



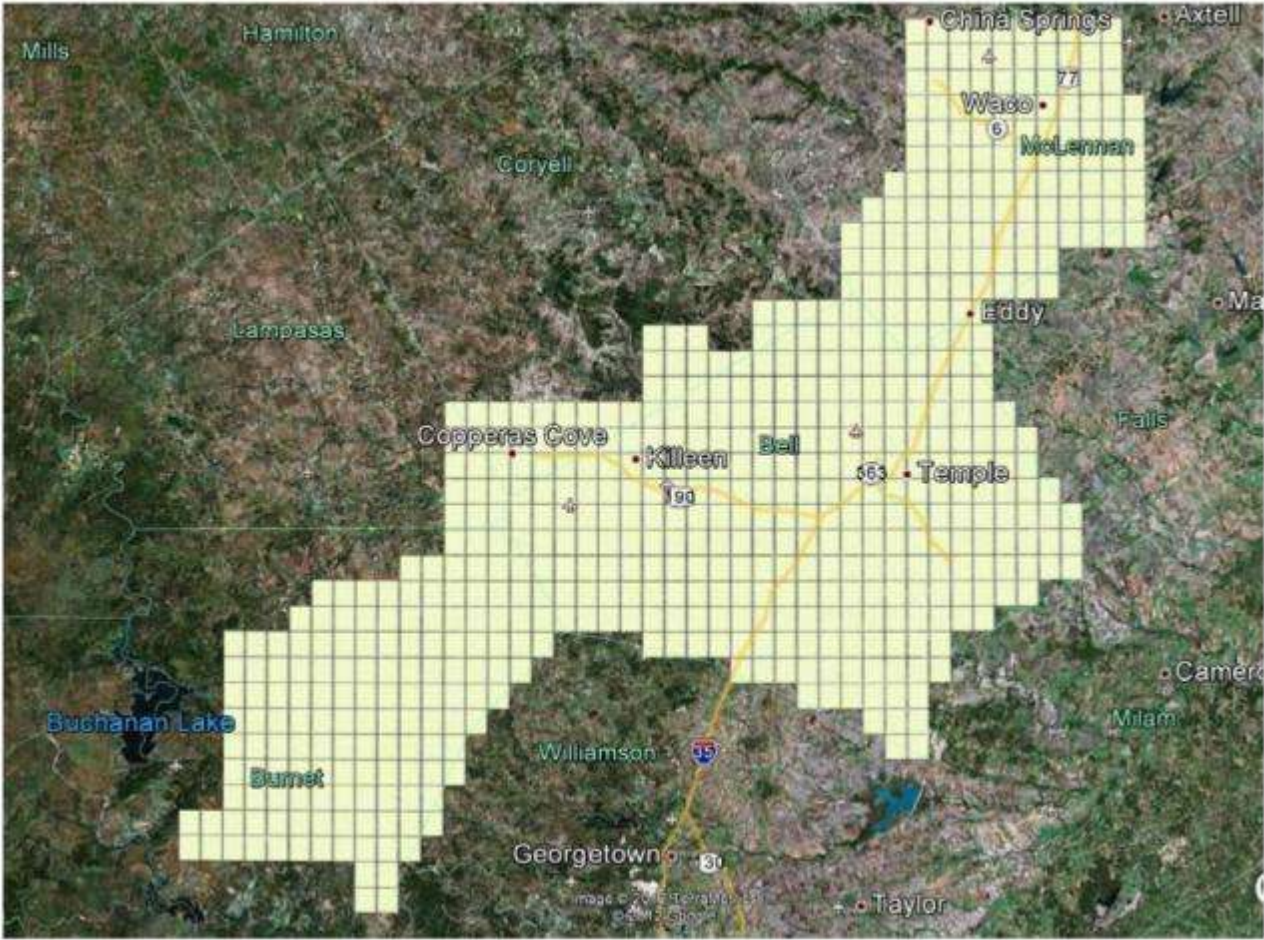
LiDAR Quality Assessment Report

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: 4/30/2012	Project Type: NSDI Agreement
Project ID: TX_Bell-Burnett-McLennan_2011	Project Description: Partnership project with Texas Water Development Board.
Project Alias(es):	Year of Collection: 2011

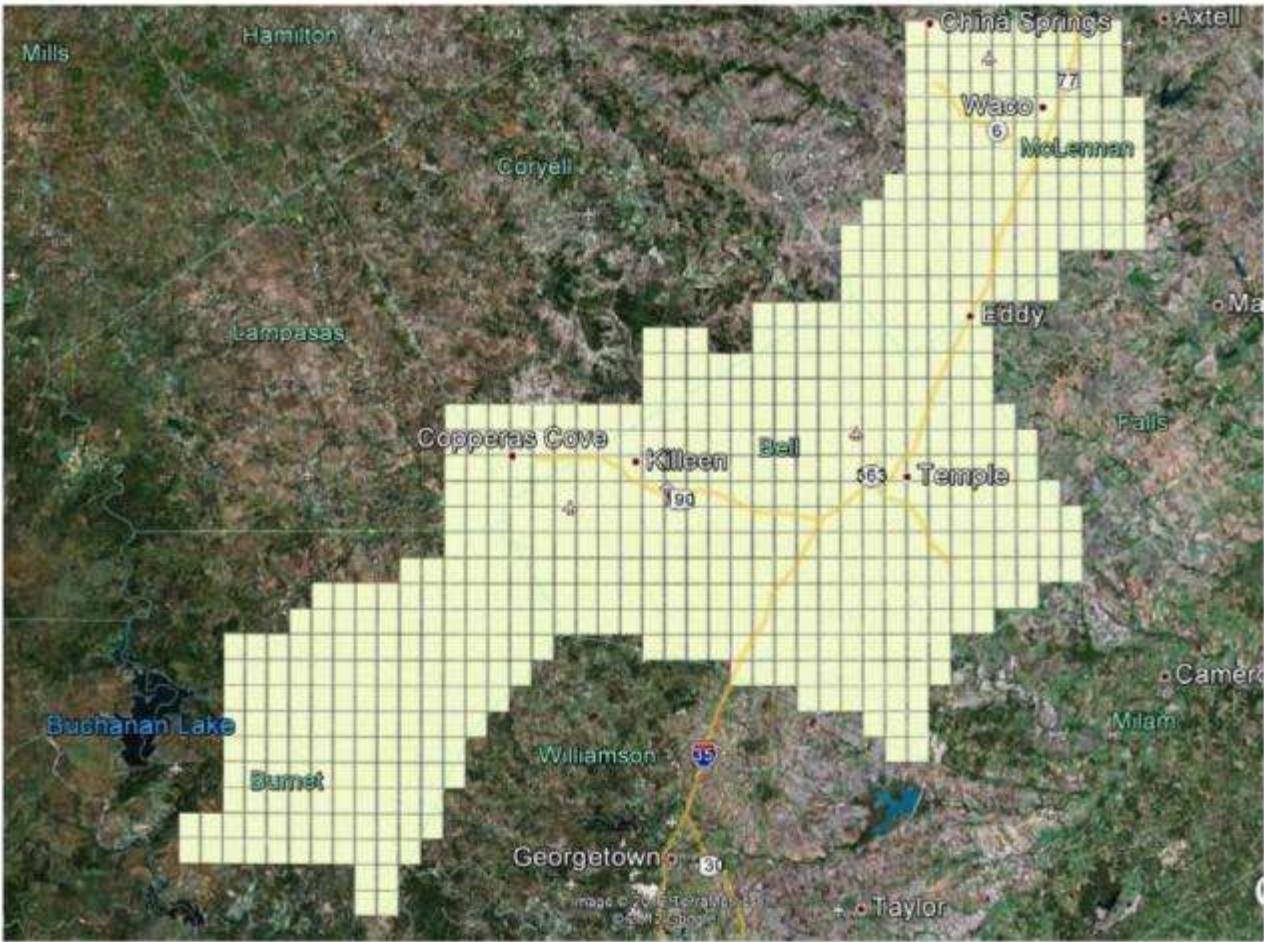
Lot 1 of 1 lots.

Project Extent:
 Project Extent image?



Project Tiling Scheme:

Project Tiling Scheme image?



Contractor:
Photo Science, Inc.

Applicable Specification:
Texas Water Development Board

Licensing Restrictions:
None

Third Party Performed QA?

Third Party QA Performed By:
URS Corporation

Project Points of Contact:

POC Name	Type	Primary Phone	E-Mail
Claire DeVaughan	NSDI Liaison	512-927-3583	cdevaugh@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/Ortho imagery Section supervisor and informed of the problem. Processing will resume after the COTR has coordinated the deposition of remaining deliverables.

- | | |
|---|---|
| <input checked="" type="checkbox"/> Collection Report | <input type="checkbox"/> Project Shapefile/Geodatabase |
| <input checked="" type="checkbox"/> Survey Report | <input checked="" type="checkbox"/> Project Tiling Scheme Shapefile/Gdb |
| <input checked="" type="checkbox"/> Processing Report | <input type="checkbox"/> Control Point Shapefile/Gdb |
| <input checked="" type="checkbox"/> QA/QC Report | <input checked="" type="checkbox"/> Breakline Shapefile/Gdb |
| <input type="checkbox"/> Control and Calibration Points | <input checked="" type="checkbox"/> Project XML Metadata |

Multi-File Deliverables

File Type	Quantity
<input type="checkbox"/> Swath LAS Files <input type="checkbox"/> Required? <input type="checkbox"/> XML Metadata?	
<input checked="" type="checkbox"/> Intensity Image Files <input checked="" type="checkbox"/> Required?	1,178
<input checked="" type="checkbox"/> Tiled LAS Files <input checked="" type="checkbox"/> Required? <input checked="" type="checkbox"/> XML Metadata?	589
<input checked="" type="checkbox"/> Breakline Files <input checked="" type="checkbox"/> Required? <input checked="" type="checkbox"/> XML Metadata?	1
<input checked="" type="checkbox"/> Bare-Earth DEM Files <input checked="" type="checkbox"/> Required? <input checked="" type="checkbox"/> XML Metadata?	589

Additional Deliverables

	Item
<input checked="" type="checkbox"/>	Aircraft Trajectories

Errors, Anomalies, Other Issues to document? Yes No

According to task order number G11PX01213, DEMs were to be delivered to NGTOC in ESRI grid format. Reviewer at NGTOC received 589 DEMs as .flt files. A discussion with Claire DeVaughan confirmed that the data had been converted from their native format as ESRI grids to float files when the drive was being prepared by the Texas Water Development Board. Once copied, the drive was then sent to the reviewer at NGTOC Denver. Reviewer at NGTOC converted all 589 of the float files into ESRI grid format.

Photo Science delivered 589 DEMs in ESRI grid format to the reviewer at NGTOC on 06/18/12.

Project shapefile was not a required deliverable, and was created by reviewer at NGTOC using the delivered project tiling scheme shapefile.

Project tiling scheme was delivered to the reviewer at NGTOC on 07/09/12.

Project Geographic Information

Areal Extent: 2,349 Sq Km

Grid Size: 1 meters

Tile Size: varies; USGS quad, quarter-quad, and quarter-quarter quads used [Select...](#)

Nominal Pulse Spacing: 2 meters

Vertical Datum: NAVD88 meters

Horizontal Datum: NAD83 meters

Project Projection/Coordinate Reference System: UTM Zone 14 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 type="checkbox"/> Checkpoints Shapefile/Geodatabase | <input type="checkbox"/> Swath LAS Files |
| <input type="checkbox"/> Project XML Metadata File | <input checked="" type="checkbox"/> Classified LAS Files |
| <input 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 |

Check Point Shapefile/Geodatabase CRS

No check point shapefile delivered

Project XML Metadata CRS

No project level metadata delivered, project level metadata was created at NGTOC.

Swath LAS XML Metadata CRS

No swath las metadata delivered

Swath LAS Files CRS

No swath las files delivered

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:

H. Boggs

Review Start Date:

5/1/2012

Action to Contractor Date	Issue Description	Return Date
5/8/2012	Sent for corrections	6/18/2012

Review Complete: 7/9/2012

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.

No project XML metadata delivered to reviewer at NGTOC. Reviewer used bare-Earth DEM XML files to create project level XML metadata named **bestuse.xml**. This is the best-use metadata for this project and is located in the Metadata-Documents folder.

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?

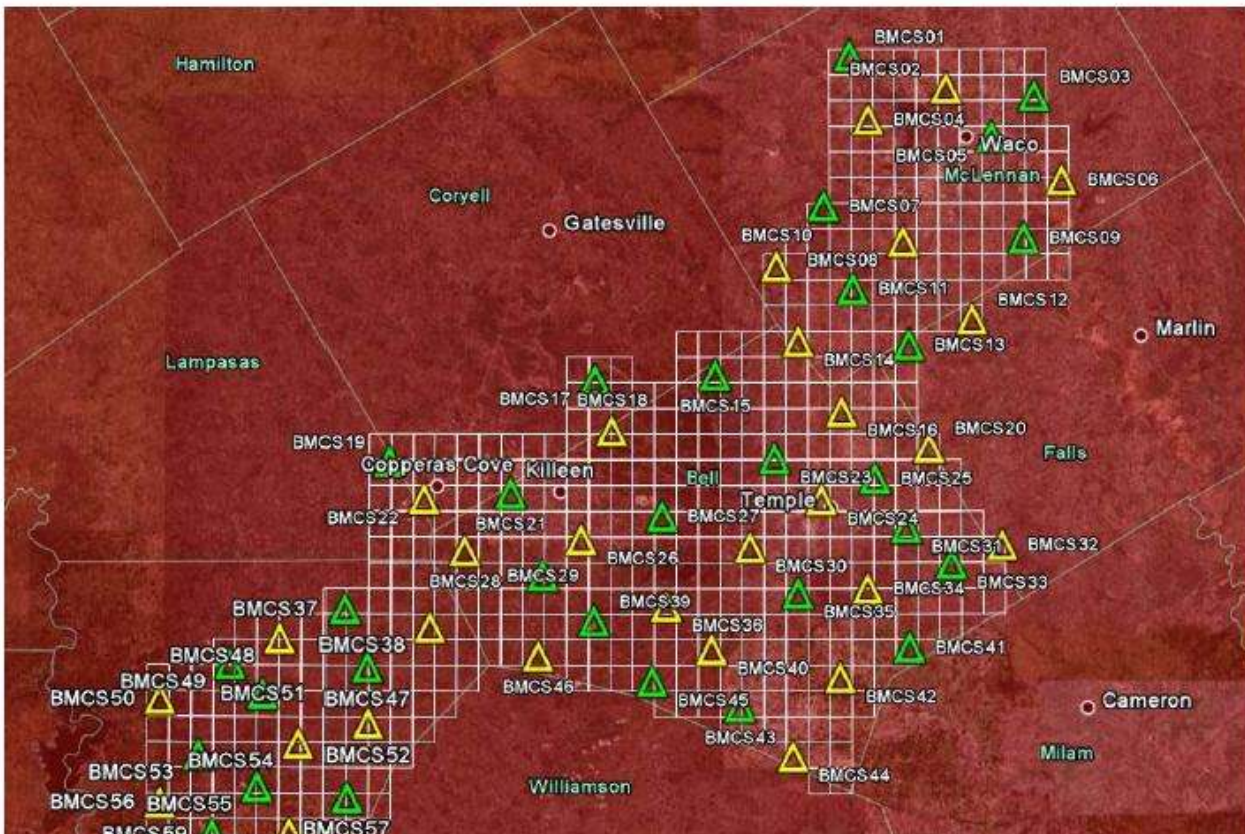




Figure 2 QA checkpoint planned layout for Bell-McLennan AOI

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?

Specification used in vertical accuracy assessment: Texas Water Development Board (TWDB), HPIDS: LiDAR Delivery and Quality Control Statement of Work – Version 1.1, May 4, 2009. Vertical accuracy assessment performed by third party used only one land cover class, flood/soils.

Image?

Detailed Statistics for this AOI – Flood/Soils Category						
Geo-referencing			Statistics			
Horizontal	NAD83, UTM Zone 14		Sum of dz ² (cm)	57.096		
Vertical	NAVD88 (Geoid03), Unless otherwise stated		Count	64		
Units	Meters (Orthometric)		Sum dz ² /count (cm)	0.892		
			RMSE (cm)	9.445		
			1.96 * RMSE (cm)	0.185		
			Mean (cm)	18.513		
			Median (cm)	-3.800		
			Skew (cm)	39.766		
			Std. dev. (cm)	9.337		
			95th percentile (cm)	16.68		
RMSE Calculation						
Square Root of $\sum(Z_n - Z'_n)^2 / N$						
Z _n = LiDAR DEM heights						
Z' _n = Checkpoint heights						
N = The number of check points						
Accuracy Targets and Results						
Land Cover	Target RMSEz (cm) ≤	Target Accuracy (cm) ≤	Actual RMSEz (cm)	95% Conf. Acc Z (cm)	Dz Min (cm)	Dz Max (cm)
Flood/Soils	15.00	29.40	9.45	18.51	-21.15	22.75

Table 21 Detailed statistics for flood/soils land cover category

Page 28 of QA report provided by URS. Actual RMSEz value differs from value reported on page 26 of the report; see statement below.

Image?

Summary of Descriptive Statistics and 95 th Percentile Calculations								
Land Cover Category	No. of Points	RMSE (cm)	Actual RMSEz (cm)	Mean Error (cm)	Median Error (cm)	Skew	STDEV (cm)	95 th Percentile (cm)
Urban	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Forest	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Coastal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Flood/Soils	64	9.445	18.513	-1.842	-3.800	39.766	9.337	16.680

Table 19 Summary of descriptive characteristics

The third party QA report provided by URS shows discrepancies in their reporting of vertical accuracy. On page 26 of the report, they provide the table shown above, summarizing descriptive statistics and 95th percentile calculations. The table shows the actual RMSEz of the flood/soils class as 18.513. However, on page 28 of the report another table showing the detailed statistics for the flood/soils category in the AOI reports the actual RMSEz as 9.45; please see tables above.

Image?

Reviewer performed vertical assessment at the NGTOC using the 589 delivered DEM tiles and the 64 surveyed checkpoint elevations provided to the reviewer in the QA report completed by URS. The project tested 15.84cm vertical accuracy at 95 percent confidence level. The RMSEz of the flood/soils class is 8.08cm.

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
<i>Tall Weeds and Crops</i>	<input type="text"/>	<input type="text" value="centimeters"/>
<i>Brush Lands and Low Trees</i>	<input type="text"/>	<input type="text" value="centimeters"/>
<i>Forested Areas Fully Covered by Trees</i>	<input type="text"/>	<input type="text" value="centimeters"/>
<i>Urban Areas with Dense Man-Made Structur...</i>	<input type="text"/>	<input type="text" value="centimeters"/>

The reported CVA of this data set is: .

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?

Additional classifications in this data set.

- 3 - Tall weeds and crops (low vegetation)
- 4 - Brush lands and low trees (medium vegetation)
- 5 - Forested areas fully covered by trees
- 6 - Urban area with dense man-made structures

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?

Final breaklines delivered to reviewer at NGTOC on 06/18/12.

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:

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 .

Reported Accuracies

Land Cover Category	# of Points	Fundamental Vertical Accuracy @95% Confidence Interval (Accuracy _z) Required FVA = <input type="text" value=""/>	Supplemental Vertical Accuracy @95th Percentile Error Target SVA = <input type="text" value=""/> or less.	Consolidated Vertical Accuracy @95th Percentile Error Required CVA = <input type="text" value=""/> or less.
Open Terrain	<input type="text" value="20"/>	<input type="text" value=""/>	<input type="text" value=""/>	<input type="text" value=""/>
Tall Weeds and Crops	<input type="text" value=""/>	<input type="text" value=""/>	<input type="text" value=""/>	<input type="text" value=""/>
Brush Lands and Low Trees	<input type="text" value=""/>	<input type="text" value=""/>	<input type="text" value=""/>	<input type="text" value=""/>
Forested Areas Fully Covered by Trees	<input type="text" value=""/>	<input type="text" value=""/>	<input type="text" value=""/>	<input type="text" value=""/>
Urban Areas with Dense Man-Made Structures	<input type="text" value=""/>	<input type="text" value=""/>	<input type="text" value=""/>	<input type="text" value=""/>
Consolidated	<input type="text" value="20"/>	<input type="text" value=""/>	<input type="text" value=""/>	<input type="text" value=""/>

QA performed Accuracy Calculations?

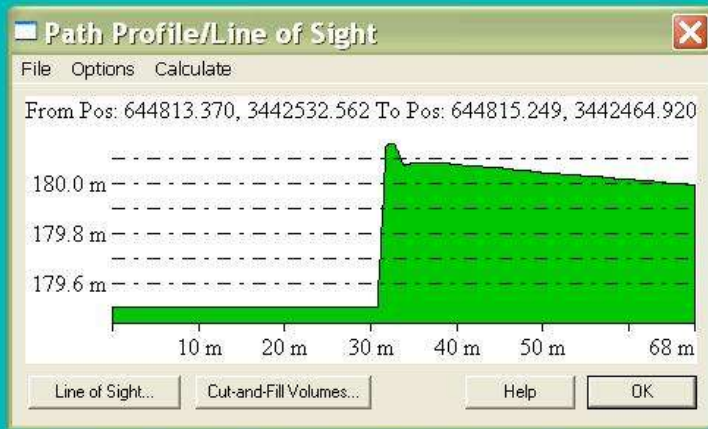
Based on this review, the USGS recommends the bare-earth DEM files for inclusion in the 1/3 Arc-Second National Elevation Dataset.

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

Bare-Earth DEM Anomalies, Errors, Other Issues

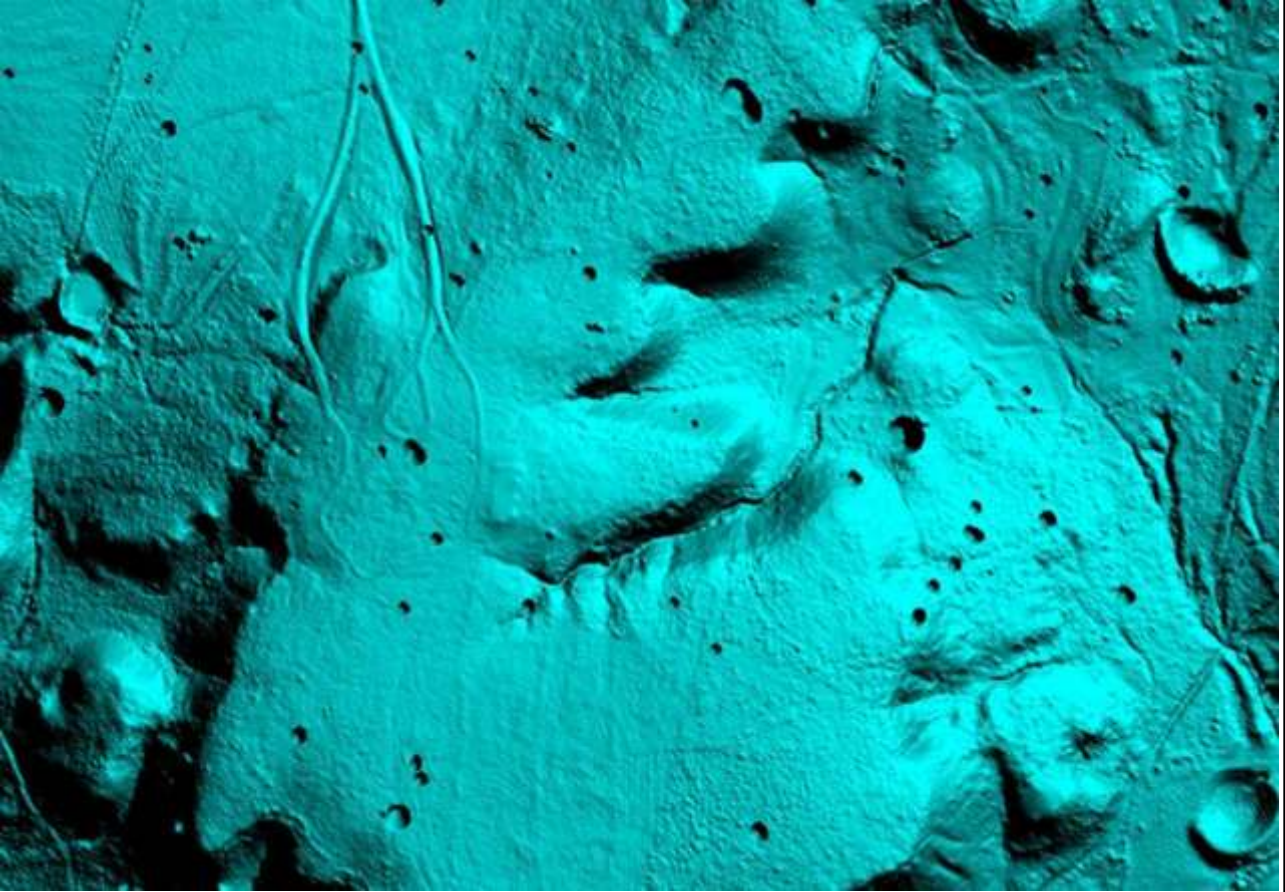
Yes No

Image?



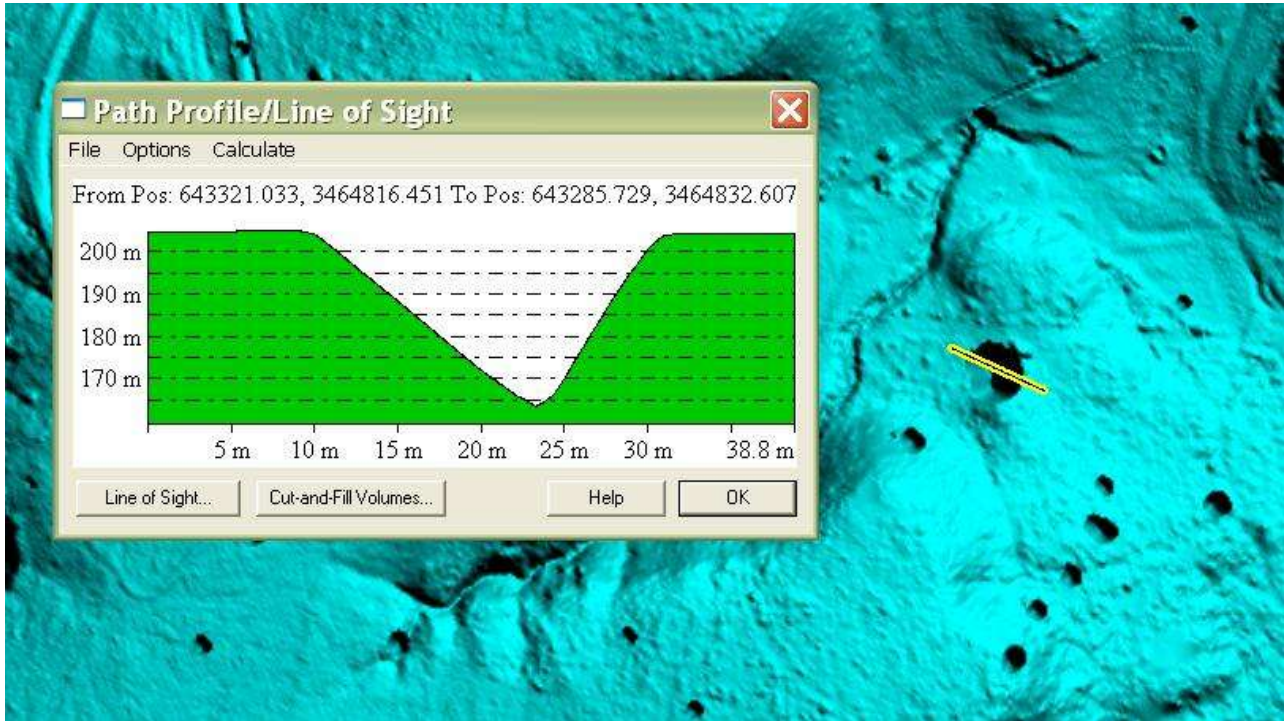
Elevation change within flattened waterbody. Corrected DEMs received by reviewer at NGTOC on 06/18/12. All waterbodies are flat.

Image?



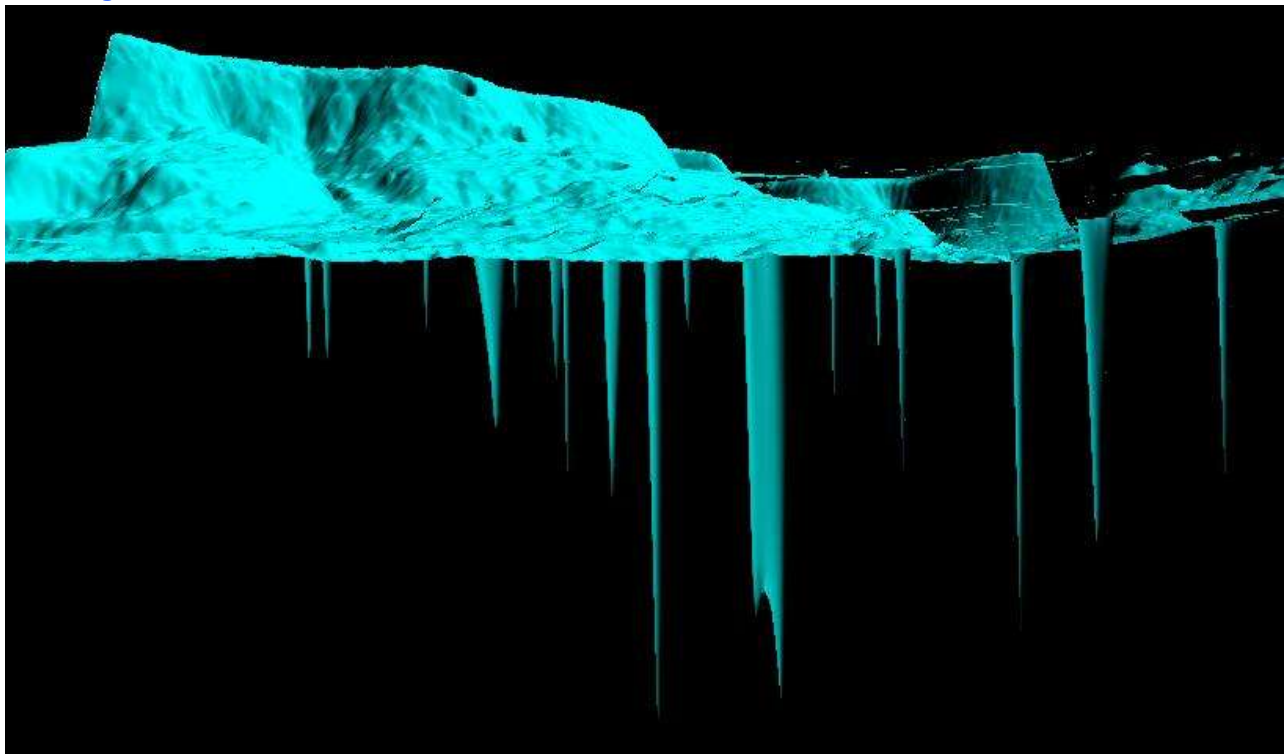
Large pits evident in DEMs. Corrected DEMs received by reviewer at NGTOC on 06/18/12. Pits are no longer present in DEMs.

Image?



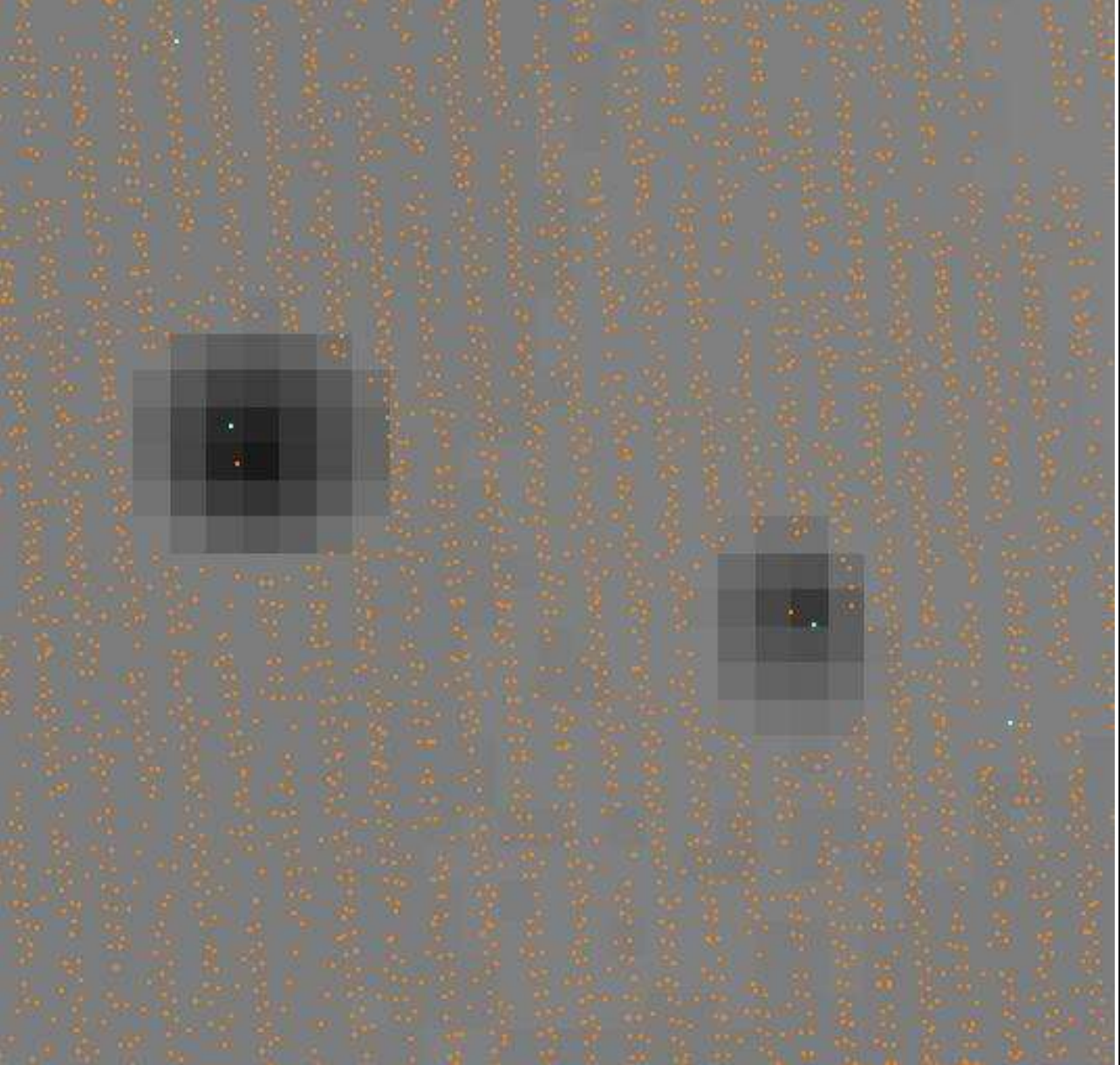
Pits in DEMs 10-30 meter in width found by reviewer at NGTOC. Corrected DEMs received by reviewer at NGTOC on 06/18/12.

Image?



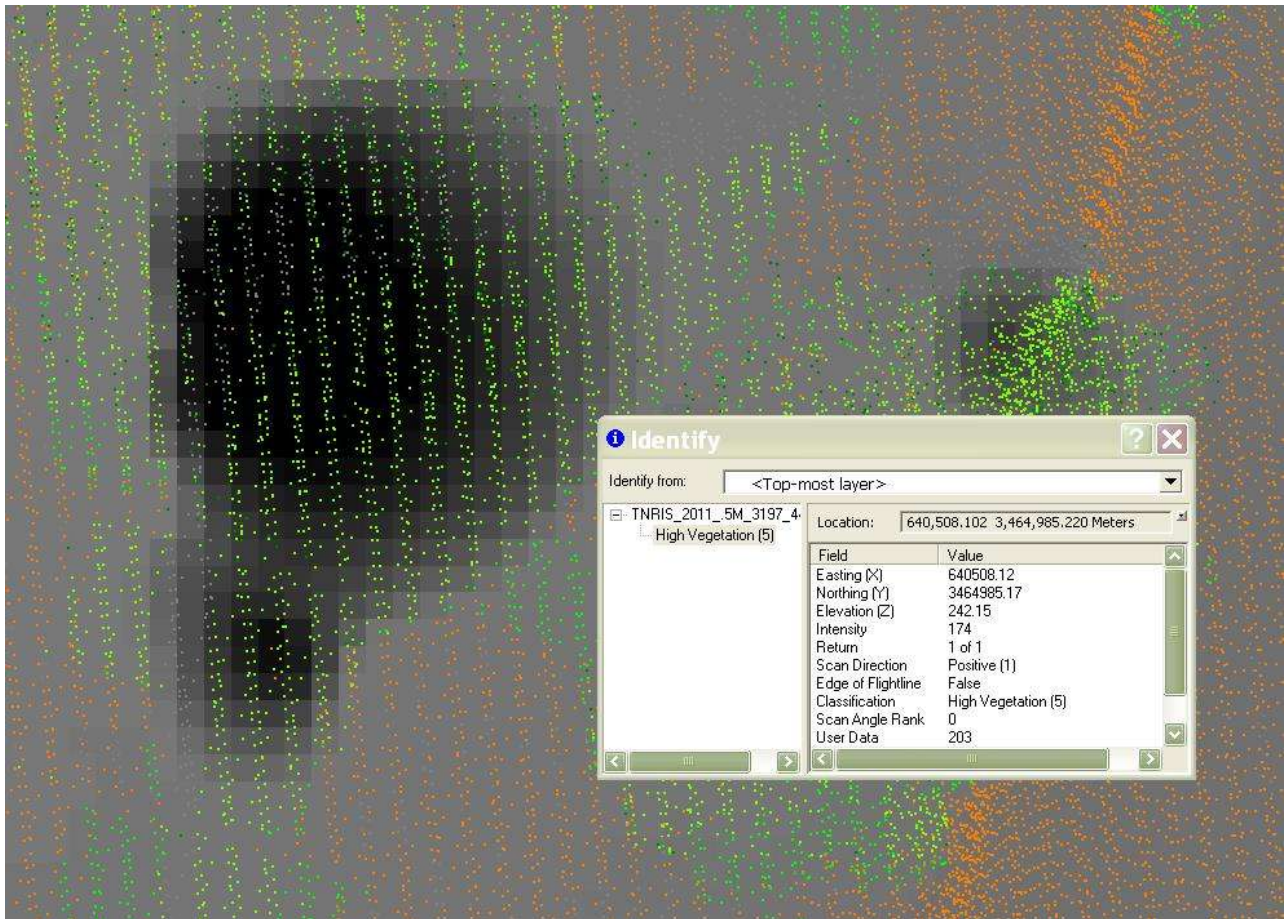
Pits in DEMs 20-40 meters deep shown in 3D. Corrected DEMs received by reviewer at NGTOC on 06/18/12.

Image?



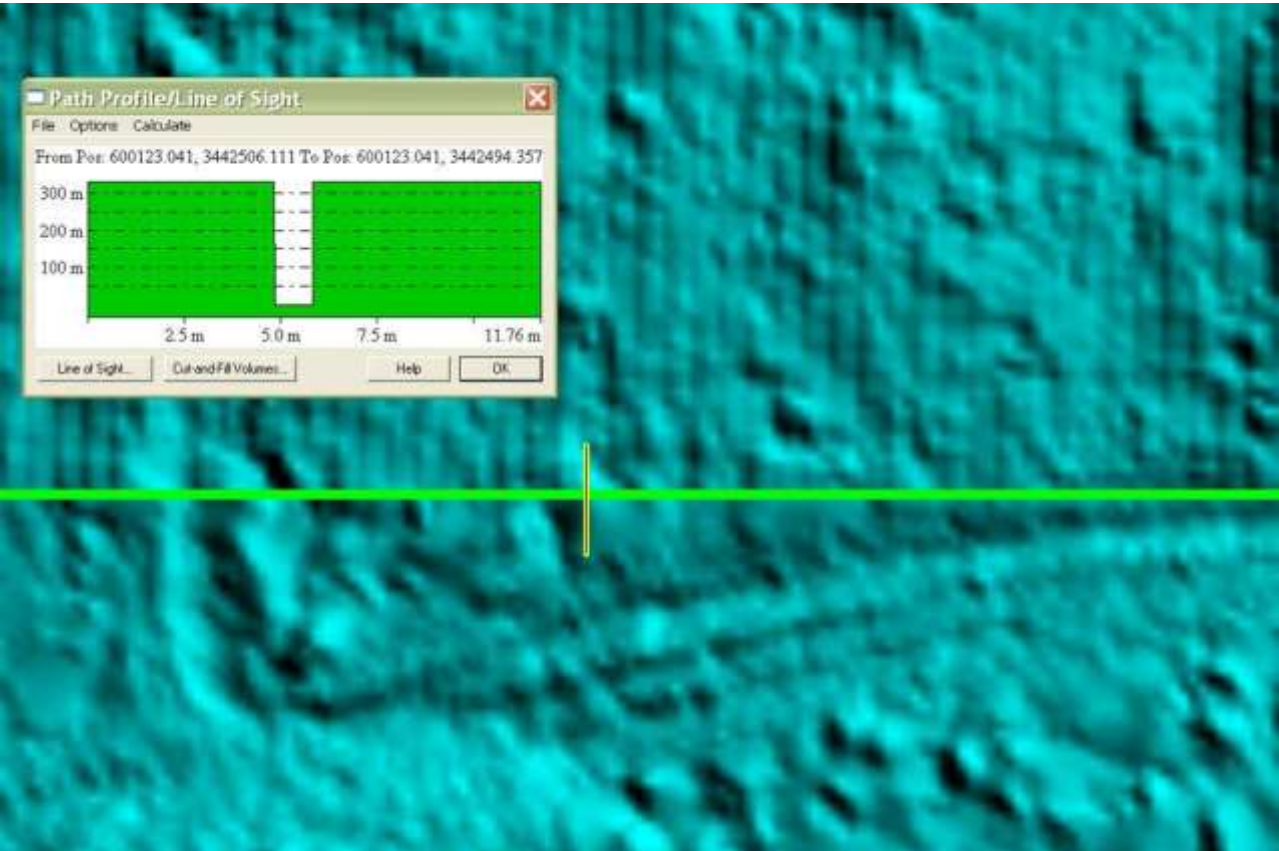
Reviewer compared pits found in the DEMs to the point cloud and filtered the display by ground and noise. Each pit contains both a ground and noise point. Corrected classified LAS point cloud received by reviewer at NGTOC on 06/18/12.

Image?



When reviewer at NGTOC removed the display filter, all points in the point cloud were displayed. It appears that the pits contain many vegetation points. As such, it is the belief of the reviewer that the points within the pits classed as ground are in fact misclassified and should be changed to class 7, noise. The reviewer at NGTOC recommends that the DEMs be regenerated using the corrected LAS files. Corrected classified LAS point cloud and DEMs received by reviewer at NGTOC on 06/18/12.

Image?



Multiple void areas found by reviewer at NGTOC. 25-35 voids exist in DEMs. Corrected DEMs received by reviewer at NGTOC on 06/18/12. Voids are no longer present in DEMs.

Internal Note:

This is the end of the report.

QA Form V1.4 12OCT11.xsn

