Lidar Project Quality Assurance Report
Washington Geologic Survey
Project: Asotin 2023

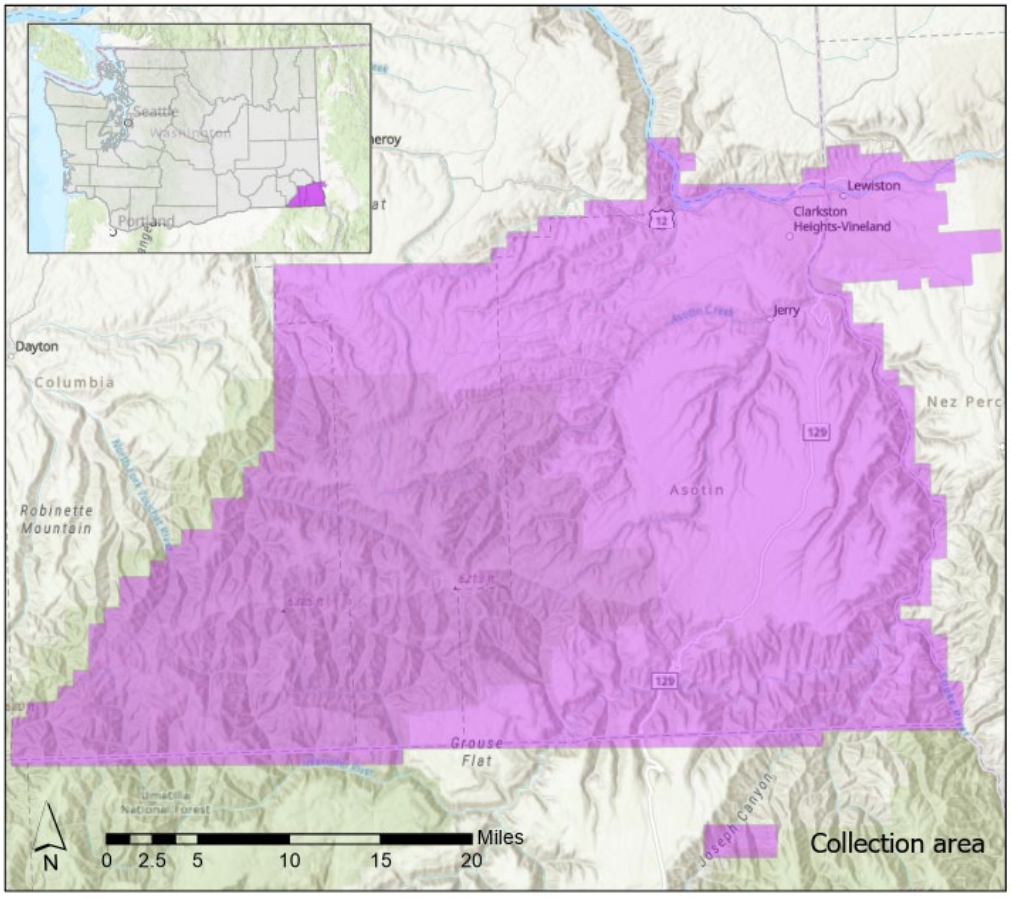

Figure 1: Location map and area extent for the Asotin 2023 lidar project

Project Summary:

The Washington Geological Survey (WGS) was awarded the opportunity to work with FEMA through the Cooperating Technical Partners (CTP) program to collect Asotin County in Washington and Lewiston, ID. The purpose of the collection was to provide for updated flood mapping as well as consistent data for the Lewiston/Clarkston urban area. The WGS added portions of Garfield and Columbia Counties that were previously collected at the 'Quality Level 2' (QL2) specification in order to update the area to the QL1 specification and achieve more regional mapping consistency. The lower elevation areas were collected in March 2023, while higher elevations were collected after snow melt in June 2023.

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Date Received: 9/25/2023	Review Date: 10/12/2023
QA document version: 1.2	Vendor: NV5 Geospatial Inc
Coverage Area: 1201.54 square miles	PASS
☒ For QA/DNR Contract	☐ Historical Review ☐ Other source:
Project QA Summary by Section ("X" in box indicates meeting WGS standards):	
☒ Survey report (Section 1) ☒ Deliverables (Section 2) ☒ DEMs (Section 3) ☒ Intensity images (Section 4) ☒ Point clouds (Section 5)	

Remaining Issues:

Section 1: Survey Report

The WGS reviews the survey report and any documentation supplied by the vendor or originating agency. For full details, please refer to any original report or metadata. Some information is reported below for context and for QA comparison. Page numbers refer to any original lidar report PDF.

Collection dates: 3/18/2023 – 6/26/2023		
☒ **Projection**	Original projection information Projection: WASP South Horizontal Datum: NAD83 (HARN) Vertical Datum: NAVD88 Geoid: 12b Units : US Survey Feet	Page : 2
☒ **Washington Surveyor Cert.**	Reported on:	Page : 28
☒ **Vendor Absolute accuracy assessment, from GCO**	Reported vertical accuracies Average: -0.008 ft RMSE: 0.091 ft Standard Deviation: 0.093 ft Number or check points: 28	Page : 20
☒ **Vendor reported point density**	Reported average point densities First return: 18.20 points/m^2 Ground returns: 6.54 points/m^2	Page : 17

Comments on Section 1:

Section 2: Original Deliverables

For WGS collection projects, this section notes whether contracted deliverables are present and note if any additional products were delivered. For historical datasets, the section inventories what datasets were received and whether that matches with documentation.

☒ **Deliverables match survey report list** **Summary of deliverables reported by vendor on Page 2**	**Deliverables present:** ☒ **point clouds files** **LAS** ☒ **bare earth DEM** **TIFF** ☒ **top surface DEM** **TIFF** ☒ **intensity images** **TIFF** ☒ **tile index** ☒ **survey report** ☒ **GCP points** **Other: Flightline overlap raster, breaklines, metadata, flightline, flight swaths, SBETs**

Comments on section 2:

Section 3: DEMs

The WGS reviews the DEMs for voids, classification errors, and anomalies. Other regional lidar collections and DEMS are compared (typically by subtracting one from the other) to determine how well the ground measurements match. Ground control points from the Washington network or other ground control points taken in the area are used to assess absolute accuracy. Additionally, if LAS points are available, a WGS derived DEM from the points are compared to the vendor DEM to look for classification errors or other anomalies.

☒ **All tiles present/readable**	**Number of delivered bare earth tiles: 1860** **Number of delivered top surface tiles: 1860**
☒ **Merge tiles:**	verified
☒ **No internal voids**	verified
☒ **Visual check of Rasters** **Look for : Seams, Spikes, Pits, Scanlines, Noise, Miss-classification, Missing or partial tiles, Extrapolated corners or edges**	Artifacts found reported as: Case A – Single DSM spike Case B –one case of cliff anomaly > 200 feet
☒ **Height difference check (top surface minus bare earth)** **Delivered Top Surface**	Average difference: 9.246 Min/max: 0.0 / 353.47 Standard deviation: 22.35 Outliers: > 200 ft Towers, power lines, trees Single occurrence of Case A and Case B
☒ **Comparison to reference DEM** **LiDAR DEM: columbia_garfield_walla_2018**	Overlap: 38.44 % 461.9 Sq Miles Average: 0.1211 Min/max: -132.666 / 76.617 Standard deviation: 1.337
☒ **Delivered DEM Compare to LAS Derived DEM** ☐ **N/A (no LAS)**	Average: -0.0199 Min/max: -69.6 / 90.4 Standard deviation: 0.909 Outliers:
☒ **Vertical Absolute accuracy GCP check**	GCPs used: ☒ Vendor ☒ Other: Average: -0.032 Abs Average: 0.0859 Min/max: -1.189 / 0.487 Standard Deviation: 0.13 RMSE = 0.1329 Number of check points: 1421
☒ **Hydro treatment complete** ☐ **N/A**	Type of hydro treatment: ☒ hydro flattening ☐ hydro enforcement
☒ **QA Script Run Successful**	
☒ **Swath Separation passed visual inspection**	

Comments on section 3:

- See Case A and Case B at the end of the report. A single detectable occurrence of each.

Section 4: Intensity Images

If intensity images are provided, WGS reviews them to make sure all tiles are readable and can merge into a mosaic, and note if there are any anomalies are present such as striping and color imbalance.

☒ **All tiles present/readable** Mosaic and see if OK	**Number of delivered tiles: 1860** **Unsigned 8-bit Integer** Average: 178.43 Min/max: 7 / 255 Standard deviation: 22.16
☒ **merged mosaic visual check**	Passed inspection

Comments on section 4:

Section 5: LAS/LAZ Files

The point cloud files are reviewed for any missing or corrupt tiles, data voids, miss-classification errors, or other anomalies. Point densities for the first return and ground return data is also derived to help determine data quality.

☒ **All tiles present/readable**	**Number of delivered tiles: 1860**
☒ **LAS version (1.2 or 1.4 most common)**	LAS version: 1.4
☒ **Min/max file extents and boundaries valid**	☒ LAS Index ☒ LAS Dataset (ESRI) ☒ Statistics Tables
☒ **No Data Voids**	**Bad Tiles** -
☒ **Visual check of Derived Rasters** **Look for : Missing or partial tiles ,Seams, Spikes, Pits, Scanlines, Noise**	Artifacts found reported as:
☒ **Min/max vertical values**	Min value: 712.63 Max value: 6443.52
☒ **Projection Defined Correctly**	
☒ **Point classification** ☒ **point classification accuracy**	Deviations or comments on point classification:
☒ **Point density (points/Square Meter)**	First return: Mean: 17.83 Max: 1242 Std Dev: 8.90 % >= 8 ppp: 97.26% % with no returns =0.315% Ground returns: Mean: 6.37 Max: 73 Std Dev: 3.83 % >= 2 ppp: 87.73% % with no returns =6.98%
☒ **Header statistics match calculated statistics**	

Comments on section 5:

Case A: Spikes

Noise or other misclassified points can often be found in the Digital Surface Model (DSM), especially if compared to the bare earth surface (or Digital Terrain Model, DTM) in a 'height raster' or normalized DSM (created by subtracting the DTM from the derived DSM). Any pixels in the height raster that are above and below established thresholds are converted to points and each is examined and assigned a cause for the anomaly. These thresholds are set by the location of the project: areas with tall trees have a maximum value of 300 feet, while areas without have a maximum of 200 feet. The minimum value is always -30 feet. Special attention is placed on locating bad pixels caused by classification and processing problems – DSM spikes and DTM pits. Bad edges can also be noted this way, and are used to create new clip polygons to remove these areas from the final raster products.

Of 7742 anomaly points, cliffs caused 5 points (Case B) and trees taller than 200 feet accounted for 2464 points. Towers and silos in town accounted for 4867 points, while power lines had 383 points. A single DSM spike was found consisting of 3 points between 238 and 229 feet high (located at 46.414987N 117.097216W).

Case B: Misclassified Areas along Cliffs

Cliff edges in the bare earth have been a challenge for all vendors in the mountainous terrain of Washington. Typical bare earth algorithms have a tendency to not classify ground points close to cliff edges and bottoms, which essentially "rounds" cliff edges, creating a large height difference between the bare earth model (DTM) and the top surface model (DSM).

Across the project there were 5 pixels identified as height anomalies on cliffs. Height differences ranged from 201 to 203 feet high. The example below is located at: 46.414987N 117.097216W.

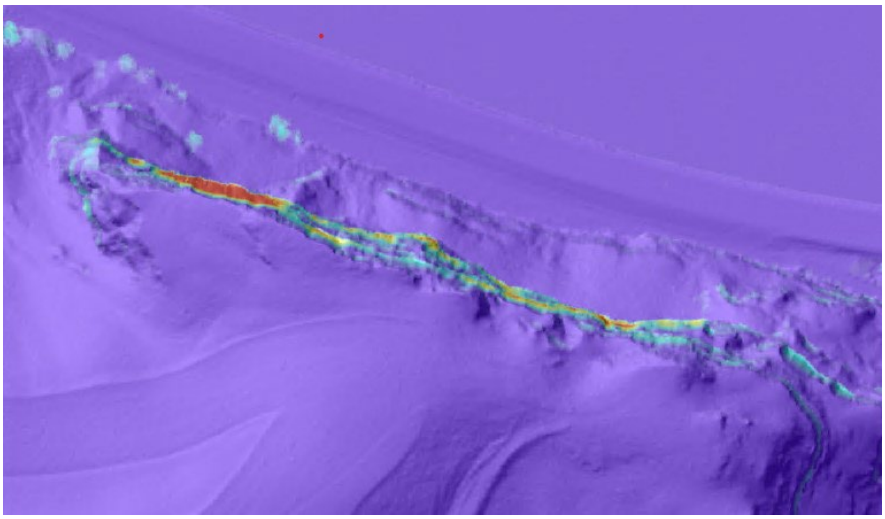

Figure 2: height difference between DSM and DTM. Red and yellow colors indicate a large difference along a cliff area

Other cliffs across this project had many similar issues, but the height model differences were less than 200 feet. Below is an example, showing the DTM and DSM surfaces, along with the lidar point cloud, illustrating this problem.

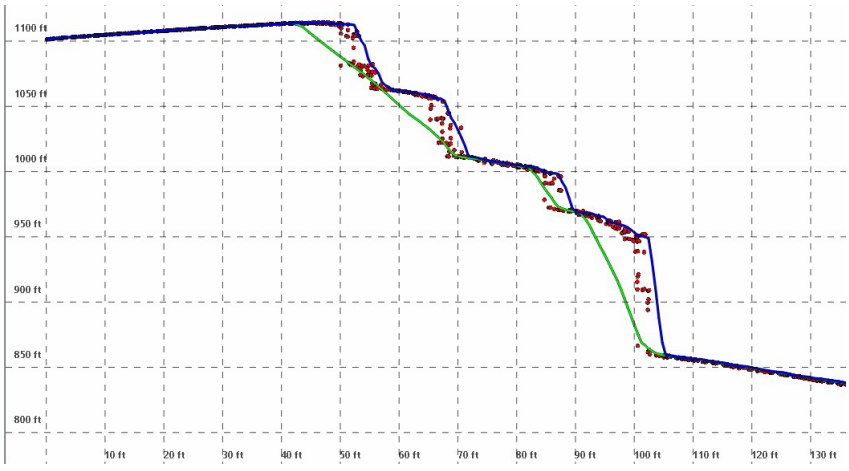

Figure 3: profile across a cliff with green representing the DTM, blue representing the DSM, and red points show the point cloud elevations. The difference between the green and blue profiles show how the DTM is 'rounded' at cliff edges.