



# 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 NGTOCooperations@usgs.gov.

Materials Received:

8/7/2012

Project Type: GPSC

Project ID:

CA\_OrangeCo\_2011

Project Description:

The primary purpose of this project was to develop a consistent and accurate surface elevation dataset derived from high-accuracy Light Detection and Ranging (LiDAR) technology for the USGS FEMA IX Orange County, California Project Area.

Project Alias(es):

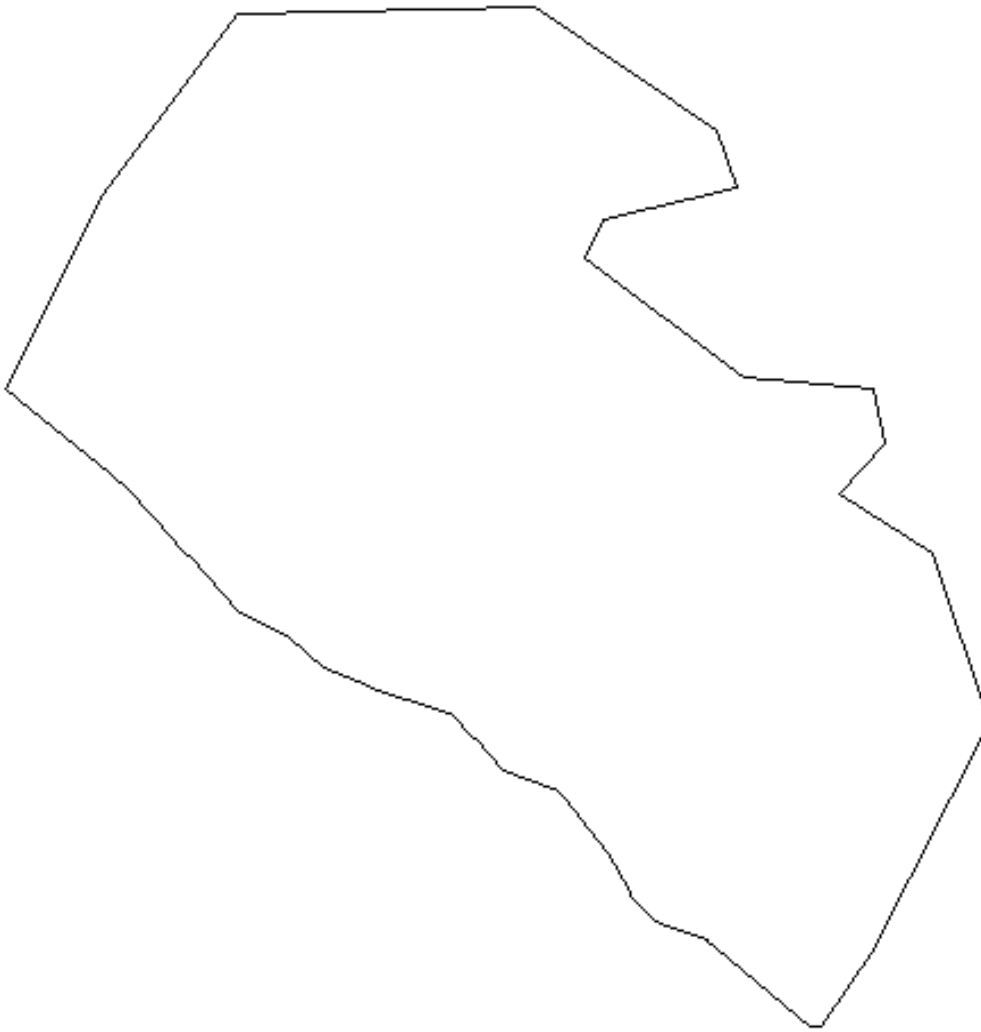
Orange County, CA

Year of Collection: 2011

Lot 1 of 1 lots.

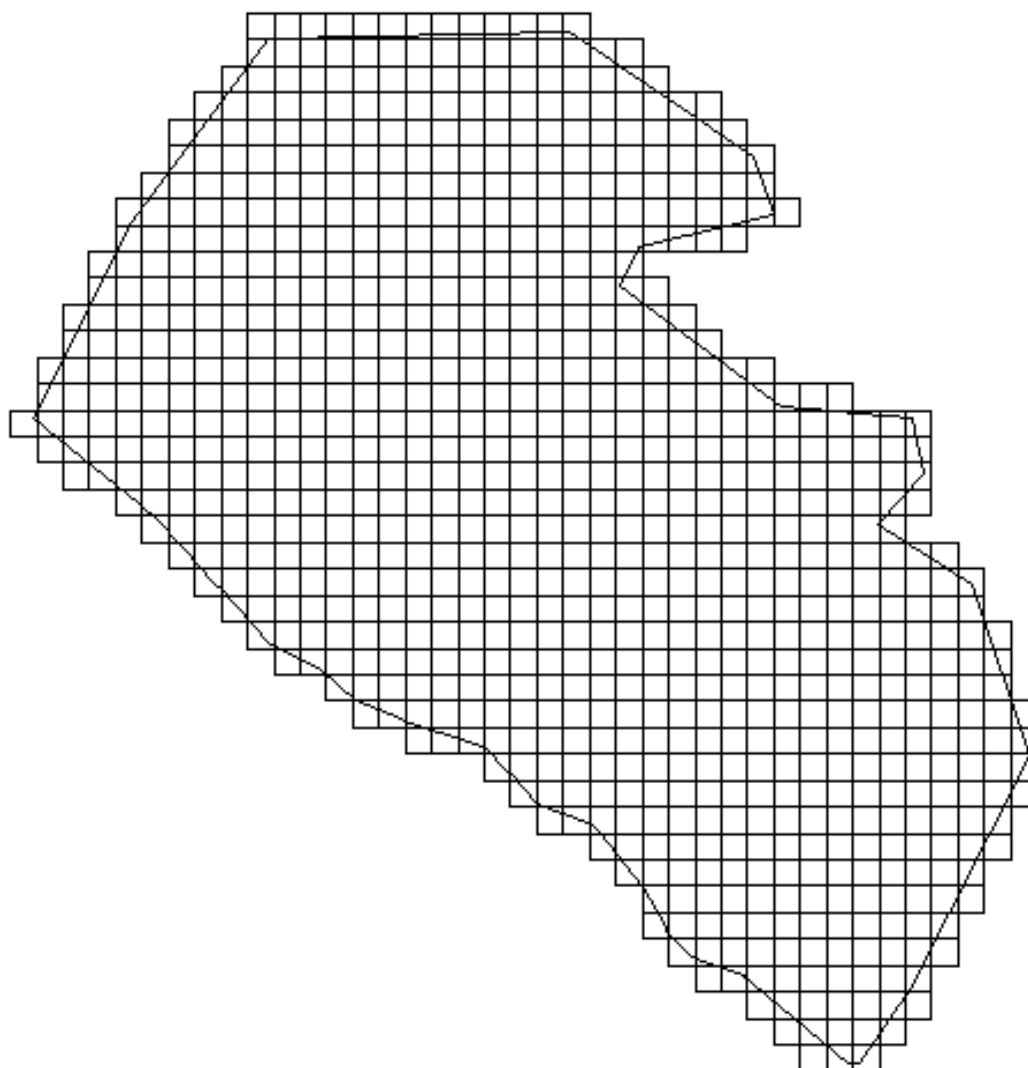
Project Extent:

Project Extent image?



Project Tiling Scheme:

Project Tiling Scheme image?



Contractor:

Dewberry

Applicable Specification:

V13

Licensing Restrictions:

None

Third Party Performed QA?

Project Points of Contact:

POC Name	Type	Primary Phone	E-Mail
Gail Dunn	CPT	573-308-3756	gdunn@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.

- Collection Report
- Survey Report
- Processing Report
- QA/QC Report
- Control and Calibration Points
- Project Shapefile/Geodatabase
- Project Tiling Scheme Shapefile/Gdb
- Control Point Shapefile/Gdb
- Breakline Shapefile/Gdb
- Project XML Metadata

## Multi-File Deliverables

File Type	Quantity
<input checked="" type="checkbox"/> Swath LAS Files <input checked="" type="checkbox"/> Required? <input checked="" type="checkbox"/> XML Metadata?	232
<input checked="" type="checkbox"/> Intensity Image Files <input checked="" type="checkbox"/> Required?	868
<input checked="" type="checkbox"/> Tiled LAS Files <input checked="" type="checkbox"/> Required? <input checked="" type="checkbox"/> XML Metadata?	868
<input checked="" type="checkbox"/> Breakline Files <input checked="" type="checkbox"/> Required? <input checked="" type="checkbox"/> XML Metadata?	6
<input checked="" type="checkbox"/> Bare-Earth DEM Files <input checked="" type="checkbox"/> Required? <input checked="" type="checkbox"/> XML Metadata?	868

## Additional Deliverables

	Item
<input checked="" type="checkbox"/>	Orange County Photos, labeled in .jpg format; 415 total
<input checked="" type="checkbox"/>	Dewberry_Response_To_USGS_Review_Orange_county_10012012.pdf
<input checked="" type="checkbox"/>	REDELIVERY REPORT.docx
<input checked="" type="checkbox"/>	Transmittal.docx
<input checked="" type="checkbox"/>	USGS_Calls_With_Dewberry_Comments.shp

Errors, Anomalies, Other Issues to document?  Yes  No

No XML metadata received for intensity image files with first delivery. XML metadata for intensity images delivered to reviewer via ftp transfer on 10/02/12 with the following comments: All metadata has been redelivered in addition to the intensity metadata due to the effect of the additional checkpoint.

Breakline files delivered in both shapefile (3) and geodatabase (3) format for a total of 6 breakline files.

No control points used to calibrate sensor received by reviewer at NGTOC. The "USGS FEMA Region IX Orange County, CA LiDAR" report lists control and accuracy checkpoint reports and points as deliverables on page 5. However, on page 15 of the report Dewberry describes their use of "DZ Orthos" to ensure the data was calibrated correctly. Control points in shapefile format delivered to reviewer via ftp on 10/02/12.

## Project Geographic Information

Areal Extent:

696

Sq Mi

Grid Size:

1

meters

Tile Size:

1500x1500

meters

Nominal Pulse Spacing:

1

meters

Vertical Datum: NAVD88 meters

Horizontal Datum: NAD83 meters

Project Projection/Coordinate Reference System: UTM Zone 11 N meters.

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

- |   |  |
|---|--|
| <input checked="" type="checkbox"/> Project Shapefile/Geodatabase       | <input checked="" type="checkbox"/> Breaklines XML Metadata File     |
| <input checked="" type="checkbox"/> Project Tiling Scheme Shapefile/Gdb | <input checked="" type="checkbox"/> Bare-Earth DEM XML Metadata File |
| <input checked="" type="checkbox"/> Checkpoints Shapefile/Geodatabase   | <input checked="" type="checkbox"/> Swath LAS Files                  |
| <input checked="" type="checkbox"/> Project XML Metadata File           | <input checked="" type="checkbox"/> Classified LAS Files             |
| <input checked="" type="checkbox"/> Swath LAS XML Metadata File         | <input checked="" type="checkbox"/> Breaklines Files                 |
| <input checked="" type="checkbox"/> Classified LAS XML Metadata File    | <input checked="" type="checkbox"/> Bare-Earth DEM Files             |



# 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:

Hannah Boggs

Review Start Date:

8/7/2012

Action to Contractor Date	Issue Description	Return Date
8/30/2012	Corrections requested.	10/2/2012

Review Complete: 10/15/2012

## 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 without errors.

The Swath LAS XML Metadata file parsed without errors.

The Classified LAS XML Metadata file parsed without errors.

The Breakline XML Metadata file parsed without errors.

The Bare-Earth DEM XML Metadata file parsed without errors.





# Project QA/QC Report Review

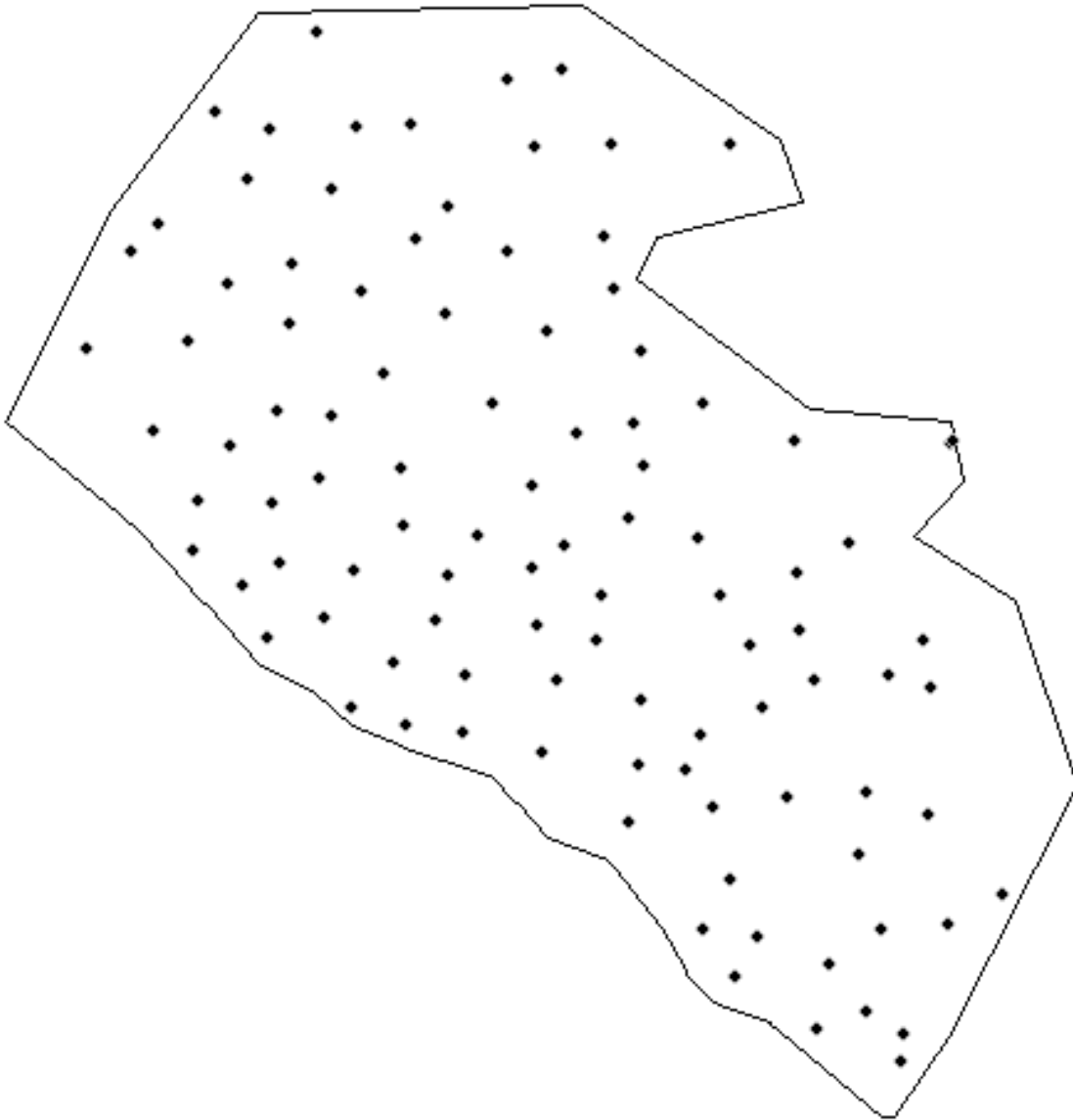
ASPRS recommends that checkpoint surveys be used to verify the vertical accuracy of LiDAR data sets. Checkpoints are to be collected by an independent survey firm licensed in the particular state(s) where the project is located. While subjective, checkpoints should be well distributed throughout the 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?



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

- 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 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

Image?

Only 19 points exist in the Forested and Fully Grown land cover class. Dewberry redelivered the checkpoint shapefile to the reviewer via ftp site on 10/02/12 with the following comments: "The missing checkpoint for the Forested and Fully Grown land cover class was located and added to the LiDAR and DEM dataset testing. This additional point changed the LiDAR dataset SVA for the Forested and Fully Grown land cover category by 0.01m. This additional point did not significantly impact the DEM dataset SVA. There was a slight change to the overall CVA for both the DEM and LiDAR datasets but it was less than 0.001m. The final report and metadata were updated to reflect these changes."

Image?

The USGS/FEMA Region IX-Orange County, CA LiDAR report produced for the U.S. Geological Survey lists the vertical accuracy testing steps on page 29 of the report. Step 2 reads, "Next, Dewberry interpolated the bare-earth LiDAR DTM to provide the z-value for each of the 102 checkpoints." This FVA assessment should be performed against unclassified swath las files. Reviewer was unable to locate FVA assessment against unclassified swath las files. Delivered to the reviewer from Dewberry on 10/02/12 the pdf, "Dewberry Response to USGS Review Orange County 10012012" explains that the swath accuracy results were included in the initial delivery in the swath xml metadata, but a small section has been added to the project report to provide additional clarity.

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:

Required FVA Value is   or less.

Target SVA Value is   or less.

Required CVA Value is   or less.

The reported FVA of the LAS Swath data is  .

The reported FVA of the Bare-Earth DEM data is  .

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	<input type="text" value="0.12"/>	<input type="text" value="meters"/>
Brush Lands and Low Trees	<input type="text" value="0.18"/>	<input type="text" value="meters"/>
Forested Areas Fully Covered by Trees	<input type="text" value="0.12"/>	<input type="text" value="meters"/>
Urban Areas with Dense Man-Made Structu...	<input type="text" value="0.16"/>	<input type="text" value="meters"/>

The reported CVA of this data set is:  .

### 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  .

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

Yes  No

Image?

Vertical Accuracy of las swath files was not reported. The USGS/FEMA Region IX-Orange County, CA LiDAR report produced for the U.S. Geological Survey lists the vertical accuracy testing steps on page 29 of the report. Step 2 reads, "Next, Dewberry interpolated the bare-earth LiDAR DTM to provide the z-value for each of the 102 checkpoints." This FVA assessment should be performed against unclassified swath las files. Reviewer was unable to locate documentation of FVA assessment against unclassified swath las files. In the pdf, "Dewberry Response to USGS Review Orange County 10012012" Dewberry explains that the swath accuracy results were included in the swath metadata, but a small section has been added to the project report to provide additional clarity.

## 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

Image?

Classified las tiles 11smt246195.las and 11smt306165.las are located within the project boundary and were not able to load into Arc Map. Once these two tiles are redelivered, the quantity of classified las tiles will conform to project tiling scheme. The las tiles were delivered to the reviewer via ftp site on 10/02/12 with the following comments: These two LAS tiles have been redelivered. USGS identified artifacts and missing water features in the delivered data. These calls resulted in the modification of twelve LAS tiles. The twelve modified LAS tiles have also been redelivered.

## 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

None.

## 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
- DEM files do not overlap
- DEM files are uniform in size
- 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 <sub>z</sub> ) Required FVA = <u>0.245</u> or less.	Supplemental Vertical Accuracy @95th Percentile Error Target SVA = <u>0.363</u> or less.	Consolidated Vertical Accuracy @95th Percentile Error Required CVA = <u>0.363</u> or less.
Open Terrain	<u>21</u>	<u>0.19</u>		
Tall Weeds and Crops	<u>20</u>		<u>0.12</u>	
Brush Lands and Low Trees	<u>22</u>		<u>0.18</u>	
Forested Areas Fully Covered by Trees	<u>20</u>		<u>0.12</u>	
Urban Areas with Dense Man-Made Structures	<u>20</u>		<u>0.16</u>	



Consolidated

103

0.17

QA performed Accuracy Calculations?

**Calculated Accuracies**

Land Cover Category	# of Points	Fundamental Vertical Accuracy @95% Confidence Interval (Accuracy <sub>Z</sub> ) Required FVA = 0.245 or less.	Supplemental Vertical Accuracy @95th Percentile Error Target SVA = 0.363 or less.	Consolidated Vertical Accuracy @95th Percentile Error Required CVA = 0.363 or less.
Open Terrain	21	0.19		
Tall Weeds and Crops	20		0.12	
Brush Lands and Low Trees	22		0.20	
Forested Areas Fully Covered by Trees	20		0.13	
Urban Areas with Dense Man-Made Structures	20		0.17	
Consolidated	103			0.17

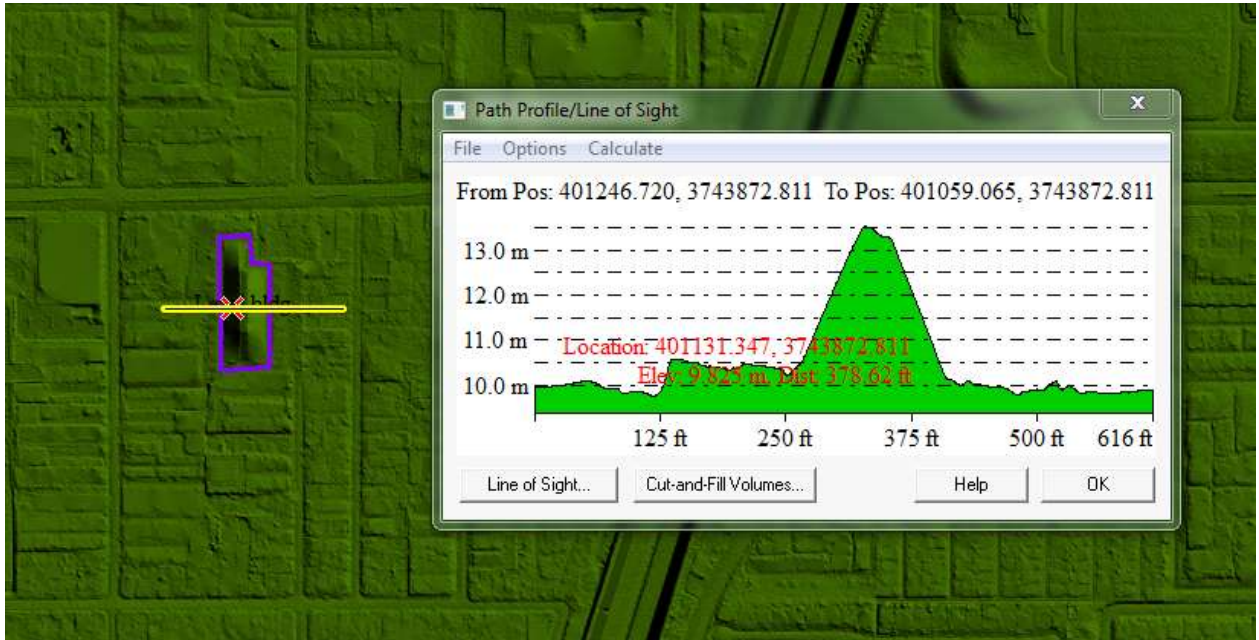
Based on this review, the USGS recommends the bare-earth DEM files for inclusion in the 1/3 Arc-Second National Elevation Dataset.

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

Image?



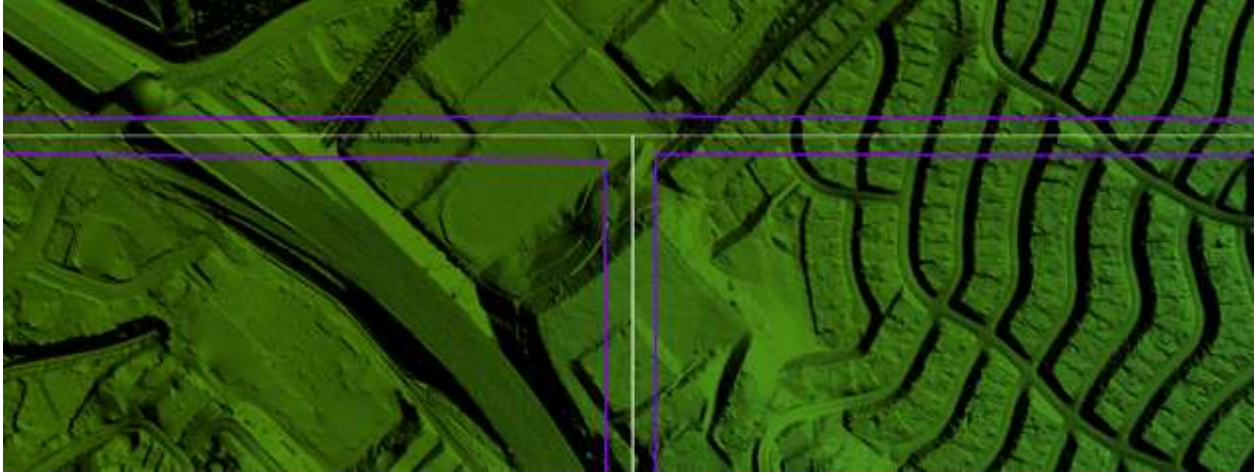
Reviewer identified buildings remaining in bare earth surface that need further removal. These errors are documented in a shapefile created by the reviewer at NGTOC named errors.shp. In the pdf, "Dewberry Response to USGS Review Orange County 10012012" Dewberry explains the common occurrence of homes built into hillsides, reviewer accepts this response.

Image?



Reviewer identified a minimum of 3 waterbodies greater than 2 acres not hydroflattened. These errors are documented in a shapefile created by the reviewer at NGTOC named errors.shp. In the pdf, "Dewberry Response to USGS Review Orange County 10012012" Dewberry explains that one of four calls regarding breaklines/waterbodies was incorrect, from viewing the intensity images it can be determined that no water existed at the time of acquisition. The other three calls were addressed, corrected, and new DEM and LAS files were redelivered to the reviewer via ftp site on 10/02/12. Reviewer visually inspected the redelivered DEMs and found them acceptable.

Image?



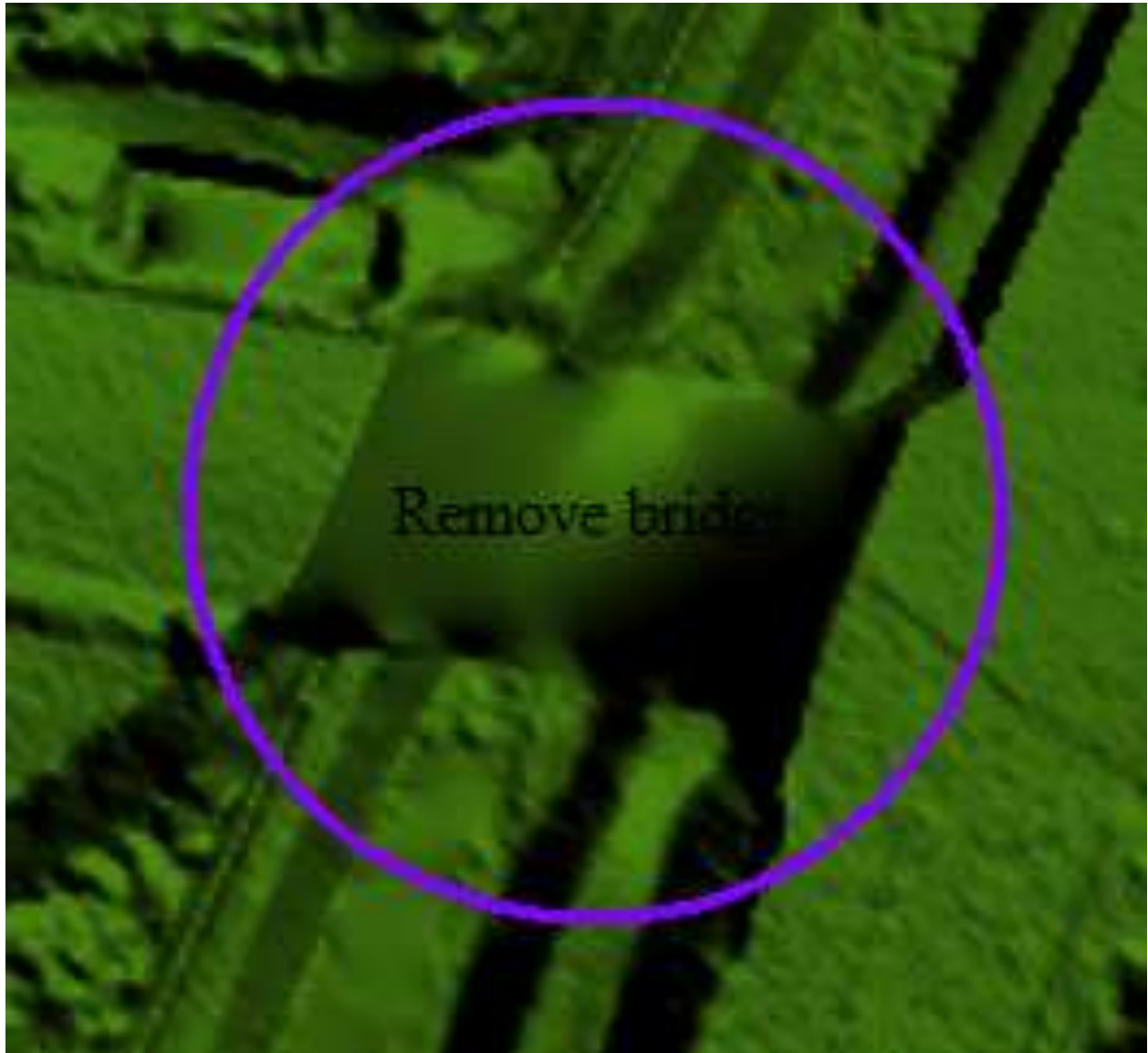
Reviewer identified 4 areas where data voids exist between tiles. The voids are located near the North, South, East and West extents of the project boundary. These errors are documented in a shapefile created by the reviewer at NGTOC named errors.shp. In the pdf, "Dewberry Response to USGS Review Orange County 10012012" Dewberry explains that these gaps were due to processing errors that occurred with the partial tiles along the project boundary. The 21 tiles where this error occurred have been reprocessed and redelivered. Reviewer visually inspected the redelivered DEMs and found them acceptable.

Image?



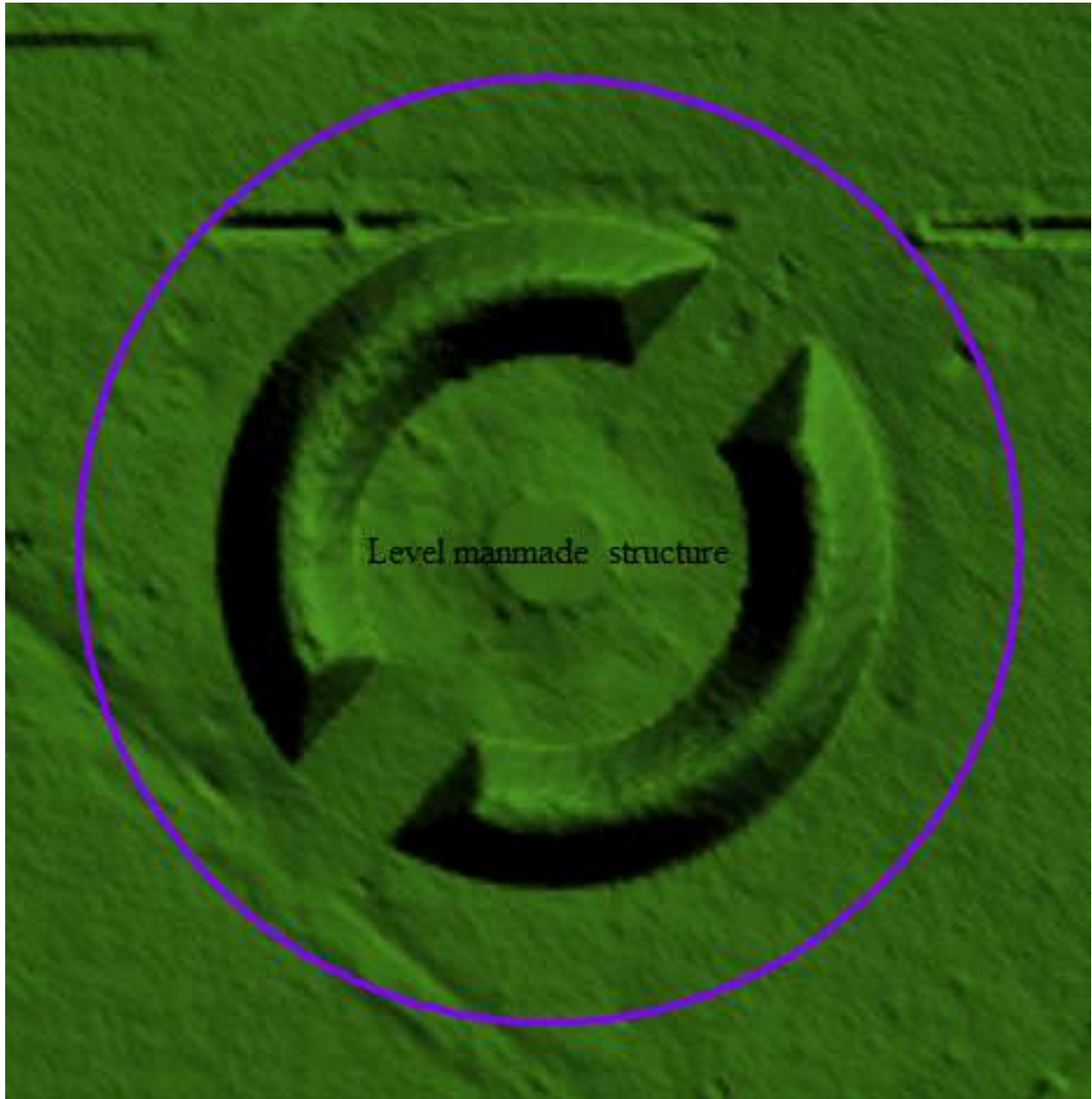
Reviewer identified bridges remaining in bare earth surface. These errors are documented in a shapefile created by the reviewer at NGTOC named errors.shp. See following image and comments for updated information.

Image?



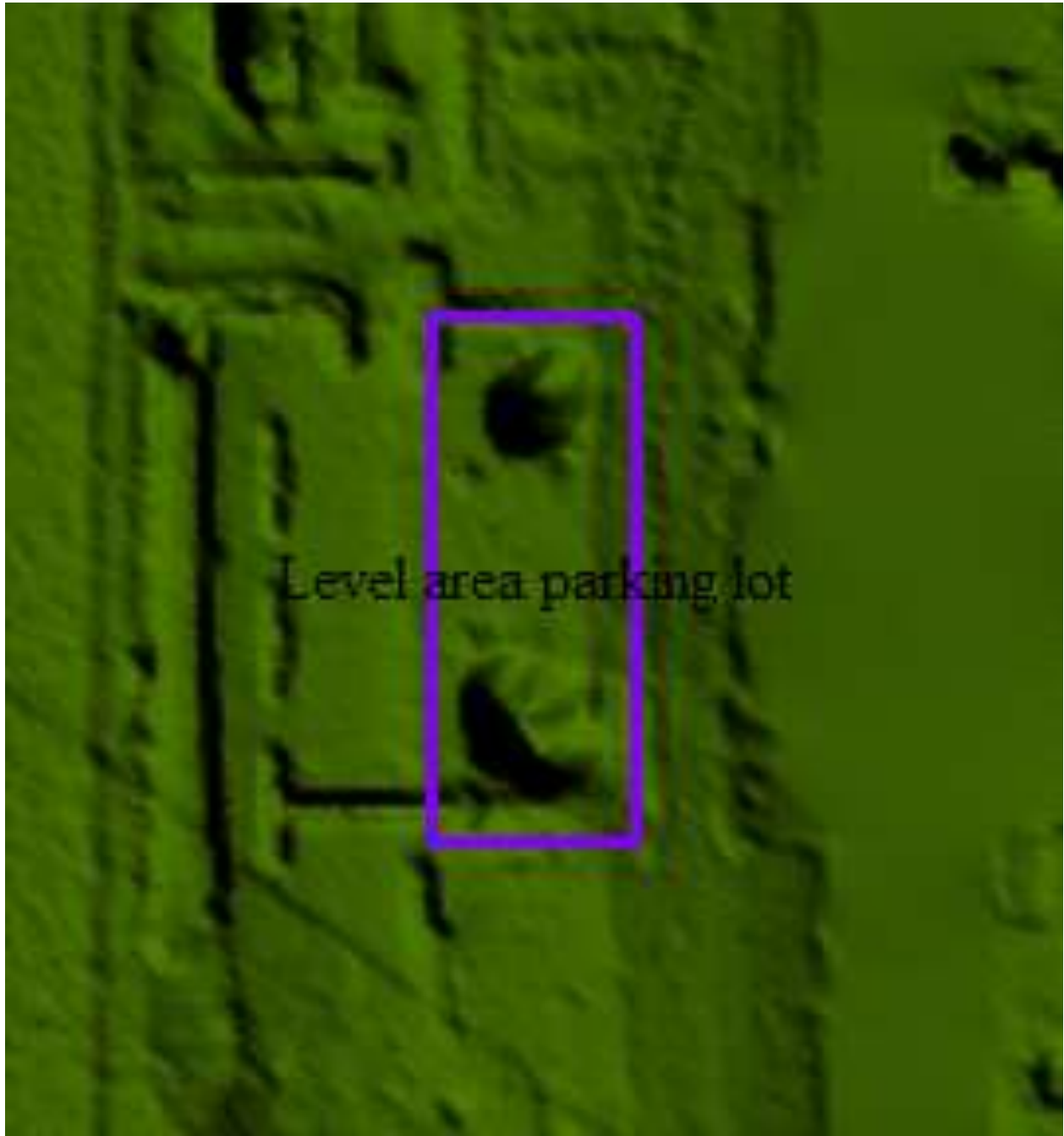
In the pdf, "Dewberry Response to USGS Review Orange County 10012012" Dewberry explains that these were originally believed to be culverts, but have been removed from the bare earth surface, DEMs were redelivered to reviewer via ftp site on 10/02/12. Reviewer visually inspected the redelivered DEMs and found them acceptable.

Image?



Reviewer identified a man-made structure in bare earth surface. This error is documented in a shapefile created by the reviewer at NGTOC named errors.shp. In the pdf, "Dewberry Response to USGS Review Orange County 10012012" Dewberry explains that in this instance earthen mounds have been formed around the feature and have been correctly included in the ground classification. Reviewer accepts this response.

Image?



Reviewer identified areas of extreme elevation change within man-made parking lot that needs further removal. This error is documented in a shapefile created by the reviewer at NGTOC named errors.shp.

Image?





In the pdf, "Dewberry Response to USGS Review Orange County 10012012" Dewberry notes that such artifacts have been removed, DEMs redelivered on 10/02/2012. Reviewer visually inspected redelivered DEMs and found them acceptable.

Based on this review, the deliverables provided meet the Task Order requirements.

Internal Note:

**This is the end of the report.**

QA Form V1.4 12OCT11.xsn