Project Report

TASK ORDER NAME: NM_SouthEast_2018_D19
TASK ORDER NUMBER: 140G219F0006
CONTRACT NUMBER: G16PC00042
ATLANTIC PROJECT NUMBER: 18079
PROJECT BLOCK NUMBER: BLOCK06

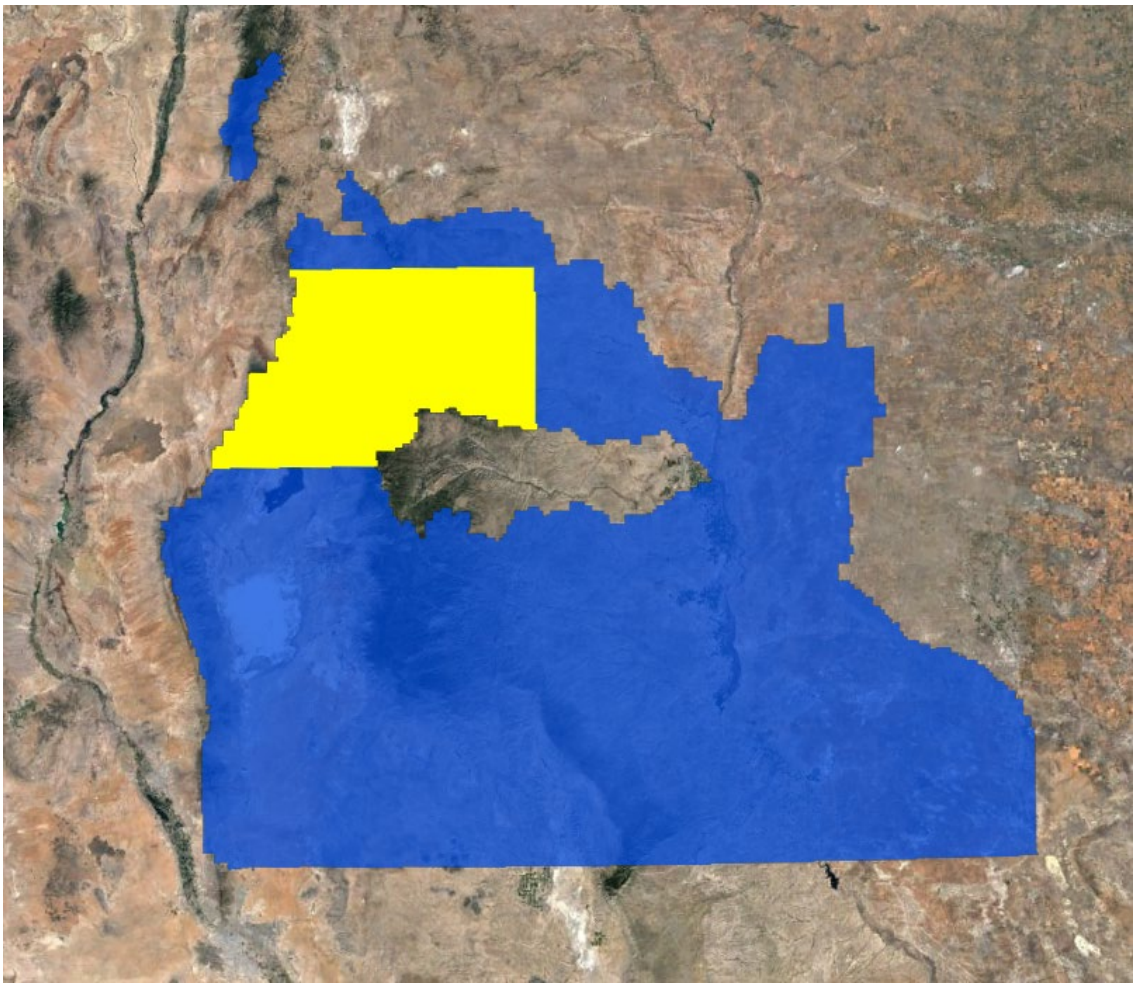
TABLE OF CONTENTS

SECTION I: PROJECT OVERVIEW & PURPOSE

1. Aerial LiDAR Project

a. Project Overview

USGS task order 140G0219F0006-NM_SouthEast_2018_D19 required Fall 2018/Spring 2019 leaf-off LiDAR surveys to be collected over 26,650 square miles covering part or all of thirteen (13) counties in Southeast New Mexico. Aerial LiDAR data for this task order was planned, acquired, processed and produced at an aggregate nominal pulse spacing (ANPS) of 0.71 meters and in compliance with USGS National Geospatial Program LiDAR Base Specification version 1.3. The Block 6 portion of this project encompasses part of Socorro, Lincoln, and Sierra counties, covering approximately 2,918 square miles.



b. Project Purpose

The collected QL2 LiDAR data will support the 3DEP mission, the Natural Resources Conservation Services (NRCS) high resolution elevation enterprise program and the Federal Emergency Management Agency (FEMA) Risk Mapping, Assessment and Planning (MAP) program.

c. Contract Deliverables

Item	Specification/Format
Classified Point Cloud	LAS 1.4
Bare Earth Surface (Raster DEM)	1m cell size, GeoTIFF format, hydroflattened
Hydro Breaklines	.gdb format
Intensity Imagery	1m cell size, GeoTIFF format
Control	.txt
Delivery Diagram	ESRI Shapefile
Metadata	.xml format, FGDC compliant
Project Report	.pdf format

Table 1: Aerial LiDAR Contract Deliverables

SECTION II: FIELD OPERATIONS

1. Aerial LiDAR Project – Aerial Acquisition

d. Aircraft & Sensor Information

Atlantic operated a PACDV (N750DV) outfitted with an Optech Galaxy Prime LiDAR system during the collection of the project area. The specifications of this system are presented in the following table:

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

Table 2: System Specifications – Galaxy Prime

e. Sensor Acquisition Information

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

Parameter	Specification
System	Optech Galaxy Prime
Nominal Pulse Density (pls/m²)	2.33
Nominal Flight Height (AGL meters)	4000

Parameter	Specification
Nominal Flight Speed (kts)	150
Pass Heading (°)	360/180
Sensor Scan Angle (°)	45
Scan Frequency (Hz)	60
Pulse Rate of Scanner (kHz)	350
Sensor Operated with Multiple Pulses	Yes
Nominal Swath Width (m)	1740
Nominal Swath Overlap (%)	20

Table 3: Aerial LiDAR Sensor Acquisition Parameters

f. Flight Plan Execution

Atlantic acquired one hundred sixty-three (163) passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 16 flight missions conducted between November 18, 2018 and April 28, 2019. 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.

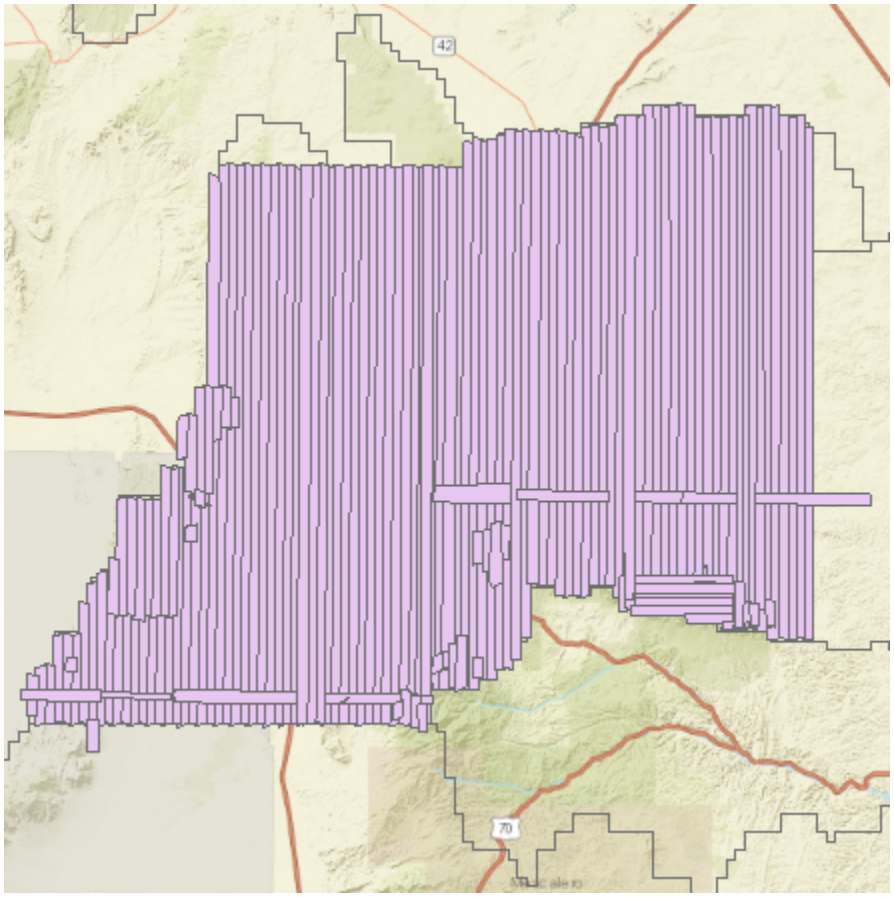


Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

g. GNSS Reference Stations

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

Designation	Type	PID	Latitude (N)	Longitude (W)	Elevation
MDO1	CORS	MDO1	N30°40'49.83668"	W104°00'53.98138"	2004.482
NMRO	CORS	NMRO	N33°23'41.84850"	W104°35'20.78284"	1094.692
P026	CORS	P026	N32°39'32.25694"	W107°11'41.54812"	1236.844
P027	CORS	P027	N32°48'06.68836"	W105°48'14.98112"	2896.72
P034	CORS	P034	N34°56'44.22768"	W106°27'33.36615"	1810.899
P035	CORS	P035	N34°36'05.01237"	W105°11'00.97396"	1780.346
P038	CORS	P038	N34°08'50.11604"	W103°24'26.42480"	1212.964
P107	CORS	P107	N35°07'55.84636"	W107°52'48.07846"	1991.638
P120	CORS	P120	N35°00'26.83828"	W105°37'33.87922"	2089.644
RG01	CORS	RG01	N34°40'01.45862"	W108°02'37.73037"	2157.523
RG03	CORS	RG03	N33°39'16.88787"	W105°09'14.99556"	1572.585
RG07	CORS	RG07	N32°29'47.37490"	W106°50'35.93656"	1400.676
RG08	CORS	RG08	N32°43'42.06691"	W104°59'38.63121"	1488.626
SC01	CORS	SC01	N34°04'04.62684"	W106°57'59.55961"	2097.38
TXEL	CORS	TXEL	N31°41'29.45124"	W106°16'17.64942"	1122.015
TXKM	CORS	TXKM	N31°50'33.37123"	W103°06'31.30090"	847.998
TXP2	CORS	TXP2	N33°10'55.80241"	W102°49'05.38308"	1089.713
ZAB1	CORS	ZAB1	N35°10'24.86905"	N35°10'24.86905"	1619.667
ZAB2	CORS	ZAB2	N35°10'24.86690"	W106°34'02.24093"	1619.74

Table 4: GNSS Reference Stations

2. Aerial LiDAR Project – Ground Acquisition

h. Ground Control Survey

A total of 124 ground survey points were collected in support of this project, including 36 LiDAR Control Points (LCP), 55 Non-vegetated Vertical Accuracy (NVA) and 33 Vegetated Vertical Accuracy (VVA).

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

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

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

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

ID	Easting	Northing	Elevation
LCP030	431092.018	3718873.675	1842.194
LCP052	416079.652	3756840.214	1746.148
LCP057	478990.331	3720405.11	1870.241
LCP058	437229.429	3737708.168	2062.788
LCP059	432228.252	3764652.921	1876.497
LCP060	462861.738	3757303.33	1857.009
LCP062	424191.15	3750717.736	1764.624
LCP063	391115.022	3708253.764	1382.087
LCP064	383993.941	3728170.139	1704.152
LCP065	381210.12	3701825.089	1348.146
LCP066	400897.611	3700076.698	1496.09
LCP097	385919.995	3704710.68	1370.239
LCP105	477144.128	3773290.199	1699.849
LCP106	422746.615	3771951.189	1955.501
LCP107	403514.514	3773709.984	1877.627
LCP122	368231.947	3710555.484	1526.457
LCP123	397386.677	3735712.111	1693.025
LCP124	462886.638	3727855.989	1847.234

ID	Easting	Northing	Elevation
LCP125	470529.28	3742744.863	1743.15
LCP148	473671.287	3765417.384	1692.871
LCP150	407278.869	3750257.237	1715.719
LCP151	411457.961	3731387.488	1625.69
LCP200	474507.194	3728741.42	1743.694
LCP201	478302.578	3745626.192	1677.653
LCP202	476338.291	3761050.018	1702.602
LCP205	439731.119	3771526.088	2014.051
LCP206	441566.713	3746210.562	2116.831
LCP207	449414.677	3735815.151	1895.69
LCP208	443947.492	3753987.059	1992.562
LCP209	449476.453	3762386.617	1925.112
LCP210	443513.212	3767106.053	2006.772
LCP211	435453.896	3774057.372	2063.371
LCP212	384802.957	3742027.076	2000.389
LCP213	391934.478	3724118.305	1565.396
LCP227	411403.868	3731410.622	1625.604
LCP233	435266.194	3773664.096	2055.974

Table 5: LiDAR Control Point Coordinates

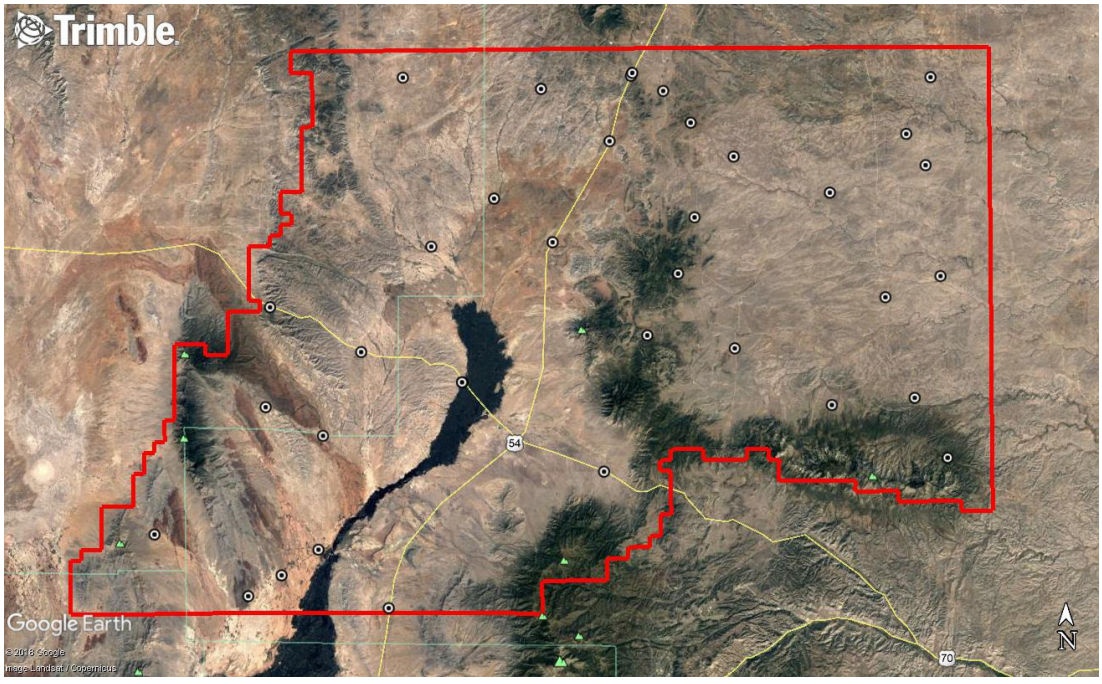


Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
BE024	391859.163	3724101.641	1560.523
BE025	420960.052	3754232.634	1786.821
BE026	411592.878	3765106.946	1835.081
BE076	413098.412	3718257.768	1604.012
BE077	422605.652	3734136.836	1699.606
BE079	449398.628	3737799.896	1870.3
BE080	474512.967	3728750.466	1743.766
BE081	481606.571	3748249.647	1609.729
BE082	459755.839	3755039.314	1802.163
BE083	440141.434	3758897.136	1973.415
BE087	475868.301	3769581.079	1639.635
BE126	393808.832	3738551.036	1766.489
BE127	392588.985	3701031.943	1360.269
BE142	383673.346	3709617.891	1437.684
BE143	412263.91	3745369.736	1670.96
BE144	432225.406	3764665.605	1875.97
OT021	449860.726	3742695.172	1958.647
OT033	474763.268	3726185.221	1773.796
OT057	439643.27	3774968.484	2011.618
OT058	427901.938	3774634.571	2017.866
OT080	403802.878	3734726.678	1672.739
OT090	466367.149	3768058.43	1732.284
OT101	424632.355	3721975.062	1730.087
OT104	449451.216	3732000.923	1915.512
OT105	485252.11	3725121.019	1594.512
OT111	449470.308	3762382.219	1925.266
OT113	477304.042	3757732.636	1673.279
OT114	469297.968	3749856.835	1773.554
OT115	458498.187	3750449.175	1819.191
OT116	458497.062	3750449.668	1819.215
OT117	416070.625	3756852.621	1746.452
OT118	391706.051	3739713.062	1821.296
OT119	392449.101	3716385.816	1462.63
OT120	417374.73	3722432.018	1648.897
OT121	427478.025	3720273.401	1794.907
OT136	400968.742	3766485.401	1885.614
OT137	383973.917	3728152.319	1703.796
OT138	370087.104	3706237.267	1475.467

ID	Easting	Northing	Elevation
UR025	384811.827	3742035.964	2000.78
UR039	399509.955	3705445.851	1490.886
UR047	467889.824	3775648.394	1752.693
UR050	422979.047	3721933.757	1714.557
UR051	409369.773	3770571.844	1869.322
UR053	380207.557	3706879.454	1432.867
UR054	391091.024	3708253.863	1382.285
UR060	411427.538	3731418.696	1626.451
UR066	368228.699	3710565.029	1526.455
UR083	438857.21	3716971.484	2121.273
UR086	394247.618	3707992.859	1392.706
UR087	426004.508	3753777.673	1788.171
UR088	408297.224	3776426.896	1889.569
UR095	469331.314	3729498.825	1825.981
UR127	462884.055	3727872.45	1847.786
UR132	422990.252	3745657.861	1778.082
UR149	411362.064	3716899.647	1575.804

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

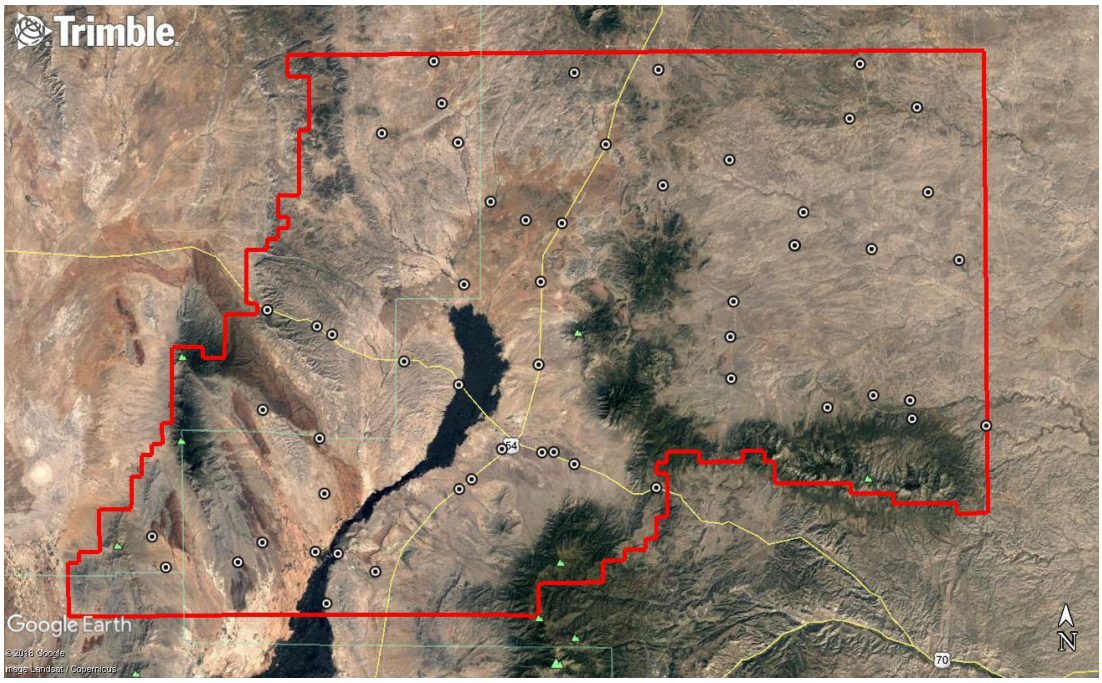


Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
BR024	471745.612	3745749.441	1716.544
BR050	421230.249	3728058.435	1671.496
BR056	470820.944	3766916.392	1714.618
BR057	482119.795	3754758.853	1632.462
BR062	404370.382	3705351.079	1586.399
BR072	481401.132	3723569.791	1677.128
BR073	456338.475	3727409.236	1919.517
BR074	456179.085	3748625.629	1841.456
BR075	394792.118	3705925.416	1404.868
BR082	415274.926	3742305.391	1665.738
BR099	439352.544	3764285.641	1986.431
BR102	446653.391	3775585.222	1946.683
HG026	398517.505	3760943.442	1849.251
HG028	444177.628	3755676.231	1959.148
HG029	443250.572	3732961.556	2040.791
HG030	475749.243	3771071.784	1688.005
HG037	456220.927	3748614.875	1840.847
HG038	456220.11	3748613.72	1840.815
HG039	449715.012	3725827.578	1964.504

ID	Easting	Northing	Elevation
HG105	407534.776	3710605.267	1619.235
HG106	395334.091	3729858.247	1648.607
TR039	369196.906	3701203.368	1421.719
TR041	470582.733	3736562.342	1740.801
TR055	376631.705	3706833.036	1410.727
TR056	375705.641	3711319.218	1509.993
TR062	399788.67	3758586.034	1839.882
TR063	460051.345	3776385.692	1832.892
TR064	469402.36	3759002.692	1778.059
TR081	362176.405	3703169.456	1582.812
TR087	435310.465	3709974.139	2194.566
TR088	415161.016	3726980.71	1596.189
TR089	437250.865	3737705.937	2062.644
TR090	425369.114	3762579.909	1859.516

Table 7: Vegetated Vertical Accuracy (VVA) Point Coordinates

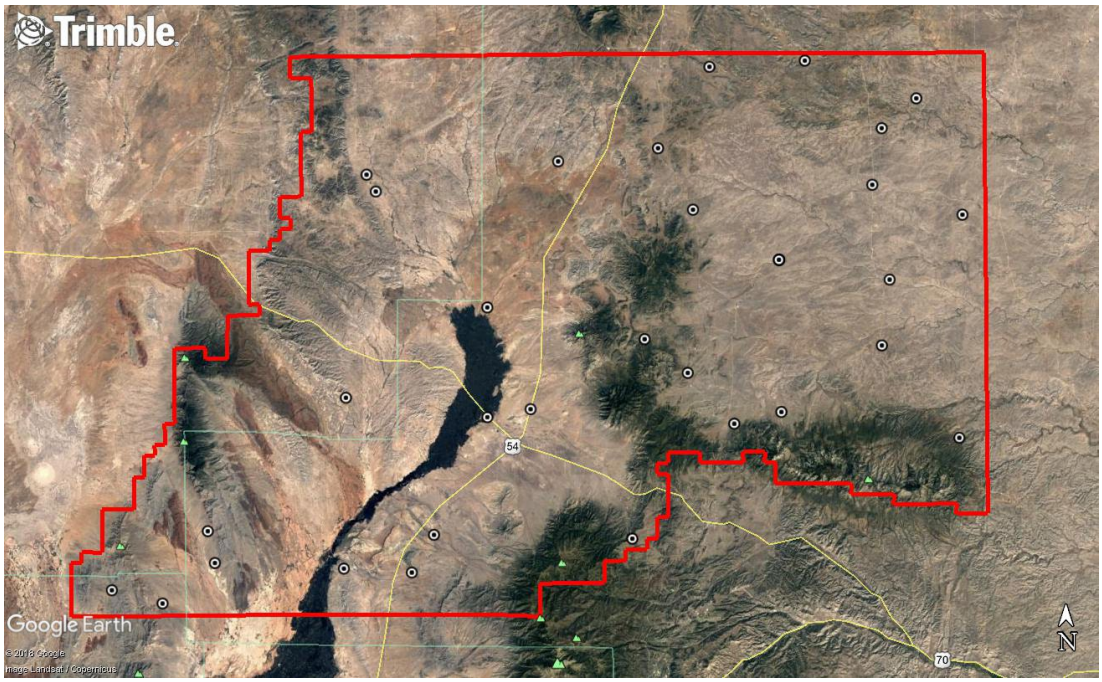


Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

SECTION III: DATA PRODUCTION

1. Aerial LiDAR Project – Calibration/Classification

i. 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.

j. Coordinate Reference System

Horizontal Datum: NAD83(NSRS2011)
Coordinate System: UTM 13N
Vertical Datum: NAVD88
Geoid Model: 12B
Units of Reference: Meter

k. LiDAR Point Cloud Statistics

Category	Value
Total Points (Nominal)	25,198,200,135
Nominal Pulse Spacing (M)	0.5656
Nominal Pulse Density (PLS/M^2)	3.1264
Total Points (Aggregate)	25,052,341,420
Aggregate Pulse Spacing (M)	0.5264
Aggregate Pulse Density (PLS/M^2)	3.6093

Table 8: LiDAR Point Cloud Statistics

l. 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.

m. 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.

n. LiDAR Classification

Multiple automated filtering routines are applied to the calibrated LiDAR point cloud identifying and extracting bare-earth and above ground features. GeoCue, TerraScan, and TerraModeler software was used for the initial batch processing, visual inspection and any manual editing of the LiDAR point clouds. Atlantic utilized collected breakline data to preform classification for classes 9 (Water) and 20 (Ignored Ground).

Code	Description
1	Processed, but unclassified
2	Bare-earth ground
7	Low Noise
9	Water
17	Bridge Decks
18	High Noise
20	Ignored Ground (breakline proximity)
21	Snow (if present and identifiable)
22	Temporal exclusion

Table 9: LiDAR Point Classification Codes and Descriptions

a. 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.

b. Hydro-line Collection/Conflation

Hydro breaklines were compiled using LiDAR intensity data and surface terrain models of the entire project area. After the collection, all delineated hydro features were validated for monotonicity and vertical variance. This procedure ensures that no points were floating above ground. Hydro-lines were then encoded into the LiDAR surface and used to hydro-enforce/flatten all significant water bodies. These final hydro-lines were then used in the production of bare Earth digital models to hydro flatten significant water bodies. This product was delivered as an ESRI geodatabase for the entire project area.

c. Bare-Earth Surface – Digital Elevation Model (DEM)

Bare earth Digital Elevation Models (DEMs) were derived using the hydro-lines and bare earth (ground) LiDAR points. All DEMs were created with a grid spacing of 1.0 meter. DEMs for this project were cut to match the tile index and its corresponding tile names and delivered in 32-bit floating point .tif format.

SECTION IV: ACCURACY ASSESSMENT

1. Aerial LiDAR Project – Vertical Accuracy Assessment

d. Requirements

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

Vertical Data Accuracy Class	RMSEz in Non-Vegetated Terrain (cm)	Non-Vegetated Vertical Accuracy (NVA) at 95% Confidence Level (cm)	Vegetated Vertical Accuracy (VVA) at 95th Percentile (cm)
I	1.0	2.0	2.9
II	2.5	4.9	7.4
III	5.0	9.8	14.7
IV	10.0	19.6	29.4
V	12.5	24.5	36.8
VI	20.0	39.2	58.8
VII	33.3	65.3	98.0
VIII	66.7	130.7	196.0
IX	100.0	196.0	294.0
X	333.3	653.3	980.0

Table 10: 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).

e. Results

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

Broad Land Cover Type	Points (#)	RMSEz	Confidence Level (95%)	Percentile (95th)
NVA (Point Cloud)	55	0.0946	0.1853	0.1192
NVA (DEM)	55	0.0950	0.1861	0.1188
VVA (Point Cloud)	33	0.0894	0.1752	0.1292
VVA (DEM)	33	0.0904	0.1772	0.1365

Table 11: NVA/VVA Accuracies

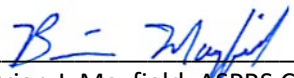
SECTION V: CERTIFICATION STATEMENTS

1. Aerial LiDAR Project

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

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

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



Brian J. Mayfield, ASPRS Certified Photogrammetrist #R1276

SECTION VI: CONTROL POINT ASSESSMENTS

1. Aerial LiDAR Project

f. Point Cloud Check Point Assessment

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
BE024	391859.1630	3724101.6410	1560.5230	1560.5940	0.0710	NVA
BE025	420960.0520	3754232.6340	1786.8210	1786.8530	0.0320	NVA
BE026	411592.8780	3765106.9460	1835.0810	1835.1680	0.0870	NVA
BE076	413098.4120	3718257.7680	1604.0120	1604.0570	0.0450	NVA
BE077	422605.6520	3734136.8360	1699.6060	1699.5940	-0.0120	NVA
BE079	449398.6280	3737799.8960	1870.3000	1870.1730	-0.1270	NVA
BE080	474512.9670	3728750.4660	1743.7660	1743.5800	-0.1860	NVA
BE081	481606.5710	3748249.6470	1609.7290	1609.8130	0.0840	NVA
BE082	459755.8390	3755039.3140	1802.1630	1802.1490	-0.0140	NVA
BE083	440141.4340	3758897.1360	1973.4150	1973.3110	-0.1040	NVA
BE087	475868.3010	3769581.0790	1639.6350	1639.3960	-0.2390	NVA
BE126	393808.8320	3738551.0360	1766.4890	1766.4740	-0.0160	NVA
BE127	392588.9850	3701031.9430	1360.2690	1360.2840	0.0150	NVA
BE142	383673.3460	3709617.8910	1437.6840	1437.6800	-0.0044	NVA
BE143	412263.9100	3745369.7360	1670.9600	1671.0040	0.0440	NVA
BE144	432225.4060	3764665.6050	1875.9700	1875.9670	-0.0028	NVA
BR024	471745.6120	3745749.4410	1716.5440	1716.6300	0.0860	VVA
BR050	421230.2490	3728058.4350	1671.4960	1671.5800	0.0840	VVA
BR056	470820.9440	3766916.3920	1714.6180	1714.5790	-0.0390	VVA
BR057	482119.7950	3754758.8530	1632.4620	1632.4460	-0.0160	VVA
BR062	404370.3820	3705351.0790	1586.3990	1586.4910	0.0920	VVA
BR072	481401.1320	3723569.7910	1677.1280	1677.1450	0.0160	VVA
BR073	456338.4750	3727409.2360	1919.5170	1919.4850	-0.0320	VVA
BR074	456179.0850	3748625.6290	1841.4560	1841.4330	-0.0230	VVA
BR075	394792.1180	3705925.4160	1404.8680	1404.9230	0.0550	VVA
BR082	415274.9260	3742305.3910	1665.7380	1665.7740	0.0360	VVA
BR099	439352.5440	3764285.6410	1986.4310	1986.3800	-0.0510	VVA
BR102	446653.3910	3775585.2220	1946.6830	1946.5980	-0.0850	VVA
HG026	398517.5050	3760943.4420	1849.2510	1849.3240	0.0730	VVA
HG028	444177.6280	3755676.2310	1959.1480	1959.1370	-0.0110	VVA
HG029	443250.5720	3732961.5560	2040.7910	2040.8490	0.0580	VVA
HG030	475749.2430	3771071.7840	1688.0050	1687.7500	-0.2550	VVA
HG037	456220.9270	3748614.8750	1840.8470	1840.7770	-0.0700	VVA
HG038	456220.1100	3748613.7200	1840.8150	1840.7940	-0.0210	VVA
HG039	449715.0120	3725827.5780	1964.5040	1964.5060	0.0018	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
HG105	407534.7760	3710605.2670	1619.2350	1619.2570	0.0220	VVA
HG106	395334.0910	3729858.2470	1648.6070	1648.6550	0.0480	VVA
OT021	449860.7260	3742695.1720	1958.6470	1958.5030	-0.1440	NVA
OT033	474763.2680	3726185.2210	1773.7960	1773.6550	-0.1410	NVA
OT057	439643.2700	3774968.4840	2011.6180	2011.5460	-0.0720	NVA
OT058	427901.9380	3774634.5710	2017.8660	2017.8430	-0.0230	NVA
OT080	403802.8780	3734726.6780	1672.7390	1672.7670	0.0280	NVA
OT090	466367.1490	3768058.4300	1732.2840	1732.2900	0.0057	NVA
OT101	424632.3550	3721975.0620	1730.0870	1730.0760	-0.0110	NVA
OT104	449451.2160	3732000.9230	1915.5120	1915.3960	-0.1160	NVA
OT105	485252.1100	3725121.0190	1594.5120	1594.8290	0.3170	NVA
OT111	449470.3080	3762382.2190	1925.2660	1925.2430	-0.0230	NVA
OT113	477304.0420	3757732.6360	1673.2790	1673.2910	0.0120	NVA
OT114	469297.9680	3749856.8350	1773.5540	1773.6490	0.0950	NVA
OT115	458498.1870	3750449.1750	1819.1910	1819.1480	-0.0430	NVA
OT116	458497.0620	3750449.6680	1819.2150	1819.1960	-0.0190	NVA
OT117	416070.6250	3756852.6210	1746.4520	1746.5440	0.0920	NVA
OT118	391706.0510	3739713.0620	1821.2960	1821.2910	-0.0052	NVA
OT119	392449.1010	3716385.8160	1462.6300	1462.6880	0.0570	NVA
OT120	417374.7300	3722432.0180	1648.8970	1648.9850	0.0880	NVA
OT121	427478.0250	3720273.4010	1794.9070	1794.8690	-0.0380	NVA
OT136	400968.7420	3766485.4010	1885.6140	1885.6230	0.0089	NVA
OT137	383973.9170	3728152.3190	1703.7960	1703.8040	0.0084	NVA
OT138	370087.1040	3706237.2670	1475.4670	1475.4610	-0.0065	NVA
TR039	369196.9060	3701203.3680	1421.7190	1421.6470	-0.0720	VVA
TR041	470582.7330	3736562.3420	1740.8010	1740.9050	0.1040	VVA
TR055	376631.7050	3706833.0360	1410.7270	1410.8910	0.1640	VVA
TR056	375705.6410	3711319.2180	1509.9930	1510.0990	0.1060	VVA
TR062	399788.6700	3758586.0340	1839.8820	1839.8610	-0.0210	VVA
TR063	460051.3450	3776385.6920	1832.8920	1832.9320	0.0400	VVA
TR064	469402.3600	3759002.6920	1778.0590	1778.1580	0.0990	VVA
TR081	362176.4050	3703169.4560	1582.8120	1582.8430	0.0310	VVA
TR087	435310.4650	3709974.1390	2194.5660	2194.5120	-0.0540	VVA
TR088	415161.0160	3726980.7100	1596.1890	1596.3910	0.2030	VVA
TR089	437250.8650	3737705.9370	2062.6440	2062.4780	-0.1670	VVA
TR090	425369.1140	3762579.9090	1859.5160	1859.4690	-0.0470	VVA
UR025	384811.8270	3742035.9640	2000.7800	2000.5910	-0.1890	NVA
UR039	399509.9550	3705445.8510	1490.8860	1491.0150	0.1290	NVA
UR047	467889.8240	3775648.3940	1752.6930	1752.7430	0.0500	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
UR050	422979.0470	3721933.7570	1714.5570	1714.5460	-0.0110	NVA
UR051	409369.7730	3770571.8440	1869.3220	1869.4120	0.0900	NVA
UR053	380207.5570	3706879.4540	1432.8670	1433.0510	0.1840	NVA
UR054	391091.0240	3708253.8630	1382.2850	1382.3090	0.0240	NVA
UR060	411427.5380	3731418.6960	1626.4510	1626.5100	0.0590	NVA
UR066	368228.6990	3710565.0290	1526.4550	1526.4910	0.0360	NVA
UR083	438857.2100	3716971.4840	2121.2730	2121.1290	-0.1440	NVA
UR086	394247.6180	3707992.8590	1392.7060	1392.7570	0.0510	NVA
UR087	426004.5080	3753777.6730	1788.1710	1788.2290	0.0580	NVA
UR088	408297.2240	3776426.8960	1889.5690	1889.6430	0.0740	NVA
UR095	469331.3140	3729498.8250	1825.9810	1826.0480	0.0670	NVA
UR127	462884.0550	3727872.4500	1847.7860	1847.9010	0.1150	NVA
UR132	422990.2520	3745657.8610	1778.0820	1778.0810	-0.0009	NVA
UR149	411362.0640	3716899.6470	1575.8040	1575.8390	0.0350	NVA

Table 22: Point Cloud Check Point Assessment

g. Digital Elevation Model (DEM) Check Point Assessment

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BE024	391859.1630	3724101.6410	1560.5230	1560.5932	0.0703	NVA
BE025	420960.0520	3754232.6340	1786.8210	1786.8670	0.0460	NVA
BE026	411592.8780	3765106.9460	1835.0810	1835.1688	0.0877	NVA
BE076	413098.4120	3718257.7680	1604.0120	1604.0592	0.0472	NVA
BE077	422605.6520	3734136.8360	1699.6060	1699.5779	-0.0281	NVA
BE079	449398.6280	3737799.8960	1870.3000	1870.1717	-0.1283	NVA
BE080	474512.9670	3728750.4660	1743.7660	1743.5753	-0.1907	NVA
BE081	481606.5710	3748249.6470	1609.7290	1609.8168	0.0878	NVA
BE082	459755.8390	3755039.3140	1802.1630	1802.1456	-0.0174	NVA
BE083	440141.4340	3758897.1360	1973.4150	1973.3090	-0.1060	NVA
BE087	475868.3010	3769581.0790	1639.6350	1639.3949	-0.2401	NVA
BE126	393808.8320	3738551.0360	1766.4890	1766.4763	-0.0127	NVA
BE127	392588.9850	3701031.9430	1360.2690	1360.2828	0.0138	NVA
BE142	383673.3460	3709617.8910	1437.6840	1437.6911	0.0071	NVA
BE143	412263.9100	3745369.7360	1670.9600	1671.0118	0.0518	NVA
BE144	432225.4060	3764665.6050	1875.9700	1875.9749	0.0049	NVA
OT021	449860.7260	3742695.1720	1958.6470	1958.5049	-0.1421	NVA
OT033	474763.2680	3726185.2210	1773.7960	1773.6468	-0.1492	NVA
OT057	439643.2700	3774968.4840	2011.6180	2011.5425	-0.0755	NVA
OT058	427901.9380	3774634.5710	2017.8660	2017.8461	-0.0199	NVA
OT080	403802.8780	3734726.6780	1672.7390	1672.7608	0.0218	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
OT090	466367.1490	3768058.4300	1732.2840	1732.2880	0.0039	NVA
OT101	424632.3550	3721975.0620	1730.0870	1730.0789	-0.0081	NVA
OT104	449451.2160	3732000.9230	1915.5120	1915.3985	-0.1135	NVA
OT105	485252.1100	3725121.0190	1594.5120	1594.8370	0.3250	NVA
OT111	449470.3080	3762382.2190	1925.2660	1925.2410	-0.0250	NVA
OT113	477304.0420	3757732.6360	1673.2790	1673.2814	0.0023	NVA
OT114	469297.9680	3749856.8350	1773.5540	1773.6501	0.0961	NVA
OT115	458498.1870	3750449.1750	1819.1910	1819.1462	-0.0448	NVA
OT116	458497.0620	3750449.6680	1819.2150	1819.1880	-0.0270	NVA
OT117	416070.6250	3756852.6210	1746.4520	1746.5615	0.1095	NVA
OT118	391706.0510	3739713.0620	1821.2960	1821.3102	0.0142	NVA
OT119	392449.1010	3716385.8160	1462.6300	1462.6789	0.0489	NVA
OT120	417374.7300	3722432.0180	1648.8970	1648.9876	0.0906	NVA
OT121	427478.0250	3720273.4010	1794.9070	1794.8703	-0.0367	NVA
OT136	400968.7420	3766485.4010	1885.6140	1885.6171	0.0031	NVA
OT137	383973.9170	3728152.3190	1703.7960	1703.8153	0.0193	NVA
OT138	370087.1040	3706237.2670	1475.4670	1475.4606	-0.0064	NVA
UR025	384811.8270	3742035.9640	2000.7800	2000.6178	-0.1622	NVA
UR039	399509.9550	3705445.8510	1490.8860	1491.0267	0.1407	NVA
UR047	467889.8240	3775648.3940	1752.6930	1752.7437	0.0507	NVA
UR050	422979.0470	3721933.7570	1714.5570	1714.5458	-0.0112	NVA
UR051	409369.7730	3770571.8440	1869.3220	1869.4119	0.0899	NVA
UR053	380207.5570	3706879.4540	1432.8670	1433.0529	0.1860	NVA
UR054	391091.0240	3708253.8630	1382.2850	1382.3071	0.0221	NVA
UR060	411427.5380	3731418.6960	1626.4510	1626.5108	0.0598	NVA
UR066	368228.6990	3710565.0290	1526.4550	1526.4973	0.0423	NVA
UR083	438857.2100	3716971.4840	2121.2730	2121.1349	-0.1380	NVA
UR086	394247.6180	3707992.8590	1392.7060	1392.7519	0.0458	NVA
UR087	426004.5080	3753777.6730	1788.1710	1788.2231	0.0521	NVA
UR088	408297.2240	3776426.8960	1889.5690	1889.6342	0.0652	NVA
UR095	469331.3140	3729498.8250	1825.9810	1826.0359	0.0549	NVA
UR127	462884.0550	3727872.4500	1847.7860	1847.8866	0.1006	NVA
UR132	422990.2520	3745657.8610	1778.0820	1778.0820	0.0000	NVA
UR149	411362.0640	3716899.6470	1575.8040	1575.8483	0.0443	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BR024	471745.6120	3745749.4410	1716.5440	1716.6282	0.0843	VVA
BR050	421230.2490	3728058.4350	1671.4960	1671.6048	0.1088	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BR056	470820.9440	3766916.3920	1714.6180	1714.5756	-0.0424	VVA
BR057	482119.7950	3754758.8530	1632.4620	1632.4425	-0.0195	VVA
BR062	404370.3820	3705351.0790	1586.3990	1586.4950	0.0960	VVA
BR072	481401.1320	3723569.7910	1677.1280	1677.1352	0.0071	VVA
BR073	456338.4750	3727409.2360	1919.5170	1919.4745	-0.0425	VVA
BR074	456179.0850	3748625.6290	1841.4560	1841.4344	-0.0217	VVA
BR075	394792.1180	3705925.4160	1404.8680	1404.9340	0.0660	VVA
BR082	415274.9260	3742305.3910	1665.7380	1665.7769	0.0389	VVA
BR099	439352.5440	3764285.6410	1986.4310	1986.3722	-0.0588	VVA
BR102	446653.3910	3775585.2220	1946.6830	1946.5750	-0.1080	VVA
HG026	398517.5050	3760943.4420	1849.2510	1849.3222	0.0712	VVA
HG028	444177.6280	3755676.2310	1959.1480	1959.1308	-0.0171	VVA
HG029	443250.5720	3732961.5560	2040.7910	2040.8526	0.0616	VVA
HG030	475749.2430	3771071.7840	1688.0050	1687.7499	-0.2551	VVA
HG037	456220.9270	3748614.8750	1840.8470	1840.7827	-0.0643	VVA
HG038	456220.1100	3748613.7200	1840.8150	1840.7873	-0.0276	VVA
HG039	449715.0120	3725827.5780	1964.5040	1964.4760	-0.0280	VVA
HG105	407534.7760	3710605.2670	1619.2350	1619.2638	0.0288	VVA
HG106	395334.0910	3729858.2470	1648.6070	1648.6459	0.0388	VVA
TR039	369196.9060	3701203.3680	1421.7190	1421.6673	-0.0517	VVA
TR041	470582.7330	3736562.3420	1740.8010	1740.9035	0.1025	VVA
TR055	376631.7050	3706833.0360	1410.7270	1410.8887	0.1616	VVA
TR056	375705.6410	3711319.2180	1509.9930	1510.1127	0.1197	VVA
TR062	399788.6700	3758586.0340	1839.8820	1839.8666	-0.0154	VVA
TR063	460051.3450	3776385.6920	1832.8920	1832.9206	0.0286	VVA
TR064	469402.3600	3759002.6920	1778.0590	1778.1762	0.1172	VVA
TR081	362176.4050	3703169.4560	1582.8120	1582.8527	0.0407	VVA
TR087	435310.4650	3709974.1390	2194.5660	2194.5070	-0.0589	VVA
TR088	415161.0160	3726980.7100	1596.1890	1596.3851	0.1961	VVA
TR089	437250.8650	3737705.9370	2062.6440	2062.5031	-0.1409	VVA
TR090	425369.1140	3762579.9090	1859.5160	1859.4729	-0.0431	VVA

Table 33: DEM Check Point Assessment

SECTION VII: ADDENDUM

1. Withheld Flag

Atlantic's standard workflow is to flag as withheld 2 degrees of the scan edge either side of nadir. During this project Teledyne Optech's SwathTRAK feature was enabled which is used to dynamically change the FOV during flight when flying in areas of varying terrain. The expectation at the time was that the FOV change would be consistent within the flight line itself, but the results displayed inconsistent changes of scan angle within a flight line. Thus, the logic of flagging to withheld based on a set scan angle captured a larger than expected amount of the actual flight swath.

To mitigate this, Atlantic devised an algorithmic method of detecting the withheld bit void areas by filtering the data appropriately. MHSRs were created of only class 1 withheld bit flagged data and rasterizing the void area based on a pixel area threshold of 5 meters. The void area rasters were converted to a polygonal shape and used as a basis for the re-flagging macro. After this processing step MHSRs were generated for validation.