LiDAR Quality Assessment Report

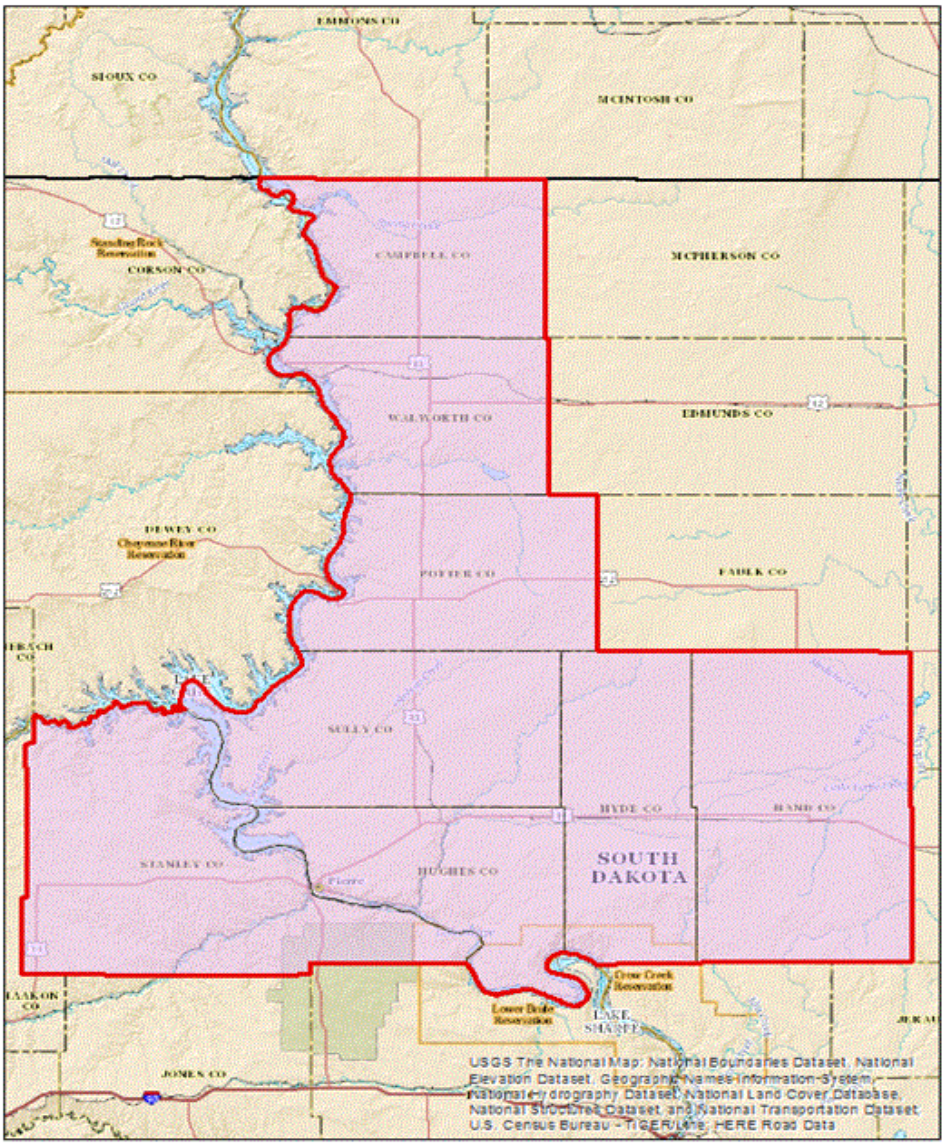
The USGS National Geospatial Technical Operations Center, Data Operations Branch is responsible for conducting reviews of all Light Detection and Ranging (LiDAR) point-cloud data and derived products delivered by a data supplier before it is approved for inclusion in the National Elevation Dataset. The 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.

SD_Missouri-River-Lidar-Dewberry-B2_2016

NGTOC

2018-06-28

Milena U. Janiec



Project Information

Project: SD_Missouri-River-Lidar-Dewberry-B2_2016

Contractor: Dewberry

Project Type:
GPSC

Applicable Specification:
NGP LiDAR Base Specification V 1.2

Project Points of Contact:

Name:	Type:	Email:
Dan Vincent	CPT	dvinc@usgs.gov

REPORT QUALIFICATION SUMMARY:

Task Order Overall:
Does Not Meet Requirements

Metadata:
1 of 1 Reviews Accepted
0 Reviews Not Accepted

Vertical Accuracy:
0 of 1 Reviews Accepted
1 Reviews Not Accepted

Tiled/Classified LAS:
1 of 1 Reviews Accepted
0 Reviews Not Accepted

Breakline:
1 of 1 Reviews Accepted
0 Reviews Not Accepted

DEM(s):
1 of 1 Reviews Accepted
0 Reviews Not Accepted

NED Review:
0 of 1 DEM tile reviews recommended for NED 1/3rd
0 of 1 DEM tile reviews recommended for NED 1/9th

Project Subdivision: Lots

List Subdivision:
- 2

of: 8

Dates Collected Range:
Collection Start: 6/11/2016
Collection End: 6/28/2016

Project Aliases:

Licensing:
Public Domain

Project Description:
Summary of the collection for Campbell, Walworth, Potter, Sully, Stanley, Hughes, Hyde, and Hand counties and their surroundings in South Dakota. The 2016 project furnishes lidar acquisition task order, issued by USGS National Geospatial Technical Operations Center (NGTOC) under their Geospatial Product and Services Contract accepted on May 19th, 2016. The project encompasses approximately 8,104 square miles. The area was acquired at Quality Level 1. Specifically, 8 points per square meter and aggregate nominal pulse spacing of 0.35 meters.

Review Information

Reviewer:	Milena U. Janiec	*Date Delivered:*	5/15/2018
3rd Party QA Performed:	☐	*Date Assigned:*	5/25/2018

Action To Contractor Date:	***Issue Description:***	***Return Date:***
6/28/2018	Please review the report.	6/28/2018

Review Complete:
6/28/2018

Dates Project Worked:

Start:	5/28/2018
End:	6/28/2018

Project Materials Received

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 Section supervisor and informed of the problem. Processing will resume after the COTR has coordinated the deposition of remaining deliverables.

METADATA

Deliverables	*Delivered*	*XML Metadata*	*Required*	*Format*	*Quantity*	*Additional Details*
Collection Report:	☑		☑	*PDF*	*1*	
Survey Report:	☑		☑	*PDF*	*1*	
Processing Report:	☑		☑	*PDF*	*1*	
QA/QC Report:	☑		☑	*PDF*	*1*	
Project Level XML Metadata:	☐		☐	*XML*	*1*	
Project Extent:	☑	☑	☑	*.shp*	*1*	
Tile Scheme:	☑	☑	☑	*.shp*	*1*	
Control (Calibration) Points:	☑	☑	☑	*.shp*	*1*	

Check (Validation) Points:	☑	☑	☑	.shp	1	
Additional Comments:						

LIDAR DATA

Deliverables	Delivered	XML Metadata	Required	Format	Quantity	Additional Details
Swath Data:	☐	☐	☐	Select...	0	
Classified/ Tiled Data:	☑	☑	☑	.las	469	Block 2
Additional Comments:						

DERIVED DELIVERABLES

Deliverables	Delivered	XML Metadata	Required	Format	Quantity	Additional Details
DEM Tiles:	☑	☑	☑	IMG	469	Block 2
Breaklines:	☑	☑	☑	FGD	1	ESRI GDB
Additional Comments:						

OTHER

Additional Comments:	

Geographic Information

Area Extent: 682.62 *Sq. Miles*

Tile Size: 2,000 x 2,000 *Meters*

DEM/DTM Grid Spacing: .5 *Meters*

Coordinate Reference System:

UTM Zone 14

Projection: Transverse Mercator

Horizontal Datum: NAD83
2011
(●) Meters ( ) U.S. Feet ( ) Int'l Feet

Vertical Datum: NAVD88
Geoid 12B
(●) Meters ( ) U.S. Feet ( ) Int'l Feet

THIS PROJECTION COORDINATE REFERENCE SYSTEM IS CONSISTENT ACROSS THE FOLLOWING DELIVERABLES

- [x] *Project Extent*
- [x] *Project Extent XML Metadata*
- [x] *Project Tile Scheme*
- [x] *Project Tile Scheme XML Metadata*
- [x] *Control Points*
- [x] *Control Points XML Metadata*
- [x] *Checkpoints*
- [x] *Checkpoint XML Metadata*
- [x] *Tiled/Classified XML Metadata*
- [x] *Tiled/Classified LiDAR*
- [x] *DEM(s)*
- [x] *DEM XML Metadata*
- [x] *Breakline(s)*
- [x] *Breakline XML Metadata*

Additional Comments:

Collection Information

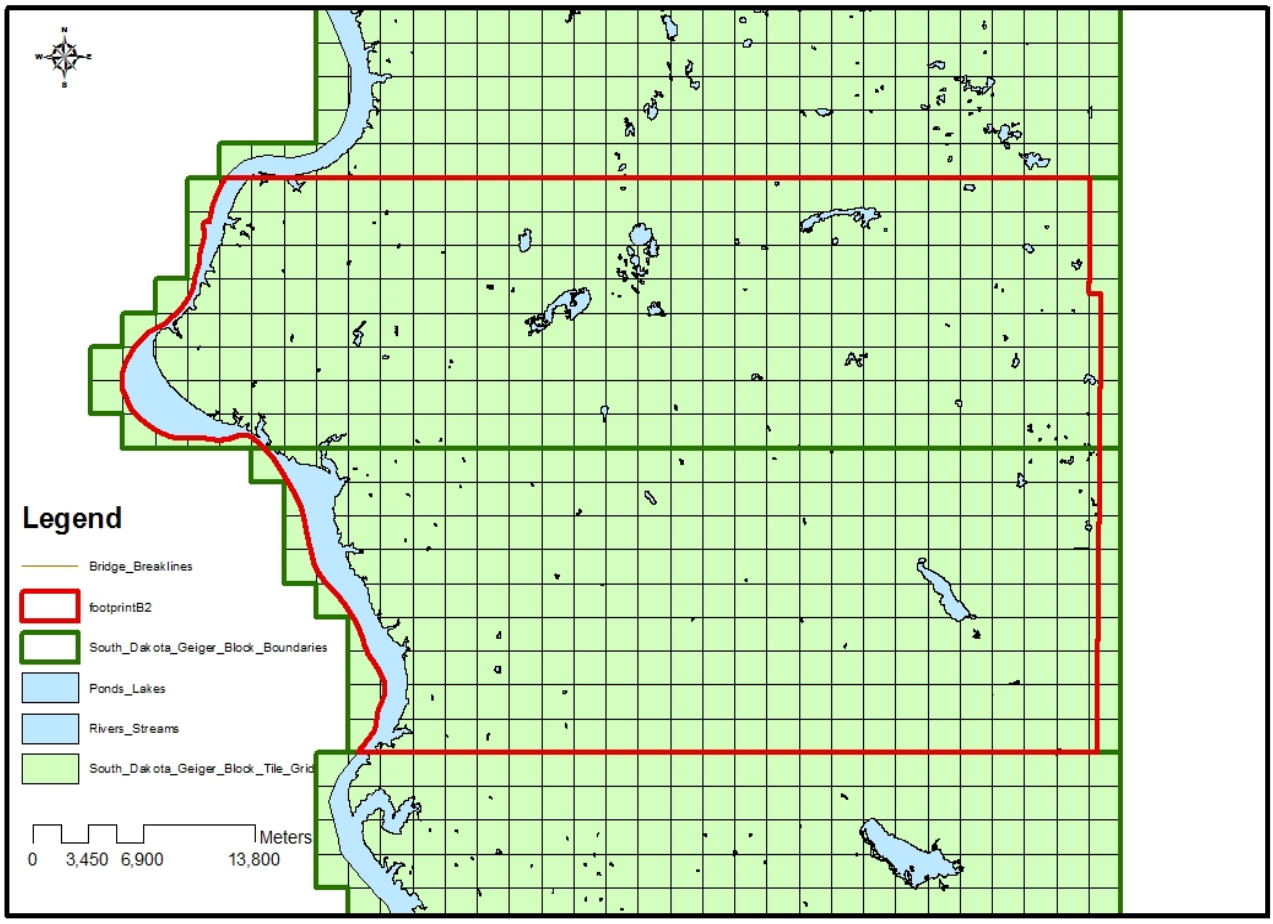
Quality Level: ***1***

Configured Nominal Pulse Spacing:
0.35 Meters

Sensor Information:
Sensor Type:
Geiger
Sensor Used:
Harris IntelliEarth
Configured Scan Angle ± from nadir:
15 *Degrees*

Additional Comments:

Please supply block and project boundaries that reflect the provided data extends (delineated in red).



Corrections were provided on 09/11/2018: This issue was not addressed. The correction files were delivered collectively.

Metadata Review Accepted

Vendor 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.
Parser can be found @ http://geo-nsdi.er.usgs.gov/validation/

The Project Extent XML Metadata parsed with errors.

- Lidar_Geoid appears in unexpected order within Lidar_Collection_Information
- Purpose appears in unexpected order within Description
(Please review additional comments)

Check if 'Best Use' metadata for NED: ☐

The Project Tile Scheme XML Metadata parsed without errors.

Check if 'Best Use' metadata for NED: ☐

The Control Point XML Metadata parsed without errors.

Check if 'Best Use' metadata for NED: ☐

The Check Point XML Metadata parsed select... errors.

Check if 'Best Use' metadata for NED: ☐

The Classified XML Metadata parsed with errors.

- Lidar_Geoid appears in unexpected order within Lidar_Collection_Information
- Purpose appears in unexpected order within Description
(Please review additional comments)

Check if 'Best Use' metadata for NED: ☐

The DEM XML Metadata parsed select... errors.

Check if 'Best Use' metadata for NED: ☐

The Breakline XML Metadata parsed select... errors.

Check if 'Best Use' metadata for NED: ☐

Additional Comments:

Metadata content:
a) The accuracy limitations of the data-set were appropriately articulated within the metadata.

b) Dan Vincent is listed as the person of contact in the Product Tracking System and acknowledged as contact within the metadata. However, under <cntper> the metadata lists Gail Dunn. Please review whether the contact information is correct.

c) The metadata describes that the project quality reflects " [t]he derived nominal pulse spacing […] 1 point every 0.35 meters." The task order states that data "shall be no greater than 0.35 meters (8 ppsm)" at Quality Level 1.
Dewberry requested that the data would be accepted at Quality Level 2.
Please evaluate the current quality level descriptions.

Corrections were provided on 09/11/2018:
a) It is expected, that the primary contractor will know the most about the dataset. Therefore, it is preferable for the provided metadata to list contractor's own information under the <cntinfo> tag. Please remove all contact information that indicates points of contact at the USGS and replace them with points of contact for the data provider.

b) It seems that some of the errors returned by the metadata parser are a result of including irrelevant tags and content within the particular file. For example, it is unnecessary for the breakline metadata to contain vertical accuracy results.

Both <vertaccv> and <horizpav> tags should be populated with a numerical value. Please review the following example of the current metadata:

Below are examples of the metadata tags containing the information in keeping with Lidar base specification 1.2:

<vertaccv>0.116</vertaccv>
<! Vertical Positional Accuracy Value RMSEz x 1.96, reported in meters. >
<vertacce>Tested 0.116 meters NVA at a 95% confidence level using RMSE(z) x 1.9600 as defined by the National Standards for Spatial Data Accuracy (NSSDA). The NVA of the raw lidar point cloud swath files was calculated against TINs derived from the final calibrated and controlled swath data using 67 independent checkpoints located in Bare Earth and Urban land cover classes.</vertacce>
<! Vertical Positional Accuracy Explanation free text field for describing vertical accuracy test. Type: text. Domain: free text.>
</qvertpa>
</vertacc>
</

Errors related to tags that are out of order are due to errors in the USGS templates. These will be

accepted as-is.

Based on this review, the USGS accepts the xml metadata provided.

End of Metadata Review

Vertical Accuracy Review Not Accepted

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.

Required Vertical Accuracy

◉ *Yes* ○ *No*

REQUIRED NON-VEGETATED VERTICAL ACCURACY FOR SWATH AND DEM FILES

Required Unit:	Centimeters
Required # of checkpoints:	166
Required RMSEz:	10
*Required Vertical Accuracy (RMSEz * 95th CI)*	19.6

REQUIRED VEGETATED VERTICAL ACCURACY FOR DEM FILES

Required Unit:	Centimeters
Required # of checkpoints:	119
Required Vertical Accuracy (@ 95th percentile)	29.4
Additional Required Vertical Accuracy Information:	

Reported Vertical Accuracy

◉ *Yes* ○ *No*

REPORTED NON-VEGETATED VERTICAL ACCURACY FOR SWATH LIDAR FILES

Reported Unit:	Centimeters
Reported # of checkpoints:	171
Reported RMSEz:	8
*Reported Vertical Accuracy (RMSEz * 95th CI)*	15.6

REPORTED NON-VEGETATED VERTICAL ACCURACY FOR DEM FILES

Reported Unit:	Centimeters
Reported # of checkpoints:	171
Reported RMSEz:	8
*Reported Vertical Accuracy (RMSEz * 95th CI)*	15.6

REPORTED VEGETATED VERTICAL ACCURACY FOR DEM FILES

Reported Unit:	Centimeters
Reported # of checkpoints:	130
Reported Vertical Accuracy (95th percentile)	42.9

Additional Reported Vertical Accuracy Information:

Reviewed Vertical Accuracy

◉ *Yes* ○ *No*

CHECKPOINT REVIEW

Checkpoints are well distributed?	☑
Enough checkpoints for task order?	☑
Checkpoints meet USGS LiDAR base-spec in quantity and quality?	☑

REVIEWED NON-VEGETATED VERTICAL ACCURACY FOR SWATH LIDAR FILES

Reviewed Unit:	Centimeters

Reviewed # of checkpoints:	163
Reviewed RMSEz:	9
*Reviewed Vertical Accuracy (RMSEz * 95th CI)*	17.7

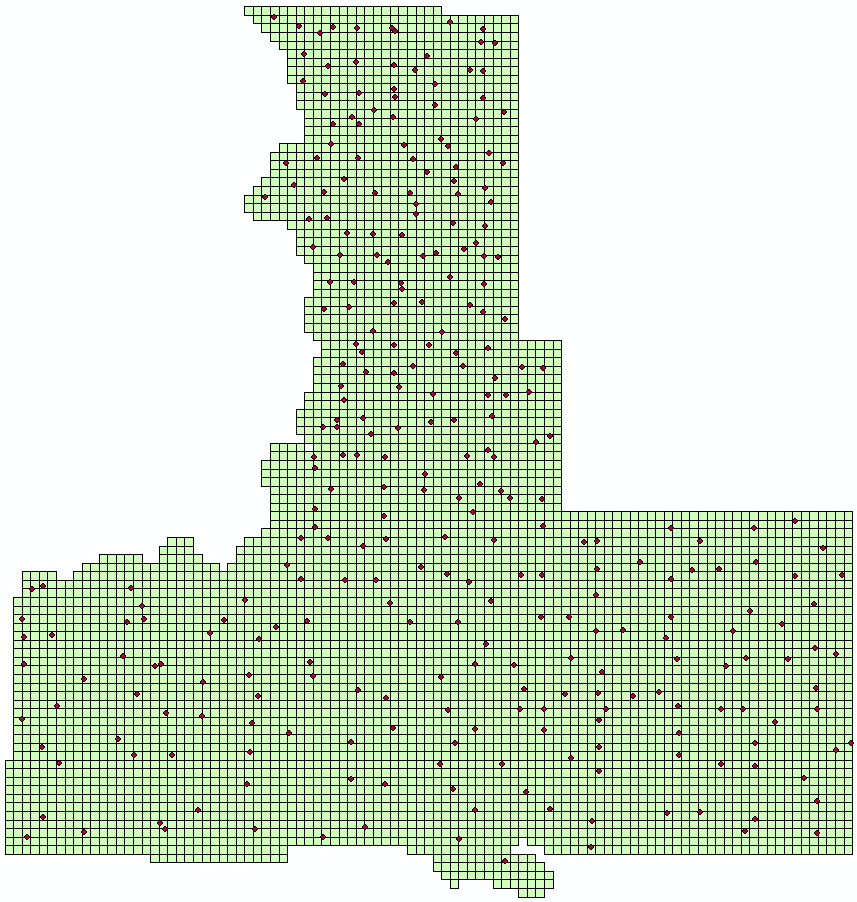
REVIEWED NON-VEGETATED VERTICAL ACCURACY FOR DEM FILES

Reviewed Unit:	Centimeters
Reviewed # of checkpoints:	170
Reviewed RMSEz:	8.06
*Reviewed Vertical Accuracy (RMSEz * 95th CI)*	15.79

REVIEWED VEGETATED VERTICAL ACCURACY

Required Unit:	Centimeters
Required # of checkpoints:	119
Reviewed Vertical Accuracy (95th percentile)	42.31

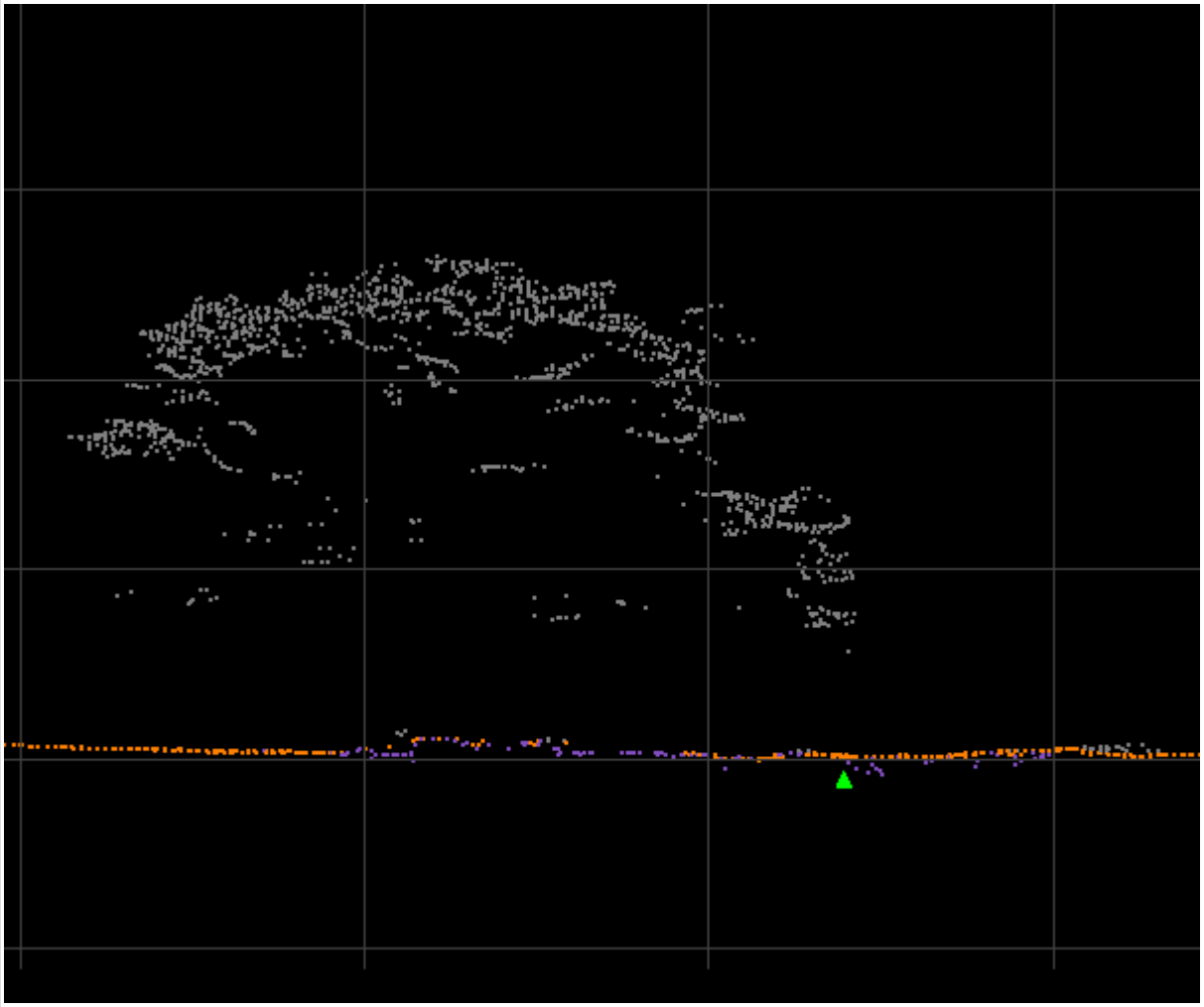
Checkpoint Distribution Image

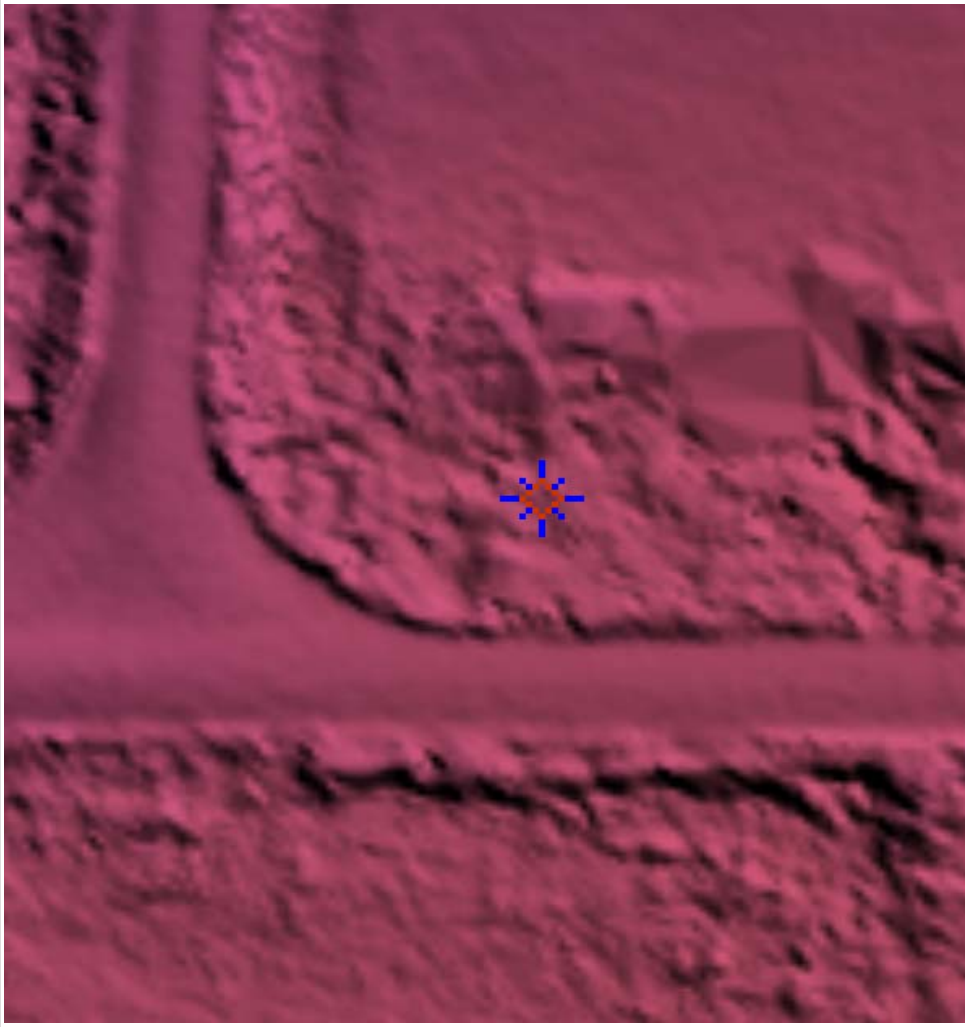


Vertical Accuracy Results:

The dataset includes additional Non-vegetative Vertical Accuracy (NVA) and Vegetated Vertical Accuracy (VVA) checkpoints. Namely, for the required 166 NVA checkpoints 171 points are provided. In addition, for the requested 119 VVA points, 130 points were supplied. All of the provided VVA checkpoints (130) were tested. The project does not meet VVA standards for the digital elevation model (DEM) data.

The image below reveals the vertical location of VVA-109 check point in relation to the point cloud. The subsequent image captures the same point as compared to the DEM. The calculated elevation difference for the point is 82.2406 centimeters.





In terms of the NVA testing, one point measured over an area exhibiting no-data values was removed, to enable the project to meet vertical accuracy standards for the digital elevation model data. Specifically, 170 points are used to calculate the RMSEz and 95% confidence interval (RMSEz * 1.96) values for NVA.

In addition, only 163 NVA checkpoints were tested against the point cloud data. Some of the las files exhibit an incorrect

global encoder. These points could not be loaded into the same layer and had to be omitted from the test.

Additional Reviewed Vertical Accuracy Information:

Based on this review, the USGS does not accept the vertical accuracy.

End of Vertical Accuracy Review

Raw-Swath LiDAR 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 Non-Vegetated Vertical Accuracy using ground control checkpoints measured in clear open terrain (*see Vertical Accuracy Review Section*).

Review Required: ○ *Yes* ◉ *No* *Not Delivered*

Tiled/Classified LiDAR Review Accepted

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. Classified LAS Tiles are comprised as follows, "all project swaths, returns, and collected points, fully calibrated, adjusted to ground, and classified and cut, by tiles, excluding calibration swaths, cross-ties, and other swaths not used, or intended to be used, in product generation".

Review Required: ◉ *Yes* ○ *No*

CLASSIFIED LIDAR TILE CHARACTERISTICS

☑ *Separate folder for classified/tiled LiDAR files*

LAS Version: 1.4

Point Record Format: 6

*If specified, *.wpd files for full waveform data have been provided:* Not Required

☑ *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*

☑ *Correct and properly formatted georeference information is included in all LAS file headers, including the use of OGC 2001 Well Known Text (WKT).*

☐ *Adjusted GPS time used with the global encoder id set to 1*

Set to 17

☑ *Classified LAS tile files have no points classified as '12' (Overlap) and correctly use overlap bit.*

☐ *Point classifications are limited to the standard values listed below:*

Code	Description	Used
1	Processed, but unclassified	☑
2	Bare-earth/Ground	☑
7	Noise (low, manually identified, if needed)	☑
8	Model key points	☐
9	Water	☑
10	Ignored ground (breakline proximity)	☑
11	Withheld (if the "Withheld Bit" is not implemented in the processing software	☐

17	*Bridges*	☑
18	*Noise (high, manually identified, if needed)*	☐

Additional comments:

1) The task order requested that the reflectance values would be scaled to 16 Bit (C.1.d.(i)(e), 8). The current point cloud suggests that the maximum observable reflectance values do not exceed 32,767 and the maximum noted value for this block is 25,048. It is unclear whether the low values suggest that the intensity field was set to 16-bit signed short instead of 16-bit unsigned short.

2) Under the System ID record, please indicate the sensor type used to collect the data.

3) The WKT parsed successfully. However, the formatting of the WKT could be potentially improved.
a) For example, the WKT contains underscores in the name fields. This could be updated by changing the text to: DATUM ["NAD83 (National Spatial Reference System 2011)",

b) Instead of AXIS["Gravity-related height",UP] the text wrapped in a VERT_CS potentially could state AXIS["Up",UP].

c) The WKT lists the AXIS tags for PROJCS as AXIS[“Easting”, EAST], AXIS[“Northing”, NORTH]. AXIS [“X”,EAST],AXIS[“Y”,NORTH] are the preferred tags formats.

4) It is understood that the GPS collection dates obtained from the metadata reflect the dates for the entire collection of the project, whereas the GPS time stamp ascertained from las files, as well as the lift metadata, matches the lot acquisition dates.

Las:
GPS Min Monday Jun 13 04:49:52 2016
GPS Max Wednesday Jun 29 10:26:24 2016

Metadata:
<begdate>20160528</begdate>
<enddate>20160629</enddate>

Corrections were provided on 09/11/2018:
a) The response to the review, including the discussion regarding the low reflectance values and system ID record, has been included with the supplied data.
b) The formatting of the WKT dialect has not been altered.

Based on this review, the USGS accepts classified/tiled LiDAR data.

End of Tiled/Classified LiDAR Review

Breakline Review Accepted

Breaklines are vector feature classes that are used to hydro-flatten the bare earth Digital Elevation Models.

Review Required: ◉ *Yes* ○ *No*

BREAKLINE FILE CHARACTERISTICS:

☑ Separate folder for breakline files.

☑ Breaklines contain elevation values.

Elevation values stored in Geometery (ZEnabled) .

Units: Meters

☑ Waterbody Breaklines.

Polyline ☐ Polygon ☑

☐ Single elevation value per waterbody feature.

☑ Required.

Waterbody Elevations were created via Proprietary waterbody level techniques.

☐ Double Line Stream Breaklines (Streams Approximately > 100 ft).

☑ Single Line Breaklines.

Lines are:

- ☐ Single Line Streams
- ☑ Bridge Cuts
- ☐ Culvert Connectors

Downstream SLS Flow is Not Applicable .

☑ No missing or misplaced breaklines.

Based on this review, the USGS accepts the breakline files.

End of Breakline Review

DEM Review Accepted

The derived bare-earth file(s) receive a review of the vertical accuracies provided by the data supplier, vertical accuracies calculated by the USGS using supplied and independent checkpoints (*see the prior Vertical Accuracy Review Section*), and a thorough visual review for any anomalies or inconsistencies in assessing the quality of the DEM(s).

BARE-EARTH DEM TILE CHARACTERISTICS:

☑ Separate folder for bare-earth DEM files

Raster File Type: IMG

Raster Cell Size: 0.5 Meters

Tile bit depth/pixel Type: 32_BIT_FLOAT

Interpolation or Resampling Technique: Proprietary

☑ DEM tiles do not overlap

☑ DEM tiles conform to Project Tiling Scheme

☑ Quantity of DEM files conforms to Project Tiling Scheme

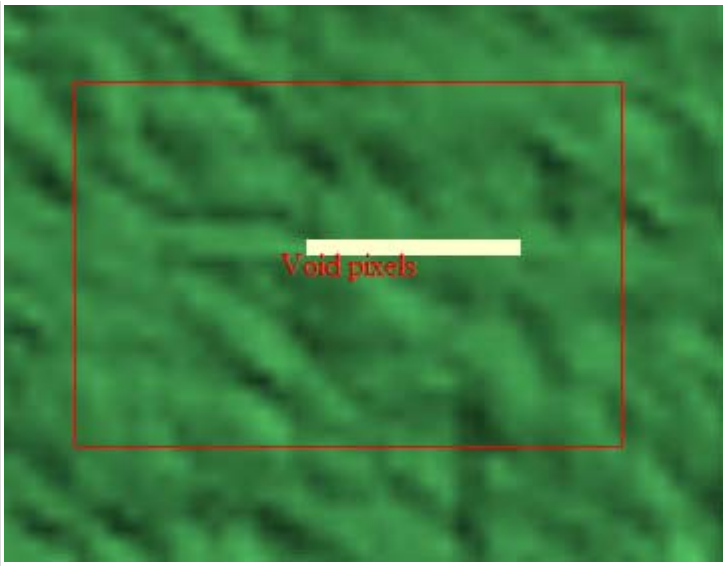
☑ DEM tiles are uniform in size

☑ DEM tiles properly edge match and free of edge artifacts

☑ Tiles are free from Spikes and Pits

☐ Tiles are free from Data Holidays (*voids due to processing or collection errors*)

The digital elevation model (DEM) presents some pixel size voids. Two areas have been identified.



Corrections were provided on 09/11/2018:
The identified features have been modified.

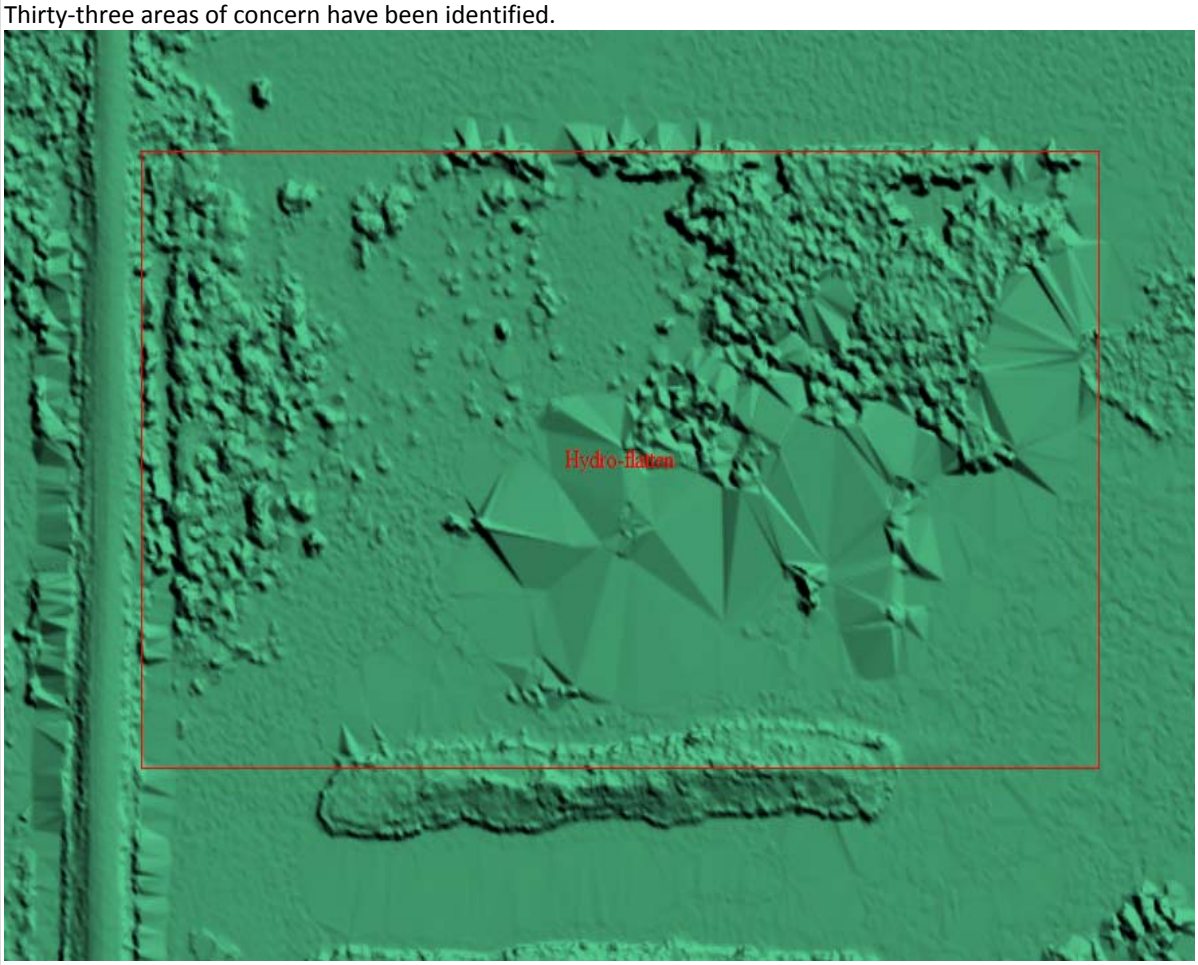
☑ Tiles do not exhibit systematic sensor error or cornrowing

Hydro Treatment: hydro-flattened

DEM tiles are properly Hydro Flattened ○ Yes ◉ No

☐ Waterbodies 2 Acres or greater are flattened

Thirty-three areas of concern have been identified.

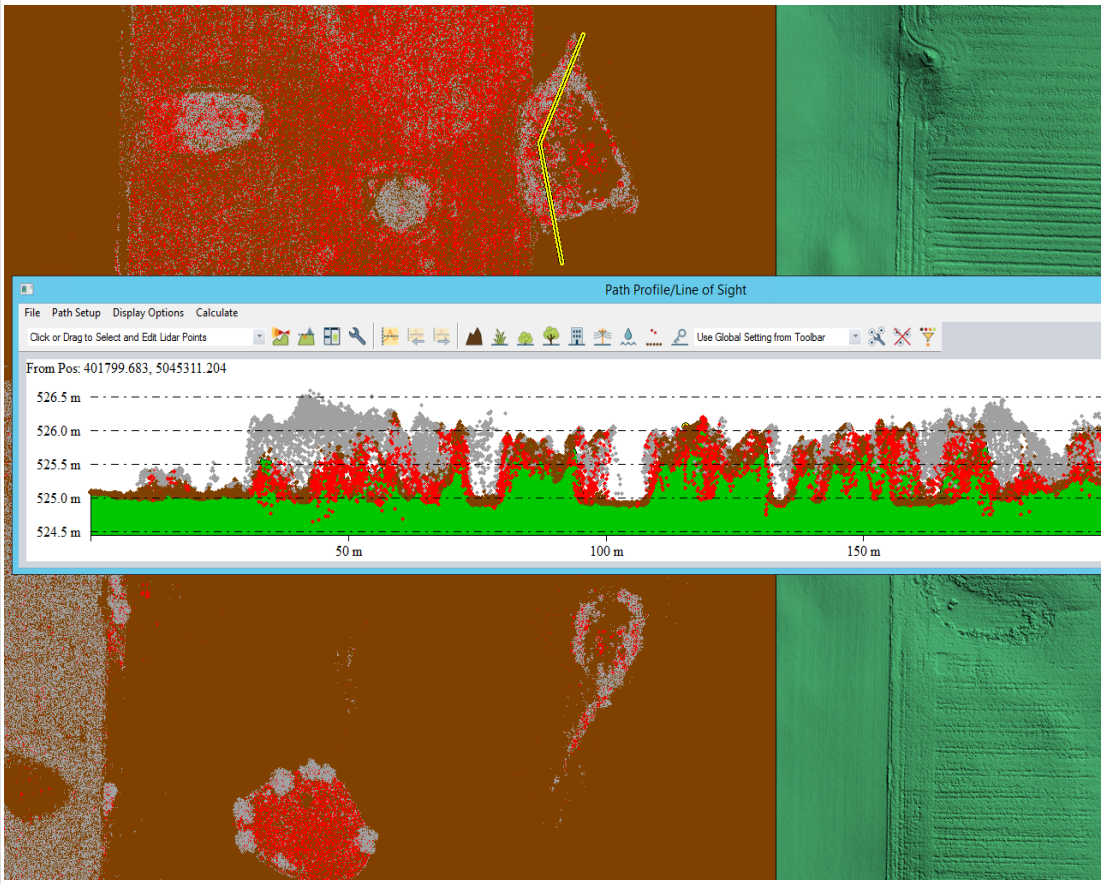


Corrections were provided on 09/11/2018:
The above-mentioned issues have been appropriately addressed.

- [x] Streams 100 ft. or greater are flattened in a downstream manner
- [x] Tidal Boundaries/Shorelines are flattened

- [x] No missing islands 1 Acre or larger
- [x] Bridges/Overpasses are properly removed
- [x] Culverts are maintained (Not Hydro Enforced)
- [x] Depressions, Sinks, are not filled in (Not Hydro Conditioned)
- [ ] Vegetation properly removed

Please remove vegetation artifacts and identified noise/ground/unclassified point distribution errors. Eight areas of concern have been identified.



In addition, please review six spaces where tinning due to limited ground points has been located.

Locations are not limited to those identified in the report and within the error files. The shapefiles are only representative of the error. This issue is endemic throughout the data set.

Please review the *Additional Comments, Errors, Anomalies, or Other Issues* section for further information.

Corrections were provided on 09/11/2018:
- The identified features have been improved.
- Gdal reading of the WKT dialect is slightly different for redelivered raster tiles.

Original 442 tiles:

```
PROJCS["NAD_1983_2011_UTM_Zone_14N",
  GEOGCS["NAD83",
    DATUM["North_American_Datum_1983",
      SPHEROID["GRS 1980",6378137,298.257222101,
        AUTHORITY["EPSG","7019"]],
      TOWGS84[0,0,0,-0,-0,-0,0],
      AUTHORITY["EPSG","6269"]],
    PRIMEM["Greenwich",0,
      AUTHORITY["EPSG","8901"]],
    UNIT["degree",0.0174532925199433,
      AUTHORITY["EPSG","9122"]],
    AUTHORITY["EPSG","4269"]],
  PROJECTION["Transverse_Mercator"],
  PARAMETER["latitude_of_origin",0],
  PARAMETER["central_meridian",-99],
  PARAMETER["scale_factor",0.9996],
  PARAMETER["false_easting",500000],
  PARAMETER["false_northing",0],
  UNIT["Meter",1],
  AUTHORITY["EPSG","26914"]]
```

Forty-seven corrected tiles:

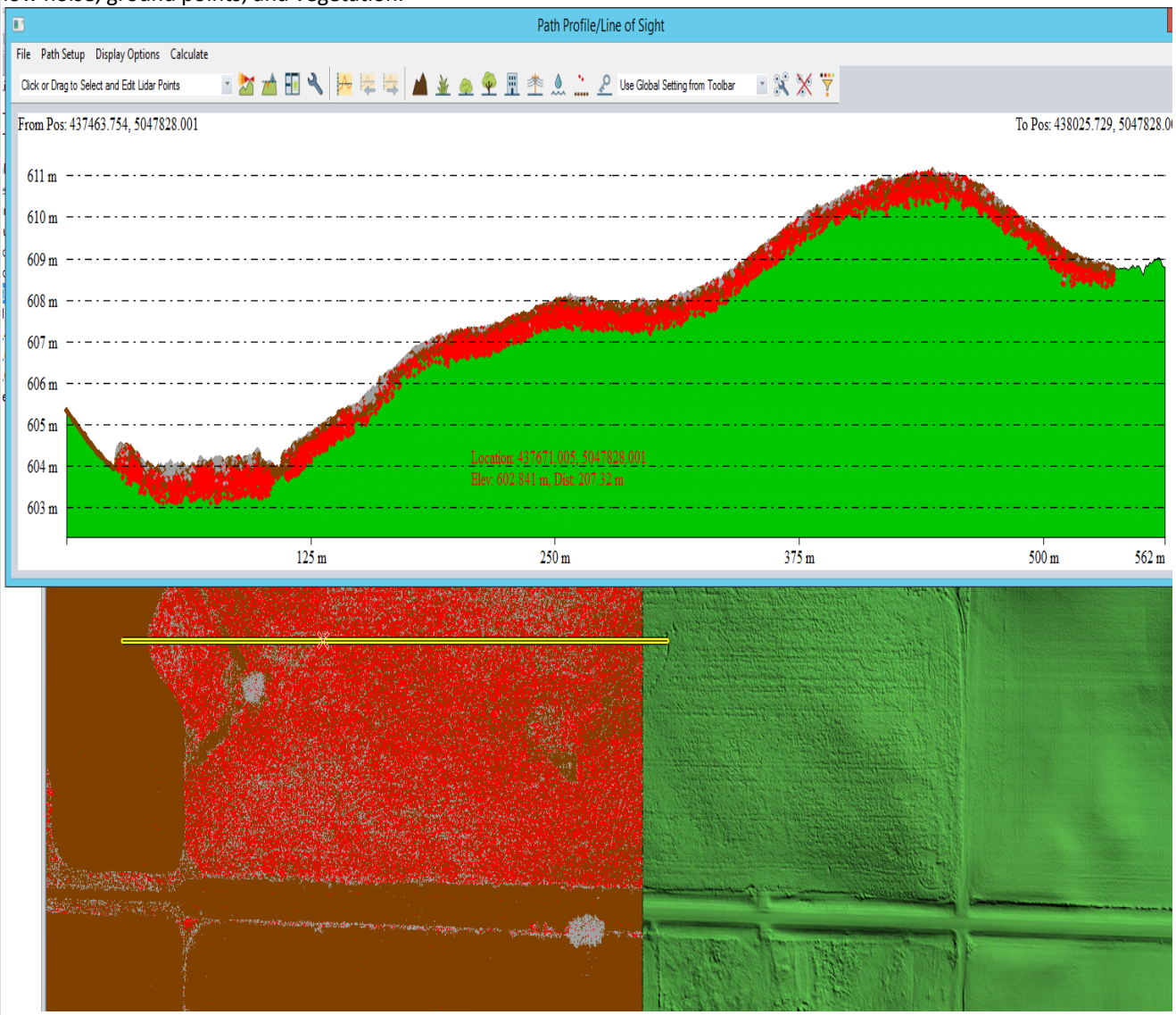
```
PROJCS["NAD_1983_2011_UTM_zone_14N",
  GEOGCS["NAD83",
    DATUM["North_American_Datum_1983",
      SPHEROID["GRS 1980",6378137,298.257222101,
        AUTHORITY["EPSG","7019"]],
      TOWGS84[0,0,0,-0,-0,-0,0],
      AUTHORITY["EPSG","6269"]],
    PRIMEM["Greenwich",0,
      AUTHORITY["EPSG","8901"]],
    UNIT["degree",0.0174532925199433,
      AUTHORITY["EPSG","9122"]],
    AUTHORITY["EPSG","4269"]],
  PROJECTION["Transverse_Mercator"],
  PARAMETER["latitude_of_origin",0],
  PARAMETER["central_meridian",-99],
  PARAMETER["scale_factor",0.9996],
  PARAMETER["false_easting",500000],
  PARAMETER["false_northing",0],
  UNIT["Meter",1],
  AUTHORITY["EPSG","26914"]]
```

☑ Manmade structures properly removed

ADDITIONAL COMMENTS, ERRORS, ANOMALIES, OR OTHER ISSUES:

1) At the outset, the review revealed problems generating the display of tiles, 14TLR39305032.img, 14TLR39505032.img, 14TLR39305034.img, 14TLR39305036.img, 14TLR39505030.img, 14TLR39705030.img, 14TLR39705026.img, 14TLR39705024.img, in Global Mapper. The issue disappears when data is brought into ArcMap.

2) At the time of the review, the accuracy of the digital elevation model (DEM) across the vegetated areas does not conform to the U.S. Geologic Survey's standards. These calculations are based on 130 ground check points over 8104 square miles. Therefore, the meaning of the statistics may seem obscure. However, combined with the view of the point cloud over the DEM the implications of the failed accuracy results become clearer. In this context, it becomes hard to distinguish between low noise, ground points, and vegetation.



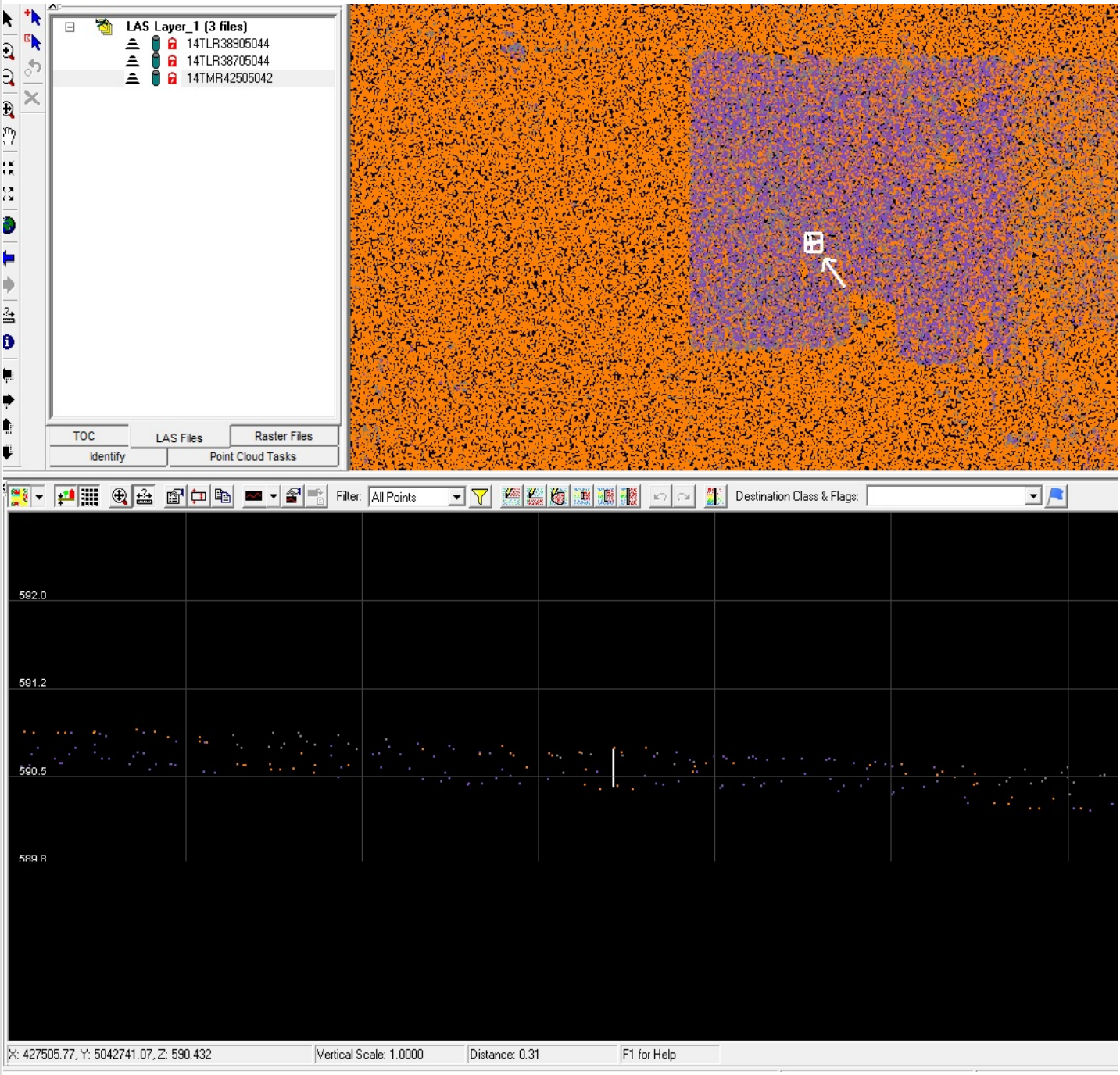
The point cloud reveals an elevated number of noise points in the areas exhibiting low vegetation. This is prevalent throughout the dataset. This is acceptable whenever the points have been correctly identified.

However, there are several areas of concern, where the noise/ground/unclassified points have been distributed in an unconventional manner. Namely, some of the ground points appear simultaneously above and below noise and unclassified points.

The intrinsic characteristics of the Geiger mode scanner limit the return values to one. Since all the points are simultaneously the first and last return, is difficult to interpret which classifications should be assigned to points located at the ground level. The elevation values in the DEM resulting from the interwoven ground, noise, and unclassified points may be ambiguous.

In addition, some of the ground points suggest a concentrated point cloud delineating the surface, beyond a customary (couple of centimeters high) vertical distribution. It is anticipated that the ground points would be horizontally densely populated; however, it is unexpected for the cross-section to reveal a thick profile of the ground points.

The following image shows an example of an area drawn at one meter depth, where the difference between the highest and lowest ground point is thirty one centimeters. The area was chosen at random and does not represent the lowest or highest vertical distance between the ground points.



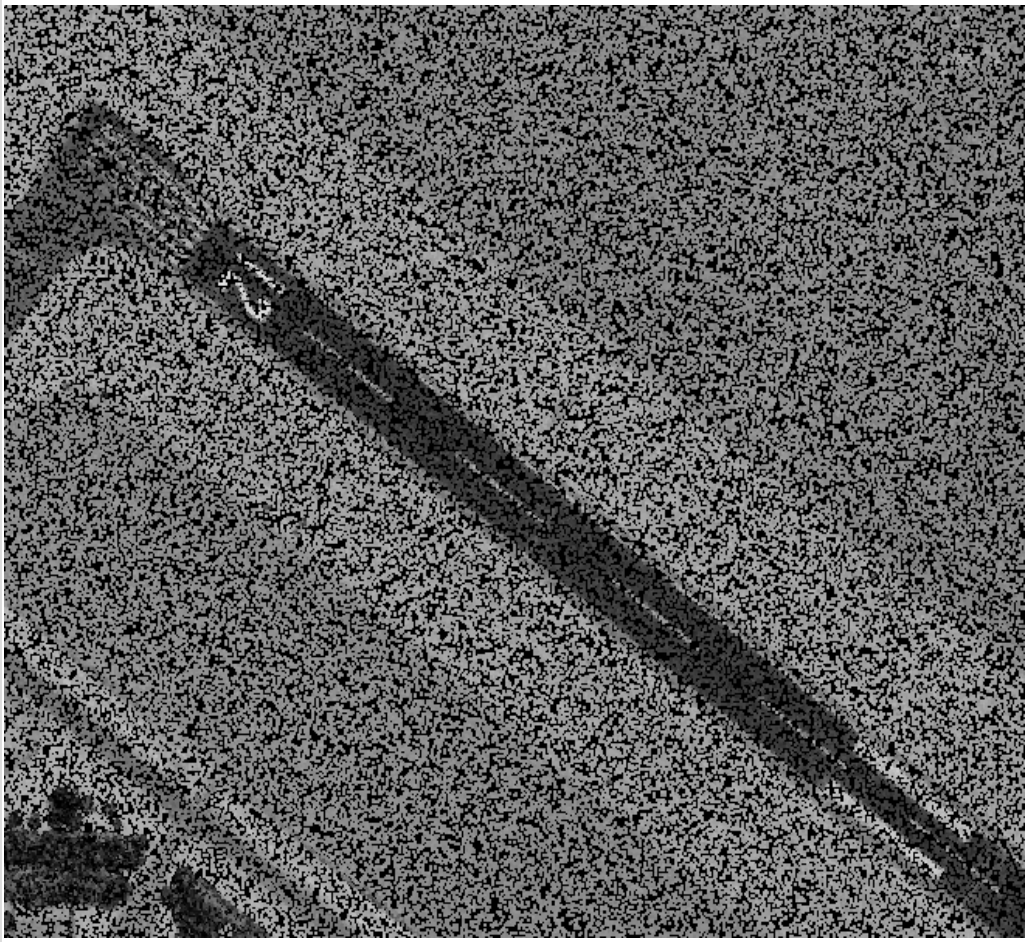
This raises a concern in terms of the accuracy the constructed digital elevation model, especially in areas exhibiting low vegetation. This seems to be line with the vertical accuracy results presented by Dewberry (2018). Yet, this review did not anticipate that the appearance of the DEM would be altered in a manner that is visually detectable. Currently, several areas exhibiting puzzling features have been identified.

In addition, the issues related to the classification of the noise and ground points are observable throughout the dataset. **These areas of concern have not been delineated with error shapefile.**

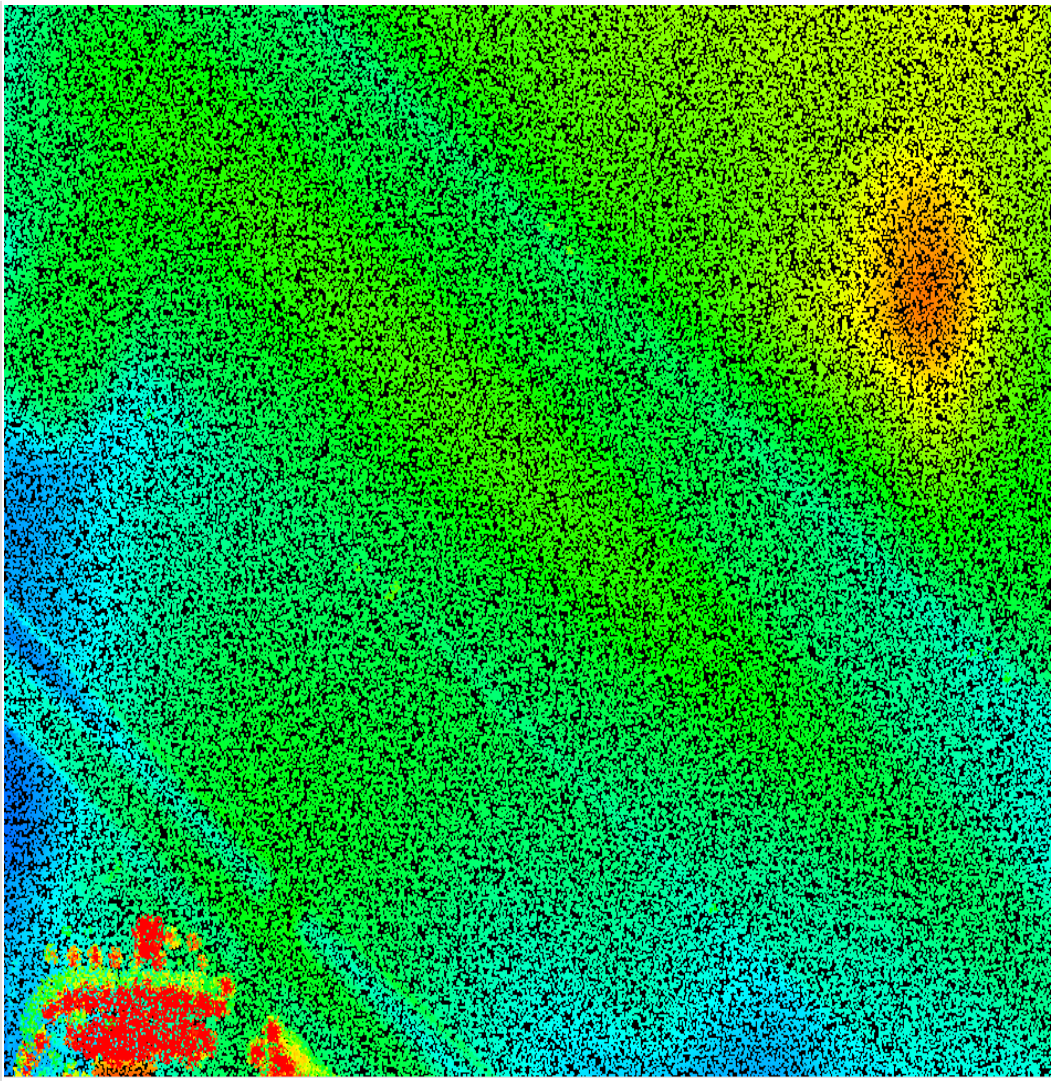
3) Stoker et al. (2016) mentioned that Geiger-mode lidar exhibits range walk issues, where reflective surfaces seem to show 15 centimeter variation. This data-set was examined to see whether it displays similar problems.

Tiles 14TLR38705044.img and 14TLR38905044.img contain point cloud obtained over Mobridge Municipal Airport (45° 32' 53.8880" N, 100° 24' 40.4293" W). Since range walk issues potentially could be expected is this area, the tiles were loaded into Global Mapper and LP 360 software to test both the point cloud and the corresponding digital elevation model (DEM).

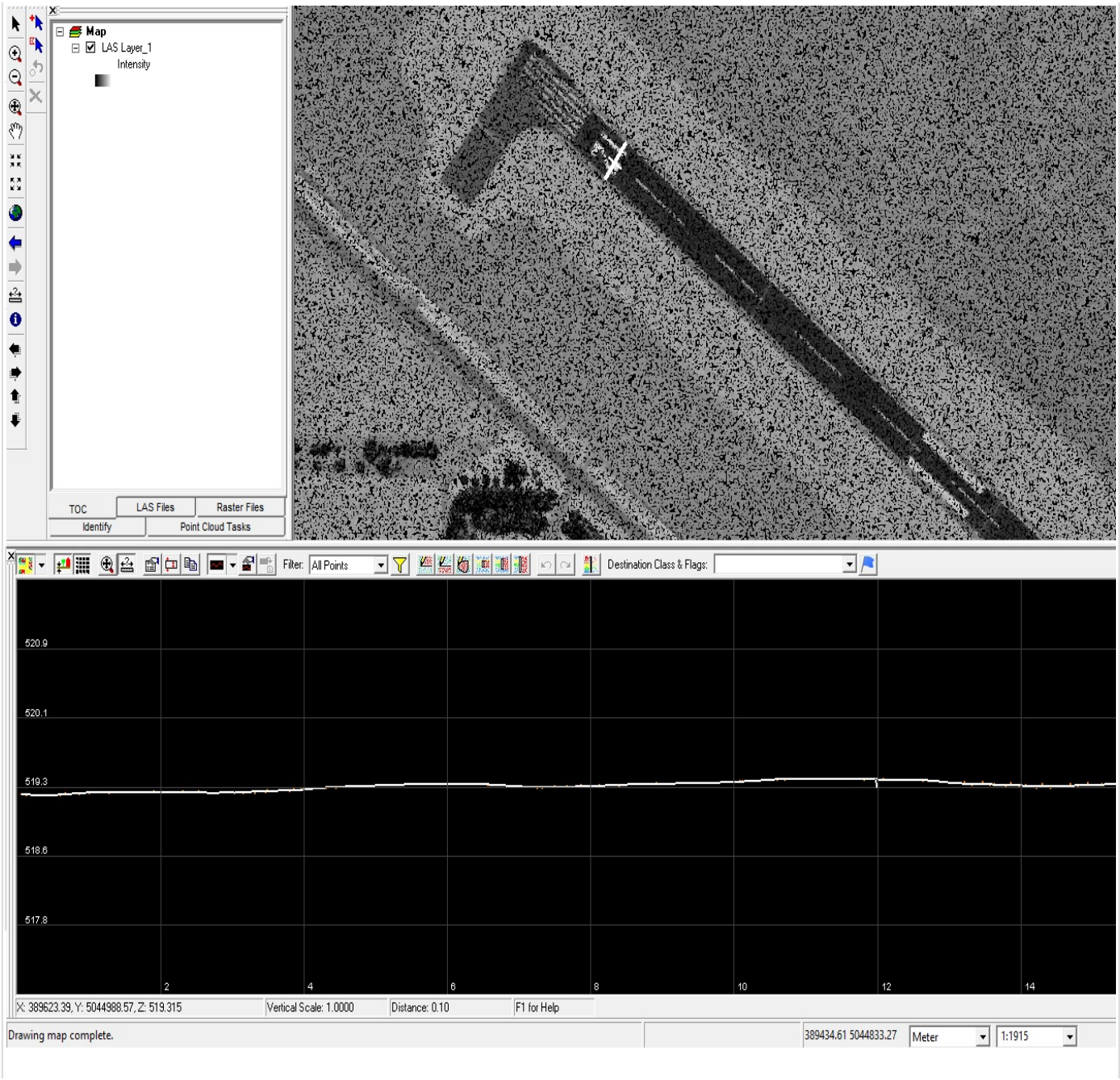
Point cloud displayed by reflectance (intensity) values (1:1915 m):

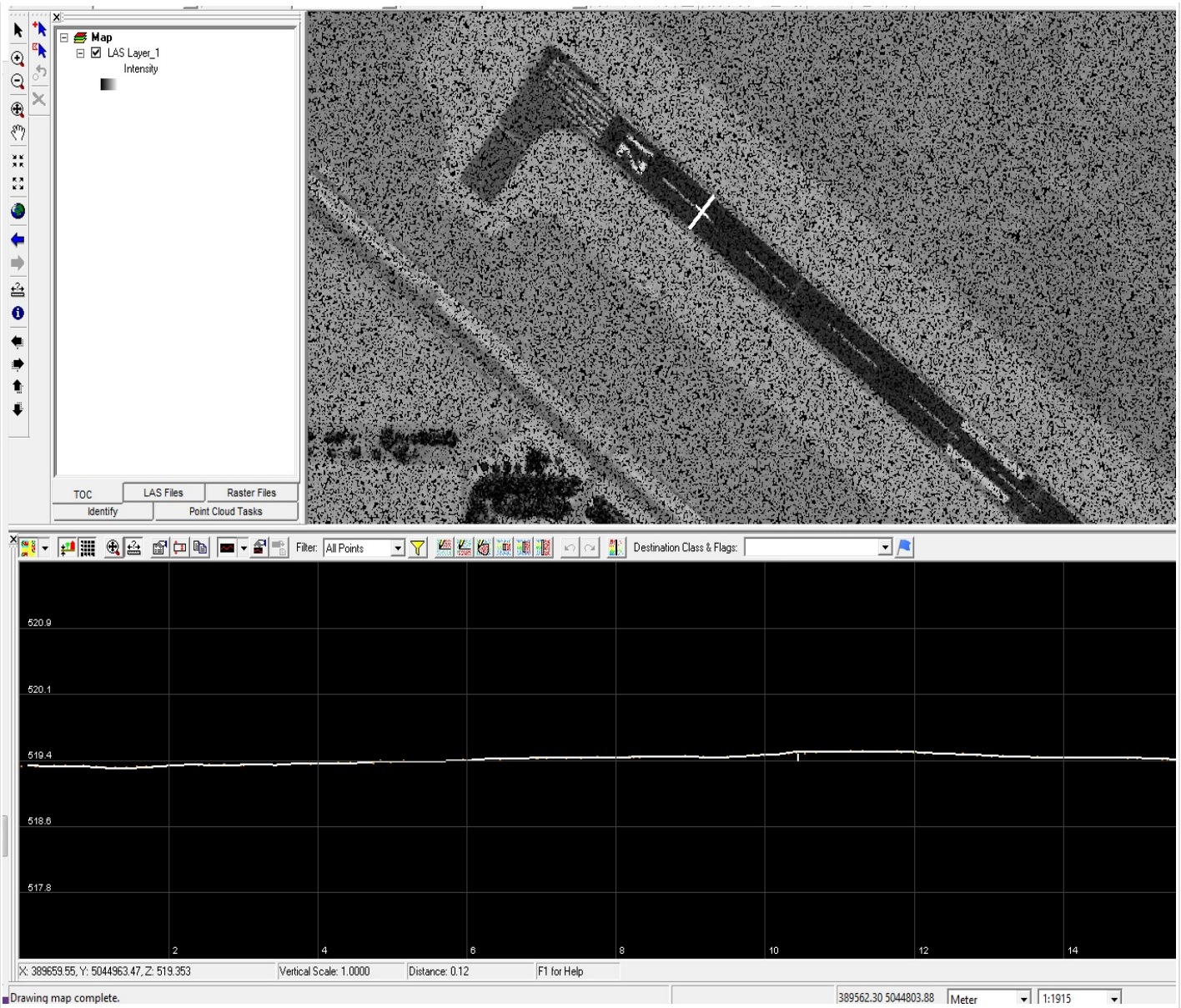


Point cloud displayed by elevation (1:1915 m):

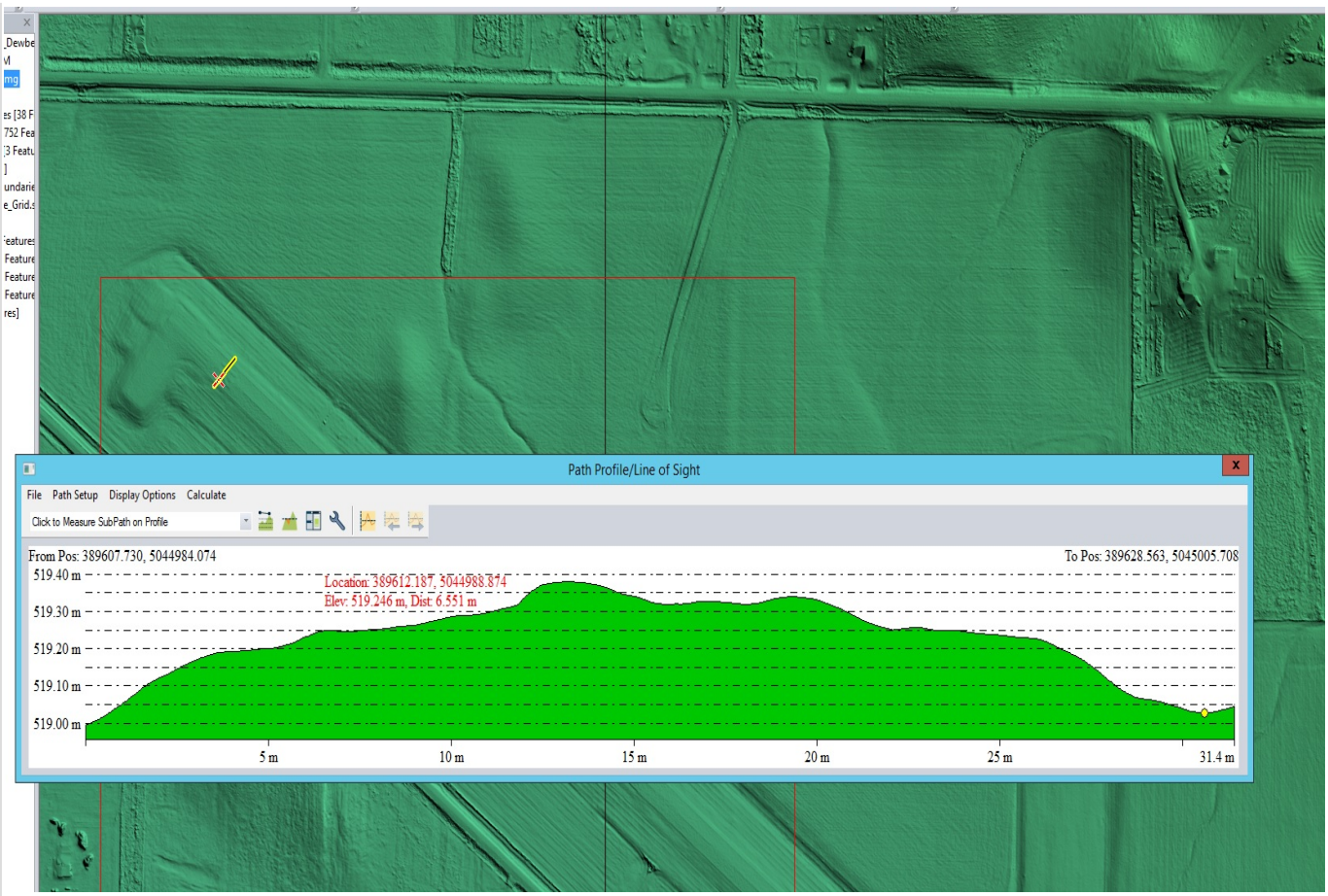


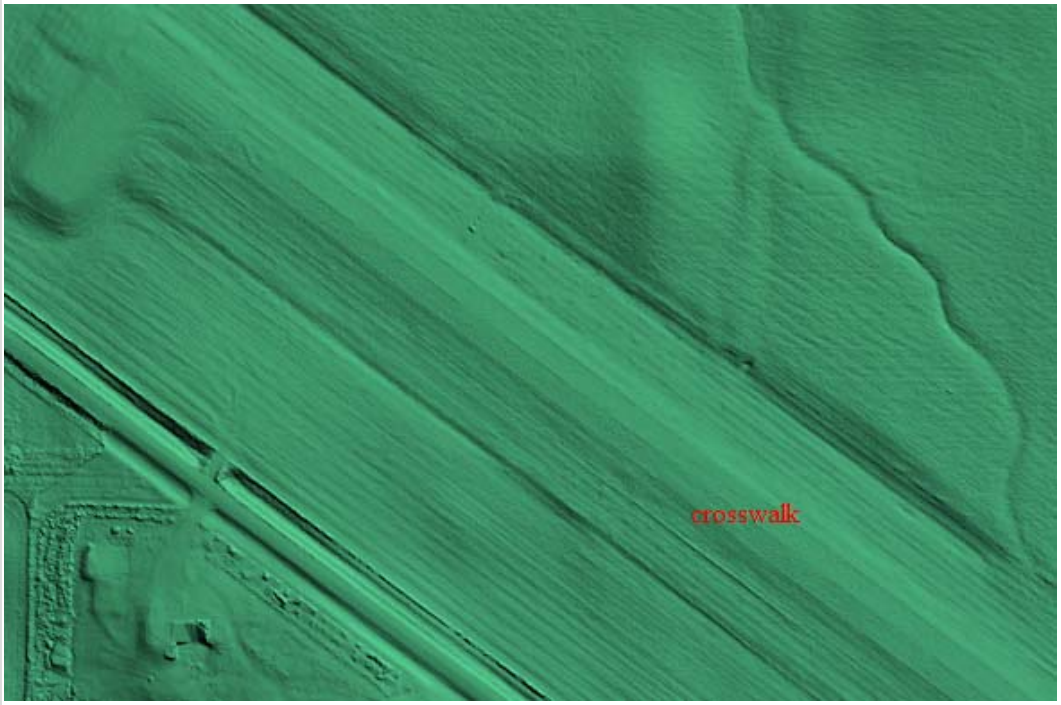
The cross-section reveals approximately 10 -15 cm variance across the point cloud (1 meter profile depth) :


Map
LAS Layer_1
Intensity
TOC
LAS Files
Raster Files
Identify
Point Cloud Tasks
Filter: All Points
Destination Class & Flags:
520.9
520.1
519.3
518.6
517.8
2
4
6
8
10
12
14
X: 389623.39, Y: 5044988.57, Z: 519.315
Vertical Scale: 1.0000
Distance: 0.10
F1 for Help
Drawing map complete.
389434.61 5044833.27
Meter
1:1915

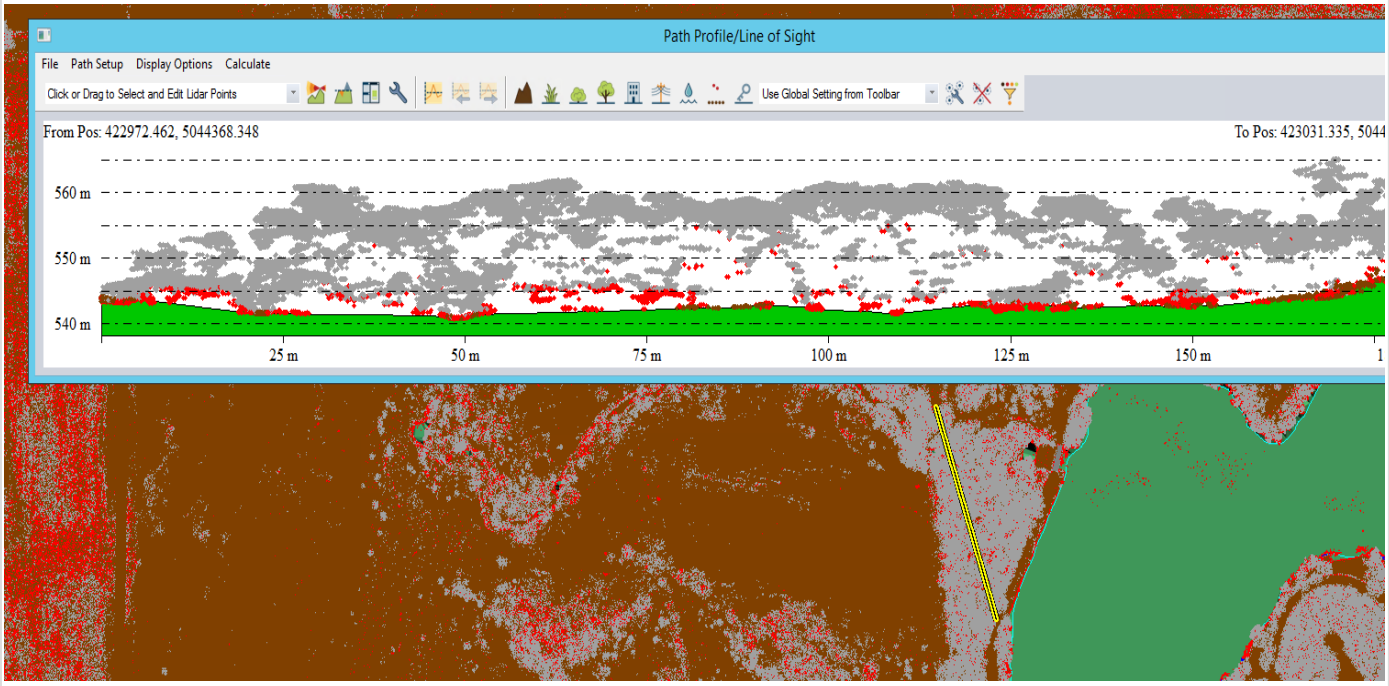


The DEM shows 15 - 20 cm vertical surface distribution.


Path Profile/Line of Sight
File Path Setup Display Options Calculate
Click to Measure SubPath on Profile
From Pos: 389607.730, 5044984.074
To Pos: 389628.563, 5045005.708
519.40 m
519.30 m
519.20 m
519.10 m
519.00 m
Location: 389612.187, 5044988.874
Elev: 519.246 m, Dist: 6.551 m
5 m
10 m
15 m
20 m
25 m
31.4 m

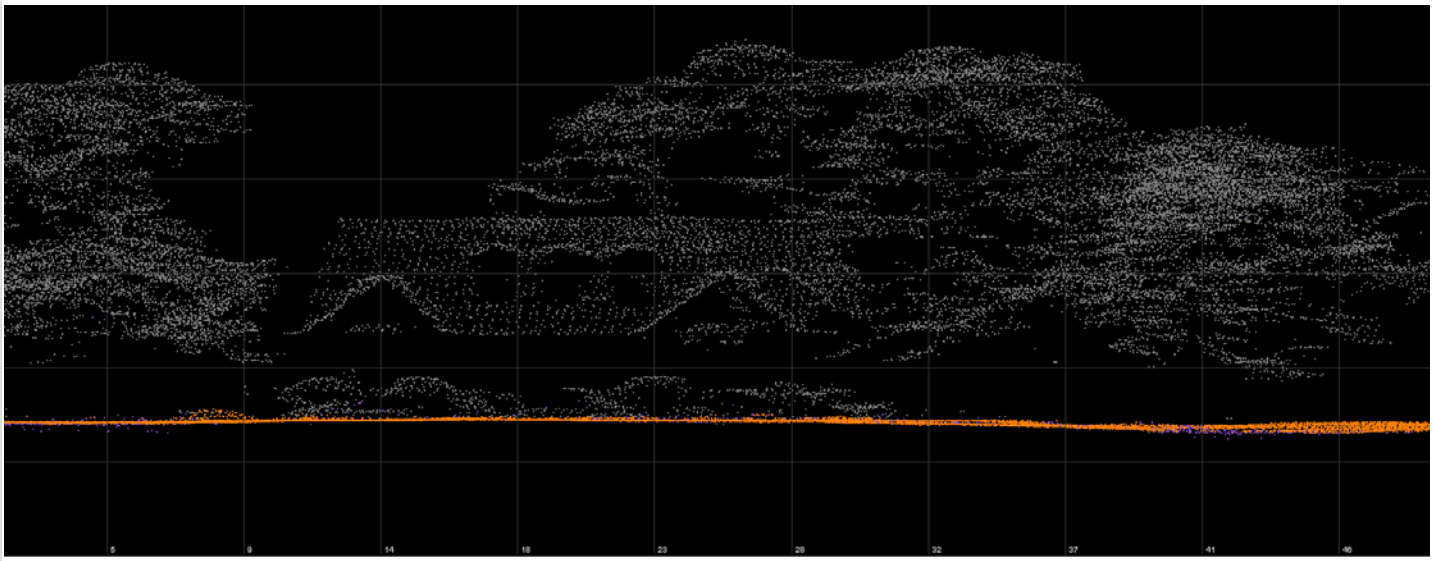

crosswalk

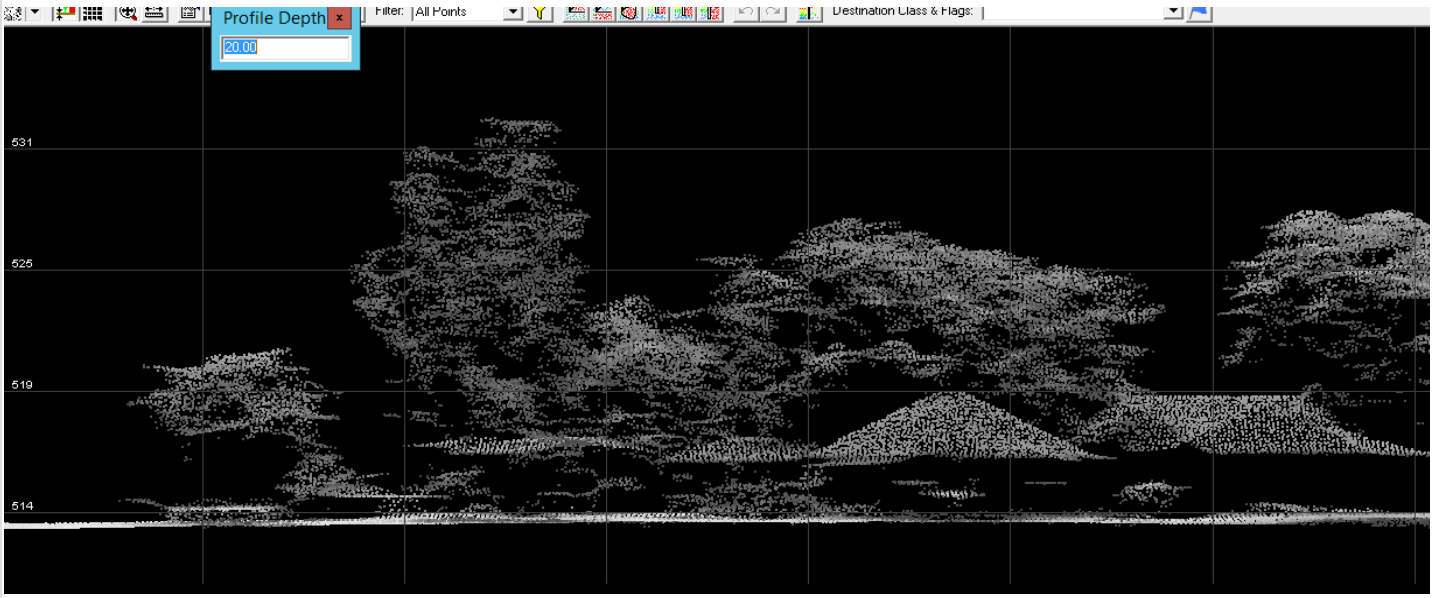
4) There are a few of areas of concern that present a reduced number of ground points resulting in aberrant, tinned spaces.



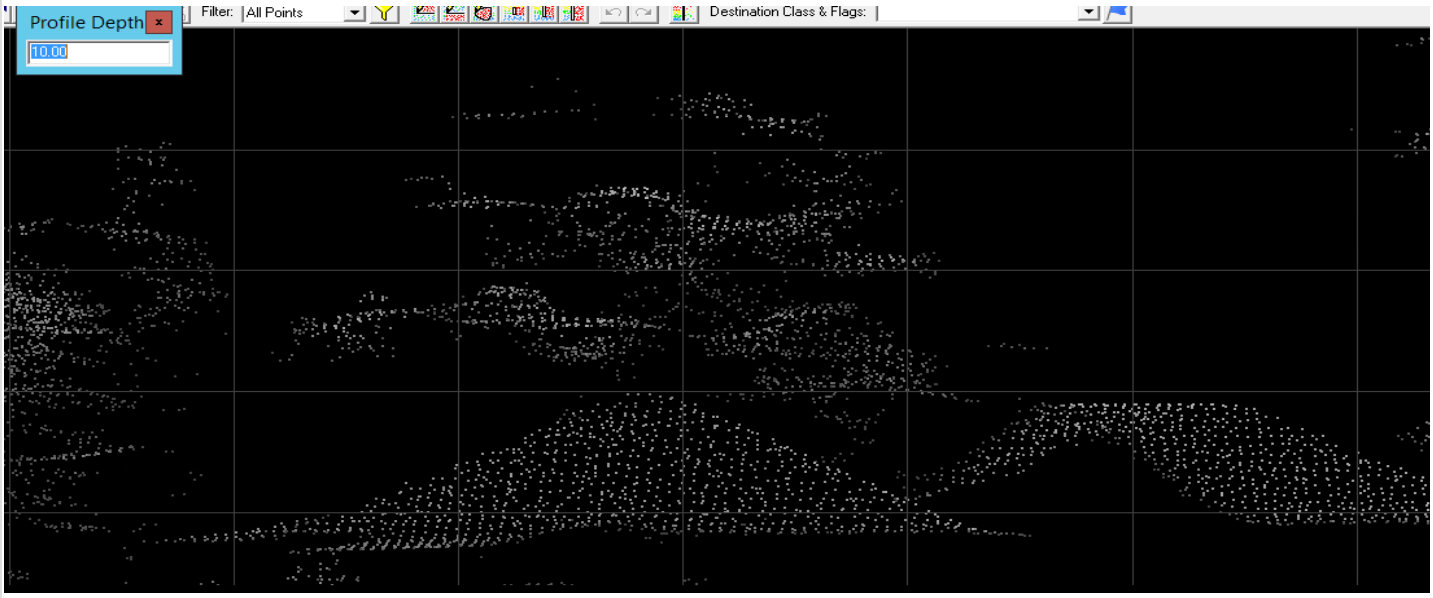
Additional images:

20 meter profile

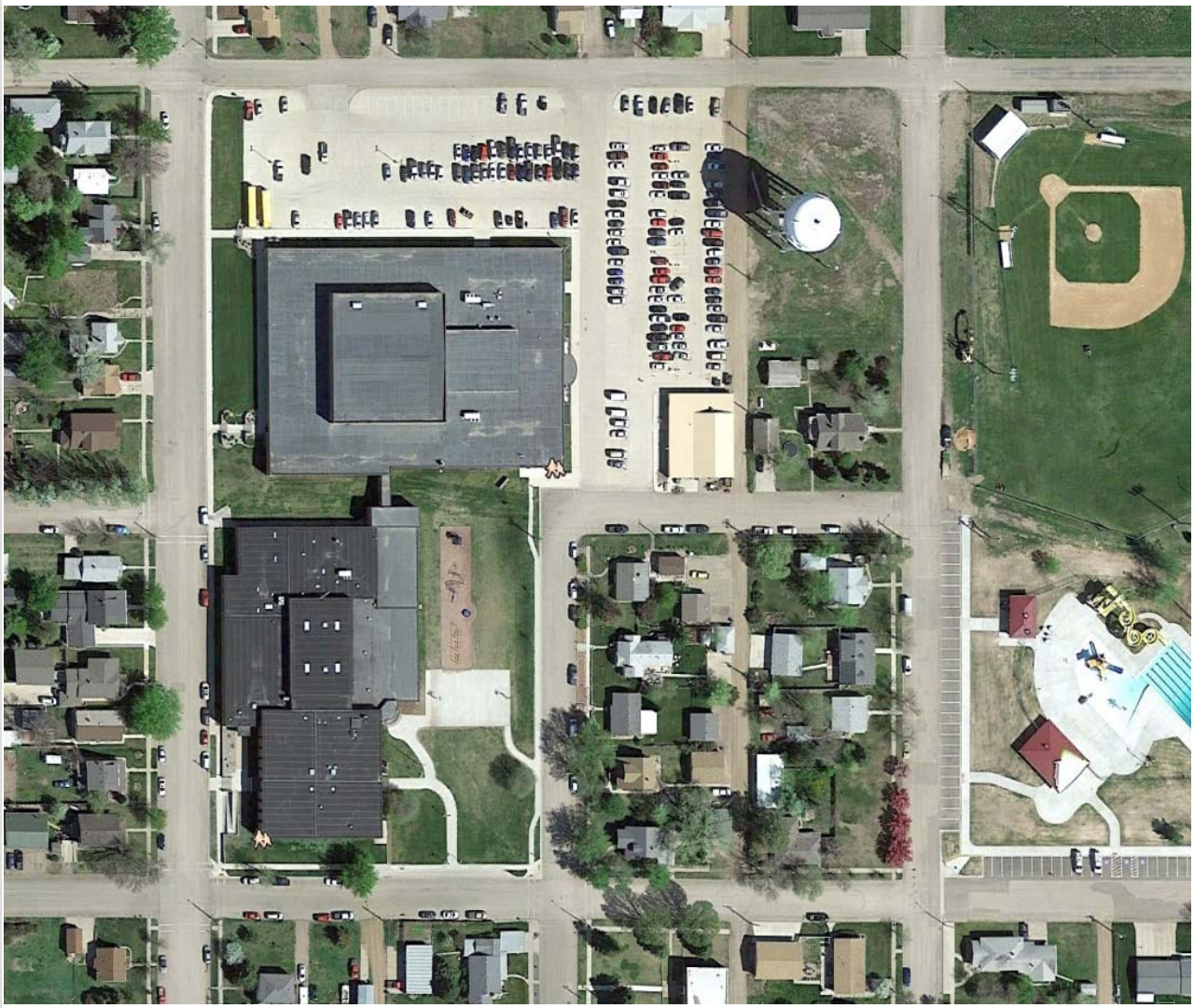


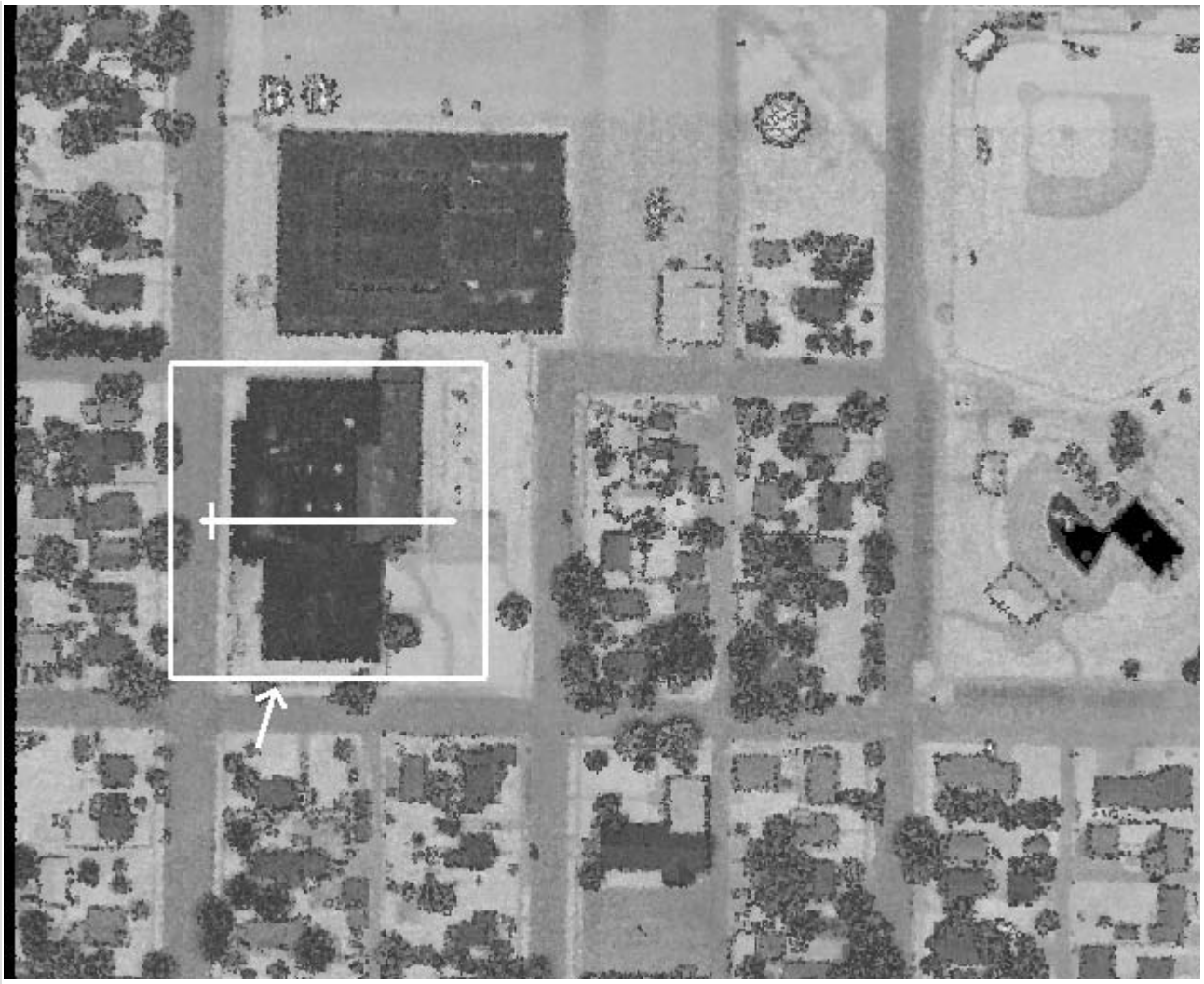


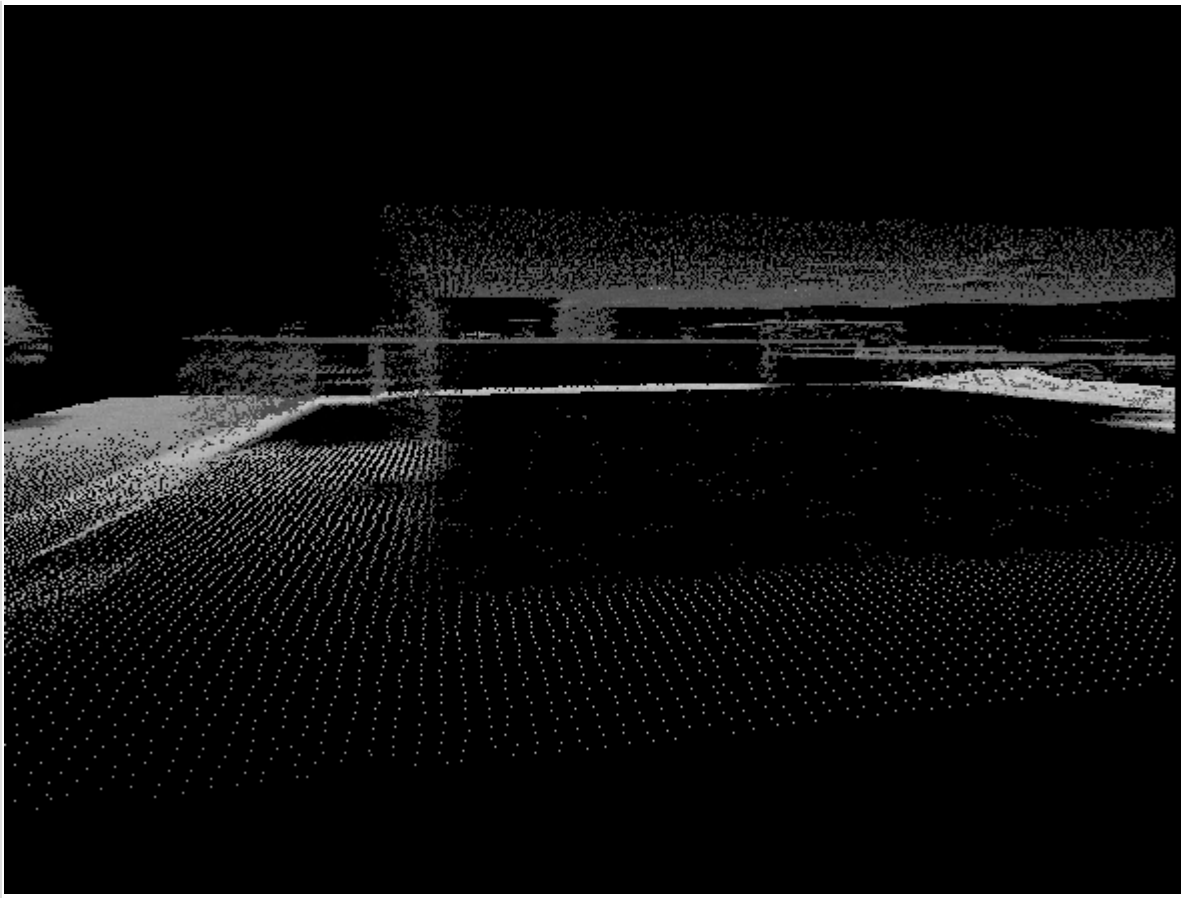
10 meter profile, close up of the rooftops:

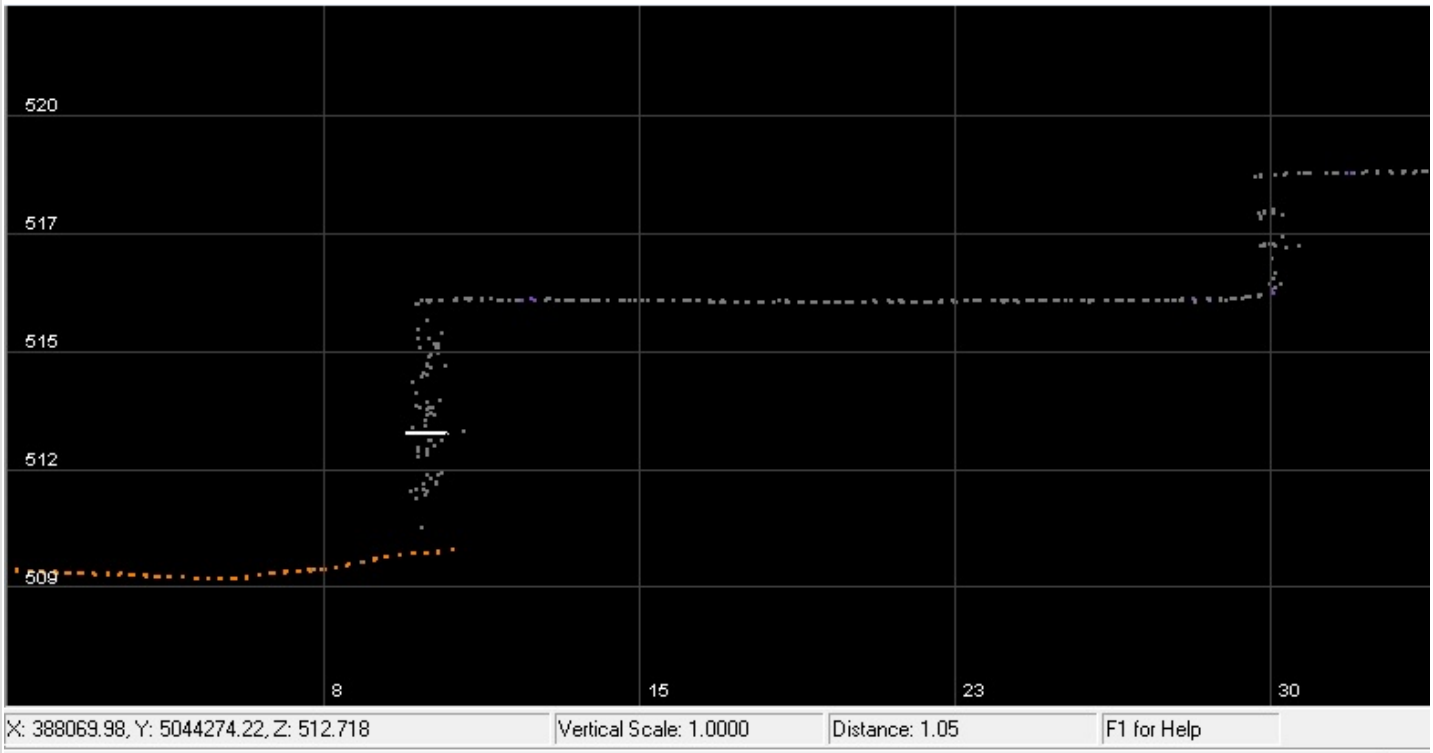


The following images reveal the areal and three-dimensional views, as well as -1meter profile drawn across point cloud representing Mobridge Middle and High School. One hundred percent resolution of the point cloud has been forced.



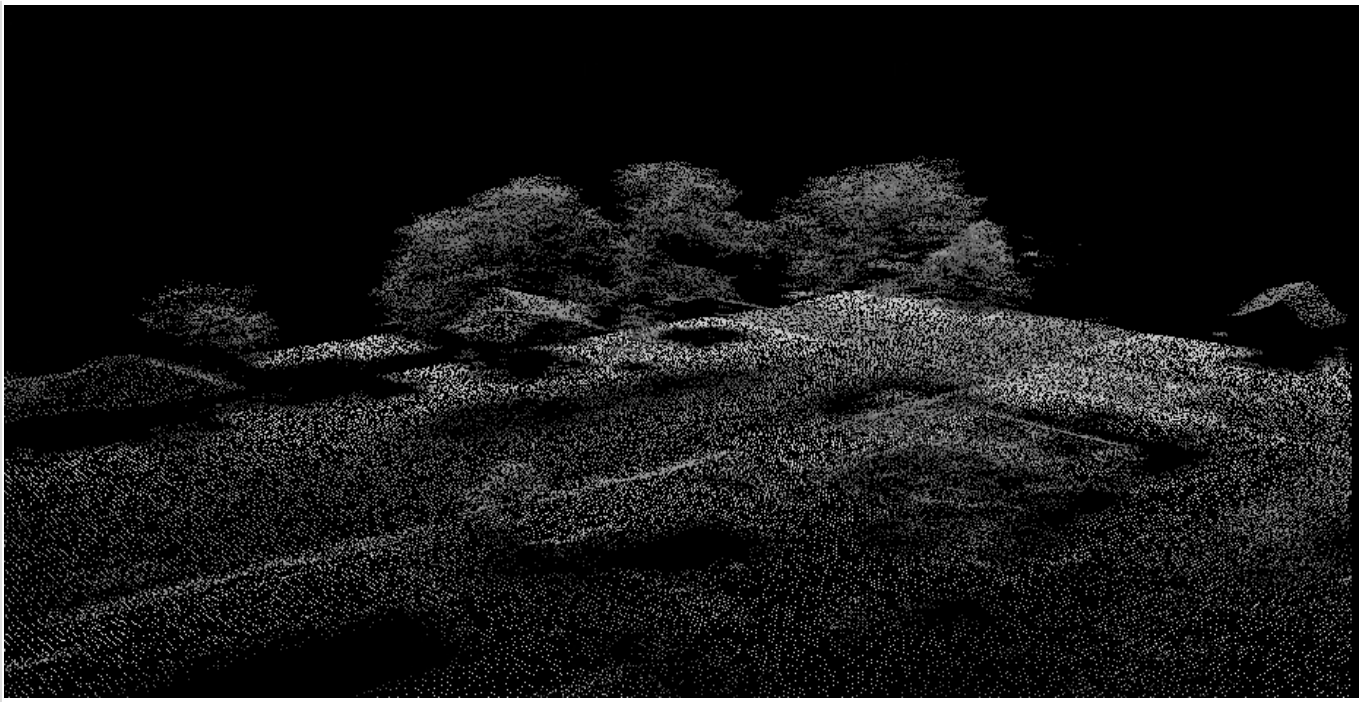






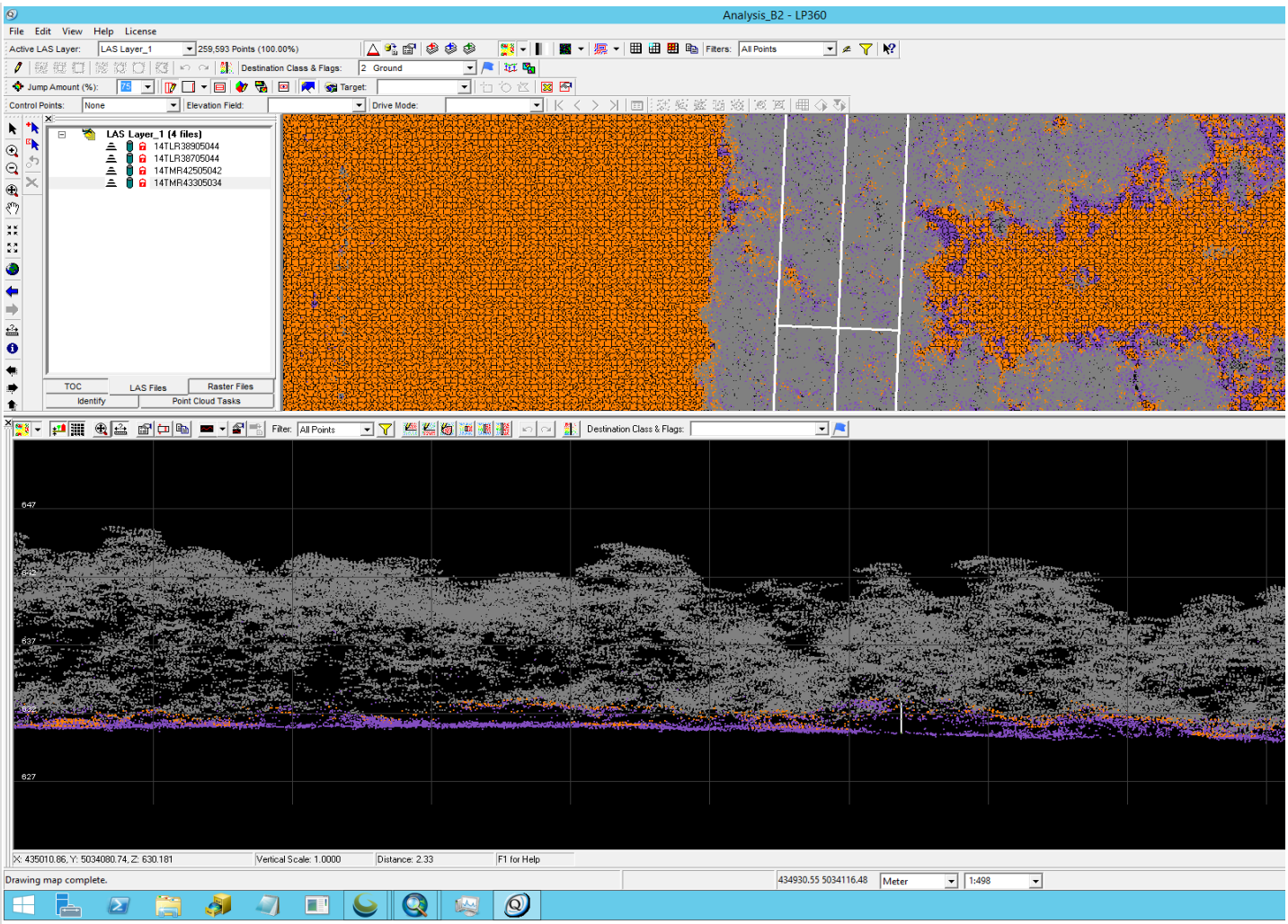
In this case, the scatter across the wall extends to approximately 1-meter length.

The image below shows three-dimensional view of a residential area. In this case, elevation of the roads appears to be correct, located slightly below the lawns. Trunks of the trees are not visible. In this view, one hundred percent resolution has been forced. The task order stipulated that only 8 points per square meter needed to be supplied.



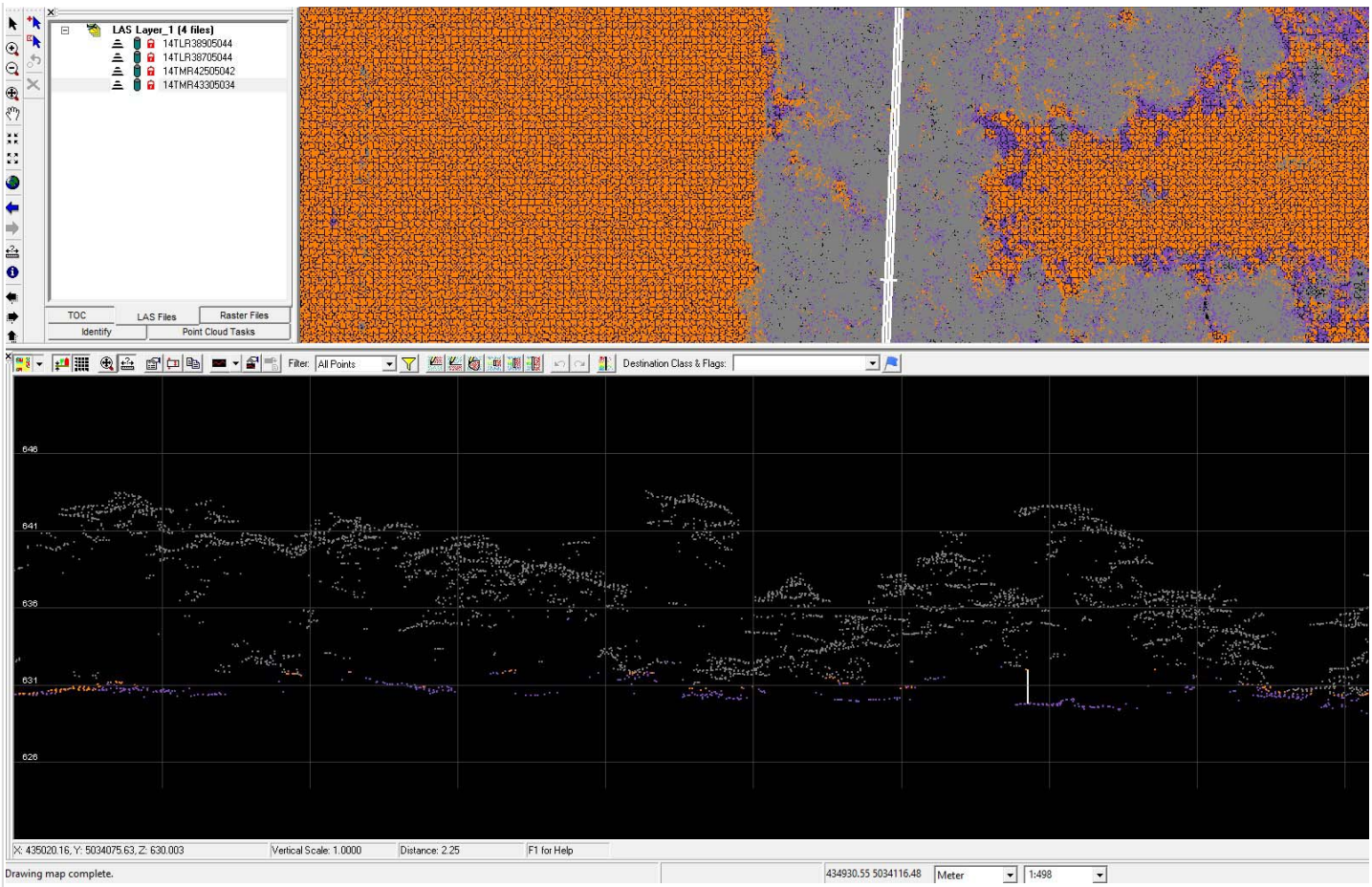
5) The following image exemplifies a tree line profile. Vegetation is classified as and portrayed in gray color, ground points are displayed in orange color, and noise points are identified in purple color. The first profile (a) has depth of twenty meters and the second contour (b) has one meter depth.

a)



The measurement of the lower section, indicating the distance between the lowest noise points and highest ground points is approximately three meters. Tree trunks could not be distinguished among the canopy cover.

b)

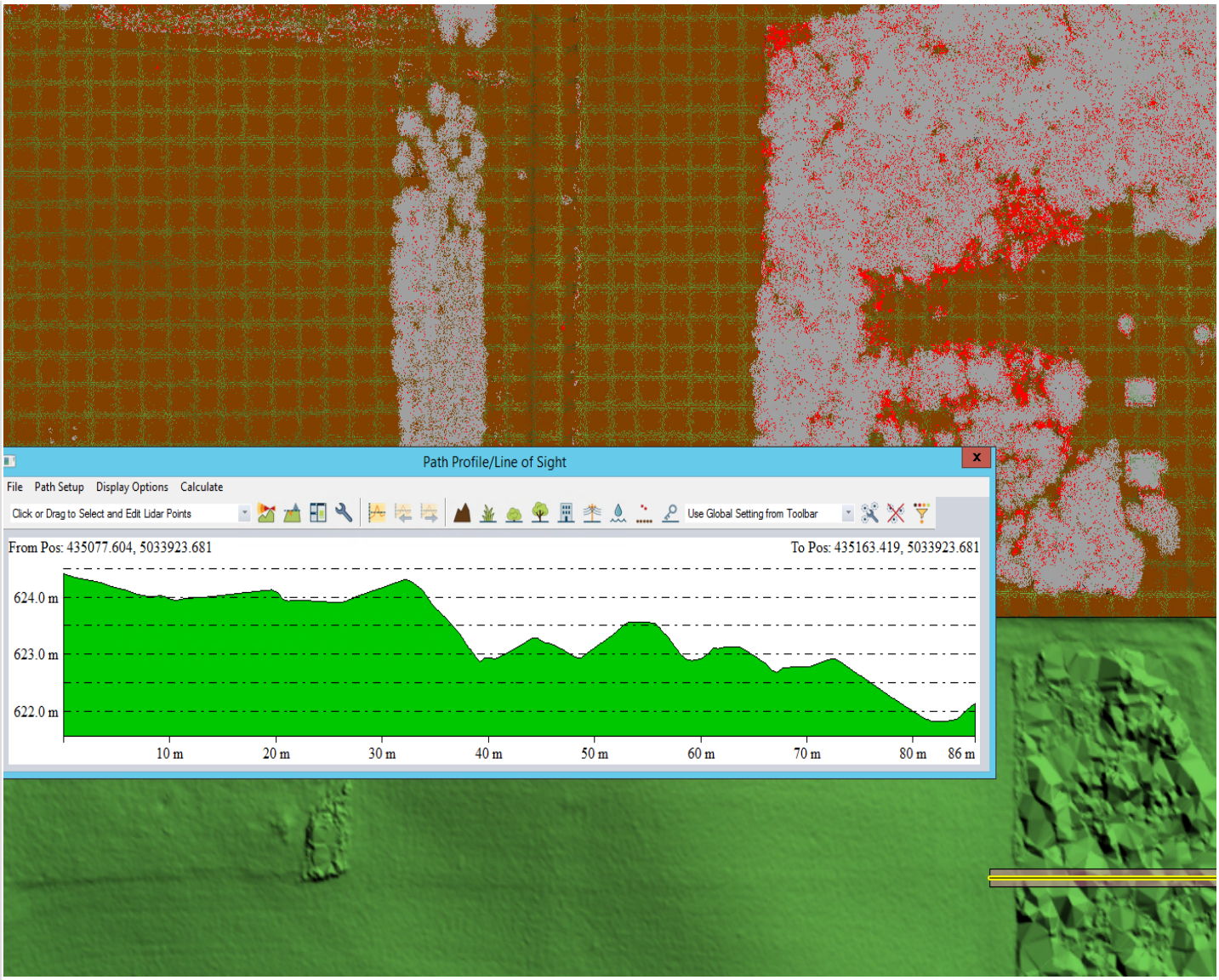


In the instance of the one meter profile, the measurement of the lower section, indicating the distance between the lowest noise points and highest ground points is approximately two and a half meters. The profile reveals sparse ground cover, suggesting relatively poor canopy penetration.

Still, possibly some of the points could be re-assigned from the noise to the ground category. This draws attention to probable difficulties associated with automatic post processing of the data derived from the Geiger-mode sensor.

A discernable pattern emerges when looking at the data at different scales and in both Global Mapper and LP360 software. In earlier discussions, Dewberry provided an explanation that the grid line pattern was generated by software rather than a remnant from the algorithm used to process the point cloud. The two screen captures above were taken at the scale of 1:498 meters. The image below shows the same area in Global Mapper at the scale of 1:1096 meters. The top part of the digital elevation model (DEM) is overlaid with the point cloud data. In the case of Global Mapper display, the one hundred percent resolution of the point cloud was not forced.

The bottom of the image reveals a tinned ground in the part of the DEM generated in the area where a strip of tree line was present.



References:

Dewberry. 2018. South Dakota Geiger Mode LiDAR - Vegetated Vertical Accuracy.

Stoker, J.M., Abdullah, Q.A., Nayegandhi, A. and Winehouse, J., 2016. Evaluation of Single Photon and Geiger Mode Lidar for the 3D Elevation Program. Remote Sensing, 8(9), p.767

Tiles recommended for NED 1/3rd: ○ Yes. ○ No.
Tiles recommended for NED 1/9th: ○ Yes. ○ No.
Tiles recommended for NED 1 Meter: ○ Yes. ○ No.
LAS dataset recommended for distribution: Select...

Based on this review, the USGS accepts the DEM tiles.

End of DEM Review

Based on this review, the provided delivery Does Not Meet the Contract and/or Task Order requirements.
Additional Comments:

At the time of writing, this review recommends that, due to the experimental nature of the project, as well as inadequate

vertical accuracy results, these data be released under "other" quality data level.

INTERNAL COMMENTS

1) The contractor has requested that the data would be accepted at Quality Level 2.
2) Point cloud, DEM, and Reflectance files were delivered in unexpected order and were divided into blocks at the NGTOC.
3) The correction files were delivered collectively. The agreed block delivery scheme was not observed and the files were divided into blocks at the NGTOC.

END OF REPORT (v2.4.0)