Project Report

USDA-FS Region-6, Gifford Pinchot et al National Forests
2017 Leaf-On Airborne LiDAR Data Acquisition
Sol. No. AG-05G2-S-17-0019
Atlantic Project No. 17042
Malhuer National Forest – Crow AOI

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SECTION I: PROJECT OVERVIEW & PURPOSE

1. Aerial LiDAR Project

a. Project Overview

The United States Forest Service, Region 6, (USFS) required leaf-on airborne LiDAR surveys to be collected over of national forestry in Oregon and Washington State. The following areas were requested to be covered: Gifford Pinchot National Forest (GIP) in Vancouver, Washington; Okanogan-Wenatchee National Forest (OKA) in Wenatchee, Washington; Malheur National Forest (MAL) in John Day, Oregon; Deschutes National Forest (DES) in Bend, Oregon, Willamette National Forest (WIL) in Eugene, Oregon, Umpqua National Forest (UMP) in Douglas, Lane, and Jackson Counties, Oregon. The following report applies to the Crow AOI, which encompasses two-hundred thirty-three (233) square miles of the Malhuer National Forest in Oregon.

Aerial LiDAR data for this task order was planned, acquired, processed and produced at an aggregate nominal pulse spacing (ANPS) of 0.35 meters and aggregate nominal pulse density of 8 pulses per square meter.

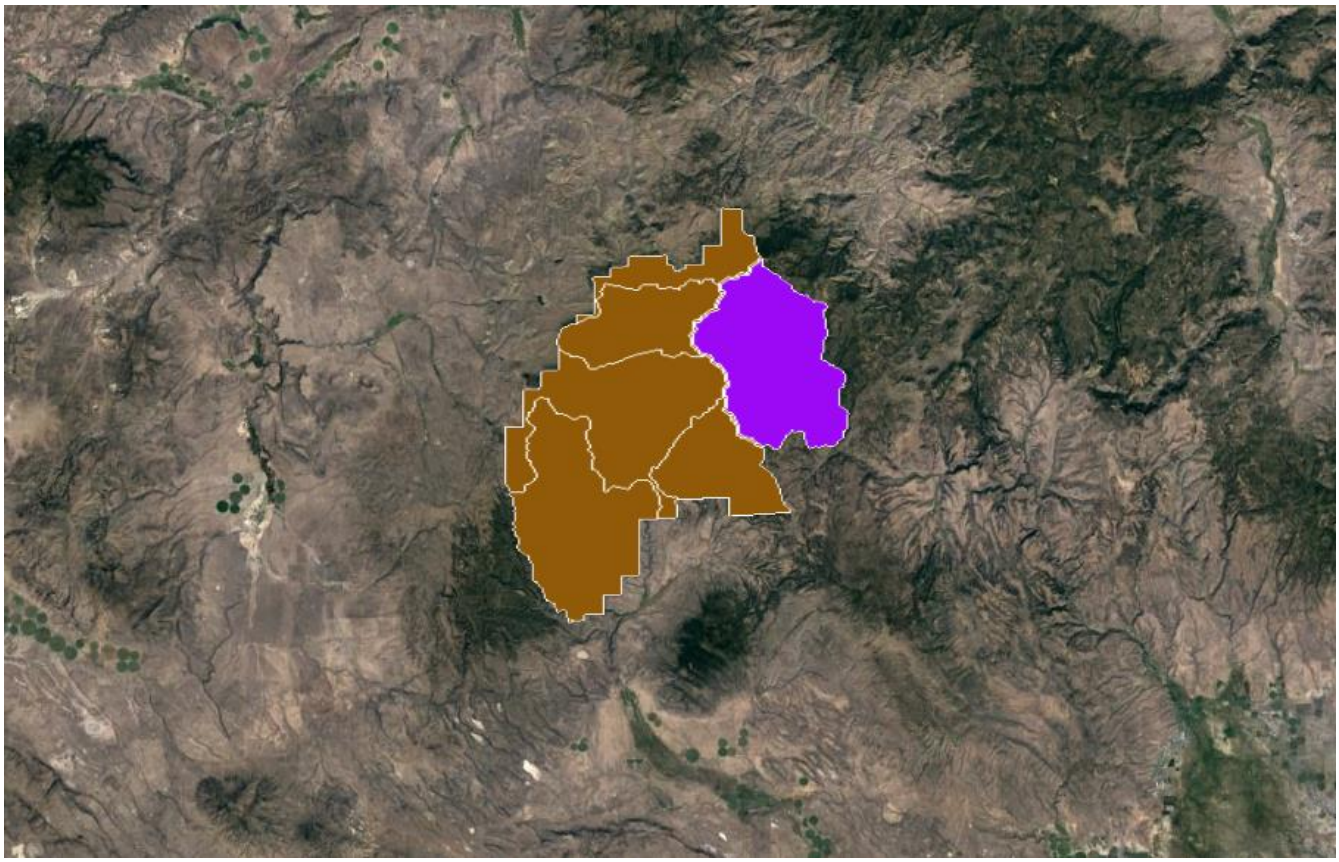

Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) and Associated Areas of Interest (AOIs)

b. Project Purpose

The primary goals of this project are to provide high accuracy Light Detection and Ranging (LiDAR) data to enhance project planning and implementation; identify areas for the implementation of forest restoration treatments designed to restore forest structure in young-growth stands; and to provide engineering and resource specialists more information for on-the-ground project planning. In addition, these data will be used

by researchers and scientists to characterize vegetation type and structure as it currently exists on the landscape and to provide a detailed, accurate, and precise benchmark for future change detection work. The data products specified herein may also be used for vegetation mapping, road identification and mapping, hydrologic feature delineation, and landcover characterization applications including a canopy height model, understory vegetation prediction, and other stand metrics.

c. Client Contact Information

Client Contact Information	
Name of Contact	Mark Riley
Organization	Forest Service R6 Data Resources Management
Position	Remote Sensing Program Lead
Telephone	503.808.2989
E-Mail Address	markriley@fs.fed.us
Mailing Address	1220 SW 3rd Ave
City	Portland
State or Province	Oregon
Postal Code	97204

Table 1: Aerial LiDAR Client Contact Information

d. Contract Deliverables

Item	Specification/Format
Report	PDF
Metadata	FGDC Content Standards for Digital Geospatial Metadata (FGDC-STD-001-1998)
Aircraft Trajectories	ArcGIS shapefile
All-Return Point Cloud	LAS 1.2 in LAZ format
Bare Earth Elevation Model (Digital Terrain Model, DTM)	ERDAS .img format
Intensity Image	ERDAS .img
Supporting Shapefiles	ArcGIS shapefile
GPS Report	PDF
Quality Analysis/Quality Control	PDF

Table 2: Aerial LiDAR Contract Deliverables

SECTION II: FIELD OPERATIONS

1. Aerial Acquisition

a. Aircraft & Sensor Information

Atlantic operated a Leica ALS70-HP LiDAR system on a Cessna (N732JE) during July 17-20, 2017 for the project area. The specifications of this LiDAR system are presented in the following table:

Parameter	Specification
Model	ALS70-HP
Manufacturer	Leica
Platform	Fixed-Wing
Scan Pattern	Sine, Triangle, Raster
Maximum Scan Rate (Hz)	Sine: 200 Triangle: 158 Raster: 120
Field of View (°)	0 – 75 (Full Angle, User Adjustable)
Maximum Pulse Rate (kHz)	500
Maximum Flying Height (m AGL)	3500
Number of Returns	Unlimited
Number of Intensity Measurements	3 (First, Second, Third)
Roll Stabilization (Automatic Adaptive, °)	75 - Active FOV
Storage Media	Removable 500 GB SSD
Storage Capacity (Hours @ Max Pulse Rate)	6
Size (cm)	Scanner: 37 W x 68 L x 26 H Control Electronics: 45 W x 47 D x 36 H
Weight (kg)	Scanner: 43 Control Electronics: 45
Operation Temperature (°C)	0 – 40
Flight Management	FCMS
Power Consumption	927 @ 22.0 – 30.3 VDC

Table 3: System Specifications – ALS70-HP

b. Sensor Acquisition Information

The following table illustrates project specific system parameters for LiDAR acquisition on this project:

Parameter	Specification
System	Leica ALS70-HP
Nominal Pulse Spacing (m)	0.35
Nominal Pulse Density (pls/m²)	4.5
Nominal Flight Height (AGL meters)	2400
Nominal Flight Speed (kts)	120
Pass Heading (°)	Varies
Sensor Scan Angle (°)	24
Scan Frequency (Hz)	43.9
Pulse Rate of Scanner (kHz)	260,000

Parameter	Specification
Line Spacing (m)	400
Pulse Duration of Scanner (ns)	4
Central Wavelength of Sensor Laser (nm)	1064
Sensor Operated with Multiple Pulses	1
Beam Divergence (mrad)	0.15
Nominal Swath Width (m)	935
Nominal Swath Overlap (%)	55
Scan Pattern	Triangle

Table 4: Aerial LiDAR Sensor Acquisition Parameters

c. Flight Plan Execution

Atlantic acquired 80 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 3 flight missions conducted between July 17, 2017 and July 20, 2017. Onboard differential Global Navigation Satellite System (GNSS) unit(s) recorded sample aircraft positions at 2 hertz (Hz) or more frequency. LiDAR data was only acquired when a minimum of six (6) satellites were in view.

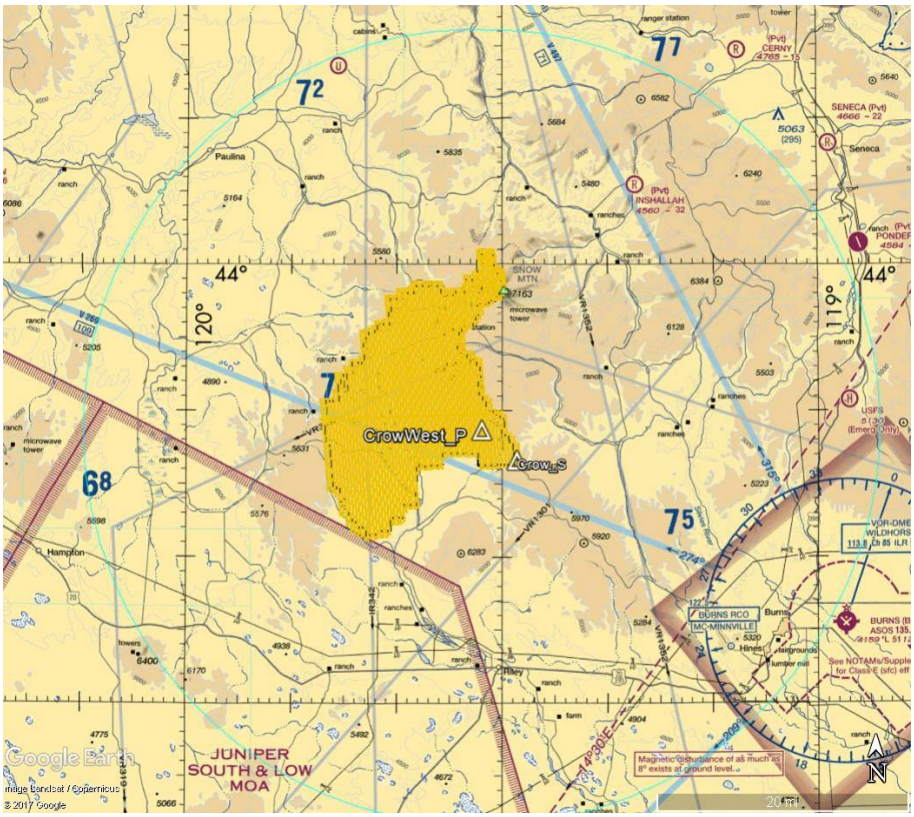

Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

d. GNSS Reference Stations

2 Continuously Operating Reference Stations (CORS) were used to control the LiDAR acquisition for the defined project area. The coordinates provided in the table below are in the specified coordinate reference system for the project, as detailed in Section III-1-b.

Designation	Type	PID	Latitude (N)	Longitude (W)	Elevation
CPXF	CORS	CPXF	46 50 24.32430	122 15 23.47654	537.791
MRSD	CORS	MRSD	46 47 07.23148	121 44 31.35518	1631.871

Table 5: GNSS Reference Stations

2. Ground Acquisition

a. Ground Control Survey

A total of 44 Non-vegetated Vertical Accuracy (NVA) points were collected in support of this project.

Point cloud data accuracy was tested against a Triangulated Irregular Network (TIN) constructed from LiDAR points in clear and open areas. A clear and open area can be characterized with respect to topographic and ground cover variation such that a minimum of five (5) times the Nominal Pulse Spacing (NPS) exists with less than 1/3 of the RMSEZ deviation from a low-slope plane. Slopes that exceed ten (10) percent were avoided.

Each land cover type representing ten (10) percent or more of the total project area were tested and reported with a VVA. In land cover categories other than dense urban areas, the tested points did not have obstructions forty-five (45) degrees above the horizon to ensure a satisfactory TIN surface. The VVA value is provided as a target. It is understood that in areas of dense vegetation, swamps, or extremely difficult terrain, this value may be exceeded.

The NVA value is a requirement that must be met, regardless of any allowed "busts" in the VVA(s) for individual land cover types within the project. Checkpoints for each assessment (NVA & VVA) are required to be well-distributed throughout the land cover type, for the entire project area.

The following tables and figures outline the coordinate values and distribution of LCP, NVA and VVA points collected in support of this project:

ID	Easting	Northing	Elevation
GCP01	295218.5	4866082	1766.543
GCP02	297216.6	4868404	1880.609
GCP03	300133.2	4868326	1851.246
GCP04	301591.8	4866253	1760.547
GCP05	302272	4863370	1706.766
GCP06	302871.7	4858141	1576.737
GCP07	300145.5	4860264	1628.042
GCP08	298727	4857004	1614.593
GCP09	298189.6	4859800	1657.79
GCP10	296655.8	4863791	1721.851
GCP11	298597.6	4865722	1720.107
GCP12	299243.1	4862144	1671.644
GCP13	303234.8	4865694	1777.081
GCP14	299817.8	4864212	1620.662
GCP15	298548.5	4868220	1799.985
GCP16	305267.4	4855196	1412.442
GCP17	301932.7	4860862	1680.614
GCP18	298264.8	4858806	1661.408
GCP19	297917.7	4863468	1649.257

ID	Easting	Northing	Elevation
GCP20	304307.2	4861408	1663.134
GCP21	278972.9	4851818	1602.487
GCP22	280306.2	4852152	1562.514
GCP23	283911.7	4857876	1592.932
GCP24	296419.7	4853996	1614.315
GCP25	292890.4	4857368	1653.691
GCP26	291281.2	4865809	1615.912
GCP27	285637.2	4847971	1408.84
GCP28	289137.7	4863012	1699.282
GCP29	284792.1	4852106	1549.938
GCP30	278931.7	4844845	1529.367
GCP31	280544.6	4860587	1644.585
GCP32	284925	4852435	1557.254
GCP33	292391.8	4869283	1686.283
GCP34	302869.2	4858144	1576.804
GCP35	284704.2	4853617	1559.958
GCP36	283874.4	4856288	1591.298
GCP37	283730.2	4858667	1598.006
GCP38	282721.6	4858635	1609.599
GCP39	280149.1	4860928	1639.748
GCP40	281036.2	4862834	1648.513
GCP41	297018.2	4855645	1660.026
GCP42	293277.6	4862762	1767.238
GCP43	284502.9	4863475	1513.055
GCP44	299997.3	4852073	1581.867

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

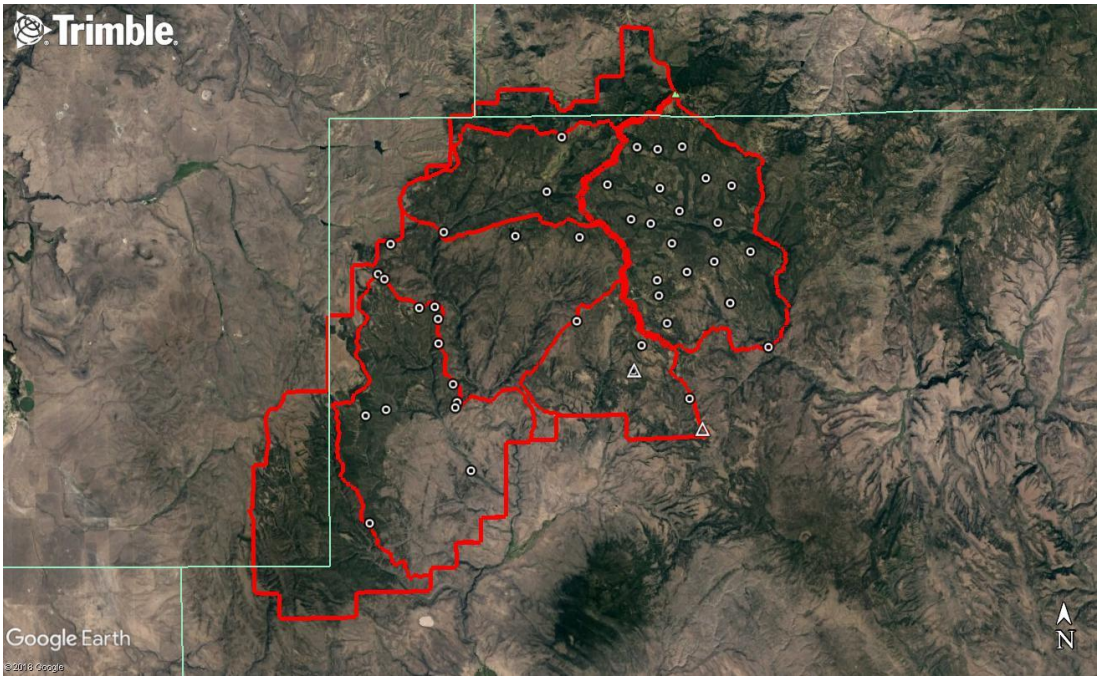

Figure 3: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

SECTION III: DATA PRODUCTION

1. Calibration/Classification

a. LiDAR Point Cloud Generation

Atlantic used Leica software products to download the IPAS ABGNSS/IMU data and raw laser scan files from the airborne system. Waypoint Inertial Explorer is used to extract the raw IPAS ABGNSS/IMU data, which is further processed in combination with controlled base stations to provide the final Smoothed Best Estimate Trajectory (SBET) for each mission. The SBETs are combined with the raw laser scan files to export the LiDAR ASCII Standard (*.las) formatted swath point clouds.

b. Coordinate Reference System

Projection: NAD 1983 Oregon Washington Albers
Horizontal Datum: NAD83
Vertical Datum: NAVD88
Spheroid: GRS1980
Horizontal Units: Meter
Vertical Units: Meter

c. LiDAR Point Cloud Statistics

Category	Value
Total Points	8,924,256,267
Nominal Pulse Spacing (m)	0.4217
Nominal Pulse Density (pls/m²)	5.6242
Nominal Pulse Spacing (ft)	1.3834
Nominal Pulse Density (pls/ft²)	0.5225
Aggregate Total Points	8,688,922,345
Aggregate Nominal Pulse Spacing (m)	0.2818
Aggregate Nominal Pulse Density (pls/m²)	12.5897
Aggregate Nominal Pulse Spacing (ft)	0.9246
Aggregate Nominal Pulse Density (pls/ft²)	1.1696

Table 6: LiDAR Point Cloud Statistics

d. Smooth Surface Repeatability (Interswath)

Departures from planarity of first returns within single swaths in non-vegetated areas were assessed at multiple locations with hard surface areas (parking lots or large rooftops) inside the project area. Each area was evaluated using signed difference rasters (maximum elevation – minimum elevation) at a cell size equal to 2 x ANPS, rounded to the next integer. The following figure depicts a sample of the assessment.

e. LiDAR Calibration

Using a combination of GeoCue, TerraScan and TerraMatch; overlapping swath point clouds are corrected for any orientation or linear deviations to obtain the best fit swath-to-swath calibration. Relative calibration was evaluated using advanced plane-matching analysis and parameter corrections derived. This process was repeated interactively until residual errors between overlapping swaths, across all project missions, was reduced to ≤2cm. A final analysis of the calibrated lidar is preformed using a TerraMatch tie line report for an

overall statistical model of the project area. Individual control point assessments for this project can be found in Section VI of this report.

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

f. LiDAR Classification

Multiple automated filtering routines are applied to the calibrated LiDAR point cloud identifying and extracting bare-earth and above ground features. GeoCue, TerraScan, and TerraModeler software was used for the initial batch processing, visual inspection and any manual editing of the LiDAR point clouds.

Code	Description
1	Processed, Unclassified
2	Ground
7	Low Point (Noise)
18	High Point (Noise)

Table 7: LiDAR Point Classification Codes and Descriptions

g. LiDAR Intensity Imagery

LiDAR intensity imagery was created from the final calibrated and classified lidar point cloud. Intensity images were produced from all classified points and posted to a 1.0-meter cell size. Intensity images were cut to match the tile index and its corresponding tile names and delivered in .tif format.

h. Bare Earth Elevation Model – Digital Terrain Model (DTM)

Bare earth Digital Elevation Models (DTMs) were derived using the bare earth (ground) LiDAR points. All DEMs were created with a grid spacing of 1.0-meter. DTMs for this project were cut to match the tile index and its corresponding tile names and delivered in img format.

SECTION IV: ACCURACY ASSESSMENT

1. Vertical Accuracy Assessment

a. Requirements

Per the table below, the Vertical Accuracy Assessment utilized the required parameters for Vertical Data Accuracy Class IV.

Vertical Data Accuracy Class	RMSEz in Non-Vegetated Terrain (cm)	Non-Vegetated Vertical Accuracy (NVA) at 95% Confidence Level (cm)	Vegetated Vertical Accuracy (VVA) at 95th Percentile (cm)
I	1.0	2.0	2.9
II	2.5	4.9	7.4
III	5.0	9.8	14.7
IV	10.0	19.6	29.4
V	12.5	24.5	36.8

Vertical Data Accuracy Class	RMSEz in Non-Vegetated Terrain (cm)	Non-Vegetated Vertical Accuracy (NVA) at 95% Confidence Level (cm)	Vegetated Vertical Accuracy (VVA) at 95th Percentile (cm)
VI	20.0	39.2	58.8
VII	33.3	65.3	98.0
VIII	66.7	130.7	196.0
IX	100.0	196.0	294.0
X	333.3	653.3	980.0

Table 8: Vertical Accuracy Standards, Source: ASPRS Positional Accuracy Standards for Digital Geospatial Data v1.0 (2014)

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

b. Results

An overall statistical assessment of the check points can be found in the following two tables (values provided in meters):

Broad Land Cover Type	# of Points	RMSEz	95% Confidence Level	95th Percentile
NVA of Point Cloud	43	0.0948	0.1858	0.1434
NVA of DEM	43	0.0992	0.1945	0.0999

Table 9: NVA/VVA Accuracies

PointID	Easting	Northing	KnownZ	LaserZ	Description	DeltaZ
Crow11	639450.9470	1094586.6030	1,720.3250	1,720.0800	OUTLIER	(0.2450)
GCPX_502	634245.8960	1091433.3970	1,767.1010	1,767.3600	OUTLIER	0.2590

Table 10: Outlier Check Points

SECTION V: CERTIFICATION STATEMENT

This accuracy assessment confirms that the data may be used for the intended applications stated in Section I of this document. This dataset may also be used as a topographic input for other applications, but the user should be aware that this LiDAR dataset was designed with a specific purpose and was not intended to meet specifications and/or requirements of users outside of the United States Geological Survey.

It should also be noted that LiDAR points do not represent a continuous surface model. LiDAR points are discrete measurements of the surface and any values derived within a triangle of three LiDAR points are interpolated. As such, the user should not use the resultant LiDAR dataset for vertical placement of a planimetric feature such as a headwall, building footprint or any other planimetric feature unless there is an associated LiDAR point that can be reasonably located on this structure.

Consideration should be given by the end user of this dataset to the fact that this LiDAR dataset was developed differently and separately than previous LiDAR datasets that may be available for this geographic location. It is likely that the data in this project was created using different geodetic control, a different Geoid, newer LiDAR technology and more up-to-date processing techniques. As such, any direct comparative analysis performed between this dataset and previous datasets could result in misleading or inaccurate results. Users are encouraged to proceed with caution while performing this type of comparative analysis and to completely understand the variables that make each of these datasets unique and not corollary.
It is encouraged that the user refers to the full FGDC Metadata and project reports for a complete understanding on the content of this dataset.
I, hereby, certify to the extent of my knowledge that the statements and statistics represented in this document are true and factual.

Brian J. Mayfield, ASPRS Certified Photogrammetrist #R1276

SECTION VI: CONTROL POINT ASSESSMENTS

1. Point Cloud Check Point Assessment

Point ID	Easting	Northing	KnownZ	LaserZ	Description	DeltaZ
Crow02	637973.950	1097217.802	1880.609	1880.610	BARE EARTH	0.001
GCPX03	625090.777	1084618.701	1591.298	1591.300	BARE EARTH	0.002
GCPX_504	641346.210	1080991.756	1581.867	1581.870	BARE EARTH	0.003
CROW_S	642144.865	1079000.702	1577.753	1577.750	BARE EARTH	(0.003)
Crow05	643206.338	1092369.053	1706.766	1706.770	BARE EARTH	0.004
GCPX_503	625457.038	1091826.541	1513.055	1513.060	BARE EARTH	0.005
GCP13	621609.226	1088795.848	1644.585	1644.580	BARE EARTH	(0.005)
Crow09	639259.254	1088651.705	1657.790	1657.780	BARE EARTH	(0.010)
CROW06	643995.906	1087163.108	1576.737	1576.720	BARE EARTH	(0.017)
Crow10	637582.081	1092585.036	1721.851	1721.830	BARE EARTH	(0.021)
GCPX02	626016.589	1081978.694	1559.958	1559.980	BARE EARTH	0.022
Crow04	642421.813	1095227.212	1760.547	1760.570	BARE EARTH	0.023
CROW20	645310.462	1090482.239	1663.134	1663.160	BARE EARTH	0.026
Crow12	640226.073	1091033.224	1671.644	1671.610	BARE EARTH	(0.034)
CROwW_P	637715.125	1082811.087	1615.024	1615.060	BARE EARTH	0.036
CROW07	641195.752	1089186.291	1628.042	1628.080	BARE EARTH	0.038
Crow18	639370.638	1087660.656	1661.408	1661.370	BARE EARTH	(0.038)
GCP11	626159.239	1080471.742	1549.938	1549.980	BARE EARTH	0.042
GCPX04	624860.269	1086992.092	1598.006	1597.950	BARE EARTH	(0.056)
GCPX07	622018.424	1091060.029	1648.513	1648.570	BARE EARTH	0.057
GCP04	637703.101	1082784.167	1614.315	1614.250	BARE EARTH	(0.065)
GCP_16X	643993.247	1087166.281	1576.804	1576.870	BARE EARTH	0.066
Crow19	638854.100	1092308.664	1649.257	1649.190	BARE EARTH	(0.067)
GCP06	632141.153	1094406.537	1615.912	1615.840	BARE EARTH	(0.072)
GCPX05	623854.266	1086923.544	1609.599	1609.690	BARE EARTH	0.091
Crow15	639310.749	1097082.421	1799.985	1799.890	BARE EARTH	(0.095)
CROW17	642958.923	1089849.232	1680.614	1680.710	BARE EARTH	0.096
Crow14	640724.635	1093121.536	1620.662	1620.560	BARE EARTH	(0.102)
Crow13	644083.068	1094728.561	1777.081	1777.190	BARE EARTH	0.109
GCPX06	621201.852	1089122.152	1639.748	1639.860	BARE EARTH	0.112
GCP10	630102.435	1091532.436	1699.282	1699.170	BARE EARTH	(0.112)
GCP14	626280.063	1080805.264	1557.254	1557.140	BARE EARTH	(0.114)
GCPX_501	638240.762	1084454.218	1660.026	1660.150	BARE EARTH	0.124
GCP02	621677.691	1080354.649	1562.514	1562.640	BARE EARTH	0.126
GCP01	620358.315	1079972.037	1602.487	1602.350	BARE EARTH	(0.137)
CROW16	646495.893	1084306.761	1412.442	1412.580	BARE EARTH	0.138

Point ID	Easting	Northing	KnownZ	LaserZ	Description	DeltaZ
Crow01	636063.154	1094823.939	1766.543	1766.400	BARE EARTH	(0.143)
Crow03	640889.539	1097246.482	1851.246	1851.390	BARE EARTH	0.144
GCP03	625070.326	1086207.518	1592.932	1592.770	BARE EARTH	(0.162)
GCP12	620570.211	1073000.233	1529.367	1529.530	BARE EARTH	0.163
GCP15	633123.574	1097920.309	1686.283	1686.120	BARE EARTH	(0.163)
Crow08	639897.846	1085875.388	1614.593	1614.410	BARE EARTH	(0.183)
GCP08	627153.477	1076369.022	1408.635	1408.840	BARE EARTH	0.205

Table 11: Point Cloud Check Point Assessment

2. Digital Elevation Model (DEM) Check Point Assessment

Point ID	Easting	Northing	KnownZ	DEMZ	Description	DeltaZ
Crow02	637973.950	1097217.802	1880.609	1880.374	BARE EARTH	(0.235)
GCPX03	625090.777	1084618.701	1591.298	1591.283	BARE EARTH	(0.015)
GCPX_504	641346.210	1080991.756	1581.867	1581.862	BARE EARTH	(0.005)
CROW_S	642144.865	1079000.702	1577.753	1577.730	BARE EARTH	(0.023)
Crow05	643206.338	1092369.053	1706.766	1706.728	BARE EARTH	(0.038)
GCPX_503	625457.038	1091826.541	1513.055	1513.042	BARE EARTH	(0.013)
GCP13	621609.226	1088795.848	1644.585	1644.572	BARE EARTH	(0.013)
Crow09	639259.254	1088651.705	1657.790	1657.770	BARE EARTH	(0.020)
CROW06	643995.906	1087163.108	1576.737	1576.624	BARE EARTH	(0.113)
Crow10	637582.081	1092585.036	1721.851	1721.757	BARE EARTH	(0.094)
GCPX02	626016.589	1081978.694	1559.958	1559.980	BARE EARTH	0.022
Crow04	642421.813	1095227.212	1760.547	1760.585	BARE EARTH	0.038
CROW20	645310.462	1090482.239	1663.134	1663.153	BARE EARTH	0.019
Crow12	640226.073	1091033.224	1671.644	1671.486	BARE EARTH	(0.158)
CROwW_P	637715.125	1082811.087	1615.024	1614.948	BARE EARTH	(0.076)
CROW07	641195.752	1089186.291	1628.042	1628.037	BARE EARTH	(0.005)
Crow18	639370.638	1087660.656	1661.408	1661.383	BARE EARTH	(0.025)
GCP11	626159.239	1080471.742	1549.938	1549.975	BARE EARTH	0.037
GCPX04	624860.269	1086992.092	1598.006	1597.972	BARE EARTH	(0.034)
GCPX07	622018.424	1091060.029	1648.513	1648.530	BARE EARTH	0.017
GCP04	637703.101	1082784.167	1614.315	1614.235	BARE EARTH	(0.080)
GCP_16X	643993.247	1087166.281	1576.804	1576.855	BARE EARTH	0.051
Crow19	638854.100	1092308.664	1649.257	1649.140	BARE EARTH	(0.117)
GCP06	632141.153	1094406.537	1615.912	1615.856	BARE EARTH	(0.056)
GCPX05	623854.266	1086923.544	1609.599	1609.649	BARE EARTH	0.050
Crow15	639310.749	1097082.421	1799.985	1799.903	BARE EARTH	(0.082)
CROW17	642958.923	1089849.232	1680.614	1680.651	BARE EARTH	0.037
Crow14	640724.635	1093121.536	1620.662	1620.473	BARE EARTH	(0.189)

Point ID	Easting	Northing	KnownZ	DEMZ	Description	DeltaZ
Crow13	644083.068	1094728.561	1777.081	1777.181	BARE EARTH	0.100
GCPX06	621201.852	1089122.152	1639.748	1639.829	BARE EARTH	0.081
GCP10	630102.435	1091532.436	1699.282	1699.174	BARE EARTH	(0.107)
GCP14	626280.063	1080805.264	1557.254	1557.140	BARE EARTH	(0.114)
GCPX_501	638240.762	1084454.218	1660.026	1660.011	BARE EARTH	(0.015)
GCP02	621677.691	1080354.649	1562.514	1562.610	BARE EARTH	0.096
GCP01	620358.315	1079972.037	1602.487	1602.375	BARE EARTH	(0.112)
CROW16	646495.893	1084306.761	1412.442	1412.489	BARE EARTH	0.047
Crow01	636063.154	1094823.939	1766.543	1766.400	BARE EARTH	(0.143)
Crow03	640889.539	1097246.482	1851.246	1851.360	BARE EARTH	0.114
GCP03	625070.326	1086207.518	1592.932	1592.756	BARE EARTH	(0.176)
GCP12	620570.211	1073000.233	1529.367	1529.500	BARE EARTH	0.133
GCP15	633123.574	1097920.309	1686.283	1686.119	BARE EARTH	(0.164)
Crow08	639897.846	1085875.388	1614.593	1614.366	BARE EARTH	(0.227)
GCP08	627153.477	1076369.022	1408.635	1408.730	BARE EARTH	0.094

Table 12: DEM Check Point Assess