



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:

1/29/2013

Project Type: Donated Data/Partnership

Project ID:

MT_Helena_2012

Project Description:

As stated in the Statement of Work for Acquisition and Production of High Resolution Elevation data for the Helena City area, this LiDAR operation was designed to create high resolution data sets that will establish an authoritative source for elevation information for the state of Montana.

Project Alias(es):

Lewis and Clark

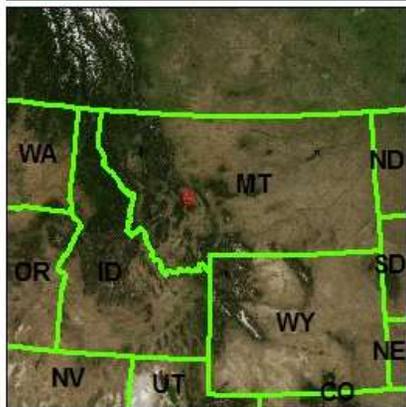
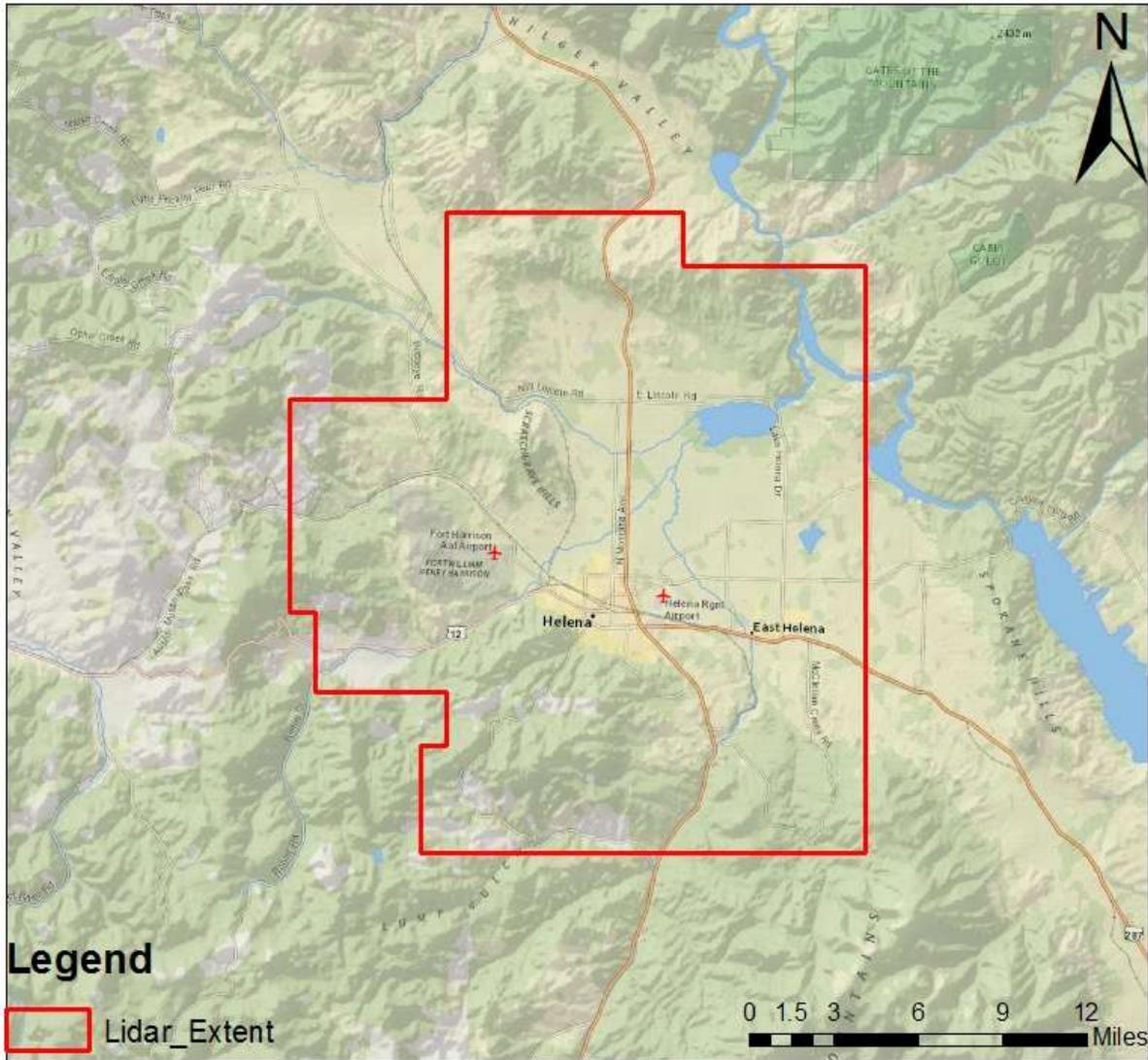
Year of Collection: 2012

Lot 1 of 1 lots.

Project Extent:

Project Extent image?

MT_Helena_2012



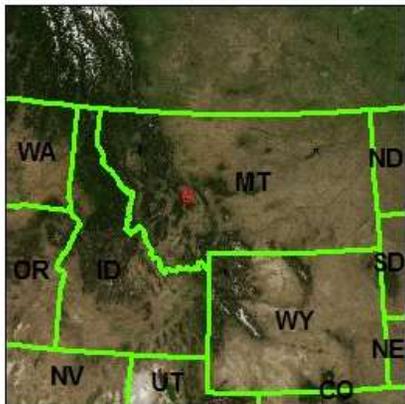
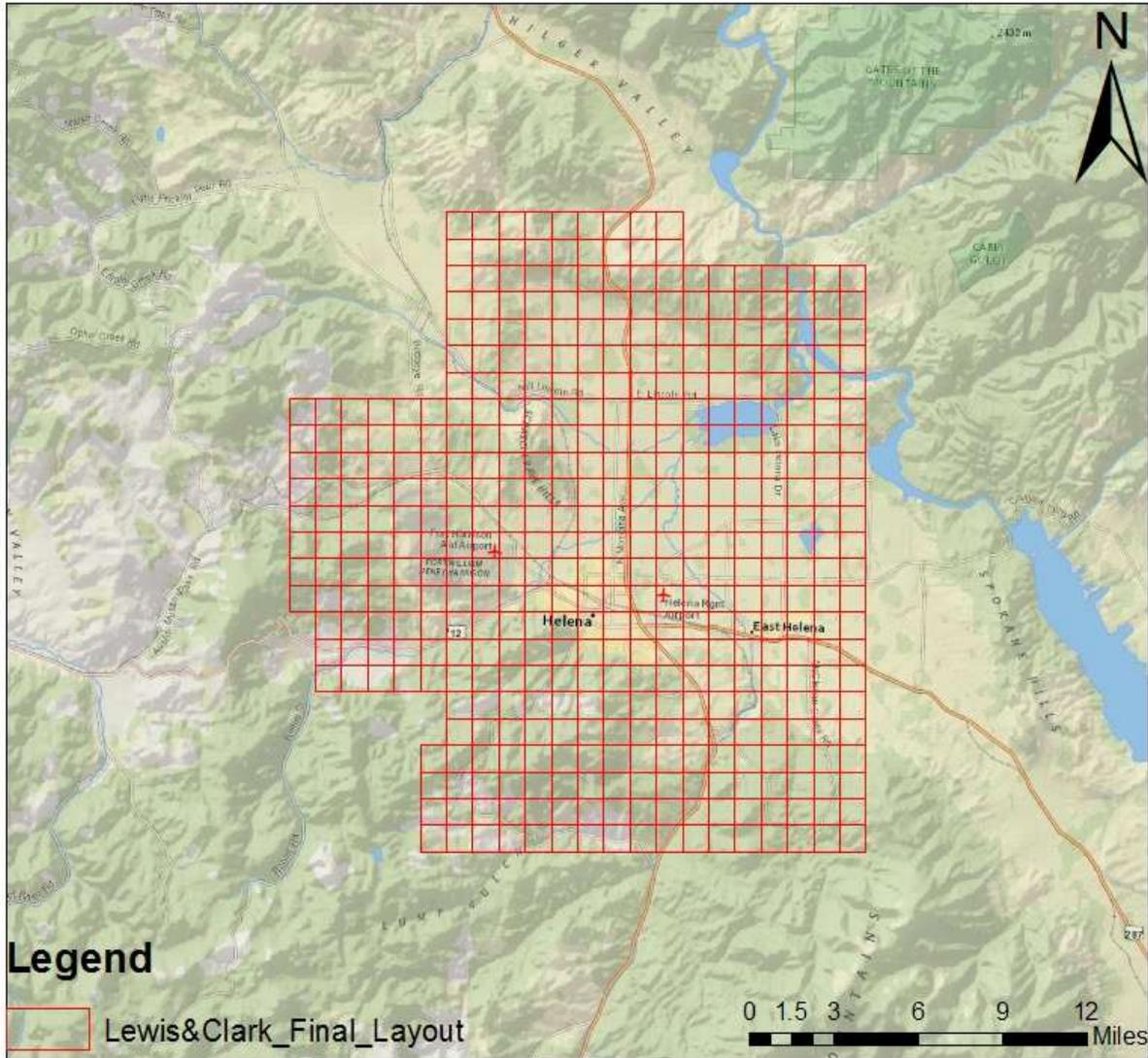
Date: 1/30/2013

Coordinate System: NAD 1983 HARN StatePlane Montana FIPS 2500
 Projection: Lambert Conformal Conic
 Datum: North American 1983 HARN
 False Easting: 600,000.0000
 False Northing: 0.0000
 Central Meridian: -109.5000
 Standard Parallel 1: 45.0000
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 Latitude Of Origin: 44.2500
 Units: Meter

Project Tiling Scheme:

Project Tiling Scheme image?

MT_Helena_2012



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Units: Meter

Contractor:

Applicable Specification:

Sanborn

V13

Licensing Restrictions:

Third Party Performed QA?

Project Points of Contact:

POC Name	Type	Primary Phone	E-Mail
Lance Clampitt	NSDI Liaison	406-994-6919	lsclampitt@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.

- | | |
|---|---|
| <input checked="" type="checkbox"/> Collection Report | <input checked="" type="checkbox"/> Project Shapefile/Geodatabase |
| <input checked="" type="checkbox"/> Survey Report | <input type="checkbox"/> Project Tiling Scheme Shapefile/Gdb |
| <input checked="" type="checkbox"/> Processing Report | <input type="checkbox"/> Control Point Shapefile/Gdb |
| <input type="checkbox"/> QA/QC Report | <input checked="" type="checkbox"/> Breakline Shapefile/Gdb |
| <input type="checkbox"/> Control and Calibration Points | <input 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 type="checkbox"/> Intensity Image Files <input type="checkbox"/> Required?	
<input checked="" type="checkbox"/> Tiled LAS Files <input checked="" type="checkbox"/> Required? <input checked="" type="checkbox"/> XML Metadata?	437
<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?	1

Additional Deliverables

	Item
<input checked="" type="checkbox"/>	Aerial Triangulation Report for Ortho Imagery
<input checked="" type="checkbox"/>	Ortho XML Metadata
<input checked="" type="checkbox"/>	Contours (Geodatabase) and Contour XML Metadata

Errors, Anomalies, Other Issues to document? Yes No

Classified Lidar XML Metadata has a few noted issues:

-LAS version 1.2 is stated in metadata while 1.3 las files were delivered
 -NAD_1983_HARN_StatePlane_South_Carolina_FIPS_3900_Feet_Intl is listed as the reference system; however, the correct Coordinate System and Projection is listed under the Projection tag.

Project Geographic Information

Areal Extent:

367.99

Sq Mi

Grid Size:

1.4

meters

Tile Size:

1500

meters

Nominal Pulse Spacing: 1.4 meters

Vertical Datum: NAVD88 meters

Horizontal Datum: NAD83_HARN meters

Project Projection/Coordinate Reference System:

NAD_1983_HARN_StatePlane_Montana_FIPS_2500 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 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 |

Project XML Metadata CRS

Not Delivered

Swath LAS XML Metadata CRS

Not Delivered

Swath LAS 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:

1/30/2013

Action to Contractor Date	Issue Description	Return Date

Review Complete: 2/4/2013

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](#).

See Bare Classified LAS XML Metadata for project or best use metadata.

The Classified LAS XML Metadata file parsed [with errors](#).

Type	Description or line numbers	Line(s) (or count)
Severity 3: Missing elements		
Error	Contact Voice Telephone (10.5) is required in Contact Information (10)	69 161

The Breakline XML Metadata file parsed [with errors](#).

Type	Description or line numbers	Line(s) (or count)
Severity 5: Misplaced elements		

Error	Contact_Information (10) is not permitted in Contact_Information (10)	159
Severity 3: Missing elements		
Error	Contact_Address (10.4) is required in Contact_Information (10)	158
Error	Contact_Information (10) requires one of Contact_Person_Primary (10.1) or Contact_Organization_Primary (10.2)	158
Error	Contact_Voice_Telephone (10.5) is required in Contact_Information (10)	158
Error	Place_Keyword (1.6.2.2) is required in Place (1.6.2)	53

The Bare-Earth DEM XML Metadata file parsed [witherrors](#).

Type	Description or line numbers	Line(s) (or count)
Severity 3: Missing elements		
Error	Place_Keyword (1.6.2.2) is required in Place (1.6.2)	54

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.

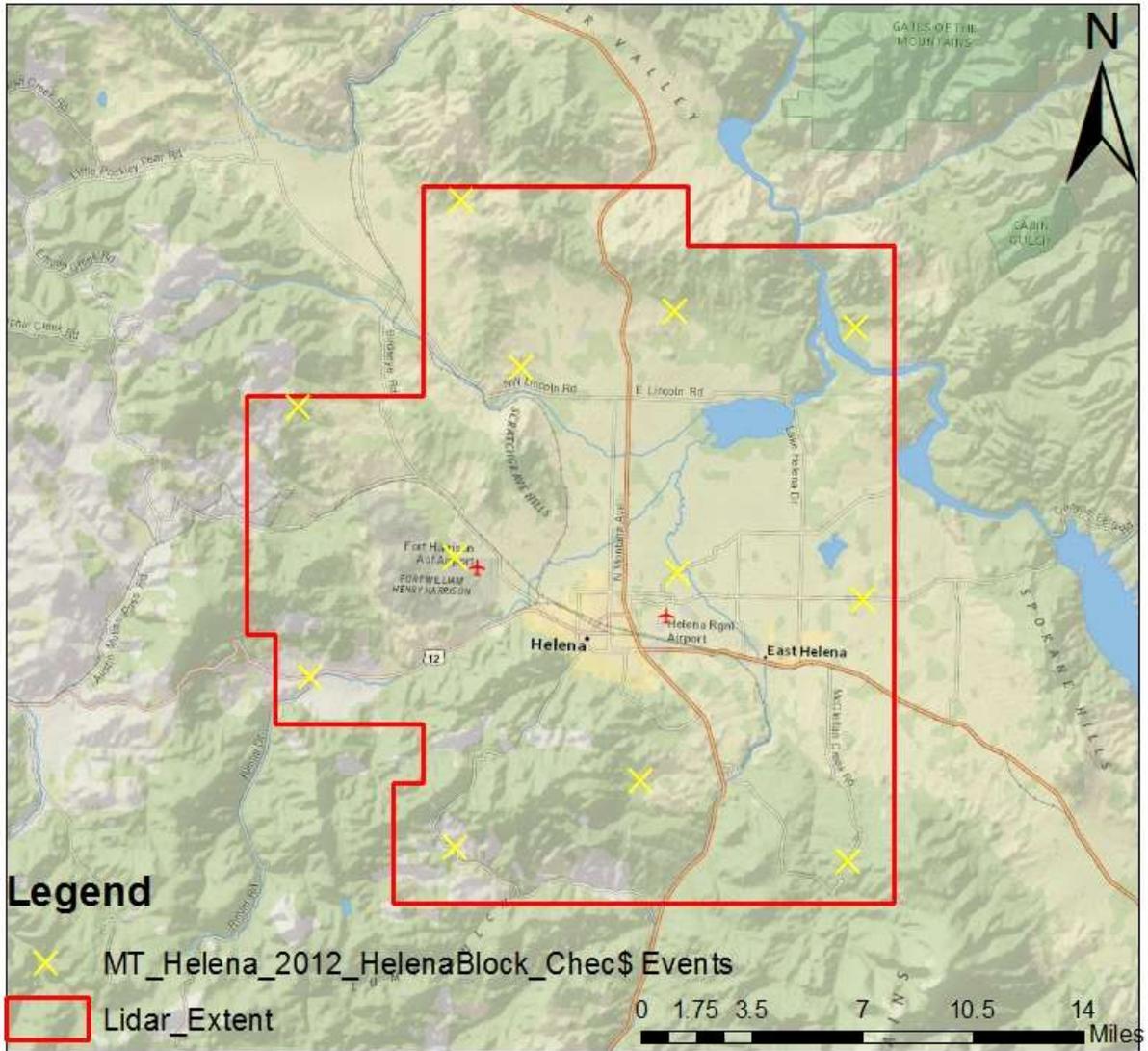
NSSDA and ASPRS require that a minimum of twenty checkpoints (thirty is preferred) are collected for each major land cover category represented in the LiDAR data. Checkpoints should be selected on flat terrain, or on uniformly sloping terrain in all directions from each checkpoint. They should not be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

MT_Helena_2012



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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 accepts the quality of the checkpoint data for these LiDAR datasets.

Errors, Anomalies, Other Issues to document? Yes No

Image?

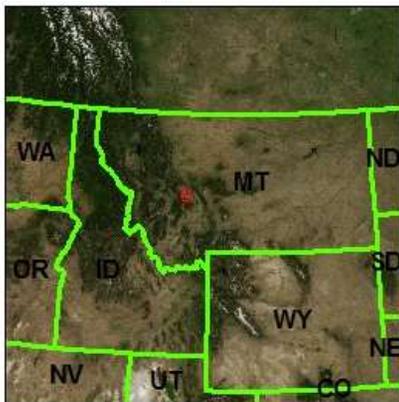
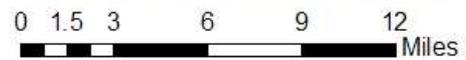
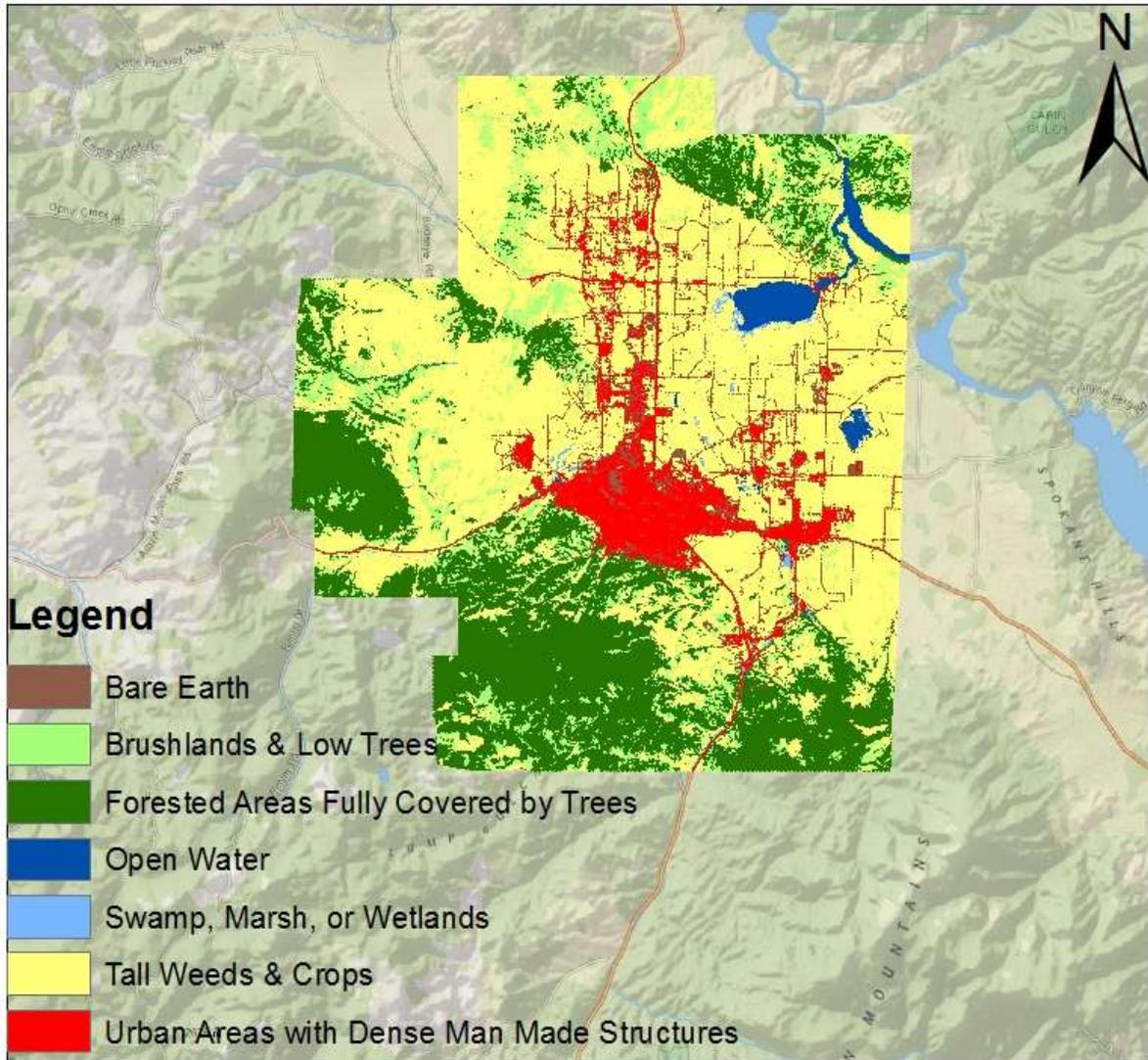
A total of 12 Checkpoints were identified via the Ariel Triangulation Report for the Helena Block. NGTOC used this table to create a Checkpoints Shapefile and assessed vertical accuracy off these points in addition to the 22 points listed under the Sanborn "Final_Report_Lewis&Clark_2012". The FVA using these 12 points was 0.219 M

Image?

Scope of work calls for an NSSDA Accuracy of 30cm; However it also stats that "All LiDAR data must meet or exceed the minimum standards in the U. S. Geological Survey National Geospatial Program Lidar Guidelines and Base Specifications Version 13 - ILMF 2010" which would call for an NSSDA FVA Accuracy of 24.5cm or better. Giving the benefit of the doubt, 30 CM will be used as the requirement.

Image?

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Significant Landcovers as determined from aggregated 2006 NLCD:
 Tall Weeds & Crops 48.49%
 Brushlands & Low Trees 11.16%
 Forested Areas Fully Covered by Trees 26.65%
 *See SVA Landcover Files for more information.
 No SVA Landcover Points were located for any of the significant landcover classes.

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 centimeters or less.

Target SVA Value is centimeters or less.

Required CVA Value is centimeters or less.

The reported FVA of the LAS Swath data is centimeters.

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=""/>	centimeters
Brush Lands and Low Trees	<input type="text" value=""/>	centimeters
Forested Areas Fully Covered by Trees	<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 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?

Extra classes include: 31, 15, 21, 23, 24.

Image?

The following Tiles retained a few points on Class 0:

L&C_LAS_256.las

L&C_LAS_411.las

L&C_LAS_360.las

Image?

Global Encoder ID bit not set for adjusted GPS Time.

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?

Not all Breaklines were Z enabled, only Hydro_Connector_undraped was enabled (perhaps as "undraped" suggests. Moreover, no field exists in the Waterbody or other breakline feature class which could be used for leveling. Nonetheless, the DEMs are correctly Leveled.

Image for error?

Breakline Geodatabase actually contained several different feature classes, Actual Breaklines were exported as a shapfile by NGTOC and put in the NED--> Breaklines Folder as well.

Image for error?

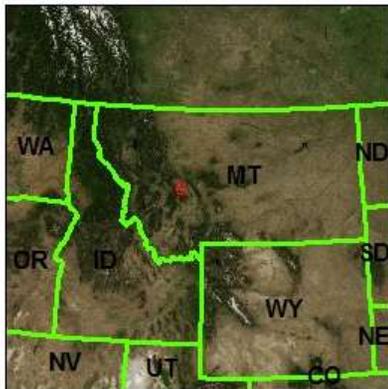
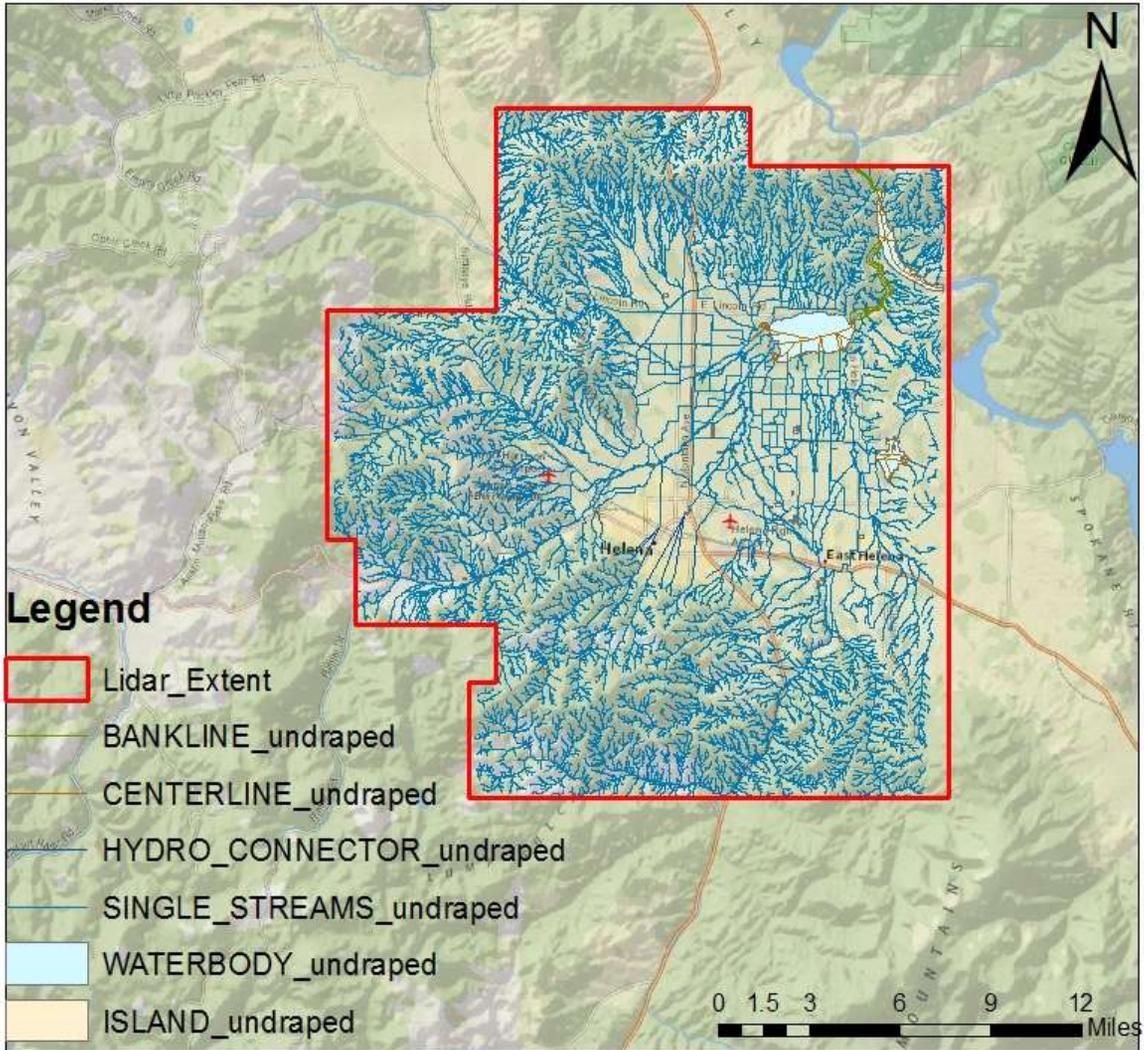
It should be noted that breaklines for this project had a much stricter set of requirements than usually required by the NGP LiDAR Base Specification. Requirements are below:
Breaklines: Breaklines for hydro-flattening: Esri feature class, same reference system as LiDAR point. The Contractor will produce hydro-enforced / hydro-flattened breaklines at NSSDA accuracy standards for 1:2,400-scale maps to the following criteria:

- Breaklines will allow water to flow from the tops of hills all the way down the stream network
- Breaklines will cut through culverts and bridges to allow water to flow down stream network
- Elevation values for the breaklines will be derived from the bare-earth LiDAR
- Single line stream centerlines for streams <2 meters wide will be created at channel bottom
- For streams >2 meters wide, double breaklines will be digitized only at the bottom of both sides of the channel at the land/water interface (but not at the top of bank)

- Drainage ditches (single line <2 meters wide)
- Drainage ditches (double line >2 meters wide at bottom of channel)
- Water bodies (ponds, lakes, reservoirs) greater than ¼ acre in size

Image for error?

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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 = 30 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	22			
Tall Weeds and Crops				
Brush Lands and Low Trees				
Forested Areas Fully Covered by Trees				
Urban Areas with Dense Man-Made Structures				
Consolidated	22			

- QA performed Accuracy Calculations?

Calculated Accuracies

		Fundamental Vertical Accuracy	Supplemental	Consolidated
--	--	-------------------------------	--------------	--------------

Land Cover Category	# of Points	@95% Confidence Interval (Accuracy _z) Required FVA = 30 or less.	Vertical Accuracy @95th Percentile Error Target SVA = 36.3 or less.	Vertical Accuracy @95th Percentile Error Required CVA = 36.3 or less.
Open Terrain	22	26.39		
Tall Weeds and Crops	1		1	
Brush Lands and Low Trees	1		1	
Forested Areas Fully Covered by Trees	1		1	
Urban Areas with Dense Man-Made Structures	1		1	
Consolidated	22			1

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?

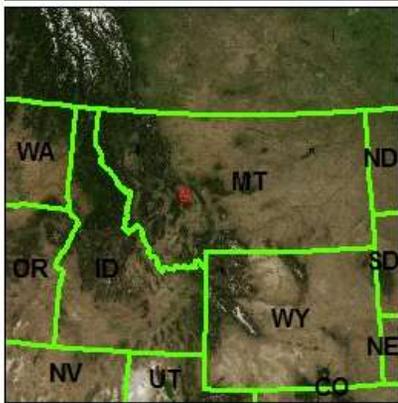
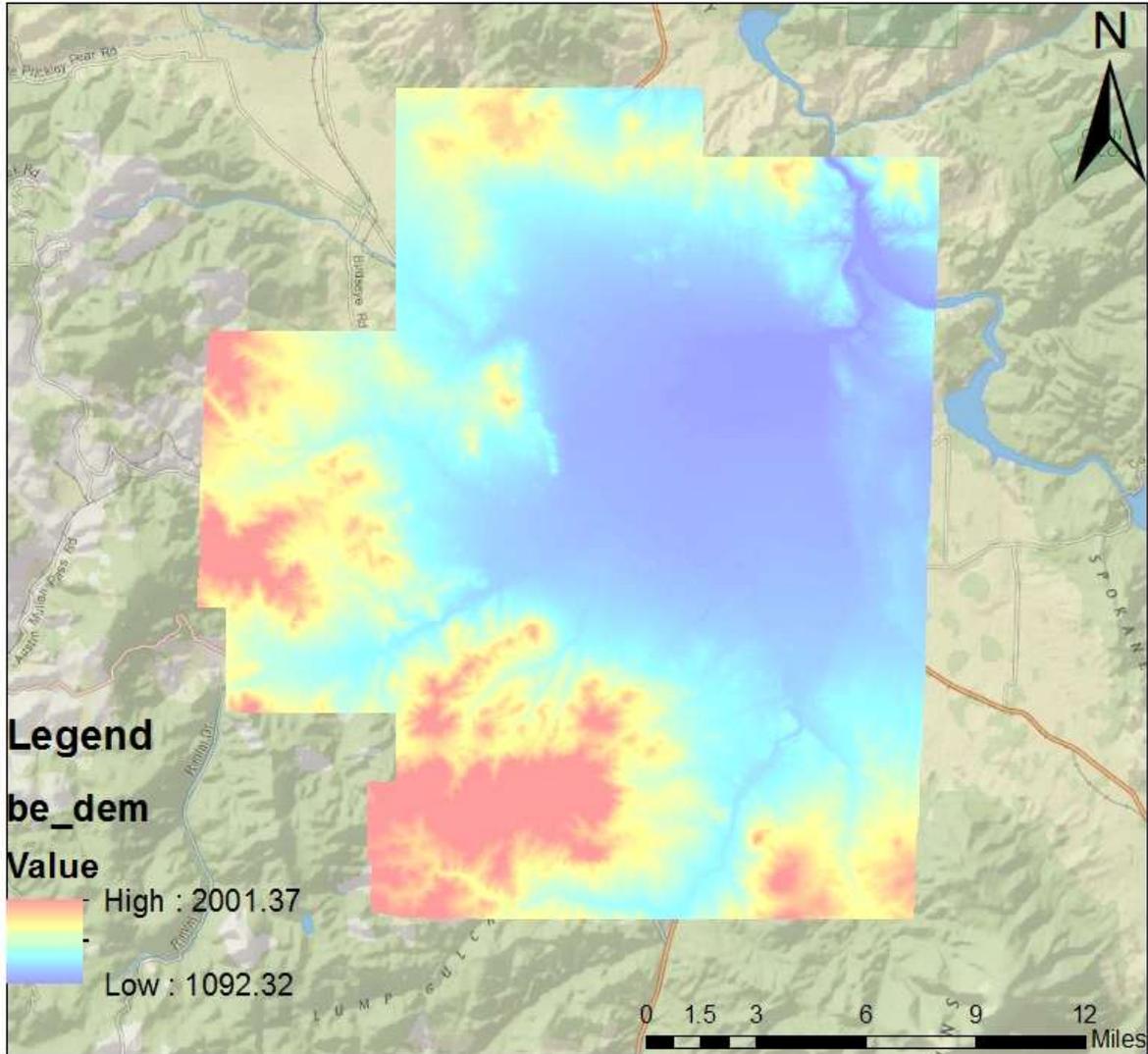
A Mosaicked DEM was delivered rather than tiles, NGTOC converted this ArcGRID Mosaic to an IMG file and removed edge tinning artifacts for the final to NED Mosaic and flattened several of the identified bridges and structures.

Image?

RFP Calls for a DEM with cell size of 1.4 Meters and the DEM was gridded at this size. THE RFP stats the lidar has a NPS of 1.4 while the Sanborn lidar report states the project was calibrated for a density of 1.4 points per M² (an NPS of 0.845). I bring this up because if the NPS is 1.4M, it plausibly makes sense to have DEMs with a cell size of 1.4 M; however, if the density is 1.4 points per M² the DEMs could have been created at the standard 1 M Cell Resolution.

Image?

MT_Helena_2012



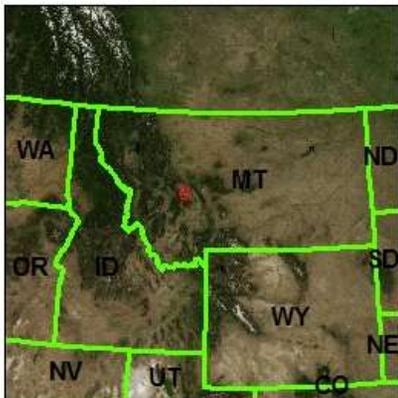
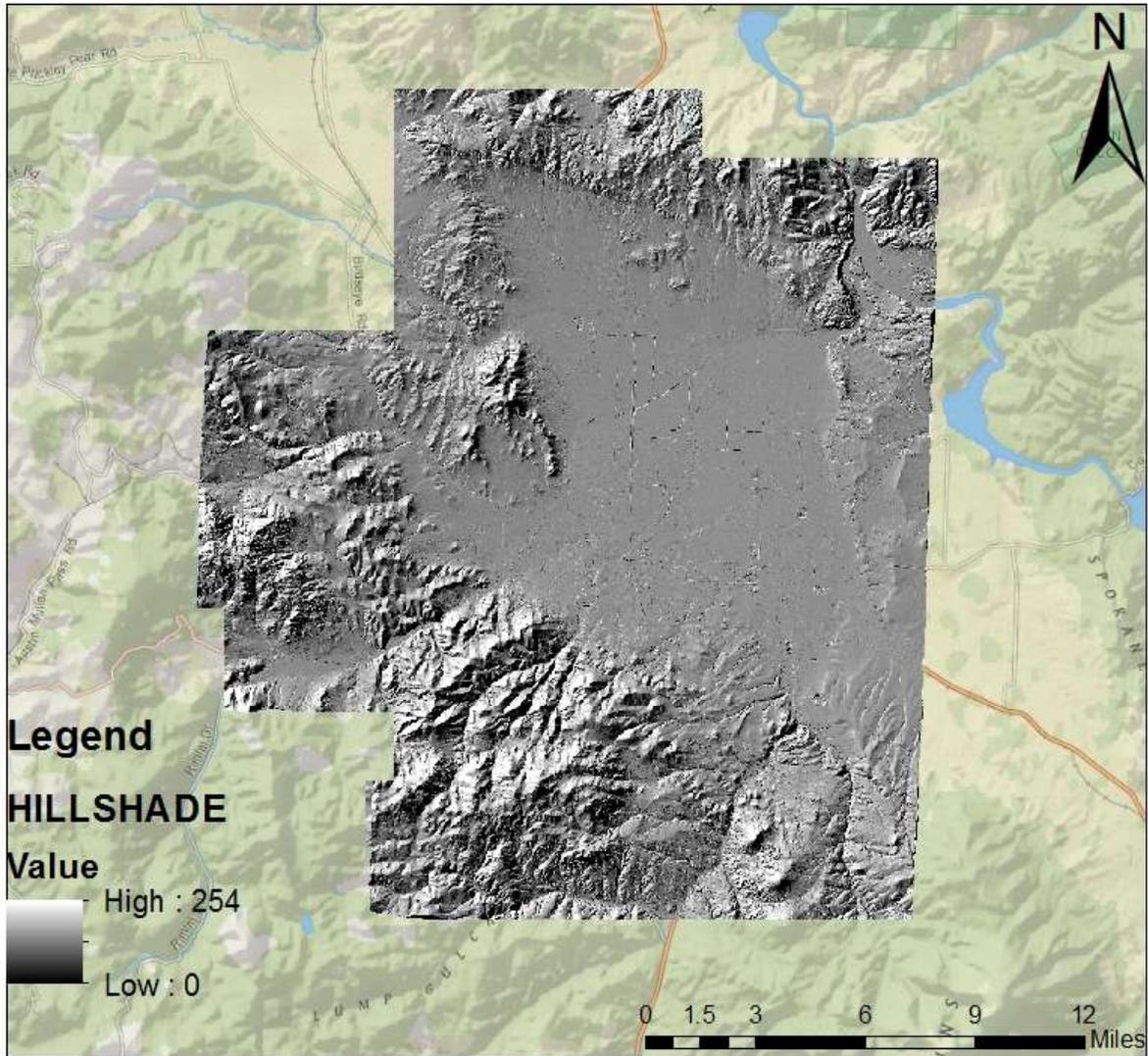
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DEM

Image?

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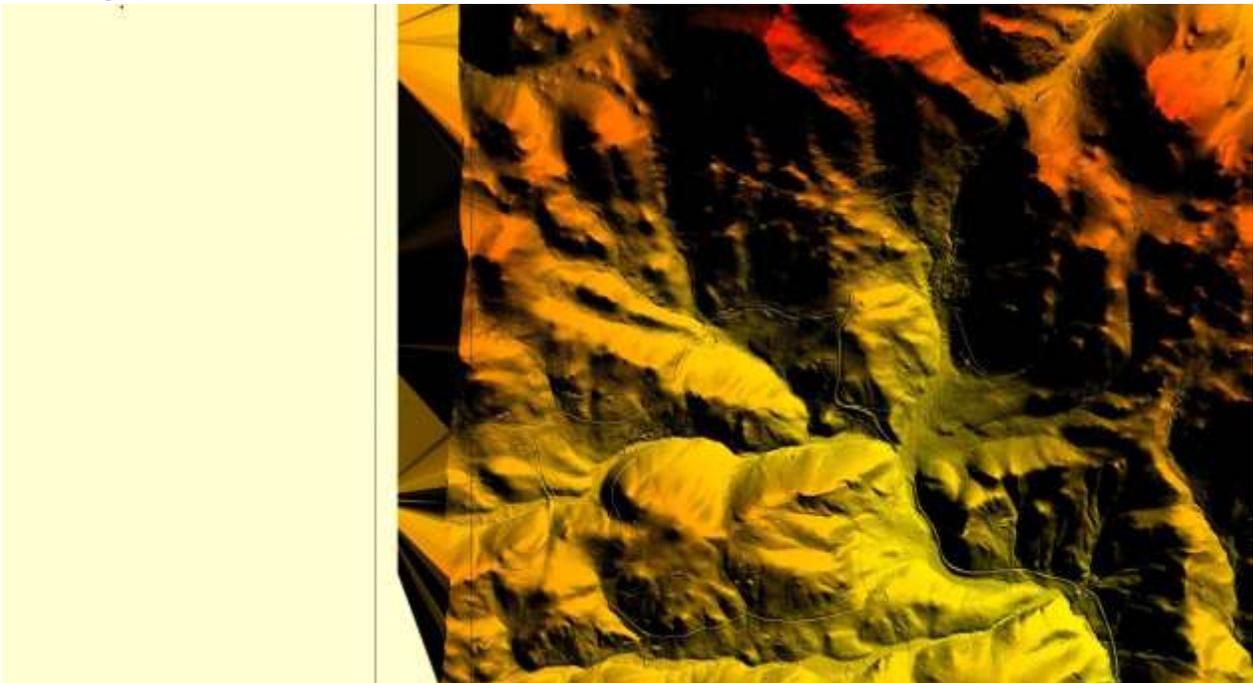
Hill-shaded DEM

Image?



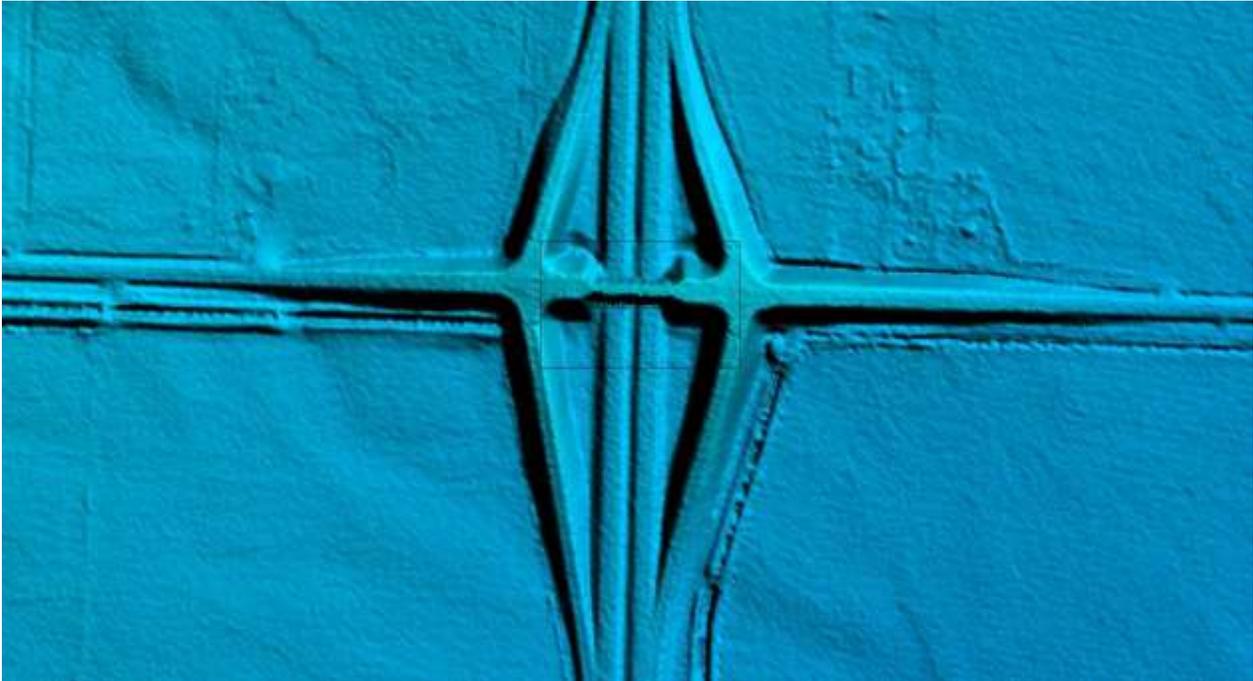
There is Edge Tinning throughout the borders of the DEM, these are an interpolation artifact from Gridding of a TIN. They can be removed by adjusting the project boundary and clipping out the bad areas or mosaicking only the adjust project extent.

Image?



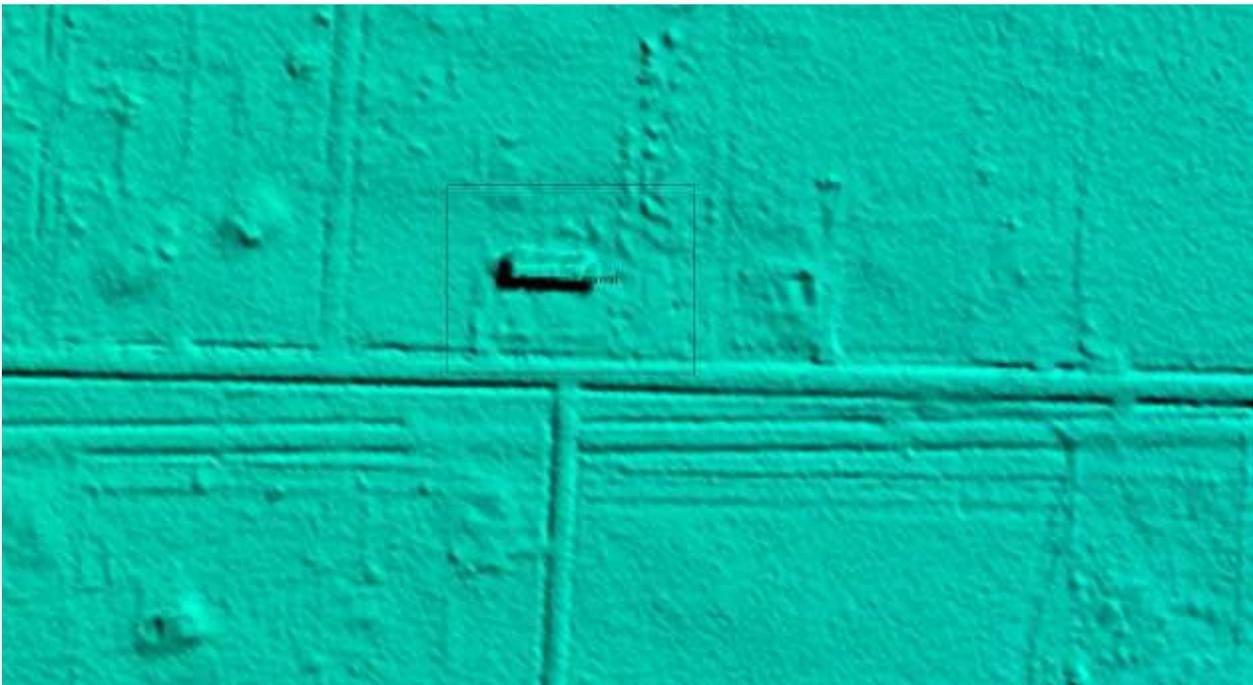
Another Example of an Edge TIN Artifact.

Image?



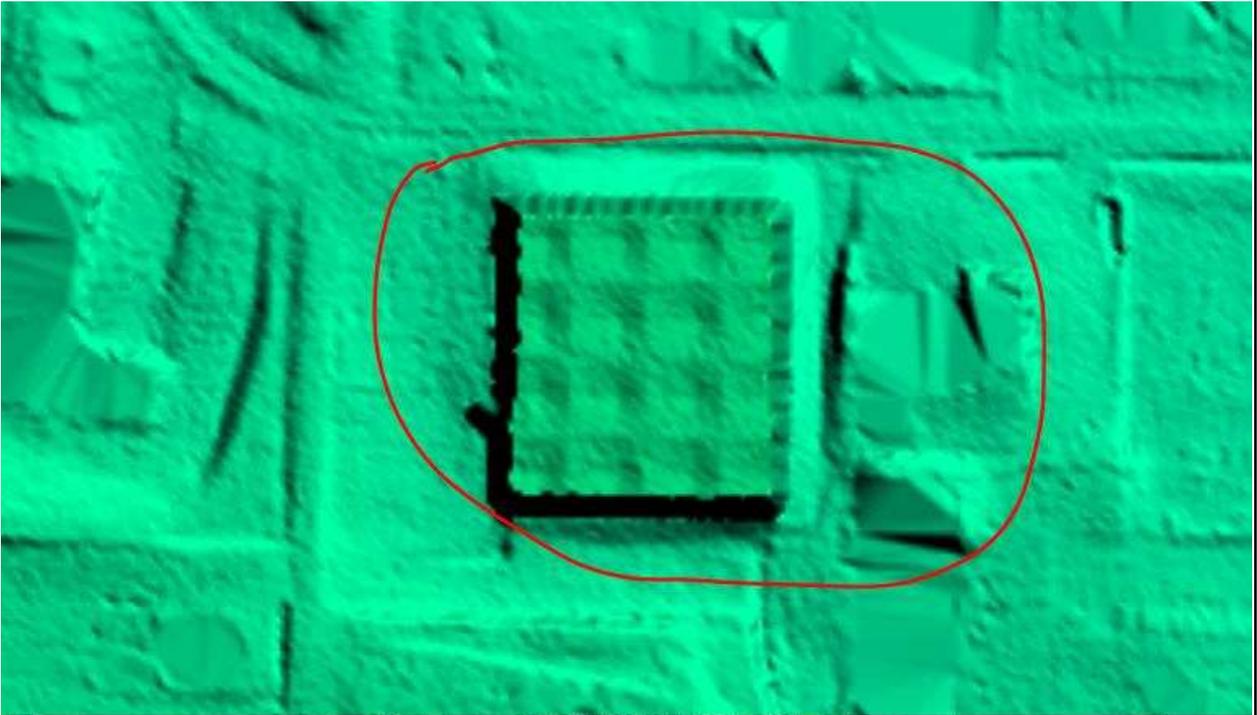
There were a total of 6 Bridges detected which were not removed.

Image?



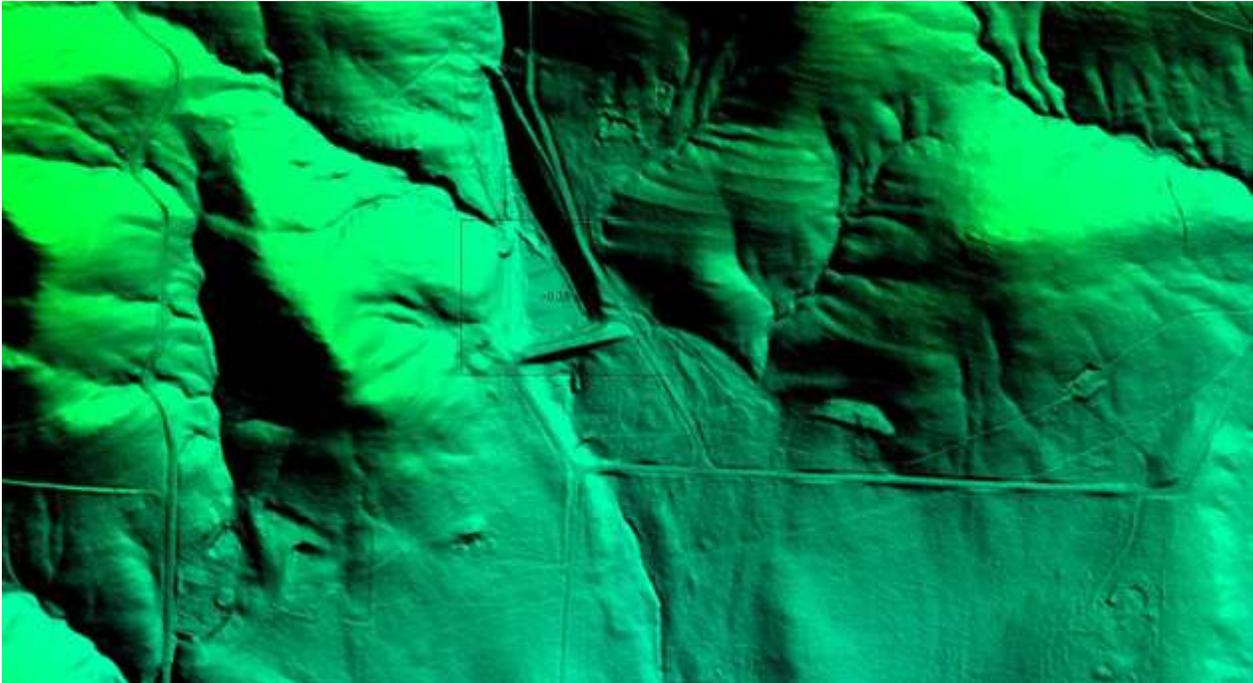
There were 13 structures found which were not removed from the DEM, some very small (above) and other larger (below).

Image?



Structure Removal.

Image?



All Waterbodies greater than 2 Acres were leveled, however, the RFP called for breaklines for Hydro Flattening with water features greater than 0.25 Acres, these areas are not of concern for the NED; however, may be of concern to the L&C County. Such areas are denoted in the DEM_ErrorTags Shapefile.

Image?



Similar to the Waterbodies issue noted above the RFP Called for Breaklines of streams greater than 2 Meters in width to be captured as double breaklines for the purpose of hydro flattening. There are several streams and drainage ditches which are not hydro flattened which meet this criteria. Again, not a concern for inclusion in the NED, but perhaps for other partners. Areas are not noted in the DEM_ErrorTags Shapefile as they are quite numerous.

This is the end of the report.

QA Form V1.4 12OCT11.xsn