



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.

KS_SthCentralAOI3_2015

NGTOC

Brent Marz



Project Information

Project:

Contractor:

Project Type:
Partnership

Applicable Specification:
NGP LiDAR Base Specification V 1.2

Project Points of Contact:

Name:	Type:	Email:
<input type="text" value="Claire DeV Vaughn"/>	<input type="text" value="Select or type..."/>	<input type="text"/>

REPORT QUALIFICATION SUMMARY:
Task Order Overall: <i>Meets Requirements</i>
Metadata: 1 of 1 Reviews Accepted 0 Reviews Not Accepted
Vertical Accuracy: 1 of 1 Reviews Accepted 0 Reviews Not Accepted
Swath/Raw LAS: 1 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:

Dates Collected Range:

Collection Start:

Collection End:

Project Aliases:

Licensing:

Public Domain

Project Description:

Review Information

Reviewer: Date Delivered:

3rd Party QA Performed: Date Assigned:

Action To Contractor Date:	Issue Description:	Return Date:
4/7/2016	swath does not meet vertical accuracy standard	

Review Complete:

Dates Project Worked:

Start:

End:

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 checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<u>PDF</u>	<input type="text" value="1"/>	<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"/>	<input type="text"/>
Project Level XML Metadata:	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<u>XML</u>	<input type="text" value="1"/>	<input type="text"/>
Project Extent:	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<u>.shp</u>	<input type="text" value="2"/>	<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>	2	
Additional Comments:						

LIDAR DATA

Deliverables	Delivered	XML Metadata	Required	Format	Quantity	Additional Details
Swath Data:	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<u>.las</u>	172	
Classified/ Tiled Data:	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<u>.las</u>	486	
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"/>	<u>IMG</u>	3,266	
Breaklines:	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<u>.shp</u>	1	
Additional Comments:						

OTHER

Additional Comments:	
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Geographic Information

Area Extent: Sq. Miles

Tile Size: Meters

DEM/DTM Grid Spacing: Meters

Coordinate Reference System:

UTM Zone 14

Projection:

Horizontal
Datum:

NAD83_HARN

- 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

- | | |
|--|---|
| <input checked="" type="checkbox"/> Project Extent | <input checked="" type="checkbox"/> Tiled/Classified XML Metadata |
| <input checked="" type="checkbox"/> Project Tile Scheme | <input checked="" type="checkbox"/> Tiled/Classified LiDAR |
| <input checked="" type="checkbox"/> Control Points | <input checked="" type="checkbox"/> Swath/Raw LiDAR XML Metadata |
| <input checked="" type="checkbox"/> Checkpoints | <input checked="" type="checkbox"/> Swath/Raw LiDAR |
| <input checked="" type="checkbox"/> Project Level XML Metadata | <input checked="" type="checkbox"/> DEM(s) |
| | <input checked="" type="checkbox"/> DEM XML Metadata |
| | <input checked="" type="checkbox"/> Breakline(s) |
| | <input checked="" type="checkbox"/> Breakline XML Metadata |

Additional
Comments:

Collection Information

Quality Level: 2

Configured Nominal Pulse Spacing:

Select...

Configured Aggregate Nominal Pulse Spacing:

0.6883 Meters

Method: Select or type...

Detailed Date(s) Collected:

Sensor Information:

Sensor Type:

Select...

Sensor Used:

Leica ALS70 - HP

Configured Scan Angle \pm from nadir:

Degrees

Additional Comments:

Atlantic's Sensor Characteristics		
Leica ALS70-HP		
Manufacturer	Leica	
Model	ALS70 - HP	
Platform	Fixed-Wing	
Scan Pattern	Sine, Triangle, Raster	
Maximum Scan Rate (Hz)	Sine	200
	Triangle	158
	Raster	120
Field of View (°)	0 - 75 (Full Angle, User Adjustable)	
Maximum Pulse rate (kHz)	500	
Maximum Flying height (m AGL)	3500	
Number of returns	Unlimited	
Number of Intensity Measurements	3 (First, Second, Third)	
Roll Stabilization (Automatic Adaptive, °)	75 - Active FOV	
Storage Media	Removable 500 GB SSD	
Storage Capacity (Hours @ Max Pulse Rate)	6	
Size (cm)	Scanner	37 W x 68 L x 26 H
	Control Electronics	45 W x 47 D x 36 H
Weight (kg)	Scanner	43
	Control Electronics	45
Operating Temperature	0 - 40 °C	
Flight Management	FCMS	
Power Consumption	927 @ 22.0 - 30.3 VDC	

Lidar System Acquisition Parameters	
Item	Parameter
System	Leica ALS-70 HP
Nominal Pulse Spacing (m)	0.6
Nominal Pulse Density (pls/m ²)	2.5
Nominal Flight Height (AGL meters)	2318
Nominal Flight Speed (kts)	130
Pass Heading (degree)	90
Sensor Scan Angle (degree)	40
Scan Frequency (Hz)	35.8
Pulse Rate of Scanner (kHz)	256.8
Line Spacing (m)	286
Pulse Duration of Scanner (ns)	4
Pulse Width of Scanner (m)	0.46
Central Wavelength of Sensor Laser (nm)	1064
Sensor Operated with Multiple Pulses	Yes
Beam Divergence (mrad)	0.15
Nominal Swath With (m)	1536
Nominal Swath Overlap (%)	20
Scan Pattern	Triangle

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 Project Level XML Metadata parsed without errors.

Check if 'Best Use' metadata for NED:

The Swath XML Metadata parsed without errors.

Check if 'Best Use' metadata for NED:

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:

Classified LAS:

CORRECTED 4/7/2016

Validation and re-expression of Classified_Tile_LiDAR.xml

mp 2.9.32 - Peter N. Schweitzer (U.S. Geological Survey)
1 errors: 1 missing

mp 2.9.32 - Peter N. Schweitzer (U.S. Geological Survey)

1 errors: 1 missing

Type	Description or line numbers	Line(s) (or count)
Severity 3: Missing elements		
Error	Entity_Type (5.1.1) is required in Detailed_Description (5.1)	633
Severity 0: Informative warnings and upgrade notes		
Other	Info: input file = phpV5C82Z.xml	0
Other	Info: process date = 20160407	0
Other	Info: process time = 10:39:30	0

Generated by [err2html](#) 2.1.13 Thu Apr 7 10:39:31 2016

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 FILES

Confidence Interval Required: th % CI

Required Unit:

Required # of checkpoints:

Required RMSEz:

*Required Vertical Accuracy (RMSEz * .% CI)*

REQUIRED NON-VEGETATED VERTICAL ACCURACY FOR DEM FILES

Confidence Interval Required: th % CI

Required Unit:

Required # of checkpoints:

Required RMSEz:

*Required Vertical Accuracy (RMSEz * .% CI)*

REQUIRED VEGETATED VERTICAL ACCURACY FOR DEM FILES

Percentile Required: th

Required Unit:

Required # of checkpoints:

Required Vertical Accuracy (RMSEz @ xth percentile)

Additional Required Vertical Accuracy Information:

Reported Vertical Accuracy

Yes No

REPORTED NON-VEGETATED VERTICAL ACCURACY FOR SWATH LIDAR FILES

Confidence Interval Reported: th % CI

Reported Unit:

Reported # of checkpoints:

Reported RMSEz:

Reported Vertical Accuracy (RMSEz * .% CI)

REPORTED NON-VEGETATED VERTICAL ACCURACY FOR DEM FILES

Confidence Interval Reported: th % CI

Reported Unit:

Reported # of checkpoints:

Reported RMSEz:

Reported Vertical Accuracy (RMSEz * .% CI)

REPORTED VEGETATED VERTICAL ACCURACY FOR DEM FILES

Percentile Reported: th

Reported Unit:

Reported # of checkpoints:

Reported Vertical Accuracy (RMSEz @ xth 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

Confidence Interval Reviewed: th % CI

Reviewed Unit:

Reviewed # of checkpoints:

Reviewed RMSEz:

Reviewed Vertical Accuracy (RMSEz * .% CI)

REVIEWED NON-VEGETATED VERTICAL ACCURACY FOR DEM FILES

Confidence Interval Reviewed: th % CI

Reviewed Unit:

Reviewed # of checkpoints:

Reviewed RMSEz:

Reviewed Vertical Accuracy (RMSEz * .% CI)

REVIEWED VEGETATED VERTICAL ACCURACY

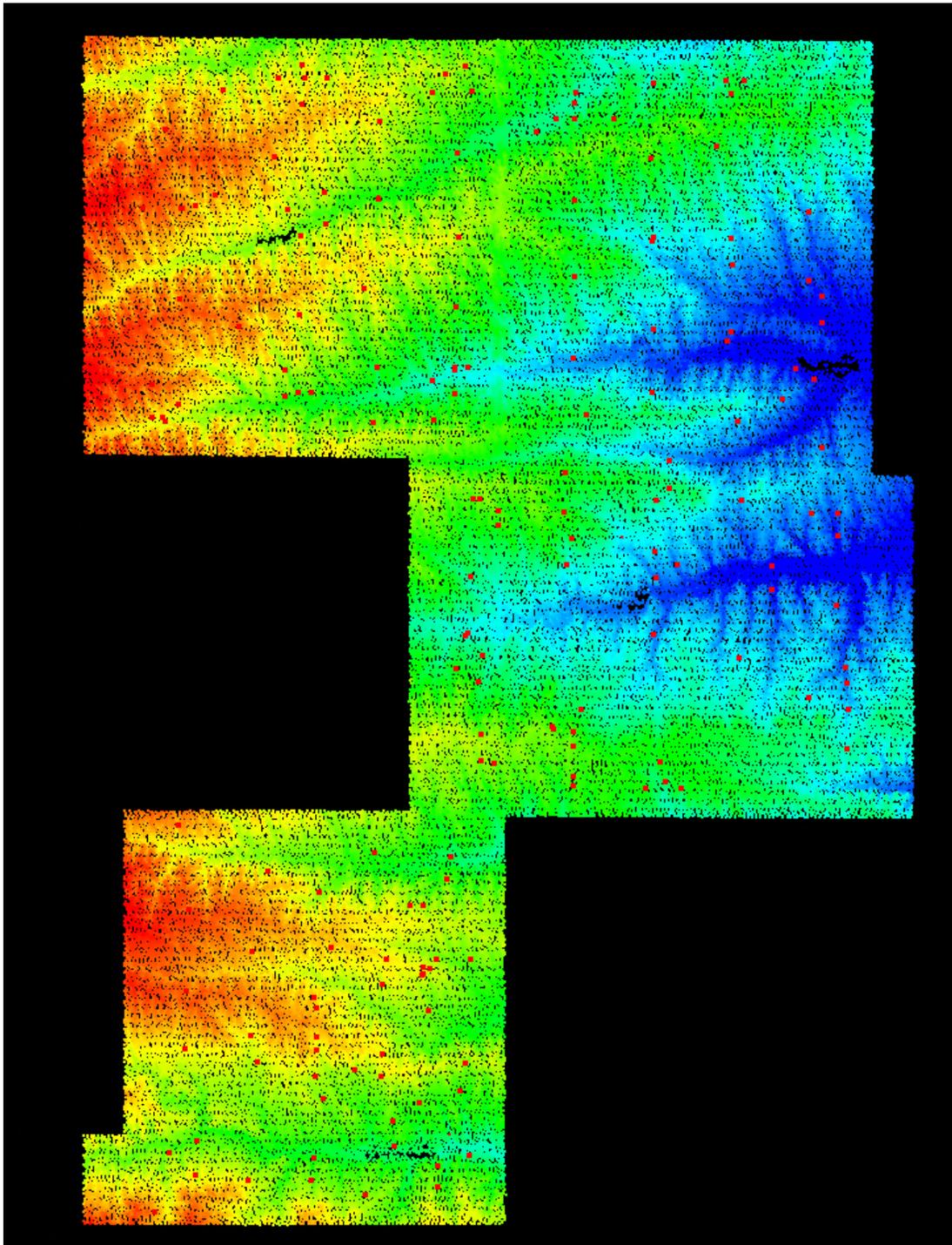
Percentile Required: th

Required Unit:

Required # of checkpoints:

Required Vertical Accuracy (RMSEz @ xth percentile)

Checkpoint Distribution Image



Vertical Accuracy Results:

Swath Vertical Accuracy fails when full 116 points are ran, below is explanation from Atlantic Group, LLC 4/8/216

Please see our LiDAR Manager's comments below.

We were not able to use 2 NVA checkpoint (OT52 and OT53) in our calculations due to the reported high slope.

If you could double check the values, we would appreciate it. We believe there must have been a mistake due to the data passing our vertical accuracy assessment as well as Dewberry's vertical accuracy assessment.

Please let me know what you think.

Thanks
Kyle

Ran vertical accuracy with-holding the 2 points mentioned above, and accuracy passes.

Additional Reviewed Vertical Accuracy Information:

SWATH DOES NOT MEET VERTICAL ACCURACY REQUIREMENTS

Check Points Error Statistics								
Category	# of	Min	Max	Mean	Median	Skew	Std Dev	RMSE _z
Open Terrain/Bare Earth	95	-0.173	0.181	0.000	0.005	-0.100	0.061	0.060
Urban Terrain	21	-0.099	0.126	0.015	0.017	-0.119	0.057	0.057
High Grass	45	-0.180	0.169	0.027	0.030	-0.415	0.064	0.069
Brush	23	-0.095	0.148	0.020	0.008	0.248	0.063	0.064
Consolidated	184	-0.180	0.181	0.011	0.009	-0.115	0.062	0.063

Table 13: Check Points Error Statistics

Check Points Vertical Accuracy Assessment				
Land Cover Category	# of Points	FVA — Fundamental Vertical Accuracy (RMSE _z x 1.9600)	CVA — Consolidated Vertical Accuracy (95th Percentile)	SVA — Supplemental Vertical Accuracy (95th Percentile)
Open Terrain/Bare Earth	95	0.118		
Urban Terrain	21			0.096
High Grass	45			0.110
Brush	23			0.126
Consolidated	184		0.108	

Table 14: Check Points Vertical Accuracy Assessment

Non-vegetated Vertical Accuracy (NVA) and Vegetated Vertical Accuracy (VVA)				
Broad Land Cover Type	# of Points	RMSE _z (m)	95% Confidence Level (m)	95th Percentile (m)
NVA of Point Cloud	114	0.065	0.128	
NVA of DEM	116	0.060	0.117	
VVA of DEM	68	0.068		0.122

Table 15: Non-vegetated Vertical Accuracy (NVA) and Vegetated Vertical Accuracy (VVA)

Comparison of NSSDA, NDEP, and ASPRS Statistics					
Land Cover Category	NSSDA Accuracy _z at 95% confidence level based on RMSE _z * 1.9600 (m)	NDEP FVA, plus SVAs and CVA based on 95th Percentile (m)	NDEP Accuracy Term	ASPRS Vertical Accuracy (m)	ASPRS Accuracy Term
Open Terrain/Bare Earth	0.118	0.089	FVA	0.117	NVA
Urban Terrain	0.112	0.096	SVA		
High Grass	0.136	0.110	SVA	0.122	VVA
Brush	0.126	0.126	SVA		
Consolidated	0.123	0.108	CVA	n/a	n/a

Table 16: Comparison of NSSDA, NDEP, and ASPRS Statistics

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

End of Vertical Accuracy Review

Raw-Swath LiDAR Review Accepted

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

RAW-SWATH LIDAR FILE CHARACTERISTICS

Separate folder for swath/raw LiDAR files

LAS Version: 1.4

Point Record Format: 6

If specified, *.wpd files for full waveform data have been provided: Select...

Correct and properly formatted georeference information is included in all LAS file headers

Adjusted GPS time used with the global encoder id set to 1

Additional comments:

Not an error (Informational for 3dep):

Global encoder 17, las1.4

Based on this review, the USGS accepts the swath/raw LiDAR data.

End of Swath/Raw LiDAR Review

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: Select...

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

Adjusted GPS time used with the global encoder id set to 1

Not an error (Informational for 3dep):

Global encoder 17, las1.4

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 checked="" 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 comments:

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 Select...

waterbody level techniques.

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

Polyline Polygon

Downstream DLS Flow is Proprietary

- Required.

- Single Line Breaklines.

- No missing or misplaced breaklines.

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: Select or type...

Interpolation or Resampling Technique: Unknown

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 corrowing

Hydro Treatment: hydro-flattened

DEM tiles are properly Hydro Flattened Yes No

Waterbodies 2 Acres or greater are flattened

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

Tidal Boundaries/Shorelines are flattened

No missing islands 1 Acre 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

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



END OF REPORT (v2.4.0)