



# 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:

9/15/2011

Project Type: ARRA Partnership

Project ID:

ARRA-MI\_LowerPeninsula\_2010

Project Description:

LiDAR Data Acquisition covering the Iosco, Arenac, and Bay Counties, MI

Project Alias(es):

CMU\_USGS\_LiDAR; the Iosco, Arenac, a...

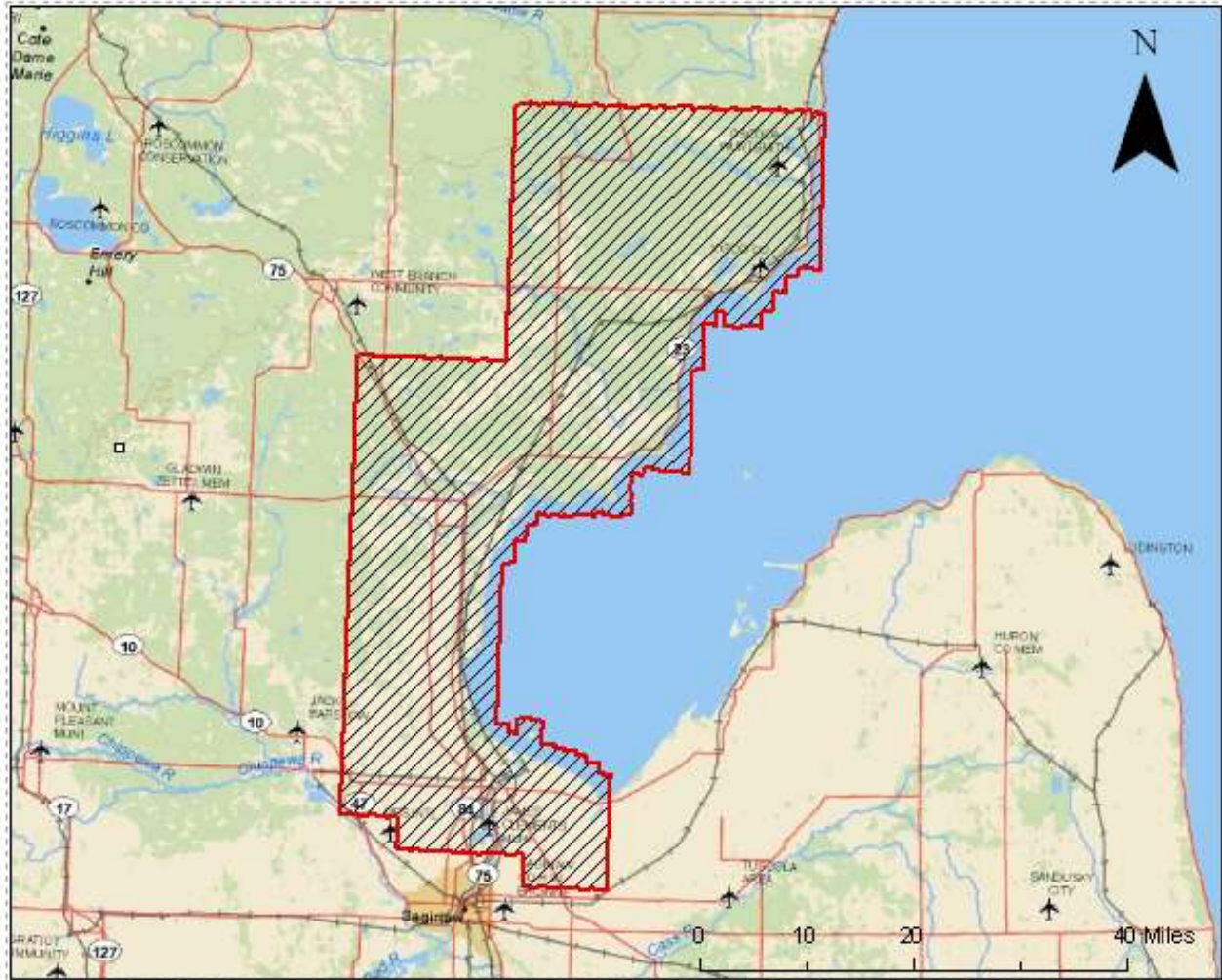
Year of Collection: 2010

Lot 1 of 1 lots.


Project Extent:

Project Extent image?

# ARRA-MI\_LowerPeninsula\_2010



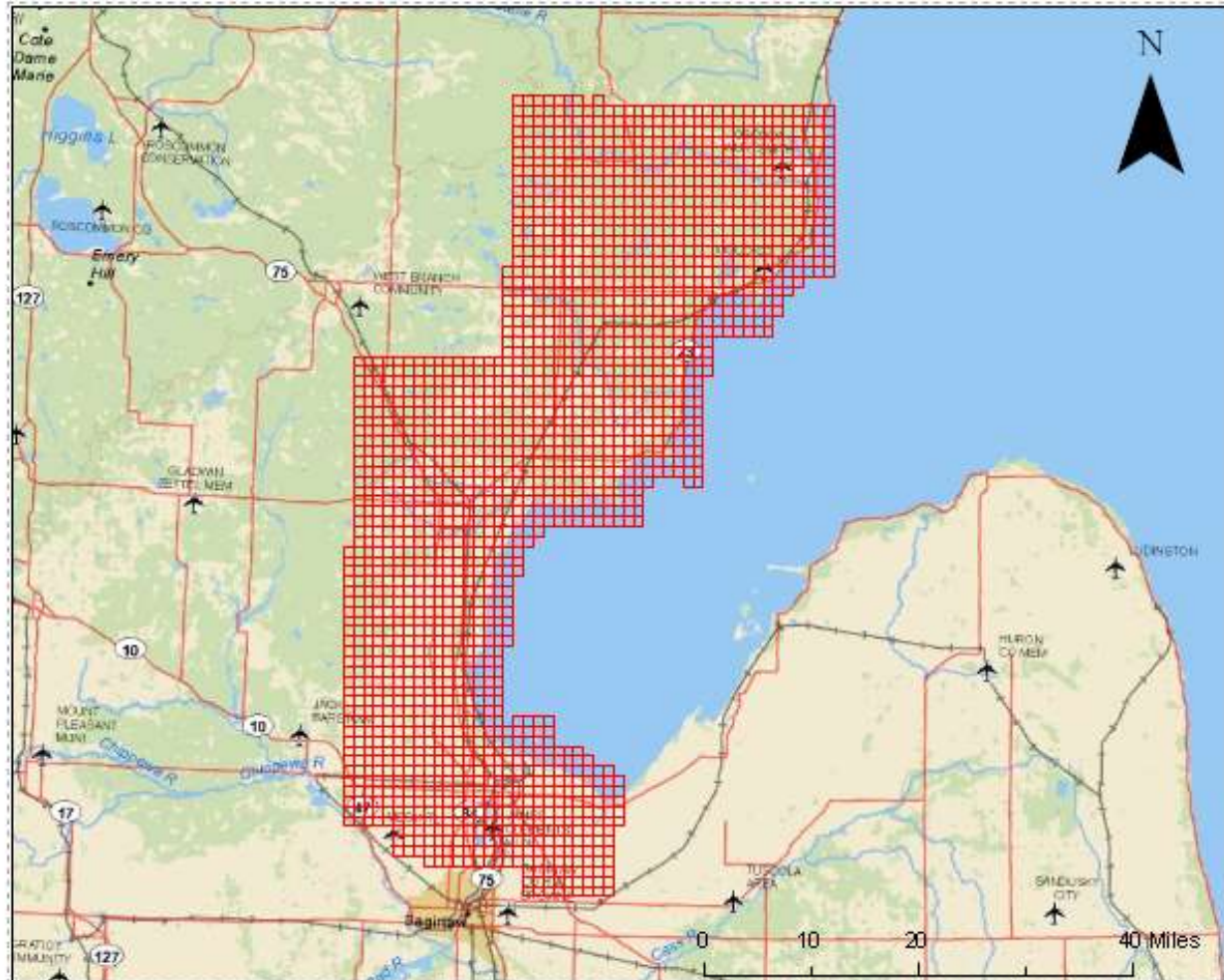
## Legend

 project\_extent


Project Tiling Scheme:

Project Tiling Scheme image?

## ARRA-MI\_LowerPeninsula\_2010



### Legend

 Tile\_Scheme

Contractor:

Applicable Specification:

Merrick and Company

V12

Licensing Restrictions:

Third Party Performed QA?

Third Party QA Performed By:

Central Michigan University Dep. of Geography (Tao Zheng)

Project Points of Contact :

POC Name	Type	Primary Phone	E-Mail
Teresa Dean	ARRA	703-648-4825	tdean@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
- Control Point Shapefile/Gdb
- Project Tiling Scheme Shapefile/Gdb
- Breakline Shapefile/Gdb
- Project XML Metadata
- Swath LAS XML Metadata
- Classified LAS XML Metadata
- Breakline XML Metadata
- Bare-Earth DEM XML Metadata

Multi-File Deliverables

File Type	Quantity
<input checked="" type="checkbox"/> Swath LAS Files	53
<input type="checkbox"/> Intensity Image Files	
<input checked="" type="checkbox"/> Tiled LAS Files	2046
<input checked="" type="checkbox"/> Breakline Files	3
<input checked="" type="checkbox"/> Bare-Earth DEM Files	2046

### Additional Deliverables

	Item
<input checked="" type="checkbox"/>	DEM Pyramid Files (.rrd)

Errors, Anomalies, Other Issues to document?  Yes  No

Some Ambiguity over project extent, Shapefile goes into Lake Huron, but there is no data for the lake's elevation. Technical section of proposal stated "Geo -referenced spatial extent of each individual final dataset" would be delivered to USGS. Provided boundary/extent shapfile does not seem consistent with DEM's or Point Cloud.

From the DEM tiles, at least 2 are incorrect (i.e. 2 tiles missing) and there is one tile out in lake Huron.

## Project Geographic Information

Areal Extent: 1647.48 Sq Mi

Grid Size: 3 meters

Tile Size: 1500x1500 meters

Nominal Pulse Spacing: 1.78 meters

Vertical Datum: NAVD88 meters

Horizontal Datum: NAD83 meters

Project Projection/Coordinate Reference System: UTM Zone 17N 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 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             |

Project XML Metadata CRS

Not Included

# 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.

Review Start Date:

9/27/2011

Action to Contractor Date	Issue Description	Return Date
10/28/2011	Fix DEM Deliverables	11/21/2011

Review Complete: 12/6/2011

## Metadata Review

Provided metadata files have been parsed using 'mp' metadata parser. Any errors from 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.

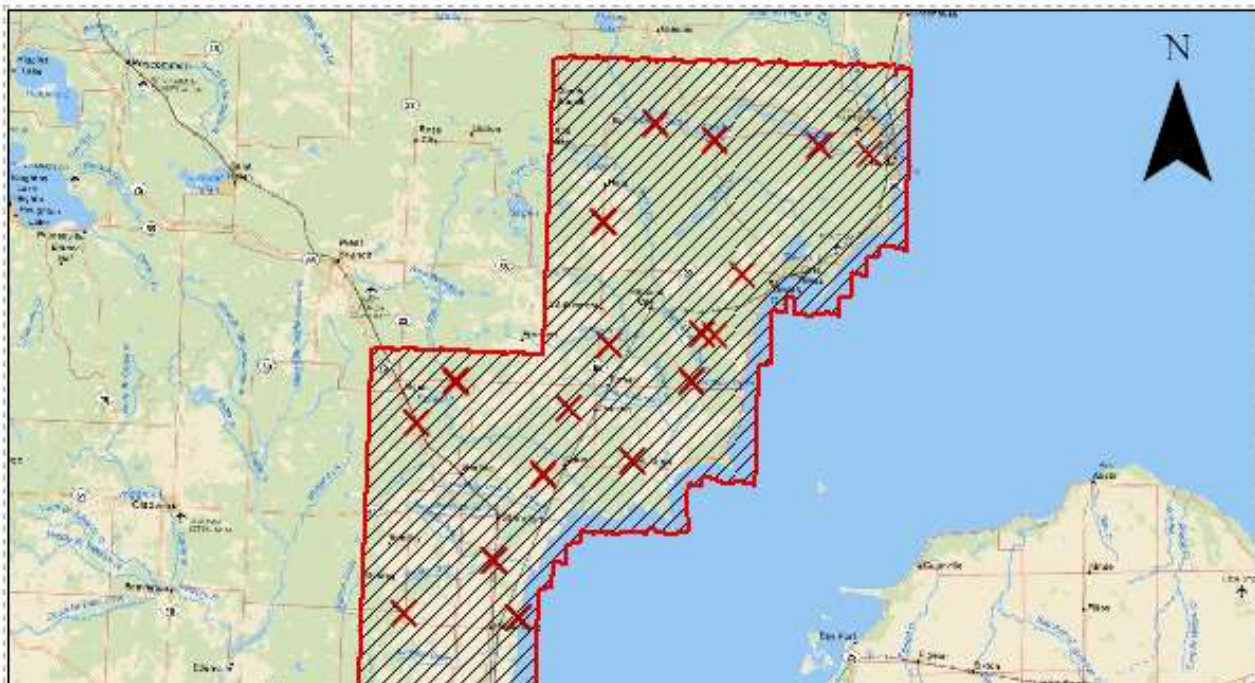
NSSDA and ASPRS require that a minimum of twenty checkpoints (thirty is preferred) are collected for each major land cover category represented in the LiDAR data. Checkpoints should be selected on flat terrain, or on uniformly sloping terrain in all directions from each checkpoint. They should not be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

## ARRA-MI\_LowerPeninsula\_2010







### Legend

- X Validation\_Points\_CMU
- project\_extent

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?

Should be noted that Control and Check Points were delivered in excel table and NGTOC had to create the Shapefile points from spatial reference information in the table.

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" value="centimeters"/>
Brush Lands and Low Trees	<input type="text" value="32.8"/>	<input type="text" value="centimeters"/>
Forested Areas Fully Covered by Trees	<input type="text" value="31.08"/>	<input type="text" value="centimeters"/>
<i>Urban Areas with Dense Man-Made Structur...</i>		<input type="text" value="centimeters"/>

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.

Errors, Anomalies, Other Issues to document?  Yes  No

Image?

Image?

Image?

Several Swath Files Contain Points on More than one class (Not class zero)

LDR100509\_142023\_1.las uses 2 classes (0, 1)

LDR100510\_024451\_1.las uses 2 classes (1, 5)

LDR100510\_025652\_1.las uses 2 classes (1, 13)

LDR100510\_043038\_1.las uses 2 classes (1, 2)

S1C1\_strip012.las uses 4 classes (1, 2, 3, 4)

S1C1\_strip014.las uses 4 classes (1, 2, 3, 4)

The Rest of the files have points assigned to Class 1 instead of Class 0.

## 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

Image?

FVA for Point Cloud was reported of Classified Bare Earth Points and is Reported as 21.34 cm NSSDA (95th CI or RMSE\*1.96)

## 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?

The Technical section of proposal document states "Breaklines for the entire data acquisition area will be delivered in a single shapefile, with geo-reference information included in a companion .prj file". Actual Deliverables are multiple breakline shapefiles broken up by Inland Lakes & Ponds; Inland Rivers & Streams; and Lake Huron Shoreline.

Image for error?

There were a couple instances of floating water, breakline elevations could be adjusted for lower water

## 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 <sub>z</sub> ) Required FVA = 24.5 or less.	Supplemental Vertical Accuracy @95th Percentile Error Target SVA = 36.3 or less.	Consolidated Vertical Accuracy @95th Percentile Error Required CVA = 36.3 or less.
Open Terrain	40	22.93		
<i>Tall Weeds and Crops</i>				
Brush Lands and Low Trees	40		32.8	
Forested Areas Fully Covered by Trees	40		31.08	
<i>Urban Areas with Dense Man-Made Structures</i>				
Consolidated	120			31.68

QA performed Accuracy Calculations?

**Calculated Accuracies**

Land Cover Category	# of Points	Fundamental Vertical Accuracy @95% Confidence Interval (Accuracy <sub>z</sub> ) Required FVA = 24.5 or less.	Supplemental Vertical Accuracy @95th Percentile Error Target SVA = 36.3 or less.	Consolidated Vertical Accuracy @95th Percentile Error Required CVA = 36.3 or less.
Open Terrain	36	23.937153862		
<i>Tall Weeds and Crops</i>				
Brush Lands and Low Trees	29		23.6144798994	
Forested Areas Fully Covered by Trees	35		18.6603301764	
<i>Urban Areas with Dense Man-Made Structures</i>				
Consolidated	100			22.9967951775

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?

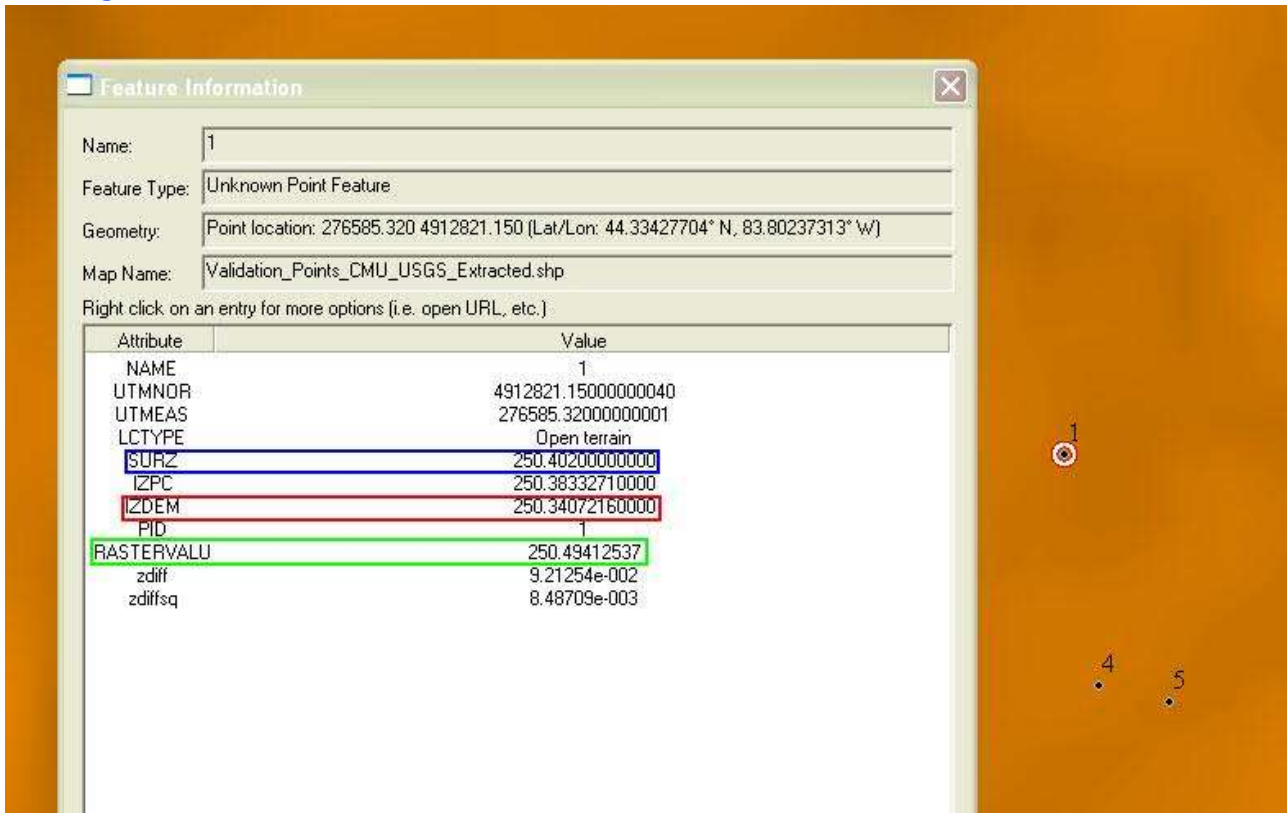
Technical section of proposal documented stated 2-m horizontal resolution DEM's would be prepared, DEM's received are 3m. Acceptable as is.

Image?

DEM's created using IDW instead of the TIN method.

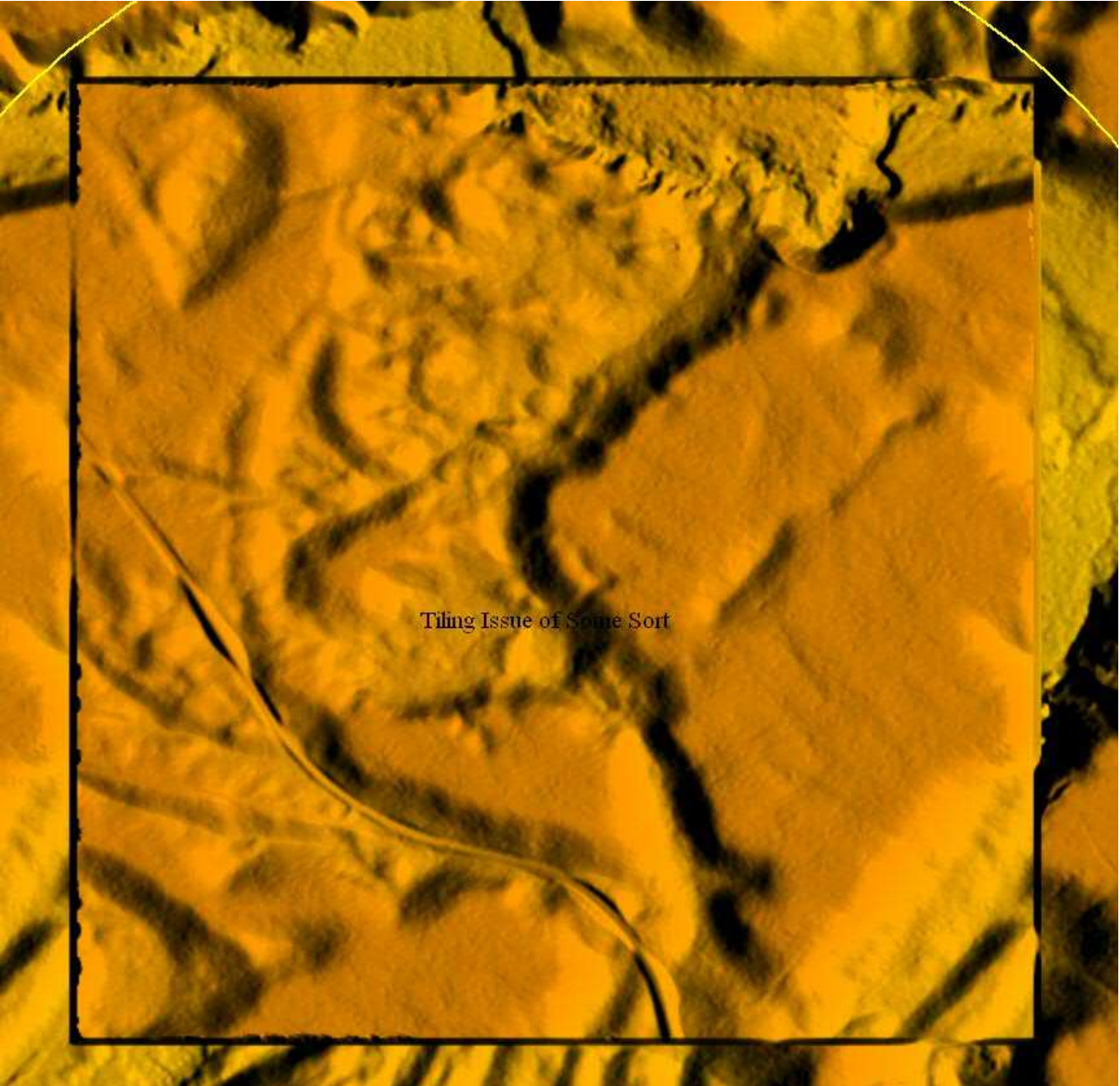


Image?



::::::::::FIXED IN RE-DELIVERY::::::::::The FVA is higher than the acceptable value for v13 when tested at the USGS using the CMU Validation points. Further investigation reveals that the CMU reported DEM values at validation point locations are incorrect. See screen capture: in this example validation point 1 was surveyed as having an elevation of SURZ=250.4020000000, and CMU reported a raster value for this point of IZDEM=250.3407216000, but NGTOC has found that raster value at this point's location is RASTERVALU=250.49412537, this issue occurs with other points as well. \*\*see Redeliver Vertical Accuracy Note

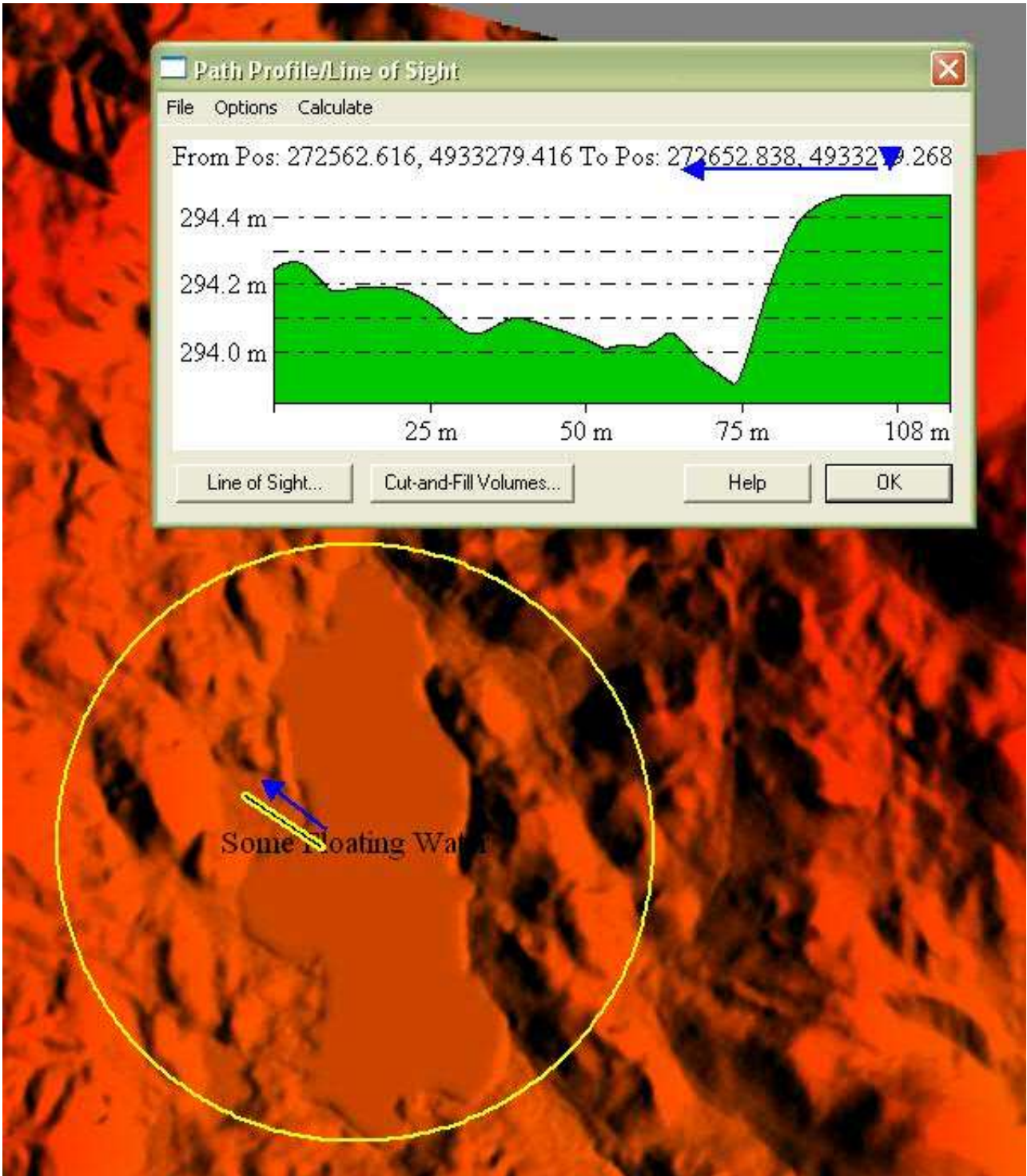
Image?



Tiling Issue of Some Sort

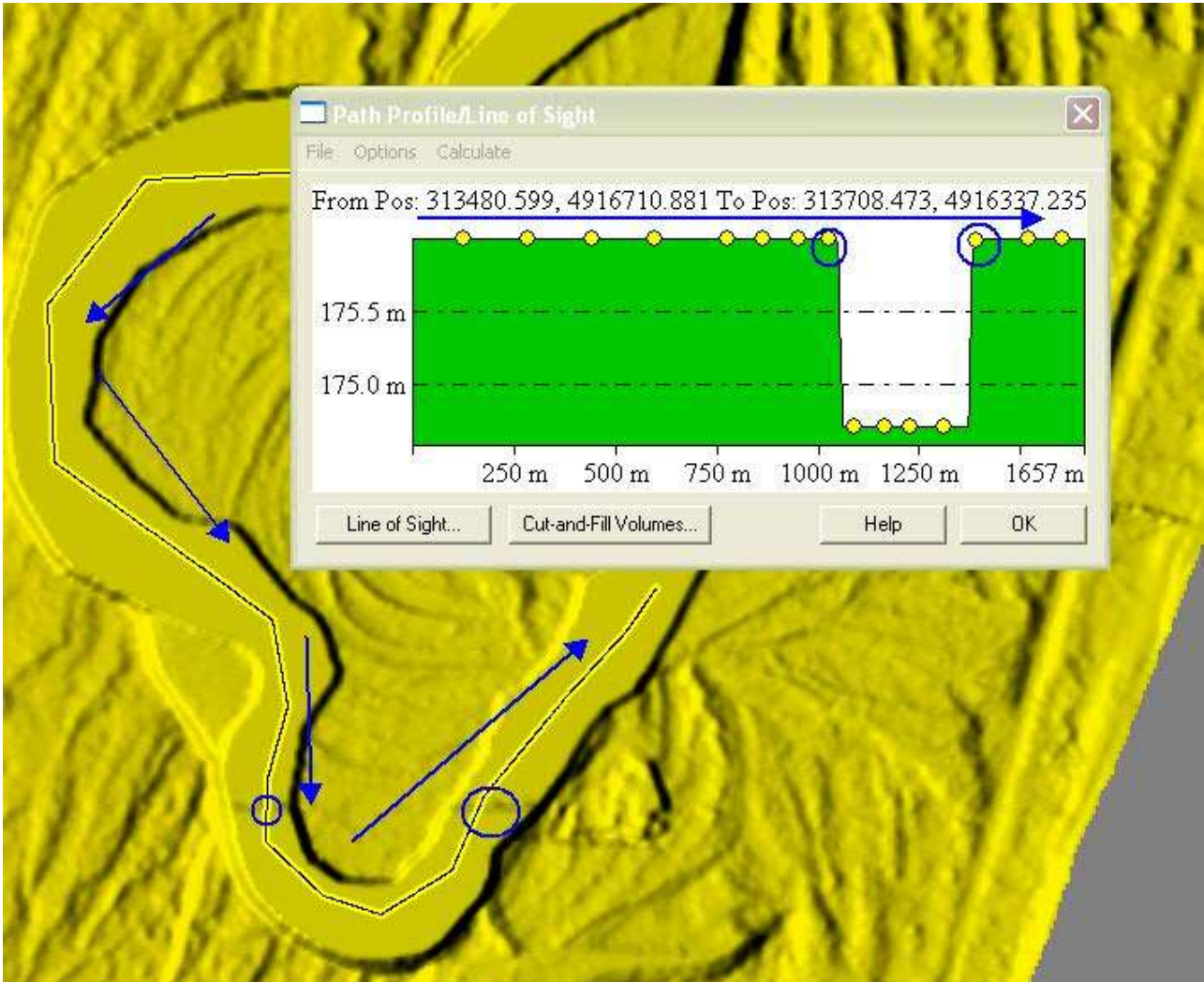
::::::::::FIXED IN RE-DELIVERY::::::::::A Major Concern of these DEM's are that at least 2 DEM's appear to be missing. Tile 345 is identical to 344 and 1894 is identical to 1893. Also 635 appears to be a random tile. I have verified that the necessary data to grid these areas is available in the point cloud.

Image?



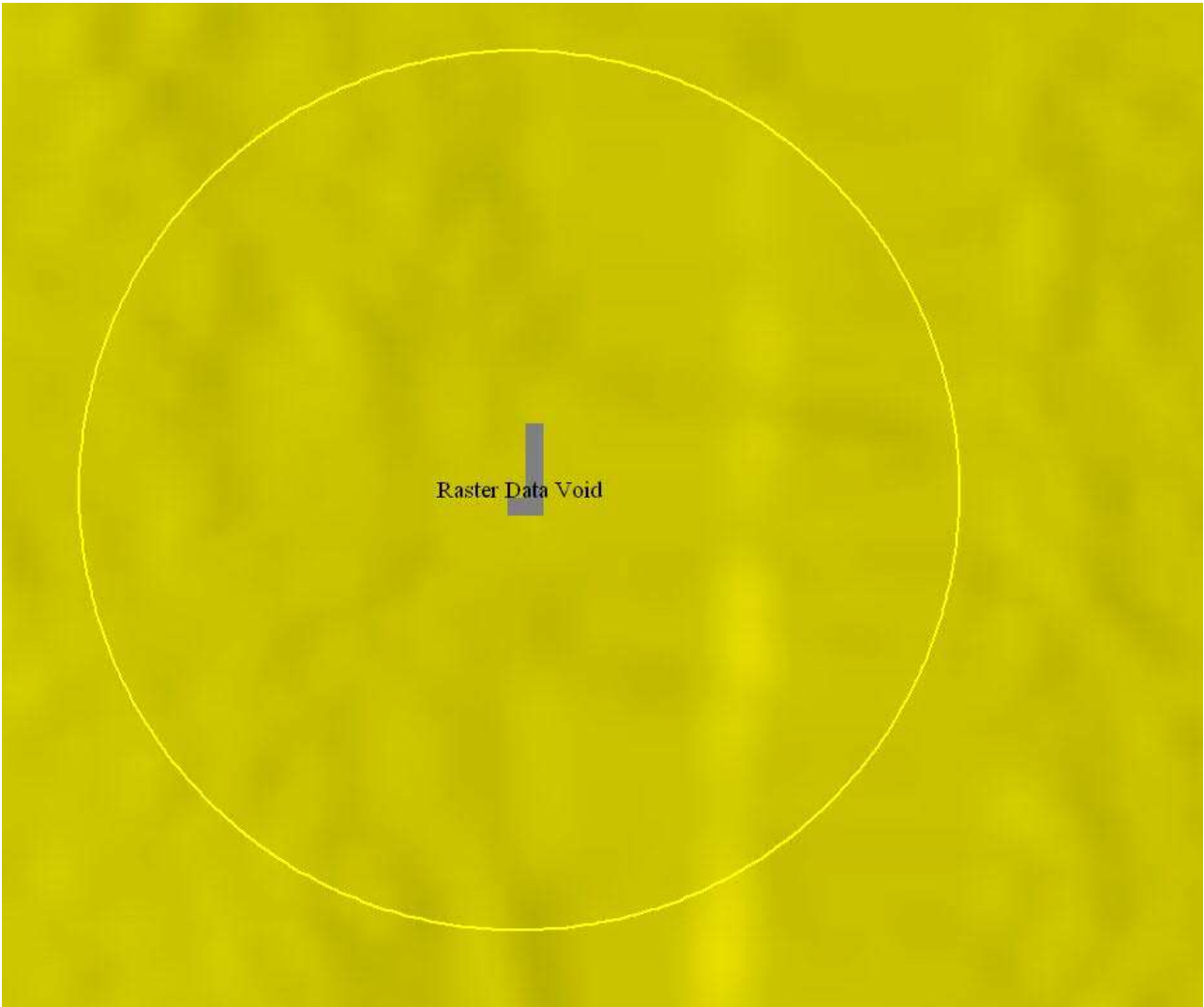
.....FIXED IN RE-DELIVERY.....There were a couple issues with water bodies: 2 Instances of mild floating water where the waterbody could be set lower.

Image?



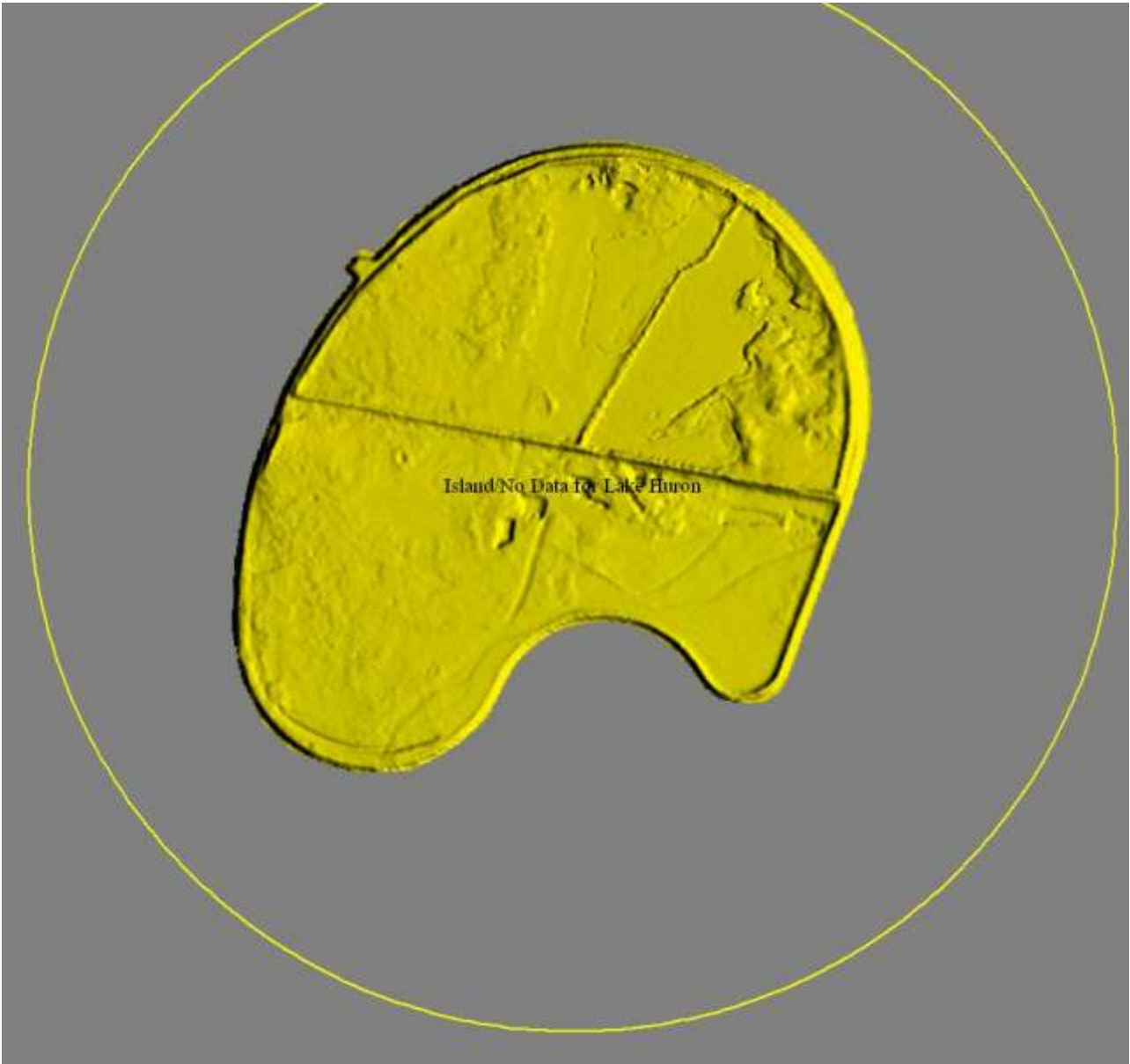
::::::::::FIXED IN RE-DELIVERY::::::::::Another Water issue occurred where the flow does not make sense, see above and DEM error tags shapefile.

Image?



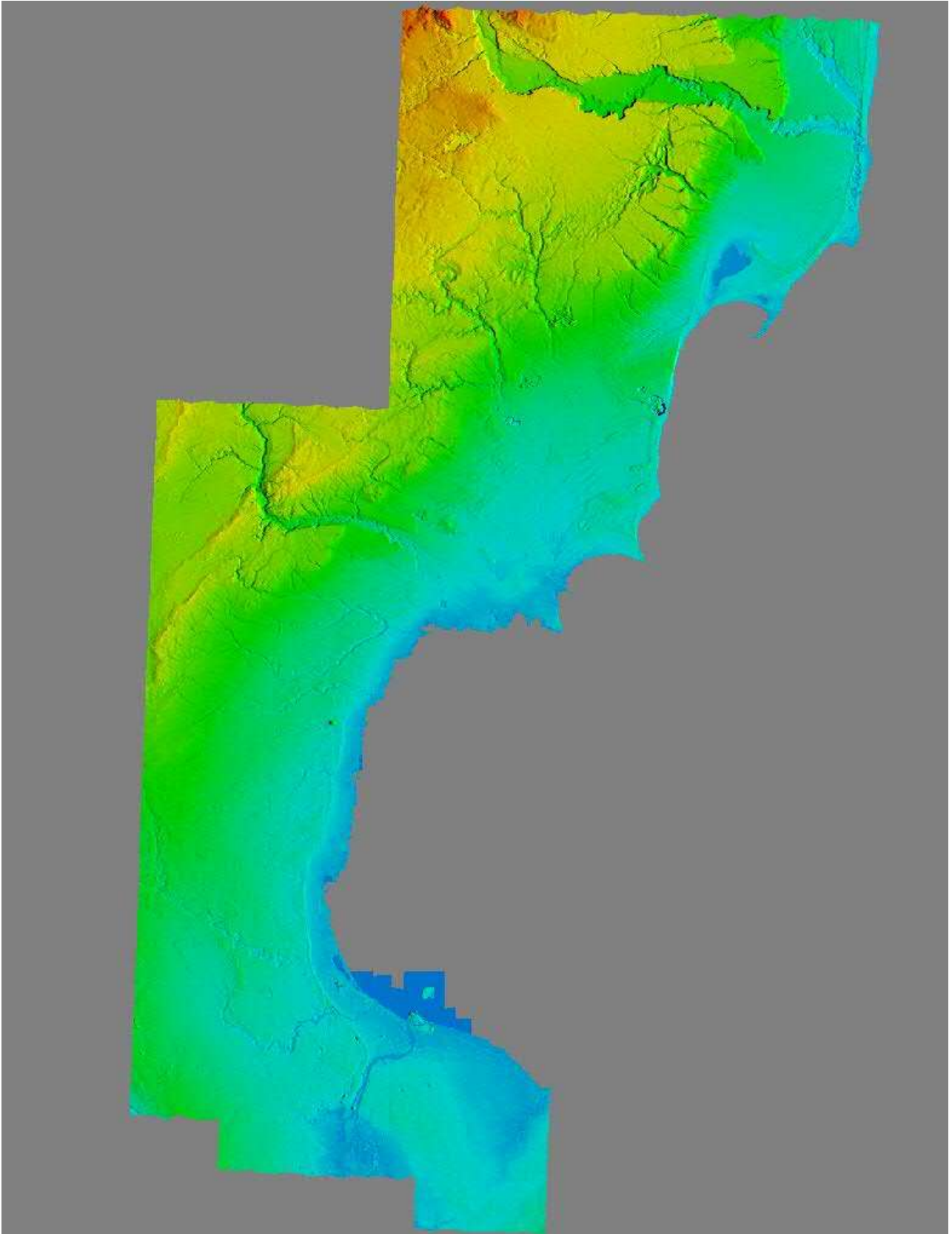
::::::::::FIXED IN RE-DELIVERY::::::::::One Raster Data Void was located and marked in the DEM\_Error\_Tags Shapefile.

Image?



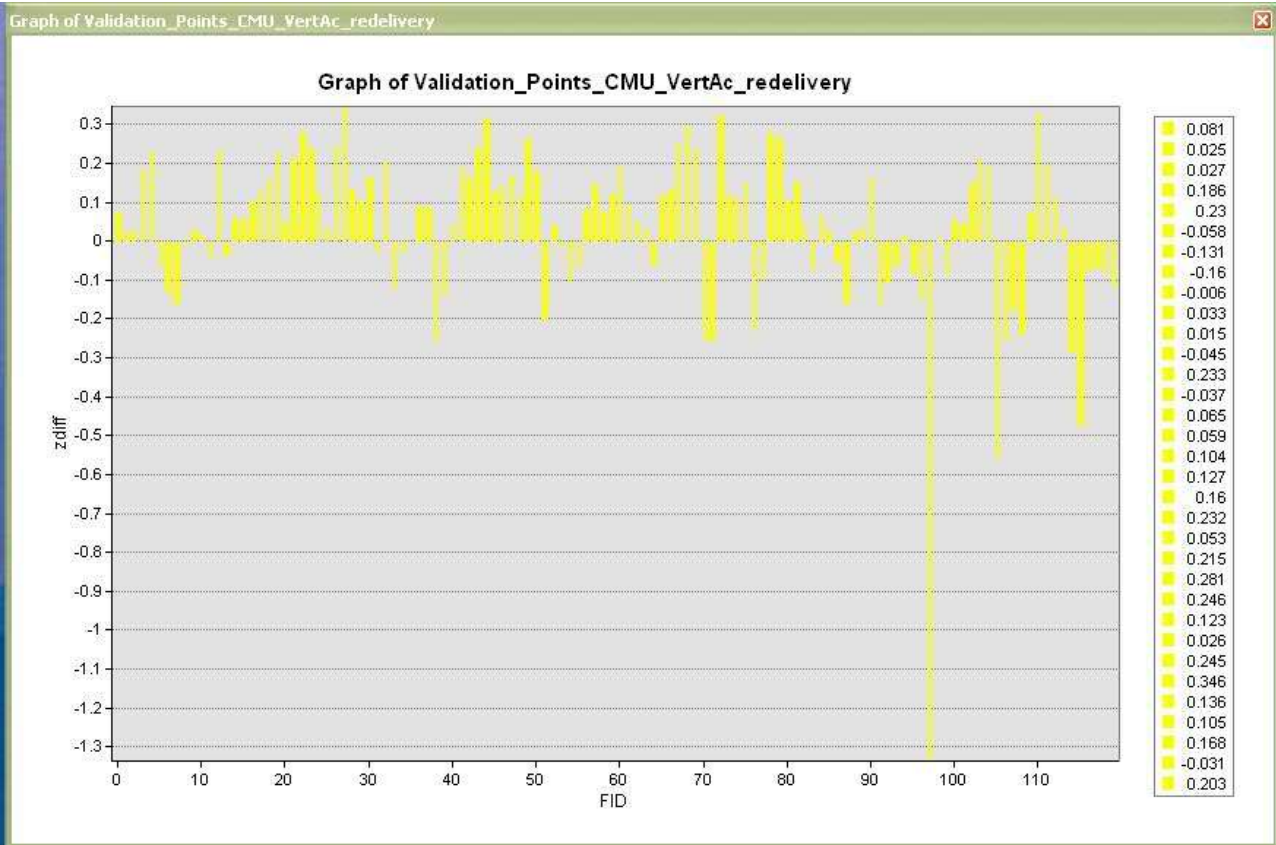
::::::::::FIXED IN RE-DELIVERY::::::::::(Lake Huron included around the area with the island) Finally, the issue of including an elevation for lake Huron needs to be addressed, especially in the context of the island located just of the coast.

Image?



Redelivered Tiles Mosaiced into a Final Bare Earth DEM, all qualitative issues noted above have been fixed (note Lake Huron Extends out to cover the Island).

Image?



Graph of Deltaz of all Validation Points (based off Redelivery), Clearly there is still some large error here, after post testing of Atwell points and removing the worst 20 outlier points, the accuracy results reported in the DEM Calculated Accuracies section above were arrived at. It is suspected that the dataset has acceptable vertical accuracy, but that some of the surveyed Validation Points may have been erroneous.

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

QA Form V1.4 12OCT11.xsn