WOOLPERT

Mississippi QL2 and Tupelo QL3 Lidar

USGS/ Rolla, MO

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Section 1: Overview

Project Name: Mississippi QL2 and Tupelo QL3 Lidar Processing

Project: # 74853

This report contains a comprehensive outline of the Mississippi QL2 and Tupelo QL3 Lidar Processing task order for the United States Geological Survey (USGS). This task is issued under USGS Contract No. G10PC00057, Task Order No. G14PD01046. This task order requires lidar data to be acquired over approximately 4385 square miles. The lidar was collected and processed to meet a maximum Nominal Post Spacing (NPS) of 0.7 meter. The NPS assessment is made against single swath, first return data located within the geometrically usable center portion (typically ~90%) of each swath.

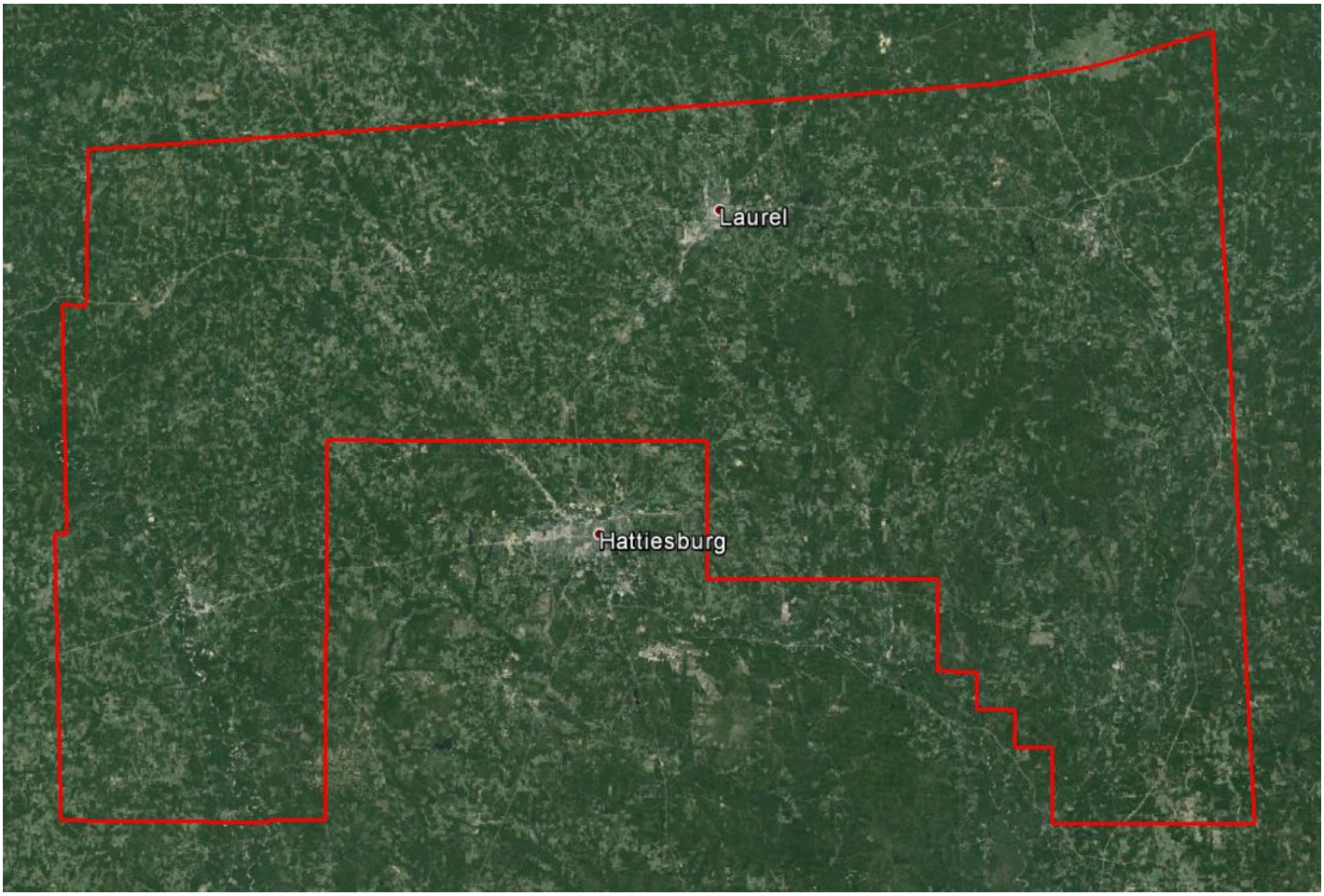
This task order also requests the processing of previously collected QL3 data near Tupelo, Mississippi. The lidar was collected and processed to meet a maximum Nominal Post Spacing (NPS) of 1.0 meter. The NPS assessment is made against single swath, first return data located within the geometrically usable center portion (typically ~90%) of each swath.

The data was collected using a Leica ALS70 500 kHz Multiple Pulses in Air (MPiA) lidar sensor. The ALS70 sensor collects up to four returns 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:

Table 1.1: ALS70 Specifications	
Post Spacing	2.3ft / 0.7 m
AGL (Above Ground Level) average flying height	6,500 ft / 1,981 m
MSL (Mean Sea Level) average flying height	varies
Average Ground Speed:	150 knots / 173 mph
Field of View (full)	40 degrees
Pulse Rate	272 kHz
Scan Rate	41 Hz
Side Lap	25%

The lidar data was processed and projected in UTM, Zone 16, North American Datum of 1983 (2011) and UTM, Zone 15, 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 existing lidar data was acquired with a Leica ALS70 500 kHz Multiple Pulses in Air (MPiA) Lidar Sensor System, on board Woolpert Cessna 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 system software is operated on an OC50 Operation Controller aboard the aircraft.

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

Table 2.1: ALS Lidar System Specifications	
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

Prior to mobilizing to the project site, Woolpert 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.

The lidar data was collected in eleven (11) missions, flown as close together as the weather permitted, to ensure consistent ground conditions across the project area.

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, Mississippi QL2 and Tupelo QL3 Lidar

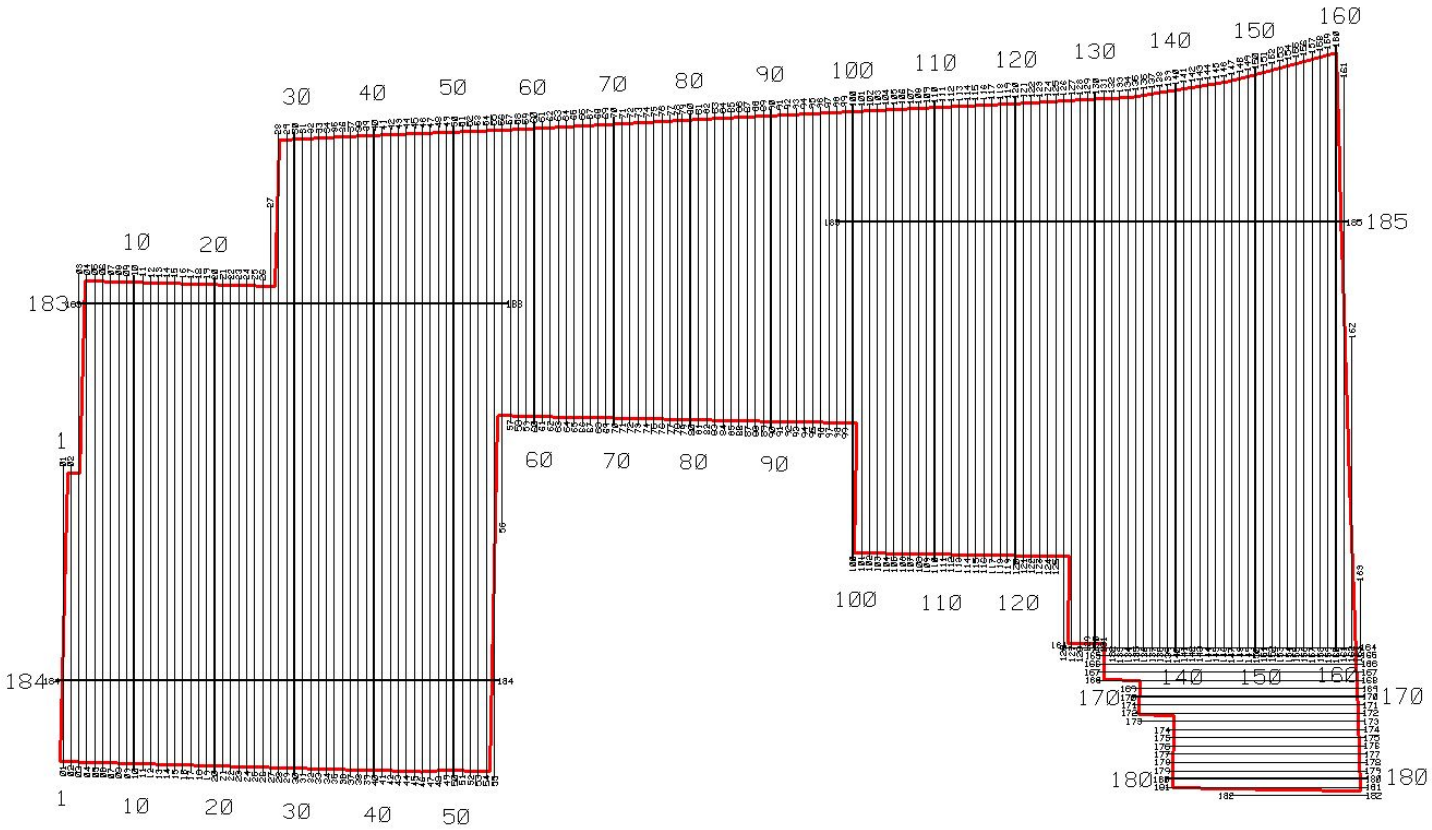


Table 2.2: Airborne Lidar Acquisition Flight Summary

Date of Mission	Lines Flown	Mission Time (UTC) Wheels Up/ Wheels Down	Mission Time (Local = EDT) Wheels Up/ Wheels Down
January 10, 2015 – Sensor ALS-7177	153-182	15:44 – 22:51	9:44 AM – 4:51 PM
January 11, 2015 – Sensor ALS-7177	148-152	16:50 – 19:19	10:50 AM - 1:19 PM
January 16, 2015 – Sensor ALS-7177	128-147	15:38 – 22:52	9:38 AM – 4:52 PM
January 17, 2015 – Sensor ALS-7177	88-99, 114-127	16:04 – 23:08	10:04 AM – 5:08PM

January 18, 2015 – Sensor ALS-7177	86-87, 100-113, 185	18:00– 23:18	12:02 AM – 5:18PM
January 19, 2015 – Sensor ALS-7177	57-85	15:54 – 22:10	9:54AM – 4:10PM
January 21, 2015 – Sensor ALS-7177	38 - 56	15:45 – 23:04	9:45 AM – 5:04 PM
January 24, 2015 – Sensor ALS-7177	26-37	19:45– 1:01	1:45 PM – 7:01 PM
January 25, 2015 – Sensor ALS-7177_A	9-25, 92, 94, 114, 148-150	14:00 – 18:55	8:00 AM – 12:55PM
January 25, 2015 – Sensor ALS-7177_B	9-17,183-184	21:00– 1:00	3:00 PM – 7:00 PM
January 26, 2015 – Sensor ALS-7177	1-10, 18-19	18:30 – 23:20	12:30 AM – 5:20 PM

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, Proprietary Software, TerraMatch v. 15.01.
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.15.01.
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.15.01.

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 where a CORS station was not utilized, and was operated by a member of the Woolpert 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 GNSS base station operated during the Lidar acquisition missions is listed below:

Table 3.1: GNSS Base Station

Station (Name)	Latitude (DMS)	Longitude (DMS)	Ellipsoid Height (L1 Phase center) (Meters)
KPIB Airport Base	31°28'08.22371"	89°20'06.73607"	61.794
MSEV CORS	31°35'42.08167"	89°12'13.27473"	53.831

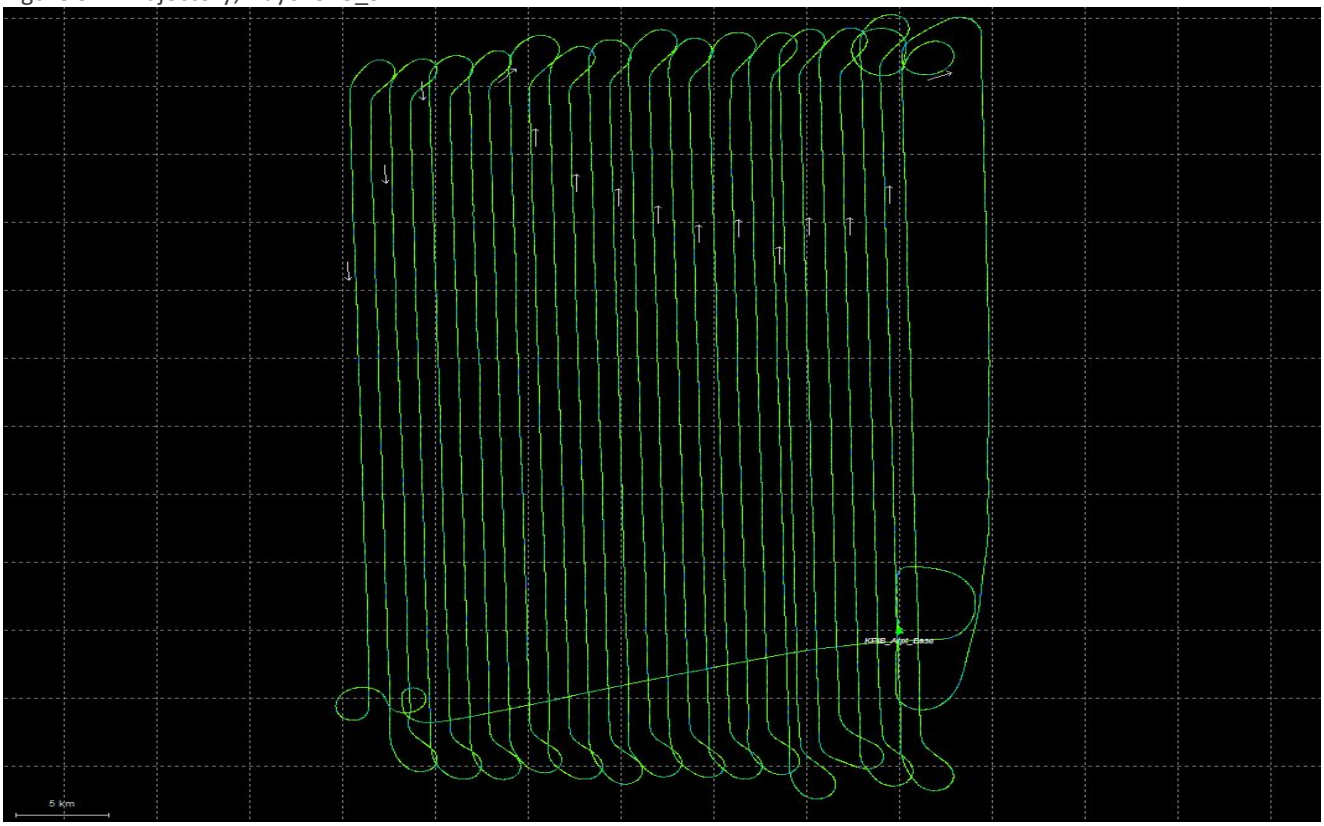
Data Processing

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).

Figure 3.1: Trajectory, Day01915_SH7177

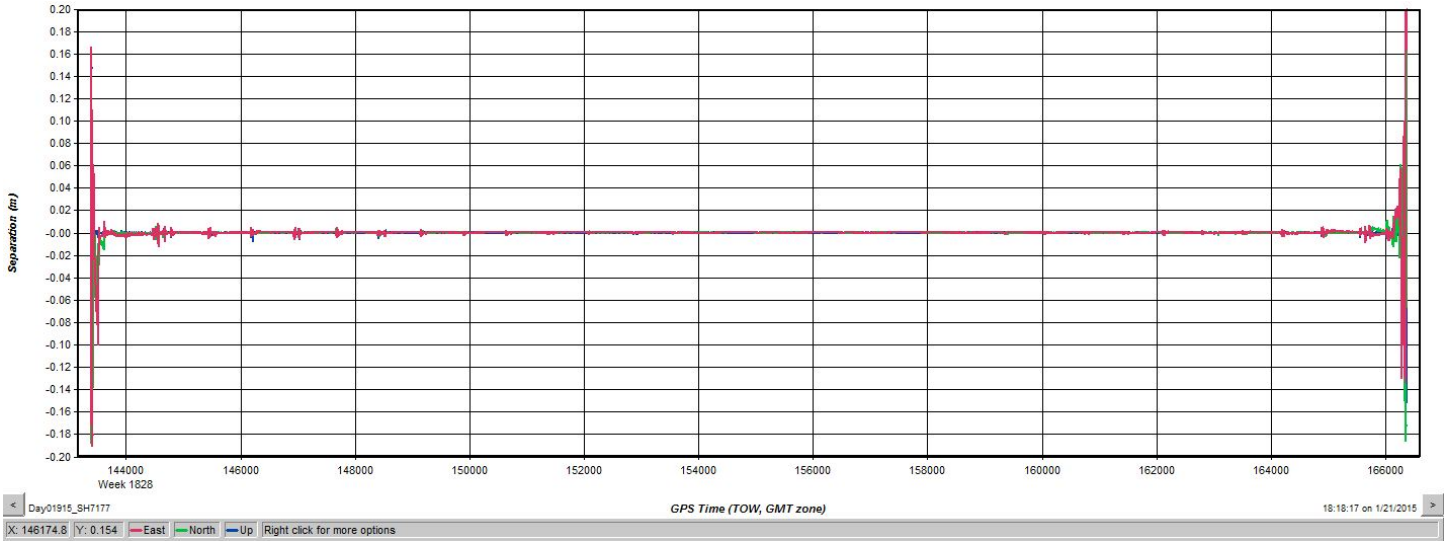


Combination Separation

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 3.2: Combined Separation, Day01915_SH7177

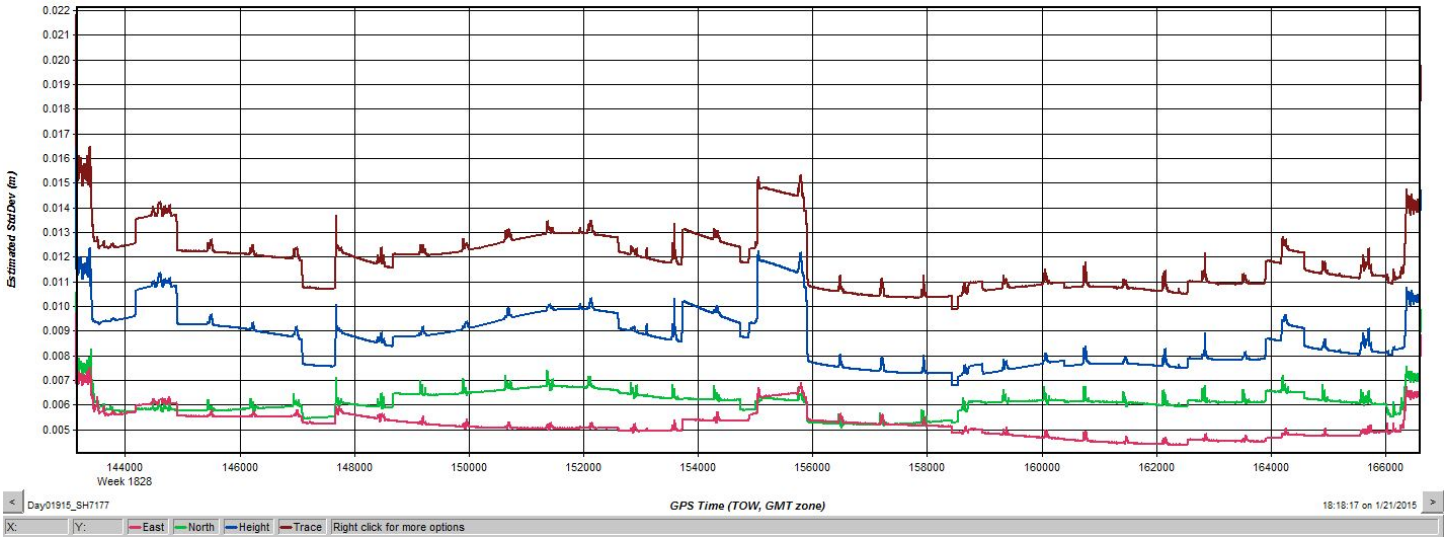


Estimated Positional Accuracy

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 3.3: Estimated Positional Accuracy, Day01915_SH7177

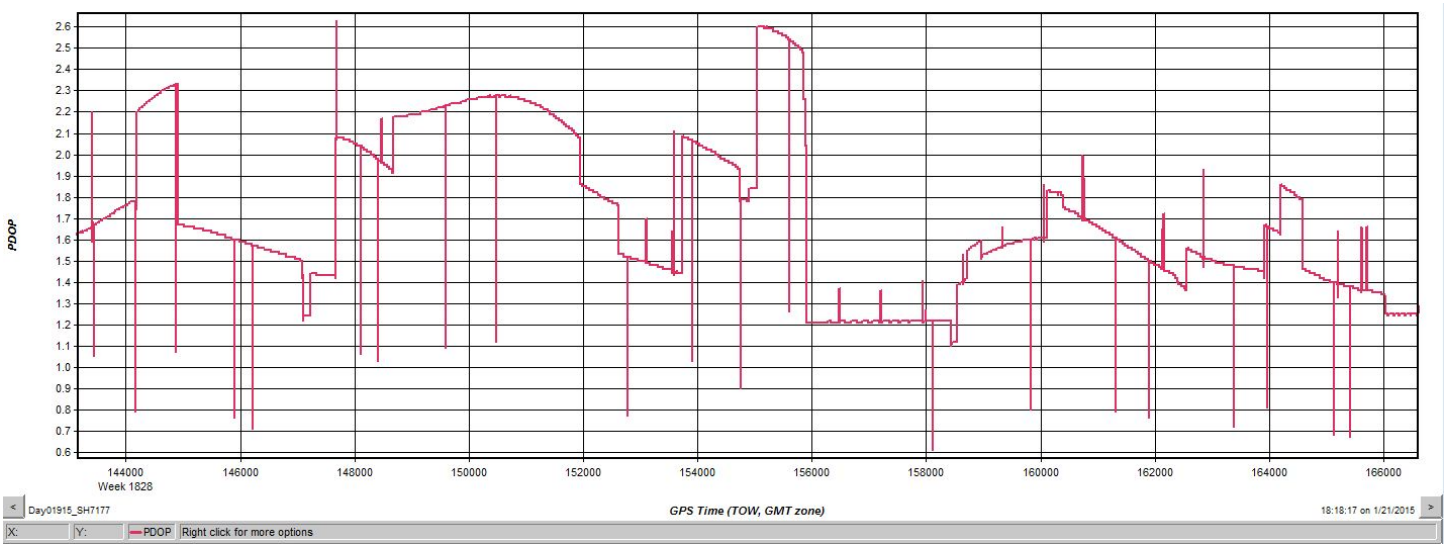


PDOP

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 3.4: PDOP, Day01915_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.
- 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), Low Noise (Class 7), Water (Class 9), Ignored Ground (Class 10), 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.
- The horizontal datum used for the task order was referenced to UTM16N North American Datum of 1983 (2011) and UTM15N North American Datum of 1983 (2011). The vertical datum used for the task order was referenced to NAVD 1988, meters, GEOID12A. Coordinate positions were specified in units of meters.

Section 4: Hydrologic Flattening

HYDROLOGIC FLATTENING OF LIDAR DEM DATA

Mississippi QL2 and Tupelo QL3 Lidar processing task order required the compilation of breaklines defining water bodies and rivers. The breaklines were used to perform the hydrologic flattening of water bodies, and gradient hydrologic flattening of double line streams and rivers. Lakes, reservoirs and ponds, at a minimum size of 2-acre or greater, were compiled as closed polygons. The closed water bodies were collected at a constant elevation. Rivers and streams, at a nominal minimum width of 30 meters (100 feet), were compiled in the direction of flow with both sides of the stream maintaining an equal gradient elevation.

LIDAR DATA REVIEW AND PROCESSING

Woolpert utilized the following steps to hydrologically flatten the water bodies and for gradient hydrologic flattening of the double line streams within the existing lidar data.

1. Woolpert used the newly acquired lidar data to manually draw the hydrologic features in a 2D environment using the lidar intensity and bare earth surface. Open Source imagery was used as reference when necessary.
2. Woolpert utilizes an integrated software approach to combine the lidar data and 2D breaklines. This process “drapes” the 2D breaklines onto the 3D lidar surface model to assign an elevation. A monotonic process is performed to ensure the streams are consistently flowing in a gradient manner. A secondary step within the program verifies an equally matching elevation of both stream edges. The breaklines that characterize the closed water bodies are draped onto the 3D lidar surface and assigned a constant elevation at or just below ground elevation.
3. The lakes, reservoirs and ponds, at a minimum size of 1-acre or greater and streams at a minimum size of 30 meters (100 feet) nominal width, were compiled to meet task order requirements. **Figure 4.1** illustrates an example of 30 meters (100 feet) nominal streams identified and defined with hydrologic breaklines. The breaklines defining rivers and streams, at a nominal minimum width of 30 meters (100 feet), were draped with both sides of the stream maintaining an equal gradient elevation.
4. All ground points were reclassified from inside the hydrologic feature polygons to water, class nine (9).
5. All ground points were reclassified from within a buffer along the hydrologic feature breaklines to buffered ground, class ten (10).
6. The lidar ground points and hydrologic feature breaklines were used to generate a new digital elevation model (DEM).

Figure 4.1: Example Hydrologic Breaklines

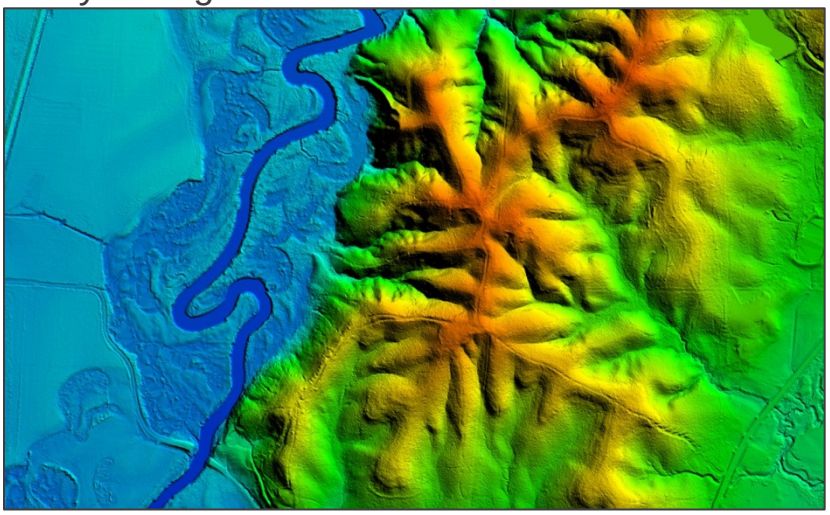


Figure 4.2 reflects a DEM generated from original lidar bare earth point data prior to the hydrologic flattening process. Note the "tinning" across the lake surface.

Figure 4.3 reflects a DEM generated from lidar with breaklines compiled to define the hydrologic features. This figure illustrates the results of adding the breaklines to hydrologically flatten the DEM data. Note the smooth appearance of the lake surface in the DEM.

Figure 4.2

Figure 4.3

Terrascan was used to add the hydrologic breakline vertices and export the lattice models. The hydrologically flattened DEM data was provided to USGS in ERDAS .IMG format.

The hydrologic breaklines compiled as part of the flattening process were provided to the USGS as an ESRI Shapefile The breaklines defining the water bodies greater than 2-acre and for the gradient flattening of all rivers and streams at a nominal minimum width of 30 meters (100 feet) were provided as a Polygon-Z feature class.

DATA QA/QC

Initial QA/QC for this task order was performed in Global Mapper v15, by reviewing the grids and hydrologic breakline features. Additionally, ESRI software and proprietary methods were used to review the overall connectivity of the hydrologic breaklines.

Edits and corrections were addressed individually by tile. If a water body breakline needed to be adjusted to improve the flattening of the DEM data, the area was cross referenced by tile number, corrected accordingly, a new DEM file was regenerated and reviewed.

Section 5: ACCURACY ASSESSMENT

Accuracy Assessment

The vertical accuracy statistics were calculated by comparison of the lidar bare earth points to the ground surveyed QA/QC points. Mississippi QL2 Lidar was processed and delivered in NAD1983(2011) UTM16, NAVD88 Geoid12A meters. Data deliverables were reprojected and also delivered in NAD1983(2011) UTM15, NAVD88 Geoid12A meters. It should be noted that accuracy analysis was reported for the UTM16 data.

Table 5.1: Overall Vertical Accuracy Statistics,

Average error	+0.025	meter
Minimum error	-0.130	meter
Maximum error	+0.221	meter
Average magnitude	0.063	meter
Root mean square	0.081	meter
Standard deviation	0.079	meter

Table 5.2: Raw Swath Quality Check Point Analysis FVA

Point ID	Easting (meter)	Northing (meter)	TIN Elevation (meter)	Dz (meter)
2001	189881.925	3445385.293	74.010	0.10
2002	204158.115	3495756.795	62.000	-0.02
2003	248360.184	3517005.413	101.150	0.03
2004	291407.794	3497428.827	69.890	-0.06
2005	352108.303	3526400.996	84.690	0.00
2006	361342.522	3480164.728	85.620	0.06
2007	355725.953	3431219.779	99.390	0.22
2008	347454.455	3448531.505	63.970	0.08
2009	316051.397	3469562.068	47.500	-0.05
2010	332901.624	3491539.558	102.180	0.01
2011	345197.927	3506824.940	72.620	0.04
2012	262636.451	3494225.584	78.800	0.00
2013	212590.046	3479427.398	59.730	0.03
2014	233425.987	3476109.099	96.430	-0.06
2015	239493.065	3434155.031	33.210	-0.02
2016	197097.678	3474416.033	141.710	0.05
2017	219751.841	3453840.011	117.510	0.06
2018	241661.963	3494182.160	137.230	-0.13
2019	273995.149	3516027.394	98.110	0.09
2020	307569.727	3518701.315	86.850	-0.04

2021	293818.112	3505393.573	70.710	-0.06
2022	227125.810	3498577.938	98.120	0.06
2023	273634.932	3510765.143	73.960	0.06
2025	354143.818	3431171.268	95.100	0.18

VERTICAL ACCURACY CONCLUSIONS

Raw LAS Swath Fundamental Vertical Accuracy (FVA) Tested 0.158 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.

LAS Swath Fundamental Vertical Accuracy (FVA) Tested 0.150 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 ground points.

Bare-Earth DEM Fundamental Vertical Accuracy (FVA) Tested 0.162 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 5.3: Urban Land Cover Quality Check Point Analysis SVA

Point ID	Easting (meter)	Northing (meter)	DEM Elevation (meter)	Dz (meter)
3001	200155.704	3446783.111	92.430	0.067
3002	203864.468	3495862.151	62.620	0.054
3003	248575.212	3517007.676	100.160	0.030
3004	291302.343	3497539.491	70.340	-0.075
3005	352059.42	3526366.189	84.890	0.001
3006	360011.433	3478710.153	77.910	0.026
3007	351990.773	3447574.144	31.370	0.130
3008	347710.327	3450188.292	74.530	0.052
3009	315828.237	3469850.073	49.520	0.013
3010	332961.41	3491431.603	103.810	0.005
3011	343903.276	3506799.819	61.470	-0.019
3012	262808.578	3494588.159	80.730	-0.061
3013	222155.284	3467942.935	49.930	0.014
3014	229851.008	3461108.774	44.120	-0.058
3015	234482.462	3461135.624	71.350	-0.098
3016	195094.075	3474225.121	135.700	0.025

3017	226635.471	3459149.855	47.820	0.056
3018	257569.981	3503403.735	96.220	-0.046
3019	274480.015	3515787.617	97.660	-0.047
3020	307481.881	3518493.753	87.200	-0.045
3021	294090.772	3504919.475	68.530	-0.063
3022	227143.168	3498528.095	97.310	0.115

VERTICAL ACCURACY CONCLUSIONS

Urban Land Cover Classification Supplemental Vertical Accuracy (SVA) Tested 0.114 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 3007, Easting 351990.773, Northing 3447574.144, Z-Error 0.130 meters
Point 3022, Easting 227143.168, Northing 3498528.095, Z-Error 0.115 meters

Table 5.4: Tall Grass Land Cover Quality Check Point Analysis SVA

Point ID	Easting (meter)	Northing (meter)	DEM Elevation (meter)	Dz (meter)
4001	189558.006	3446971.275	73.68	0.134
4002	203427.745	3495846.72	68.85	0.243
4003	246648.761	3517709.51	118.66	0.011
4004	292593.486	3497304.113	88.49	0.028
4005	351585.463	3526702.385	86.62	-0.015
4006	361002.846	3478786.012	81.43	0.114
4008	346938.028	3449637.029	75.4	0.28
4009	316034.392	3469599.172	47.75	0.074
4010	332861.997	3491488.768	99.46	-0.04
4011	342390.301	3500931.838	86.03	-0.027
4012	261325.083	3494110.006	79.53	0.11
4013	212279.777	3479818.578	74.62	0.137
4014	234456.98	3478268.673	111.39	0.097
4015	238710.327	3434987.748	32.61	-0.031
4016	196344.956	3474164.261	140.42	-0.027
4017	219933.231	3453796.981	121.91	0.041
4018	240539.21	3495798.311	140.78	-0.072
4019	274446.08	3515920.29	93.75	0.048
4020	306677.732	3517696.273	85.72	-0.034
4021	294693.835	3504828.676	66.38	0.128
4022	224676.882	3503885.255	155.67	0.106

4023	344344.012	3504027.688	51.21	0.151
4001	189558.006	3446971.275	73.68	0.134

VERTICAL ACCURACY CONCLUSIONS

Tall Grass Land Cover Classification Supplemental Vertical Accuracy (SVA) Tested 0.238 meters supplemental vertical accuracy at the 95th percentile in the Tall Weeds/Crops supplemental class reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the DEM. There were no Tall Grass Errors exceeding the 95th percentile. Tall Weeds/Crops Errors at the 95th percentile include:
Point 4002, Easting 203427.745, Northing 3495846.72, Z-Error 0.243 meters
Point 4008, Easting 346938.028, Northing 3449637.029, Z-Error 0.280 meters

Table 5.5: Brushlands/Trees Land Cover Quality Check Point Analysis SVA

Point ID	Easting (meter)	Northing (meter)	DEM Elevation (meter)	Dz (meter)
5001	189900.889	3445448.589	72.95	0.099
5002	205172.326	3492181.395	70.64	0.253
5003	247678.736	3516771.255	108	0.083
5004	289577.064	3497566.248	62.58	0.1
5005	352065.055	3523360.788	80.99	0.174
5006	361502.852	3479859.386	82.13	0.218
5007	356480.449	3433025.575	86.98	0.312
5008	348027.815	3449724.812	66.89	0.05
5009	315498.745	3470643.2	56.43	0.054
5010	333250.614	3490924.548	102.18	-0.006
5011	342515.789	3501033.13	80.04	0.11
5012	261104.671	3493995.9	81.13	0.197
5013	209872.882	3481815.929	67.3	0.173
5014	234225.458	3476639.688	88.51	0.019
5015	238851.045	3438456.66	38.48	0.083
5016	195680.147	3474139.517	143.13	0.081
5017	219740.654	3453824.012	117.56	0.186
5018	244864.48	3494098.501	101.22	0.027
5019	273448.763	3514484.633	96.28	0.096
5020	305621.394	3516322.658	84.41	0.117
5021	295128.377	3505001.708	66.19	0.112
5022	228974.759	3498518.717	106.31	0.027
5023	274957.337	3513720.515	79.25	0.188

VERTICAL ACCURACY CONCLUSIONS

Brushlands/Trees Land Cover Classification Supplemental Vertical Accuracy (SVA) Tested 0.249 meters supplemental vertical accuracy at the 95th percentile in the Brushlands/Trees supplemental class reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the DEM. Brushlands/Trees Errors larger than 95th percentile include:
Point 5002, Easting 205172.326, Northing 3492181.395, Z-Error 0.253 meters
Point 5007, Easting 356480.449, Northing 3433025.575, Z-Error 0.312 meters

Table 5.6: Forested and Fully Grown Land Cover Quality Check Point Analysis SVA

Point ID	Easting (meter)	Northing (meter)	DEM Elevation (meter)	Dz (meter)
6001	189910.012	3445416.799	72.98	0.061
6001A	189798.77	3445391.12	73.84	0.1
6002	203275.437	3495283.924	66.13	0.221
6002A	203260.312	3495322.62	66.12	0.188
6003A	247405.58	3516785.672	118.03	0.107
6004	290618.222	3497078.306	60.85	-0.056
6004A	290680.892	3497093.186	60.93	0.018
6005	352005.516	3526177.108	83.95	0.03
6005A	352060.797	3526320.523	84.45	0.047
6006	361663.21	3480011.407	87.71	0.002
6006A	361587.987	3480006.769	84.9	0.28
6007	353865.963	3431027.09	94.45	0.014
6007A	353887.841	3431030.304	94.26	0.151
6008	346896.133	3449659.984	72.21	-0.09
6008A	346880.481	3449673.679	69.24	0.004
6009	316296.356	3469648.255	45.12	-0.124
6009A	316281.467	3469577.206	45.06	0.032
6010	332916.037	3491485.024	100.97	0.251
6010A	332943.203	3491482.81	101.37	-0.054
6011	342475.25	3501095.02	83.15	0.078
6011A	342447.407	3501070.342	81.79	0.049
6012	261561.532	3494232.716	74.34	-0.112
6012A	261552.549	3494194.767	74.69	0.176

6013	212257.432	3479815.872	73.56	0.071
6013A	212270.286	3479796.159	72.93	0.238
6014	234248.065	3477132.448	86.31	-0.158
6014A	234223.927	3476928.84	91.18	-0.132
6015	239525.934	3434061.158	33.28	-0.107
6016	197187.285	3474464.654	142.24	-0.139
6016A	197313.114	3474510.634	141.28	-0.029
6017	218405.371	3453368.365	121.11	0.053
6017A	218375.464	3453400.244	119.94	0.179
6018	245020.693	3494078.804	103.21	-0.02
6018A	244955.256	3494075.836	101.88	-0.004
6019	274257.221	3515936	97.19	0
6019A	274282.398	3515931.768	96.79	0.053
6020	305648.187	3516500.765	80.87	-0.119
6020A	305637.943	3516527.913	81.86	-0.179
6021	294785.532	3504036.42	63.44	-0.074
6021A	294820.778	3504045.407	63.62	-0.138
6022	227642.677	3498481.39	92.88	0.065
6022A	227616.918	3498481.17	92.11	-0.016

VERTICAL ACCURACY CONCLUSIONS

Forested and Fully Grown Land Cover Classification Supplemental Vertical Accuracy (SVA) Tested 0.237 meters supplemental vertical accuracy at the 95th percentile in the Forested/Fully Grown supplemental class reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the DEM. Forested/Fully Grown Errors larger than 95th percentile include:
Point 6006A, Easting 361587.987, Northing 3480006.769, Z-Error 0.280 meters
Point 6010, Easting 332916.037, Northing 3491485.024, Z-Error 0.251 meters
Point 6013A, Easting 212270.286, Northing 3479796.159, Z-Error 0.238 meters

Table 5.7: Swamp Land Cover Quality Check Point Analysis SVA

Point ID	Easting (meter)	Northing (meter)	DEM Elevation (meter)	Dz (meter)
7001	189967.975	3445684.203	72.12	0.04
7001A	189994.525	3445713.938	72.09	0.063
7002	203218.889	3495300.349	66.57	0.231
7002A	203204.715	3495288.341	66.71	0.116

7003	249315.33	3516219.718	98.74	0.024
7003A	249333.298	3516253.622	97.23	0.054
7004	290708.138	3497080.302	60.39	-0.029
7004A	290613.091	3497053.695	60.53	0.019
7005	352001.991	3523344.876	79.8	-0.101
7005A	352315.504	3523303.044	82.74	0.083
7006	358653.676	3478879.785	57.91	-0.031
7006A	358675.685	3478871.177	58.46	-0.009
7007	355629.926	3431213.509	100.67	0.082
7007A	355593.108	3431217.697	99.85	0.001
7008	343936.591	3449541.666	33.37	0.018
7008A	343882.342	3449604.894	32.61	0.14
7009	316283.41	3470181.826	44.49	-0.052
7009A	316268.093	3470175.615	44.7	-0.101
7010	338867.921	3494782.531	58.15	-0.051
7010A	338844.044	3494766.75	57.91	-0.016
7011	343582.788	3501921.053	47.71	0.072
7011A	343451.076	3501873.936	43.75	-0.06
7012	261543.888	3494182.209	74.59	0.017
7012A	261522.079	3494147.036	74.96	0.015
7013	212607.98	3479414.213	59.31	0.024
7013A	212639.688	3479434.572	58.52	0.02
7014	233975.931	3475119.922	69.4	-0.028
7014A	233938.106	3475108.138	69.37	-0.045
7015	239497.136	3434072.285	33.47	-0.085
7015A	239520.423	3434094.796	33.51	-0.097
7016	191701.772	3475813.5	112.37	0.025
7016A	191686.747	3475782.062	111.87	0.062
7017	221077.274	3454769.615	98.76	0.253
7017A	221074.869	3454739.389	97.27	0.023
7018	244115.957	3494284.028	100.42	-0.045
7018A	244138.355	3494307.551	100.91	-0.065
7019	269958.91	3510675.253	76	0.054
7019A	269940.864	3510696.06	76.16	0.08
7020	307094.306	3516023.911	75.71	0.087
7020A	307082.697	3515985.821	76.26	0.041
7021	294788.265	3504070.676	63.76	-0.038
7021A	294741.516	3504075.568	63.66	-0.061
7022	227547.96	3498469.273	92.48	0.043
7022A	227517.295	3498465.671	92.5	0.073

VERTICAL ACCURACY CONCLUSIONS

Swamp Land Cover Classification Supplemental Vertical Accuracy (SVA) Tested 0.136 meters supplemental vertical accuracy at the 95th percentile in the Forested/Fully Grown supplemental class reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the DEM. Swamp Errors larger than 95th percentile include:
Point 7002, Easting 203218.889, Northing 3495300.349, Z-Error 0.231 meters
Point 7008A, Easting 343882.342, Northing 3449604.894, Z-Error 0.140 meters
Point 7017, Easting 221077.274, Northing 3454769.615, Z-Error 0.253 meters

CONSOLIDATED VERTICAL ACCURACY ASSESSMENT AND CONCLUSION

Consolidated Vertical Accuracy (CVA) Tested 0.232 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 2007, Easting 355725.953, Northing 3431219.779, Z-Error 0.241 meters
Point 4002, Easting 203427.745, Northing 3495846.72, Z-Error 0.243 meters
Point 4008, Easting 346938.028, Northing 3449637.029, Z-Error 0.280 meters
Point 5002, Easting 205172.326, Northing 3492181.395, Z-Error 0.253 meters
Point 5007, Easting 356480.449, Northing 3433025.575, Z-Error 0.312 meters
Point 6006A, Easting 361587.987, Northing 3480006.769, Z-Error 0.280 meters
Point 6010, Easting 332916.037, Northing 3491485.024, Z-Error 0.251 meters
Point 6013A, Easting 212270.286, Northing 3479796.159, Z-Error 0.238 meters
Point 7017, Easting 221077.274, Northing 3454769.615, Z-Error 0.253 meters

Approved by:	Name	Signature	Date
Associate Member, Lidar Specialist Certified Photogrammetrist #1381	Qian Xiao		December 2015

Section 6: Flight Logs

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

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	1/10/2015	10	74835		ncrs ms

Operator	Aircraft	Hobbs Start	Local Start Time	Zulu Start Time	base
SMITH	N7079F	3510.3	9:44:00	15:44:00	
Pilot	**Sensor Type**	**Hobbs End**	**Local End Time**	**Zulu End Time**	**PID**
GEBHART	ALS-7177	3517.4	4:51:00	22:51:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
090/6	10			0	-9	3055		Departing	pib
								Arriving	pib

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	41	272	100	Gain - Course/Up		Single		A	170
				Gain - Fine/Down		Multi	x	B	150

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
150	Kts	6500	Ft	var	Ft	Yes		No		@	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:
		↓ Times entered are Zulu / GMT ↓						Verify S-Turns Before Mission Yes X No
164	e	16:02:00	16:11:00	8:35:00	14	0.8	1.3	
165	w	16:14:00	16:21:00	0:00:00	15	0.8	1.3	
166	e	16:24:00	16:32:00	0:00:00	13	0.8	1.4	
167	w	16:35:00	16:42:00	0:00:00	13	0.8	1.3	
168	e	16:45:00	16:53:00	0:00:00	14	0.8	1.3	
169	w	16:56:00	17:02:00	0:00:00	15	0.8	1.3	
170	e	17:05:00	17:12:00	0:00:00	16	0.7	1.2	
171	w	17:15:00	17:21:00	0:00:00	15	0.7	1.2	
172	e	17:24:00	17:31:00	0:00:00	15	0.7	1.2	
173	w	17:34:00	17:40:00	0:00:00	17	0.7	1.1	
174	e	17:43:00	17:49:00	0:00:00	17	0.7	1.1	
175	w	17:52:00	17:58:00	0:00:00	17	0.7	1.1	
176	e	18:00:00	18:06:00	0:00:00	17	0.7	1.2	
177	w	18:09:00	18:14:00	0:00:00	16	0.7	1.2	
178	e	18:17:00	18:23:00	0:00:00	15	0.7	1.5	
179	w	18:26:00	18:32:00	0:00:00	16	0.7	1.4	
180	e	18:35:00	18:41:00	0:00:00	16	0.7	1.5	
181	w	18:44:00	18:50:00	0:00:00	17	0.7	1.3	
182	e	18:54:00	18:58:00	0:00:00	17	0.7	1.3	
163	n	19:04:00	19:06:00	0:00:00	17	0.7	1.3	
162	s	19:15:00	19:24:00	0:00:00	17	0.7	1.3	
161	n	19:28:00	19:44:00	0:00:00	20	0.7	1	
160	s	19:48:00	20:05:00	0:00:00	20	0.7	1	
159	n	20:08:00	20:25:00	0:00:00	19	0.7	1.1	
158	s	20:28:00	20:45:00	0:00:00	18	0.7	1.1	
157	n	20:48:00	21:06:00	0:00:00	18	0.7	1.1	
156	s	21:08:00	21:26:00	0:00:00	17	0.7	1.3	
155	n	21:29:00	21:45:00	0:00:00	16	0.7	1.3	
154	s	21:49:00	22:07:00	0:00:00	16	0.7	1.2	
153	n	22:09:00	22:26:00	0:00:00	16	0.7	1.1	
				0:00:00				
↑ Times entered are Zulu / GMT ↑				Page		1		Verify S-Turns After Mission Yes X No

Additional Comments: Drive #

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	1/11/2015	11	74835		ncrs ms

Operator	Aircraft	HOBBS Start	Local Start Time	Zulu Start Time	Base
SMITH	N7079F	3517.4	10:50:00	16:50:00	
Pilot	**Sensor Type**	**HOBBS End**	**Local End Time**	**Zulu End Time**	**PID**
GEBHART	ALS-7177	3519.9	1:19:00	19:19:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
090/6	10			0	-9	3055		Departing	pib
								Arriving	pib

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	41	272	100	Gain - Course/Up		Single		A	170
				Gain - Fine/Down		Multi	x	B	150

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
150	Kts	6500	Ft	var	Ft	Yes		No		@	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:
		↕ Times entered are Zulu / GMT ↕						Verify S-Turns Before Mission Yes x No
152	s	17:15:00	17:34:00	11:29:00	17	0.6	1.2	
151	n	17:36:00	17:53:00	0:00:00	18	0.6	1.1	
150	s	17:56:00	18:15:00	0:00:00	18	0.6	1.1	clds wp 53
149	n	18:17:00	18:34:00	0:00:00	16	0.6	1.4	clds wp 42-36
148	s	18:38:00	18:56:00	0:00:00	16	0.6	1.5	clds wp 24-32,64-end
				0:00:00				
↑ Times entered are Zulu / GMT ↑				Page		1		Verify S-Turns After Mission Yes x No

Additional Comments: Drive #

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	1/16/2015	16	74835		ncrs ms

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
SMITH	N7079F	3523.5	9:38:00	15:38:00	
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
GEBHART	ALS-7177	3530.7	4:52:00	22:52:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
030/4	10			4	0	3035		Departing	pib
								Arriving	pib

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	41	272	100	Gain - Course/Up		Single		A	170
				Gain - Fine/Down		Multi	x	B	150

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
150	Kts	6500	Ft	var	Ft	Yes		No		@	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:
		↓ Times entered are Zulu / GMT ↓						Verify S-Turns Before Mission: Yes x No
147	n	16:01:00	16:18:00	8:58:00	14	0.7	1.2	
146	s	16:21:00	16:37:00	0:00:00	16	0.7	1.2	
145	n	16:41:00	16:58:00	0:00:00	17	0.7	1.1	
144	s	17:01:00	17:18:00	0:00:00	17	0.7	1.1	
143	n	17:21:00	17:38:00	0:00:00	16	0.7	1.2	
142	s	17:41:00	17:58:00		16	0.7	1.2	
141	n	18:02:00	18:19:00		15	0.7	1.5	
140	s	18:22:00	18:38:00		16	0.7	1.3	
139	n	18:42:00	18:58:00		16	0.7	1.3	
138	s	19:01:00	19:18:00		17	0.7	1.2	
137	n	19:21:00	19:37:00		18	0.7	1.1	
136	s	19:41:00	19:57:00		19	0.7	1	
135	n	20:00:00	20:16:00		19	0.7	1	
134	s	20:19:00	20:36:00		18	0.7	1.1	
133	n	20:39:00	20:55:00		17	0.7	1.3	
132	s	20:58:00	21:15:00		16	0.7	1.3	
131	n	21:18:00	21:34:00		16	0.7	1.2	
130	s	21:37:00	21:53:00		17	0.7	1.1	
129	n	21:56:00	22:12:00		16	0.7	1.2	
128	s	22:15:00	22:31:00		17	0.7	1.1	
				0:00:00				
↑ Times entered are Zulu / GMT ↑				Page		1		Verify S-Turns After Mission: Yes x No

Additional Comments:

Drive #

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	1/17/2015	17	74835		ncrs ms

Operator	Aircraft	HOBBS Start	Local Start Time	Zulu Start Time	Base
SMITH	N7079F	3530.7	10:04:00	16:04:00	
Pilot	**Sensor Type**	**HOBBS End**	**Local End Time**	**Zulu End Time**	**PID**
GEBHART	ALS-7177	3537.8	5:08:00	23:08:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
170/8	10			10	2	3026		Departing	pib
								Arriving	pib

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	41	272	100	Gain - Course/Up		Single		A	170
				Gain - Fine/Down		Multi	x	B	150

Air Speed	AGL	MSL	Waveform Used		Waveform Mode	Pre-Trigger Dist.
150 Kts	6500 Ft	var Ft	Yes	No	@ 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:
		↕ Times entered are Zulu / GMT ↕						Verify S-Turns Before Mission Yes X No
127	n	16:26:00	16:42:00		15	0.7	1.3	
126	s	16:45:00	17:01:00		16	0.7	1.1	
125	n	17:06:00	17:20:00		17	0.7	1.1	
124	s	17:23:00	17:37:00		16	0.7	1.2	
123	n	17:39:00	17:53:00		15	0.7	1.2	
122	s	17:56:00	18:10:00		14	0.7	1.5	
121	n	18:13:00	18:26:00		16	0.7	1.3	
120	s	18:29:00	18:43:00		15	0.7	1.3	
119	n	18:46:00	18:59:00		16	0.7	1.3	
118	s	19:03:00	19:17:00		18	0.7	1.1	
117	n	19:20:00	19:33:00		19	0.7	1.1	
116	s	19:37:00	19:50:00		20	0.7	1	
115	n	19:54:00	20:07:00		21	0.7	1	
114	s	20:10:00	20:24:00		19	0.7	1.1	clds wp 56-end
99	n	20:30:00	20:39:00		19	0.7	1.2	
98	s	20:43:00	20:52:00		18	0.7	1.2	clds wp 43
97	n	20:55:00	21:04:00		17	0.7	1.3	clds wp 55
96	s	21:08:00	21:18:00		16	0.7	1.3	clds at end
95	n	21:20:00	21:30:00		15	0.7	1.3	clds wp 43
94	s	21:33:00	21:42:00		16	0.7	1.1	clds wp 18-21,28,41
93	n	21:45:00	21:55:00		15	0.7	1.2	clds wp 20,21
92	s	21:58:00	22:07:00		16	0.7	1.2	clds wp 31
91	n	22:10:00	22:19:00		16	0.7	1.1	clds wp 29
90	s	22:22:00	22:31:00		15	0.7	1.2	clds wp 31
89	n	22:34:00	22:44:00		14	0.7	1.3	
88	s	22:47:00	22:56:00		15	0.7	1.1	clds wp 41
				0:00:00				
↑ Times entered are Zulu / GMT ↑				Page		1		Verify S-Turns After Mission Yes X No

Additional Comments:

Drive #

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	1/18/2015	18	74835		ncrs ms

Operator	Aircraft	Hobbs Start	Local Start Time	Zulu Start Time	Base
SMITH	N7079F	3537.8	12:00:00	18:00:00	
Pilot	**Sensor Type**	**Hobbs End**	**Local End Time**	**Zulu End Time**	**PIC**
GEBHART	ALS-7177	3543.0	5:18:00	23:18:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
330/11	10			17	-1	3026		Departing	pib
								Arriving	pib

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	41	272	100	Gain - Course/Up		Single		A	170
				Gain - Fine/Down		Multi	X	B	150

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
150	Kts	6500	Ft	var	Ft	Yes		No		@	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:	10:00:00
↓ Times entered are Zulu / GMT ↓								Verify S-Turns Before Mission	Yes X No
185	e	18:16:00	18:31:00		17	0.7	1.3		
113	s	18:47:00	19:00:00		19	0.7	1.1		
112	n	19:03:00	19:18:00		20	0.7	1.1		
111	s	19:21:00	19:34:00		20	0.7	1		
110	n	19:36:00	19:51:00		19	0.7	1.1		
109	s	19:54:00	20:07:00		20	0.7	1.1		
108	n	20:10:00	20:24:00		18	0.7	1.1		
107	s	20:27:00	20:40:00		18	0.7	1.2		
106	n	20:43:00	20:57:00		16	0.7	1.4		
105	s	21:00:00	21:13:00		15	0.7	1.4		
104	n	21:15:00	21:29:00		16	0.7	1.1		
103	s	21:33:00	21:46:00		16	0.7	1.1		
102	n	21:48:00	22:02:00		15	0.7	1.3		
101	s	22:05:00	22:18:00		16	0.7	1.2		
100	n	22:21:00	22:35:00		15	0.7	1.3		
87	s	22:40:00	22:49:00		14	0.7	1.3		
86	n	22:52:00	23:02:00		16	0.7	1.1		
				0:00:00					
↑ Times entered are Zulu / GMT ↑				Page		1		Verify S-Turns After Mission	Yes X No

Additional Comments:	Drive #

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	1/19/2015	19	74835		ncrs ms

Operator	Aircraft	Hobbs Start	Local Start Time	Zulu Start Time	Base
SMITH	N7079F	3543.0	9:54:00	15:54:00	
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
GEBHART	ALS-7177	3549.3	4:10:00	22:10:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
240/5	10			12	1	3022		Departing	pib
								Arriving	pib

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	41	272	100	Gain - Course/Up		Single		A	170
				Gain - Fine/Down		Multi	x	B	150

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
150	Kts	6500	Ft	var	Ft	Yes		No		@	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:	9:30:00
		↓ Times entered are Zulu / GMT ↓						Verify S-Turns Before Mission	Yes x No
85	s	16:14:00	16:23:00		16	0.7	1.2		
84	n	16:26:00	16:35:00		17	0.7	1.1		
83	s	16:39:00	16:48:00		17	0.7	1.1		
82	n	16:51:00	17:00:00		17	0.7	1.1		
81	s	17:03:00	17:13:00		18	0.7	1.1		
80	n	17:15:00	17:25:00		18	0.7	1.1		
79	s	17:28:00	17:37:00		18	0.7	1.1		
78	n	17:41:00	17:49:00		16	0.7	1.3		
77	s	17:53:00	18:02:00		16	0.7	1.4		
76	n	18:05:00	18:14:00		16	0.7	1.5		
75	s	18:17:00	18:26:00		16	0.7	1.4		
74	n	18:29:00	18:38:00		16	0.7	1.3		
73	s	18:41:00	18:50:00		16	0.7	1.2		
72	n	18:53:00	19:02:00		18	0.7	1.1		
71	s	19:06:00	19:15:00		19	0.7	1		
70	n	19:17:00	19:26:00		19	0.7	1		
69	s	19:29:00	19:38:00		20	0.7	1		
68	n	19:41:00	19:50:00		21	0.7	1		
67	s	19:54:00	20:03:00		19	0.7	1.1		
66	n	20:05:00	20:14:00		19	0.7	1.2		
65	s	20:18:00	20:26:00		18	0.7	1.2		
64	n	20:29:00	20:38:00		17	0.7	1.3		
63	s	20:41:00	20:49:00		16	0.7	1.4		
62	n	20:52:00	21:01:00		16	0.7	1.3		
61	s	21:04:00	21:12:00		16	0.7	1.1		
60	n	21:15:00	21:24:00		15	0.7	1.2		
59	s	21:27:00	21:36:00		16	0.7	1.1		
58	n	21:38:00	21:47:00		15	0.7	1.2		
57	s	21:50:00	21:59:00		16	0.7	1.1		
				0:00:00					
↑ Times entered are Zulu / GMT ↑				Page		1		Verify S-Turns After Mission	Yes x No

Additional Comments:	Drive #

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	1/21/2015	21	74835		ners ms

Operator	Aircraft	Hobbs Start	Local Start Time	Zulu Start Time	Base
SMITH	N7079F	3549.3	9:45:00	15:45:00	
Pilot	**Sensor Type**	**Hobbs End**	**Local End Time**	**Zulu End Time**	**PID**
GEBHART	ALS-7177	3556.6	5:04:00	23:04:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
030/6	10			12	3	3018		Departing	pib
								Arriving	pib

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	41	272	100	Gain - Course/Up		Single		A	170
				Gain - Fine/Down		Multi	x	B	150

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
150	Kts	6500	Ft	var	Ft	Yes		No		@	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:	9:15:00
↓ Times entered are Zulu / GMT ↓								Verify S-Turns Before Mission	Yes x No
56	n	16:01:00	16:13:00		15	0.7	1.2		
55	s	16:16:00	16:35:00		16	0.7	1.2		
54	n	16:37:00	16:56:00		16	0.7	1.2		
53	s	16:59:00	17:18:00		17	0.7	1.1		
52	n	17:21:00	17:39:00		16	0.7	1.1		
51	s	17:42:00	18:01:00		15	0.7	1.5		
50	n	18:04:00	18:23:00		16	0.7	1.3		
49	s	18:26:00	18:45:00		16	0.7	1.3		
48	n	18:48:00	19:07:00		18	0.7	1.1		
47	s	19:10:00	19:28:00		19	0.7	1.1		
46	n	19:31:00	19:50:00		21	0.7	1		
45	s	19:53:00	20:12:00		19	0.7	1.1		
44	n	20:15:00	20:34:00		18	0.7	1.2		
43	s	20:37:00	20:55:00		17	0.7	1.3		
42	n	20:58:00	21:17:00		16	0.7	1.2		
41	s	21:21:00	21:39:00		16	0.7	1.1		
40	n	21:42:00	22:01:00		16	0.7	1.2		
39	s	22:04:00	22:22:00		15	0.7	1.2		
38	n	22:25:00	22:45:00		14	0.7	1.3		
				0:00:00					
↑ Times entered are Zulu / GMT ↑				Page		1		Verify S-Turns After Mission	Yes x No

Additional Comments:	Drive #

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	1/24/2015	24	74835	2	NRCS-Mississippi

Operator	Aircraft	Hobbs Start	Local Start Time	Zulu Start Time	Base
GALAMBOS	N7079F	35556.9	1:45:00	19:45:00	WOOLPERT PIN
Pilot	**Sensor Type**	**Hobbs End**	**Local End Time**	**Zulu End Time**	**PIB**
RADER	ALS-7177				PIB

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
280 6	10+	Clear		12	-1	3008		Departing	KPIB
								Arriving	KPIB

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain	X	Mode		Threshold Values	
40	41	272	100	Gain - Course/Up		Single		A	170
				Gain - Fine/Down		Multi		B	150

Air Speed		AGL		MSL		Waveform Used				Waveform Mode	Pre-Trigger Dist.	
150	Kts	6500	Ft	Varies	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:	20:12:05
		↓ Times entered are Zulu / GMT ↓						Verify 5-Turns Before Mission	Yes X No
37	S	20:43:00	21:01:33	18:26:15	16	0.7	1.2	Takeoff:20:20z	
36	N	21:03:44	21:22:31	0:00:00	16	0.7	1.2		
35	S	21:25:04	21:43:44	0:00:00	16	0.7	1.2		
34	N	21:45:52	22:04:32	0:00:00	17	0.6	1.1		
33	S	22:07:24	22:26:06	0:00:00	15	0.7	1.2		
32	N	22:27:07	22:46:49	0:00:00	16	0.6	1.1		
31	S	22:48:41	23:07:16	0:00:00	14	0.7	1.1		
30	N	23:09:22	23:28:02	0:00:00	14	0.7	1.1		
29	S	23:30:02	23:48:40	0:00:00	16	0.7	1.1		
28	N	23:50:45	0:09:36	0:00:00	16	0.7	1.3		
27	S	0:13:12	0:29:42	0:00:00	14	0.7	1.4		
26	N	0:31:48	0:46:16	0:00:00	17	0.6	1.2		
				0:00:00				72 gb	
				0:00:00				Landing:	
				0:00:00				Static:	
				0:00:00					
				0:00:00					
				0:00:00					
				0:00:00					
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				0:00:00					
				0:00:00					
				0:00:00					
↑ Times entered are Zulu / GMT ↑				Page		1		Verify 5-Turns After Mission	Yes X No

Additional Comments:	Drive #
	783516

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	1/25/2015	25	74835	2	NRCS-Mississippi

Operator	Aircraft	Hobbs Start	Local Start Time	Zulu Start Time	Base
GALAMBOS	N7079F	3561.6	8:00:00	14:00:00	WOOLPERT PIN
Pilot	**Sensor Type**	**Hobbs END**	**Local End Time**	**Zulu End Time**	**PID**
RADER	ALS-7177	3565.5	12:55:00	18:55:00	PIB

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
230 6	10+	Clear		8	-5	29.99		Departing	KPIB
								Arriving	KPIB

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain	X	Mode		Threshold Values	
40	41	272	100	Gain - Course/Up		Single		A	170
				Gain - Fine/Down		Multi		B	150

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.	
150	Kts	6500	Ft	Varies	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: 14:50:51
		↓ Times entered are Zulu / GMT ↓						Verify 5-Turns Before Mission Yes X No
25	S	15:21:03	15:35:22	7:29:22	15	0.7	1.1	Takeoff: 14:57z
24	N	15:37:27	15:51:55	0:00:00	15	0.7	1.2	
23	S	15:53:54	16:08:16	0:00:00	15	0.7	1.3	
22	N	16:10:25	16:24:56	0:00:00	16	0.6	1.1	
21	S	16:27:00	16:41:18	0:00:00	16	0.6	1.2	
20	N	16:43:15	16:57:40	0:00:00	17	0.6	1.1	
19	S	17:03:29		0:00:00	17	0.6	1.2	sensor started by accident offline
		17:04:10		0:00:00				CCNS states next line is 81 miles
				0:00:00				away with a course 300 !
92	N	17:19:05	17:23:45	0:00:00	15	0.8	1.4	Manual Start, wpts 34-14, UL001
94	S	17:26:48	17:34:04	0:00:00	15	0.8	1.5	Manual Start , wpts 14-44, UL002
114	N	17:40:41	17:43:40	0:00:00	16	0.7	1.3	Manual Stop, wpts 63-51
148	S	17:54:43	18:08:22	0:00:00	16	0.6	1.3	Manual Start, wpts 19-78 UL003
150	N	18:13:34	18:16:46	0:00:00	16	0.7	1.4	Manual Start, wpts 57-49, UL004
149	N	18:20:43	18:23:30	0:00:00	18	0.6	1.1	Manual Start, wpts 46-35, UL005
				0:00:00				47GB
				0:00:00				
				0:00:00				
				0:00:00				Landing: 1840z
				0:00:00				Static: 18:49:30-18:51:30
				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				
				0:00:00				
↑ Times entered are Zulu / GMT ↑				Page		1		Verify 5-Turns After Mission Yes X No

Additional Comments:	Drive #
	783516

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	1/25/2015	25	74835	2	NRCS-Mississippi

Operator	Aircraft	Hobbs Start	Local Start Time	Zulu Start Time	Base
GALAMBOS	N7079F	3565.5	3:00:00	21:00:00	WOOLPERT PIN
Pilot	Sensor Type	HOBBS END	Local End Time	Zulu End Time	PID
RADER	ALS-7177	3569.1	7:00:00	1:00:00	PIB

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud	Departing	KPIB
200v260 g22	10+	Clear		19	4	29.82		Arriving	KPIB

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain	X	Mode	Threshold Values	
40	41	272	100	Gain - Course/Up		Single	A	170
				Gain - Fine/Down		Multi	B	150

Air Speed		AGL		MSL		Waveform Used				Waveform Mode	Pre-Trigger Dist.
150	Kts	6500	Ft	Varies	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:	21:04:20
		⇕ Times entered are Zulu / GMT ⇕						Verify S-Turns Before Mission	Yes X No
183	W	21:28:48	21:44:18	19:53:51	16	0.7	1.1	Takeoff: 2111z	
17	S	21:49:41	22:04:10	0:00:00	15	0.7	1.2		
16	N	22:06:16	22:20:47	0:00:00	14	0.7	1.3		
15	S	22:23:04	22:37:37	0:00:00	15	0.7	1.1		
14	N	22:39:48	22:54:22	0:00:00	16	0.7	1.1		
13	S	22:56:35	23:10:54	0:00:00	14	0.7	1.1		
12	N	23:12:50	23:27:20	0:00:00	13	0.7	1.3		
11	S	23:29:34	23:43:55	0:00:00	15	0.7	1.2		
10	N	23:46:02	0:00:32	0:00:00	16	0.7	1.2	cloud wpts 47-39	
9	S	0:02:42	0:16:56	0:00:00	15	0.7	1.5	cloud wpts	
184	E	0:24:04	0:36:54	0:00:00	17	0.6	1.2	Clouds wpt 23-27, 47-60	
				0:00:00				Landing: 00:51	
				0:00:00				Static: 00:53:25 - 00:55:25	
				0:00:00				60 GB	
				0:00:00					
				0:00:00					
				0:00:00					
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				0:00:00					
				0:00:00					
↑ Times entered are Zulu / GMT ↑				Page		1		Verify S-Turns After Mission	Yes X No

Additional Comments:	Drive #
	783516

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	1/26/2015	26	74835	2	NRCS-Mississippi

Operator	Aircraft	Hobbs Start	Local Start Time	Zulu Start Time	Base
GALAMBOS	N7079F	3569.1	12:30:00	18:30:00	WOOLPERT PIN
Pilot	**Sensor Type**	**Hobbs END**	**Local End Time**	**Zulu End Time**	**PID**
RADER	ALS-7177	3572.9	5:20:00	23:20:00	PIB

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud	Departing	KPIB
310 11 g 15	10+	Clear		13	1	30.08		Arriving	KPIB

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain	X	Mode		Threshold Values	
40	41	272	100	Gain - Course/Up		Single		A	170
				Gain - Fine/Down		Multi		B	150

Air Speed	AGL	MSL	Waveform Used				Waveform Mode	Pre-Trigger Dist.
150 Kts	6500 Ft	Varies 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: 19:10:24
↓ Times entered are Zulu / GMT ↓								Verify 5-Turns Before Mission Yes X No
19	S	19:41:35	19:55:58	16:12:44	19	0.6	1.1	Takeoff: 1917z
18	N	19:58:25	20:14:19	0:00:00	17	0.8	1.3	
9	S	20:19:33	20:29:47	0:00:00	16	0.8	1.4	wpt 23-60, manual start UL001
8	N	20:32:20	20:48:04	0:00:00	17	0.6	1.1	
7	S	20:50:30	21:04:50	0:00:00	15	0.7	1.2	
6	N	21:07:16	21:23:00	0:00:00	16	0.6	1.1	
5	S	21:25:10	21:39:26	0:00:00	16	0.6	1.2	
4	N	21:41:54	21:57:34	0:00:00	15	0.7	1.3	
3	S	21:59:25	22:13:34	0:00:00	14	0.7	1.3	
2	N	22:15:59	22:25:54	0:00:00	15	0.6	1.1	
1	S	22:27:52	22:26:34	0:00:00	16	0.7	1	
10	N	22:42:38	22:45:35	0:00:00	14	0.8	1.3	wpts 47-39
				0:00:00				58GB
				0:00:00				Landing: 2305z
				0:00:00				Static: 23:06:21-23:08:21
				0:00:00				
				0:00:00				
				0:00:00				
				0:00:00				
				0:00:00				
				0:00:00				
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				0:00:00				
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				0:00:00				
↑ Times entered are Zulu / GMT ↑				Page		1		Verify 5-Turns After Mission Yes X No

Additional Comments:

Drive #: 783516

Section 7: 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.
- Hydro Breaklines as ESRI shapefile
- Digital Elevation Model in ERDAS .IMG format
- 8-bit intensity images in .GEOTIF format
- 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