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 and the Center for LiDAR Information Coordination and Knowledge. 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 or NGTOCoperations@usgs.gov.

Materials Received:
4/15/2011

Project ID:
CA\NV_Lake-Tahoe_2010

Project Alias(es):

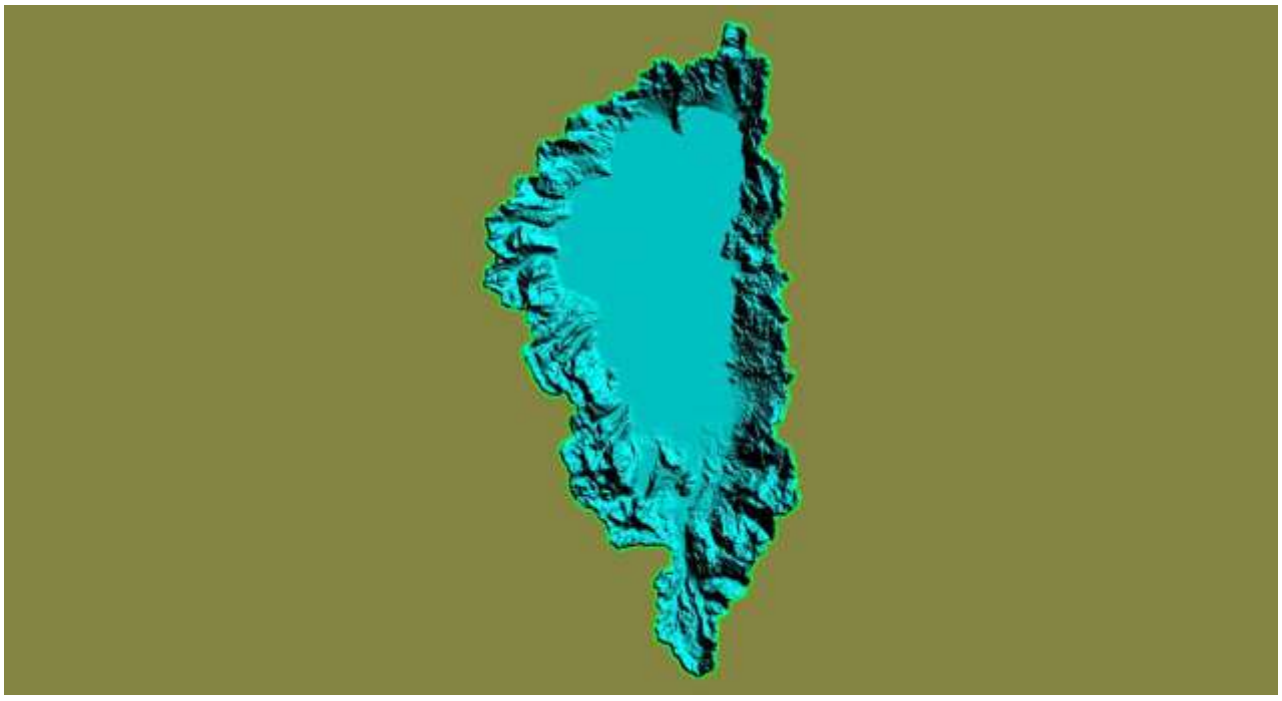
Project Type: Partnership

Project Description:
LiDAR generated point cloud acquired in 2010. Five hunded and forty six square mile area encompassing Lake Tahoe CA\NV.

Year of Collection: 2010

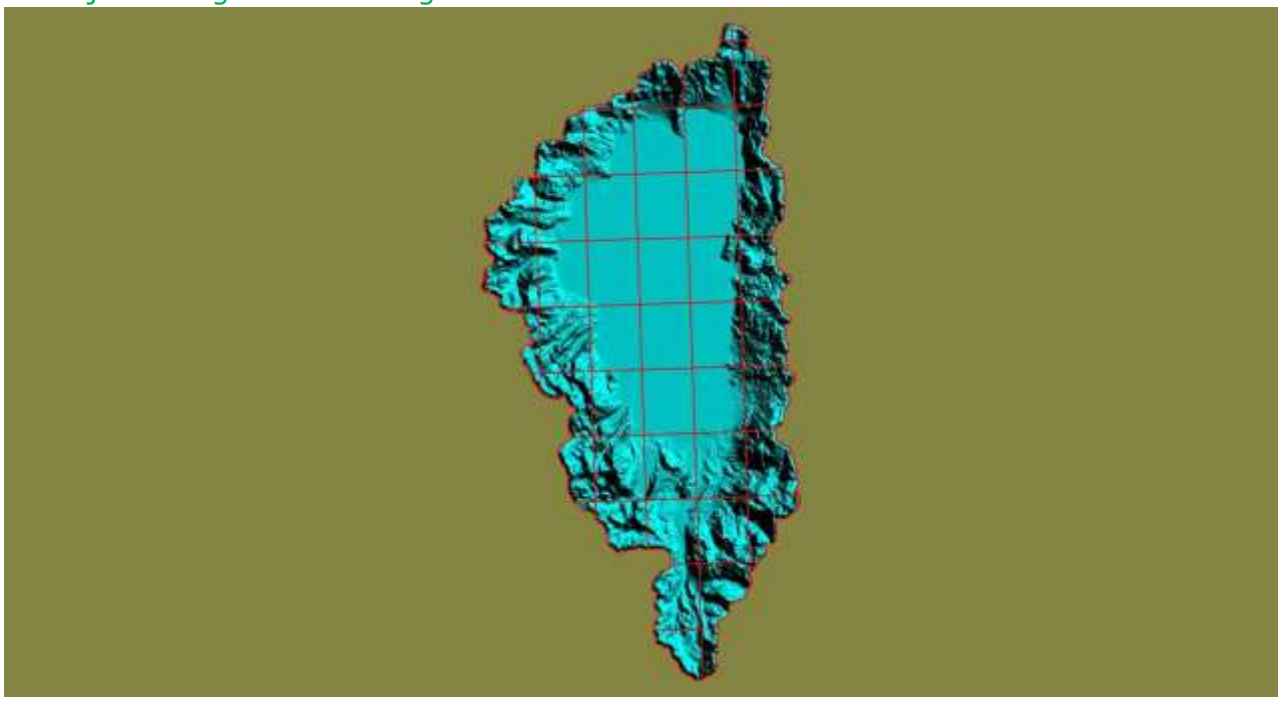
Lot 1 of 1 lots.

Project Extent:
☑ Project Extent image?



Project Tiling Scheme:

☑ Project Tiling Scheme image?



Contractor:

Water Shed Sciences Inc.

Applicable Specification:

The Tahoe Regional Planning Agency

Licensing Restrictions:

None

☐ Third Party Performed QA?

Project Points of Contact:

POC Name	Type	Primary Phone	E-Mail
Carol Ostergren	NSDI Liaison	(916) 278-9510	costergren@usgs.gov

Project Deliverables

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/Orthoimagery Section supervisor and informed of the problem. Processing will resume after the COTR has coordinated the deposition of remaining deliverables.

- [x] Collection Report
- [x] Survey Report
- [x] Processing Report
- [ ] QA/QC Report
- [ ] Control and Calibration Points
- [x] Project Shapefile/Geodatabase
- [ ] Control Point Shapefile/Gdb
- [x] Project Tiling Scheme Shapefile/Gdb
- [x] Breakline Shapefile/Gdb
- [ ] Project XML Metadata
- [ ] Swath LAS XML Metadata
- [ ] Classified LAS XML Metadata
- [x] Breakline XML Metadata
- [x] Bare-Earth DEM XML Metadata

Multi-File Deliverables

File Type	Quantity
☐ Swath LAS Files	
☑ Intensity Image Files	57
☑ Tiled LAS Files	967
☑ Breakline Files	11
☑ Bare-Earth DEM Files	58

Additional Deliverables

	Item
☑	All return Ascii .txt files
☑	All return projected .las files
☑	Highest hit .img files
☐	Hydro Enforced Bare Earth .img files

Errors, Anomalies, Other Issues to document? ○ Yes ◉ No

None.

Project Geographic Information

Areal Extent:

546

Sq Mi

Grid Size:

.5

meters

Tile Size:

3.4 x 4.3

miles

Nominal Pulse Spacing:

8

meters

Vertical Datum: NAVD88 meters

Horizontal Datum: NAD83 meters

Project Projection/Coordinate Reference System: UTM Zone 10 NAD 83 meters.

This Projection Coordinate Reference System is consistent across the following deliverables:

- [x] Project Shapefile/Geodatabase
- [x] Project Tiling Scheme Shapefile/Gdb
- [ ] Checkpoints Shapefile/Geodatabase
- [ ] Project XML Metadata File
- [ ] Swath LAS XML Metadata File
- [ ] Classified LAS XML Metadata File
- [x] Breaklines XML Metadata File
- [x] Bare-Earth DEM XML Metadata File
- [ ] Swath LAS Files
- [x] Classified LAS Files
- [x] Breaklines Files
- [x] Bare-Earth DEM Files

Check Point Shapefile/Geodatabase CRS

None sent

Project XML Metadata CRS

None sent

Swath LAS XML Metadata CRS

None sent

Classified LAS XML Metadata CRS

None sent

Swath LAS Files CRS

None sent

Review Cycle

This section documents who performed the QA Review on a project as well as when QA reviews were started, actions passed, received, and completed.

Reviewer:
E. Jaramillo

Review Start Date:
4/15/2011

Action to Contractor Date	Issue Description	Return Date
5/4/2011	Water not hydro flattened	11/28/2012

Review Complete: 12/10/2012

Metadata Review

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.

The Project XML Metadata file parsed with errors.

None sent

The Breakline XML Metadata file parsed without errors.

The Bare-Earth DEM XML Metadata file parsed with errors.

Type	Description or line numbers	Line(s (or count

Severity 5: Misplaced elements		
Error	Lineage (2.5) is not permitted in Metadata (0)	197
Severity 3: Missing elements		
Error	Altitude_Encoding_Method (4.2.1.4) is required in Altitude_System_Definition (4.2.1)	133
Error	Altitude_Resolution (4.2.1.2) is required in Altitude_System_Definition (4.2.1)	133
Error	Attribute_Definition (5.1.2.2) is required in Attribute (5.1.2)	146 149
Error	Attribute_Definition_Source (5.1.2.3) is required in Attribute (5.1.2)	146 149
Error	Attribute_Domain_Values (5.1.2.4) is required in Attribute (5.1.2)	146 149
Error	Digital_Transfer_Option (6.4.2.2) is required in Digital_Form (6.4.2)	167
Error	Distribution_Liability (6.3) is required in Distribution_Information (6)	154
Error	Entity_Type_Definition (5.1.1.2) is required in Entity_Type (5.1.1)	136
Error	Entity_Type_Definition_Source (5.1.1.3) is required in Entity_Type (5.1.1)	136
Error	Entity_Type_Label (5.1.1.1) is required in Entity_Type (5.1.1)	136
Error	Fees (6.4.3) is required in Standard_Order_Process (6.4)	166
Error	Format_Name (6.4.2.1.1) is required in Digital_Transfer_Information (6.4.2.1)	168
Error	Horizontal_Positional_Accuracy_Report (2.4.1.1) is required in Horizontal_Positional_Accuracy (2.4.1)	79
Error	Horizontal_Positional_Accuracy_Value (2.4.1.2.1) is required in Quantitative_Horizontal_Positional_Accuracy_Assessment (2.4.1.2)	80
Error	Place_Keyword_Thesaurus (1.6.2.1) is required in Place (1.6.2)	52
Error	Process_Date (2.5.2.3) is required in Process_Step (2.5.2)	92 97
Error	Process_Step (2.5.2) is required in Lineage (2.5)	197
Error	Vertical_Positional_Accuracy_Report (2.4.2.1) is required in Vertical_Positional_Accuracy (2.4.2)	84

Project QA/QC Report Review

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.

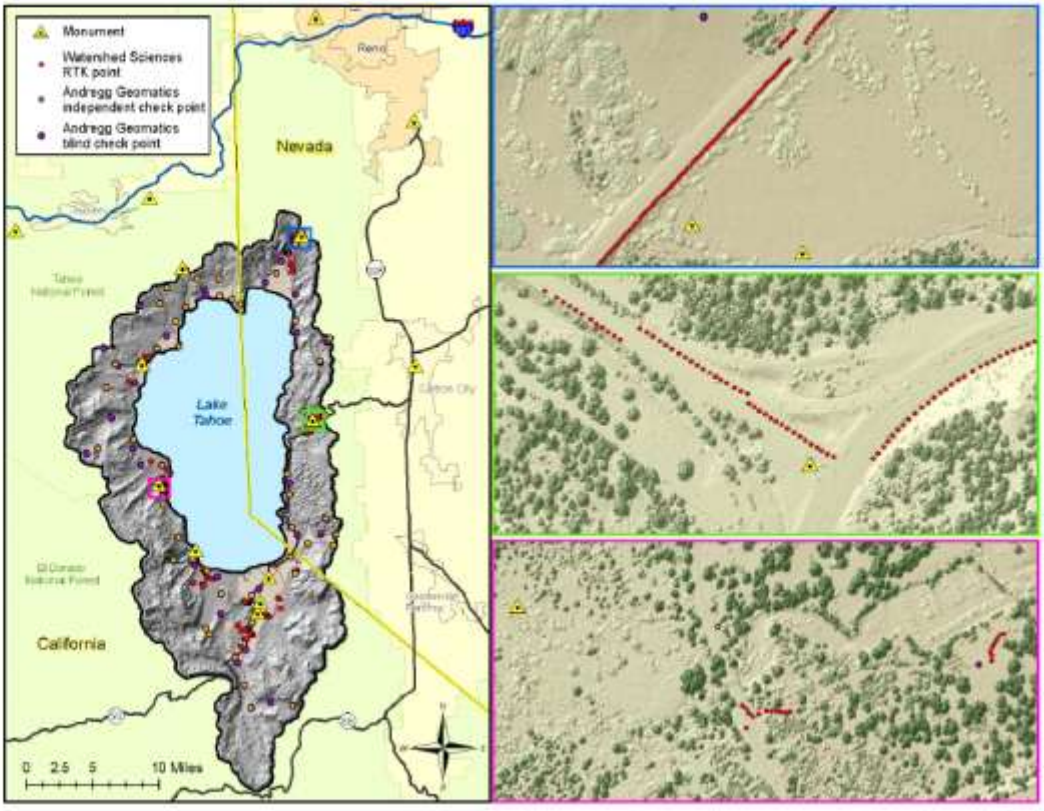
NSSDA and ASPRS require that a minimum of twenty checkpoints (thirty is preferred) are collected for each major land cover category represented in the LiDAR data. Checkpoints should be selected on flat terrain, or on uniformly sloping terrain in all directions from each checkpoint. They should not be 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.

Checkpoint Shapefile or Geodatabase:

☑ Checkpoint Distribution Image?

Figure 2. RTK and fast static check point and control monument locations used for Lake Tahoe data acquisition, processing, and accuracy checks



The following land cover classes are represented in this dataset (uncheck any that do not apply):

- [x] Bare Earth
- [ ] Tall Weeds and Crops
- [ ] Brush Lands and Low Trees
- [ ] Forested Areas Fully Covered by Trees
- [ ] Urban Areas with Dense Man-Made Structures

There are a minimum of 20 checkpoints for each land cover class represented. Points within each class are uniformly distributed throughout the dataset. USGS was not able to locate independent checkpoints for this analysis. USGS accepts the quality of the checkpoint data for these LiDAR datasets.

Errors, Anomalies, Other Issues to document? (•) Yes ( ) No

- [x] Image?

Table 5. *Andregg Geomatic blind check point elevations compared with Watershed Science's LiDAR-derived elevations (see* ***Appendix B****)*

Northing (m)	Easting (m)	Andregg Geomatics Elevation (m)	Watershed Sciences Elevation (m)	Elevation Difference (m)	Slope (degrees)
4341217.456	741910.542	1908.35	1908.36	-0.01	18.96
4329068.691	745496.960	2028.48	2028.45	0.03	15.77
4315106.077	752984.795	1970.29	1970.28	0.01	4.52
4309141.692	756112.695	2116.53	2116.53	0.00	23.84
4332411.342	767114.222	2149.18	2149.24	-0.06	4.62
4354971.457	765734.385	2616.27	2616.34	-0.07	8.84
4351669.767	763430.525	2184.00	2183.97	0.03	3.8
4348221.356	754169.466	1954.60	1954.64	-0.04	2.13
4342659.288	749549.896	2019.46	2019.58	-0.12	2.15
4339010.970	743763.546	1895.73	1895.73	0.00	5.39
4336956.483	745714.562	2003.25	2003.28	-0.03	4.12
4332737.575	742916.643	1940.29	1940.26	0.03	0.84
4313668.431	755726.440	1911.65	1911.67	-0.02	0.45
4312673.541	753986.546	1955.90	1955.92	-0.03	2.19
4312164.137	760706.880	1901.83	1901.93	-0.10	1.46
4303297.157	758153.229	1939.43	1939.51	-0.08	0.61
4298580.135	762147.591	2341.19	2341.40	-0.21	19.04
4318744.155	765371.059	1926.69	1926.81	-0.12	2.87
4318809.772	768236.427	2158.64	2158.64	0.00	19.52
4341933.718	768956.079	2520.95	2521.07	-0.12	1.91
4339417.893	768253.576	2433.43	2433.62	-0.19	16.61
4349090.236	761469.845	1955.78	1955.85	-0.07	27.46
4324714.073	749059.612	1901.46	1901.48	-0.02	0.29
4327019.010	746478.525	1965.80	1965.73	0.07	1.29
4328457.629	739899.058	2337.73	2337.70	0.03	8.49
4346275.471	746360.302	2403.99	2403.99	0.00	3.77
4343063.191	765324.516	1903.30	1903.33	-0.03	3.2
4304879.781	759109.667	1933.04	1933.12	-0.08	1.42
4324872.024	764540.643	1985.39	1985.58	-0.19	14.37
4347667.943	765171.283	1929.72	1929.68	0.04	2.66
4347617.901	754274.762	1902.06	1902.08	-0.02	1.21

100% of Points	RMSEz (m)	ACCURACYz (m) 1.96xRMSEz Spec=0.20m	Mean (m)	Std Dev (m)	# of Points	Min (m)	Max (m)
	0.08	0.16	0.01	0.01	31	0.0	0.04

A fundamental vertical accuracy test was conducted by Andregg Geomatic. They compared 31 blind check points and Watersheds Science LiDAR derived elevations data . Andregg Geomatic used the Accuracy(z) method to calculate FVA. The resulting Accuracy(z) was 0.16 meters. This is below the requirement of 0.2 meters Accuracy(z) for this dataset. For details regarding the vertical accuracy check, see Appendix B in the "Lake_Tahoe_LiDAR.pdf".

Accuracy values are reported in terms of Fundamental Vertical Accuracy (FVA), Supplemental Vertical Accuracy(s) (SVA), and Consolidated Vertical Accuracy (CVA).

Accuracy values are reported in: meters

Required FVA Value is 0.2 meters or less.
Target SVA Value is n/a meters or less.
Required CVA Value is n/a meters or less.

The reported FVA of the LAS Swath data is **n/a** meters.

The reported FVA of the Bare-Earth DEM data is **n/a** meters.
SVA are required for each land cover type present in the data set with the exception of bare-earth. SVA is calculated and reported as a 95th Percentile Error.

Land Cover Type	SVA Value	Units
Tall Weeds and Crops		N/A
Brush Lands and Low Trees		N/A
Forested Areas Fully Covered by Trees		N/A
Urban Areas with Dense Man-Made Structur...		N/A

The reported CVA of this data set is: n/a meters.

LAS Swath File 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 Fundamental Vertical Accuracy using ground control checkpoints measured in clear open terrain. The following was determined for LAS swath data for this project:

LAS Version
- (•) LAS 1.2
- ( ) LAS1.3
- ( ) LAS 1.4

Swath File Characteristics
- [ ] Separate folder for LAS swath files
- [ ] Each swath files <= 2GB

☐ *If specified, *.wdp files for full waveform have been provided

The reported FVA of the LAS swath data is n/a meters.

Based on this review, the USGS does not accept at this time the LAS swath file data.

Errors, Anomalies, Other Issues to document? ◉ Yes ○ No

☐ Image?

No Swath data sent

LAS Tile File Review

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. The following was determined for classified LAS files for this project:

Classified LAS Tile File Characteristics

- ☑ Separate folder for Classified LAS tile files
- ☑ 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
- ☑ Classified LAS tile files have no points classified as '12'

☐ Point classifications are limited to the standard values listed below:

Code	Description
1	Processed, but unclassified
2	Bare-earth ground
7	Noise (low or high, manually identified, if needed)
9	Water
10	Ignored ground (breakline proximity)
11	Withheld (if the "Withheld" bit is not implemented in processing software)

☐ Buy up?

Based on this review, the USGS accepts the classified LAS tile file data.

Errors, Anomalies, Other Issues to document? ○ Yes ◉ No

None.

Breakline File Review

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

Breakline File Characteristics

- ☑ Separate folder for breakline files
- ☐ All breaklines captured as PolylineZ or PolygonZ features
- ☑ No missing or misplaced breaklines

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

Errors, Anomalies, Other Issues to document? ◉ Yes ○ No

☐ Image for error?

Breaklines for Fallen Lake and Lake Tahoe don't say if they are Polygon Z or Polyline Z, they just say Polygon. All other breaklines say Polyline ZM.

Bare-Earth DEM Tile File Review

The derived bare-earth DEM file receives a review of the vertical accuracies provided by the data supplier, vertical accuracies calculated by USGS using supplied and independent checkpoints, and a manual check of the appearance of the DEM layer.

Bare-Earth DEM files provided in the following format: Erdas Imagine *.img

Bare-Earth DEM Tile File Characteristics

- ☑ Separate folder for bare-earth DEM files
- ☑ DEM files conform to Project Tiling Scheme
- ☑ Quantity of DEM files conforms to Project Tiling Scheme

- [x] DEM files do not overlap
- [x] DEM files are uniform in size
- [x] DEM files properly edge match
- [ ] Independent check points are well distributed

All accuracy values reported in meters.

Reported Accuracies

Land Cover Category	# of Points	Fundamental Vertical Accuracy @95% Confidence Interval ($Accuracy_z$) Required FVA = 0.2 or less.	Supplemental Vertical Accuracy @95th Percentile Error Target SVA = n/a or less.	Consolidated Vertical Accuracy @95th Percentile Error Required CVA = n/a or less.
Open Terrain	20	**n/a**		
Tall Weeds and Crops				
Brush Lands and Low Trees				
Forested Areas Fully Covered by Trees				
Urban Areas with Dense Man-Made Structures				
Consolidated	20			n/a

- [ ] QA performed Accuracy Calculations?

Based on this review, the USGS recommends the bare-earth DEM files for inclusion in the 1/3 Arc-Second National Elevation Dataset.

Based on this review, the USGS accepts the bare-earth DEM files.

Bare-Earth DEM Anomalies, Errors, Other Issues

Errors, Anomalies, Other Issues to document? ○ Yes ◉ No

None.

Internal Note:

This project was started before we incorporated checking las files and running .xml metadata through a check parcer and so on. It took awhile to get the fixes back. I ran stats on the data that was sent and reported it.

This is the end of the report.

QA Form V1.4 12OCT11.xsn