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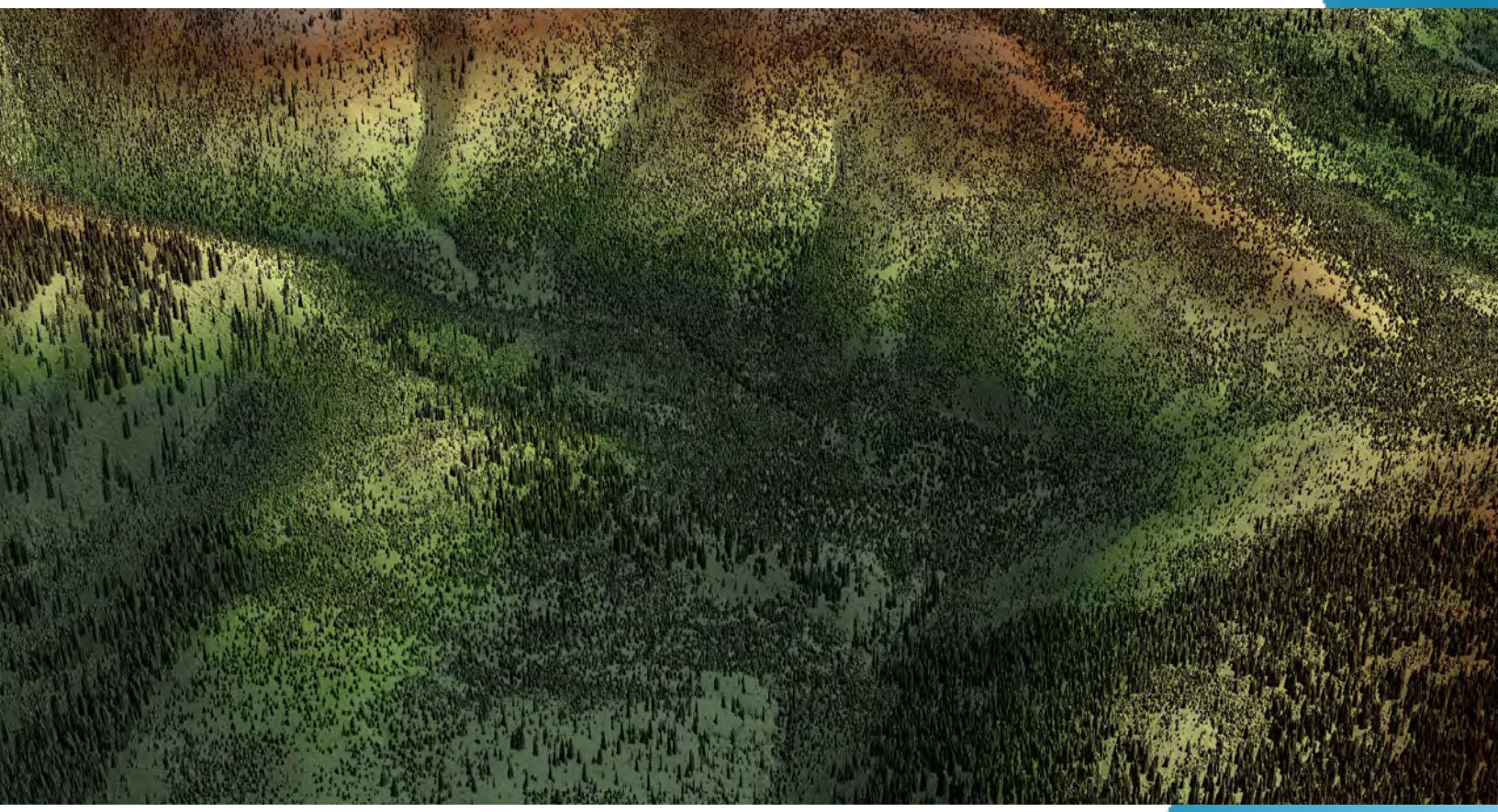

MT_RAVALLIGRANITECUSTERPOWDERRIVER_2019_B19 LIDAR PROCESSING REPORT

Work Package: 183671
Work Unit: 220298

2021

Submitted: August 20, 2021

Prepared for:

USGS science for a changing world

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1. Summary / Scope

1.1. Summary

This report contains a summary of the MT_RavalliGraniteCusterPowderRiver_2019_B19, Work Unit 220298 lidar acquisition task order, issued by USGS under their Contract G16PC00016 on September 23, 2019. This delivery includes QL1 data and yielded a project area covering approximately 1,658 square miles over Montana. The intent of this document is only to provide specific validation information for the data acquisition/collection, processing, and production of deliverables completed as specified in the task order.

1.2. Scope

Aerial topographic lidar was acquired using state of the art technology along with the necessary surveyed ground control points (GCPs) and airborne GPS and inertial navigation systems. The aerial data collection was designed with the following specifications listed in Table 1 below.

Table 1. Originally Planned Lidar Specifications

Average Point Density	Flight Altitude (AGL)	Field of View	Minimum Side Overlap	RMSEz
8 pts / m^2	1824 m	58.5°	50%	≤ 10 cm

1.3. Coverage

The work unit boundary covers approximately 1,658 square miles over Montana. A buffer of 100 meters was created to meet task order specifications. Project extents are shown in Figure 1.

1.4. Duration

Lidar data was acquired from May 9, 2020 to August 29, 2020 in 42 total lifts. See “Section: 2.4. Time Period” for more details.

1.5. Issues

There were no major issues to report for this project.

MT_RavalliGraniteCusterPowderRiver_2019_B19 Work Unit 220298 Projected Coordinate System: State Plane Montana FIPS 2500 Horizontal Datum: NAD 1983 (2011) Vertical Datum: NAVD88 (GEOID 12b) Units: Meters	
Lidar Point Cloud	Classified Point Cloud in .LAS 1.4 format
Rasters	• 0.5-meter Hydro-flattened Bare Earth Digital Elevation Model (DEM) in GeoTIFF format • 0.5-meter First Return Digital Surface Model (DSM) in GeoTIFF format • 0.5-meter Intensity images in GeoTIFF format • 0.5-meter Swath Separation images in GeoTIFF format
Vectors	Shapefiles (*.shp) • Project Boundary • Lidar Tile Index Geodatabase (*.gdb) • Continuous Hydro-flattened Breaklines
Reports	Reports in PDF format • Focus on Delivery • Focus on Accuracy • Processing Report
Metadata	XML Files (*.xml) • Breaklines • Classified Point Cloud • DEM • Intensity Imagery • DSM

MT_RavalliGraniteCusterPowderRiver_2019_B19
Work Unit 220298 Boundary

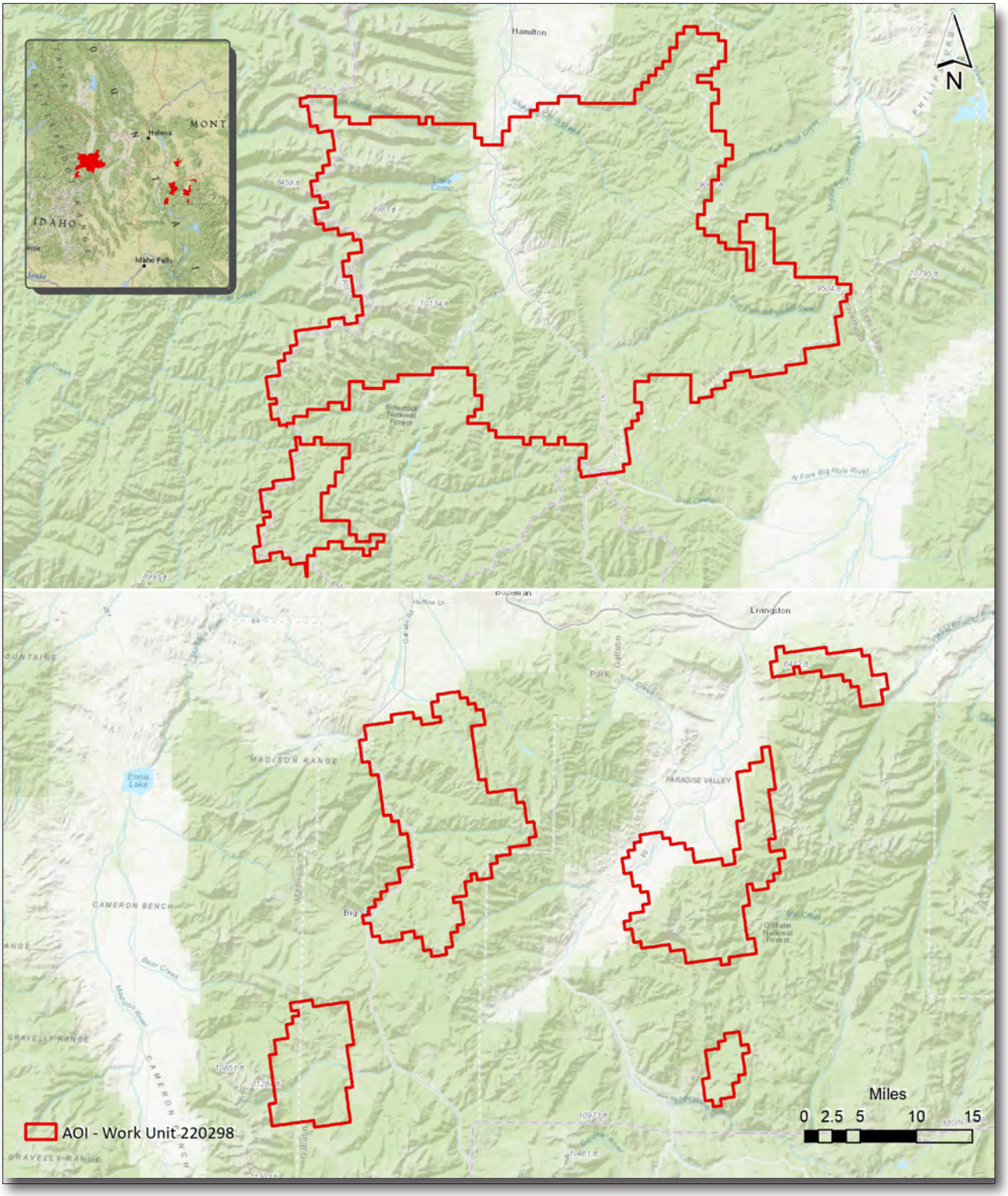


Figure 1. Work Unit AOI

2. Planning / Equipment

2.1. Flight Planning

Flight planning was based on the unique project requirements and characteristics of the project site. The basis of planning included: required accuracies, type of development, amount / type of vegetation within project area, required data posting, and potential altitude restrictions for flights in project vicinity.

Detailed project flight planning calculations were performed for the project using RiPARAMETER planning software. Planned flight lines are shown in Figure 2.

2.2. Lidar Sensor

NV5 Geospatial utilized the following sensors for lidar data collection:

Riegl VQ1560i: 3061, 3546
Riegl VQ1560ii: 4040, 4045

The Riegl 1560i system has a laser pulse repetition rate of up to 2 MHz resulting in more than 1.3 million measurements per second. The system utilizes a Multi-Pulse in the Air option (MPIA). The sensor is also equipped with the ability to measure up to an unlimited number of targets per pulse from the laser.

The Riegl 1560II system is a dual channel waveform processing airborne scanning system. It has a laser pulse repetition rate of up to 4 MHz resulting in up to 2.66 million measurements per second. The system utilizes a Multi-Pulse in the Air option (MPIA) and an integrated IMU/GNSS unit.

A brief summary of the aerial acquisition parameters for the project are shown in the Lidar System Specifications in Table 2.

MT_RavalliGraniteCusterPowderRiver_2019_B19
Work Unit 220298 Planned Flight Lines

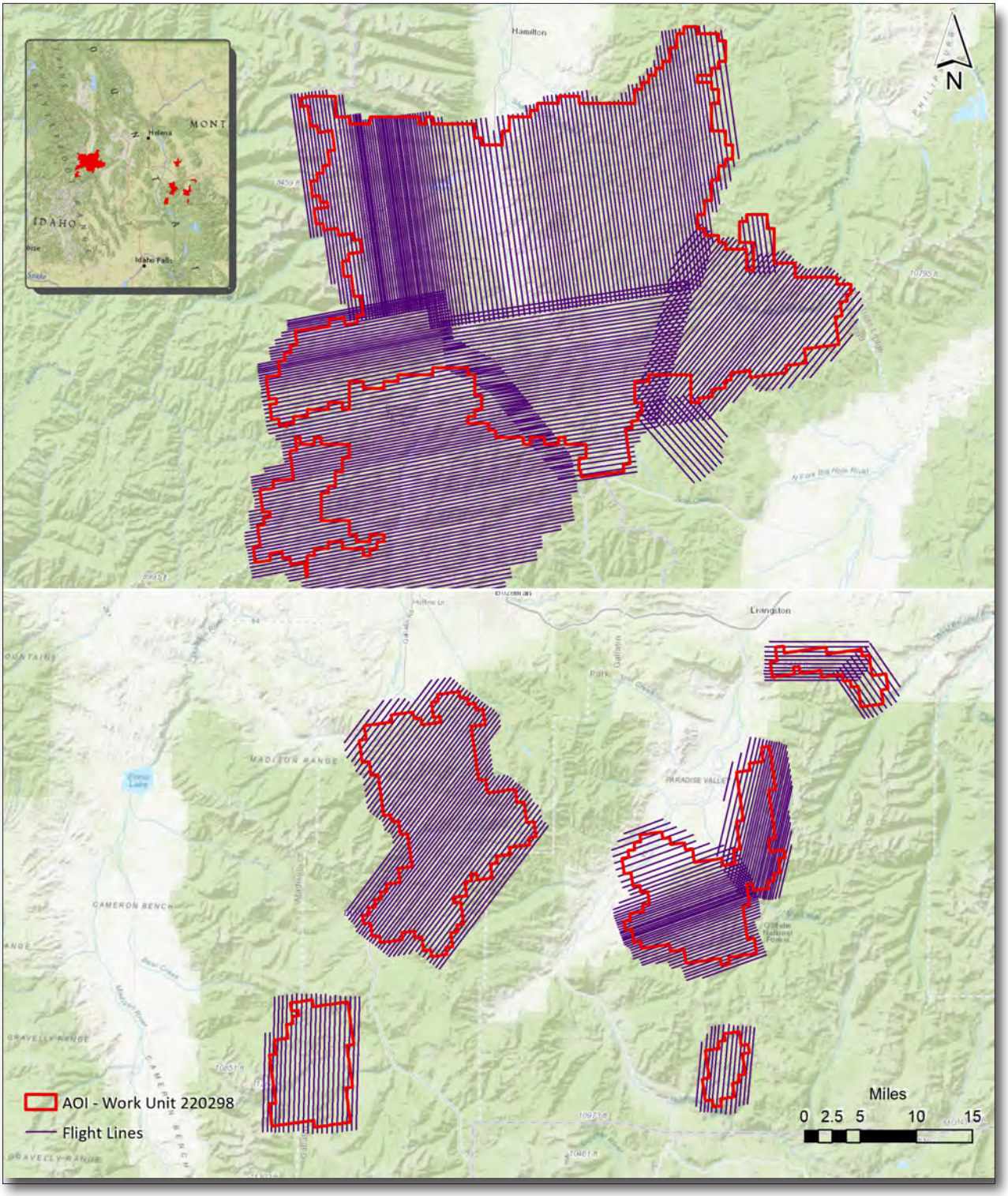


Figure 2. Planned Flight Lines

Table 2. Lidar System Specifications

		Riegl VQ1560i (3061, 3546, 4045; QL1)	Riegl VQ1560i (3061, 3546, 4040;QL1)
Terrain and Aircraft Scanner	Flying Height	2079 m	1824 m
	Recommended Ground Speed	115 kts	145 kts
Scanner	Field of View	58.5°	58.5°
	Scan Rate Setting Used	2 x 80.6 Hz	2 x 117 Hz
Laser	Laser Pulse Rate Used	2 x 500 kHz	2 x 700 kHz
	Multi Pulse in Air Mode	yes	yes
Coverage	Full Swath Width	2330 m	2044 m
	Line Spacing	1048 m	920 m
Point Spacing and Density	Average Point Spacing	<0.35 m	<0.35 m
	Average Point Density	9.68 pts / m2	12.22 pts / m2

Figure 3. Riegl VQ1560i, and VQ1560ii Lidar Sensors

2.3. Aircraft

All flights for the project were accomplished through the use of customized planes. Plane type and tail numbers are listed below.

LiDAR Collection Planes

- Piper Navajo, Tail Numbers: N22GE
- Cessna Caravan (single-turboprop), Tail Numbers: N704MD, N604MD, N208JA, N840JA

These aircraft provided an ideal, stable aerial base for LiDAR acquisition. These aerial platforms have relatively fast cruise speeds, which are beneficial for project mobilization / demobilization while maintaining relatively slow stall speeds, proving ideal for collection of high-density, consistent data posting using a state-of-the-art Riegl Lidar systems, Some of NV5 Geospatial's operating aircraft can be seen in Figure 4 below.

Figure 4. Some of NV5 Geospatial's Planes

2.4. Time Period

Project specific flights were conducted between May 9, 2020 and August 29, 2020. Forty-two aircraft lifts were completed. Accomplished lifts are listed below.

Lift	Start UTC	End UTC
05092020A (SN3546,N704MD)	5/09/2020 5:24:31 PM	5/09/2020 7:29:13 PM
06022020A (SN4045,N208JA)	6/02/2020 3:52:34 PM	6/02/2020 8:36:20 PM
06242020A (SN3061,N840JA)	6/24/2020 5:10:30 PM	6/24/2020 5:10:32 PM
06262020A (SN3061,N840JA)	6/26/2020 4:34:16 PM	6/26/2020 8:11:26 PM
07222020B (SN4040,N22GE)	7/22/2020 7:31:03 PM	7/22/2020 8:27:47 PM
07232020A (SN4040,N22GE)	7/23/2020 3:12:18 PM	7/23/2020 3:24:40 PM
07252020A (SN3546,N704MD)	7/25/2020 9:58:43 PM	7/25/2020 11:15:13 PM
07252020A (SN4040,N22GE)	7/25/2020 2:52:42 PM	7/25/2020 6:07:51 PM
07252020B (SN4040,N22GE)	7/25/2020 8:04:05 PM	7/25/2020 10:17:24 PM
07262020A (SN4040,N22GE)	7/26/2020 2:56:11 PM	7/26/2020 6:57:09 PM
07262020A1 (SN3546,N704MD)	7/26/2020 3:27:17 PM	7/26/2020 5:59:02 PM
07262020A2 (SN3546,N704MD)	7/26/2020 6:12:55 PM	7/26/2020 8:15:45 PM
07272020A (SN3546,N704MD)	7/27/2020 3:45:55 PM	7/27/2020 9:35:42 PM
07272020B (SN4040,N22GE)	7/27/2020 4:46:54 PM	7/27/2020 6:33:40 PM
07282020A (SN3546,N704MD)	7/28/2020 3:25:50 PM	7/28/2020 8:22:49 PM
07282020B (SN4040,N22GE)	7/28/2020 4:12:03 PM	7/28/2020 6:02:26 PM
07292020A (SN3546,N704MD)	7/29/2020 3:09:01 PM	7/29/2020 7:41:34 PM
07292020A (SN4040,N22GE)	7/29/2020 3:48:51 PM	7/29/2020 6:05:20 PM
07292020B (SN4040,N22GE)	7/29/2020 7:31:25 PM	7/29/2020 8:44:20 PM
07302020A (SN3546,N704MD)	7/30/2020 2:14:23 PM	7/30/2020 8:25:15 PM
07312020A (SN3546,N704MD)	7/31/2020 1:55:25 PM	7/31/2020 8:40:59 PM
08012020A (SN3546,N704MD)	8/01/2020 2:27:33 PM	8/01/2020 8:25:17 PM
08042020A (SN3546,N704MD)	8/04/2020 5:56:17 PM	8/04/2020 8:22:53 PM
08052020A (SN3546,N704MD)	8/05/2020 2:08:14 PM	8/05/2020 8:07:50 PM
08072020A (SN3546,N704MD)	8/07/2020 4:06:08 PM	8/07/2020 5:35:49 PM

Lift	Start UTC	End UTC
08082020A (SN3546,N704MD)	8/08/2020 1:56:15 PM	8/08/2020 5:56:12 PM
08082020B (SN3546,N704MD)	8/08/2020 8:04:14 PM	8/08/2020 10:22:18 PM
08092020A (SN3546,N704MD)	8/09/2020 1:51:44 PM	8/09/2020 6:06:24 PM
08092020A (SN4040,N22GE)	8/09/2020 1:46:16 PM	8/09/2020 3:29:38 PM
08102020A (SN4040,N22GE)	8/10/2020 4:19:21 PM	8/10/2020 4:49:21 PM
08172020A (SN4040,N22GE)	8/17/2020 3:52:21 PM	8/17/2020 5:34:33 PM
08172020B (SN4040,N22GE)	8/17/2020 7:02:01 PM	8/17/2020 7:37:41 PM
08182020A (SN4040,N22GE)	8/18/2020 2:33:55 PM	8/18/2020 5:31:40 PM
08212020A (SN3546,N704MD)	8/21/2020 3:20:33 PM	8/21/2020 5:30:04 PM
08222020B (SN3546,N704MD)	8/22/2020 2:27:54 PM	8/22/2020 3:04:43 PM
08222020C (SN3546,N704MD)	8/22/2020 3:48:45 PM	8/22/2020 6:10:40 PM
08232020A (SN3546,N704MD)	8/23/2020 2:21:46 PM	8/23/2020 6:12:29 PM
08262020A (SN4040,N22GE)	8/26/2020 3:57:29 PM	8/26/2020 4:48:09 PM
08262020A (SN4046,N604MD)	8/26/2020 4:01:33 PM	8/26/2020 7:15:52 PM
08282020A (SN4040,N22GE)	8/28/2020 3:58:16 PM	8/28/2020 5:45:05 PM
08282020B (SN4046,N604MD)	8/28/2020 4:14:02 PM	8/28/2020 4:57:40 PM
08292020A (SN4040,N22GE)	8/29/2020 2:51:04 PM	8/29/2020 5:54:10 PM

3. Processing Summary

3.1. Flight Logs

Flight logs were completed by lidar sensor technicians for each mission during acquisition. These logs depict a variety of information, including:

- Job / Project #
- Flight Date / Lift Number
- FOV (Field of View)
- Scan Rate (HZ)
- Pulse Rate Frequency (Hz)
- Ground Speed
- Altitude
- Base Station
- PDOP avoidance times
- Flight Line #
- Flight Line Start and Stop Times
- Flight Line Altitude (AMSL)
- Heading
- Speed
- Returns
- Crab

Notes: (Visibility, winds, ride, weather, temperature, dew point, pressure, etc).

3.2. Lidar Processing

Applanix + POSPac software was used for post-processing of airborne GPS and inertial data (IMU), which is critical to the positioning and orientation of the lidar sensor during all flights. Applanix POSPac combines aircraft raw trajectory data with stationary GPS base station data yielding a “Smoothed Best Estimate Trajectory” (SBET) necessary for additional post processing software to develop the resulting geo-referenced point cloud from the lidar missions.

During the sensor trajectory processing (combining GPS & IMU datasets) certain statistical graphs and tables are generated within the Applanix POSPac processing environment which are commonly used as indicators of processing stability and accuracy. This data for analysis include: max horizontal / vertical GPS variance, separation plot, altitude plot, PDOP plot, base station baseline length, processing mode, number of satellite vehicles, and mission trajectory.

Point clouds were created using RiPROCESS software. The generated point cloud is the mathematical three dimensional composite of all returns from all laser pulses as determined from the aerial mission. The point cloud is imported into GeoCue distributive processing software. Imported data is tiled and then calibrated using TerraMatch and proprietary software. Using TerraScan, the vertical accuracy of the surveyed ground control is tested and any bias is removed from the data. TerraScan and TerraModeler software packages are then used for automated data classification and manual cleanup. The data are manually reviewed and any remaining artifacts removed using functionality provided by TerraScan and TerraModeler.

DEMs and Intensity Images are then generated using proprietary software. In the bare earth surface model, above-ground features are excluded from the data set. Global Mapper is used as a final check of the bare earth dataset.

Finally, proprietary software is used to perform statistical analysis of the LAS files.

Software	Version
RiPROCESS	1.8.6
Applanix + POSPac	8.6
GeoCue	2020.1.22.1
Global Mapper	19.1;20.1
TerraModeler	21.008
TerraScan	21.016
TerraMatch	21.007

3.3. LAS Classification Scheme

The classification classes are determined by the USGS Version 1.3 specifications and are an industry standard for the classification of lidar point clouds. All data starts the process as Class 1 (Unclassified), and then through automated classification routines, the classifications are determined using TerraScan macro processing.

The classes used in the dataset are as follows and have the following descriptions:

Table 3. LAS Classifications

	Classification Name	Description
1	Processed, but Unclassified	Laser returns that are not included in the ground class, or any other project classification
2	Bare earth	Laser returns that are determined to be ground using automated and manual cleaning algorithms
6	Buildings	Points falling on buildings, structures inside of water bodies, docks, and piers.
7	Low Noise	Laser returns that are often associated with scaterring from reflective surfaces, or artificial points below the ground surface
9	Water	Laser returns that are found inside of hydro features
17	Bridge Deck	Laser returns falling on bridge decks
18	High Noise	Laser returns that are often associated with birds or artificial points above the ground surface
20	Ignored Ground	Ground points that fall within the given threshold of a collected hydro feature.
21	Snow	Ground points that fall on snow, where identifiable

3.4. Classified LAS Processing

The bare earth surface is then manually reviewed to ensure correct classification on the Class 2 (Ground) points. After the bare- earth surface is finalized; it is then used to generate all hydro-breaklines through heads-up digitization.

All ground (ASPRS Class 2) Lidar data inside of the Lake Pond and Double Line Drain hydro flattening breaklines were then classified to water (ASPRS Class 9) using TerraScan macro functionality. A buffer of 3 feet was also used around each hydro flattened feature to classify these ground (ASPRS Class 2) points to Ignored ground (ASPRS Class 20). All Lake Pond Island and Double Line Drain Island features were checked to ensure that the ground (ASPRS Class 2) points were reclassified to the correct classification after the automated classification was

completed.

Any noise that was identified either through manual review or automated routines was classified to the appropriate class (ASPRS Class 7 and/or ASPRS Class 18) followed by flagging with the withheld bit.

All data was manually reviewed and any remaining artifacts removed using functionality provided by TerraScan and TerraModeler. Global Mapper is used as a final check of the bare earth dataset. GeoCue was then used to create the deliverable industry-standard LAS files for all point cloud data. NV5 Geospatial's proprietary software was used to perform final statistical analysis of the classes in the LAS files, on a per tile level to verify final classification metrics and full LAS header information.

3.5. Hydro-Flattened Breakline Processing

Class 2 (ground) lidar points was used to create a bare earth surface model. The surface model was then used to heads-up digitize 2D breaklines of inland streams and rivers with a 100-foot nominal width and inland ponds and lakes of 2 acres or greater surface area.

Elevation values were assigned to all inland streams and rivers using NV5 Geospatial's proprietary software.

All Ground (ASPRS Class 2) lidar data inside of the collected inland breaklines were then classified to Water (ASPRS Class 9) using TerraScan macro functionality. A buffer of 1.5 feet was also used around each hydro-flattened feature. These points were moved from ground (ASPRS Class 2) to Ignored Ground (ASPRS Class 20).

The breakline files were then translated to Esri file geodatabase format using Esri conversion tools.

Breaklines are reviewed against lidar intensity imagery to verify completeness of capture. All breaklines are then compared to TINs (triangular irregular networks) created from ground only points prior to water classification. The horizontal placement of breaklines is compared to terrain features and the breakline elevations are compared to lidar elevations to ensure all breaklines match the lidar within acceptable tolerances. Some deviation is expected between breakline and lidar elevations due to monotonicity, connectivity, and flattening rules that are enforced on the breaklines. Once completeness, horizontal placement, and vertical variance is reviewed, all breaklines are reviewed for topological consistency and data integrity using a combination of Esri Data Reviewer tools and proprietary tools.

3.6. Hydro-Flattened Raster DEM Processing

Class 2 Lidar in conjunction with the hydro breaklines were used to create 0.5-meter, hydro-flattened raster DEMs. Using automated scripting routines within proprietary software, a GeoTIFF file was created for each tile. Each surface is reviewed using Global Mapper to check for any surface anomalies or incorrect elevations found within the surface.

3.7. Intensity Image Processing

GeoCue software was used to create the deliverable intensity images. All withheld points were ignored during this process. This helps to ensure a more aesthetically pleasing image. The GeoCue software was then used to verify full project coverage as well. GeoTIFF files with a cell size of 0.5-meter were then provided as the deliverable for this dataset requirement.

3.8. First Return DSM Processing

First return lidar points were used to create a 0.5-meter first-return raster DSM. Using automated scripting routines within proprietary software, GeoTIFF files were created for each tile. Each surface is reviewed using Global Mapper to check for any surface anomalies or incorrect elevations found within the surface.

3.9. Height Separation Raster Processing

Swath Separation Images are rasters that represent the interswath alignment between flight lines and provide a qualitative evaluation of the positional quality of the point cloud. Proprietary software was used to create 1-meter raster images in GeoTIFF format.

MT_RavalliGraniteCusterPowderRiver_2019_B19
Work Unit 220298 Tile Layout

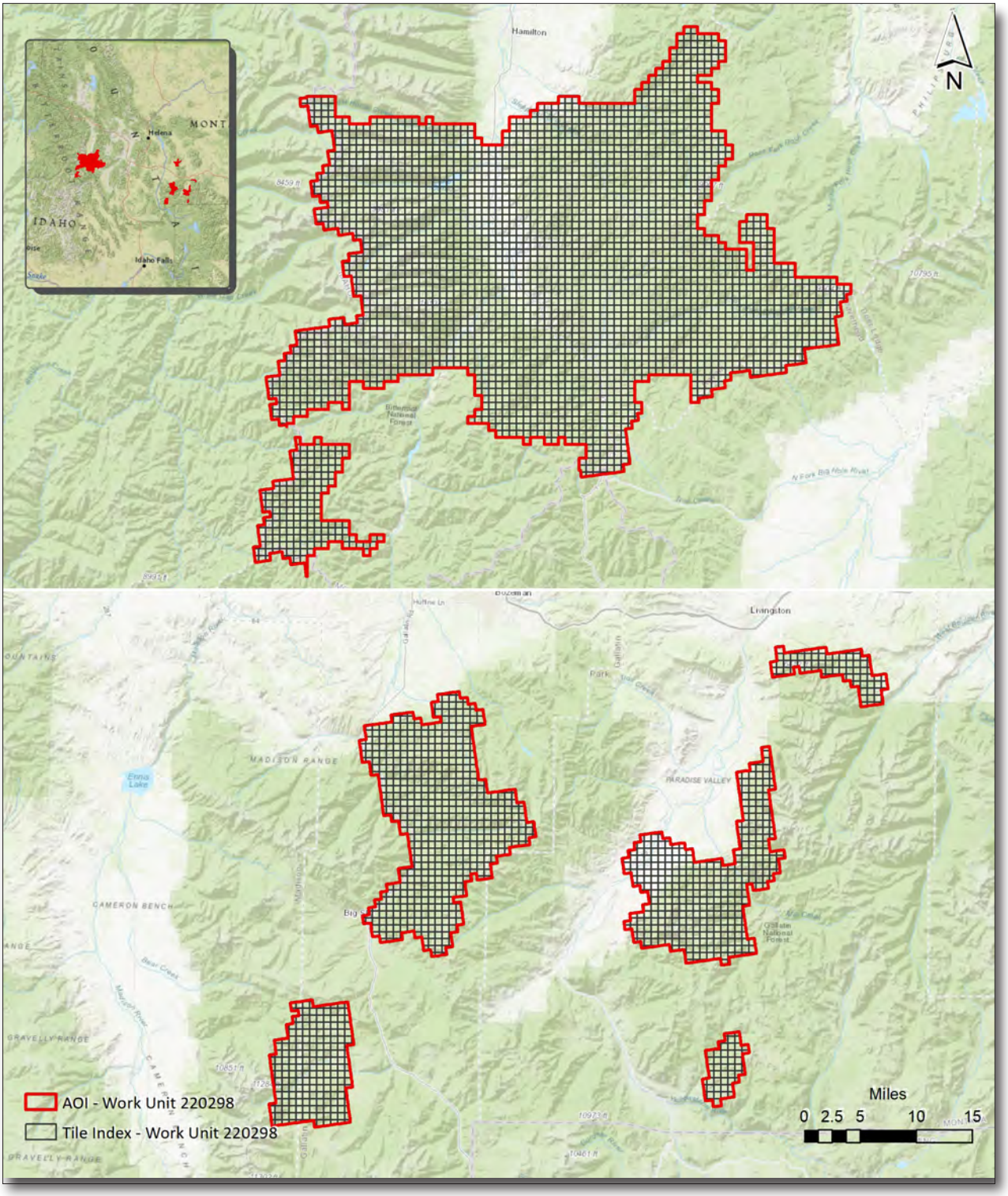


Figure 5. Lidar Tile Layout

4. Project Coverage Verification

Coverage verification was performed by comparing coverage of processed .LAS files captured during project collection to generate project shape files depicting boundaries of specified project areas. Please refer to Figures 6.

MT_RavalliGraniteCusterPowderRiver_2019_B19
Work Unit 220298 Coverage

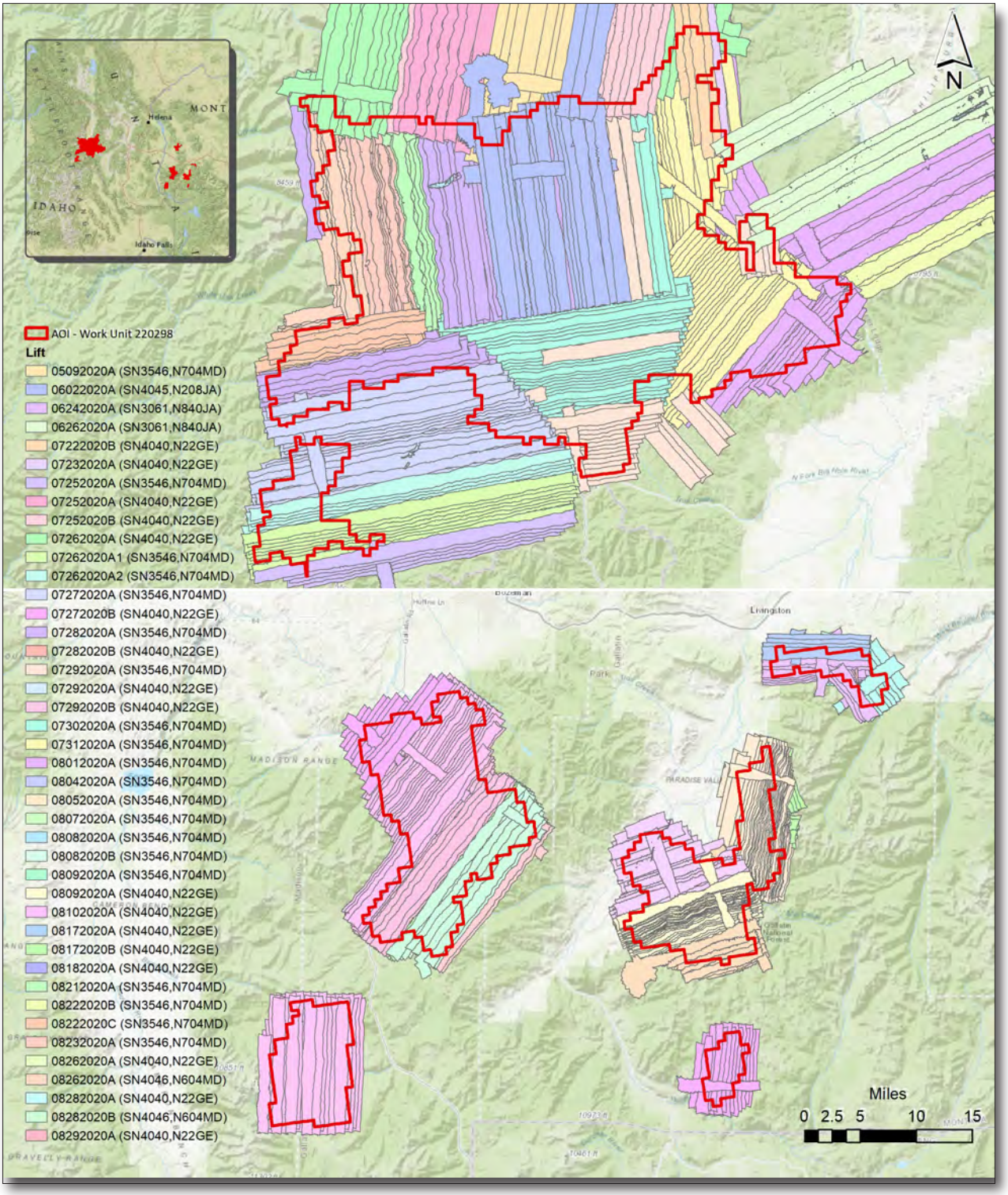


Figure 6. Lidar Coverage

5. Geometric Accuracy

5.1. Horizontal Accuracy

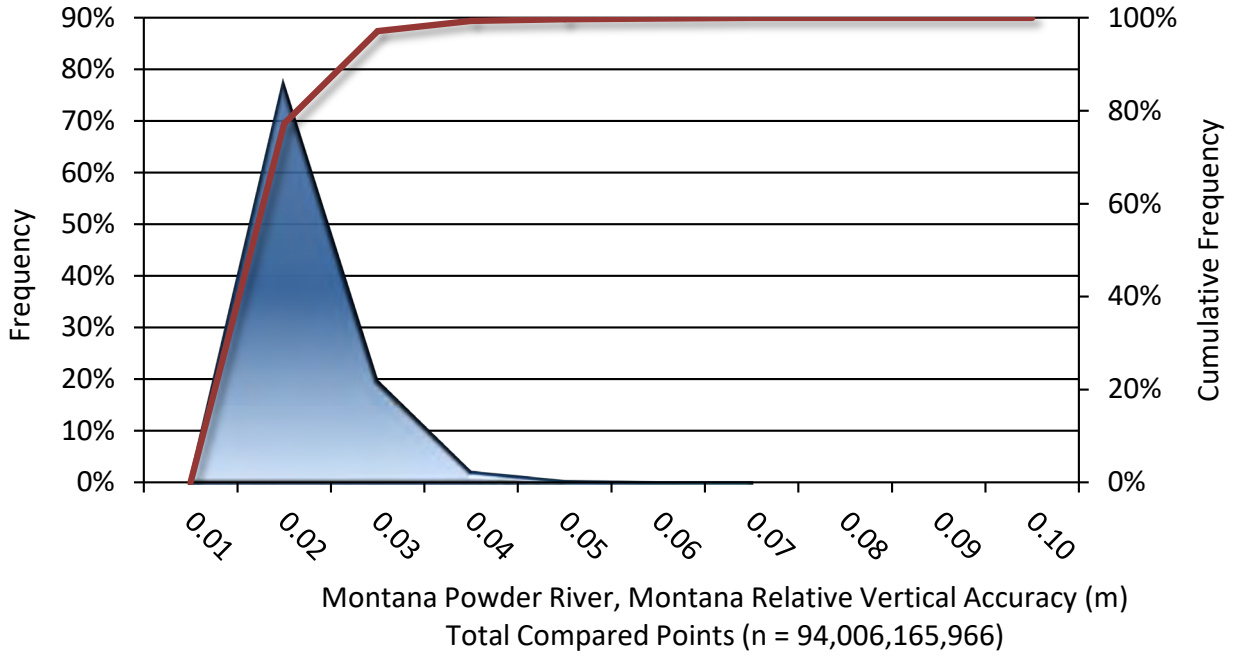
Lidar horizontal accuracy is a function of Global Navigation Satellite System (GNSS) derived positional error, flying altitude, and INS derived attitude error. The obtained $RMSE_r$ value is multiplied by a conversion factor of 1.7308 to yield the horizontal component of the National Standards for Spatial Data Accuracy (NSSDA) reporting standard where a theoretical point will fall within the obtained radius 95% of the time. Based on a flying altitude of 2300 meters, an IMU error of 0.002 decimal degrees, and a GNSS positional error of 0.018 meters, this project was compiled to meet 0.40 meter horizontal accuracy at the 95% confidence level. A summary is shown below.

Horizontal Accuracy	
$RMSE_r$	0.23 m
	0.76 ft
ACC_r	0.40 m
	1.31 ft

5.2. Relative Vertical Accuracy

Relative vertical accuracy refers to the internal consistency of the data set as a whole: the ability to place an object in the same location given multiple flight lines, GPS conditions, and aircraft attitudes. When the lidar system is well calibrated, the swath-to-swath vertical divergence is low (<0.10 meters). The relative vertical accuracy was computed by comparing the ground surface model of each individual flight line with its neighbors in overlapping regions. The average (mean) line to line relative vertical accuracy for Work Unit 220298 was 0.058 feet (0.018 meters). A summary is shown below.

Relative Vertical Accuracy	
Sample	730 flight line surfaces
Average	0.058 ft
	0.018 m
Median	0.057 ft
	0.017 m
RMSE	0.063 ft
	0.019 m
Standard Deviation (1σ)	0.016 ft
	0.005 m
1.96σ	0.031 ft
	0.010 m



6. Ground Control and Check Point Collection

NV5 Geospatial utilized 217 ground control (calibration) points along with 353 blind QA points (208 NVA points and 145 VVA points) in Non-Vegetated and Vegetated land cover classifications. QA points were used as an independent test of the accuracy of this project.

The required accuracy testing was performed on the lidar dataset (both the lidar point cloud and derived DEM's) according to the USGS Lidar Base Specification Version 1.3.

6.1. Calibration Control Point Testing

Figure 7 shows the location of each bare earth calibration point for the project area. TerraScan was used to perform a quality assurance check using the lidar bare earth calibration points. The results of the surface calibration are not an independent assessment of the accuracy of these project deliverables, but the statistical results do provide additional feedback as to the overall quality of the elevation surface.

6.2. Point Cloud Testing

The project specifications require that only Non-Vegetated Vertical Accuracy (NVA) be computed for the raw lidar point cloud. The required accuracy (ACCz) is: 19.6 cm at a 95% confidence level, derived according to NSSDA, i.e., based on RMSE of 10 cm in the "bare earth" and "urban" land cover classes. The NVA was tested with 208 checkpoints located in bare earth and urban (non-vegetated) areas. These check points were not used in the calibration or post processing of the lidar point cloud data. The checkpoints were distributed throughout the project area and were surveyed using GPS techniques. See survey report for additional survey methodologies.

Elevations from the unclassified lidar surface were measured for the x,y location of each check point. Elevations interpolated from the lidar surface were then compared to the elevation values of the surveyed control points. AccuracyZ has been tested to meet 19.6 cm or better Non-Vegetated Vertical Accuracy at 95% confidence level using RMSE(z) x 1.9600 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines.

6.3. Digital Elevation Model (DEM) Testing

The project specifications require the accuracy (ACCz) of the derived DEM be calculated and reported in two ways:

1. The required NVA is: 19.6 cm at a 95% confidence level, derived according to NSSDA, i.e., based on RMSE of 10 cm in the "bare earth" and "urban" land cover classes. This is a required accuracy. The NVA was tested with 208 checkpoints located in bare earth and urban (non-vegetated) areas. See Figure 8.

2. Vegetated Vertical Accuracy (VVA): VVA shall be reported for "brushlands/low trees" and "tall weeds/crops" land cover classes. The target VVA is: 29.4 cm at the 95th percentile, derived according to ASPRS Guidelines, Vertical Accuracy Reporting for Lidar Data, i.e., based on the 95th percentile error in all vegetated land cover classes combined. This is a target accuracy. The VVA was tested with 145 checkpoints located in tall weeds/ crops and brushlands/low trees (vegetated) areas. The checkpoints were distributed throughout the project area and were surveyed using GPS techniques. See Figure 9.

AccuracyZ has been tested to meet 19.6 cm or better Non-Vegetated Vertical Accuracy at 95% confidence level using RMSE(z) x 1.9600 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported using National Digital Elevation Program (NDEP)/ ASRPS Guidelines.

A brief summary of results are listed below.

	Target	Measured	Point Count
Raw NVA	0.196 m	.0692 m	208
NVA	0.196 m	.0656 m	208
VVA	0.294 m	.2116 m	145

MT_RavalliCusterGranitePowderRiver Calibration Points

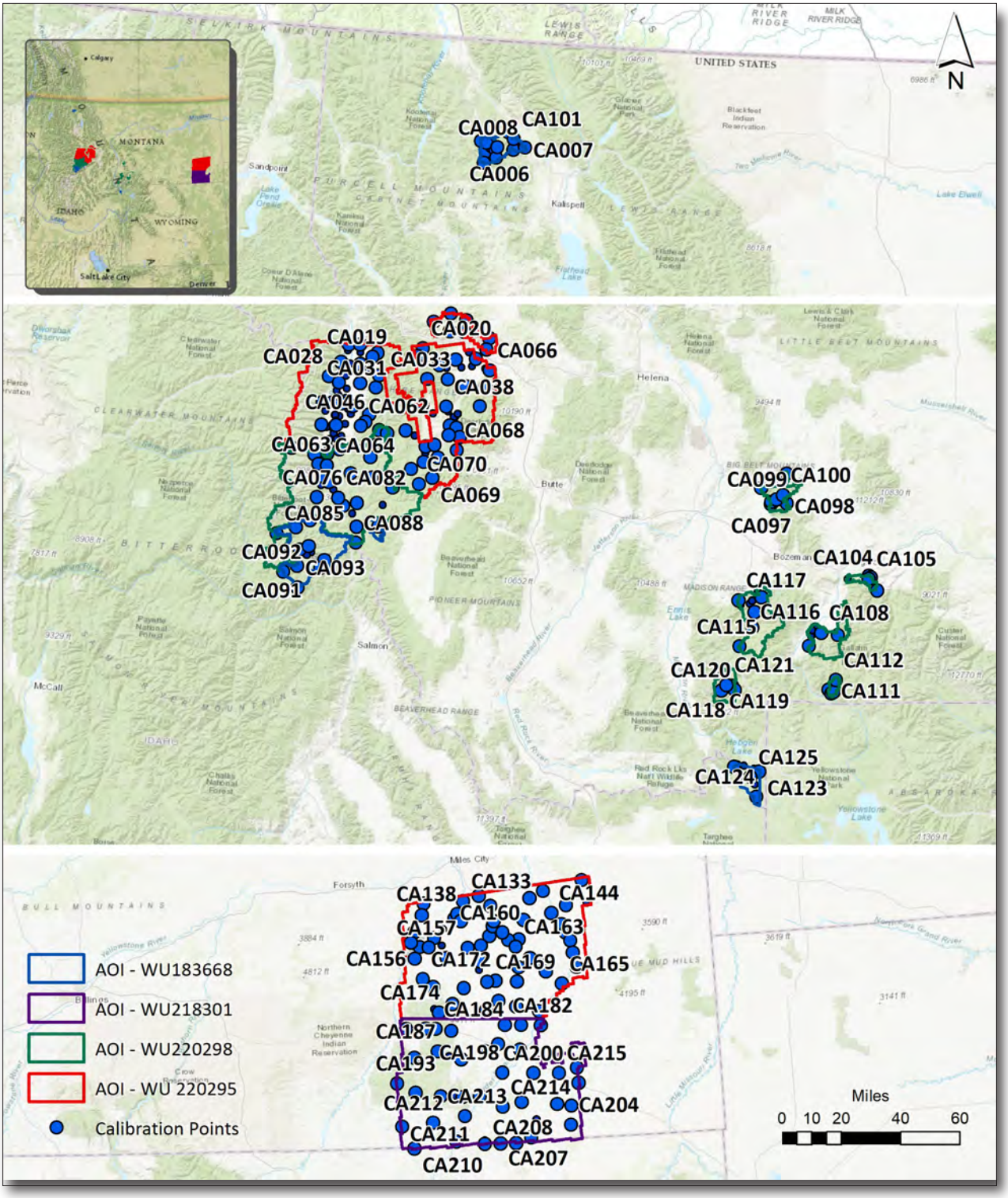


Figure 7. Calibration Control Point Locations

MT_RavalliCusterGranitePowderRiver
NVA Points

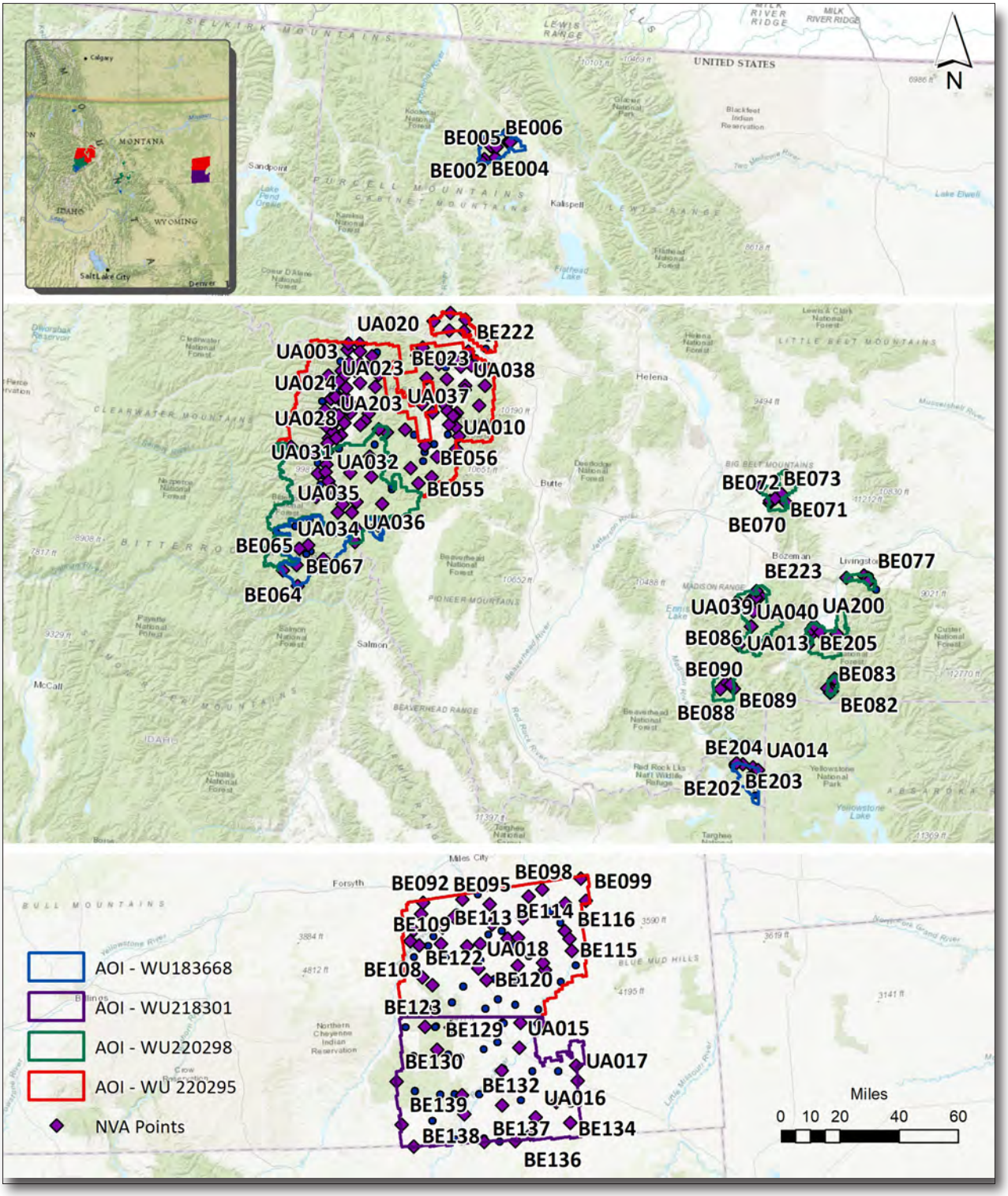


Figure 8. QC Checkpoint Locations - NVA

MT_RavalliCusterGranitePowderRiver
VVA Points

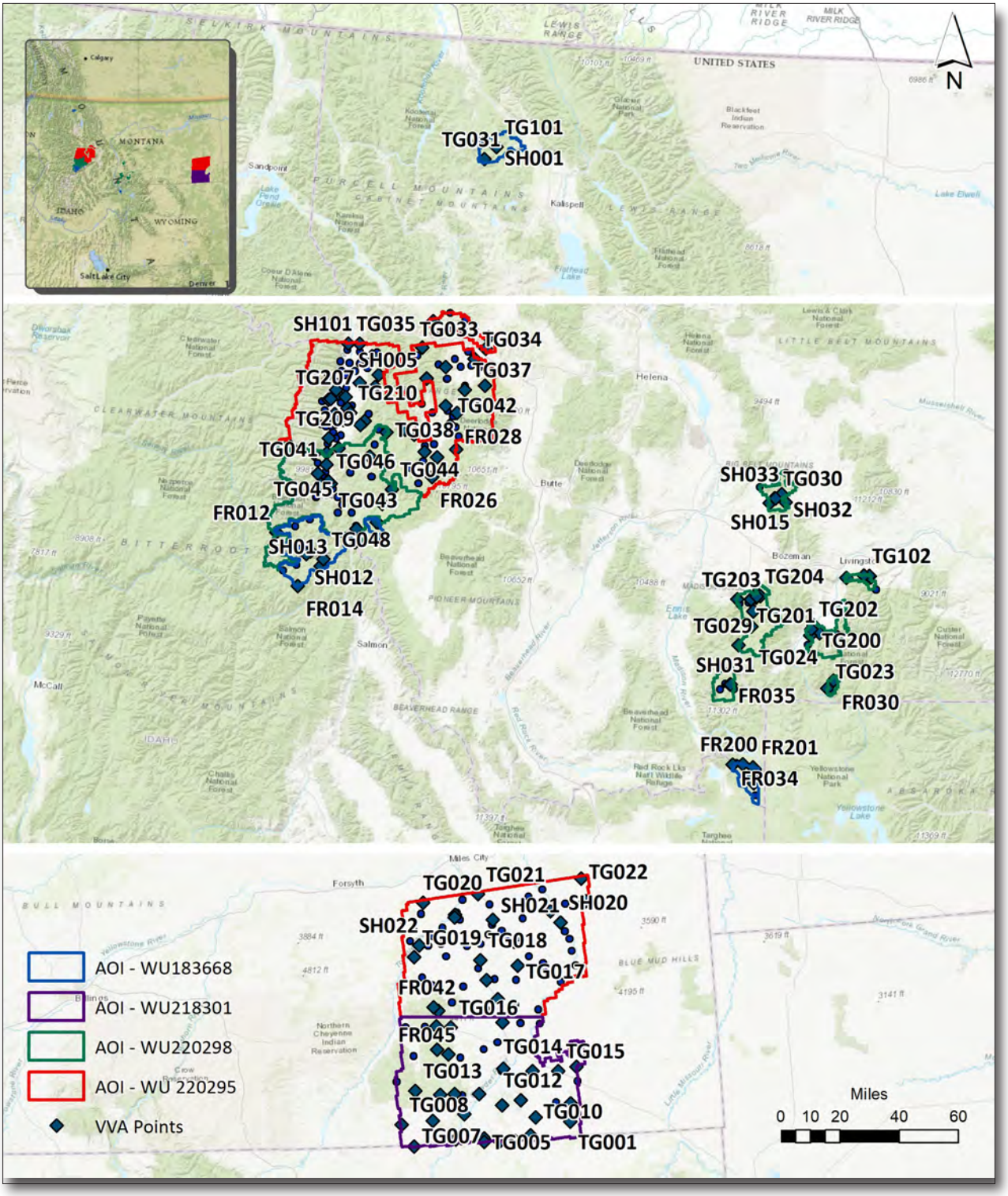


Figure 9. QC Checkpoint Locations - VVA

Project Report Appendices

The following section contains the appendices as listed in the MT_RavalliGraniteCusterPowderRiver Lidar Project Report.

Appendix A

Flight Logs

Julian Day	292	Flight	A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date	Oct 19, 2019	Aircraft	C-FFRY
Project	3186 QSI Powder River	Pilot	MacQuarrie
Location	Sheridan, WYO	Operator	Westergard
Mission Objective			

System	Riegl 1560i
Unit	43
IMU	
GPS Rx	Trimble
Scanner 1 Drive	
Scanner 2 Drive	

Additional Notes

Time to next maintenance: _____ ☐ 50 hr ☐ 100 hr

Aircraft Block Time		
Engine On 1705	Takeoff 1721	
Engine Off 2105	Landing 2052	
Total 4.0 hrs	Total 3.5 hrs	

Mission Plan			
AGL Height	2000 m	Pulse Rate	500 Khz
Target Speed	160 kts	Scan Rate	109
Laser Current	100 %	FOV	60 degs

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	1712	1717
Post Mission	2058	2103

Flight Line	LIDAR File Name	Flight Direction	GPS Time Start	GPS Time End	Line Aborted Time	Line Aborted nmi to End	Mission ID Time Stamp 191019	Comments
figure 8		∞	1753	1758				inertial
X-LINE	431929201	355	1759	1803			175902	
1001	431929202	85	1807	1813			180745	lots of turbulence.
1002	431929203	265	1815	1826			181552	
1003	431929204	85	1830	1840			183029	
1004	431929205	265	1843	1855			184349	
1005	431929206	85	1859	1910			185905	
1006	431929207	265	1913	1925			191340	
1007	431929208	85	1927	1939			192755	
1008	431929209	265	1941	1953			194137	
1009	431929210	85	1956	2007			195621	
figure 8		∞	2007	2012			—	inertial

Julian Day 297	Flight A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date Oct 24, 2019	Aircraft C FFRY
Project 3186_QSI_Powder.	Pilot MacQuarrie
Location Sheridan. WYO	Operator Westergaard
Mission Objective	

System Reigl 1560i	
Unit 43	
IMU	
GPS Rx Trimble	
Scanner 1 Drive	
Scanner 2 Drive	

Additional Notes

Time to next maintenance: _____ ☐ 50 hr ☐ 100 hr

Aircraft Block Time		
Engine On 1517 17.15	Takeoff 1728	
Engine Off 2310	Landing 2300	
Total 5.9 hrs	Total 5.5 hrs	

Mission Plan			
AGL Height	2000 m	Pulse Rate	500 kHz
Target Speed	160 kts	Scan Rate	109
Laser Current	100 %	FOV	60° degs

Static Alignment	GPS Time Start	GPS Time End
Pre Mission	1719	1724
Post Mission	2304	2309

Flight Line	LIDAR File Name	Flight Direction	GPS Time Start	GPS Time End	Line Aborted Time	Line Aborted nmi to End	Mission ID Time Stamp 191024	Comments
test		∞	1747	1749			174725	
Figure 8		∞	1804	1808			—	inertial
x line	431929701	355	1810	1816			181050	
2001	431929702	85	1821	1827			182142	
2002	431929704	265	1829	1839			182956	
2003	431929705	85	1845	1856			184512	
2004	431929706	265	1859	1911			185936	
2005	431929707	85	1914	1925			191438	
2006	431929708	265	1928	1939			192835	
2007	431929709	85	1943	1954			194310	
2008	431929710	265	1956	2008			195656	
2009	431929711	85	2011	2022			201112	
2010	431929112	265	2024	2036			202456	
2011	431929713	85	2038	2049			203856	
2012	431929714	265	2053	2103			205307	

Julian Day 297	Flight A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date Oct 24, 2019	Aircraft CFFRY
Project 3186 QSI Powder	Pilot MacQuarrie
Location Sheridan WYO.	Operator Westergard
Mission Objective	

System Reigl Q1560i	
Unit 43	
IMU	
GPS Rx Trimble	
Scanner 1 Drive	
Scanner 2 Drive	

Additional Notes

Time to next maintenance: _____ ☐ 50 hr ☐ 100 hr

Aircraft Block Time		
Engine On 1715	Takeoff 1728	
Engine Off 2310	Landing 2300	
Total 5.9 hrs	Total 5.5 hrs	

Mission Plan			
AGL Height	2000 m	Pulse Rate	500 kHz
Target Speed	160 kts	Scan Rate	109
Laser Current	100 %	FOV	60 degs

Static Alignment	GPS Time	
	Start	End
Pre Mission	1719	1724
Post Mission	2304	2309

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID Time Stamp 191024	Comments
			Start	End	Time	nmi to End		
X-LINE	431929715	85	2110	2114			211019	
3069	431929716	175	2119	2127			211925	
3068	431929717	355	2130	2138			213011	
3067	431929715	175	2141	2150			214112	
3066	431929716	355	2153	2201			215303	
3065	43929718	175	2204	2211			220407	
Figure 8		∞	2211	2216			—	Inertial

Julian Day 298	Flight A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date Oct 25, 2016	Aircraft C-FFRY
Project 3186 QSI POWDER..	Pilot MACQUARRIE
Location SHERIDAN, WYO	Operator WESTERGARD
Mission Objective	

System REIGL Q1560i	
Unit 43	
IMU	
GPS Rx Trimble	
Scanner 1 Drive	
Scanner 2 Drive	

Additional Notes

Time to next maintenance: _____ ☐ 50 hr ☐ 100 hr

Aircraft Block Time		
Engine On 1538	Takeoff 1555	
Engine Off 2153	Landing 2141	
Total 6.3 hrs	Total 5.8 hrs	

Mission Plan			
AGL Height	2000 m	Pulse Rate	500 Khz
Target Speed	160 kts	Scan Rate	109
Laser Current	100 %	FOV	60 degs

Static Alignment	GPS Time	
	Start	End
Pre Mission	1546	1551
Post Mission	2146	2151

Flight Line	LIDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID Time Stamp 191025	Comments
			Start	End	Time	nmi to End		
test		∞	1619	1621			161930	test
figure 8		∞	1624	1629			—	inertial
X-LINE	431929801	85	1629	1639			162953	
3064	431929802	355	1644	1653			164440	
3063	431929803	175	1656	1705			165619	
3062	431929804	355	1707	1716			170757	
3061	431929805	175	1719	1729			171946	
3060	431929806	355	1732	1741			173211	
3059	431929807	175	1744	1755			174433	
3058	431929808	355	1757	1808			175746	
3057	431929809	175	1810	1821			181051	
3056	431929810	355	1824	1835			182433	
3055	431929811	175	1837	1849			183739	
3054	431929812	355	1853	1906			185331	
3053	431929813	175	1909	1922			190900	

Julian Day 298	Flight A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date Oct 25, 2019	Aircraft C-FFRY
Project 3186 QSI, Powder	Pilot MacQuarrie
Location Sheridan, WYO	Operator Westergard
Mission Objective	

System Reigl Q1560i
Unit 43
IMU
GPS Rx Trimble
Scanner 1 Drive
Scanner 2 Drive

Additional Notes

Time to next maintenance: _____ ☐ 50 hr ☐ 100 hr

Aircraft Block Time		
Engine On 1538	Takeoff 1555	
Engine Off 2153	Landing 2141	
Total 6.3 hrs	Total 5.8 hrs	

Mission Plan			
AGL Height	2000 m	Pulse Rate	500 kHz
Target Speed	160 kts	Scan Rate	109
Laser Current	100 %	FOV	60 degs

Static Alignment	GPS Time	
	Start	End
Pre Mission	1546	1551
Post Mission	2146	2151

Flight Line	LIDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID Time Stamp 191025	Comments
			Start	End	Time	nmi to End		
3052	431929814	355	1925	1938			192512	
3051	431929815	175	1941	1954			194114	
3050	431929816	355	1957	2011			195700	
3049	431929817	175	2013	2027			201354	
3048	431929818	355	2029	2044			202942	
3047	431929819	175	2046	2059			204630	
figure 8		∞	2059	2105			—	inertial

Julian Day	089	Flt	A

LIDAR Flight Log

AIRBORNE IMAGING INC

Date	March 29, 2020	Aircraft	CFKMA
Project	3186 QSI Powder River	Pilot	N. Emson
Location	Sheridan, WY	Operator	B. Eisenbart
Mission Objective			

System	LMS-1560
Unit	64
IMU	**Applanix AP60**
GPS Rx	**Trimble**
Scanner 1 Drive	1
Scanner 2 Drive	2

Additional Notes

Aircraft Block Time		
Engine On 15:39	Ramp Out	Takeoff 15:58
Engine Off 22:17	Ramp In	Landing 22:06
Total 6.6 **hrs**	Total **hrs**	Total 6.1 **hrs**

Mission Plan			
AGL Height	2300 **m**	Pulse Rep Rate	400 **kHz**
Ground Speed	160 **kts**	Scan Rate	89 **Hz**
Laser Current	100 **%**	FOV	60 **Deg's**

Static Alignment	GPS Time	
	Start	End
Pre Mission	15:42	15:47
Post Mission	22:10	22:15

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Ln Aborted	Date Stamp	ALS Time Stamp	Comments
			Start	End	Time			
PPP-8	-		16:29	16:34			-	Figure 8
3046	6420089-01	351°	16:38	16:51		200329	163836	
3045	02	171°	16:55	17:08			165523	
3044	03	351°	17:12	17:26			171225	
3043	04	171°	17:30	17:44			173018	
3042	05	351°	17:47	18:01			174744	
3041	06	171°	18:05	18:18			180531	
3040	07	351°	18:22	18:35			1822125	
3039	08	171°	18:39	18:53			183927	
3038	09	351°	18:57	19:11			185711	
3037	10	171°	19:15	19:29			191502	
3036	11	351°	19:33	19:47			193307	
3035	12	171°	19:50	20:05			195048	
3034	13	351°	20:08	20:22			200856	
3033	14	171°	20:25	20:40			202541	

Julian Day	089	Flt	A

LIDAR Flight Log

AIRBORNE IMAGING INC

Date	March 29, 2020	Aircraft	CFKMA
Project	3186 QSI Powder River	Pilot	N. Emson
Location	Sheridan, WY	Operator	B. Eisenbart
Mission Objective			

System	LMS-1560
Unit	64
IMU	**Applanix AP50**
GPS Rx	**Trimble**
Scanner 1 Drive	1
Scanner 2 Drive	2

Additional Notes

Aircraft Block Time					
Engine On	15:39	Ramp Out		Takeoff	15:58
Engine Off	22:17	Ramp In		Landing	22:06
Total	6.6 **hrs**	Total	**hrs**	Total	6.1 **hrs**

Mission Plan			
AGL Height	2300 **m**	Pulse Rep Rate	400 **kHz**
Ground Speed	160 **kts**	Scan Rate	89 **Hz**
Laser Current	100 **%**	FOV	60 **Deg's**

Static Alignment	GPS Time	
	Start	End
Pre Mission	15:42	15:47
Post Mission	22:10	22:15

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Ln Aborted	Date Stamp	ALS Time Stamp	Comments
			Start	End	Time			
3032	15	351°	20:44	20:57		200329	204406	
3031	16	171°	21:01	21:15			210118	
X-TIE	17	81°	21:19	21:25			211945	
PPP-8	-		21:25	21:30			-	Figure 8

Julian Day	090	Flt	A

LIDAR Flight Log

AIRBORNE IMAGING INC

Date	March 30, 2020	Aircraft	CFKMA
Project	3186 QSI Powder River	Pilot	N. Emson
Location	Sheridan, WY	Operator	B. Eisenbart
Mission Objective			

System	1560
Unit	64
IMU	**Applanix AP60**
GPS Rx	**Trimble**
Scanner 1 Drive	1
Scanner 2 Drive	2

Additional Notes

Powder River 2 MOA closed today
Limited to the west end of block

Aircraft Block Time					
Engine On	14:50	Ramp Out		Takeoff	15:10
Engine Off	20:58	Ramp In		Landing	20:46
Total	6.1 **hrs**	Total	**hrs**	Total	5.6 **hrs**

Mission Plan			
AGL Height	2300 **m**	Pulse Rep Rate	400 **kHz**
Ground Speed	160 **kts**	Scan Rate	89 **Hz**
Laser Current	100 **%**	FOV	60 **Deg's**

Static Alignment	GPS Time	
	Start	End
Pre Mission	15:03	15:08
Post Mission	20:51	20:56

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Ln Aborted	Date Stamp	ALS Time Stamp	Comments
			Start	End	Time			
PPP-8	-		15:38	15:43			-	Figure 8
3001	6420090-01	350°	15:54	10:02			155444	
3002	02	170°	16:04	16:11			160450	
3003	03	350°	16:14	16:28			161456	
3004	04	170°	16:31	10:44			163100	small patches of snow at south end
3005	05	350°	16:49	17:02			164904	small patches of snow at south end
3006	06	170°	17:06	17:20			170647	small patches of snow at south end
4003	07	170°	17:26	17:40			172631	
4002	08	350°	17:45	17:54			174528	small patches of snow
4001	09	170°	17:58	18:08			175826	small patches of snow
X-TIE	10	80°	18:11	18:13			181127	
4004	11	350°	18:20	18:33			182007	
3007	12	350°	18:39	18:52			183902	small patches of snow at south end
3008	13	170°	18:56	19:10			185617	
3009	14	350°	19:13	19:27			191341	

Julian Day	090	Flt	A

LIDAR Flight Log

Date	March 30, 2020	Aircraft	CFKMA
Project	3186 QSI Powder River	Pilot	N. Emson
Location	Sheridan, WY	Operator	B. Eisenbart
Mission Objective			

System	1560
Unit	64
IMU	**Applanix AP60**
GPS Rx	**Trimble**
Scanner 1 Drive	1
Scanner 2 Drive	2

Additional Notes

Powder River 2 MOA closed today
Limited to the west end of block

Aircraft Block Time					
Engine On	14:50	Ramp Out		Takeoff	15:10
Engine Off	20:58	Ramp In		Landing	20:46
Total	6.1 **hrs**	Total	**hrs**	Total	5.6 **hrs**

Mission Plan			
AGL Height	2300 **m**	Pulse Rep Rate	400 **kHz**
Ground Speed	160 **kts**	Scan Rate	89 **Hz**
Laser Current	100 **%**	FOV	60 **Deg's**

Static Alignment	GPS Time	
	Start	End
Pre Mission	15:03	15:08
Post Mission	20:51	20:56

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Ln Aborted	Date Stamp	ALS Time Stamp	Comments
			Start	End	Time			
3010	15	170°	19:30	19:44		200330	193038	
3011	16	350°	19:48	20:01			194801	
X-TIE	17	260°	20:14	20:18			201434	
PPP-8	-		20:19	20:24			-	Figure 8

Julian Day	091	Flt	A

LIDAR Flight Log

AIRBORNE IMAGING INC

Date	March 31, 2020	Aircraft	CFKMA
Project	3186 QSI Powder River	Pilot	N. Emson
Location	Sheridan, WY	Operator	B. Eisenbart
Mission Objective			

System	1560
Unit	64
IMU	**Applanix AP60**
GPS Rx	**Trimble**
Scanner 1 Drive	1
Scanner 2 Drive	2

Additional Notes

Aircraft Block Time					
Engine On	14:45	Ramp Out		Takeoff	15:03
Engine Off	18:43	Ramp In		Landing	18:31
Total	4.0 **hrs**	Total	**hrs**	Total	3.5 **hrs**

Mission Plan			
AGL Height	2300 **m**	Pulse Rep Rate	400 **kHz**
Ground Speed	160 **kts**	Scan Rate	89 **Hz**
Laser Current	100 **%**	FOV	60 **Deg's**

Static Alignment	GPS Time	
	Start	End
Pre Mission	14:55	15:00
Post Mission	18:35	18:40

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Ln Aborted	Date Stamp	ALS Time Stamp	Comments
			Start	End	Time			
PPP-8	-		15:28	15:33			-	Figure 8
3030	6420091-01	350°	15:37	15:50		200331	153722	
3029	02	170°	15:54	16:08			155444	
3028	03	350°	16:12	16:43			161215	
3027	04	170°	16:29	16:43			162917	virga on the south end of line - refly
X-TIE	05	260°	16:47	16:49			164725	
X-TIE	06	80°	16:52	16:54			165211	reflew X-TIE
4068	07	171°	17:08	17:12			170808	
4067	08	351°	17:15	17:19			171527	
4066	09	171°	17:22	17:34			172250	patches of snow at south end - refly
X-TIE	10	261°	17:48	17:50			174841	clouds moving in from the west
PPP-8	-		17:50	17:55			-	Figure 8

Julian Day 113	Flight A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date 4/22/2020	Aircraft CFFRY
Project 3186_QSI_PowderRiver_QL2	Pilot J.MATHIESON
Location KSHR	Operator C.EDGAR
Mission Objective Weather: KAR location:	

System VQ-1560I
Unit 38
IMU Applanix
GPS Rx Trimble
Scanner 1 Drive
Scanner 2 Drive

Additional Notes

29.1 - today = hrs to 100hr

Time to next maintenance: _____ ☐ 50 hr ☐ 100 hr

Aircraft Block Time		
Engine On 14:53	Takeoff 15:12	
Engine Off 21:56	Landing 21:44	
Total 7.1 hrs	Total 6.5 hrs	

Mission Plan			
AGL Height 2000	m	Pulse Rate 500	
Target Speed 160	kts	Scan Rate 109Hz	
Laser Current 100	%	FOV 60	degs

Static Alignment	GPS Time	
	Start	End
Pre Mission	14:56	15:01
Post Mission	21:49	21:54

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID Time Stamp 200422	Comments
			Start	End	Time	nmi to End		
TEST			1516	1516			161538	
F8			1533	1538				
XTIE			1538	1548			153905	
3027			1552	1606			155257	
3026			1610	1623			161002	
3025			1626	1639			162625	
3024			1643	1657			164316	
3023			1700	1714			170002	
3022			1716	1730			171635	
3021			1732	1745			173042	
3020			1748	1801			174858	
3019			1806	1819			180603	
3018			1822	1836			182249	
3017			1839	1852			183922	
3016			1856	1910			185604	

Julian Day 113	Flight A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date 4/22/2020	Aircraft CFFRY
Project 3186_QSI_PowderRiver_QL2	Pilot J.MATHIESON
Location KSHR	Operator C.EDGAR
Mission Objective Weather: KAR location:	

System VQ-1560I
Unit 38
IMU Applanix
GPS Rx Trimble
Scanner 1 Drive
Scanner 2 Drive

Additional Notes

Time to next maintenance: _____ ☐ 50 hr ☐ 100 hr

Aircraft Block Time		
Engine On 14:53	Takeoff 15:12	
Engine Off 21:56	Landing 21:44	
Total 7.1 hrs	Total 6.5 hrs	

Mission Plan			
AGL Height 2000	m	Pulse Rate 500	
Target Speed 160	kts	Scan Rate 109Hz	
Laser Current 100	%	FOV 60	degs

Static Alignment	GPS Time	
	Start	End
Pre Mission	14:56	15:01
Post Mission	21:49	21:54

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID Time Stamp 200422	Comments
			Start	End	Time	nmi to End		
3015			1912	1925			191222	
3014			1928	1943			192834	
3013			1945	1959			194509	
3012			2001	2015			200123	
3008			2017	2030			201752	
3007			2034	2047			203409	
3006			2050	2103			205043	
F8			2104	2109				

Project	USGS Ravalli Granite Custer Powder River																					
Date	Mission ID	Sensor	Aircraft Make/Model	Aircraft Tail Number	Project Name	Flight Plan	Lines Flown	Flight 1 Wheels Up (PDT)	Flight 1 Wheels Down (PDT)	Flight 1 Begin Hobbs	Flight 1 End Hobbs	Flight 1 Total Hobbs	Flight 2 Wheels Up	Flight 2 Wheels Down	Flight 2 Begin Hobbs	Flight 2 End Hobbs	Flight 2 Total Hobbs	Daily Hobbs Total	Operator	Pilot	Base of Operations (airport	Notes
4/20/2020	20200420_SN3546	Riegl VQ-1560i SN3546	Cessna Caravan 208B	704MD	MT Counties R035553	USGS Ravalli County QL2	26-32	10:52:00 AM	5:18:00 PM	14429.3	14434.8	5.5	5:58:00 PM	6:51:00 PM	14434.8	14435.6	0.8	6.3	Stephanie Cohee	Brian Butler	KGTF	We finally got our weather window today! We acquired what we could of the Ravalli
5/9/2020	2020509_SN3546	Riegl VQ-1560i SN3546	Cessna Caravan 208B	704MD	MT Counties R035553	USGS_RavalliCounty_QL2	26-32	10:29:00 AM	2:29:00 PM	14493.4	14497.3	3.9						3.9	Scott White	Chris Gattman	KGTF	Looked like the clouds were lifting in our priority area but around 10 they closed back in fast. Ravalli by Missoula looked clear so we gave it a go. Lots of clouds around but we at least got a handful of lines in after we ran out of cloud free lines.
5/30/2020	20200530_SN4045	Riegl VQ-1560ii SN4045	Cessna Caravan 208	208JA	MT Counties R035553	USGS_MTCounties_Base_QL2_fieldlog	79-86	8:42:00 AM	12:51:00 AM	7997	8001.1	4.1						4.1	Noah Edelson	Chris Gattman	KBTM	Flew a few lines before we got clouded out.
6/1/2020	20200601_SN4045	Riegl VQ-1560ii SN4045	Cessna Caravan 208	208JA	MT Counties R035553	USGS_MTCounties_Base_QL2_fieldlog	87-89, 110-116	9:02:00 AM	11:36:00 AM	8001.1	8003.7	2.6						2.6	Noah Edelson	Chris Gattman	KBTM	Started where we left off Saturday and flew three lines before small clouds started popping up in the way and it looked like there were a few patches of snow in the next line. Then we switched to another block that was cloud and snow free and few a few more lines before clouds drifted in with poor weather quickly approaching called it a day.
6/2/2020	20200602_SN4045	Riegl VQ-1560ii SN4045	Cessna Caravan 208	208JA	MT Counties R035553	USGS_MTCounties_BaseAddon_QL1_Fieldlog. USGS_RavalliCounty_QL2_R035553_FieldLog	QL1 base 296-308, 312-322, QL2 Ravalli 33-35	9:06:00 AM	2:54:00 PM	8003.7	8009.5	5.8						5.8	Noah Edelson	Chris Gattman	KMSO	Got in a full lift of data collection today! Our first target AOI still had scattered clouds when we arrived so we began work on our second choice AOI. The clouds dissolved with us as we flew lines progressing east before bumping into the snow line, then worked west until unstable air coming off the mountains became too much. Flew a few Ravalli lines on the way to Missoula to end the day as our new base.
6/3/2020	20200603_SN4045	Riegl VQ-1560ii SN4045	Cessna Caravan 208	208JA	MT Counties R035553	USGS_MTCounties_R035553_Fieldlog	Base QL2 87-88	9:32:00 AM	11:59:00 AM	8009.5	8012	2.5						2.5	Noah Edelson	Chris Gattman	KMSO	Arrived on station to find partly cloudy skies, tried a few different blocks and were unable to fly more than one line in each. Flew two refly lines for this mission a few hundred feet below planned to fly below clouds, encountered heavy turbulence and decided to head back to base.
6/5/2020	20200605_SN4045	Riegl VQ-1560ii SN4045	Cessna Caravan 208	208JA	MT Counties R035553	USGS_MTCounties_R035553_Fieldlog	BaseQL2 49-56, 90-91, 117-123	9:11:00 AM	2:08:00 PM	8013	8017.9	4.9	4:27:00 PM	6:35:00 PM	8017.9	8021.1	3.2	8.1	Noah Edelson	Chris Gattman	KUAO	We flew most of the snowfree lines in the northern section of Base QL2 before returning to KMSO to pack up our things and flew to KUAO to prep for upcoming maintenance.
6/23/2020	20200623_SN3061	Riegl VQ-1560i SN3061	Cessna Caravan 208B	840JA	MT Counties R035553	USGS_RavalliCounty_QL2	1-10, 123, 124	7:30:00 AM	12:38:00 PM	2123	2127.8	0.6	5:51:00 PM	7:12:00 PM	2131.6	2133.2	1.6	2.2	Erin Guillory	Tyler Ledeboer	KHLN	We collected on USGS MT QL2 until we ran out of snow free area.
6/26/2020	20200626_SN3061	Riegl VQ-1560i SN3061	Cessna Caravan 208	840JA	MT Counties R035553	USGS_MontanaCounties_Base_QL2	11-20, 30-32, 36-39, 57-67, 108,109	8:53:00 AM	2:55:00 PM	2137.6	2143.6	6.0						6.0	Scott White	Nathan Sharp	KMSO	Got a good lift in targeting whatever was snow and cloud free.
7/22/2020	20200722_SN4040	Riegl VQ-1560i SN4040	Piper Navajo	22GE	MT Counties R035553	flight 1 adama, flight 2 montana counties	1071-1077 48,49,50 adams. 21-24 montana	9:00:00 AM	11:29:00 AM	10713.1	10715.5	2.4	1:06:00 PM	2:47:00 PM	10715.5	10717.2	1.7	4.1	Mark Smith	Alex Sessions	KMSO	none
7/23/2020	20200723_SN4040	Riegl VQ-1560i SN4040	Piper Navajo	22GE	MT Counties R035553	montana counties	25,34,142-144, 124, 125	8:50:00 AM	10:42:00 AM	10717.1	10718.8	1.7						1.7	Mark Smith	Alex Sessions	KMSO	none
7/25/2020	N4040 A & 2020072	Riegl VQ-1560i SN4040	Piper Navajo	22GE	MT Counties R035553	Montana counties	13-25, 36-42	8:30:00 AM	12:29:00 PM	10719.4	10723.2	3.8	1:47:00 PM	4:30:00 PM	10723.2	10725.8	2.6	6.4	Mark Smith	Alex Sessions	KMSO	none
7/26/2020	20200726_SN4040	Riegl VQ-1560i SN4040	Piper Navajo	22GE	MT Counties R035553	Montana counties	43-49 1-12	8:33:00 AM	1:16:00 PM	10725.8	10730.4	4.6						4.6	Mark Smith	Alex Sessions	KMSO	completed Ravalli block.
7/28/2020	20200728_SN3546	Riegl VQ-1560i SN3546	Cessna Caravan 208B	704MD	MT Counties R035553	Addon	231-233, 284-296, 309-312, 422-431	8:36:00 AM	2:56:00 PM	7687	7693.2	6.2						6.2	Ben Miller	Dan Luckett	KMSO	Launched for Addon adn had areas of rain to contend with, flew around all of the nw aoi that had snow.
7/29/2020	20200729_SN3546	Riegl VQ-1560i SN3546	Cessna Caravan 208B	704MD	MT Counties R035553	USGS_MTCounties_Base_addon_QL1	55-71, 323-328, 387-401	8:36:00 AM	2:09:00 PM	7693.2	7698.6	5.4						5.4	Ben Miller	Dan Luckett	KMSO	Launched for MT counties addon and acquired without incident until rained out. RTB
7/30/2020	20200730_SN3546	Riegl VQ-1560i SN3546	Cessna Caravan 208B	704MD	MT Counties R035553	USGS_MTCounties_Base_addon_QL1	327, 329-333, 355-389	7:36:00 AM	2:55:00 PM	7698.6	7705.8	7.2						7.2	Ben Miller	Dan Luckett	kmso	Launched early to try and beat the clouds and first aoi had fog on it, continued where we left off completing one aoi and working another. No issues.
7/31/2020	20200731_SN3546	Riegl VQ-1560i SN3546	Cessna Caravan 208B	704MD	MT Counties R035553	QL1	190-215, 334-354	7:29:00 AM	3:07:00 PM	7705.8	7713.4	7.6						7.6	Ben Miller	Dan Luckett	kmso	Launched for QL1, acquired with no issues
8/1/2020	20200801_SN3546	Riegl VQ-1560i SN3546	Cessna Caravan 208B	704MD	MT Counties R035553	QL1, QL2	QL1 216-232, QL2 26-30, 33, 35, 40-48, 68-73	7:49:00 AM	2:55:00 PM	7713.4	7720.3	6.9						6.9	Ben Miller	Dan Luckett	kmso	Launched for QL1 and QL2, acquired without incident, snow on peaks.
8/2/2020	20200802_SN3546	Riegl VQ-1560i SN3546	Cessna Caravan 208B	704MD	MT Counties R035553	QL2	92-107, 125	7:34:00 AM	12:25:00 PM	2720.3	2725	4.7						4.7	Ben Miller	Dan Luckett	KMSO	Launched for remaining QL2 blocks and were clouded out after the first block completed. Trackair aborted two lines that were reflown, and after acquiring, had channel 2 com error. Sys doc and compressed folder on operator uploads.
8/3/2020	20200803_SN3546	Riegl VQ-1560i SN3546	Cessna Caravan 208B	704MD	MT Counties R035553	QL2	125-141	7:31:00 AM	10:57:00 AM	7725	7728.3	3.3						3.3	Ben Miller	Dan Luckett	kmso	Launched for remaining snow free lines, no issues

8/21/2020	20200821_SN3546	Riegl VQ-1560i SN3546	Cessna Caravan 208B	704MD	MT Counties R035553	USGS MT Counties QL1 addon R035553	270-281	9:20:00 AM	11:28:00 AM	14790.9	14794.5	3.6						3.6	Spencer Beck	Chris Gattman	KMSO	One lift for MT Counties addon QL1. We left Kallspell in the morning and MOBed to the project near Missoula. We flew on line for a little over two hours, until around 11:30 when the turbulence in the mountains got really bad. We were unable to stay on line so we landed in Missoula. There is some haze in the area from fires, but nothing too significant.
8/22/2020	20200822_SN3546	Riegl VQ-1560i SN3546	Cessna Caravan 208B	704MD	MT Counties R035553	USGS MT Counties Base QL1 Addon, and Base QL2	QL1 addon: 409-421 QL2: 74-78	7:28:00 AM	12:39:00 PM	14794.5	14799.7	5.2						5.2	Spencer Beck	Chris Gattman	KMSO	One lift for USGS MT Counties. We collected data on MT Counties Base QL2 and completed this block today. There was a lot of smoke in the area but the terrain was visible. After finishing that block we worked on some of the E-W lines of the Base QL1 Addon block. The smoke was slightly better in this area. There were some small patches of snow on the peaks. We stopped collecting data when the wind became stronger and it was hard to maintain the proper groundspeed.
8/23/2020	20200823_SN3546	Riegl VQ-1560i SN3546	Cessna Caravan 208B	704MD	MT Counties R035553	USGS MT Counties Base QL1 Addon 8ppsm	248-269	7:52:00 AM	12:15:00 PM	14799.7	14804.4	4.7						4.7	Spencer Beck	Chris Gattman	KMSO	One lift for MT Counties Base QL1 Addon. We flew just over half of a full lift on this project today before turbulence became too bad and we returned to base. There was smoke in the area but not nearly as much as the day before. Smoke seemed to be getting worse later in the day.
8/26/2020	20200826_SN4046	Riegl VQ-1560ii SN4046	Cessna Caravan 208B	604MD	MT Counties R035553	USGS MTCounties Base addon QL1	236-247, 402-408	9:29:00 AM	1:39:00 PM	4951.5	4955.6	4.1						4.1	Scott White	Jamon Neilson	KMSO	Got lucky and dodged early fog and clouds in order to just finish up the Mt Counties base project.

Project	USGS Ravalli Granite Custer Powder River																						
Date	Mission ID	Sensor	Aircraft Make/Model	Aircraft Tail Number	Project Name	Flight Plan	Lines Flown	Flight 1 Wheels Up (PDT)	Flight 1 Wheels Down (PDT)	Flight 1 Begin Hobbs	Flight 1 End Hobbs	Flight 1 Total Hobbs	Flight 2 Wheels Up	Flight 2 Wheels Down	Flight 2 Begin Hobbs	Flight 2 End Hobbs	Flight 2 Total Hobbs	Daily Hobbs Total	Operator	Pilot	Base of Operations (airport, KXXX)	Notes
6/24/2020	20200624_SN3061A	Riegl VQ-1560i SN3061	Cessna Caravan 208	840JA	MT Counties R035553	USGS_MontanaCounties_Base_QL1	18-20	9:00:00 AM	12:00:00 PM	2131.6	2134.5	2.9					0.0	2.9	Erin Guillory	Tyler Ledeboer	KHLN	Went up to scout out AOIs around Bozeman. Snow at elevation and small patches on the lower levels prevented much collected. MOB'd all the way south to West Yellowstone, were able to collect a few lines but scattered patches at the south end
7/25/2020	20200725_SN3546A	Riegl VQ-1560i SN3546	Cessna Caravan 208B	704MD	MT Counties R035553	Adams Navajo and Adams QL1, then MT Counties addon	1069: 126-128: 478-502	10:12:00 AM	4:55:00 PM	7667.3	7673.8	6.5					0.0	6.5	Ben Miller	Dan Luckett	KMSO	Launched for MT Counties addon. We acquired without incident other than heavy turb and a tiny bit of snow.
7/26/2020	20200726_SN3546A1 & A2	Riegl VQ-1560i SN3546	Cessna Caravan 208B	704MD	MT Counties R035553	MTCounties_Base_addon	460-477	8:45:00 AM	3:07:00 PM	7673.8	7680.1	6.3					0.0	6.3	Ben Miller	Dan Luckett	KMSO	Launched for southern addon lines, riacquired crashed from a buffer error, restarted riacquire and reflew two lines.
7/27/2020	20200727_SN4040B	Riegl VQ-1560i SN4040	Piper Navajo	22GE	MT Counties R035553	MT Counties	175-191	8:00:00 AM	9:48:00 AM	10730.4	10731.5	1.1	10:24:00 AM	1:32:00 PM	10731.5	10734.4	2.9	4.0	Christopher Sanchez	Matthew Archambault	KMSO	Good flight, no issues to report.
7/27/2020	20200727_SN3546A	Riegl VQ-1560i SN3546	Cessna Caravan 208B	704MD	MT Counties R035553	Addon	432-459	9:05:00 AM	4:09:00 PM	7680.1	7687	6.9					0.0	6.9	Ben Miller	Dan Luckett	KMSO	Launched for MT Counties addon no issues
7/28/2020	20200728_SN4040A	Riegl VQ-1560i SN4040	Piper Navajo	22GE	MT Counties R035553	MT Counties	192-206	9:06:00 AM	12:29:00 AM	10734.4	10737.5	3.1					0.0	3.1	Christopher Sanchez	Matthew Archambault	KBZN	Flew lines near KBZN. Clouds above flight plan altitude and virga just outside the AOI, no rain hit the windshield so data should be good.
7/29/2020	20200729_SN4040A & B	Riegl VQ-1560i SN4040	Piper Navajo	22GE	MT Counties R035553	MTCounties_Base_QL1_navajo	206-234	9:18:00 AM	11:30:00 AM	10737.5	10740.3	2.8	12:18:00 PM	2:01:00 PM	10740.3	10742	1.7	4.5	Christopher Sanchez	Matthew Archambault	KBZN	Thunderstorms forming in AOI cut second mission short.
8/4/2020	20200804_SN3546A	Riegl VQ-1560i SN3546	Cessna Caravan 208B	704MD	MT Counties R035553	QL1 Navajo	1-40, 66-77	7:40:00 AM	2:41:00 PM	7728.3	7735.2	6.9					0.0	6.9	Ben Miller	Dan Luckett	KBZN	Launched from KMSO and started acquiring QL1 Navajo. No issues, heavy turb.
8/5/2020	20200805_SN3546A	Riegl VQ-1560i SN3546	Cessna Caravan 208B	704MD	MT Counties R035553	QL1 Navajo	41-65, 78-104	7:41:00 AM	2:26:00 PM	7735.2	7741.8	6.6					0.0	6.6	Ben Miller	Dan Luckett	KBZN	Continued on QL1 Navajo slated for 704 MD.
8/7/2020	20200807_SN3546A	Riegl VQ-1560i SN3546	Cessna Caravan 208B	704MD	MT Counties R035553	MT Counties R035553	298-310	9:42:00 AM	12:04:00 PM	14741.8	14744.1	2.3					0.0	2.3	Miranda Geller	Chris LaRosa	KBZN	Great day for a lift, but lots of turb
8/8/2020	20200808_SN3546A &B	Riegl VQ-1560i SN3546	Cessna Caravan 208B	704MD	MT Counties R035553	MT Counties R035553	244-297	7:36:00 AM	12:16:00 PM	14744.1	14748.8	4.7	1:50:00 PM	4:45:00 PM	14748.8	14751.7	2.9	7.6	Miranda Geller	Chris LaRosa	KBZN	Great day, got out early to avoid turb. 2 missions.
8/9/2020	20200809_SN3546A	Riegl VQ-1560i SN3546	Cessna Caravan 208B	704MD	MT Counties R035553	MT Counties R035553	136-174	7:33:00 AM	12:30:00 PM	14751.7	14756.6	4.9					0.0	4.9	Miranda Geller	Chris LaRosa	KBZN	Finished last block with 22GE, only 3 lines remain in entire area
8/9/2020	20200809_SN4040A	Riegl VQ-1560ii SN4040	Piper Navajo	22GE	MT Counties R035553	MTCounties_Base_QL1_navajo	121-132	7:26:00 AM	9:48:00 AM	10760.6	10762.8	2.2	1:06:00 PM	2:17:00 PM	10762.8	10763.5	0.7	2.9	Christopher Sanchez	Matthew Archambault	KBZN	Flew lines on MT Counties, ran into clouds with three lines left. Matt needed to do IFR approaches, so I went up with Matt and Tyler just in case the area was clear. Ran into clouds again.
8/10/2020	20200810_SN4040A	Riegl VQ-1560ii SN4040	Piper Navajo	22GE	MT Counties R035553	MTCounties_Base_QL1_Navajo	133-135	10:06:00 AM	11:03:00 AM	10763.5	10764.5	1.0					0.0	1.0	Christopher Sanchez		KBZN	Flew last three lines of block.
8/17/2020	20200817_SN4040A &B	Riegl VQ-1560ii SN4040	Piper Navajo	22GE	MT Counties R035553	mt counties QL1 navajo	192-210	9:05:00 AM	11:41:00 AM	10780.5	10783.1	2.6	12:51:00 PM	1:57:00 PM	10783.1	10784.2	1.1	3.7	Annie Pastemack	Alex Sessions	KBZM	moved to BZM to refly counties project
8/18/2020	20200818_SN4040A	Riegl VQ-1560ii SN4040	Piper Navajo	22GE	MT Counties R035553	mt counties QL1 navajo 1560i	104-117, 211-218	8:21:00 AM	11:39:00 AM	10784.2	10787.5	3.3					0.0	3.3	Annie Pastemack	Alex Sessions	KBZN	continued on reflys, afternoon storms kept us from a second lift
8/23/2020	20200823_SN3546A	Riegl VQ-1560i SN3546	Cessna Caravan 208B	704MD	MT Counties R035553	USGS MT Counties Base QL1 Addon 8ppsm	248-269	7:52:00 AM	12:15:00 PM	14799.7	14804.4	4.7					0.0	4.7	Spencer Beck	Chris Gattman	KMSO	One lift for MT Counties Base QL1 Addon. We flew just over half of a full lift on this project today before turbulence became too bad and we returned to base. There was smoke in the area but not nearly as much as the day before. Smoke seemed to be getting worse later in the day.
8/26/2020	20200826_SN4040A	Riegl VQ-1560i SN4040	Piper Navajo	22GE	MT Counties R035553	MT counties QL1 Navajo 35553	219-226	9:45:00 AM	11:07:00 AM	10788.4	10789.8	1.4					0.0	1.4	Annie Pastemack	Greg Simonds	KBZN	finally got a little done today, visibility continues to be a challenge.
8/28/2020	20200828_SN4040A	Riegl VQ-1560i SN4040	Piper Navajo	22GE	MT Counties R035553	MT counties QL1 Navajo 35553	227-243	9:40:00 AM	12:07:00 PM	10789.8	10792.2	2.4					0.0	2.4	Jonathon Swan	Greg Simonds	KBZN	Flew until Clouds prevented further ACQ. Clouds lingered in remaining AOIS for the rest of the day.
8/28/2020	20200828_SN4046A	Riegl VQ-1560ii SN4046	Cessna Caravan 208B	604MD	MT Counties R035553	BaseQL1_MT_Cty_MSO_reflies	1-11	9:31:00 AM	2:55:00 PM	4950.6	4965.7	5.1						5.1	Scott White	Jamon Neilson	KMSO	Re flew MT County Base QL1 lines
8/29/2020	20200829_SN4040A	Riegl VQ-1560i SN4040	Piper Navajo	22GE	MT Counties R035553	Same as Yesterdays entry and BaseQL1_MT_Cty_BZN reflies	118-121 and 1-25 on the reflight plan	8:30:00 AM	12:18:00 PM	10792.2	10795.9	3.7					0.0	3.7	Jonathon Swan	Greg Simonds	KBZN	One lift today to finish the 35553 QL1 lines in addition to the reflights flight plan sent by SV.