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:
8/6/2012

Project Type: Donated Data

Project ID:
UT_GSLNorth_2011

Project Description:
This data set was collected from airborne surveys completed between September 27, 2011 and October 10, 2011 and covers approximately 619 square miles contained in the following county(s): Box Elder County, Utah; Weber County, Utah.

Project Alias(es):

Year of Collection: 2011

Lot 1 of 1 lots.

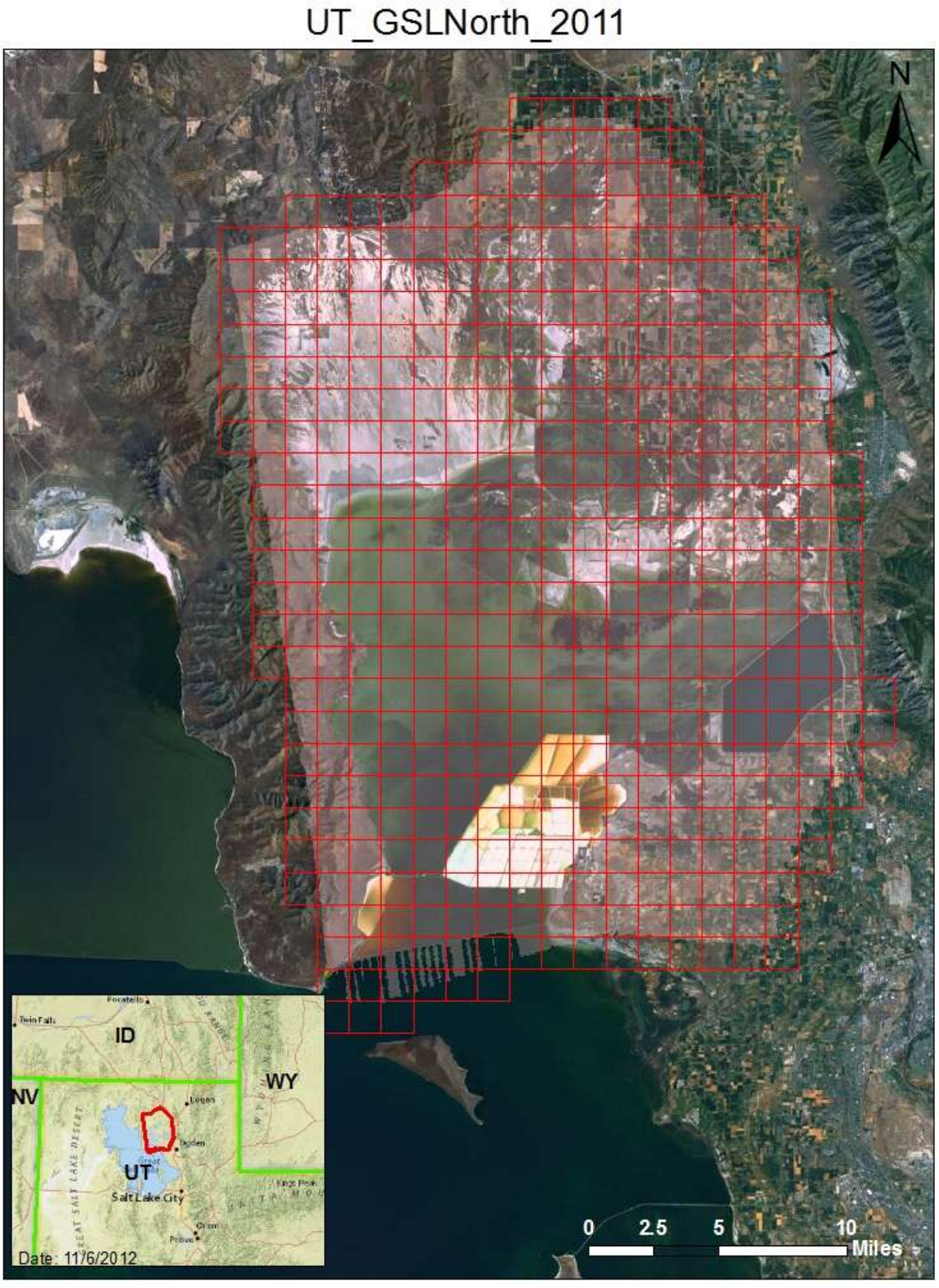
Project Extent:

☑ Project Extent image?

UT_GSLNorth_2011

Project Tiling Scheme:

☑ Project Tiling Scheme image?



Contractor:

Applicable Specification:

Utah AGRC & USU LASSI Service Center	V13 + Custom

Licensing Restrictions:

☐ Third Party Performed QA?

Project Points of Contact:

POC Name	Type	Primary Phone	E-Mail
Dave Vincent	NSDI Liaison	801-975-3435	dmvincent@usgs.gov
Robert Pack	Utah State University	453-797-7049	robert.pack@usu.edu
Rick Kelson	Utah AGRC	801-538-3237	rkelson@utah.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
- [x] QA/QC Report
- [ ] Control and Calibration Points
- [x] Project Shapefile/Geodatabase
- [x] Project Tiling Scheme Shapefile/Gdb
- [ ] Control Point Shapefile/Gdb
- [ ] Breakline Shapefile/Gdb
- [ ] Project XML Metadata

Multi-File Deliverables

File Type	Quantity
[x] Swath LAS Files [x] Required? [x] XML Metadata?	203
[ ] Intensity Image Files [x] Required?	
[x] Tiled LAS Files [x] Required? [x] XML Metadata?	463
[ ] Breakline Files [ ] Required? [ ] XML Metadata?	
[x] Bare-Earth DEM Files [x] Required? [x] XML Metadata?	459

Additional Deliverables

	Item
[x]	DSM Metadata (XML)
[x]	DSM Files (IMG, 459)

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

Either the DEM or Lidar Metadata file would be the "Best Use" XML file for Project Metadata.

Project Geographic Information

Areal Extent:

619

Sq Mi

Grid Size:

1

meters

Tile Size:

2000 x 2000

meters

Nominal Pulse Spacing: 0.85 meters

Vertical Datum: NAVD88 GEOID09 meters

Horizontal Datum: NAD83(CORS96) meters

Project Projection/Coordinate Reference System: NAD_1983_UTM_Zone_12N 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
- [x] Swath LAS XML Metadata File
- [x] Classified LAS XML Metadata File
- [ ] Breaklines XML Metadata File
- [x] Bare-Earth DEM XML Metadata File
- [x] Swath LAS Files
- [x] Classified LAS Files
- [ ] Breaklines Files
- [x] Bare-Earth DEM Files

Check Point Shapefile/Geodatabase CRS

Not Delivered

Project XML Metadata CRS

Not Delivered

Breakline XML Metadata CRS

Not Delivered

Breakline Files CRS

Not 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.

Review Start Date:
10/29/2012

Action to Contractor Date	Issue Description	Return Date

Review Complete: 11/9/2012

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 without errors.

The Swath LAS XML Metadata file parsed without errors.

The Classified LAS 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 notable to locate independent checkpoints for this analysis. USGS does not acccept at this timethe quality of the checkpoint data for these LiDAR datasets.

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

☐ Image?

Other Significant Supplemental Landcover Categories include Swamp, Marsh, or Wetlands; as well as, a significant amount of Open Water.

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: centimeters

Required FVA Value is 24.5 centimeters or less.
Target SVA Value is 36.3 centimeters or less.
Required CVA Value is 36.3 centimeters or less.

The reported FVA of the LAS Swath data is 08.1 centimeters.

The reported FVA of the Bare-Earth DEM data is 08.1 centimeters.
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		centimeters
Brush Lands and Low Trees		centimeters
Forested Areas Fully Covered by Trees		N/A
Urban Areas with Dense Man-Made Structu...		N/A

The reported CVA of this data set is: centimeters.

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

- [x] Separate folder for LAS swath files
- [x] Each swath files <= 2GB
- [ ] *If specified, *.wdp files for full waveform have been provided

The reported FVA of the LAS swath data is 08.1 centimeters.

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

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

[ ] Image?

Points Reside on Classes 2, 4, and 5 instead of unclassified and unprocessed class 0.

[ ] Image?

Spatial Reference not defined in Header of Classified LAS Tiles.

[ ] Image?

Vertical Accuracy was not assessed in the Traditional Manner for this Project, for more information see the GSL_CompletionReport. It is reported that:
There is a tested < 4 cm RMSEz relative accuracy,
There is a tested < 7 cm RMSEz overlap accuracy, and
There is a tested < 8 cm RMSEz fundamental vertical accuracy.

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

- [x] Separate folder for Classified LAS tile files
- [x] Classified LAS tile files conform to Project Tiling Scheme
- [x] Quantity of Classified LAS tile files conforms to Project Tiling Scheme
- [x] Classified LAS tile files do not overlap
- [x] Classified LAS tile files are uniform in size
- [x] 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)

- [x] Buy up?

Additional classifications in this data set.

- [x] 3 - Tall weeds and crops (low vegetation)
- [x] 4 - Brush lands and low trees (medium vegetation)
- [x] 5 - Forested areas fully covered by trees
- [x] 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?

Spatial Reference not defined in Header of Classified LAS Tiles.

☐ Image?

Points Reside on Classes 14, 17, 18, 19, 20, 21, 22, 23, 25, 26.

☐ Image?

It is stated in the GSL Completion Report that Hydro Flattening was achieved via the inclusion of breakpoints in the point cloud, class 14 (from Metadata), the text states:

"Significant effort was given to the creation of automated routines that would detect the dozens of river banks and hundreds of lake shorelines within the subject areas. The routine then automatically creates polylines that then serve as breaklines for hydro-flattening. For this work, custom tools were developed using LAS-tools, a set of routines developed by Martin Isenburg (out of Germany), and custom Matlab scripts developed in-house. These breaklines, consisting of a series of closely spaced points were then added to the point cloud LAS files with a unique classification code. When combined in a LAS file with original lidar points, the quality of the hydro-flattening can immediately be exploited as a triangulated irregular network (TIN) in any LAS viewer or GIS system (such as ArcGIS)."

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

- [x] Separate folder for bare-earth DEM files
- [x] DEM files conform to Project Tiling Scheme
- [ ] Quantity of DEM files conforms to Project Tiling Scheme
- [ ] 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 centimeters.

Reported Accuracies

Land Cover Category	# of Points	Fundamental Vertical Accuracy @95% Confidence Interval ($Accuracy_z$) 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	3	8.1		

Tall Weeds and Crops				
Brush Lands and Low Trees				
Forested Areas Fully Covered by Trees				
Urban Areas with Dense Man-Made Structures				
Consolidated				

☐ QA performed Accuracy Calculations?

Based on this review, the USGS does not recommend 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?

Vertical Accuracy was not assessed in the Traditional Manner for this Project, for more information see the GSL_CompletionReport. It is reported that:
There is a tested < 4 cm RMSEz relative accuracy,
There is a tested < 7 cm RMSEz overlap accuracy, and
There is a tested < 8 cm RMSEz fundamental vertical accuracy.
The Metadata contains the following statement in regards to Vertical Accuracy:
"Quality control and assurance procedures have been completed and there are known discrepancies between local benchmark control elevations and LiDAR elevations. If this LiDAR data is to be adapted for local use with a local datum, it is strongly recommended that the services of a professional surveyor be obtained in order to make custom adjustments to the data".

☐ Image?

DEM Tiles do not Perfectly Conform to the Tiling Scheme in Terms of Quantity, i.e., 459 DEM Tiles out of a Tile Scheme of 463 Tiles. As noted above, lake water has been removed and set to no data, rather than flattened, the Missing DEM tiles fall in these no data water areas. Missing Tiles are: GSL_North_000379, GSL_North_000149, GSL_North_000282, GSL_North_000338.

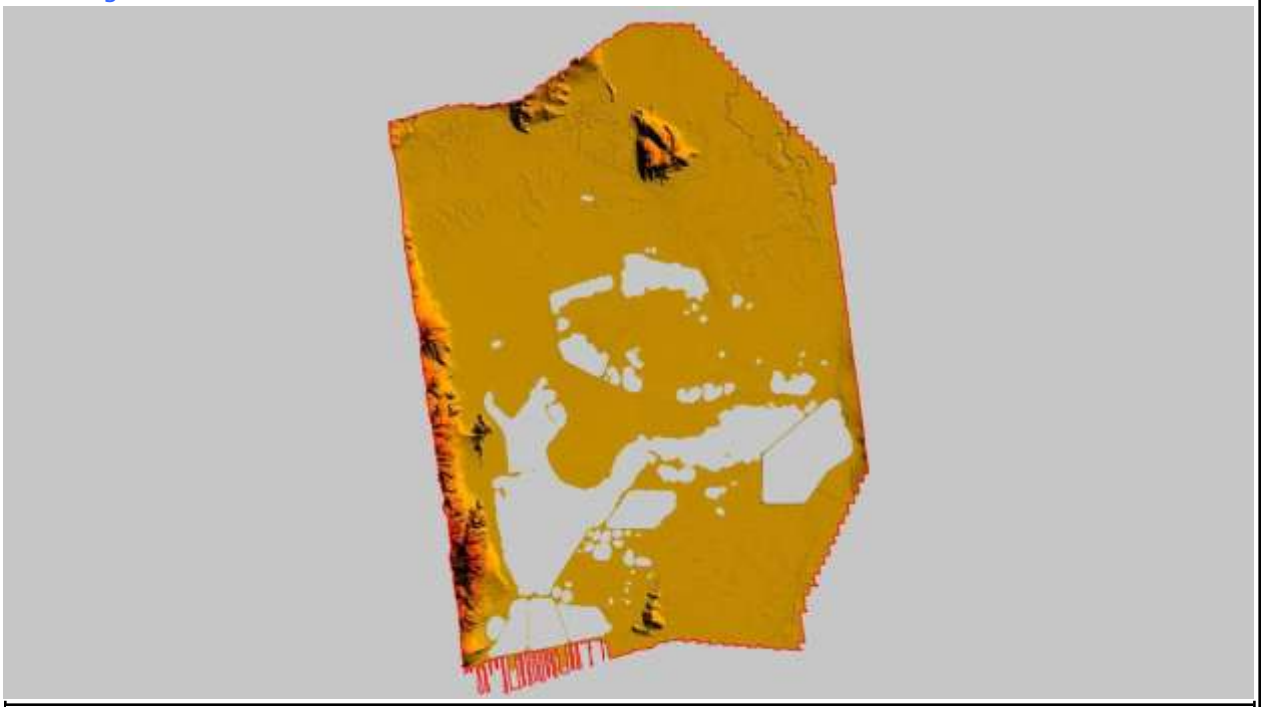
☐ Image?

There are also several instances of Overlapping DEM Tiles or tiles which have the same data. These tiles include: (409,410), (455,461), (456,462), (457,463), (445,460), (435,449,450). The do not present a problem in the USGS created Mosaic.

☑ Image?

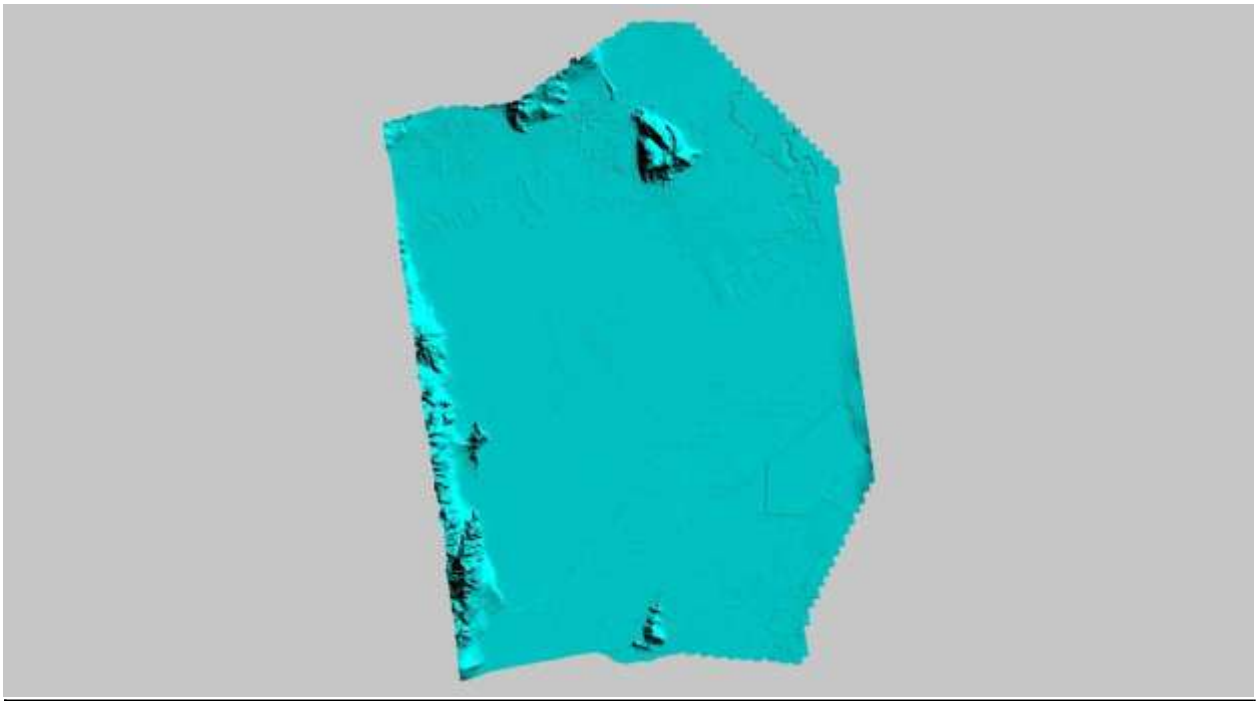
Note that Lake Areas are not gridded at a constant value in DEMs, but is removed or no data.

☑ Image?



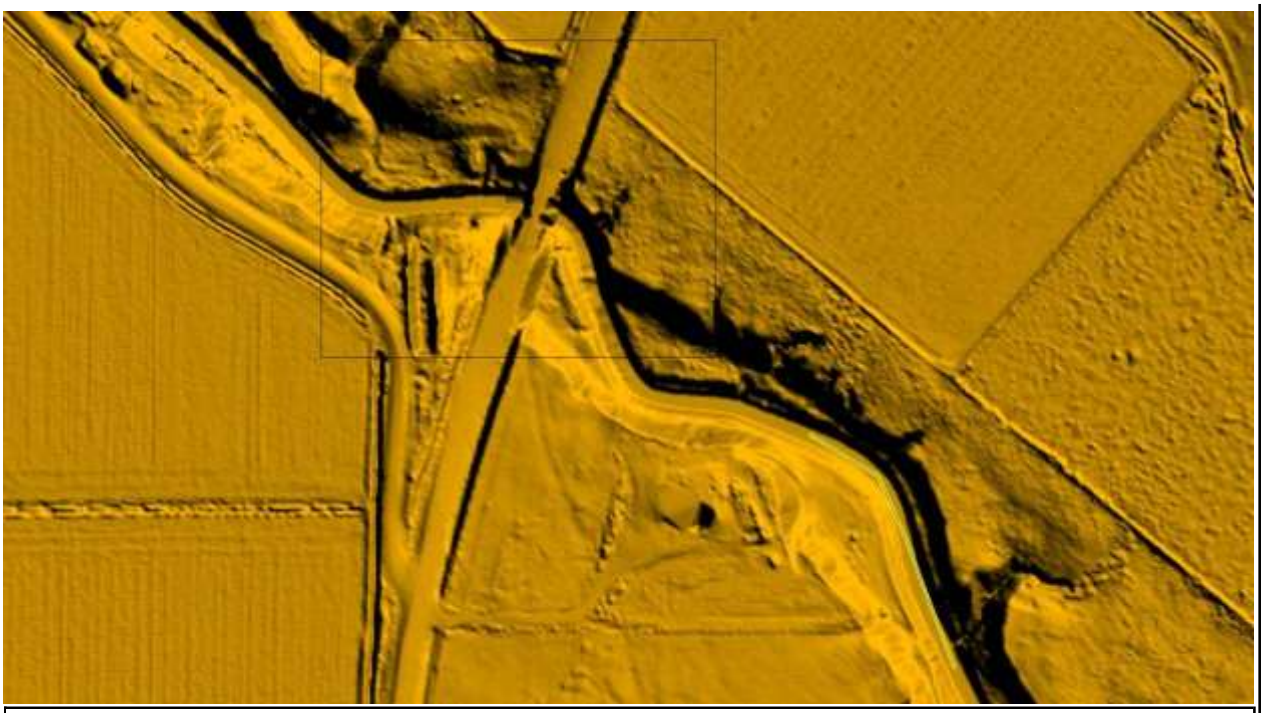
Mosaic of original DEM tiles above, many water areas gridded as "no data".

☑ Image?



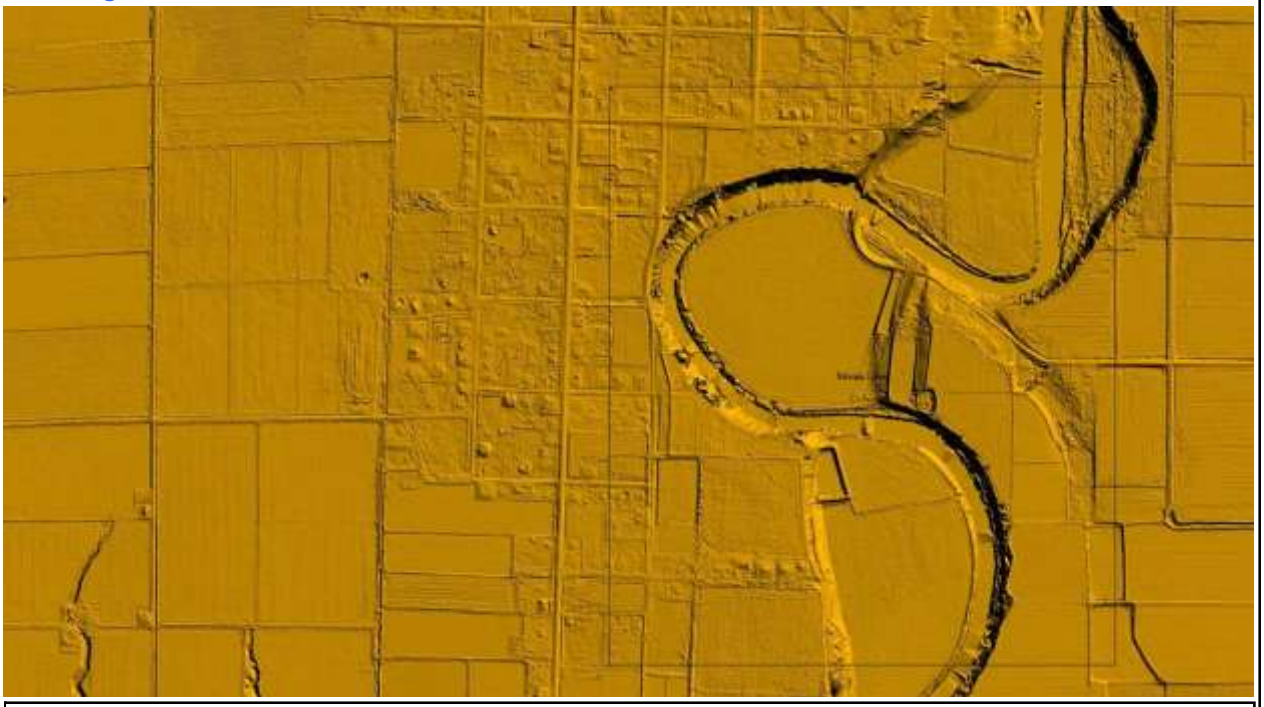
In order to make the DEM usable in the 1/9th NED the Water needed to have a value, A final mosaic was created by the USGS that coded each interior lake with a constant (flat) value of the lowest bordering pixel. The project boundary for the project was also determined to be the maximum swath extents and was buffered in by 100 Meters and cut out on the southern portion to ensure there were no gaps in the data due to the flight lines. The final product sent to the NED should be free of data voids and have adequate point density for gridded areas included in the final mosaicked DEM. This also has an accompanying DEM Project Footprint and is 607.40 SqMi.

☑ Image?



Several instances of bridge or overpass removal. Errors tagged as "Bridge" are highly suspect; whereas, errors tagged as "overpass or culvert" could not be determined if they needed to be removed or where culverts in the ground.

☑ Image?

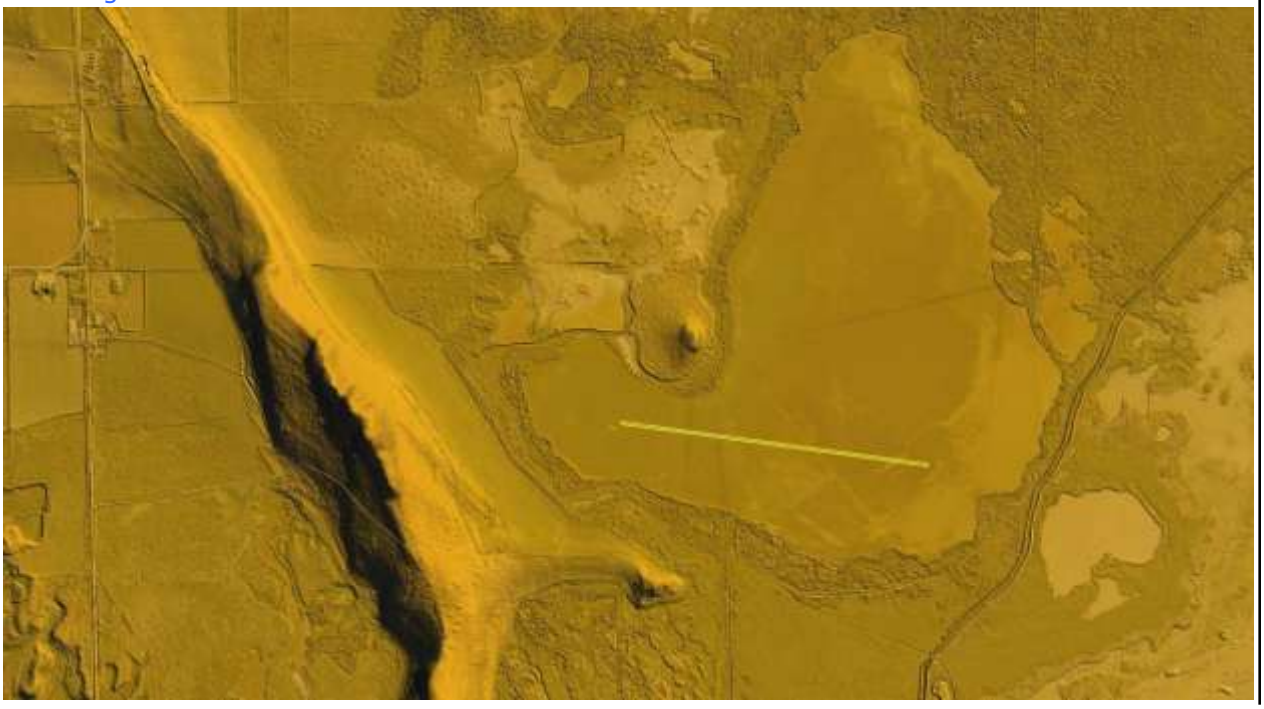


Greater than 100ft nominal width "double line streams" exhibit large amounts of tinning throughout the DEMs.

☑ Image?

A few instances of questionable structure removal. Errors denoted with the tag "building removal".

☑ Image?



Many Water/Swamp areas exhibit tinning or stair stepping, it is evident that some form of hydro treatment was done in certain areas, however they are not a completely flat surface. Greater familiarity with the area would be required to make Swamp v. Water leveling treatment recommendations for the areas in question. The "Water Level(s)" Tag denotes areas in question.

This is the end of the report.