# 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_B1_2018

NGTOC

2019-06-17

Brian Pfeiffer
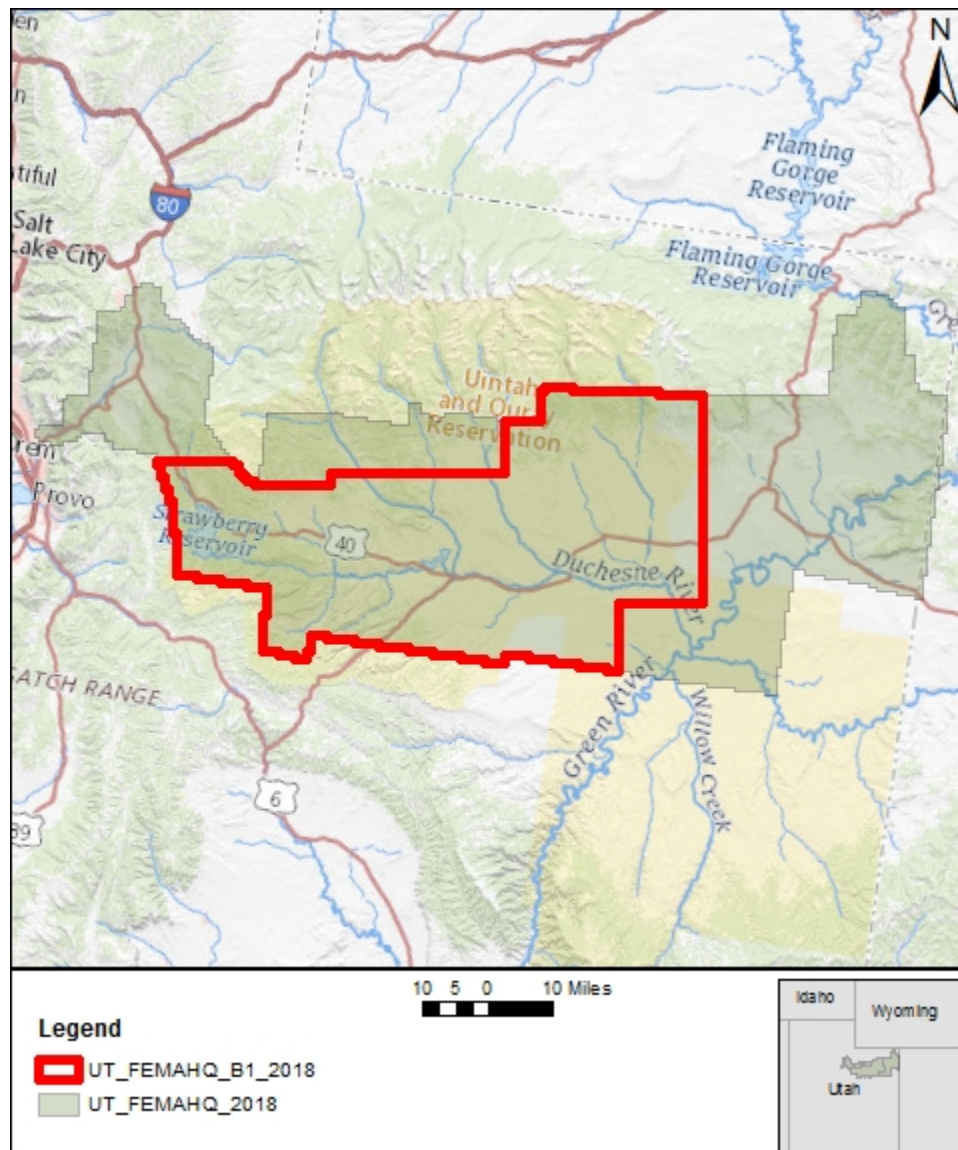
Project Information

Project: UT_FEMAHQ_B1_2018

Contractor: Quantum Spatial, Inc.

Project Type:
GPSC

Applicable Specification:
Other
NGP Lidar Base Specifications v 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:
0 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:
- 1

of: 2

Dates Collected Range:

Collection Start: 4/27/2018

Collection End: 6/2/2018

Project Aliases:
UT_FEMAHQ_2018_D18

Licensing:
Public Domain

Project Description:

This task order 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).   The project AOI has been expanded to the Albers National Indexing Scheme. 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.

Review Information

Reviewer: Brian Pfeiffer

Date Delivered: 11/16/2018

3rd Party QA Performed: ☐

Date Assigned: 11/28/2018

Action To Contractor Date:	Issue Description:	Return Date:
	For this project errors will be written in RED and corrections written in GREEN. Missing Deliverables: Corrected 2/20/19 - Project report, collection report, processing report, QC report. - Flight Index shapefile. - Final XML DEM Errors: Corrected 2/20/19 - 1 lake that requires hydro-flattening. - 1 bridge that requires removal. - 2 river geometry errors. LAS Errors: Corrected 2/20/19 - There are 26 LAS tiles that have points with a classification of 4. The use of this classification is inconsistent with the project's classification scheme. - There are 8 LAS tiles that have pulses with a return number of zero. Please repair and replace these LAS tiles. - The WKT for all LAS files does not validate with gdalsrsinfo. (corrected WKT has been provided in this report and with a .txt file) XML Metadata: Corrected 2/20/19 - The preliminary XML data passes the USGS parser. -The information under the <lasclass> tag for LAS XML is incorrect and includes classes that are not used in this project.	
	**This project is accepted pending passing Vertical Accuracy Testing Completed 6/17/19	

Review Complete:
6/17/2019

Dates Project Worked:

Start:	11/28/2018	2/20/2019
End:	12/3/2018	2/20/2019

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:	☐		☑	Select...	0	
Survey Report:	☐		☑	Select...	0	
Processing Report:	☐		☑	Select...	0	
QA/QC Report:	☐		☑	Select...	0	
Project Level XML Metadata:	☐		☐	XML	0	
Project Extent:	☑	☐	☑	.shp	1	Lot1_DeliveryArea_10312018
Tile Scheme:	☑	☐	☑	.shp	1	Lot1_TileLayout_10312018
Control (Calibration) Points:	☐	☐	☐	.shp	1	
Check (Validation) Points:	☐	☐	☐	.shp	1	Lot1_QA_Control_10312018
Additional Comments:						

LIDAR DATA

Deliverables	Delivered	XML Metadata	Required	Format	Quantity	Additional Details
Swath Data:	☐	☐	☐	Select...	0	
Classified/ Tiled						

Data:	☑	☑	☑	.las	6,094	
Additional Comments:	Missing swath flight index shapefile as required by LBS 1.3.Corrected 2/20/19					

DERIVED DELIVERABLES

Deliverables	Delivered	XML Metadata	Required	Format	Quantity	Additional Details
DEM Tiles:	☑	☑	☑	IMG	6,094	
Breaklines:	☑	☑	☑	.shp	1	
Additional Comments:						

OTHER

Additional Deliverables	Delivered	XML Metadata	Required	Format	Quantity	Additional Details
Intensity	☑	☑	☑	tif	6,094	
Swatj shapefile	☑	☐	☑	.shp	1	
Additional Comments:						

Geographic Information

Area Extent: 2352 _Sq. Miles_

Tile Size: 1000 x 1000 _Meters_

DEM/DTM Grid Spacing: 1 _Meters_

Coordinate Reference System:
NAD83(2011) / Conus Albers (meter)

Projection: Albers

Horizontal Datum: NAD83
2011
    ⦿ Meters
    ◯ U.S. Feet
    ◯ Int'l Feet

Vertical Datum: NAVD88
    ⦿ Meters
    ◯ U.S. Feet
    ◯ Int'l Feet

THIS PROJECTION COORDINATE REFERENCE SYSTEM IS CONSISTENT ACROSS THE FOLLOWING DELIVERABLES

☑ _Project Extent_   ☑ _Tiled/Classified XML Metadata_

☑ _Project Tile Scheme_   ☑ _Tiled/Classified LiDAR_

☑ *DEM(s)*
☑ *DEM XML Metadata*
☑ *Breakline(s)*
☑ *Breakline XML Metadata*

Additional Comments:	

Collection Information

Quality Level: 2
Configured Nominal Pulse Spacing:

0.7	

Meters

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:	All the preliminary metadata delivered passed the USGS parser.
	The information under the <lasclass> tag for LAS XML is incorrect and includes classes that are not used in this project. Corrected 2/20/19

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:	Centimeters
Required # of checkpoints:	115
Required RMSEz:	10
*Required Vertical Accuracy (RMSEz * 95th CI)*	19.6

REQUIRED VEGETATED VERTICAL ACCURACY FOR DEM FILES

Required Unit:	Centimeters
Required # of checkpoints:	85
Required Vertical Accuracy (@ 95th percentile)	29.4

Additional Required Vertical Accuracy Information:	

Reported Vertical Accuracy

◉ Yes ○ No

REPORTED NON-VEGETATED VERTICAL ACCURACY FOR SWATH LIDAR FILES

Reported Unit:	Centimeters
Reported # of checkpoints:	122
Reported RMSEz:	
*Reported Vertical Accuracy (RMSEz * 95th CI)*	6.6

REPORTED NON-VEGETATED VERTICAL ACCURACY FOR DEM FILES

Reported Unit: Centimeters

Reported # of checkpoints: 122

Reported RMSEz:

*Reported Vertical Accuracy (RMSEz * 95th CI)* 6.8

REPORTED VEGETATED VERTICAL ACCURACY FOR DEM FILES

Reported Unit: Centimeters

Reported # of checkpoints: 121

Reported Vertical Accuracy (95th percentile) 23.3

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: Centimeters

Reviewed # of checkpoints: 122

Reviewed RMSEz:

*Reviewed Vertical Accuracy (RMSEz * 95th CI)* 6.5

REVIEWED NON-VEGETATED VERTICAL ACCURACY FOR DEM FILES

Reviewed Unit: Centimeters

Reviewed # of checkpoints: 124

Reviewed RMSEz: 3.78

*Reviewed Vertical Accuracy (RMSEz * 95th CI)* 7.41

REVIEWED VEGETATED VERTICAL ACCURACY

Required Unit:

	Centimeters
Required # of checkpoints:	123
Reviewed Vertical Accuracy (95th percentile)	22.97

Checkpoint Distribution Image
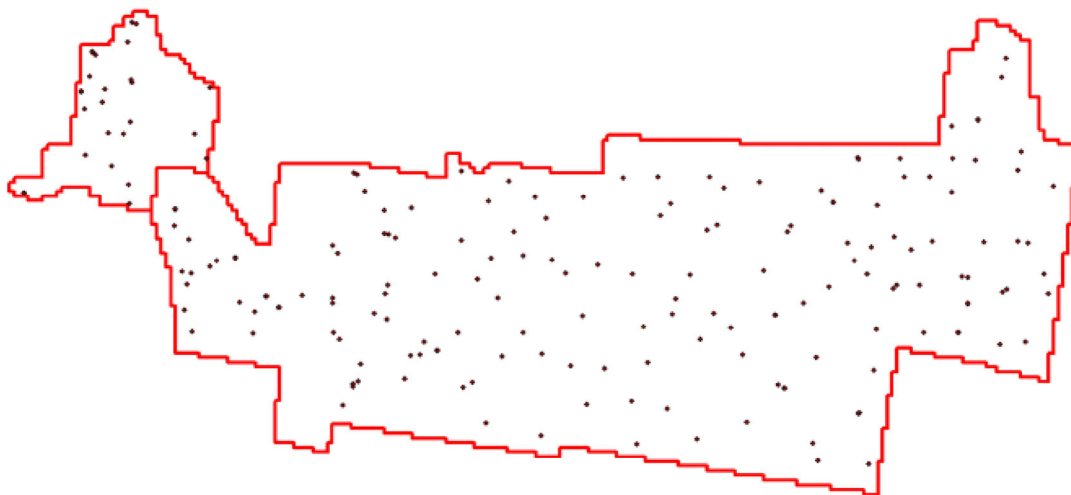
Vertical Accuracy Results:

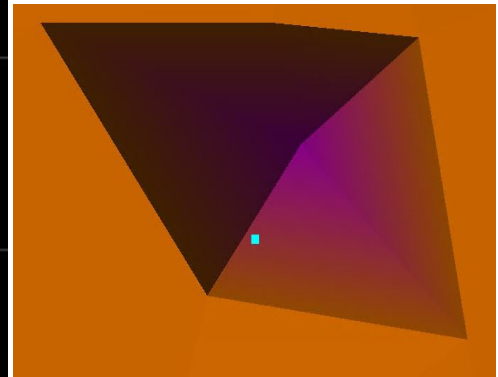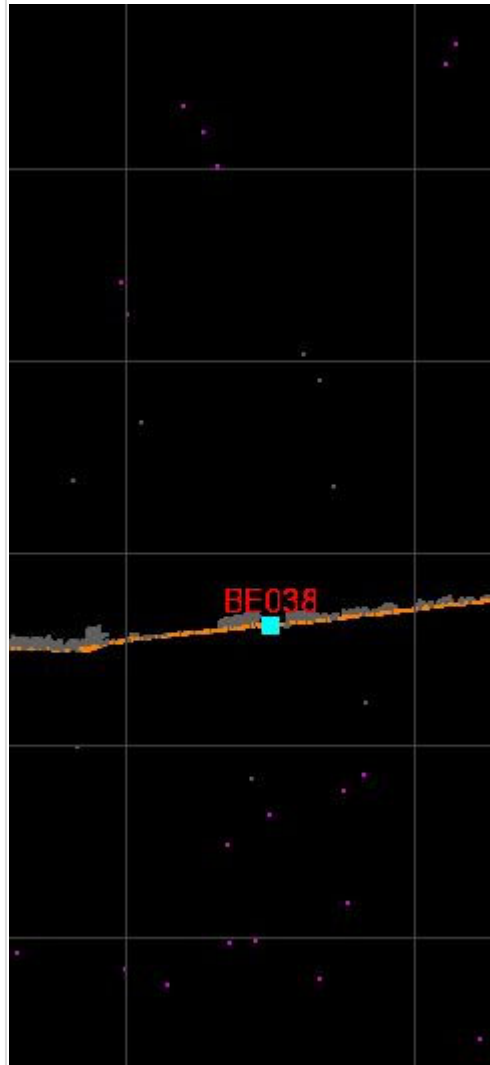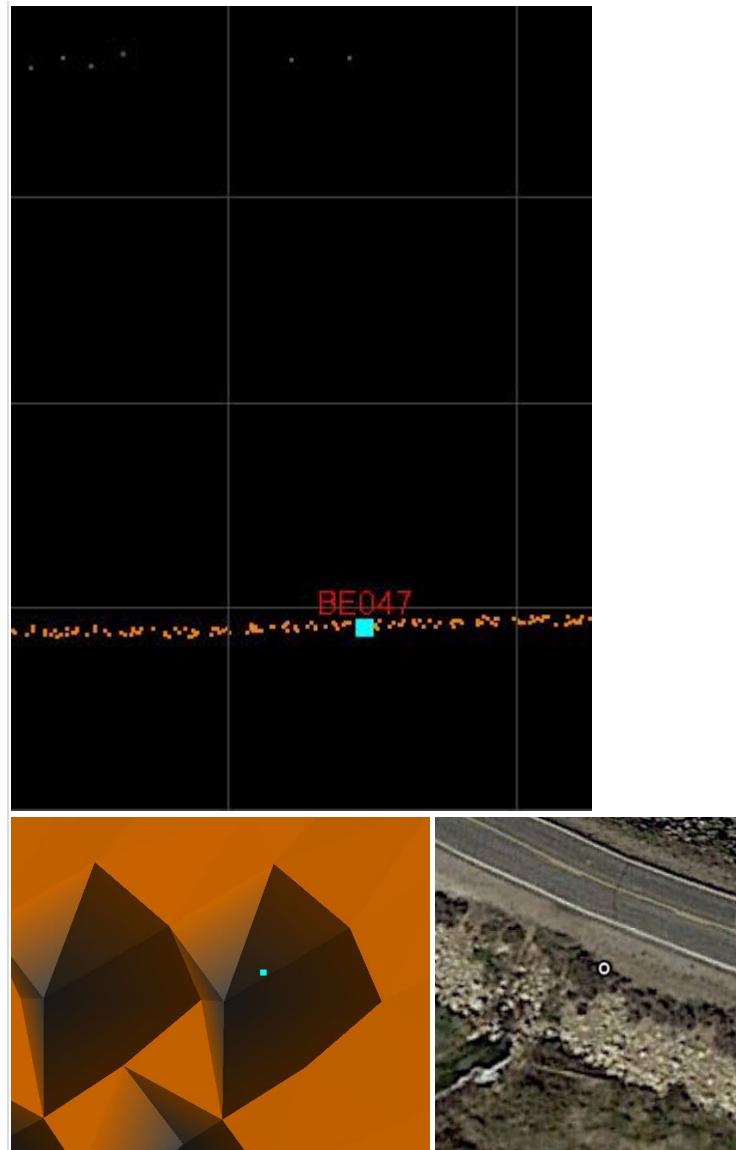|	
Additional Reviewed Vertical Accuracy Information:	- BE38 and BE47 have a DeltaZ over 6. All LPC Images below have withheld and overlap points removed. BE38 -1246817.102 2020561.545 2213.710 2190.125 Control 23.585 Corrected 5/15/2019 Points removed from analysis by contractor

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).
Corrected 5/15/2019 Points
removed from analysis by contractor
**Reported NVA VA for the LPC is significantly different from NGTOC Tested NVA VA for the LPC. Please provide and explain/elaborate your BE47 and BE38 zDiff values.

Based on this review, the USGS <u>accepts</u> 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: <u>1.4</u>

Point Record Format: <u>6</u>

If specified, *.wpd files for full waveform data have been provided: <u>Not Required</u>

☑ *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).*

> - The LAS WKT for all LAS files does not validate gdalsrsinfo. All LAS files will have to be corrected. The main problem with the WKT is the vertical datum section. Corrected 2/20/19
> (see bottom of report for copy of corrected and parsed WKT)
> Original:
> VERT_CS["NAVD_1988",
>   VDATUM["North_American_Vertical_Datum_1988"],
>   UNIT["Meter",1.0],
>   AXIS["Up",UP],
>   AUTHORITY["EPSG","5703"]]]
> Corrected:
>   VERT_CS["NAVD88 height - Geoid12B (meters)",
>   VERT_DATUM["North American Vertical Datum 1988",2005,
>   AUTHORITY["EPSG","5103"]],
>   UNIT["metre",1,
>   AUTHORITY["EPSG","9001"]],
>   AXIS["Up",UP],
>   AUTHORITY["EPSG","5703"]]]

☑ *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	☑
2	Bare-earth/Ground	☑
7	Noise (low, manually identified, if needed)	☑
8	Model key points	☐
9	Water	☑
10	Ignored ground (breakline proximity)	☐
11	Withheld (if the "Withheld Bit" is not implemented in the processing software	☐
17	Bridges	☑

| 18 | Noise (high, manually identified, if needed) | ☑ |

Additional Classes:

Class	Description
20	Ignored ground

Additional comments:

There are 8 LAS tiles that have pulses with a return number of zero. Please repair and replace these LAS tiles. Corrected 2/20/19
w1151n1992.las
w1166n1996.las
w1180n1996.las
w1182n2001.las
w1184n1998.las
w1186n1997.las
w1188n2002.las
w1189n1996.las

There are 26 LAS tiles that have points with a classification of 4. The use of this classification is inconsistent with the project's classification scheme (see list of LAS files at the bottom of this report). Corrected 2/20/19

Based on this review, the USGS <u>accepts</u> 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 <u>Geometery (ZEnabled)</u>   .
Units: <u>Meters</u>

☑ Waterbody Breaklines.

Polyline ☐ Polygon ☑
☑ Single elevation value per waterbody feature.
☑ Required.
Waterbody Elevations were created via <u>Unknown</u>   waterbody level techniques.

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

Polyline ☐ Polygon ☑
Downstream DLS Flow is <u>Monotonic</u>   .
☑ Required.

☐ Single Line Breaklines.
☑ No missing or misplaced breaklines.

Based on this review, the USGS <u>accepts</u> 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: Triangulated Irregular Network (TIN)

☑ 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*)
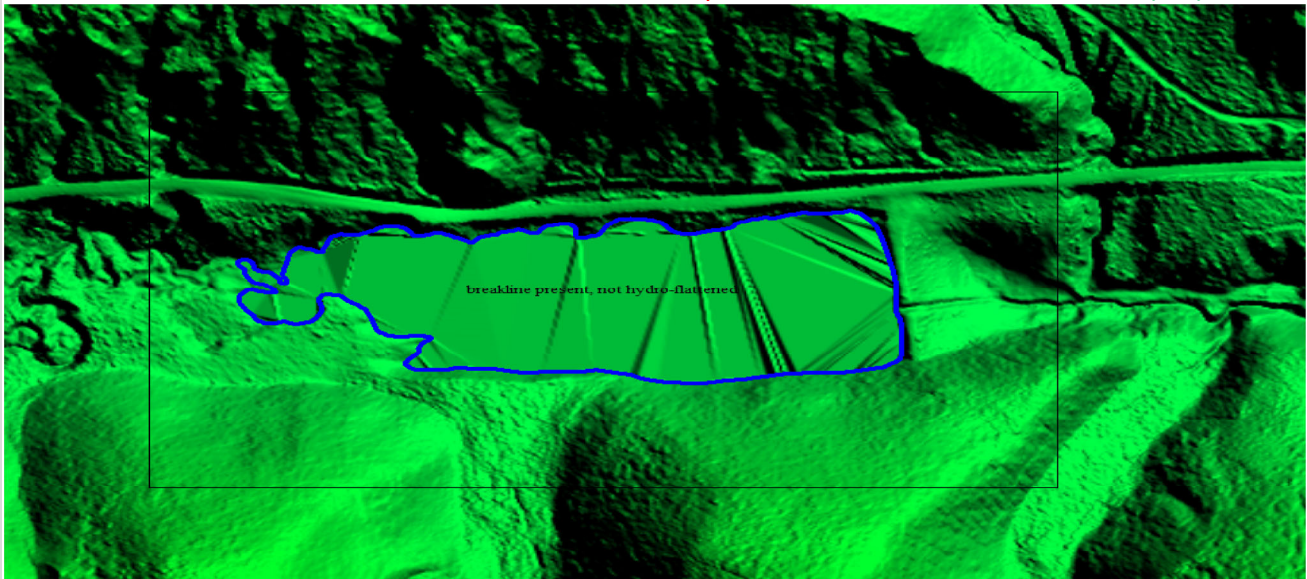
☑ Tiles do not exhibit systematic sensor error or cornrowing

Hydro Treatment: hydro-flattened

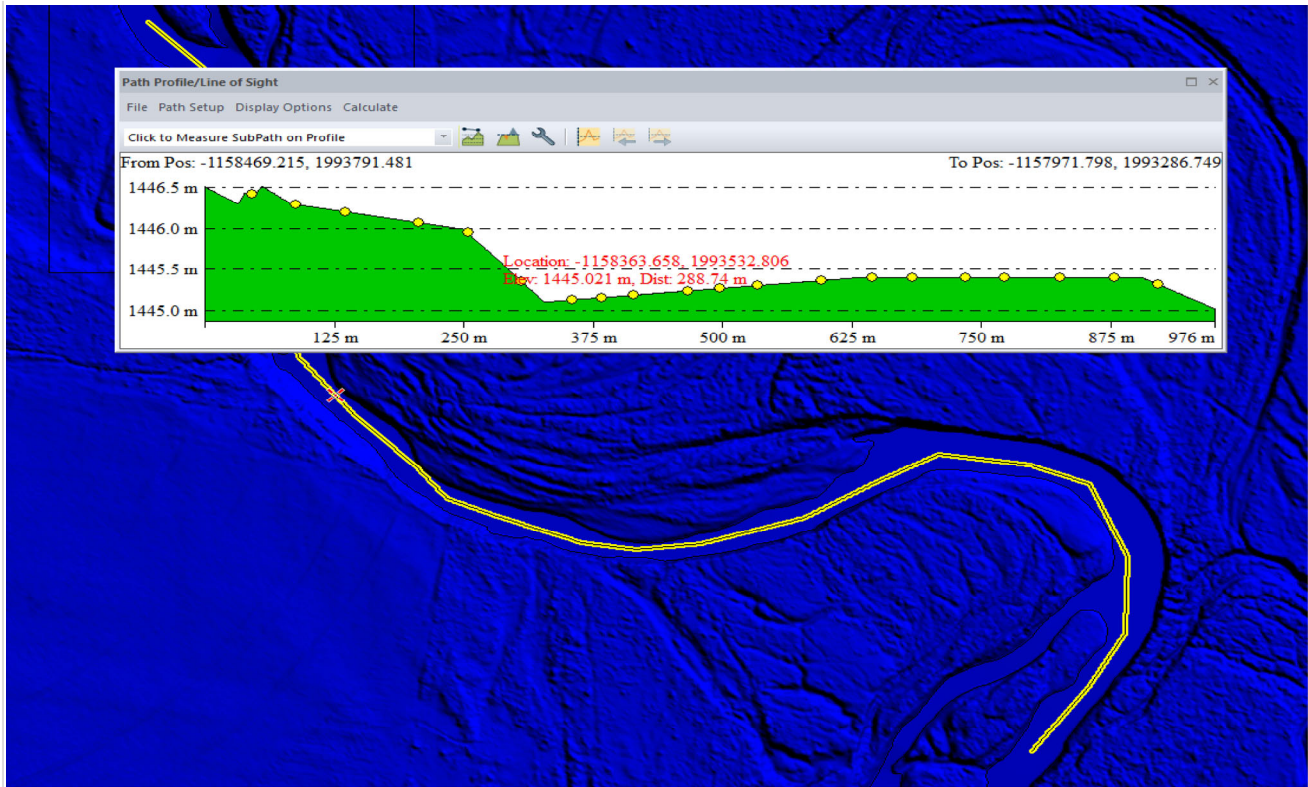DEM tiles are properly Hydro Flattened ⦿ Yes ◯ No

☐ Waterbodies 2 Acres   or greater are flattened

There is one lake where there is a breakline, but the lake is not hydro-flattened in the DEM. Corrected 2/20/19

breakline present, not hydro-flattened

☐ Streams 100 ft.   or greater are flattened in a downstream manner

There are two river_geometry_errors. Corrected 2/20/19

☑ Tidal Boundaries/Shorelines are flattened

☑ No missing islands [1 Acre] or larger
☐ Bridges/Overpasses are properly removed

There is one bridge that requires removal from the ground class. Corrected 2/20/19

☑ Culverts are maintained (Not Hydro Enforced)
☑ Depressions, Sinks, are not filled in (Not Hydro Conditioned)
☑ Vegetation properly removed
☑ Manmade structures properly removed

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:
Corrected and parsed WKT:
COMPD_CS["NAD83(2011) / Conus Albers + NAVD88 height - Geoid12B (meters)",
  PROJCS["NAD83(2011) / Conus Albers",
    GEOGCS["NAD83(2011)",

```
        DATUM["NAD83 (National Spatial Reference System 2011)",
          SPHEROID["GRS 1980",6378137,298.257222101,
            AUTHORITY["EPSG","7019"]],
          AUTHORITY["EPSG","1116"]],
        PRIMEM["Greenwich",0,
          AUTHORITY["EPSG","8901"]],
        UNIT["degree",0.0174532925199433,
          AUTHORITY["EPSG","9122"]],
        AUTHORITY["EPSG","6318"]],
      PROJECTION["Albers_Conic_Equal_Area"],
      PARAMETER["standard_parallel_1",29.5],
      PARAMETER["standard_parallel_2",45.5],
      PARAMETER["latitude_of_center",23],
      PARAMETER["longitude_of_center",-96],
      PARAMETER["false_easting",0],
      PARAMETER["false_northing",0],
      UNIT["metre",1,
        AUTHORITY["EPSG","9001"]],
      AXIS["X",EAST],
      AXIS["Y",NORTH],
      AUTHORITY["EPSG","6350"]],
   VERT_CS["NAVD88 height - Geoid12B (meters)",
      VERT_DATUM["North American Vertical Datum 1988",2005,
        AUTHORITY["EPSG","5103"]],
      UNIT["metre",1,
        AUTHORITY["EPSG","9001"]],
      AXIS["Up",UP],
      AUTHORITY["EPSG","5703"]]]
```

26 LAS tiles have points with a classification of 4:
w1151n2041.las
w1216n2021.las
w1216n2022.las
w1161n2011.las
w1164n2038.las
w1164n2039.las
w1164n2040.las
w1164n2041.las
w1165n2038.las
w1165n2039.las
w1165n2040.las
w1165n2041.las
w1166n2038.las
w1166n2039.las
w1283n2025.las
w1231n1981.las
w1284n2025.las
w1285n2025.las
w1232n1981.las
w1239n1984.las
w1240n1983.las
w1240n1984.las
w1241n1983.las
w1244n1984.las
w1244n1985.las
w1245n1985.las

INTERNAL COMMENTS

END OF REPORT (v2.4.0)