AIRBORNE LIDAR TASK ORDER REPORT

UNITED STATES GEOLOGICAL SURVEY
ELWHA RIVER LIDAR 2014 W/MODIFICATION

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PROJECT REPORT

ELWHA RIVER LIDAR 2014 W/ MODIFICATION

WOOLPERT PROJECT #74275

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SECTION 1: OVERVIEW

PROJECT NAME: USGS ELWHA RIVER LIDAR 2014 W/MODIFICATION

WOOLPERT PROJECT #74275

This report contains a comprehensive outline of the Elwha River Lidar 2014 W/Modification Processing task order for the United States Geological Survey (USGS). This task order requires lidar data to be acquired for approximately 52 square miles along and at the mouth of the Elwha River in Washington.

Upon initial collect of the Elwha River Valley in November 2014 a flow surge event occurred in mid-December on the river. Lidar for the Elwha River Valley was re-acquired in February 2015 to support change detection analysis. The post flow surge event dataset will be referred to as MOD2 henceforth.

The initial lidar was collected and processed to meet a maximum Nominal Post Spacing (NPS) of 0.3 meters. The MOD2 lidar was collected and processed to meet a maximum Nominal Post Spacing (NPS) of 0.7 meters. The NPS assessment is made against single swath, first return data located within the geometrically usable center portion (typically ~90%) of each swath.

The data was collected using a Leica ALS70 and an Optech Orion H300 lidar sensor. Both sensors collect up to four returns (echo) per pulse, as well as intensity data, for the first three returns. If a fourth return was captured, the system does not record an associated intensity value. The aerial lidar was collected at the following sensor specifications:

ALS70 SPECIFICATIONS

Post Spacing (Minimum):	0.9 ft / 0.3m
AGL (Above Ground Level) average flying height:	5,997 ft / 1,828 m
MSL (Mean Sea Level) average flying height:	variable
Average Ground Speed:	130 knots / 149 mph
Field of View (full):	12 degrees
Pulse Rate:	292 kHz
Scan Rate:	71.4 Hz
Side Lap (Average):	25%

OPTECH ORION H300 SPECIFICATIONS

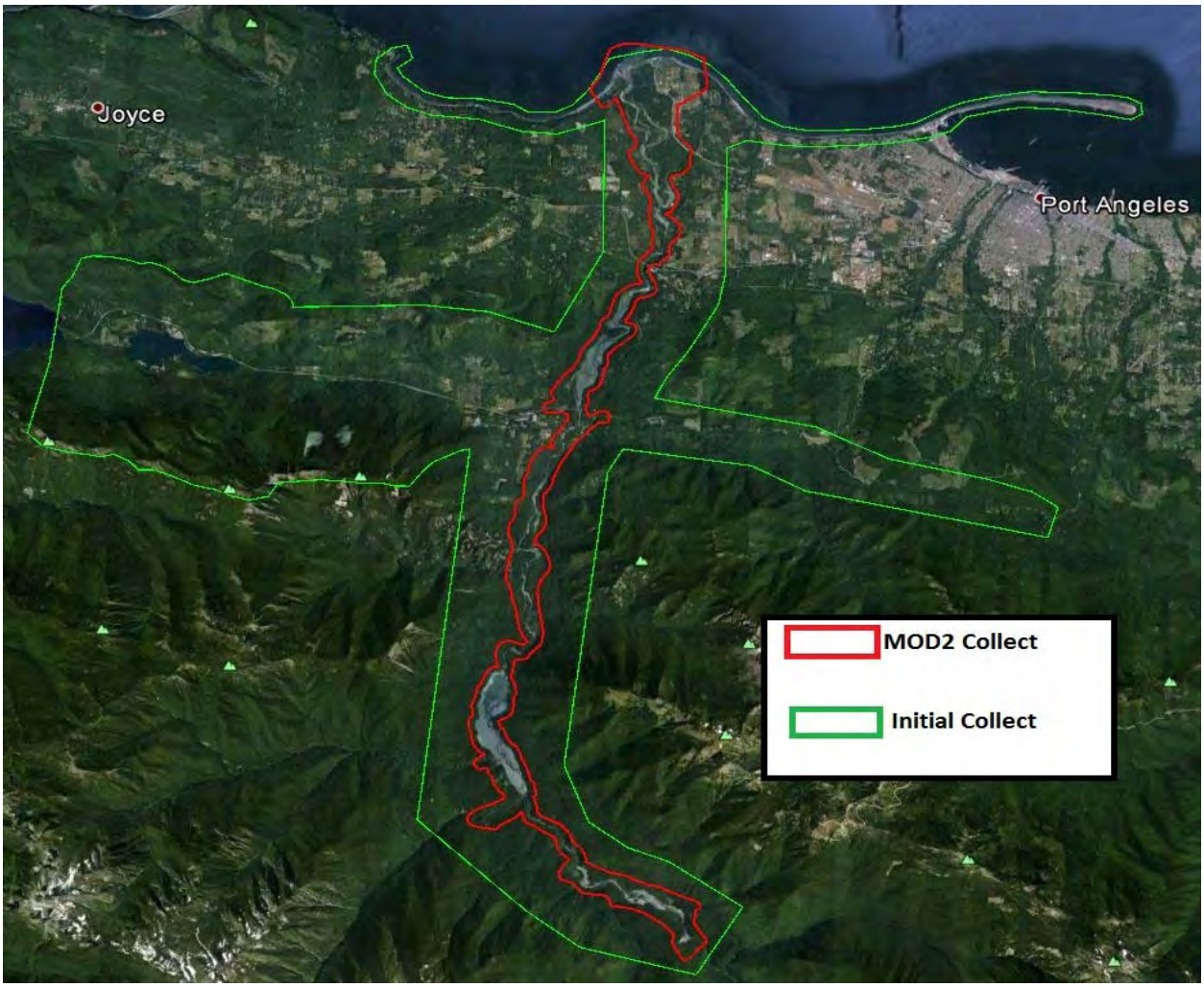
Post Spacing (Minimum):	0.9 ft / 0.3m
AGL (Above Ground Level) average flying height:	7,053 ft / 2,150 m
MSL (Mean Sea Level) average flying height:	variable
Average Ground Speed:	100 knots / 115 mph
Field of View (full):	16 degrees
Pulse Rate:	175 kHz
Scan Rate:	50 Hz
Side Lap (Average):	50%

OPTECH ORION H300 SPECIFICATIONS FOR MOD2 COLLECT

Post Spacing (Minimum):	2.3 ft / 0.7m
AGL (Above Ground Level) average flying height:	7,545 ft / 2,300 m
MSL (Mean Sea Level) average flying height:	variable
Average Ground Speed:	100 knots / 115 mph
Field of View (full):	24 degrees
Pulse Rate:	150 kHz
Scan Rate:	42 Hz
Side Lap (Average):	50%

The lidar data for this AOI and the MOD2 AOI was processed and projected in UTM, Zone 10N, North American Datum of 1983 (2011) in units of meters. The vertical datum used for the task order was referenced to NAVD 1988, GEOID12A, in units of meters.

Figure 1.1 Lidar Task Order AOI



SECTION 2: ACQUISITION

The lidar data was acquired with a Leica ALS70 500 kHz Multiple Pulses in Air (MPiA) lidar sensor system, on board a Cessna 404 aircraft and an Optech Orion H300 Lidar System on board a Cessna 180 aircraft. The ALS70 lidar system, developed by Leica Geosystems of Heerbrugg, Switzerland, includes the simultaneous first, intermediate and last pulse data capture module, the extended altitude range module, and the target signal intensity capture module. The Optech Orion H300 developed by Optech of Canada includes up to 4 range measurements, including 1st, 2nd, 3rd, and last returns.

Table 2.1: ALS70 Lidar System Specifications

The ALS70 500 kHz Multiple Pulses in Air (MPiA) Lidar System has the following specifications:

Specification	
Operating Altitude	200 – 3,500 meters
Scan Angle	0 to 75° (variable)
Swath Width	0 to 1.5 X altitude (variable)
Scan Frequency	0 – 200 Hz (variable based on scan angle)
Maximum Pulse Rate	500 kHz (Effective)
Range Resolution	Better than 1 cm
Elevation Accuracy	7 - 16 cm single shot (one standard deviation)
Horizontal Accuracy	5 – 38 cm (one standard deviation)
Number of Returns per Pulse	7 (infinite)
Number of Intensities	3 (first, second, third)
Intensity Digitization	8 bit intensity + 8 bit AGC (Automatic Gain Control) level
MPiA (Multiple Pulses in Air)	8 bits @ 1nsec interval @ 50kHz
Laser Beam Divergence	0.22 mrad @ $1/e^2$ (~0.15 mrad @ 1/e)
Laser Classification	Class IV laser product (FDA CFR 21)
Eye Safe Range	400m single shot depending on laser repetition rate
Roll Stabilization	Automatic adaptive, range = 75 degrees minus current FOV
Power Requirements	28 VDC @ 25A
Operating Temperature	0-40°C
Humidity	0-95% non-condensing
Supported GNSS Receivers	Ashtech Z12, Trimble 7400, Novatel Millenium

Table 2.2: Optech Orion H300 Lidar System Specifications

The Optech Orion H300 Multiple Pulses in Air (MPiA) Lidar System has the following specifications:

Specification	
Operating Altitude	150 – 4,000m AGL nominal
Scan Angle	0 to 50° (variable)
Swath Width	0 to 1.5 X altitude (variable)
Scan Frequency	0 – 90 Hz (variable based on scan angle)
Maximum Pulse Rate	300kHz
Range Resolution	Better than 1 cm
Elevation Accuracy	3 - 15 cm single shot (one standard deviation)
Horizontal Accuracy	1/7,500 x altitude
Number of Returns per Pulse	4 (first, second, third, last)
Number of Intensities	4 (first, second, third, last)
Intensity Digitization	12 bit dynamic measurement range
Laser Beam Divergence	Dual Divergence: .25 mrad (1/e) and 0.8 mrad(1/e) nominal
Laser Classification	Class IV laser product (FDA CFR 21)
Eye Safe Range	400m single shot depending on laser repetition rate
Roll Compensation	±30° FOV dependent
Power Requirements	28 V; 300 W; 12A
Operating Temperature	0-35°C
Humidity	0-95% non-condensing

Prior to mobilizing to the project site, flight crews coordinated with the necessary Air Traffic Control personnel to ensure airspace access.

Woolpert survey crews were onsite, operating a Global Navigation Satellite System (GNSS) Base Station for the airborne GPS support. A CORS station (PTAA) was also utilized.

The lidar data was collected in six (6) separate missions, flown as close together as the weather permitted, to ensure consistent ground conditions across the project area. The MOD2 AOI was acquired in one mission.

An initial quality control process was performed immediately on the lidar data to review the data coverage, airborne GPS data, and trajectory solution. Any gaps found in the lidar data were relayed to the flight crew, and the area was re-flown.

Figure 2.1: Lidar Flight Layout: Elwha River Lidar 2014 w/ Modification

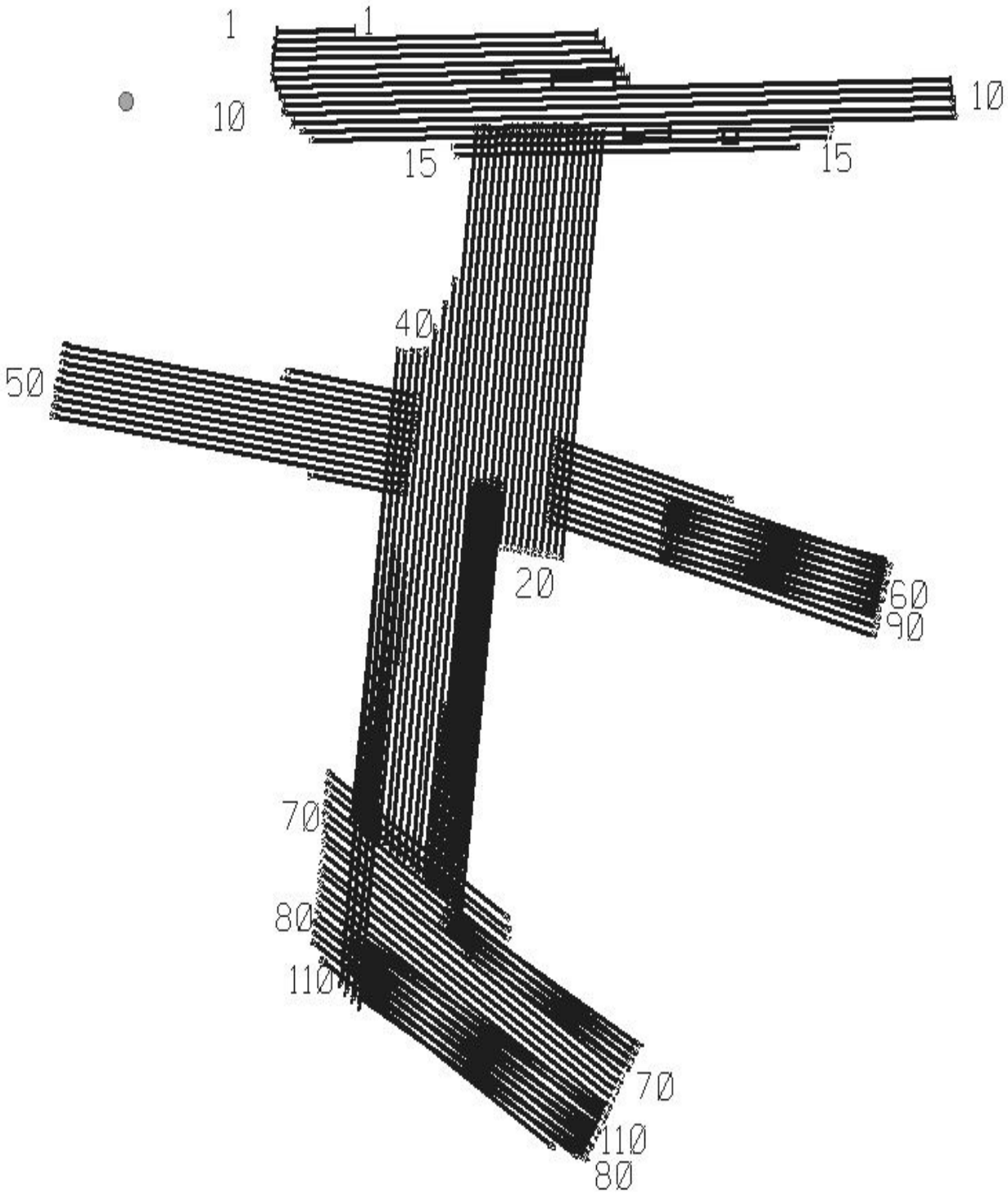


Table 2.3: Airborne Lidar Acquisition Flight Summary

Airborne Lidar Acquisition Flight Summary			
Date of Mission	**Lines Flown**	**Mission Time (UTC)** **Wheels Up/** **Wheels Down**	**Mission Time (Local = PDT)** **Wheels Up/** **Wheels Down**
November 07, 2014 – Sensor7177	1-10,16,20-42,65-83	17:15 - 23:02	09:15AM - 03:02PM
November 10, 2014 –Sensor7177	2-7,10-15	05:00 – 07:02	09:00PM – 11:02 PM
November 11, 2014 – Sensor7177	84-112,43-51,55,56	21:35 – 02:07	01:35PM – 06:37PM
November 12, 2014 – Sensor7177	16-19,52-54,56-64	18:00 – 20:05	10:00AM – 12:05PM
November 13, 2014 – Sensor7177	7,13,14	05:40 – 07:00	09:40PM – 11:00PM

SECTION 3: LIDAR DATA PROCESSING

APPLICATIONS AND WORK FLOW OVERVIEW

1. Resolved kinematic corrections for three subsystems: inertial measurement unit (IMU), sensor orientation information and airborne GPS data. Developed a blending post-processed aircraft position with attitude data using Kalman filtering technology or the smoothed best estimate trajectory (SBET).
   Software: POSPac Software v. 5.3, IPAS Pro v.1.35.

2. Calculated laser point position by associating the SBET position to each laser point return time, scan angle, intensity, etc. Created raw laser point cloud data for the entire survey in LAS format. Automated line-to-line calibrations were then performed for system attitude parameters (pitch, roll, heading), mirror flex (scale) and GPS/IMU drift.
   Software: ALS Post Processing Software v.2.75 build #25, Dashmap v5, Proprietary Software, TerraMatch v. 14.01.

3. Imported processed LAS point cloud data into the task order tiles. Resulting data were classified as ground and non-ground points with additional filters created to meet the task order classification specifications. Statistical absolute accuracy was assessed via direct comparisons of ground classified points to ground RTK survey data. Based on the statistical analysis, the lidar data was then adjusted to reduce the vertical bias when compared to the survey ground control.
   Software: TerraScan v.14.011.

4. The LAS files were evaluated through a series of manual QA/QC steps to eliminate remaining artifacts from the ground class.
   Software: TerraScan v.14.011.

GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)-INERTIAL MEASUREMENT UNIT (IMU) TRAJECTORY PROCESSING

EQUIPMENT

Flight navigation during the lidar data acquisition mission is performed using IGI CCNS (Computer Controlled Navigation System). The pilots are skilled at maintaining their planned trajectory, while holding the aircraft steady and level. If atmospheric conditions are such that the trajectory, ground speed, roll, pitch and/or heading cannot be properly maintained, the mission is aborted until suitable conditions occur.

The aircraft are all configured with a NovAtel Millennium 12-channel, L1/L2 dual frequency Global Navigation Satellite System (GNSS) receivers collecting at 2 Hz.

All Woolpert aerial sensors are equipped with a Litton LN200 series Inertial Measurement Unit (IMU) operating at 200 Hz.

A base-station unit was mobilized for each acquisition mission, and was operated by a member of the acquisition team. Each base-station setup consisted of one Trimble 4000 – 5000 series dual frequency receiver, one Trimble Compact L1/L2 dual frequency antenna, one 2-meter fixed-height tripod, and essential battery power and cabling. Ground planes were used on the base-station antennas. Data was collected at 1 or 2 Hz.

The acquisition team was on site, operating GNSS base stations, along with utilizing CORS stations.

The GNSS base station operated during the lidar acquisition missions are listed below:

Table 3.1: GNSS Base Station

Station Name	Latitude (DMS)	Longitude (DMS)	Ellipsoid Height (L1 Phase center) (Meters)
KCLM Airport	48°06'56.61632"	-123°29'56.32963"	64.781
PTAA (CORS)	48°07'00.57175"	-123°29'36.63493"	67.140

DATA PROCESSING

All airborne GNSS and IMU data was post-processed and quality controlled using Applanix MMS software. GNSS data was processed at a 1 and 2 Hz data capture rate and the IMU data was processed at 200 Hz.

TRAJECTORY QUALITY

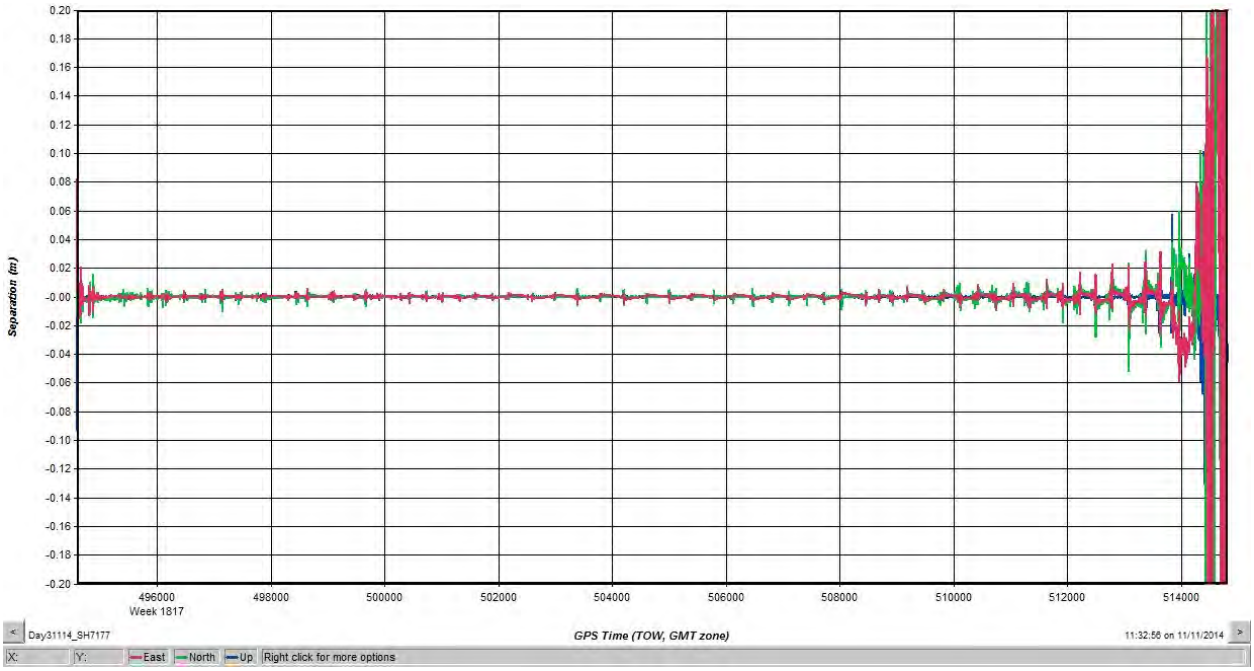
The GNSS Trajectory, along with high quality IMU data are key factors in determining the overall positional accuracy of the final sensor data. Within the trajectory processing, there are many factors that affect the overall quality, but the most indicative are the Combined Separation, the Estimated Positional Accuracy, and the Positional Dilution of Precision (PDOP).

Combined Separation

The Combined Separation is a measure of the difference between the forward run and the backward run solution of the trajectory. The Kalman filter is processed in both directions to remove the combined directional anomalies. In general, when these two solutions match closely, an optimally accurate reliable solution is achieved.

Woolpert's goal is to maintain a Combined Separation Difference of less than ten (10) centimeters. In most cases we achieve results below this threshold.

Figure 3.1: Combined Separation, Day31114 SH7177

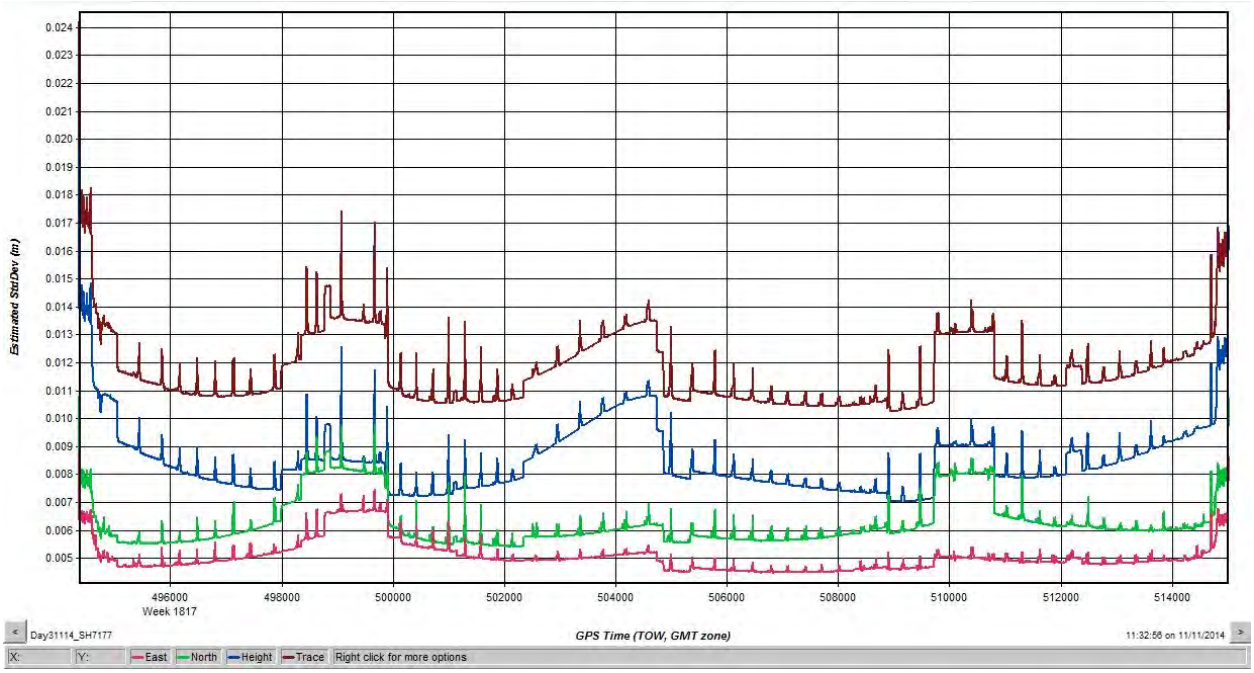


Estimated Positional Accuracy

The Estimated Positional Accuracy plots the standard deviations of the east, north, and vertical directions along a time scale of the trajectory. It illustrates loss of satellite lock issues, as well as issues arising from long baselines, noise, and/or other atmospheric interference.

Woolpert's goal is to maintain an Estimated Positional Accuracy of less than ten (10) centimeters, often achieving results well below this threshold.

Figure 3.2: Estimated Positional Accuracy, Day31114 SH7177

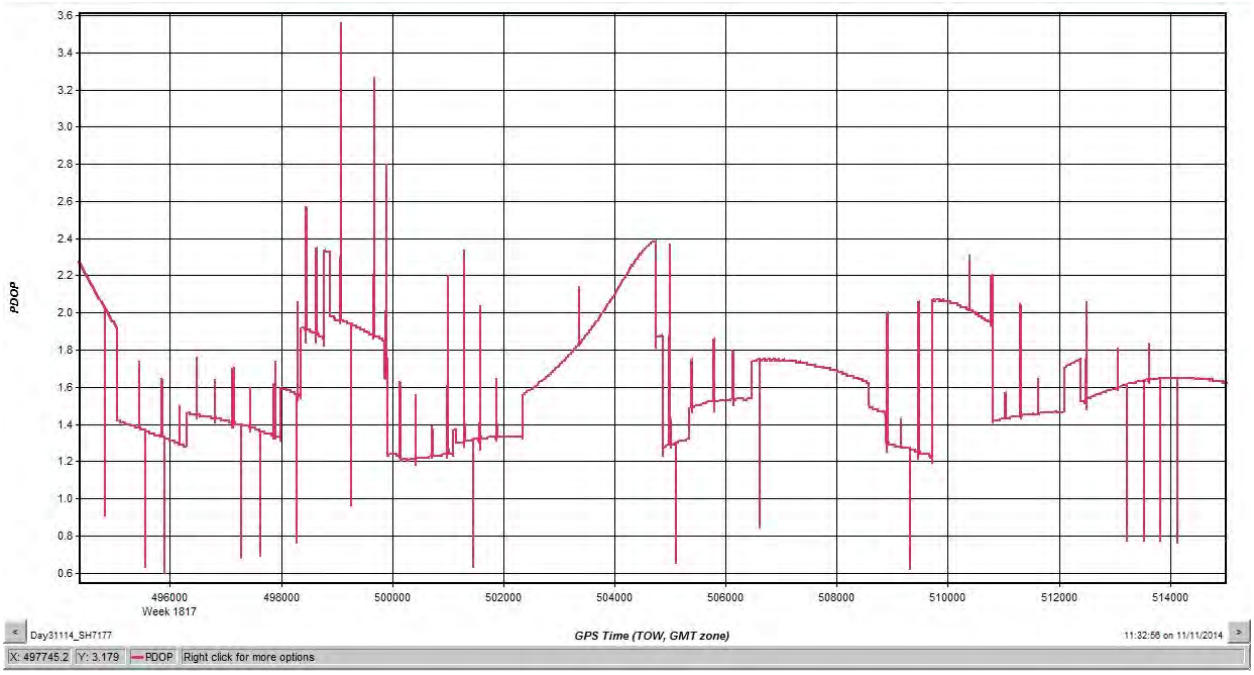


PDOP

The PDOP measures the precision of the GPS solution in regards to the geometry of the satellites acquired and used for the solution.

Woolpert's goal is to maintain an average PDOP value below 3.0. Brief periods of PDOP over 3.0 are acceptable due to the calibration and control process if other metrics are within specification.

Figure 3.3: PDOP, Day31114 SH7177



LIDAR DATA PROCESSING

When the sensor calibration, data acquisition, and GPS processing phases were complete, the formal data reduction processes by Woolpert lidar specialists included:

- Processed individual flight lines to derive a raw "Point Cloud" LAS file. Matched overlapping flight lines, generated statistics for evaluation comparisons, and made the necessary adjustments to remove any residual systematic error.

- Calibrated LAS files were imported into the task order tiles and initially filtered to create a ground and non-ground class. Then additional classes were filtered as necessary to meet client specified classes.

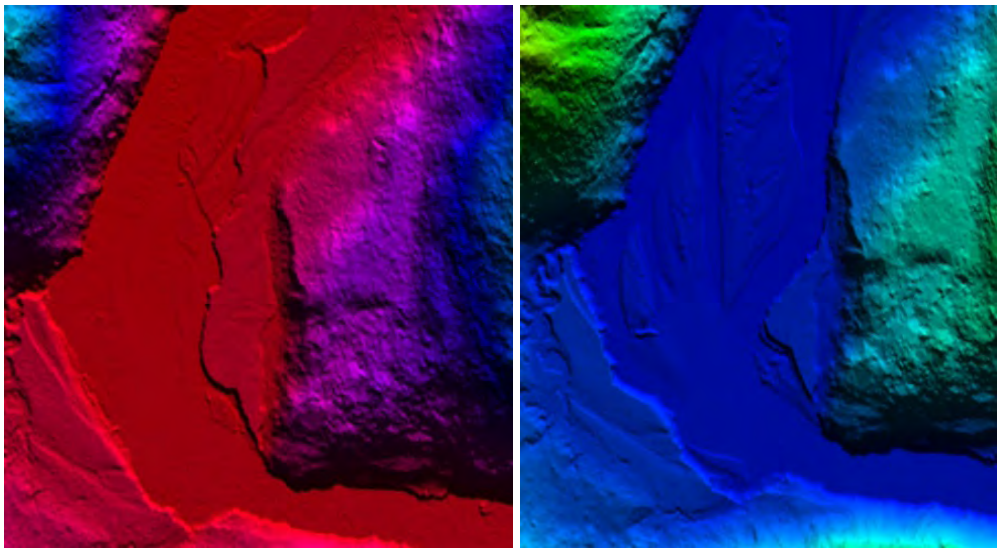
- Once all project data was imported and classified, survey ground control data was imported and calculated for an accuracy assessment. As a QC measure, Woolpert has developed a routine to generate accuracy statistical reports by comparisons against the TIN and the DEM using surveyed ground control of higher accuracy. The lidar is adjusted accordingly to meet or exceed the vertical accuracy requirements. For MOD2 accuracy reporting available control from the initial Elwha collect was used to test against the TIN and the DEM.

- The lidar tiles were reviewed using a series of proprietary QA/QC procedures to ensure it fulfills the task order requirements. A portion of this requires a manual step to ensure anomalies have been removed from the ground class.

- The lidar LAS files are classified into the Default (Class 1), Ground (Class 2), Noise (Class 7), Overlap default (Class 17), and Overlap Ground (Class 18) classifications.

- FGDC Compliant metadata was developed for the task order in .xml format for the final data products.

Figure 3.4: Comparative DEM pre and post river surge event



SECTION 4: FINAL ACCURACY ASSESSMENT

FINAL VERTICAL ACCURACY ASSESSMENT

The vertical accuracy statistics were calculated by comparison of the unclassified lidar points to the ground surveyed quality check points.

Table 4.1: Overall Vertical Accuracy Statistics

Average error	0.046	meters
Minimum error	-0.036	meters
Maximum error	0.132	meters
Root mean square	0.066	meters
Standard deviation	0.048	meters

Table 4.2: Raw Swath Quality Check Point Analysis, FVA, UTM 10N, NAD83, NAVD88 GEOID12A, Elwha River Lidar 0.3m NPS Lidar

Point ID	Easting (UTM meters)	Northing (UTM meters)	TIN Elevation (meters)	Dz (meters)
2000	453187.63	5331703.742	73.2	**0.**031
2000A	453189.96	5331681.736	75.03	0.052
2002	468101.644	5332129.183	3.56	0.059
2002A	468080.389	5332131.674	3.81	0.074
2004	457587.306	5330533.947	73.15	-0.006
2004A	457598.583	5330515.389	73.59	-0.018
2005	458744.952	5327444.57	101.23	-0.003
2005A	458745.247	5327484.504	100.37	-0.024
2006	454929.657	5323669.123	123.53	0.038
2006A	454905.049	5323682.623	122.31	-0.023
2007	447074.238	5326015.873	192.36	0.048
2007A	447054.136	5326023.352	193.34	0.052
2008	462661.68	5322921.982	311.9	0.132
2008A	462650.012	5322906.028	313.1	0.13
2009	455093.183	5321782.71	185.28	-0.036

Point ID	Easting (UTM meters)	Northing (UTM meters)	TIN Elevation (meters)	Dz (meters)
2009A	455093.1	5321770.016	185.69	0.034
2010	459343.332	5332478.03	4.73	0.074
2010A	459314.463	5332479.175	4.59	0.048
2011	452248.889	5333217.996	47.51	0.06
2011A	452259.315	5333194.12	47.69	-0.002
2012	457739.577	5332688.933	3.83	0.024
2012A	457746.348	5332708.282	3.26	0.105
2013	462046.904	5330860.244	47.01	0.058
2013A	462054.717	5330873.567	46.53	0.023
2014	457707.051	5323588.264	76.01	-0.032
2014A	457697.634	5323583.509	75.55	0.063
2015	468046.895	5320959.379	557.17	0.122
2015A	468039.405	5320952.428	555.73	0.115
2017	459321.92	5331501.483	10.01	0.058
2017A	459322.011	5331487.153	10.03	0.049
2018	446380.342	5326071.861	187.51	0.026
2018A	446366.039	5326062.194	187.32	-0.033
2019	460058.537	5328892.831	106.05	0.099
2019A	460074.385	5328876.592	105.72	0.094
2020	448947.504	5325908.52	490.27	0.069
2020A	448947.122	5325919.952	491.54	0.08

VERTICAL ACCURACY CONCLUSIONS

Raw LAS Swath Fundamental Vertical Accuracy (FVA) Tested 0.129 meters fundamental vertical accuracy at a 95 percent confidence level, derived according to NSSDA, in open terrain using (RMSEz) x 1.96000 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the TIN using all points.

Bare-Earth DEM Fundamental Vertical Accuracy (FVA) Tested 0.123 meters fundamental vertical accuracy at a 95 percent confidence level, derived according to NSSDA, in open terrain using (RMSEz) x 1.96000 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the DEM.

SUPPLEMENTAL VERTICAL ACCURACY ASSESSMENTS

Table 4.3: Quality Check Point Analysis, Urban, UTM 10N, NAD83, NAVD88 GEOID12A, Elwha River Lidar 0.3m NPS Lidar

Point ID	Easting (UTM meters)	Northing (UTM meters)	DEM Elevation (meters)	Dz (meters)
3000	453094.665	5331713.07	75.240	0.076
3000A	453111.739	5331716.81	74.890	0.002
3001A	452075.237	5333135.839	68.570	-0.053
3002	459732.219	5332493.482	4.290	0.014
3002A	459750.432	5332492.195	4.430	0.183
3003	456269.738	5331203.072	67.410	0.100
3003A	456287.727	5331194.123	68.200	-0.001
3004	457758.587	5330530.048	72.870	-0.018
3004A	457753.456	5330521.297	72.930	-0.032
3005	458763.116	5327507.938	100.480	0.020
3005A	458769.867	5327519.346	100.220	-0.016
3006	457804.726	5323567.572	78.500	-0.055
3006A	457795.806	5323571.938	78.450	0.026
3007	454625.562	5323820.495	123.920	-0.037
3007A	454626.707	5323834.9	124.060	-0.007
3008	446522.122	5326164.38	201.560	0.075
3008A	446558.257	5326148.332	200.500	0.049
3009	445926.735	5325480.493	156.000	-0.076
3009A	445930.827	5325469.583	156.170	-0.064
3010	460514.636	5323345.789	230.280	0.039

Point ID	Easting (UTM meters)	Northing (UTM meters)	DEM Elevation (meters)	Dz (meters)
3010A	460519.859	5323362.599	233.040	0.009
3011	468110.642	5320866.127	546.300	-0.148
3011A	468090.642	5320848.993	545.430	-0.177
3011B	445862.936	5325384.472	166.360	0.027
3012	467757.946	5321183.974	571.780	-0.045
3012A	467771.887	5321181.31	571.600	0.015
3013	455126.277	5321821.385	180.380	0.058
3013A	455147.087	5321822.509	178.880	-0.007
3014	456044.292	5319523.4	95.550	-0.022
3014A	456052.128	5319549.932	95.140	-0.044
3015	455918.02	5317558.97	127.910	-0.019
3015A	455913.269	5317552.651	128.370	-0.040
3016	454222.137	5314606.253	461.690	0.105
3016A	454219.745	5314593.181	462.500	-0.091
3017	456475.858	5312941.365	353.450	-0.031
3018	455135.564	5316822.679	194.800	0.007
3018A	455170.313	5316821.843	190.560	0.050
3019	455762.036	5323219.559	131.480	-0.016
3019A	455755.212	5323221.585	131.350	-0.113
3020	448944.43	5325933.796	490.690	0.064
3020A	448922.589	5325906.556	489.090	-0.050
3050	447743.521	5324488.031	280.720	0.302
3051	447515.86	5324598.6	270.450	0.010
3052	447622.009	5324642.76	272.510	0.101
3053	448120.46	5324660.1	166.240	-0.352
3054	446882.807	5324694.336	173.650	0.012
3055	446895.06	5324669.648	173.590	-0.011

ACCURACY CONCLUSIONS

Urban Land Cover Classification Supplemental Vertical Accuracy (SVA) Tested 0.181 meters supplemental vertical accuracy at the 95th percentile in the Urban supplemental class reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the DEM. Urban Errors larger than 95th percentile include:

- Point 3002A, Easting 459750.432, Northing 5332492.195, Z-Error 0.183 meters
- Point 3050, Easting 447743.521, Northing 5324488.031, Z-Error 0.302 meters
- Point 3053, Easting 448120.460, Northing 5324660.100, Z-Error 0.352 meters

Table 4.4: Quality Check Point Analysis, Brushlands & Trees, UTM 10N, NAD83, NAVD88 GEOID12A, Elwha River Lidar 0.3m NPS Lidar

Point ID	Easting (UTM meters)	Northing (UTM meters)	DEM Elevation (meters)	Dz (meters)
4000	452933.803	5331748.186	67.990	0.087
4000A	452948.445	5331742.767	69.050	0.079
4002	458617.223	5332969.893	4.900	0.044
4002A	458620.901	5332954.842	4.900	0.007
4003A	459307.168	5331872.462	6.700	0.175
4004	461806.897	5331018.262	41.150	-0.170
4004A	461797.642	5331027.91	41.000	0.023
4006	458721.164	5327449.472	100.230	-0.067
4006A	458699.053	5327442.684	100.040	-0.024
4007	454455.541	5323854.109	122.100	0.115
4007A	454442.943	5323858.015	122.290	0.078
4008	446385.849	5326098.667	187.850	-0.179
4008A	446384.935	5326080.019	187.790	0.025
4009	445848.195	5325387.906	167.320	0.040
4009A	445855.094	5325371.406	167.100	0.095
4010	454857.984	5322051.924	210.180	-0.083

Point ID	Easting (UTM meters)	Northing (UTM meters)	DEM Elevation (meters)	Dz (meters)
4010A	454868.451	5322052.858	209.290	-0.092
4011	459788.12	5323405.628	196.900	0.088
4011A	459780.183	5323393.14	196.720	0.119
4012A	462991.774	5322972.554	288.040	0.298
4013	465532.312	5321679.526	545.790	0.122
4013A	465555.674	5321703.125	547.870	0.257
4014	457233.341	5327041.022	194.010	0.099
4014A	457254.027	5327041.992	194.520	0.020
4015	458012.385	5330822.917	58.240	-0.045
4015A	458026.437	5330827.25	58.190	-0.004

ACCURACY CONCLUSIONS

Brushlands and Trees Land Cover Classification Supplemental Vertical Accuracy (SVA) Tested 0.237 meters supplemental vertical accuracy at the 95th percentile in the Brushlands and Trees supplemental class reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the DEM. Brushlands and Trees Errors exceeding the 95th percentile include:

- Point 4012A, Easting 462991.774, Northing 5322972.554, Z-Error 0.298 meters
- Point 4013A, Easting 465555.674, Northing 5321703.125, Z-Error 0.257 meters

Table 4.5: Quality Check Point Analysis, Forested and Fully Grown, UTM 10N, NAD83, NAVD88 GEOID12A, Elwha River Lidar 0.3m NPS Lidar

Point ID	Easting (UTM meters)	Northing (UTM meters)	DEM Elevation (meters)	Dz (meters)
5000	453320.244	5331663.523	72.680	0.008
5000A	453318.292	5331673.914	72.450	0.056
5001	456120.079	5331184.736	67.100	0.013
5001A	456170.502	5331194.694	68.360	0.083

Point ID	Easting (UTM meters)	Northing (UTM meters)	DEM Elevation (meters)	Dz (meters)
5002	457490.549	5330393.207	75.480	0.167
5002A	457490.04	5330377.292	75.760	-0.047
5003	458735.918	5332969.429	3.880	0.342
5003A	458719.96	5332973.174	3.770	0.156
5004	463827.763	5330957.21	48.710	0.084
5004A	463836.653	5330980.047	48.230	0.026
5005	459336.447	5332131.778	6.730	0.052
5005A	459336.365	5332148.08	6.590	0.006
5006	454972.765	5323694.732	123.460	-0.019
5006A	454985.794	5323689.564	123.100	0.043
5007	450610.821	5324649.517	152.620	0.164
5007A	450598.831	5324648.477	153.090	0.254
5008	455446.371	5323257.542	129.150	0.120
5008A	455444.264	5323238.838	129.820	0.055
5009	455108.176	5321878.857	181.140	0.064
5009A	455121.434	5321872.02	179.990	0.053
5010	455942.495	5320677.823	82.500	0.140
5010A	456003.128	5320662.16	82.160	0.068
5011	459858.032	5323423.502	199.180	0.189
5011A	459859.859	5323440.229	199.330	0.231
5012	462487.025	5323022.806	304.410	0.153
5012A	462491.324	5322998.791	304.430	0.122
5013	454235.038	5314598.022	462.220	0.026
5013A	454231.534	5314587.308	462.680	0.123
5014	457185.794	5323349.218	67.710	0.030
5014A	457170.039	5323333.625	67.710	0.039
5015	447157.53	5326100.211	206.550	0.051

Point ID	Easting (UTM meters)	Northing (UTM meters)	DEM Elevation (meters)	Dz (meters)
5015A	447153.516	5326075.651	201.750	-0.054

ACCURACY CONCLUSIONS

Forested and Fully Grown Land Cover Classification Supplemental Vertical Accuracy (SVA) Tested 0.241 meters supplemental vertical accuracy at the 95th percentile in the Forested and Fully Grown supplemental class reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the DEM. Forested and Fully Grown Errors larger than 95th percentile include:

- Point 5003, Easting 458735.918, Northing 5332969.429, Z-Error 0.342 meters
- Point 5007A, Easting 450598.831, Northing 5324648.477, Z-Error 0.254 meters

CONSOLIDATED VERTICAL ACCURACY ASSESSMENT

ACCURACY CONCLUSIONS

Consolidated Vertical Accuracy (CVA) Tested 0.189 meters consolidated vertical accuracy at the 95th percentile level; reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the DEM. CVA is based on the 95th percentile error in all land cover categories combined.

- Point 3050, Easting 447743.521, Northing 5324488.031, Z-Error 0.302 meters
- Point 3053, Easting 448120.460, Northing 5324660.100, Z-Error 0.352 meters
- Point 4012A, Easting 462991.774, Northing 5322972.554, Z-Error 0.298 meters
- Point 4013A, Easting 465555.674, Northing 5321703.125, Z-Error 0.257 meters
- Point 5003, Easting 458735.918, Northing 5332969.429, Z-Error 0.342 meters
- Point 5007A, Easting 450598.831, Northing 5324648.477, Z-Error 0.254 meters
- Point 5011A, Easting 459859.859, Northing 5323440.229, Z-Error 0.231 meters

FINAL VERTICAL ACCURACY ASSESSMENT MOD2

Using available control that fell within the MOD2 AOI, the vertical accuracy statistics were calculated by comparison of the unclassified lidar points to the ground surveyed quality check points.

Table 4.6: Overall Vertical Accuracy Statistics MOD2 AOI

Average error	0.027	meters
Minimum error	-0.082	meters
Maximum error	0.282	meters
Root mean square	0.078	meters
Standard deviation	0.075	meters

Table 4.7: Raw Swath Quality Check Point Analysis, FVA, UTM 10N, NAD83, NAVD88 GEOID12A, Elwha River Lidar 0.7m NPS Lidar MOD2 AOI

Point ID	Easting (UTM meters)	Northing (UTM meters)	TIN Elevation (meters)	Dz (meters)
2010	459343.332	5332478.03	4.68	0.024
2010A	459314.463	5332479.175	4.58	0.038
2012	457739.577	5332688.933	3.8	-0.006
2012A	457746.348	5332708.282	3.22	0.065
3002	459732.219	5332493.482	4.32	0.044
3002A	459750.432	5332492.195	4.29	0.043
3014	456044.292	5319523.4	95.49	-0.082
3014A	456052.128	5319549.932	95.13	-0.054
3015	455918.02	5317558.97	127.87	-0.059
3015A	455913.269	5317552.651	128.33	-0.08
3018	455135.564	5316822.679	194.86	0.067
3018A	455170.313	5316821.843	190.61	0.1
4002	458617.223	5332969.893	4.9	0.044

Point ID	Easting (UTM meters)	Northing (UTM meters)	TIN Elevation (meters)	Dz (meters)
4002A	458620.901	5332954.842	4.92	0.027
5003	458735.918	5332969.429	3.82	0.282
5003A	458719.96	5332973.174	3.73	0.116
5005	459336.447	5332131.778	6.63	-0.048
5005A	459336.365	5332148.08	6.59	0.006
5010	455942.495	5320677.823	82.42	0.06
5010A	456003.128	5320662.16	82.15	0.058
5014	457185.794	5323349.218	67.69	0.01
5014A	457170.039	5323333.625	67.71	0.039
1003	458585.007	5333077.529	4.47	0.005
1018	456051.39	5319535.007	95.12	-0.043

VERTICAL ACCURACY CONCLUSIONS MOD2 AOI

Using available control in the MOD 2 area raw LAS Swath Fundamental Vertical Accuracy (FVA) Tested 0.156 meters fundamental vertical accuracy at a 95 percent confidence level, derived according to NSSDA, using (RMSEz)x 1.96000 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the TIN using all points.

Using available control in the MOD 2 area bare-earth DEM Fundamental Vertical Accuracy (FVA) Tested 0.147 meters fundamental vertical accuracy at a 95 percent confidence level, derived according to NSSDA, in open terrain using (RMSEz) x 1.96000 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the DEM.

Approved By:			
Title	Name	Signature	Date
Associate Lidar Specialist Certified Photogrammetrist #1281	Qian Xiao		April 2015

SECTION 5: FLIGHT LOGS

FLIGHT LOGS

Flight logs for the project are shown on the following pages.

Woolpert

Leica LIDAR					
	11/7/2014	909	74275	1	Elwha River, WA

GALAMBOS	N7079F	3454.8	9:15:00	17:15:00	WOOLPERT PIN
SWAN	AS-7177				KCLM Woolp

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Rain/Fog/Clear		
220 9	10	clear	0	9	4	30.47		Departing	KCLM
								Arriving	KCLM

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain	255	Mode		Threshold Values	
12	71.4	292	100	Gain - Course/Up		Single		A	120
				Gain - Fine/Down		Multi		B	150

Air Speed	AGL	MSL	Waveform Used				Waveform Mode	Pre-Trigger Dist.
130 Kts	6000 Ft	Ft	Yes		No	X	@ NS	Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP	PDOP	Line Notes/Comments	
Text	n/a			n/a	n/a	n/a	n/a	GPS Began Logging At:	17:20:17
↑ Times entered are Zulu / GMT ↑								Verify 5-Turns Before Mission Start: Y	N
1	E	17:40:30	17:41:09	11:33:00	16	0.7	1.3	Takeoff:1728z/9:28(L)	
2	W	17:45:18	17:47:42	0:00:00	16	0.7	1.3		
3	E	17:50:42	17:53:10	0:00:00	16	0.7	1.3		
4	W	17:56:00	17:58:31	0:00:00	16	0.7	1.3		
5	E	18:01:21	18:03:54	0:00:00	16	0.6	1.3		
6	W	18:06:38	18:09:17	0:00:00	16	0.6	1.2		
7	E	18:11:40	18:14:20	0:00:00	17	0.6	1.2		
8	W	18:18:46	18:23:46	0:00:00	17	0.6	1.2		
9	E	18:31;30	18:36:40	0:00:00	17	0.6	1.2		
10	W	18:38:58	18:43:58	0:00:00	18	0.6	1.2		
16	S	18:51:41	????	0:00:00	17	0.6	1.1		
20	S	19:01:17	19:03:49	0:00:00	17	0.6	1		
21	N	19:06:00	19:08:27	0:00:00	17	0.6	1.1		
22	S	19:10:59	19:13:24	0:00:00	17	0.6	1.1		
23	N	19:15:41	19:18:11	0:00:00	16	0.6	1.1		
24	S	19:20:38	19:23:04	0:00:00	16	0.6	1.1		
25	N	19:25;20	19:27:45	0:00:00	17	0.6	1.2		
26	S	19:30:18	19:34:45	0:00:00	17	0.6	1.2		
27	N	19:36:52	19:41:15	0:00:00	15	0.7	1.4		
28	S	19:43:42	19:48:10	0:00:00	16	0.7	1.2		
29	N	19:50:13	19:54:36	0:00:00	15	0.7	1.1		
30	S	19:57:14	20:01:38	0:00:00	15	0.8	1.1		
31	N	20:03;56	20:08:15	0:00:00	16	0.8	1.2		
32	S	20:10:48	20:15:07	0:00:00	16	0.6	1.2		
33	N	20:17:09	20:21:25	0:00:00	16	0.6	1.2		
34	S	20:23;55	20:28:12	0:00:00	16	0.6	1.2		
35	N	20:30:31	20:33:51	0:00:00	15	0.7	1.2		
36	S	20:36:14	20:39:21	0:00:00	15	0.7	1.2		
37	E	20:42:00	20:45:04	0:00:00	15	0.7	1.3		
38	S	20:47:26	20:50:19	0:00:00	15	0.7	1.3		
39	E	20:52;20	20:55:17	0:00:00	15	0.7	1.3	See Page #2	
↑ Times entered are Zulu / GMT ↑				Page		1		Verify 5-Turns After Mission: Yes	X No

Additional Comments: Drive #

Woolpert

Leica LIDAR	11/7/2014	311	74275	1	Elwha River, WA
GALAMBOS	N70796	3454.8	9:15:00	17:15:00	WOOLPERT PIN
SWAIN	ALS-7177	3480.1	9:00:00	23:02:00	KCMI_Woolp

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Raining/Icing/Clear		
220 9	10	clear	0	9	4	30.47		Departing	KCLM
								Arriving	KCLM

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain	255	Mode		Threshold Values	
12	71.4	292	100	Gain - Course/Up		Single		A	120
				Gain - Fine/Down		Multi		B	150

Air Speed	AGL		MSL		Waveform Used			Waveform Mode		Pre-Trigger Dist.
130 Kts	6000	Ft	6000	Ft	Yes		No	X	@ NS	Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP	PDOP	Line Notes/Comments	
Test	n/a			n/a	n/a	n/a	n/a	GPS Began Logging At:	17:20:17
↑ Times entered are Zulu / GMT ↑								Verify 5-Turns Before Mission	Yes / No
40	S	20:57:42	21:00:28	18:07:55	15	0.7	1.2		
41	N	21:02:34	21:05:21	0:00:00	16	0.8	1.4		
42	S	21:07:47	21:10:28	0:00:00	16	0.7	1.1		
65	W	21:14;44	21:16:15	0:00:00	16	0.7	1.1		
66	E	21:18:42	21:20:16	0:00:00	16	0.7	1.1		
67	W	21:22:53	21:24:29	0:00:00	16	0.7	1.1		
68	E	21:26:56	21:29:34	0:00:00	16	0.7	1.1		
69	W	21:32:19	21:35:02	0:00:00	18	0.6	1		
70	E	21:37:23	21:39:59	0:00:00	18	0.6	1		
71	W	21:42:36	21:45;15	0:00:00	18	0.6	0.9		
72	E	21:47:43	21:50;15	0:00:00	16	0.6	1.1		
73	W	21:52:54	21:55:32	0:00:00	16	0.6	1.1		
74	E	21:57:53	22:00:24	0:00:00	16	0.6	1.1		
75	W	22:02:47	22:05:21	0:00:00	16	0.6	1.1		
76	E	22:07:45	22:10:13	0:00:00	16	0.6	1.1		
77	W	22:12:24	22:14;57	0:00:00	16	0.6	1.1		
78	E	22:17:29	22:19:57	0:00:00	16	0.6	1.1		
79	W	22:22:16	22:24:36	0:00:00	16	0.6	1.1		
80	E	22:27:02	22:29:30	0:00:00	15	0.8	1.5		
81	W	22:31:53	22:34:16	0:00:00	15	0.8	1.5	Possible thin fog spotty	
82	E	22:36:48	22:39:10	0:00:00	15	0.8	1.5	Possible thin fog spotty	
83	W	22:41:16	22:43:16	0:00:00	15	0.8	1.5	Possible thin fog spotty	
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
↑ Times entered are Zulu / GMT ↑				Page		2		Verify 5-Turns After Mission	Yes / No

Additional Comments: Drive #

Woolpert

Leica LIDAR

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11/10/2014	314	74275	1	Elwha River, WA

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
GALAMBOS	N707?F	3460.3	9:00:00	5:00:00	WOOLPERT PIN
SWNN	ALS-7177	3461.9	11:02:00	7:02:00	KCLM

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Departing	KCLM
Calm	10	Clear	0	3	-1	30.22		Arriving	KCLM

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain	255	Mode		Threshold Values	
12	71.4	292	100	Gain - Course/Up		Single		A	170
				Gain - Fine/Down		Multi		B	150

Air Speed		AGL		MSL		Waveform Used				Waveform Mode	Pre-Trigger Dist.	
130	kts	6000	Ft	6000	Ft	Yes		No	X	@ NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP	PDOP	Line Notes/Comments
Test	n/a			n/a	n/a	n/a	n/a	GPS Began Logging At: 5:05:31
		↓ Times entered are Zulu / GMT ↓						Verify 5-Turns Before Mission Yes X No
10	W	5:32:17	5:37:10	11:26:18	17	0.8	1.2	Takeoff: 9:15 (L) 05:15z
11	E	5:40:35	5:45:43	0:00:00	17	0.7	1	
12	W	5:48:15	5:52:58	0:00:00	17	0.8	1.1	
13	E	5:56:13	6:00:15	0:00:00	16	0.6	1.2	
14	W	6:02:42	6:05:28	0:00:00	17	0.7	1	
15	E	6:08:18	6:10:57	0:00:00	17	0.7	1	
2	W	6:13:24	6:15:31	0:00:00	18	0.6	1	
3	E	6:18:35	6:21:21	0:00:00	18	0.6	1	
4	W	6:24:36	6:26:33	0:00:00	18	0.6	1	
5	E	6:29:49	6:32:33	0:00:00	18	0.6	1	
6	W	6:35:13	6:37:49	0:00:00	18	0.6	1	
7	E	6:40:39	6:43:42	0:00:00	18	0.6	1	
				0:00:00				Landing: 06:55z 10:55 (L)
				0:00:00				Static: 07:00:00 - 07:02:00
				0:00:00				
				0:00:00				
				0:00:00				
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↑ Times entered are Zulu / GMT ↑			Page		1			Verify 5-Turns After Mission Yes X No

Additional Comments:	Drive #
	96

Woolpert

Leica LIDAR	Date (mm/dd/yyyy)	Day of Year	Project #	Flight #	Project Name
	11/11/2014	315	74275	1	Elwha River, WA

Operator	Aircraft #	Aircraft Start	Lunch Start Time	Lunch End Time	Base
GALAMBOS	N7079F	3461.9	1:35:00	21:35:00	WOOLPERT PIN
Pilot	**Sensor Type**	**Aircraft End**	**Local Start Time**	**Take Off Time**	**FBO**
SWAIN	ALS-7177	3466.1	6:07:00	2:07:00	KCLM

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Relay/Hwy/Cloud		
Unknown	10	Clear	0	8	-7	30.28		Departing	KCLM
								Arriving	KCLM

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain	255	Mode		Threshold Values	
12	71.4	292	100	Gain - Course/Up		Single		A	120
				Gain - Fine/Down		Multi		B	150

Nir Speed	AGL	MSL	Waveform Used				Waveform Mode		Pre-Trigger Dist.
130 Kts	6000 Ft	7582 GPS Ft	Yes		No	X	@	NS	Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP	PDOP	Line Notes/Comments	
Test	n/a			n/a	n/a	n/a	n/a	GPS Began Logging At:	21:39:04
↑ Times entered are Zulu / GMT ↑								Verify 5-Turns Before Mission	Yes X No
84	W	22:03:50	22:05:20	20:26:00	15	0.7	1.2	Refly too fast Takeoff @ 2148z	
84	W	22:12:10	22:13:50	0:00:00	15	0.7	1.2	Landing: 02:02z	
85	E	22:16:34	22:18:20	0:00:00	15	0.8	1.5	Finish Static: 02:04:50 - 06:50	
86	W	22:21:05	22:22:44	0:00:00	15	0.8	1.5		
87	E	22:25:29	22:27:21	0:00:00	15	0.8	1.5		
88	W	22:30:20	22:30:00	0:00:00	15	0.8	1.5		
88	W	22:33:18	22:34:54	0:00:00	15	0.8	1.5		
89	E	22:37:39	22:39:25	0:00:00	17	0.7	1.2		
90	W	22:41:40	22:43:25	0:00:00	18	0.7	1.2		
91	S	22:47:17	22:50:23	0:00:00	20	0.7	1.2		
92	N	22:52:47	22:55:46	0:00:00	20	0.7	1.2		
93	S	22:58:47	23:01:20	0:00:00	19	0.6	1.3		
94	N	23:03:47	23:06:31	0:00:00	19	0.6	1.2		
95	S	23:08:58	23:09:32	0:00:00	18	0.6	1		
96	N	23:13:06	23:14:11	0:00:00	18	0.6	1		
97	S	23:17:50	23:20:10	0:00:00	18	0.6	1.1		
98	N	23:22:44	23:25:13	0:00:00	18	0.6	1.1		
99	S	23:27:30	23:29:48	0:00:00	19	0.6	1.1		
100	N	23:32:38	23:35:24	0:00:00	19	0.6	1.1		
101	S	23:38:06	23:40:29	0:00:00	19	0.6	1.1		
102	W	23:45:12	23:46:14	0:00:00	20	0.6	1.1		
103	E	23:49:38	23:51:14	0:00:00	20	0.6	1.1		
104	W	23:53:49	23:55:18	0:00:00	20	0.6	1.1		
105	E	23:58:32	23:59:57	0:00:00	20	0.6	1.1		
106	W	0:02:07	0:04:16	0:00:00	20	0.6	1.1		
107	E	0:07:26	0:09:36	0:00:00	20	0.6	1.1		
108	W	0:12:01	0:14:08	0:00:00	20	0.6	1.1		
109	E	0:17:15	0:19:33	0:00:00	20	0.6	1.1		
110	W	0:21:58	0:23:57	0:00:00	20	0.6	1.1		
111	E	0:27:34	0:29:36	0:00:00	20	0.6	1.1		
112	W	0:32:10	9:57:00	0:00:00	19	0.6	1.2	See Page #2	
↑ Times entered are Zulu / GMT ↑				Page		1		Verify 5-Turns After Mission	Yes X No

Additional Comments: Drive #

Woolpert

Leica LIDAR					
	11/11/2014	315	74275	1	Elwha River, WA
Operator	Aircraft		Lens #	Camera Start Time	System Start Time	Area
GALAMBOS	N70796		3461.9	1:35:00	21:35:00	WOOLPERT PIN
Pilot	Sensor Type		Cal Dat	Laser End Time	Sys End Time	PID
SWAN	RAS-T177					

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fog/Clouds	Departing	KCLM
unknown	10	clear	0	8	-7	30.28		Arriving	KCLM

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain	255	Mode		Threshold Values	
12	71.4	292	100	Gain - Course/Up		Single		A	120
				Gain - Fine/Down		Multi		B	150

Air Speed	AGL	MSL	Waveform Used			Waveform Mode	Pre-Trigger Dist.
130 kts	6000 Ft	5862 GPS Ft	Yes		No	@ NS	Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP	PDOP	Line Notes/Comments	
Text	n/a			n/a	n/a	n/a	n/a	GPS Began Logging At:	21:39:04
↑ Times entered are Zulu / GMT ↑								Verify 5-Turns Before Mission	Yes / No
104	W	0:40:33	0:42:07	1:42:14	19	0.6	1.1		
43	E	0:50:33	0:51:41	0:00:00	18	0.6	1.2		
44	W	0:54:07	0:55:11	0:00:00	18	0.6	1.2		
45	E	0:59:33	1:02:25	0:00:00	18	0.6	1.2		
46	W	1:05:00	1:07:38	0:00:00	18	0.6	1.2		
47	E	1:10:36	01:13;33	0:00:00	18	0.6	1.2		
48	W	1:16:22	1:18:53	0:00:00	18	0.6	1.2		
49	E	1:21:27	1:24:20	0:00:00	18	0.6	1.2		
50	W	1:26:40	1:29:08	0:00:00	20	0.6	1		
51	E	1:32:15	1:35:15	0:00:00	20	0.6	1		
55	E	1:41:40	1:43:06	0:00:00	18	0.6	1.3		
56	W	1:46:42	1:49:10	0:00:00	20	0.6	1		
				0:00:00					
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↑ Times entered are Zulu / GMT ↑				Page		2		Verify 5-Turns After Mission	Yes / No

Additional Comments:

Drive #

Woolpert

Leica LIDAR	Date (mm/dd/yyyy)	Julian Day	Project #	Flight #	Project Name
	11/12/2014	316	74275	1	Elwha River, WA

Operator	Aircraft	Aircraft Start	Local Start Time	Local End Time	Base
GALAMBOS	N7079F	3466.1	10:00:00	18:00:00	WOOLPERT PIN
Pilot	Sensor Type	Aircraft End	Local Start Time	Local End Time	FBO
SWAIN	RAS-TI77	3487.9	12:05:00	20:05:00	KCLM

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Heavy/Hvy/Clear	Departing	KCLM
100 11	10	clear	0	4	-13	30.27		Arriving	KCLM

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain	255	Mode		Threshold Values	
12	71.4	292	100	Gain - Course/Up		Single		A	120
				Gain - Fine/Down		Multi		B	150

Air Speed	AGL	MSL	Waveform Used				Waveform Mode	Pre-Trigger Dist.
130 Kts	6000 Ft	5862 GPS Ft	Yes		No	X	@ NS	Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP	PDOP	Line Notes/Comments	
Test	n/a			n/a	n/a	n/a	n/a	GPS Began Logging At:	18:07:26
↑ Times entered are Zulu / GMT ↑								Verify 5-Turns Before Mission Start: Y	No
16	S	18:27:20	18:29:48	#VALUE!	18	0.6	1.1	Reflight/takeoff 18:16	
17	N	18:31:40	18:34;15	0:00:00	17	0.6	1.1		
18	S	18:37:07	18:39:42	0:00:00	18	0.6	1.1		
19	N	18:41:50	18:44:18	0:00:00	18	0.6	1.1		
52	W	18:50:54	18:53:35	0:00:00	17	0.6	1.1		
53	E	18:56:20	18:59:03	0:00:00	18	0.6	1.1		
54	W	19:01:48	19:02:30	0:00:00	18	0.6	1.1		
57	E	19:05:32	19:08:05	0:00:00	18	0.6	1		
56	W	19:13:09	19:13;11	0:00:00	18	0.6	1		
59	E	19:15:30	19:18:00	0:00:00	18	0.6	1.1		
58	W	19:20:30	19:23:01	0:00:00	18	0.6	1.1		
61	E	19:25:28	19:27:56	0:00:00	18	0.6	1		
60	W	19:30:25	19:32:56	0:00:00	18	0.6	1		
63	E	19:35:25	19:31:47	0:00:00	17	0.6	1.1		
62	W	19:41:04	19:43:33	0:00:00	17	0.6	1.1		
64	W	19:49:14	19:51:45	0:00:00	17	0.6	1.1		
				0:00:00				Landing: 20:00:33	
				0:00:00				Static: 20:03:11-20:05:11	
				0:00:00					
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↑ Times entered are Zulu / GMT ↑				Page		2		Verify 5-Turns After Mission: Yes	No

Additional Comments: Drive #

Woolpert

Leica LIDAR					
	11/13/2014	317	74275	1	Elwha River, WA

GALAMBOS	N70796	3467.9	9:40:00	5:40:00	WOOLPERT PIN
SWAN	KLS-7177	3468.7	11:00:00	7:0000	KCLM

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Departing	KCLM
220 8	10	clear	0	-1	-8	30.04	Arriving	KCLM

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain	255	Mode	Threshold Values
12	71.4	292	100	Gain - Course/Up		Single	A 120
				Gain - Fine/Down		Multi	B 150

Air Speed	AGL	MSL	Waveform Used				Waveform Mode	Pre-Trigger Dist.
130 Kts	6000 Ft	5862 GPS Ft	Yes		No	X	@ NS	Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP	PDOP	Line Notes/Comments	
Test	n/a			n/a	n/a	n/a	n/a	GPS Began Logging At:	5:54:37
		↑ Times entered are Zulu / GMT ↑						Verify 5-Turns Before Mission Start: Y	N
7	E	6:26:45	6:27:56	13:14:14	18	0.6	1	wpts 8-11/Reflight/UL001	
14	W	6:36:13	6:38:01	0:00:00	19	0.6	1	wpts 6-11/ Reflight	
13	E	6:41:49	6:43:50	0:00:00	19	0.6	1	wpts 9-14/ Reflight/ UL002	
				0:00:00				UL = Manual Starts	
				0:00:00				Takeoff: 06:04z	
				0:00:00				tide 10:24 until 2:48	
				0:00:00					
				0:00:00				Landing: 06:52:51	
				0:00:00				Static: 06:58:10 - 07:00:10	
				0:00:00					
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Additional Comments:

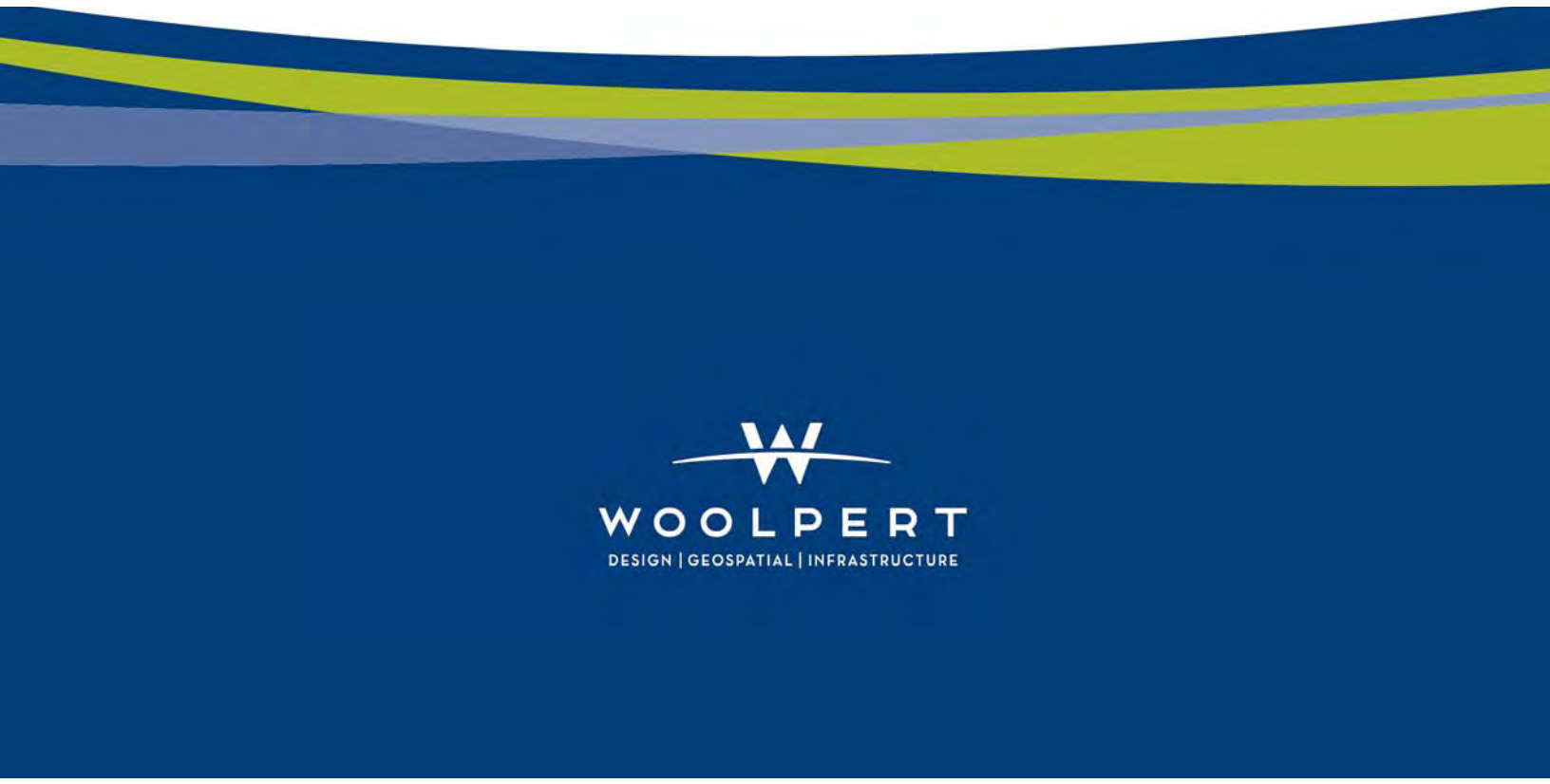
Drive #

SECTION 6: FINAL DELIVERABLES

FINAL DELIVERABLES

The final lidar deliverables are listed below.

- LAS v1.2 classified point cloud
- LAS v1.2 raw unclassified point cloud flight line strips no greater than 2GB. Long swaths greater than 2GB will be split into segments)
- Bare-earth 1-meter DEM in ERDAS .IMG format
- 8-bit gray scale intensity images
- Tile layout and data extent provided as ESRI shapefile
- Control points provided as ESRI shapefile
- FGDC compliant metadata per product in XML format
- Lidar processing report in pdf format
- Survey report in pdf format
- Flight Line Vectors provided as ESRI shapefile


WOOLPERT
DESIGN | GEOSPATIAL | INFRASTRUCTURE