



## LiDAR Quality Assessment Report

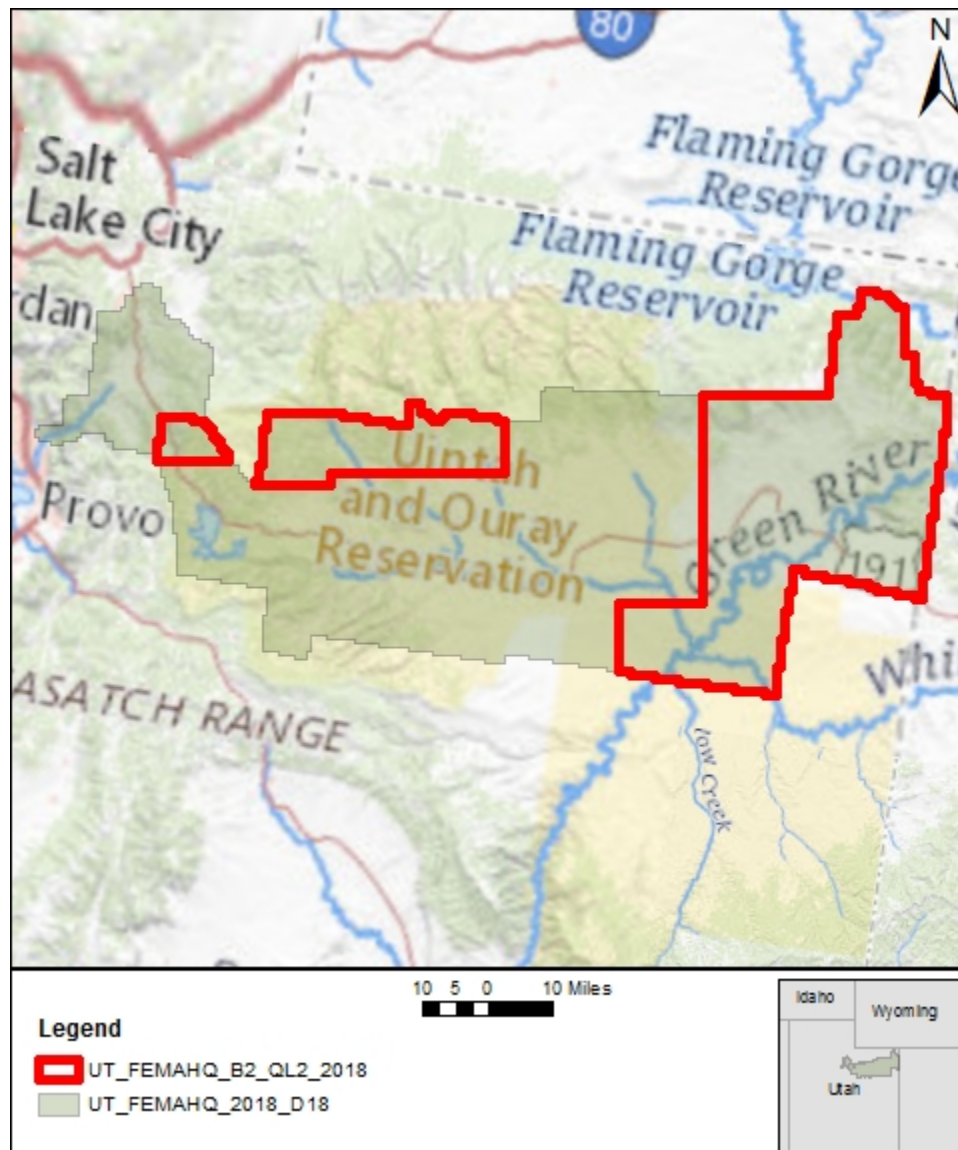
The USGS National Geospatial Technical Operations Center, Data Operations Branch is responsible for conducting reviews of all Light Detection and Ranging (LiDAR) point-cloud data and derived products delivered by a data supplier before it is approved for inclusion in the National Elevation Dataset. The USGS recognizes the complexity of LiDAR collection and processing performed by the data suppliers and has developed this Quality Assessment (QA) procedure to accommodate USGS collection and processing specifications with flexibility. The goal of this process is to assure LiDAR data are of sufficient quality for database population and scientific analysis. Concerns regarding the assessment of these data should be directed to the Chief, Data Operations Branch, 1400 Independence Road, Rolla, Missouri 65401.

UT\_FEMAHQ\_B2\_QL2\_2018

NGTOC

2019-06-17

Tim Willingham



# Project Information

Project: UT\_FEMAHQ\_B2\_QL2\_2018

Contractor: Quantum Spatial, Inc.

Project Type:  
GPSC

Applicable Specification:  
Other

NGP Lidar Base Specification Version 1.3

Project Points of Contact:

Name:	Type:	Email:
Leslie Lansbery	CPT	llansbery@usgs.gov

## REPORT QUALIFICATION SUMMARY:

### Task Order Overall:

*Meets Requirements*

### Metadata:

1 of 1 Reviews Accepted

0 Reviews Not Accepted

### Vertical Accuracy:

1 of 1 Reviews Accepted

0 Reviews Not Accepted

### Swath/Raw LAS:

0 of 1 Reviews Accepted

0 Reviews Not Accepted

### Tiled/Classified LAS:

1 of 1 Reviews Accepted

0 Reviews Not Accepted

### Breakline:

1 of 1 Reviews Accepted

0 Reviews Not Accepted

### DEM(s):

1 of 1 Reviews Accepted

0 Reviews Not Accepted

### NED Review:

1 of 1 DEM tile reviews recommended for NED  
1/3rd

0 of 1 DEM tile reviews recommended for NED  
1/9th

Project Subdivision: Lots

List Subdivision:

- 2

of: 2

Dates Collected Range:

Collection Start: 4/21/2018

Collection End: 10/15/2018

Project Aliases:

Licensing:

Public Domain

Project Description:

**This report is for Block 2 QL2 only.**

USGS requests a spring 2018 lidar survey to be collected over one (1) distinct Area of Interest (AOI) in northeastern Utah identified as Uintah\_Heber. The AOI covers approximately 4693 square miles in total and covers the partial counties of Summit, Utah, Salt Lake, Wasatch, Duchesne, Uintah, Daggett and Moffat (Colorado).<br />This project will support the 3D Elevation Program (3DEP) mission, the Federal Emergency Management Agency (FEMA) Risk Mapping, Assessment and Planning (MAP) program and the State of Utah, Automated Geographic Reference Center (AGRC) and its partners.<br />This task order is for the planning, acquisition, processing, and derivative products of lidar data to be collected at an aggregate nominal pulse spacing (ANPS) of 0.35 meters (8 ppsm) for the western portion of Utah (~380 sq mi), including overlap, and 0.71 meters for the remainder of the AOI (~4,313 sq mi), including overlap.

## Review Information

Reviewer:	<input type="text" value="Tim Willingham"/>	Date	<input type="text" value="12/19/2018"/>
		Delivered:	
3rd Party QA	<input type="checkbox"/>	Date	<input type="text" value="2/7/2019"/>
Performed:		Assigned:	

Action To Contractor Date:	Issue Description:	Return Date:
<input type="text" value="6/17/2019"/>	<input type="text" value="NA"/>	<input type="text"/>

### Review Complete:

Dates Project Worked:

Start:	<input type="text" value="2/8/2019"/>	<input type="text" value="5/14/2019"/>	<input type="text" value="6/14/2019"/>
End:	<input type="text" value="2/15/2019"/>	<input type="text" value="5/17/2019"/>	<input type="text" value="6/17/2019"/>

## Project Materials Received

All project deliverables must be supplied according to collection and processing specifications. The USGS will postpone the QA process when any of the required deliverables are missing. When deliverables are missing, the Contracting Officer Technical Representative (COTR) will be contacted by the Elevation Section supervisor and informed of the problem. Processing will resume after the COTR has coordinated the deposition of remaining deliverables.

### METADATA

Deliverables	Delivered	XML Metadata	Required	Format	Quantity	Additional Details
Collection Report:	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<u>PDF</u>	<input type="text" value="1"/>	<input type="text"/>
Survey Report:	<input type="checkbox"/>		<input type="checkbox"/>	<u>Select...</u>	<input type="text" value="0"/>	<input type="text"/>
Processing Report:	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<u>PDF</u>	<input type="text" value="1"/>	<input type="text"/>
QA/QC Report:	<input type="checkbox"/>		<input type="checkbox"/>	<u>Select...</u>	<input type="text" value="0"/>	<input type="text"/>
Project Level XML Metadata:	<input type="checkbox"/>		<input type="checkbox"/>	XML	<input type="text" value="0"/>	<input type="text"/>
Project Extent:	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<u>.shp</u>	<input type="text" value="1"/>	<input type="text"/>
Tile Scheme:	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<u>.shp</u>	<input type="text" value="1"/>	<input type="text"/>
Control (Calibration) Points:	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<u>.shp</u>	<input type="text" value="1"/>	<input type="text"/>

Check (Validation) Points:	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<u>.shp</u>	1	
Additional Comments:						

## LIDAR DATA

Deliverables	Delivered	XML Metadata	Required	Format	Quantity	Additional Details
Swath Data:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Select...	0	
Classified/ Tiled Data:	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	.las	5,076	
Additional Comments:						

## DERIVED DELIVERABLES

Deliverables	Delivered	XML Metadata	Required	Format	Quantity	Additional Details
DEM Tiles:	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	IMG	5,099	Extra tiles are for overlap tiles
Breaklines:	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	FGD	1	
Additional Comments:						

## OTHER

Additional Deliverables	Delivered	XML Metadata	Required	Format	Quantity	Additional Details
Intensity Imagery	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	TIFF	5,076	
Classified LPC 100m Buffer	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	LAS	816	
Flight Lines	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	SHP	1	
Additional Comments:						

## Geographic Information

Area Extent: 1959.85 Sq. Miles

Tile Size: 1,000 x 1,000 Meters

DEM/DTM Grid  Meters

Spacing:

Coordinate Reference System:

Conus Albers

Projection:

Horizontal NAD83

Datum:

☒ Meters

☐ U.S. Feet

☐ Int'l Feet

Vertical NAVD88

Datum:

☒ Meters

☐ U.S. Feet

☐ Int'l Feet

## THIS PROJECTION COORDINATE REFERENCE SYSTEM IS CONSISTENT ACROSS THE FOLLOWING DELIVERABLES

☒ Project Extent

☒ Project Tile Scheme

☒ Control Points

☒ Checkpoints

☒ Tiled/Classified XML Metadata

☒ Tiled/Classified LiDAR

☒ DEM(s)

☒ DEM XML Metadata

☒ Breakline(s)

☒ Breakline XML Metadata

Additional  
Comments:

## Collection Information

Quality Level: 2

Configured Nominal Pulse Spacing:

Meters

### Sensor Information:

Sensor Type:

Aerial Oscillating Mirror

Sensor Used:

Configured Scan Angle  $\pm$  from nadir:

Degrees

Sensor Type:

Aerial Rotating Prism

Sensor Used:

Configured Scan Angle  $\pm$  from nadir:

Degrees

Additional Comments:

## Metadata Review **Accepted**

Vendor provided metadata files have been parsed using 'mp' metadata parser. Any errors generated by the parser are

documented below for reference and/or corrective action.  
Parser can be found @ <http://geo-nsdi.er.usgs.gov/validation/>

**The Classified XML Metadata parsed without errors.**

Check if 'Best Use' metadata for NED: ☐

**The DEM XML Metadata parsed without errors.**

Check if 'Best Use' metadata for NED: ☐

**The Breakline XML Metadata parsed without errors.**

Check if 'Best Use' metadata for NED: ☐

Additional  
Comments:

Corrected 5/14/2019

- QL2 Classified Las XMLs have classifications (3, 4, 5, 6, 8, and 13) that are not in the Project report or Las Files.

**Based on this review, the USGS accepts the xml metadata provided.**

End of Metadata Review

## Vertical Accuracy Review Accepted

ASPRS recommends that checkpoint surveys be used to verify the vertical accuracy of LiDAR data sets. Checkpoints are to be collected by an independent survey firm licensed in the particular state(s) where the project is located. While subjective, checkpoints should be well distributed throughout the dataset. National Standards for Spatial Data Accuracy (NSSDA) guidance states that checkpoints may be distributed more densely in the vicinity of important features and more sparsely in areas that are of little or no interest. Checkpoints should be distributed so that points are spaced at intervals of at least ten percent of the diagonal distance across the dataset and at least twenty percent of the points are located in each quadrant of the dataset.

NSSDA and ASPRS require that a minimum of twenty checkpoints (thirty is preferred) are collected for each major land cover category represented in the LiDAR data. Checkpoints should be selected on flat terrain, or on uniformly sloping terrain in all directions from each checkpoint. They should not be selected near severe breaks in slope, such as bridge abutments, edges of roads, or near river bluffs. Checkpoints are an important component of the USGS QA process. There is the presumption that the checkpoint surveys are error free and the discrepancies are attributable to the LiDAR dataset supplied.

For this dataset, USGS checked the spatial distribution of checkpoints with an emphasis on the bare-earth (open terrain) points; the number of points per class; the methodology used to collect these points; and the relationship between the data supplier and checkpoint collector. When independent control data are available, USGS has incorporated this into the analysis.

## Required Vertical Accuracy

☒ Yes ☐ No

### REQUIRED NON-VEGETATED VERTICAL ACCURACY FOR SWATH AND DEM FILES

Required Unit:	<input type="text" value="Centimeters"/>
Required # of checkpoints:	<input type="text" value="115"/>
Required RMSEz:	<input type="text" value="10"/>
Required Vertical Accuracy (RMSEz * 95th CI)	<input type="text" value="19.6"/>

**REQUIRED VEGETATED VERTICAL ACCURACY FOR DEM FILES**

*Required Unit:*

*Required # of checkpoints:*

*Required Vertical Accuracy (@ 95th percentile)*

*Additional Required  
Vertical Accuracy  
Information:*

**Reported Vertical Accuracy**

☒ Yes ☐ No

**REPORTED NON-VEGETATED VERTICAL ACCURACY FOR SWATH LIDAR FILES**

*Reported Unit:*

*Reported # of checkpoints:*

*Reported RMSEz:*

*Reported Vertical Accuracy (RMSEz \* 95th CI)*

**REPORTED NON-VEGETATED VERTICAL ACCURACY FOR DEM FILES**

*Reported Unit:*

*Reported # of checkpoints:*

*Reported RMSEz:*

*Reported Vertical Accuracy (RMSEz \* 95th CI)*

**REPORTED VEGETATED VERTICAL ACCURACY FOR DEM FILES**

*Reported Unit:*

*Reported # of checkpoints:*

*Reported Vertical Accuracy (95th percentile)*

*Additional Reported  
Vertical Accuracy  
Information:*

## Reviewed Vertical Accuracy

☒ Yes ☐ No

### CHECKPOINT REVIEW

Checkpoints are well distributed? ☒

Enough checkpoints for task order? ☒

Checkpoints meet USGS LiDAR base-spec in quantity and quality? ☒

### REVIEWED NON-VEGETATED VERTICAL ACCURACY FOR SWATH LIDAR FILES

Reviewed Unit:

Reviewed # of checkpoints:

Reviewed RMSEz:

Reviewed Vertical Accuracy (RMSEz \* 95th CI)

### REVIEWED NON-VEGETATED VERTICAL ACCURACY FOR DEM FILES

Reviewed Unit:

Reviewed # of checkpoints:

Reviewed RMSEz:

Reviewed Vertical Accuracy (RMSEz \* 95th CI)

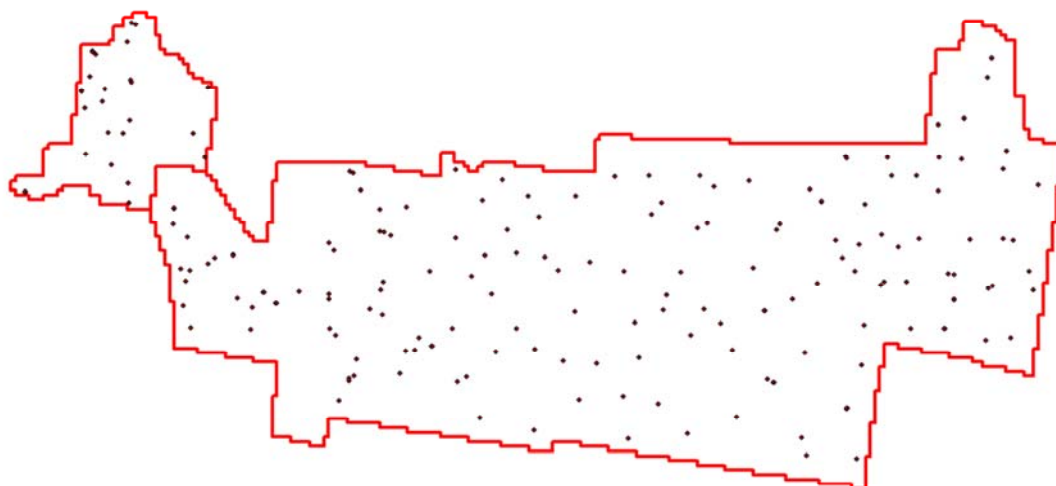
### REVIEWED VEGETATED VERTICAL ACCURACY

Required Unit:

Required # of checkpoints:

Reviewed Vertical Accuracy (95th percentile)

Checkpoint Distribution Image



Vertical Accuracy Results:

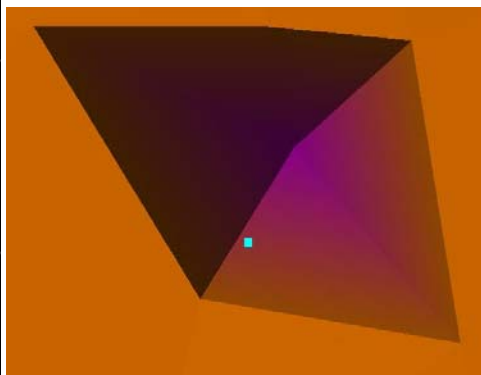
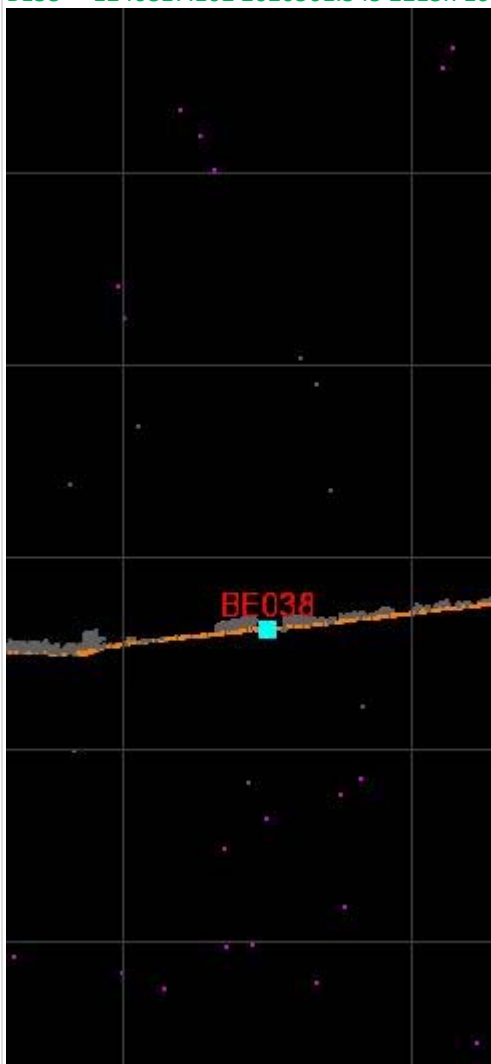


Corrected 5/15/2019 - Points removed from analysis by contractor

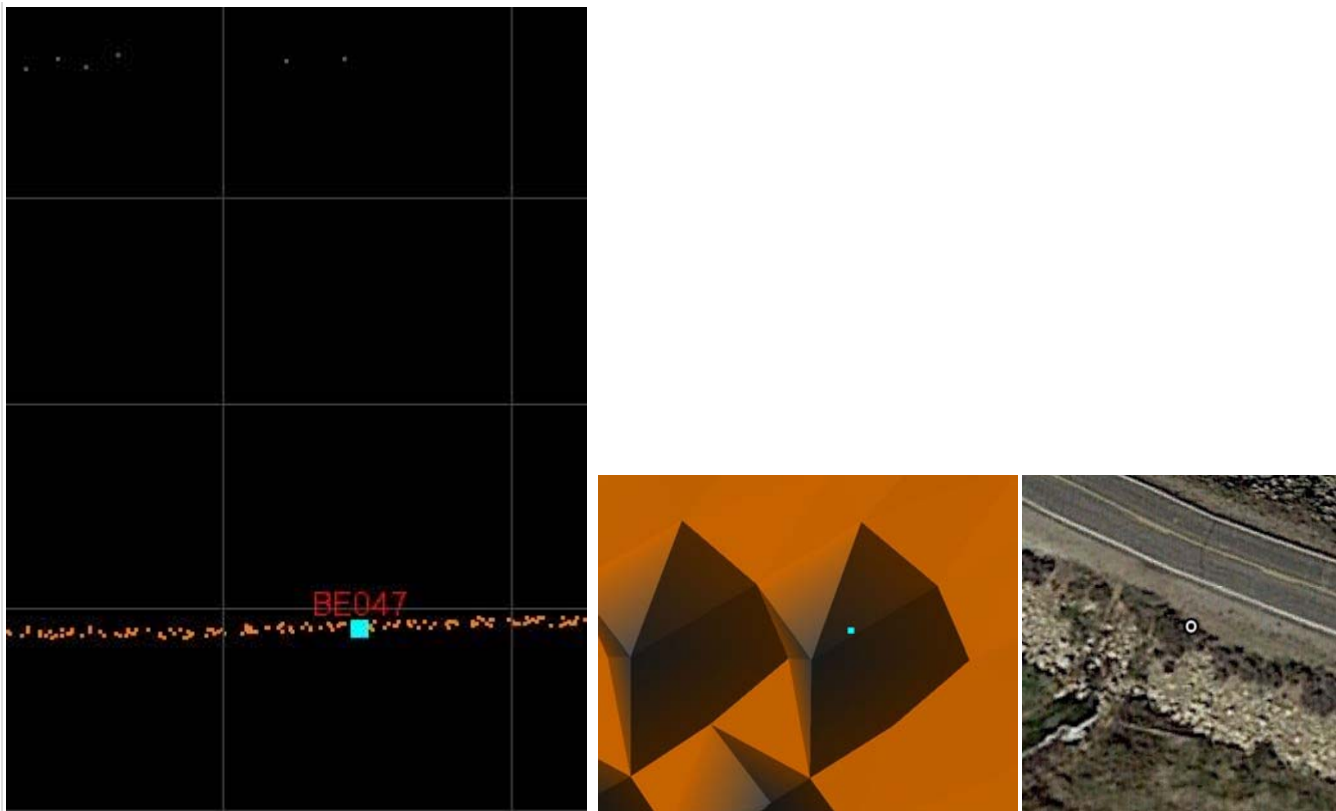
- BE38 and BE47 have a DeltaZ over 6.

All LPC Images below have withheld and overlap points removed.

BE38 -1246817.102 2020561.545 2213.710 2190.125 Control 23.585



BE47 -1212071.899 2009534.697 1788.150 1794.571 Control -6.421



If BE47 ( $zDiff = -6.421$ ) is removed, the VA fails ( $RMSEz = 218.07$  cm).

If BE38 ( $zDiff = 35.828$ ) is removed, the VA fails ( $RMSEz = 58.0$  cm).

If both BE38 and BE47 are removed, the VA passes ( $RMSEz = 3.3$  cm).

Additional Reviewed  
Vertical Accuracy  
Information:

Based on this review, the USGS accepts the vertical accuracy.

End of Vertical Accuracy Review

## Raw-Swath LiDAR Review

LAS swath files or raw unclassified LiDAR data are reviewed to assess the quality control used by the data supplier during collection. Furthermore, LAS swath data are checked for positional accuracy. The data supplier should have calculated the Non-Vegetated Vertical Accuracy using ground control checkpoints measured in clear open terrain (see *Vertical Accuracy Review Section*).

Review Required: ☒ Yes ☐ No Not Delivered

## Tiled/Classified LiDAR Review **Accepted**

Classified LAS tile files are used to build digital terrain models using the points classified as ground. Therefore, it is important that the classified LAS are of sufficient quality to ensure that the derivative product accurately represents the landscape that was measured. Classified LAS Tiles are comprised as follows, "all project swaths, returns, and collected points, fully calibrated, adjusted to ground, and classified and cut, by tiles, excluding calibration swaths, cross-ties, and other swaths not used, or intended to be used, in product generation".

Review Required: ☒ Yes ☐ No

### CLASSIFIED LIDAR TILE CHARACTERISTICS

☒ Separate folder for classified/tiled LiDAR files

LAS Version: 1.4

Point Record Format: 6

If specified, \*.wpd files for full waveform data have been provided: Not Required

- ☒ Classified LAS tile files conform to project tiling scheme
- ☒ Quantity of classified LAS tile files conforms to project tiling scheme
- ☒ Classified LAS tile files do not overlap
- ☒ Classified LAS tile files are uniform in size
- ☐ Correct and properly formatted georeference information is included in all LAS file headers, including the use of OGC 2001 Well Known Text (WKT).

Corrected 5/14/2019

WKT is not well formed.

- ☒ Adjusted GPS time used with the global encoder id set to 1
- ☒ Classified LAS tile files have no points classified as '12' (Overlap) and correctly use overlap bit.
- ☒ Point classifications are limited to the standard values listed below:

Code	Description	Used
1	Processed, but unclassified	<input checked="" type="checkbox"/>
2	Bare-earth/Ground	<input checked="" type="checkbox"/>
7	Noise (low, manually identified, if needed)	<input checked="" type="checkbox"/>
8	Model key points	<input type="checkbox"/>
9	Water	<input checked="" type="checkbox"/>
10	Ignored ground (breakline proximity)	<input type="checkbox"/>
11	Withheld (if the "Withheld Bit" is not implemented in the processing software)	<input type="checkbox"/>
17	Bridges	<input checked="" type="checkbox"/>
18	Noise (high, manually identified, if needed)	<input checked="" type="checkbox"/>

**Additional Classes:**

Class	Description
20	Ignore Ground

**Additional comments:**

Corrected 5/14/2019

- Las Files have classifications of 10 (1 Las tile), 11 (926 Las tiles), and 14(13 Las tiles). Project Report and Metadata XML's do not contain those classifications.

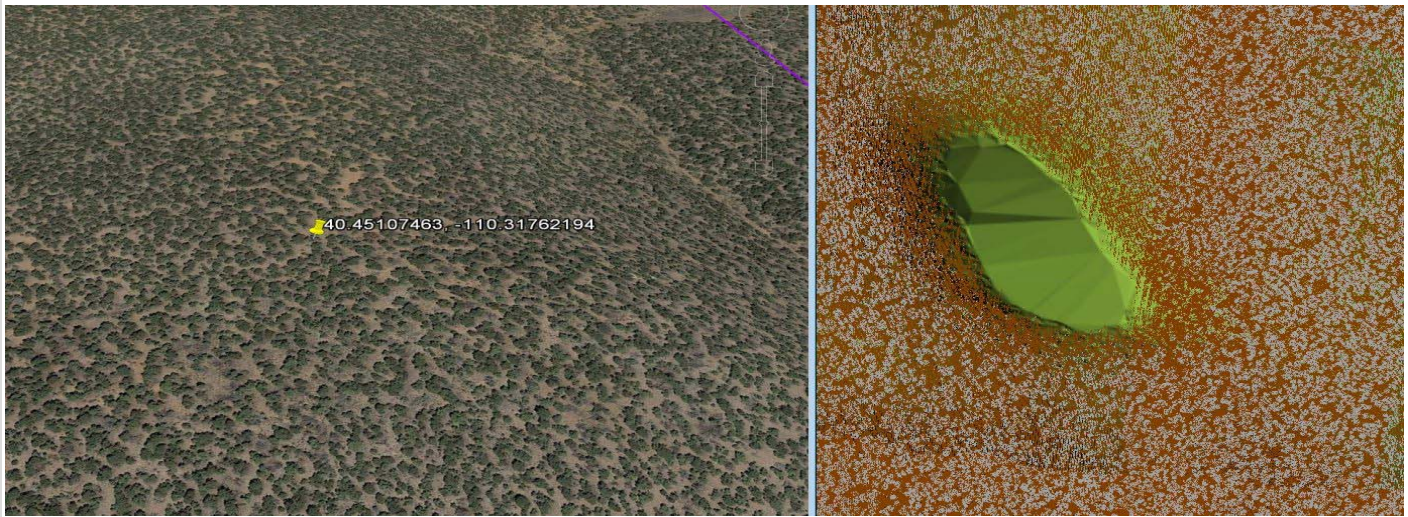
Corrected 5/14/2019

- Scan Angles appear to be incorrect for most Las tiles. Scan Angle Min's and Max's are above 30. Project Report and Metadata XML's have sensor's Field of View at 30 or Scan Angle at 15.

Corrected 5/14/2019

- 1 Area with no LPC points and feature is not a water body, See UT\_FEMAHQ\_B2\_2018.

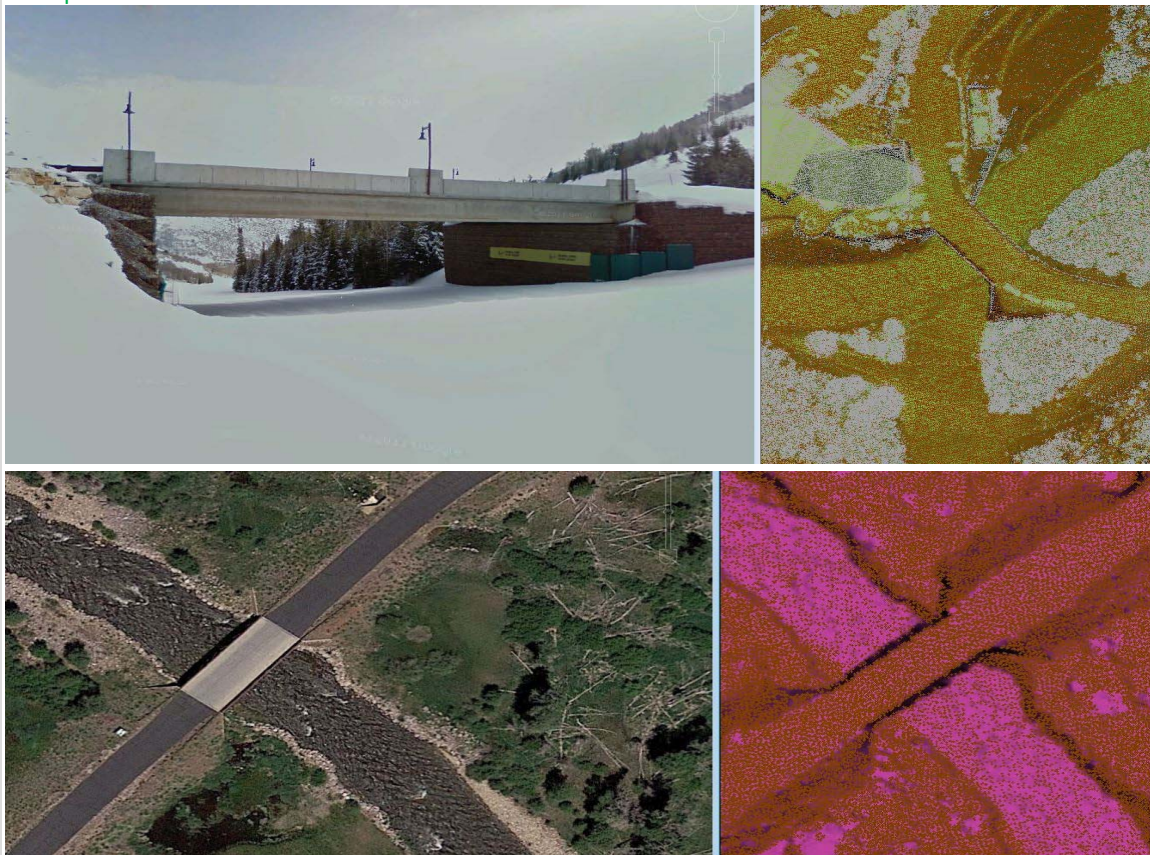




Corrected 5/14/2019

- 3 Bridge areas with points not classified correctly, causing bridges to be left in DEM, see UT\_FEMAHQ\_B2\_QL1\_Errors and UT\_FEMAHQ\_B2\_QL2\_Errors error shapefiles.

Examples:



Based on this review, the USGS accepts classified/tiled LiDAR data.

*End of Tiled/Classified LiDAR Review*

## Breakline Review Accepted

Breaklines are vector feature classes that are used to hydro-flatten the bare earth Digital Elevation Models.

Review Required: ☒ Yes ☐ No

**BREAKLINE FILE CHARACTERISTICS:**

- ☒ Separate folder for breakline files.
- ☒ Breaklines contain elevation values.
- Elevation values stored in Geometry (ZEnabled)
- Units: Meters

- ☒ Waterbody Breaklines.

Polyline ☒ Polygon ☐

☐ Single elevation value per waterbody feature.

☒ Required.

Waterbody Elevations were created via Unknown waterbody level techniques.

- ☒ Double Line Stream Breaklines (Streams Approximately > 100 ft).

Polyline ☒ Polygon ☐

Downstream DLS Flow is Monotonic

☒ Required.

- ☒ Single Line Breaklines.

Lines are:

☐ Single Line Streams

☒ Bridge Cuts

☐ Culvert Connectors

Downstream SLS Flow is Monotonic

- ☐ No missing or misplaced breaklines.

ADDITIONAL COMMENTS, ERRORS, ANOMALIES, OR OTHER ISSUES:

Corrected 5/14/2019  
- Missing for non-hydroflattened lakes/ponds, see DEM section.

Based on this review, the USGS accepts the breakline files.

End of Breakline Review

## DEM Review Accepted

The derived bare-earth file(s) receive a review of the vertical accuracies provided by the data supplier, vertical accuracies calculated by the USGS using supplied and independent checkpoints (*see the prior Vertical Accuracy Review Section*), and a thorough visual review for any anomalies or inconsistencies in assessing the quality of the DEM(s).

### BARE-EARTH DEM TILE CHARACTERISTICS:

- ☒ Separate folder for bare-earth DEM files
- Raster File Type: IMG
- Raster Cell Size: 1 Meters
- Tile bit depth/pixel Type: 32\_BIT\_FLOAT
- Interpolation or Resampling Technique: Select...

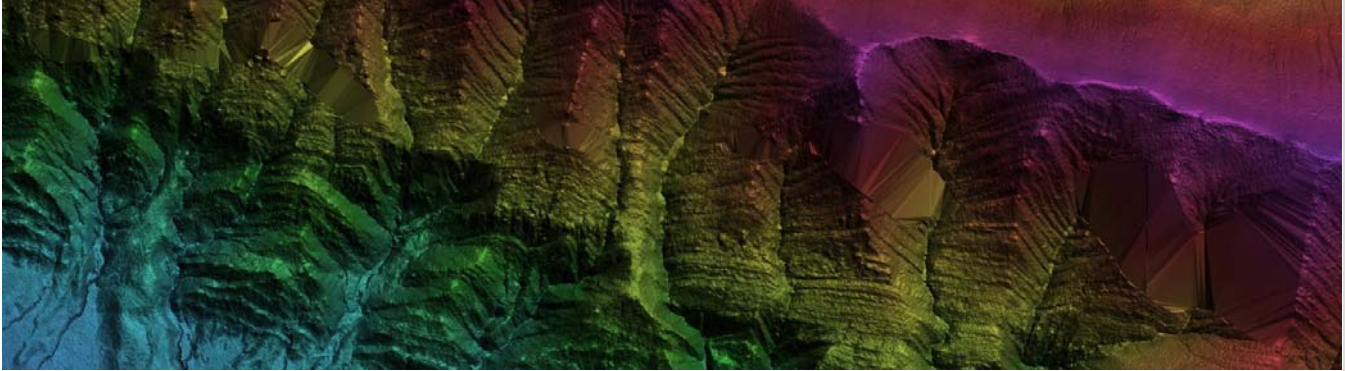
- ☒ DEM tiles do not overlap
- ☒ DEM tiles conform to Project Tiling Scheme



- ☒ Quantity of DEM files conforms to Project Tiling Scheme
- ☒ DEM tiles are uniform in size
- ☒ DEM tiles properly edge match and free of edge artifacts
- ☒ Tiles are free from Spikes and Pits
- ☐ Tiles are free from Data Holidays (*voids due to processing or collection errors*)

Corrected 5/14/2019

- 1 Area of tinning, ground points classified in area, see UT\_FEMAHQ\_B2\_QL2\_Errors.



- ☒ Tiles do not exhibit systematic sensor error or corrowing

#### Hydro Treatment: hydro-flattened

DEM tiles are properly Hydro Flattened ☒ Yes ☐ No

☐ Waterbodies  or greater are flattened

Corrected 5/14/2019

- 1 Lake/Pond > 2 acres not hydroflattened, See UT\_FEMAHQ\_B2\_QL2\_Errors shapefile.

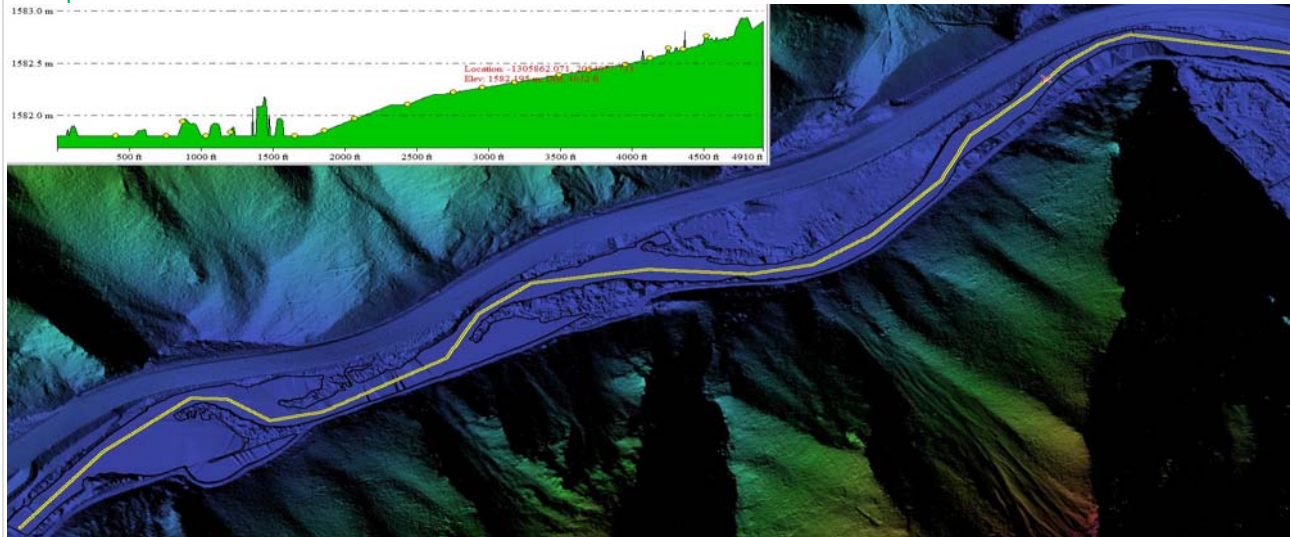
☐ Streams  or greater are flattened in a downstream manner

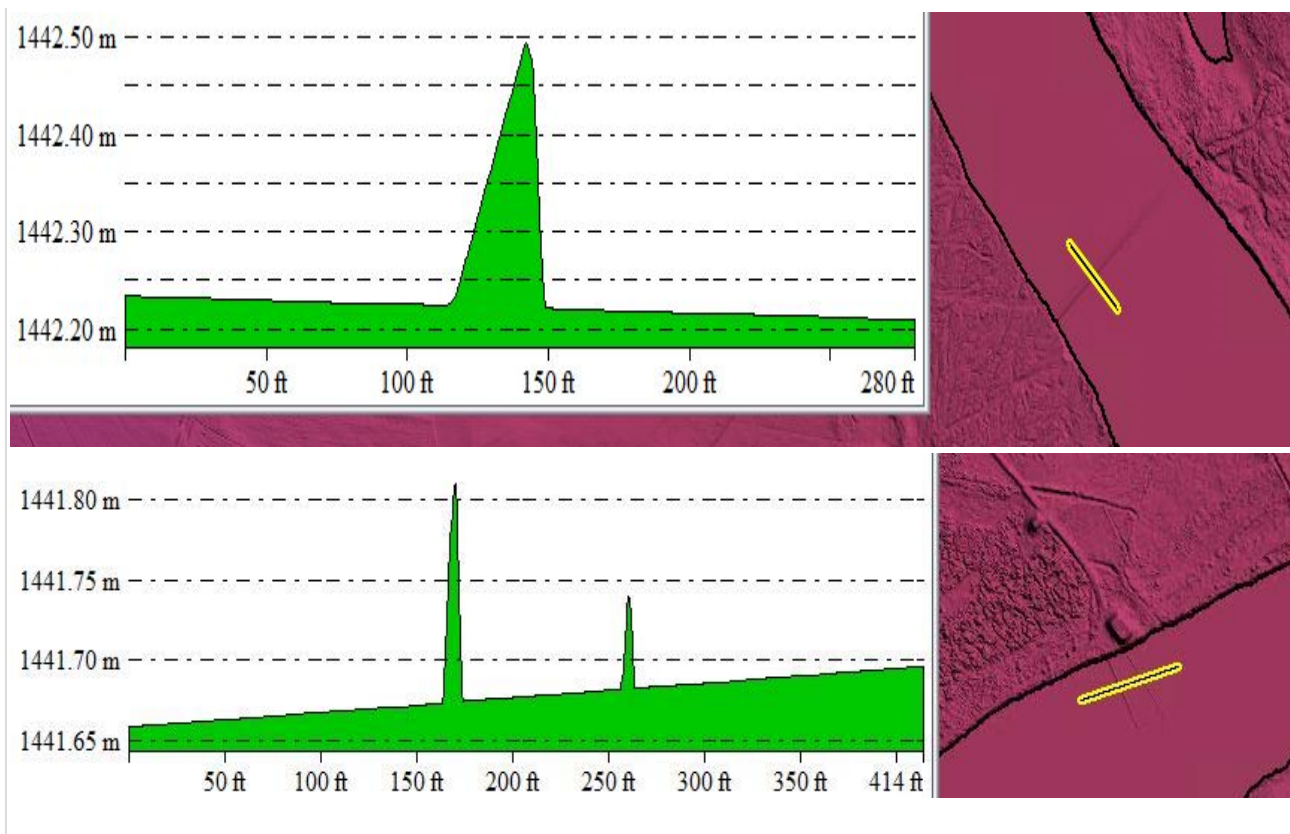
Corrected 6/13/2019

1 Not Corrected 5/14/2019, see UT\_FEMAHQ\_B2\_QL2\_Errors\_v2 shapefiles.

- 23 River sections not hydroflattened correctly, rivers have spikes or floating water, see UT\_FEMAHQ\_B2\_QL1\_Errors and UT\_FEMAHQ\_B2\_QL2\_Errors error shapefiles.

Examples:





- ☒ Tidal Boundaries/Shorelines are flattened
- ☒ No missing islands  or larger
- ☒ Bridges/Overpasses are properly removed
- ☒ Culverts are maintained (Not Hydro Enforced)
- ☒ Depressions, Sinks, are not filled in (Not Hydro Conditioned)
- ☒ Vegetation properly removed
- ☒ Manmade structures properly removed

ADDITIONAL COMMENTS, ERRORS, ANOMALIES, OR OTHER ISSUES:

Tiles recommended for NED 1/3rd: ☒ Yes. ☐ No.  
Tiles recommended for NED 1/9th: ☐ Yes. ☐ No.  
Tiles recommended for NED 1 Meter: ☒ Yes. ☐ No.  
LAS dataset recommended for distribution: tile classified

**Based on this review, the USGS accepts the DEM tiles.**

End of DEM Review

Based on this review, the provided delivery Meets the Contract and/or Task Order requirements.  
*Additional Comments:*

### INTERNAL COMMENTS

- 100 DEM tiles do not have the same NoDataValue as the remaining 4,999.
- Same 100 DEM tiles have valid SRS, but not Authority Code.
- 23 Overlap tiles from QL1 work unit have a 0.5m cell size.
- Work Unit boundary intersects with Tribal Lands.

END OF REPORT (v2.4.0)