Lidar Quality Assurance Report
Version 1.0

Project Summary:

Date Received: 10/25/2022	**Review Date: 11/9/2022**
QA document version: 1.2	PASS
Coverage Area: 1527.0 square miles	
Project QA Summary by Section (“X” in box indicates meeting requirements):	
☒ Survey report (Section 1) ☒ Deliverables (Section 2) ☒ DEMs (Section 3) ☒ Intensity images (Section 4) ☒ Point clouds (Section 5)	

Section 1: Survey Report

The Contractor reviews the survey report and any documentation supplied by the State of Alaska. Some information is reported below for context and use in QA/QC workflow and comparison. Page numbers refer to submitted lidar report for reference.

Collection Start Date:	**Collection End Date:**
☒ **Projection**	Page: 2 Projection: Horizontal Datum: Vertical Datum: Geoid: Units:
☒ **Absolute accuracy assessment**	Reported vertical accuracies Page: 2 0 Average: RMSE: Standard Deviation: Number or check points:
☒ **Reported point density**	Reported average point densities Page: 16 First return: points/m^2 Ground returns: points/m^2

Comments on Section 1:

Section 2: Original Deliverables

This section notes whether contracted deliverables are present and note if any additional products were delivered.

☒ **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: Swath separation raster, Breaklines, Flight line index, Snow classification polygon,**

Comments on section 2:

Section 3: DEMs

Methods for validating DEMs described within.

☐ **All tiles present/readable**	**Number of delivered bare earth tiles:** **Number of delivered top surface tiles:**
☐ **Merge tiles – no overlaps, gaps or edge artifacts**	verified
☐ **No internal voids**	verified
☐ **Cell Size**	verified
☐ **Visual check of rasters** **Look for: Seams, spikes, pits, scanlines, noise, misclassification, missing or partial tiles, extrapolated corners or edges**	Artifacts found reported as: Case A or Case B in report
☐ **Height difference check (top surface minus bare earth)**	Average difference: Min/max: Standard deviation: Outliers:
☐ **Comparison to reference DEM (if provided)** **LiDAR DEM Name:**	Overlap: Average: Min/max: Standard deviation:
☐ **Delivered DEM Compared to LAS Derived DEM** ☐ **N/A (no LAS)**	Average: Min/max: Standard deviation: Outliers:
☐ **Vertical Absolute accuracy GCP check**	GCPs used: Average: Abs Average: Min/max: Standard Deviation: RMSE = Number of check points:
☐ **Hydro treatment complete** ☐ **N/A**	Type of hydro treatment:
	☐ hydro flattening ☐ hydro enforcement

Comments on section 3:

- Case A – DSM Spikes
- Case B – height anomalies on cliffs, from misclassified points

Section 4: Intensity Images

Methods for validating Intensity Images described within.

☐ **All tiles present/readable**	**Number of delivered tiles:** **Unsigned x-bit Integer** Average: Min/max: Standard deviation:
☐ **Merged mosaic visual check**	Passed/failed inspection

Comments on section 4:

Section 5: LAS/LAZ Files

Methods for validating LAS/LAZ described within.

☐ **All tiles present/readable**	**Number of delivered tiles:**
☐ **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/Max values:
☐ **Projection defined correctly**	Projection:
☐ **Point classification schema** ☐ **Point classification accuracy**	Deviations or comments on point classification:
☐ **Point density (points/Square Meter)**	First return: Mean: Max: Std Dev: % >= 8 ppp: Ground returns: Mean: Max: Std Dev: % >= 2 ppp:
☐ **Header statistics match calculated statistics**	

Comments on section 5:

Section 6: Metadata and Tile Schema

XML Metadata format will be provided and validated against State requirements.

☐ **Metadata delivered at directory level**	
☐ **Metadata standards**	
☐ **Tile naming convention**	
☐ **Tile size**	

Comments on section 6:

Case A: Spikes

Noise or other misclassified points can often be found in the DSM, especially if compared to the bare earth surface in a ‘height raster’ (created by subtracting the DTM from the derived DSM, this is also sometime referred to as a normalized DEM, or nDEM). 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 60,644 anomaly points, only 30 were DSM spikes and one was a DSM pit. Cliffs were the cause of another 43,721 points (Case B) and trees taller than 300 feet accounted for 534 points. Power lines were 12,688 points, towers 21 points, and a dam caused 3,166 points.

DSM spikes and noise examples:

- -121.745666, 47.488263 Decimal Degrees, single pixel pit in the DSM, 61 feet deep
- -121.463974, 47.199829 Decimal Degrees, 9 pixels, 371 to 320 feet high

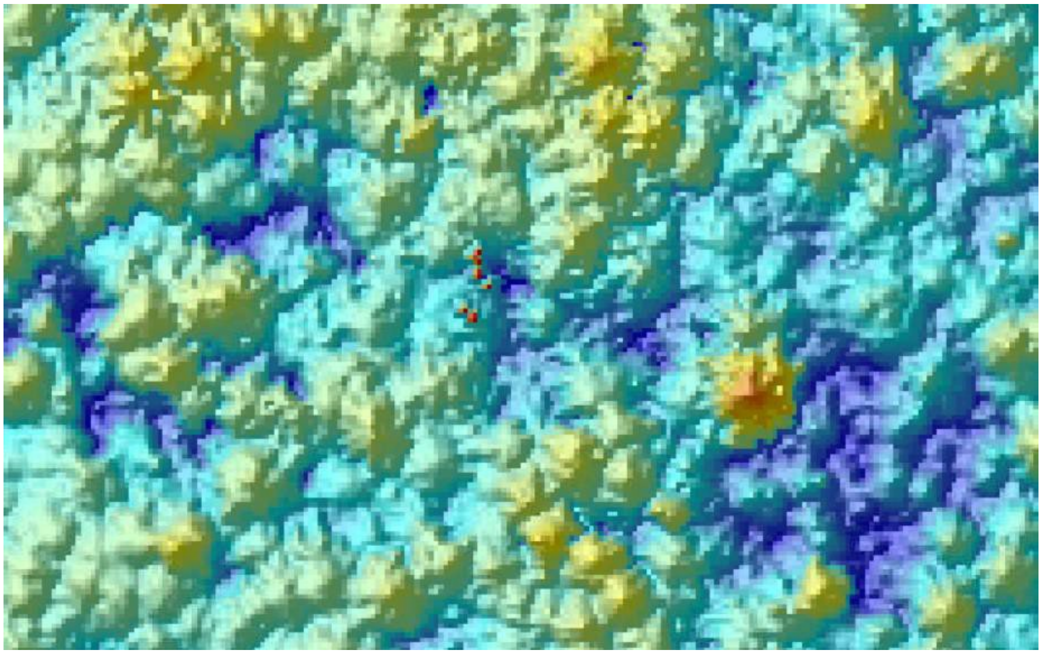

Figure 2: red pixels in the center of the image represent spikes, where noise was misclassified and included in the surface model.

Case B: Misclassified Areas along Cliffs

Cliff edges in the bare earth have been a challenge for all vendors in the mountainous terrain of Alaska. 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). In this project, cliff edges shift in the DSM, making it much higher than the DTM, when this area should be identical on the bare cliff. These points are first returns, but not classified as ground returns, and therefore used to generate the DSM but not the DTM.

Across the project there were 43,721 pixels identified as height anomalies on cliffs. Height differences ranged from -253 to 663 feet high. 18,588 of these points were less than -30 feet deep, while 25,133 were taller than 300 feet. The total number of points, and that so many were negative values, is significantly different than previous lidar projects. WGS has determined that this is due to the higher resolution of the dataset. At 1.5 ft resolution rather than the previous standard of 3 ft resolution, the number of anomalies increases when comparing the DTM to the DSM.

The example below is located at: -143.420313, 60.458846 Decimal Degrees. Green triangles are height points less than -30 feet. Yellow are points greater than 300 feet. The image below shows how these anomaly points are closely correlated to the terrain and are a result of how the DSM and DTM are generated.

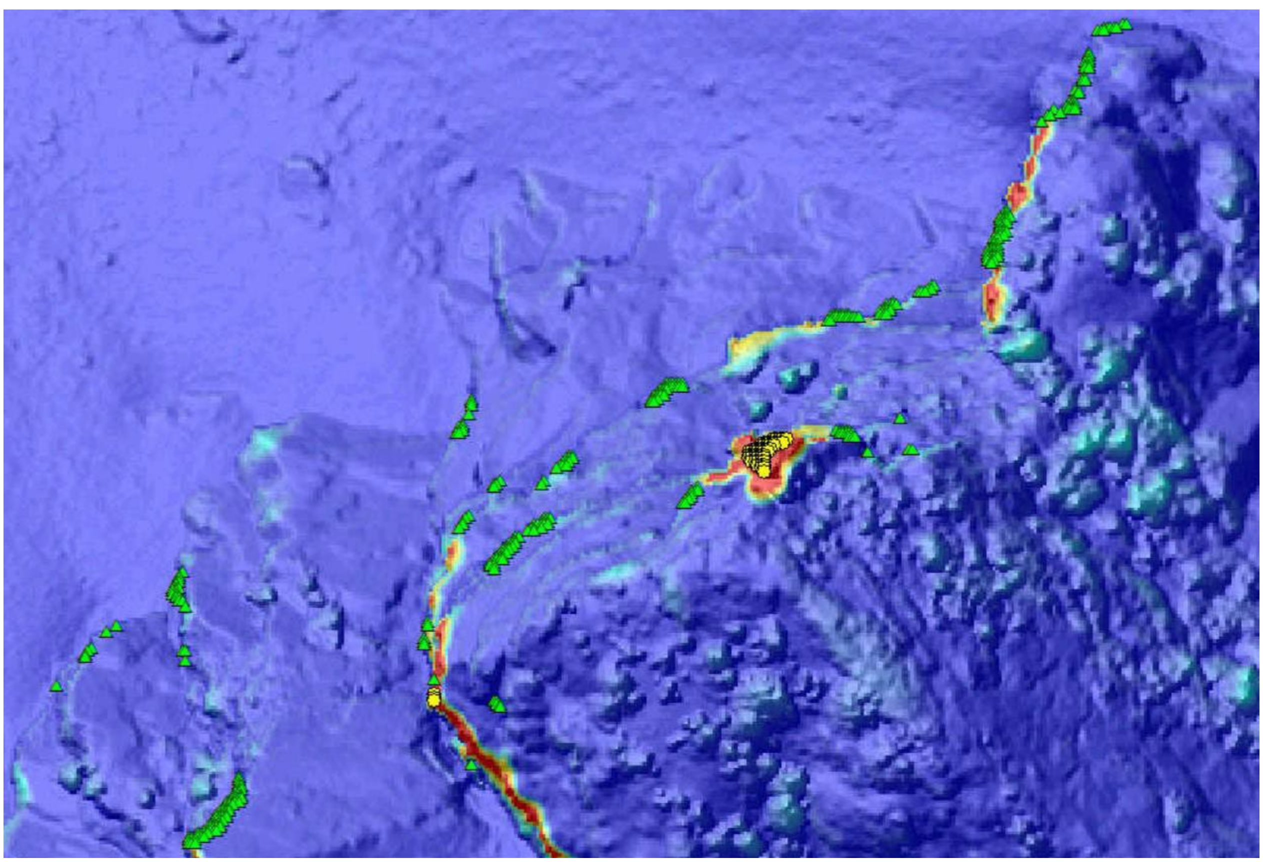

Figure 3: Height model over the DSM shaded Relief map