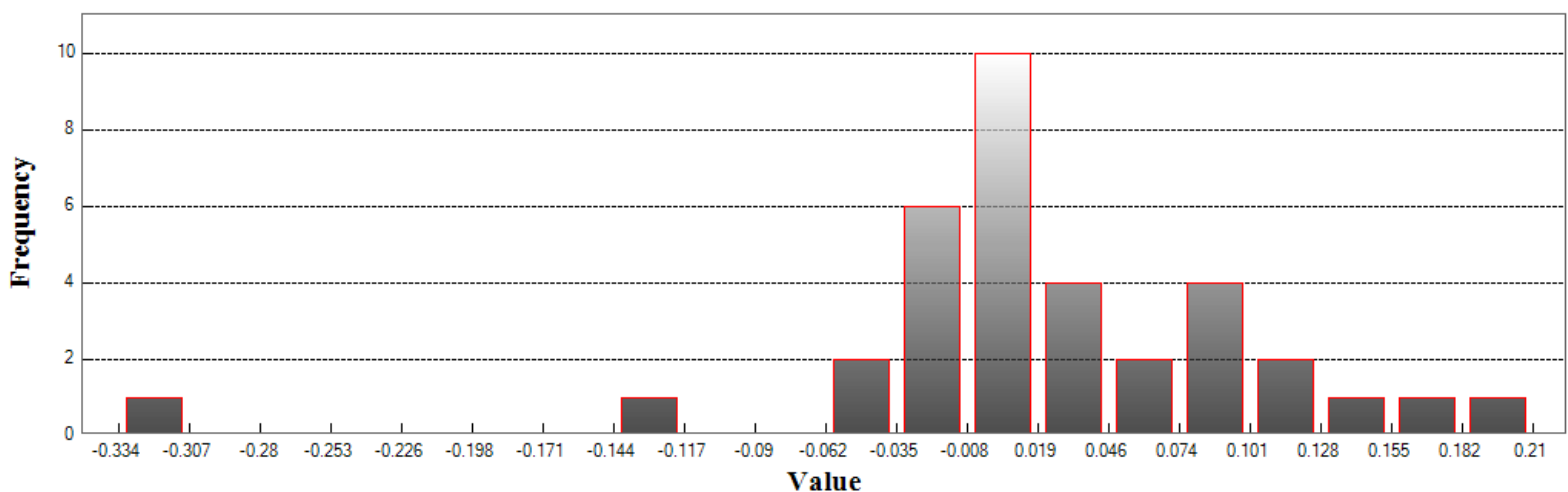
Standard Deviation DZ: 0.092

RMSE Z: 0.092

95th Percentile: 0.18

Units: Meters

Histogram



Min: -0.335

Max: 0.209

Number Of Bins: 20

Bin Interval: 0.027



DEM (Continued)

Supplemental Vertical Accuracy

LandCover Type: TallWeeds

Minimum DZ: -0.198

Maximum DZ: 0.19

Mean DZ: 0.053

Mean Magnitude DZ: 0.266

Number Observations: 60

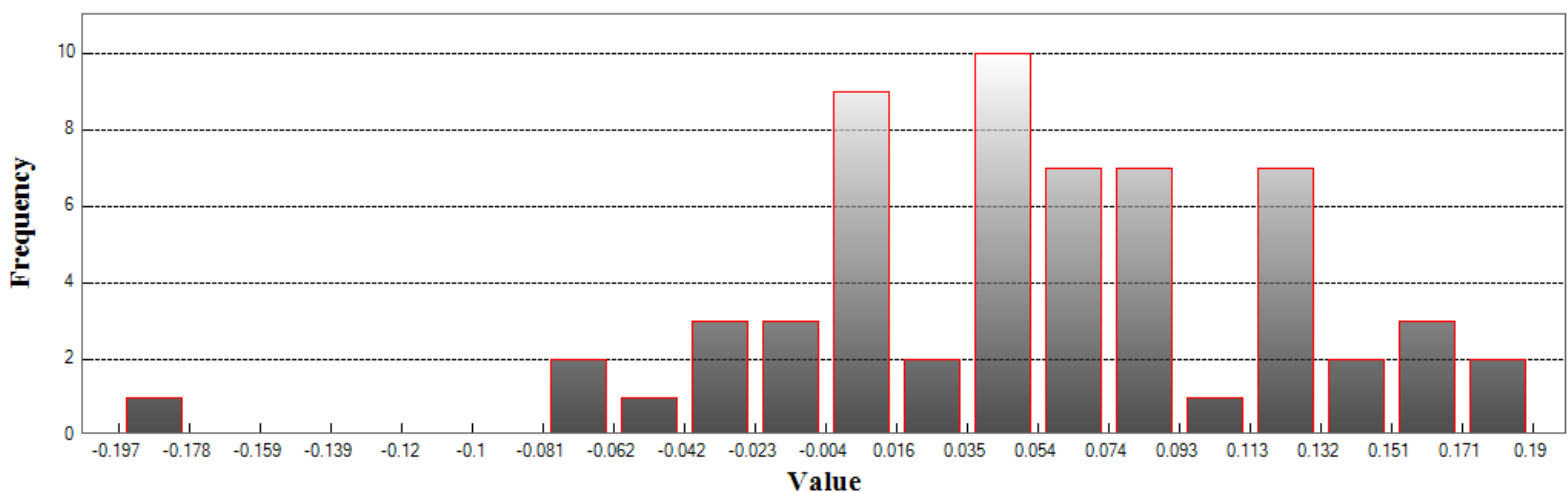
Standard Deviation DZ: 0.072

RMSE Z: 0.089

95th Percentile: 0.17

Units: Meters

Histogram



Min: -0.198

Max: 0.19

Number Of Bins: 20

Bin Interval: 0.019

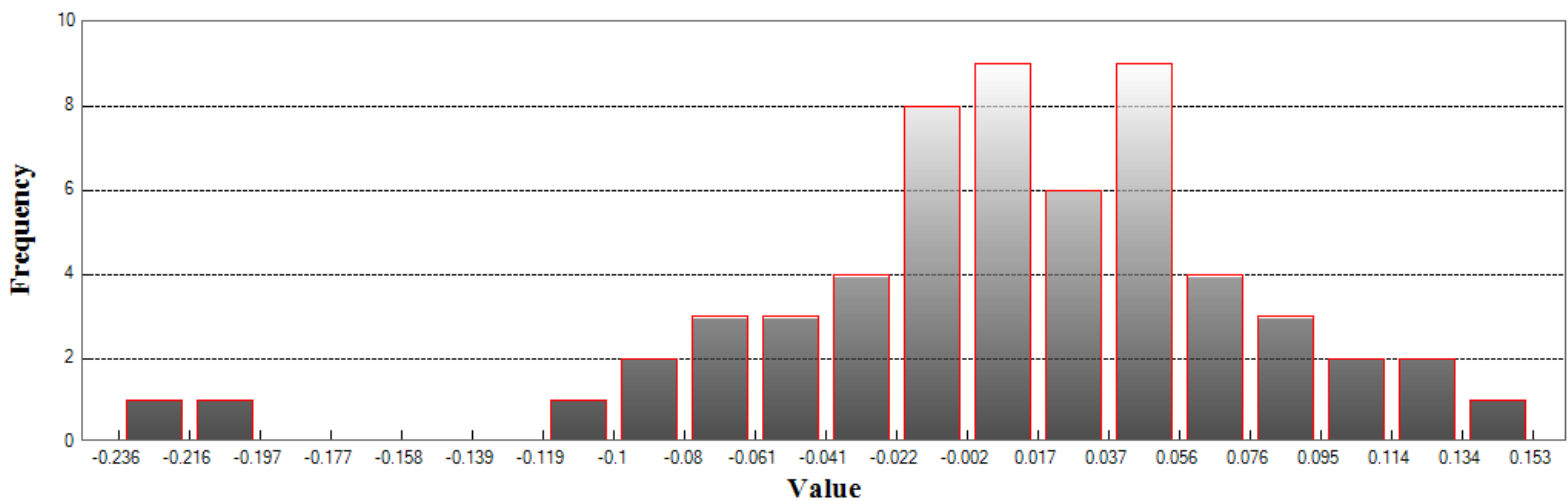


DEM (Continued)

Supplemental Vertical Accuracy

LandCover Type: Urban
Minimum DZ: -0.236
Maximum DZ: 0.153
Mean DZ: 0.008
Mean Magnitude DZ: 0.227
Number Observations: 59
Standard Deviation DZ: 0.071
RMSE Z: 0.07
95th Percentile: 0.128
Units: Meters

Histogram



Min: -0.236

Max: 0.153

Number Of Bins: 20

Bin Interval: 0.019

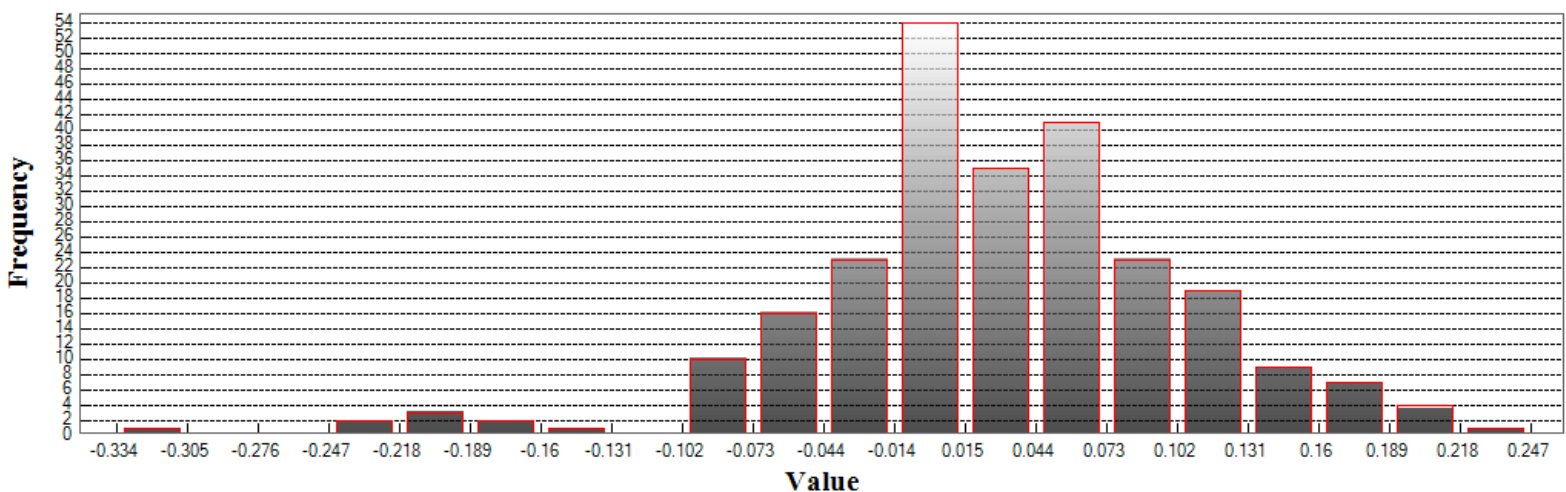


DEM (Continued)

Consolidated Vertical Accuracy

LandCover Type: ALL
Minimum DZ: -0.335
Maximum DZ: 0.247
Mean DZ: 0.027
Mean Magnitude DZ: 0.25
Number Observations: 251
Standard Deviation DZ: 0.08
RMSE Z: 0.084
95th Percentile: 0.17
Units: Meters

Histogram



Min: -0.335
Max: 0.247
Number Of Bins: 20
Bin Interval: 0.029