LiDAR QA/QC
- Quantitative and Qualitative Assessment Report -
Northwest Florida Water Management District
July 17, 2008

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EXECUTIVE SUMMARY

This LiDAR project consisted of several separate LiDAR datasets flown by Merrick & Company between March 2007 and January 2008. The LiDAR data covered approximately 3029 sq. miles and encompassed Holmes, Jackson, and Gadsden Counties and part of Washington, Calhoun, and Liberty Counties. An additional dataset was flown and processed by Sanborn which covers the southern half of Washington County, the southwestern portion of Jackson County, and the eastern portion of Calhoun County. This data is being processed by Sanborn and will be reviewed at a later date.

Merrick provided the vertical accuracy of these data and Dewberry verified the results using the survey data they provided. Dewberry also performed a quality assessment of these data including a completeness check and a qualitative review to ensure accuracy.

First, based on the survey checkpoint data provided by Merrick, the elevation meets the accuracy required for this project. It should be noted that the methodology to assess accuracy does not explicitly comply with FEMA guidelines but does comply and surpass the NSSDA on which the FEMA specifications are based. Additionally a partial NDEP methodology was utilized again indicating good results. All methods yielded accuracies to support the generation of 2 foot contours.

Secondly, Dewberry inventoried the files and inspected 100% of the data at a macro level. No remote sensing data void was found and the data are free of major systematic errors. The cleanliness of the bare earth model was assessed on 30% of the tiles at the micro level and exhibits good quality and should meet most users' needs. Minor errors were found (poor penetration, potential divots, and artifacts) but are not representative of the majority of the data.

In essence, these LIDAR datasets produced by Merrick are of good quality and meet the needs of NWFWMD. This report will detail the QAQC process performed by Dewberry for each dataset as well as discuss how the datasets fit together.

NWFWMD LiDAR Project Extents

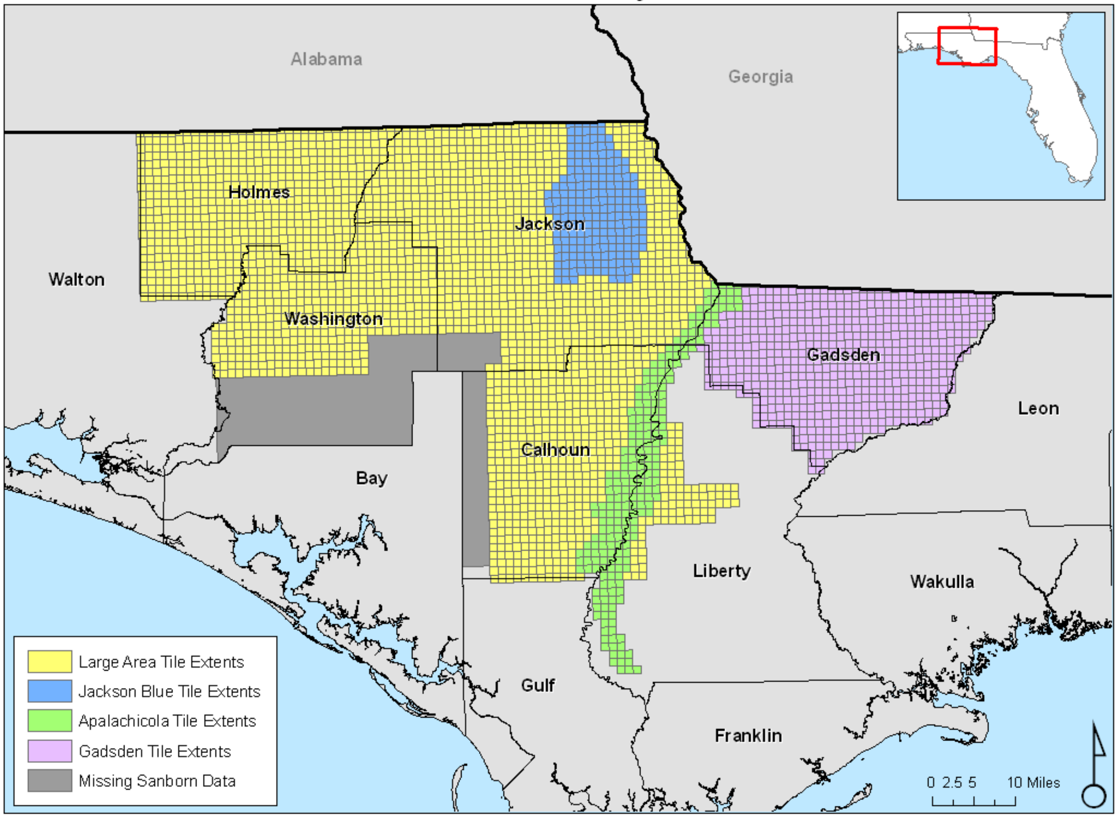

Figure 1 - LiDAR project extents.

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1 Introduction

LiDAR technology data gives access to precise elevation measurements at a very high resolution resulting in a detailed definition of the earth's surface topography. Dewberry's role is to provide an independent verification of this data using a vertical accuracy assessment, a completeness validation of the LiDAR mass points, and a qualitative review of the derived bare earth surface.

First, the quantitative analysis addresses the quality of the data based on absolute accuracy of a limited collection of discrete checkpoint survey measurements. Typically LiDAR accuracy is assessed using FEMA Flood Hazard Mapping Program, *Guidelines and Specifications for Flood Hazard Mapping Partners Appendix A: Guidance for Aerial Mapping and Surveying* methodology that tests a minimum of 20 checkpoints for each land cover representative of the floodplain. However the current number of checkpoints and attributes does not meet this standard so a modified National Digital Elevation Model (NDEP) approach was utilized to assess accuracy. The NDEP methodology has an advantage over the FEMA methodology as it assumes that the errors do not follow a normal distribution where as the FEMA method does assume a normal distribution. Errors typically do not follow a normal distribution particularly in areas of vegetation where the LiDAR might not penetrate to the ground. Again since we did not have the land cover type we assessed the data based on the consolidated vertical accuracy.

To compute the accuracy, the checkpoints z-values are compared to z-values computed at the same horizontal locations from an elevation model generated from the bare-earth LiDAR. For this project, Merrick assessed the vertical accuracy of each dataset and Dewberry reviewed their results using the survey data they provided. Based on NSSDA and NDEP methodology, the specifications outlined for this project are as follows:

- Consolidated RMSE of 18.5 cm (0.61 ft.) for the equivalent of 2 ft. contours
- Consolidated Vertical Accuracy of 36.3 cm (1.19 ft.) at the 95% confidence level (18.5 cm x 1.9600)

Second, the completeness verification is conducted at a project scale (files are considered as the entities). It consists of a file inventory and a validation of data format conformity (tiling scheme), projection, georeference specifications, and elevation ranges. Based on our understanding of the scope of work for this project, NWFWMD required that all deliverables include and adhere to the following specifications:

- Projection: UTM Zone 16 North, NAD83
- Vertical Datum: NAVD88
- Units: horizontal in meters, vertical in US Survey Feet.
- ASPRS LAS mass point files
    - Classes 2 (bare earth) and 5 (canopy)
    - Intensity
- LAS header information
    - Flightline information
    - Return values
- Bare earth ESRI DEMs
    - 4' cell size
    - Correctly projected
- ESRI 3D Masspoint shapefiles

- FGDC compliant metadata

Dewberry also generates statistical information from each LAS file and imports it into a database. The statistics include the number of points for each return as well as the minimum, maximum, and mean elevation for each class. This process allows us to statistically review 100% of the data to identify any gross outliers.

It should be noted that all of the LiDAR datasets submitted by Merrick were delivered in the FDEM (Florida Department of Emergency Management) tile scheme. This tile scheme was originally created in State Plane Florida North (orthogonal) but for this project it was reprojected to UTM 16N (see Figure 22). As a consequence, the tile shape used to divide the dataset is rotated as compared to the state plane coordinate tile scheme. It should be noted that even though the extent shapes (or bounding rectangle in UTM) created from the LAS files will seem to have an overlap, the LiDAR points actually do not overlap. However, the DEM rasters have to be orthogonal in UTM, as a consequence, adjacent DEMs will overlap with the pixels being duplicated between 2 adjacent DEMs, as illustrated in Figure 2. We verified that the overlapping section matches between adjacent DEMs and the differences were within the excepted tolerance.

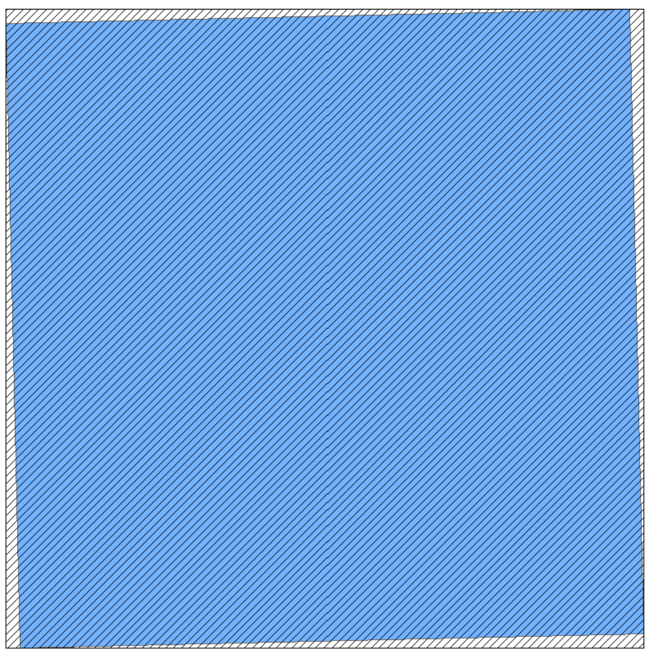


Figure 2 – Tiling scheme illustration. The blue is the FDEM tiling scheme while the hatched tile is the extents of the LiDAR data that was delivered. The rotated offset is a result of reprojecting the tile scheme from State Plane to UTM.

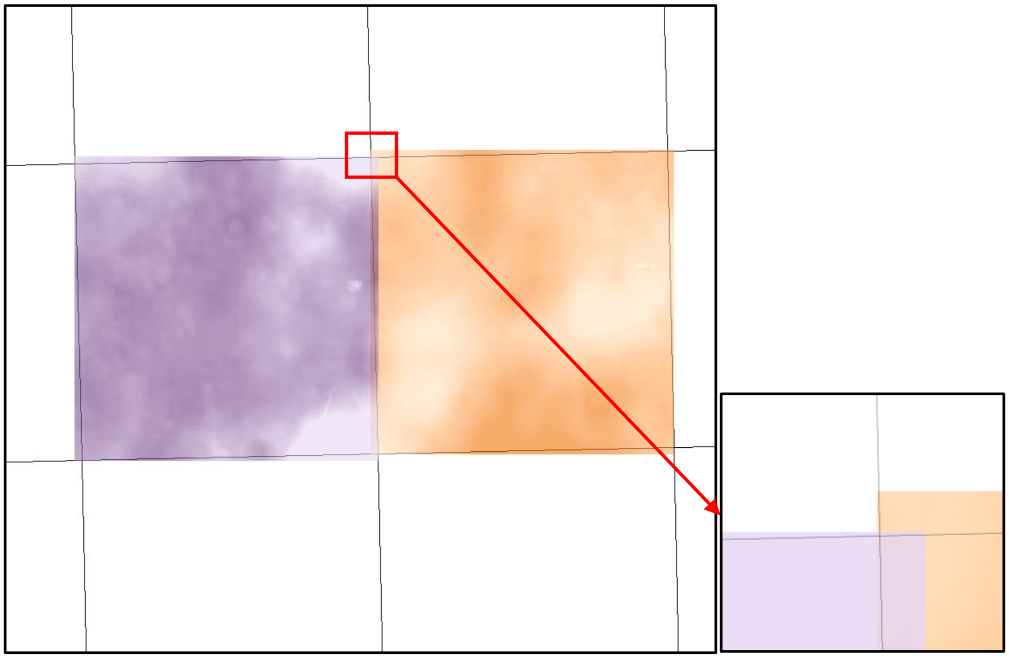


Figure 3 – Tiling scheme illustration for LAS files and DEM rasters.

The metadata for the LAS is acceptable, but does not fully meet the FDGC requirements. For each area of the errors were different. The Large Area has no errors and is fully compliant with FDGC standards. The remaining three areas have several issues including but not limited to detailed entity and attribute citations, horizontal accuracy value, publication date, and extraneous point of contact information. Since this information is not critical (the horizontal accuracy was not formerly to be assessed), we believe that the metadata contains enough details to be used.

Finally, to fully address the data for overall accuracy and quality, a qualitative review of the data is conducted. As no automatic method exists yet, Dewberry performs a manual visualization process based on the knowledge of our analysts. This includes creating pseudo-image products such as 3-dimensional models. By creating multiple images and using overlay techniques, not only can potential errors be found, but we can also find where the data meets and exceeds expectations.

Within this Quality Assurance/Quality Control process, three fundamental questions are addressed:

- Did the LiDAR system perform to specifications?
- Was the data complete?
- Did the ground classification process yield desirable results for the intended bare-earth terrain product?

The primary goal of this qualitative review is to assess the continuity and level of cleanliness of the bare earth product. To ensure its conformance to support the intended final product the LiDAR data is assessed according to the following acceptance criteria:

- ➢ The point density should be homogeneous, correctly supported by flightline overlap and sufficient to meet the user needs.

- Correct classification of ground points (no manmade structures and vegetation remains, no gap except over water bodies),
- Correct definition of ground surface model, especially within stream channels (no aggressive classification, no over-smoothing, no inconsistency in the post-processing),
- No obvious anomalies due to sensor malfunction or systematic processing artifact is present (data holidays, spikes, divots, ridges between tiles, cornrows…).

The visual inspection performed by experienced Dewberry analysts is done on bare-earth digital elevation models (bare-earth DEM) that are created from the LiDAR points. The mass points are first gridded based on the point spacing. Then a triangulated irregular network (TIN) is built based on this gridded DEM and displayed as a 3D surface. A shaded relief effect is applied which enhances 3D rendering. The software used for visualization allows the user to navigate, zoom and rotate models and to display elevation information with an adaptive color coding in order to better identify anomalies.

One of the variables established when creating the models is the threshold for missing data. For each individual triangle, the point density information is stored; if it meets the threshold, the corresponding surface will be displayed in green, if not it will be displayed in red (see *Figure* 4).

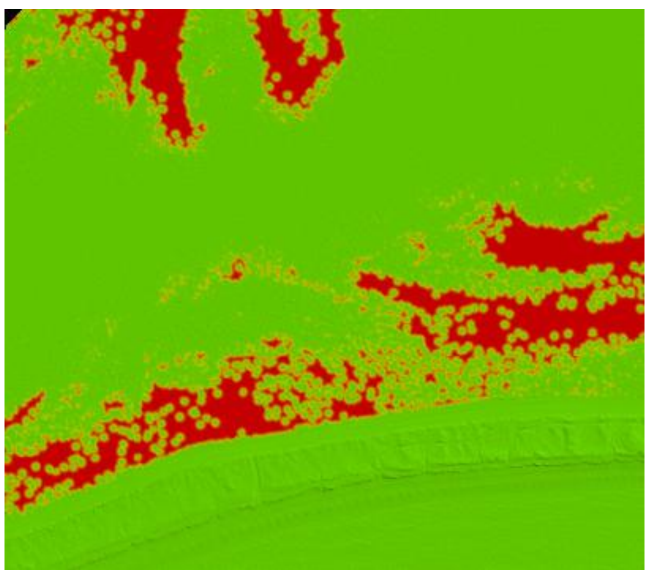


Figure 4 – Ground model with density information (red means no data).

The first step of our qualitative workflow is to verify the point distribution by systematically loading 10% of the tiles as mass points colored by class or by flightline. This particular type of display helps us visualize and better understand the scan pattern, the flight line orientation and coverage and gives an additional confirmation that all classes are present and seem to logically represent the terrain.

The second step is to verify data completeness and continuity using the bare-earth surface model with density information, displayed at a macro level. If, during this macro review of the ground models, we find potential artifacts or large voids, we use the digital surface model based on the full point cloud including vegetation and buildings to help us better pinpoint the extent and the cause of the issue. Moreover, the intensity information stored in the LiDAR data can be visualized over this surface model, helping in interpretation of the terrain.

Finally, in case the analyst suspects a systematic errors relating to data collection, a visualization of the 3D raw mass points is performed, rather than visualizing as a surface.

The process of importing, comparing and analyzing these two later types of models (DSM with intensity and raw mass point), along with cross section extraction, surface measurements, density evaluation, constitutes our micro level of review. For this project, Dewberry reviewed 100% of the data at a decimated level (5x the ground sampling distance, all classes) and 30% of the data at the micro level (ground models). The most common anomalies that were found are described below.

Potential divots

Divots may be caused by one or more “low” points that were left in the ground during the classification process, producing what looks like a hole in the terrain. Most of the potential divots are found in areas of dense vegetation where classification becomes difficult. Potential divots can also be found in residential areas where LiDAR pulses can bounce off of certain surfaces (house wall) and take longer to return to the sensor, thus returning a lower elevation.

Poor penetration

Another problem that we often found was patches of sparse data. In areas of dense vegetation, the LiDAR pulse may not penetrate the canopy all the way to the ground. This results in fewer ground points during the ground classification process. Nevertheless, in flat areas, an acceptable 3D model can be built from these few points. However, the smoothness of the surface is often of less quality since low understory vegetation that completely blocks the pulse may be classified as ground resulting in a rather noisy surface.

Cornrows

An additional anomaly that was found was the presence of cornrows. There are several reasons as to why this happens but in this case it seems as though adjacent scanlines are slightly offset from each other. This produces a high-to-low furrow effect resembling crops in a field however in these datasets they are only noticeable due to the high resolution of the LiDAR points. Although this phenomenon is found frequently throughout the dataset, the differences in elevation are not large enough to have a significant effect on any anticipated modeling.

Vegetation artifacts

Another classification issue that was discovered was the presence of potential vegetation artifacts. Although it is conceivable that the soil exhibits natural small relief, we believe that they are vegetation remains. These artifacts are limited in height and appear as noise in the bare earth model.

2 Jackson Blue LiDAR QAQC Review

The Jackson Blue project area is approximately 183 sq miles and covers a northeastern section of Jackson County, Florida. This dataset was acquired and processed by Merrick in March of 2007.

2.1 Vertical Accuracy Assessment

The field survey was conducted and prepared by Allen Nobles & Associates for Merrick in May 2007. A total of 19 checkpoints were captured throughout the project area; these points are listed in Appendix A – JacksonBlue Checkpoints. In the LAS metadata Merrick states that the RMSE of the checkpoints was 0.26 ft. and the Consolidated Vertical Accuracy was 0.51 ft. In order to verify these calculations as well as derive other useful statistics, Dewberry performed an additional accuracy check utilizing the survey checkpoints as provided by Merrick.

Figure 5 shows the distribution of the checkpoints throughout Jackson Blue LiDAR extents. Although there was no land cover information for the individual checkpoints, a review of the survey photos revealed that most of the points were taken in rural areas of flat terrain.

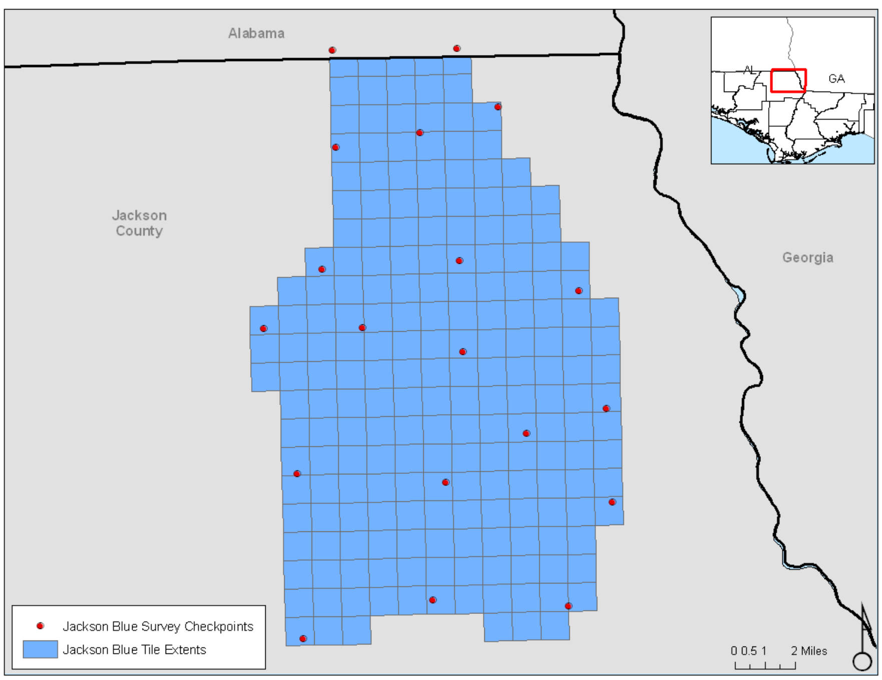


Figure 5 – Check Points for Merrick Survey.

Table 1 and Table 2 - Dewberry RMSE Report.**Error! Reference source not found.** show the complete results of the Jackson Blue data set run through the Dewberry RMSE process. Without official land cover data for the GPS points, the bare earth RMSE could not be precisely defined. Despite this, the consolidated RMSE and CVA well exceed the specifications for 2 ft. contours. The Dewberry values matched Merrick's results to within a fraction of an inch.

100 % of Totals	RMSE (ft) Spec=0.61 ft	Mean (ft)	Median (ft)	Skew	Std Dev (ft)	# of Points	Min (ft)	Max (ft)
Consolidated	0.253	-0.052	-0.011	-0.384	0.254	19	-0.516	0.36

Table 1 – Dewberry RMSE Report.

Land Cover Category	# of Points	FVA — Fundamental Vertical Accuracy (RMSEz x 1.9600) Spec=1.195 ft	CVA — Consolidated Vertical Accuracy (95th Percentile) Spec=1.195 ft	SVA — Supplemental Vertical Accuracy (95th Percentile) Target=1.195 ft
Consolidated	19		0.492	

Table 2 - Dewberry RMSE Report.

Table 3 illustrates the distribution of the elevation differences between the LiDAR data and the surveyed points. The points are evenly dispersed around 0 indicating a normal distribution.

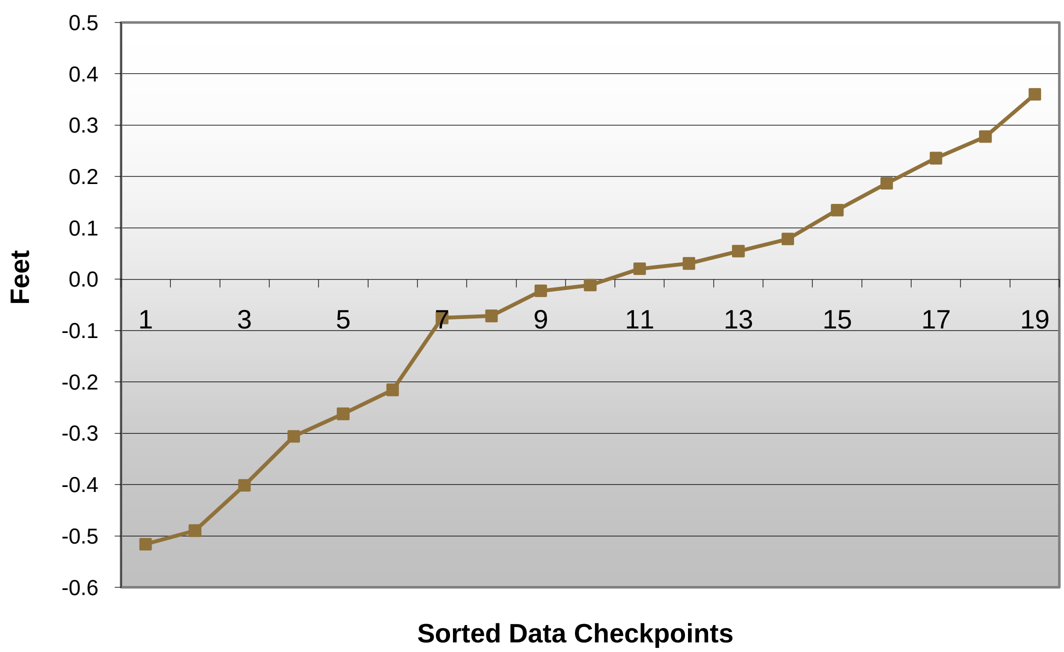


Table 3 - Sorted checkpoint errors for 19 survey points.

Dewberry's review of the vertical accuracy of the Jackson Blue LiDAR data confirms Merrick's statement that the dataset meets accuracy standards according to NSSDA specifications. Although Dewberry was provided with a minimal amount of checkpoints, the data tested well enough to be considered usable for NWFWMD's needs.

2.2 Completeness of LiDAR Variables

A total of 204 LAS tiles and 204 DEM rasters in ArcGIS GRID format were delivered by Merrick for the entire project overlapping all the required area (Figure 6). Dewberry verified that the data is in the correct projection and each LAS file includes the following information:

- XYZ coordinates
- Intensity
- Return number, number of returns, GPS time
- Classification
    - Class 2
    - Class 5

It seems as though all non-ground points were thrown into class 5. Based on our knowledge of the specifications for this project this is incorrect and only canopy points should have been included in this class.

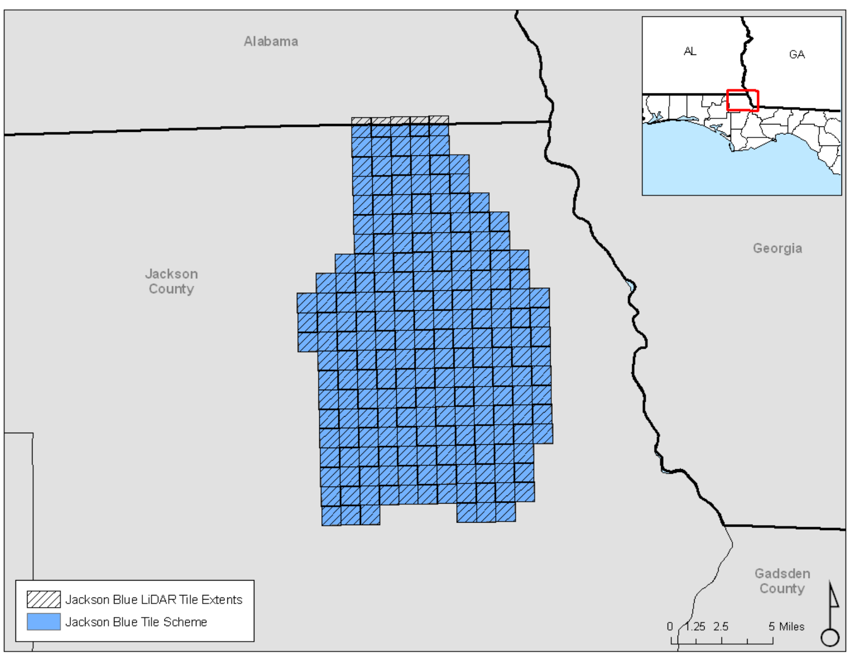


Figure 6 - Delivered LiDAR tiles and extents.

Only 78 masspoint shapefiles were delivered compared to the 2004 LAS and DEM tiles. Also missing was the flightline information which is usually stored in the Source ID field. This information aids in the quality assurance process by identifying where the overlap between flightlines is located in case there is an offset between flightlines. Figure 7 shows two LiDAR tiles classified by Source ID. The tile on the left is classified by Source ID and shows distinct flightlines. The Jackson Blue tile on the right is also classified by Source ID although the flightline information is clearly missing.

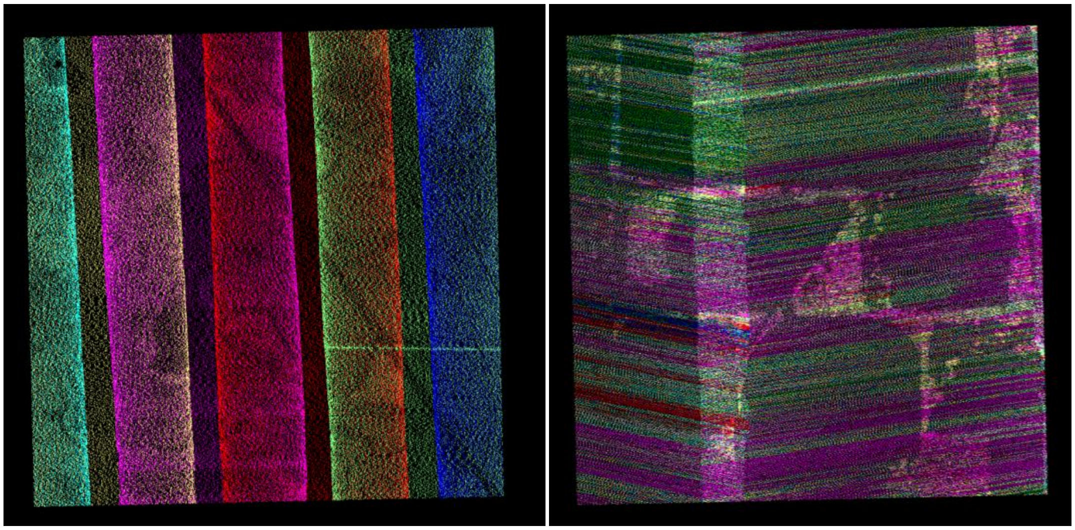


Figure 7 - LAS files classified by Source ID. File in left image displays the LiDAR points by flightline, this information is missing in Jackson Blue LiDAR tile on right.

2.2.1 Statistical analysis of tile content

Each tile was queried to extract the number of LiDAR points and all tiles are within the anticipated size range.

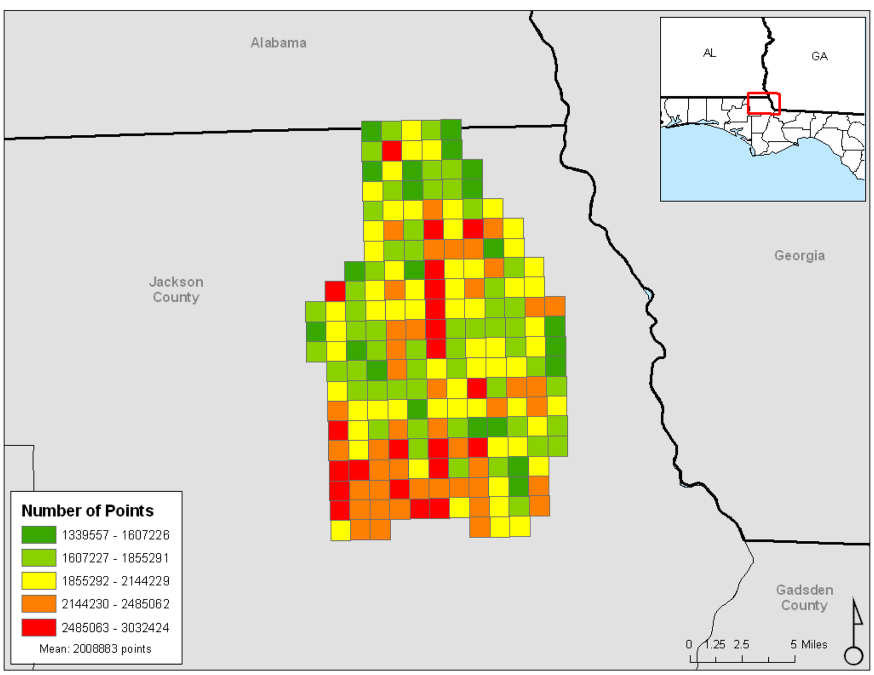


Figure 8 – Number of Points per Tile.

To first identify incorrect elevations, the z-minimum and z-maximum values for the ground class were reviewed. With maximum values between 113 and 196 ft, no noticeable anomalies were identified. Figure 9 shows the spatial distribution of these elevations. The green tiles in the eastern area of the dataset correspond with a swampy drainage area that can be seen in the image of the decimated ground points in Figure 11. Considering the anticipated swampy terrain of this area, the images of the spatial distribution of the highest and lowest elevations seem to correlate with one another.

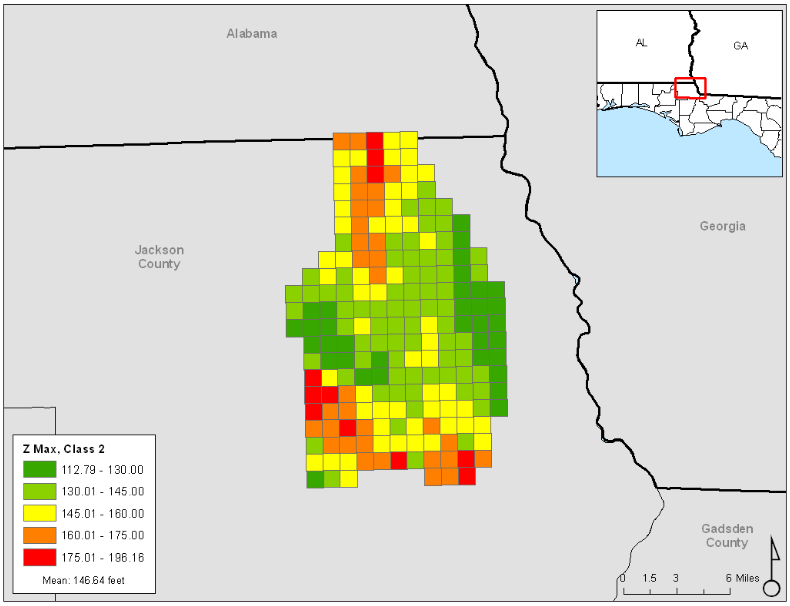


Figure 9 - Tiles classified by highest elevation in feet, class 2.

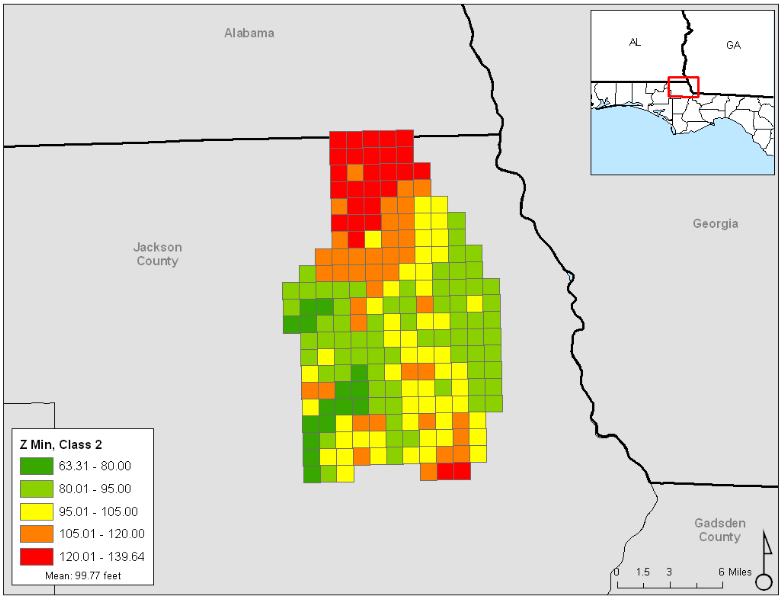


Figure 10 - Tiles classified by lowest elevation in feet, class 2.

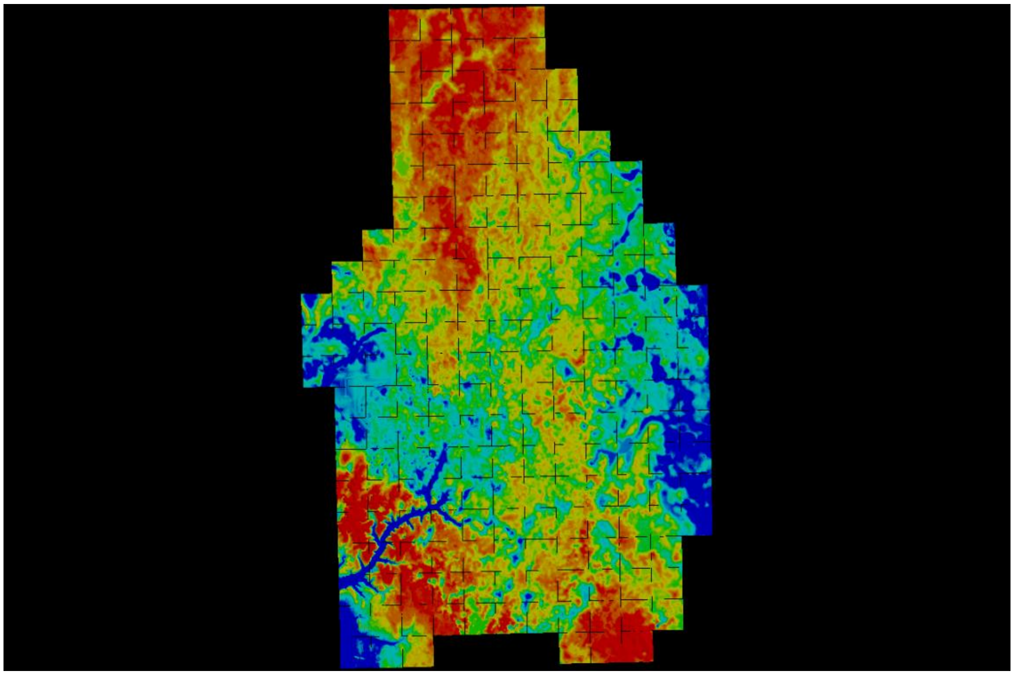


Figure 11 - Decimated image of all Jackson Blue LiDAR tiles. This illustration allows us to quickly ensure that the minimum and maximum elevation values make sense.

2.3 Qualitative Assessment

Our Qualitative review was to perform a macro visual inspection of all the tiles and to inspect a minimum of 30% at a micro level of detail. Additionally we reviewed 10% of the data for the scanning and flightline consistency. The Jackson Blue data proved to be of good quality and no significant voids or anomalies were found. There were a few minor issues discovered with are outlined in the text and images below.

Divots

Divots were found throughout the dataset although most were found in areas of dense vegetation. Figure 12 displays a typical example of the type of divots that we found.

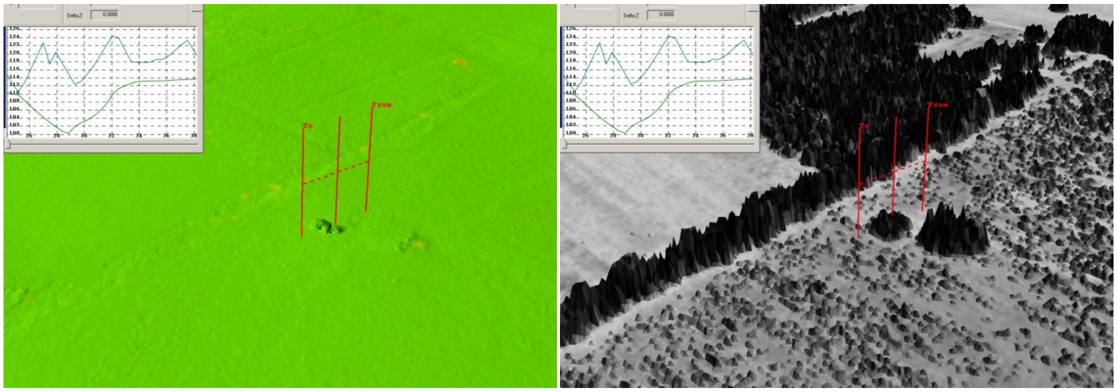


Figure 12 – Tile 32588.The bare earth image on the left depicts a possible divot and cross section. The full point cloud image on the right shows that this divot is located in dense vegetation.

A couple of these divots appear to be legitimate upon finding corresponding imagery where these "holes" are visible (Figures 13 & 14). Although considered common for these types of sensors, these anomalies should be re-examined based upon the scale of analysis performed on the area in question. While these divots will not have a significant effect on the overall quality of the data, they could affect small scale analysis.

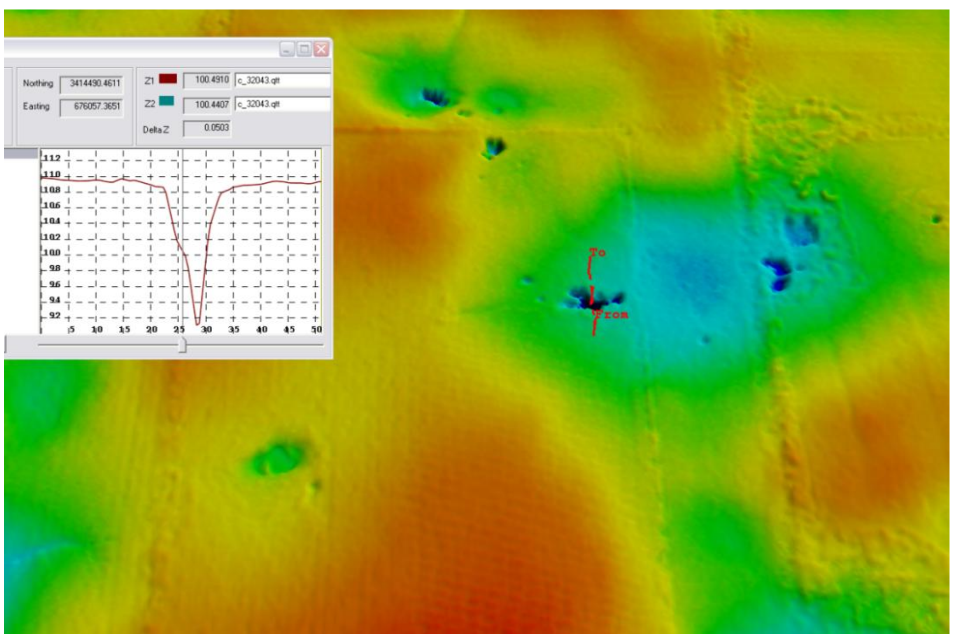


Figure 13 – Tile 32043. Ground LiDAR Image displaying a possible divot of almost 18 feet.

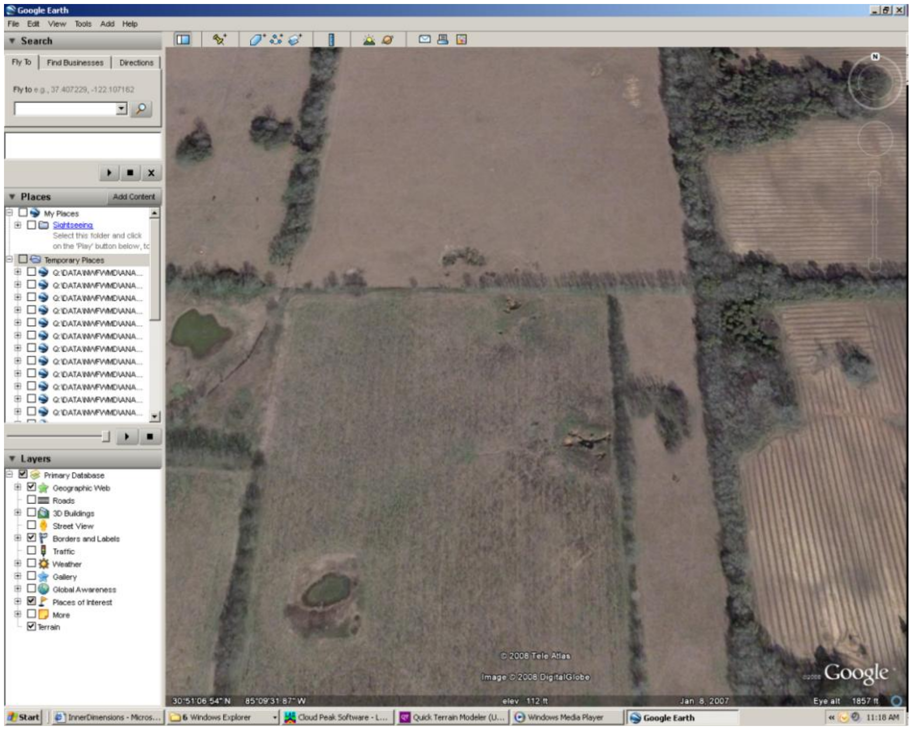


Figure 14 - Google image of possible divot shown above. From this image the low points seem to be legitimate as this is a true ground formation.

Poor penetration

Another problem that we often found was patches of sparse data. This is illustrated in Figures 15-17. Figure 15 is a density image of tile 36902 where red indicates missing data and green indicates dense data. Figure 16 is a full point cloud image of the same area showing dense vegetation. The image in Figure 17 displays bare earth where the LiDAR did not get to the ground and vegetation was left in.

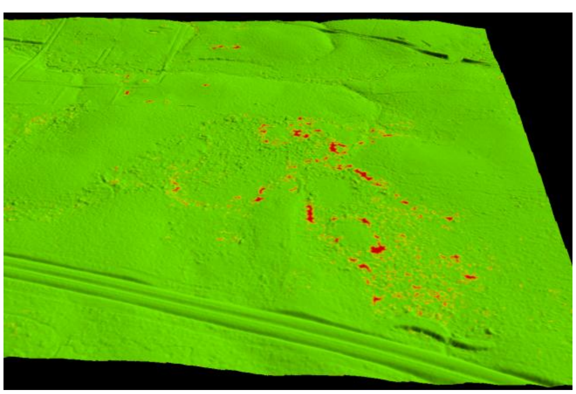


Figure 15 – Tile 36902

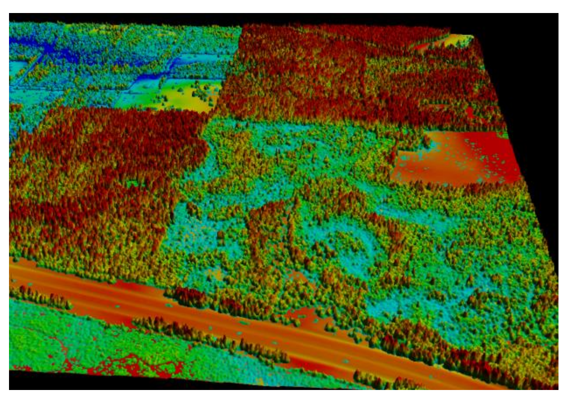


Figure 16 – Tile 36902

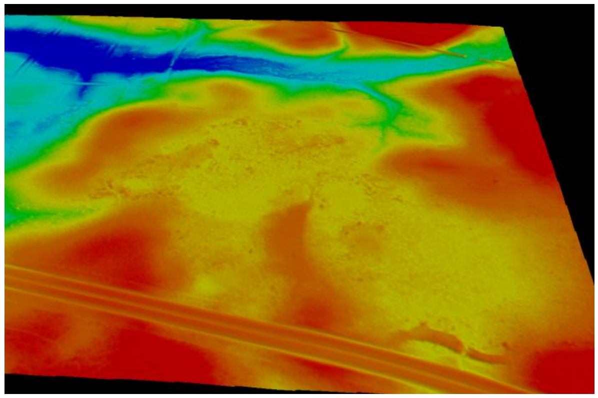


Figure 17 – Tile 36902

Cornrows

Although this phenomenon is found frequently throughout the dataset, the differences in elevation are not large enough to have a significant effect on any anticipated modeling. Figures 18 and 19 display examples of cornrows found in the data.

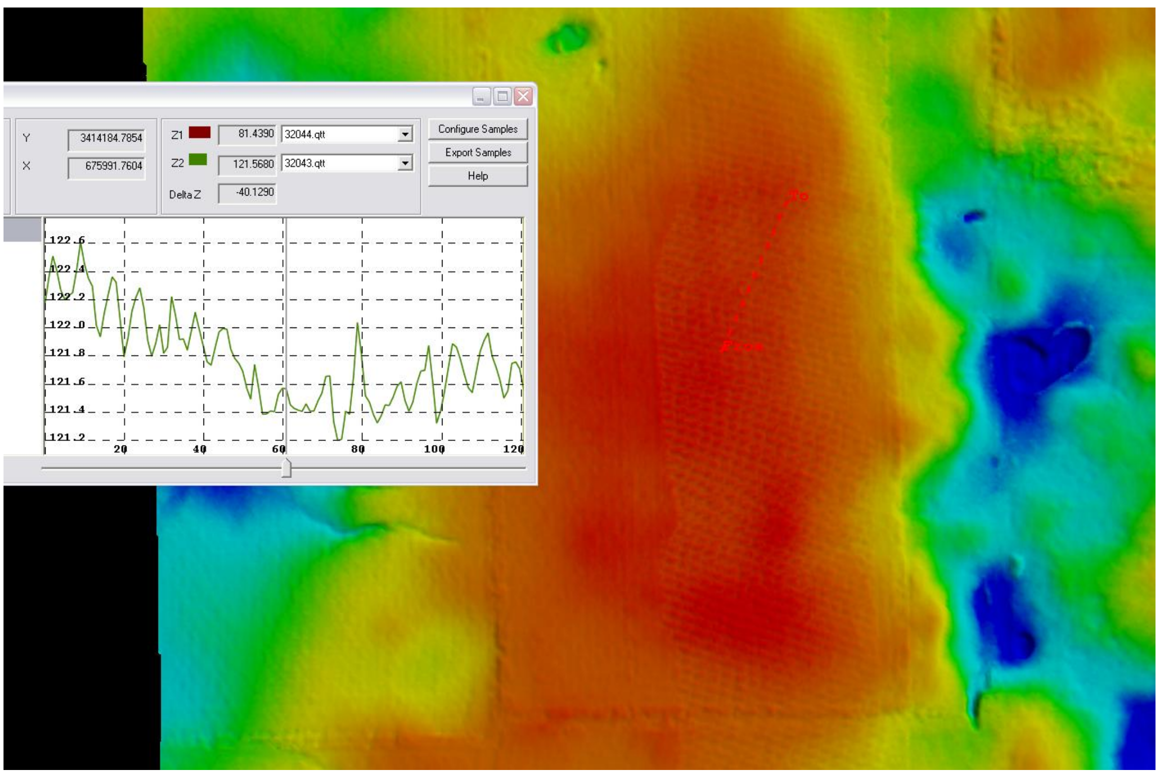


Figure 18 – Tile 32043. Bare earth image of edge of scanline and corresponding cornrows.

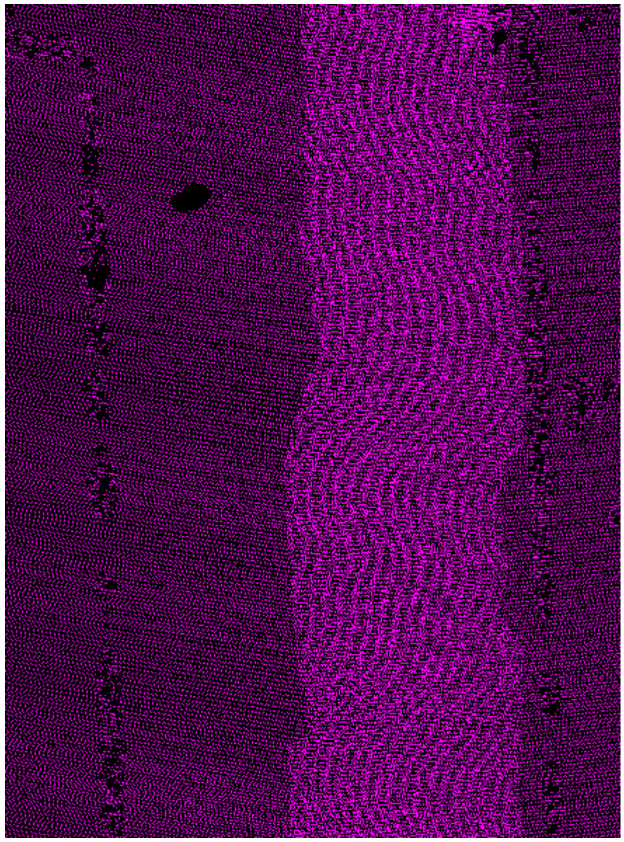


Figure 19 – Tile 32043. Ground points showing the edge of the scanline.

3 Apalachicola LiDAR QAQC Review

This LiDAR dataset covered approximately 209 sq. miles and covers the Apalachicola River basin through Jackson, Gadsden, Calhoun, and Liberty Counties in Florida. The data were acquired and processed by Merrick & Company in March of 2007.

3.1 Vertical Accuracy Assessment

The field survey was conducted and prepared by Allen Nobles & Associates for Merrick in May 2007. A total of 11 checkpoints were collected throughout the project area (Appendix C – Apalachicola Checkpoints). In the LAS metadata Merrick states that the data exceeds the NSSDA vertical accuracy specification of 1.2 ft. In order to verify this as well as derive other useful statistics, Dewberry performed an additional accuracy check utilizing the survey checkpoints as provided by Merrick. Figure 5 shows the distribution of the checkpoints throughout Jackson Blue LiDAR extents.

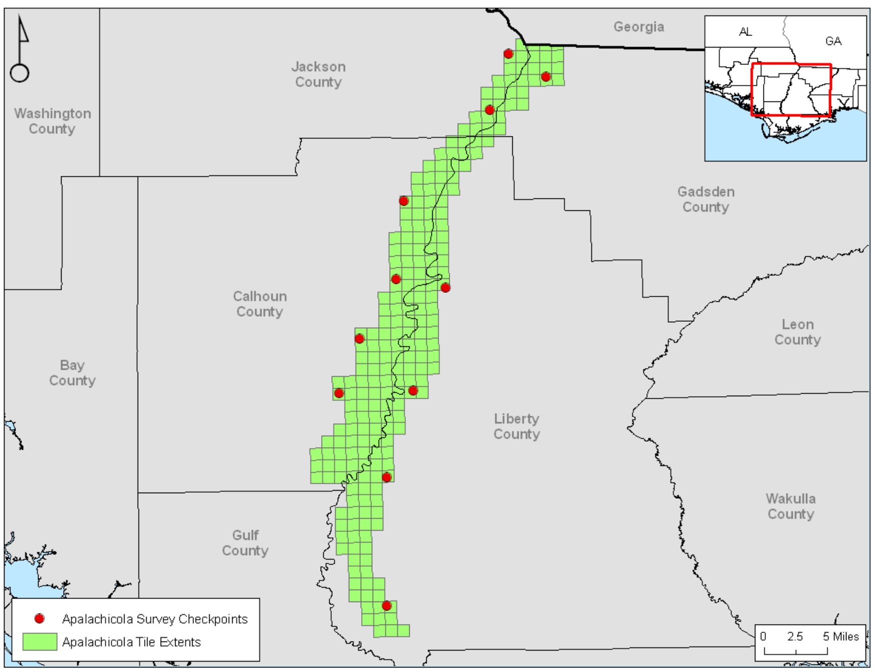


Figure 20 – Check Points for Merrick Survey of the Apalachicola River basin.

Tables 4 and 5 show the complete results of the Apalachicola data set run through the Dewberry RMSE process. The survey report did not include land cover information or images of the point locations so the calculations were completed based on consolidated values. The results proved to be well within the specified RMSE and CVA.

Table 4 - Dewberry RMSE Report.

100 % of Totals	RMSE (ft) Spec=0.61 ft	Mean (ft)	Median (ft)	Skew	Std Dev (ft)	# of Points	Min (ft)	Max (ft)
Consolidated	0.209	-0.111	-0.098	-0.591	0.186	11	-0.423	0.123

Table 5 - Dewberry RMSE Report.

Land Cover Category	# of Points	FVA — Fundamental Vertical Accuracy (RMSEz x 1.9600) Spec=1.195 ft	CVA — Consolidated Vertical Accuracy (95th Percentile) Spec=1.195 ft	SVA — Supplemental Vertical Accuracy (95th Percentile) Target=1.195 ft
Consolidated	11		0.413	

Error! Reference source not found. 6 illustrates the distribution of the elevation differences between the LiDAR data and the surveyed points. The elevation deltas center around -0.1 ft. which indicates a slight negative bias in the LiDAR data.

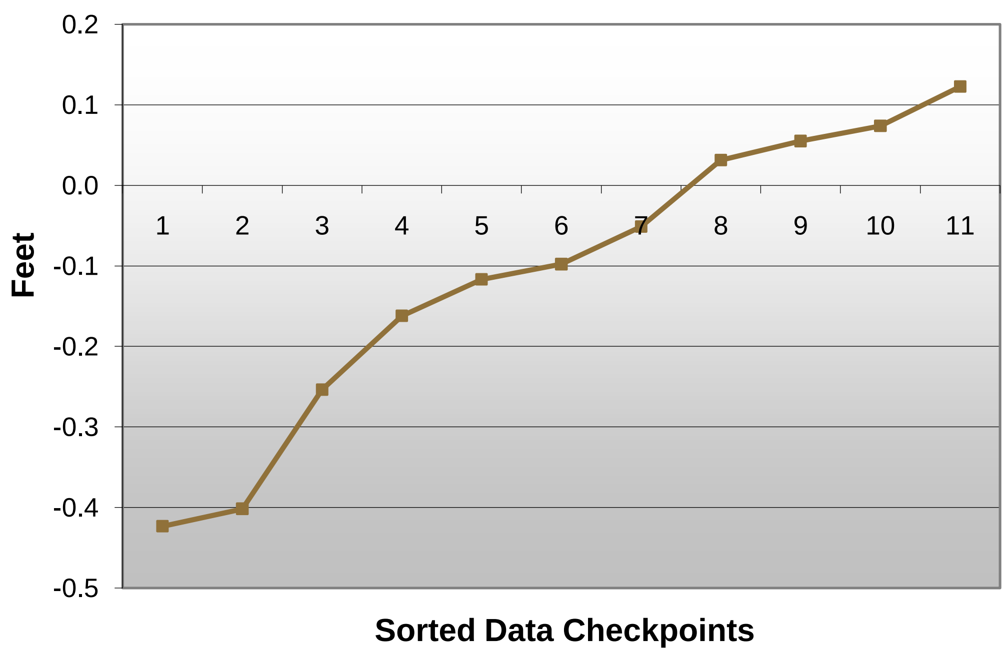


Table 6 - Sorted checkpoint errors for 11 points.

Although there are not enough checkpoints to explicitly state that the Apalachicola LiDAR data meets NSSDA specifications, Dewberry believes that it is good data based on the excellent statistics shown above.

3.2 Completeness of LiDAR Variables

A total of 233 LAS tiles, 233 DEM rasters in ArcGIS GRID format, and 233 masspoint shapefiles were delivered by Merrick for the entire project overlapping all the required area (Figure 21). Dewberry verified that the data is in the correct projection and each LAS file includes the following information:

- XYZ Coordinates
- Intensity
- Return number, number of returns, GPS time
- Classification
    - Class 2
    - Class 5

As with the Jackson Blue data, class 5 included all non-ground points instead of only canopy and is in error. Also missing was the flightline data.

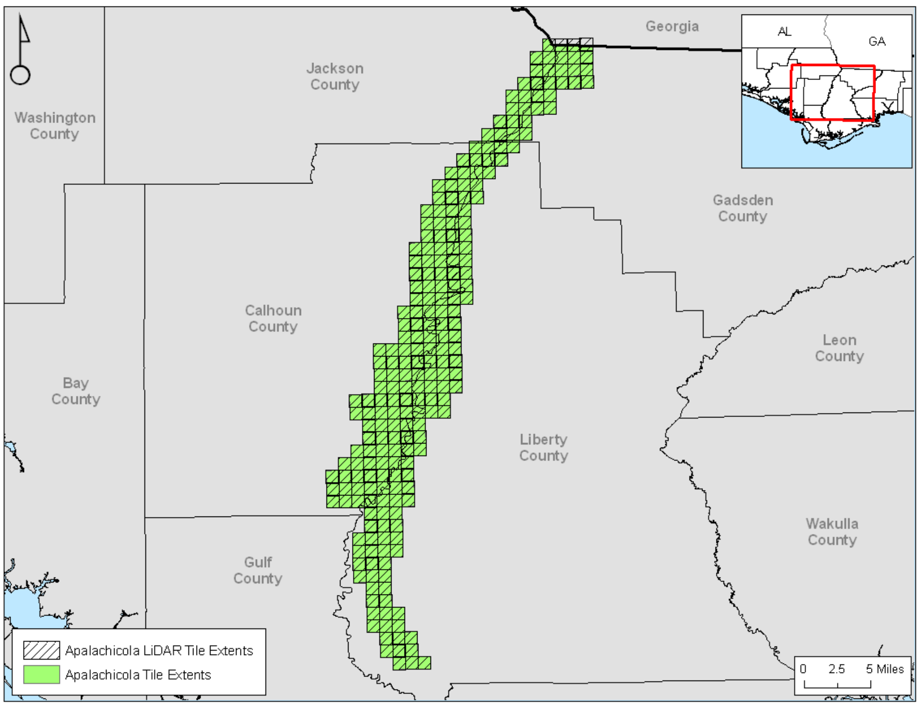


Figure 21 - Delivered LiDAR tiles – extent of the LAS files.

3.2.1 Statistical Analysis of Tile Content

Each tile was queried to extract the number of LiDAR points and all tiles are within the anticipated size range.

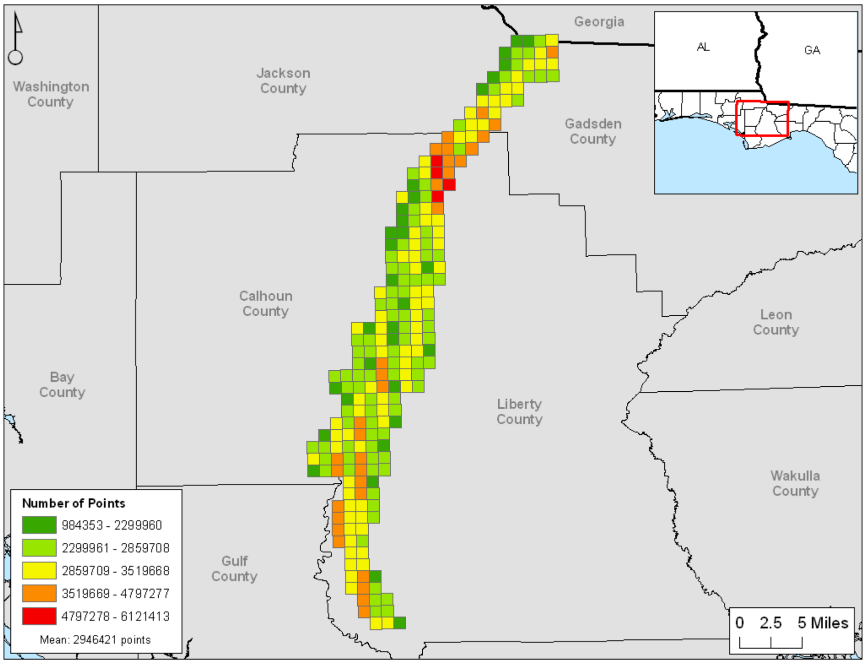


Figure 22 - Number of points per tile.

To first identify incorrect elevations, the z-minimum and z-maximum values for the ground class were reviewed. The spatial distributions of these elevations are shown in Figures 23 and 24. Tile number 59046 includes a point with an elevation of -14.47 feet. Upon further investigation of this tile, it was revealed that this point is located in water which frequently causes erroneous return vales. Merrick should have removed this point during the processing stage. No other significant anomalies were identified. Considering that the Apalachicola River drains into the Gulf of Mexico, the images of the spatial distribution of the highest and lowest elevations seem to correlate with one another.

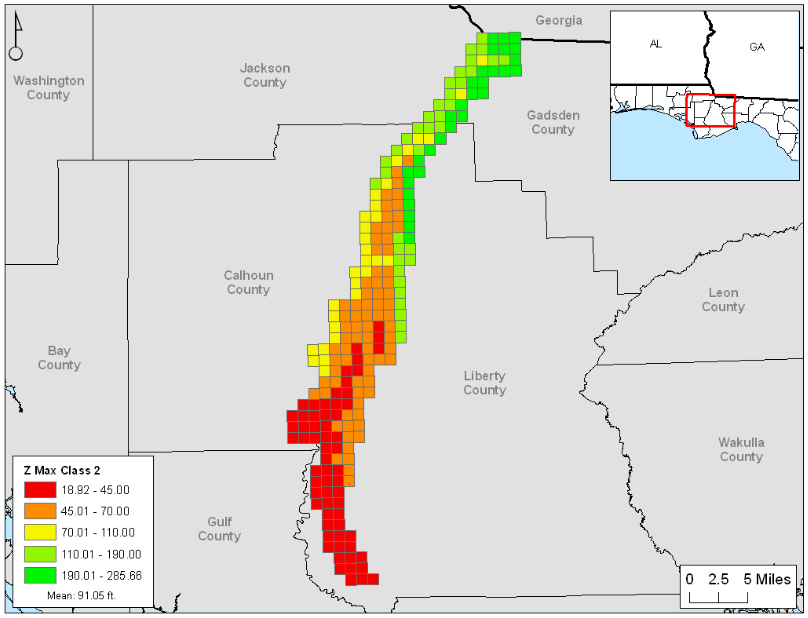


Figure 23 - Tiles classified by highest elevation in feet, class 2.

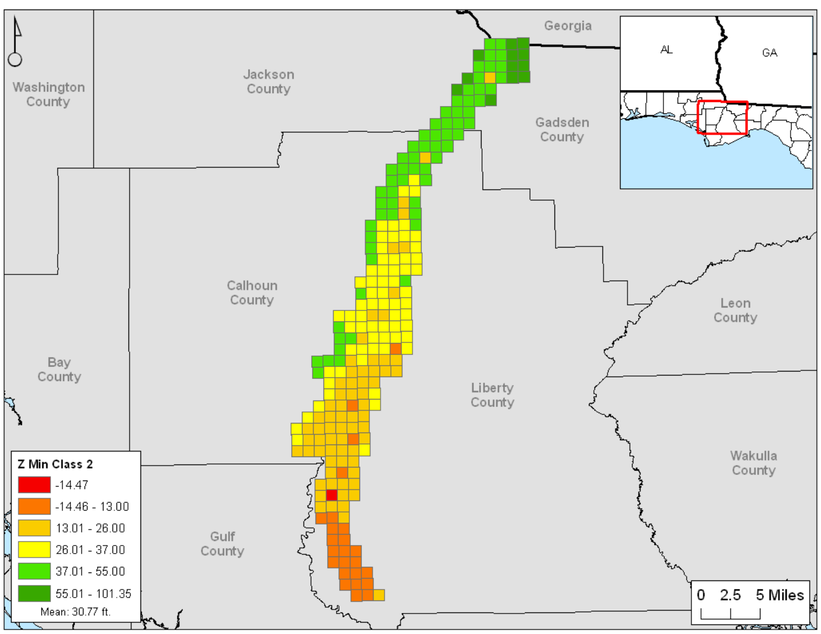


Figure 24 - Tiles classified by lowest elevation in feet, class 2.

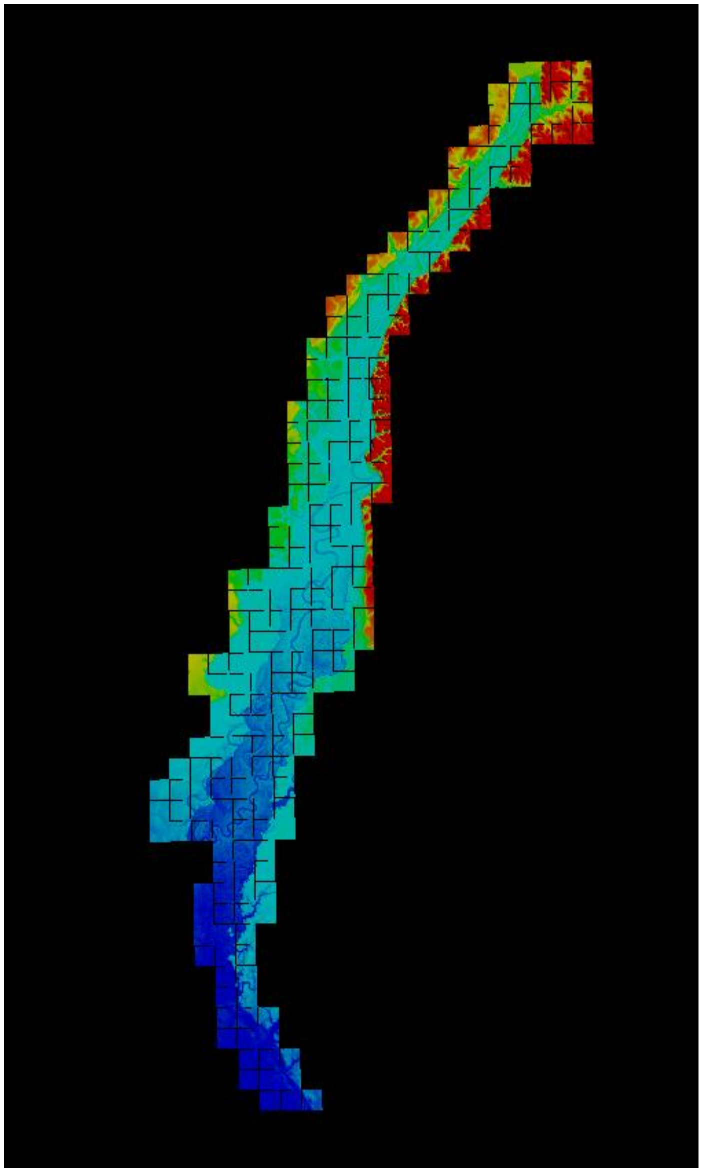


Figure 25 - Decimated image of all Apalachicola tiles. This illustration allows us to quickly ensure that the maximum and minimum values make sense.

3.3 Qualitative Assessment

Our Qualitative review was to perform a macro visual inspection of all the tiles and to inspect a minimum of 30% at a micro level of detail. Additionally we reviewed 10% of the data for the scanning and flightline consistency. The Apalachicola data proved to be of good quality. Generally speaking no voids or significant anomalies were found although Dewberry did find a few minor errors which are explained below.

Divots

There were very few divots seen in the data the most noticeable of which occurred in urban areas where the points are more likely to bounce off of hard surfaces. Figure 26 illustrates an example of this.

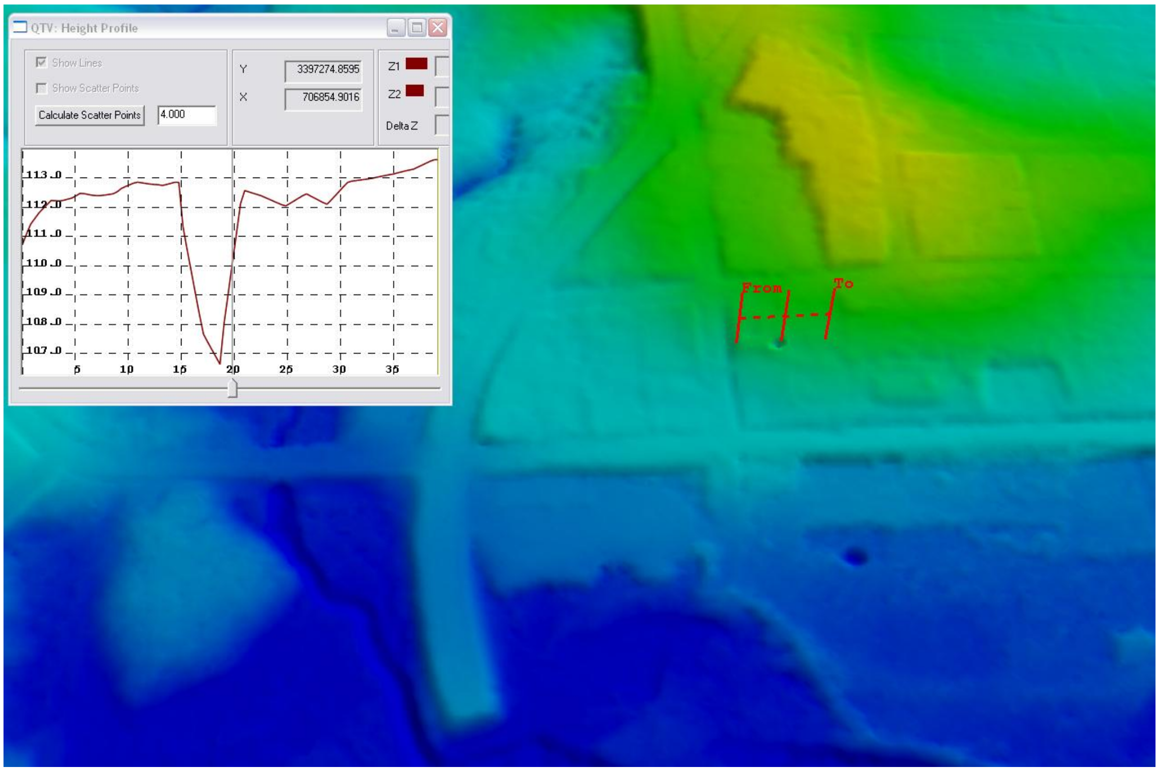


Figure 26 – Residential area of tile 38543. The low point is approximately 6 feet below the surrounding LiDAR points.

Vegetation Artifacts/Noisy Data

There were a couple areas where the vegetation removal process was not completely successful. We did not consider this to be a significant issue considering it was not widespread as well as the fact that the dense, swampy terrain makes classification difficult in some areas.

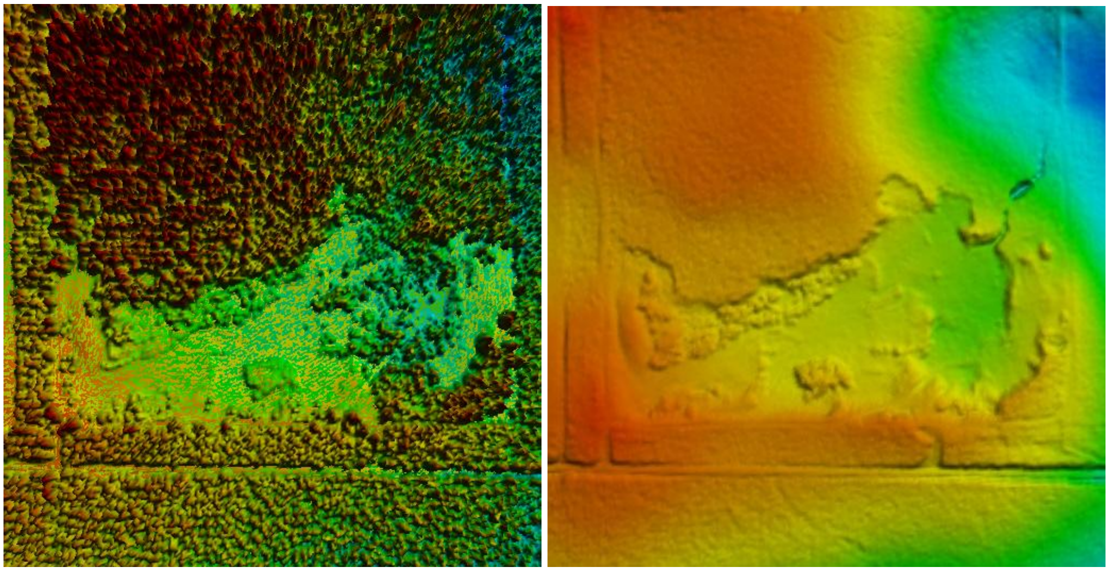


Figure 27 – Tile 42853. Left image is full point cloud of tile showing the dense vegetation. Right image is the same tile showing ground points. The changes in vegetation density make classification difficult.

Poor Penetration

Patches of sparse data were also found. The images in Figure 28 are a typical example of this problem in the Apalachicola dataset although this can be expected due to the swampy terrain.

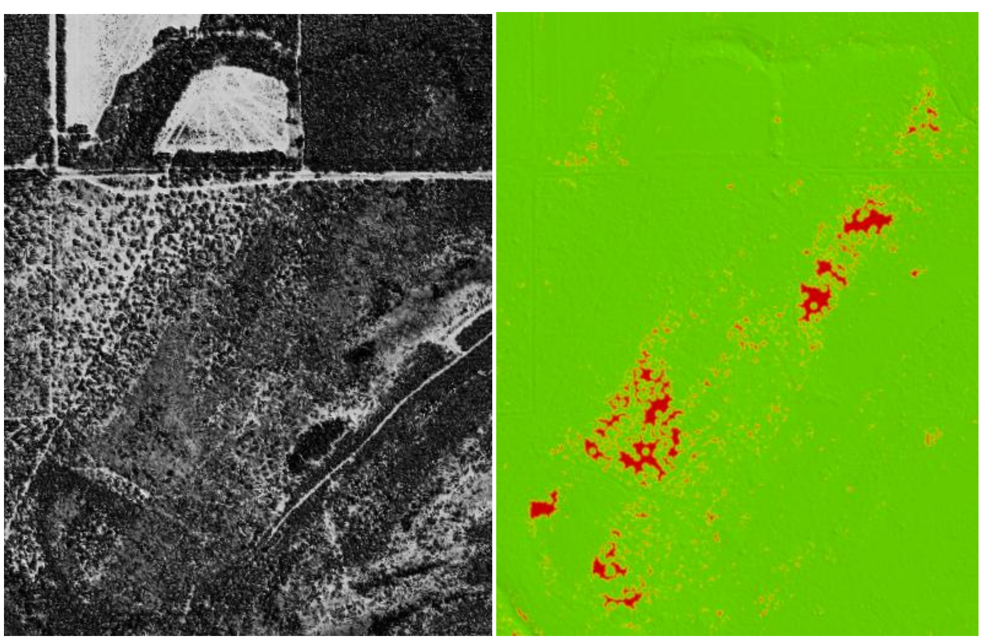


Figure 28 – Tile 57428. Left image is full point cloud representation, right is density image. The red in the density image indicates areas of no data.

4 Gadsden LiDAR QAQC Review

The Gadsden project area is approximately 535 square miles in Gadsden County, Florida. The dataset was acquired and processed by Merrick in September of 2007.

4.1 Vertical Accuracy Assessment

The field survey was conducted and prepared by Gustin, Cothern, & Tucker, Inc. in September and October 2007 for Merrick. A total of 45 points were captured throughout the project area; these points are listed in Appendix E – Gadsden Checkpoints. In the LAS metadata Merrick states that the LiDAR data exceeds the NSSDA specification of 1.2 feet. In order to verify this value, Dewberry performed an additional accuracy check utilizing the survey checkpoints as provided by Merrick. Figure 39 shows the distribution of the checkpoints throughout the Gadsden LiDAR extents.

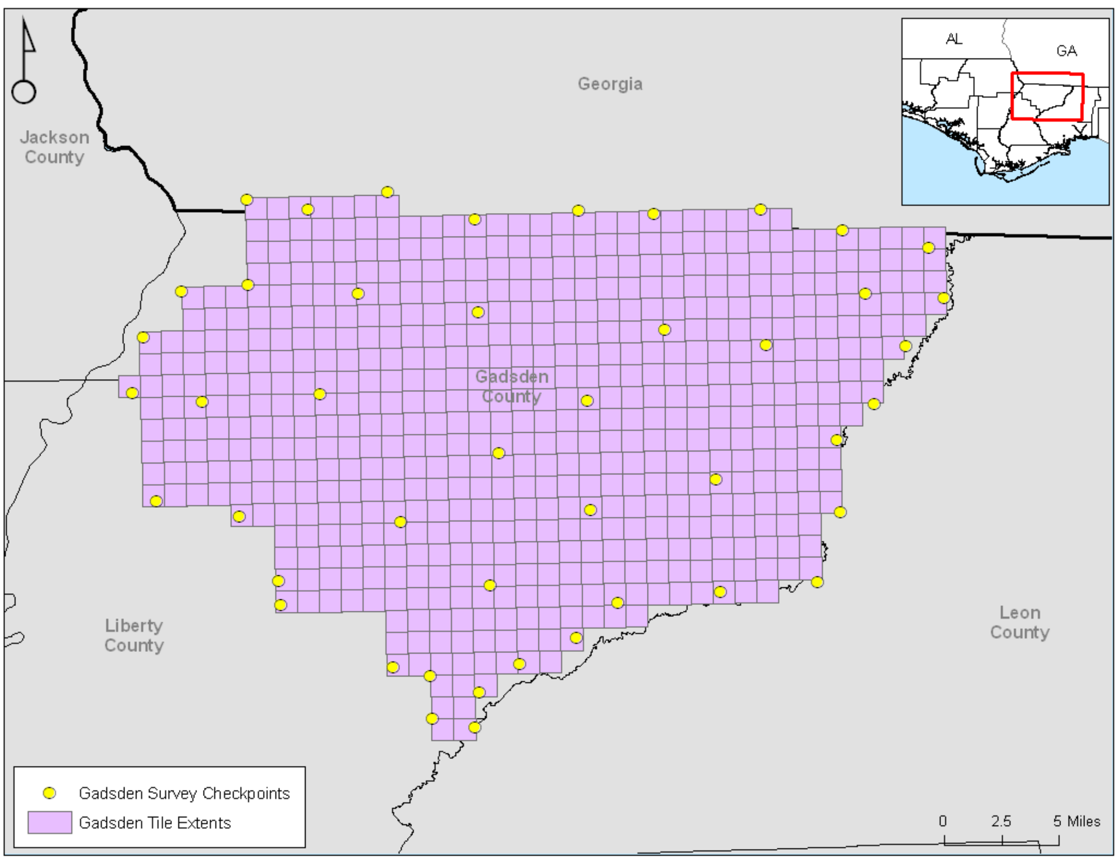


Figure 29 - Checkpoints for survey of Gadsden LiDAR data.

Tables 7 and 8 show the complete results of the Apalachicola dataset run through the Dewberry RMSE process. The Gadsden survey data was missing land cover information so the calculations were completed based on consolidated values as well. Merrick's results were confirmed and the data meets specifications.

Table 7 - Dewberry RMSE Report.

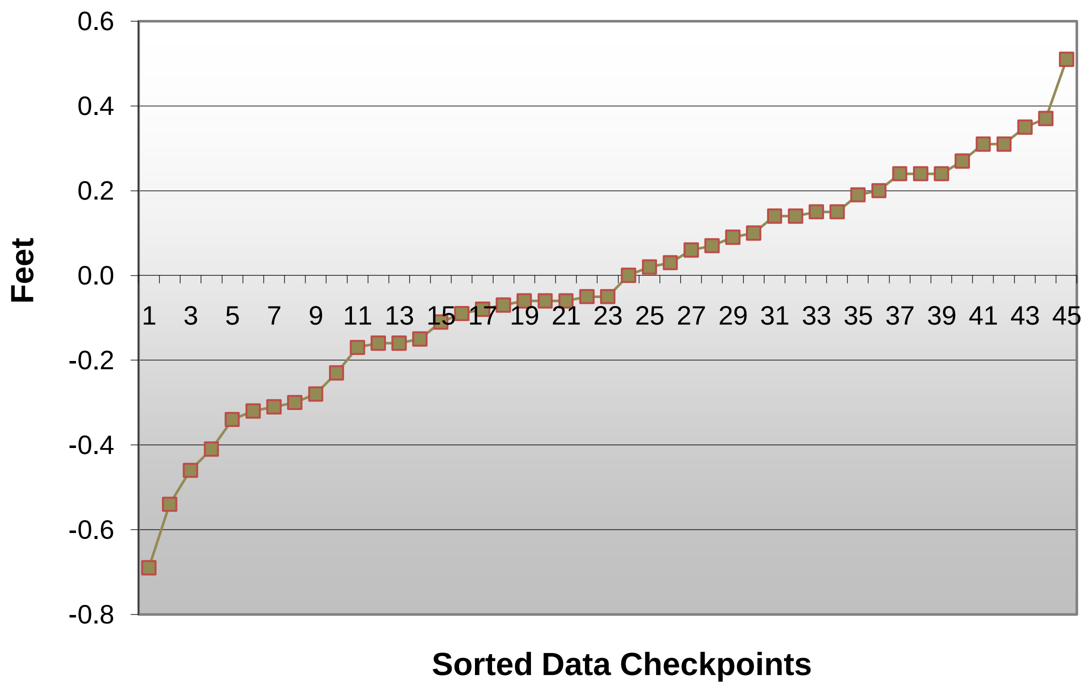
100 % of Totals	RMSE (ft) Spec=0.61ft	Mean (ft)	Median (ft)	Skew	Std Dev (ft)	# of Points	Min (ft)	Max (ft)
Consolidated	0.257	-0.022	-0.050	-0.365	0.259	45	-0.690	0.510

Table 8 - Dewberry RMSE Report.

Land Cover Category	# of Points	FVA — Fundamental Vertical Accuracy (RMSEz x 1.9600) Spec=1.195 ft	CVA — Consolidated Vertical Accuracy (95th Percentile) Spec=1.195 ft	SVA — Supplemental Vertical Accuracy (95th Percentile) Target=1.195 ft.
Consolidated	45		0.500	

Table 9 illustrates the distribution of the elevation differences between the LiDAR data and the surveyed points. The elevation deltas are centered on around zero which indicates a normal error distribution.

Table 9 - Sorted elevation errors for 45 survey checkpoints.



Dewberry's review of the vertical accuracy confirms Merrick's statement that the Gadsden LiDAR data meets accuracy standards according to NSSDA specifications.

4.2 Completeness of LiDAR Variables

A total of 597 LAS files and 597 DEM rasters in ArcGIS GRID format as well as 597 masspoint shapefiles were delivered by Merrick for the project. The extents of the LiDAR tiles are illustrated in Figure 31. The area without data in the northwestern part of the county is covered by the Apalachicola LiDAR dataset. The tiles on the eastern boundary of the county are located in water (as shown by the decimated point image in Figure 31) and were not delivered.

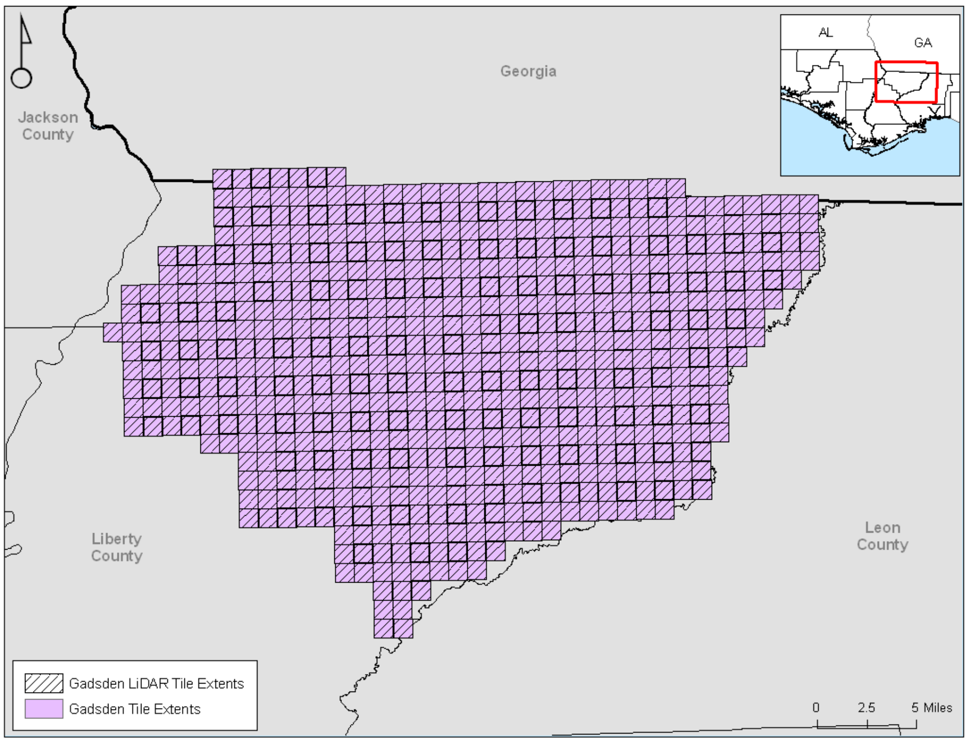


Figure 30 - Delivered LiDAR tiles - extent of LAS files.

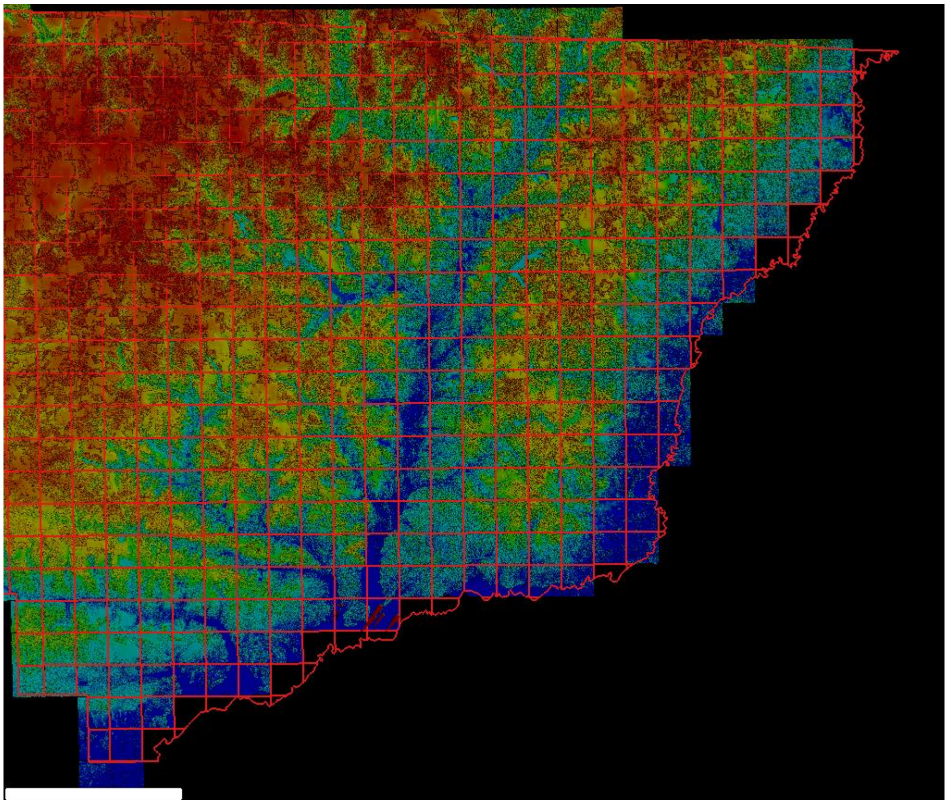


Figure 31 - Decimated point image of Gadsden LiDAR data. Note the Ochlockonee River along the eastern boundary of the county.

Dewberry verified that the data is in the correct projection and each LAS file includes the following information:

- Intensity
- Return Number, number of returns, GPS time
- Classification
    - Class 1 for unclassified
    - Class 2 for ground
    - Class 9 for water

These classes do not conform to the NWFWMD specifications which called for class 2 for ground and class 5 for canopy.

4.2.1 Statistical Analysis of Tile Content

Each tile was queried to extract the number of LiDAR points and no noticeable errors were found.

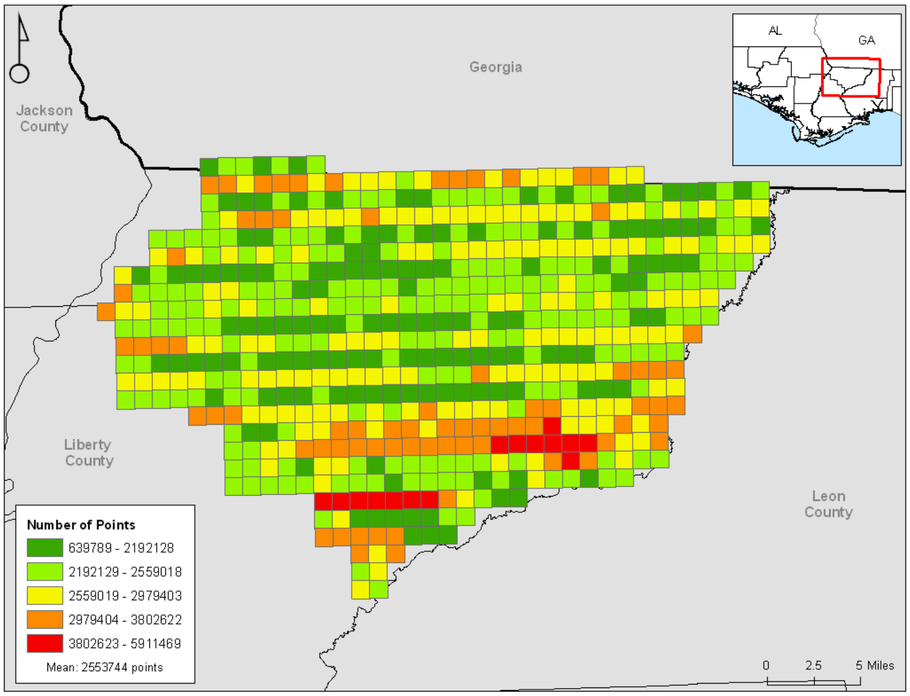


Figure 32 - Number of points per tile.

To first identify incorrect elevations, the z-minimum and z-maximum values for the ground class were reviewed. The spatial distributions of these elevations are shown in Figures 33 and 34. With maximum values between 83 and 334 ft, no noticeable anomalies were identified.

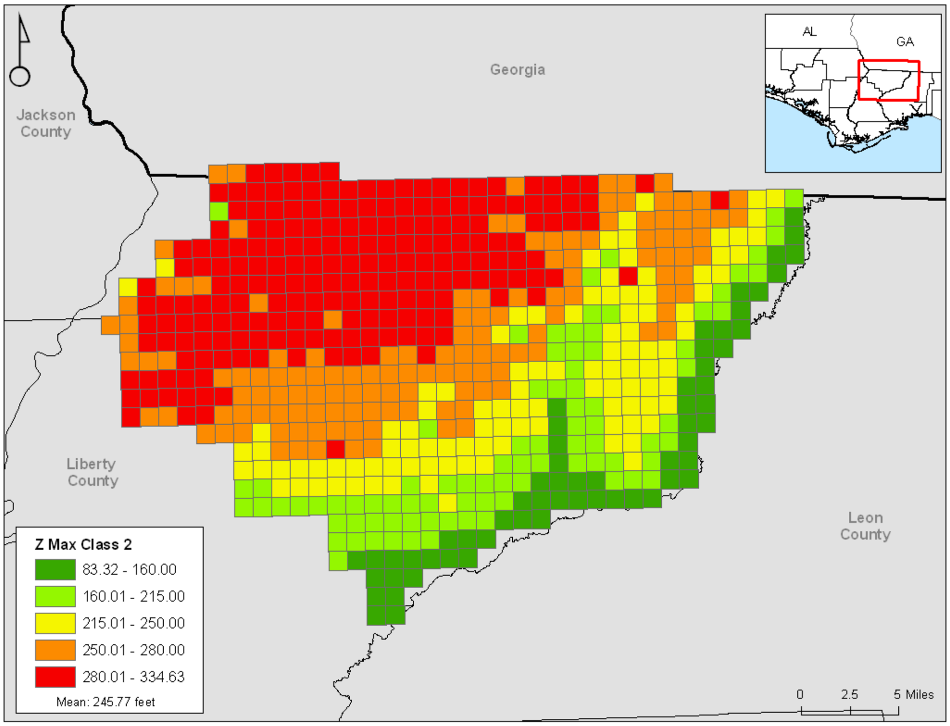


Figure 33 - Tiles classified by highest elevation in feet, class 2.

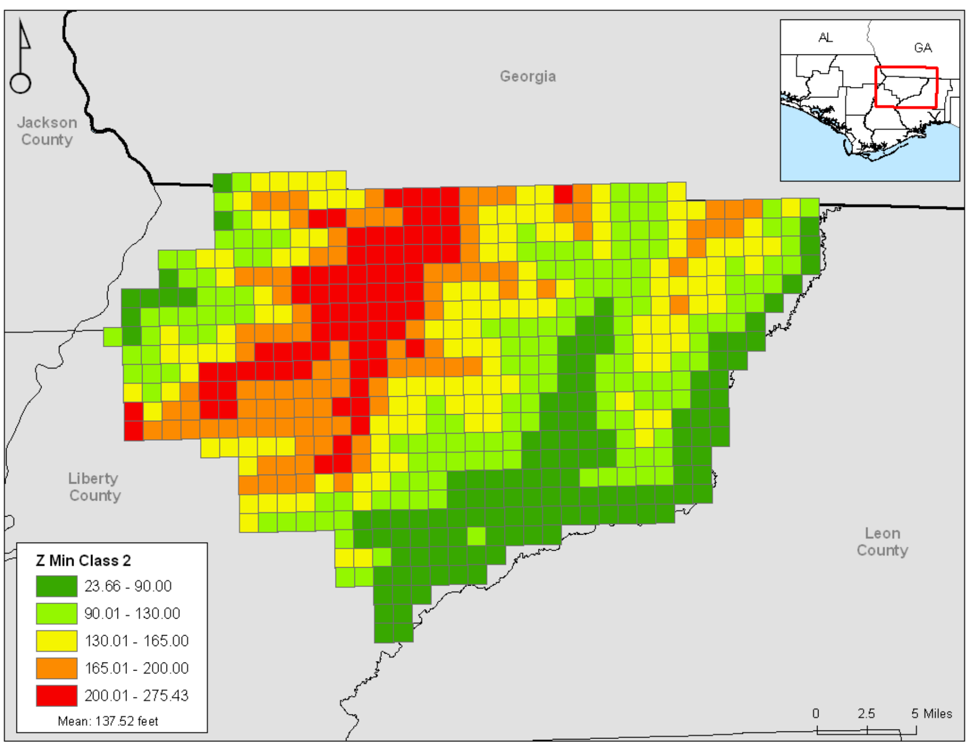


Figure 34 - Tiles classified by lowest elevation, class2.

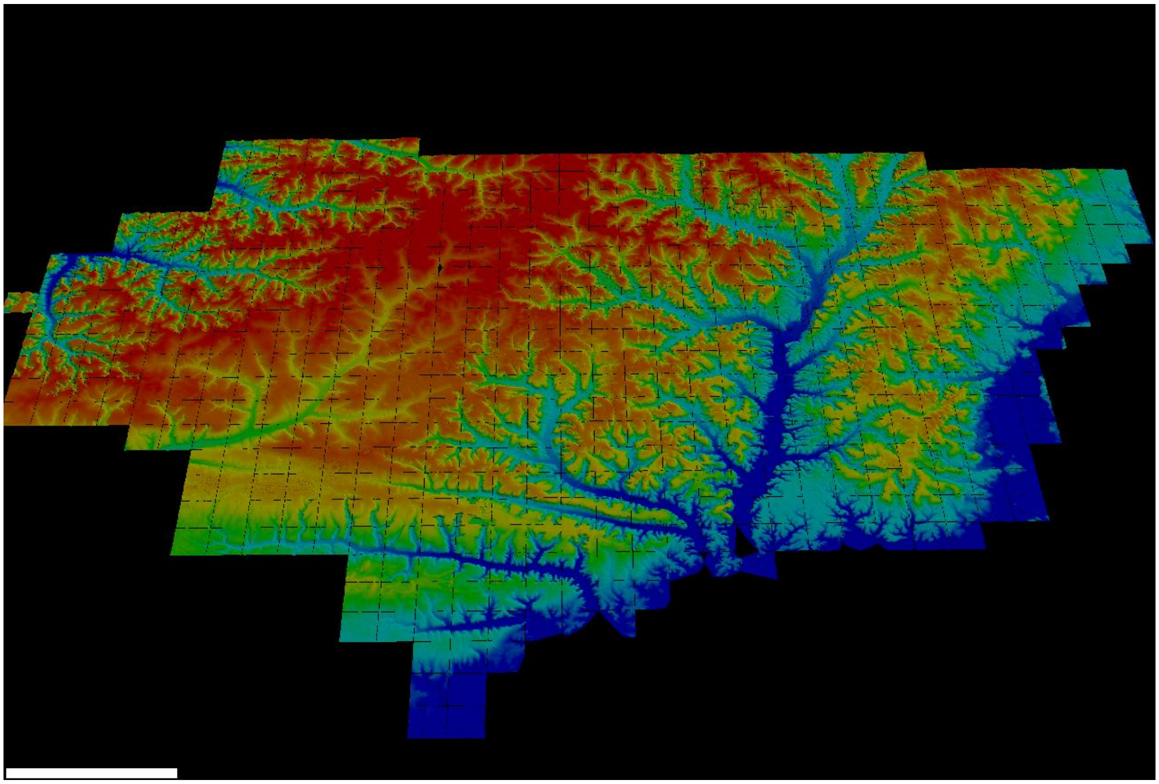


Figure 35 - Decimated image of all the Gadsden tiles.

4.3 Qualitative Assessment

Our Qualitative review was to perform a macro visual inspection of all the tiles and to inspect a minimum of 30% at a micro level of detail. Additionally we reviewed 10% of the data for scanning and flightline consistency. The Gadsden data proved to be of good quality and no major errors were found. There were some minor anomalies discovered which are outlined in the text and images below.

Poor Penetration

As seen in the decimated image of the Gadsden LiDAR data in Figure 36, the terrain in Gadsden County is extremely swampy and includes a lot of water. As a result, the LiDAR data had a hard time penetrating to the ground. The images in Figures 37-39 are representative of the many areas of poor penetration that were see throughout this dataset.

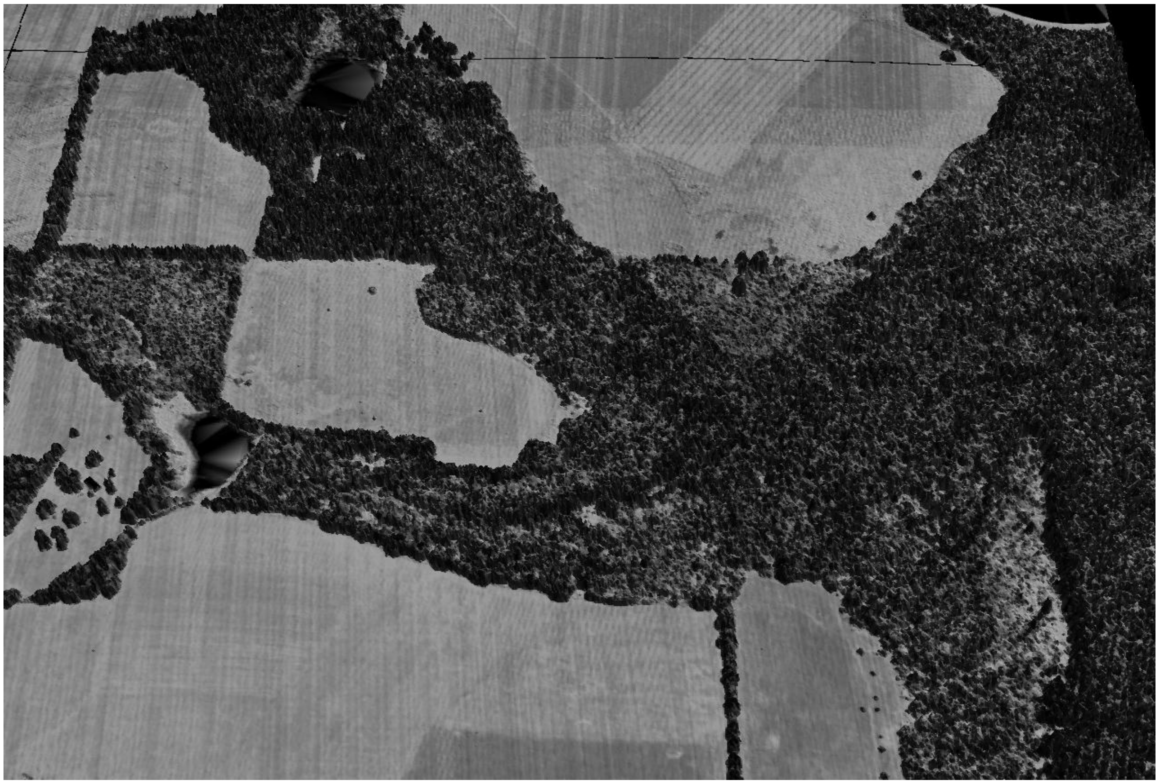


Figure 36 – Tile 42870. Full point cloud intensity image of densely vegetated stream channel.

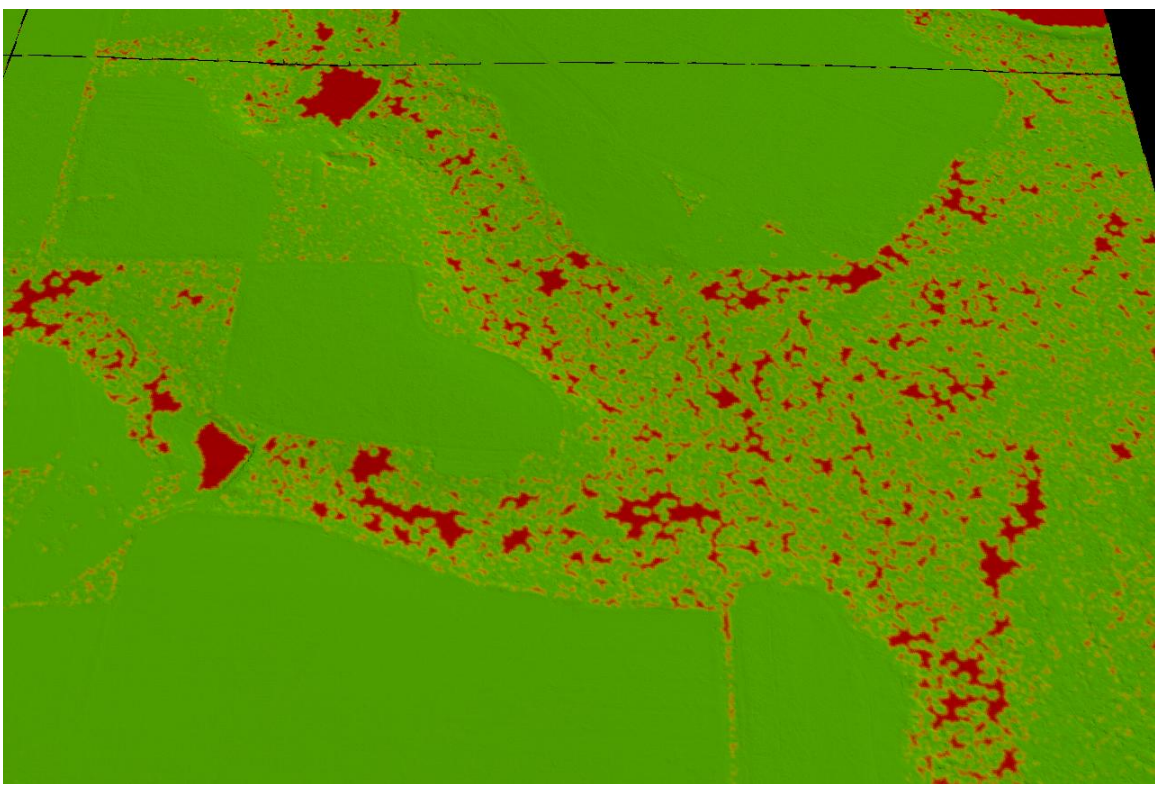


Figure 37 – Ground density image of same area. The red indicates areas of no data where the LiDAR was unable to penetrate the vegetation.

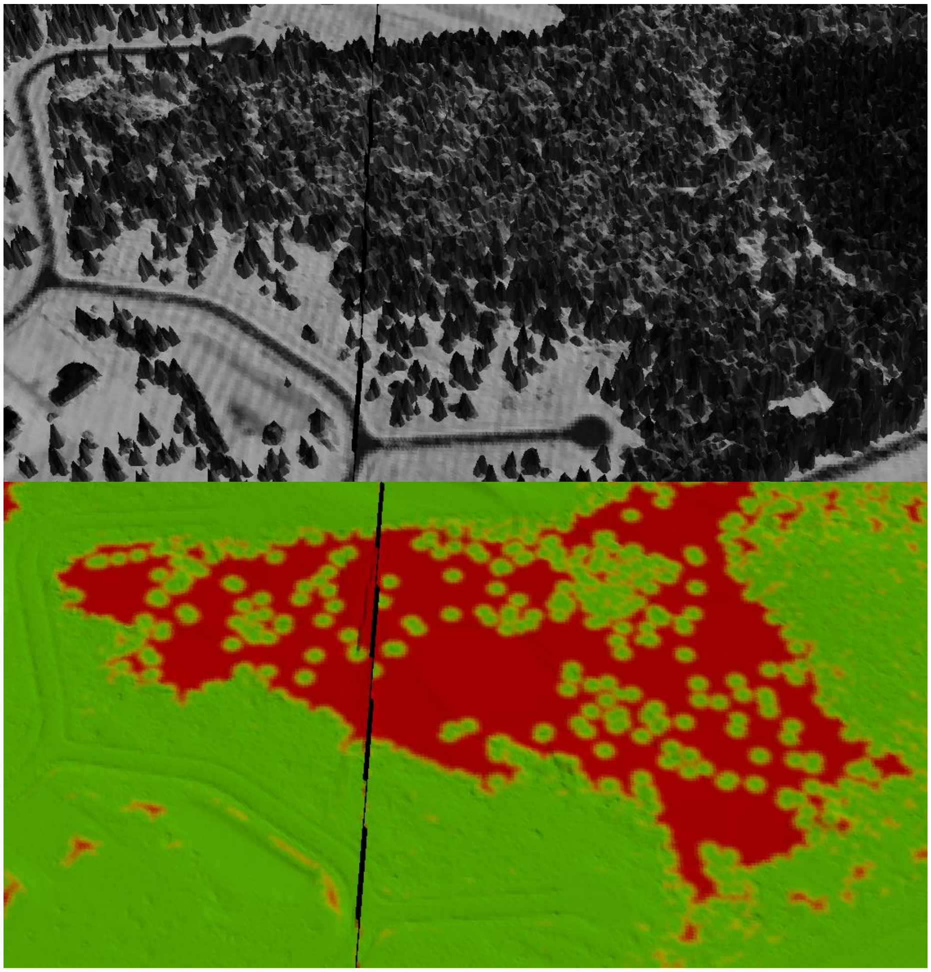


Figure 38 – Tiles 40730 and 40731. Top image is full point cloud intensity. Bottom is ground density image. Very few points penetrated here.

Misclassification

There were a few instances where the parameters used to classify the data produced erroneous results. This can happen in locations where the density of the terrain varies within a relatively small area. Figure 39 displays an example of this. The area within the white circle was removed from the ground class although it looks like these points were in fact the ground.

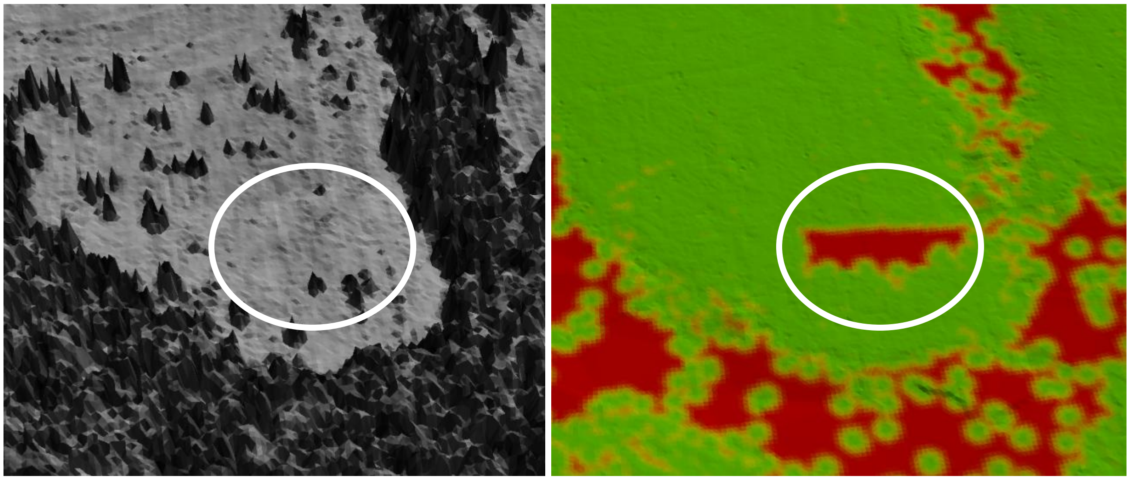


Figure 39 – Tile 41270. Left image is full point cloud with intensity. Right image is ground density and shows a gap in the data created during the classification process.

Artifacts and Noisy Data

During the review of the Gadsden LiDAR data many instances were found where vegetation or buildings were left in. The building artifacts (Figure 40) seemed to be rather isolated incidents while the vegetation artifacts proved to be rather rampant throughout the dataset.

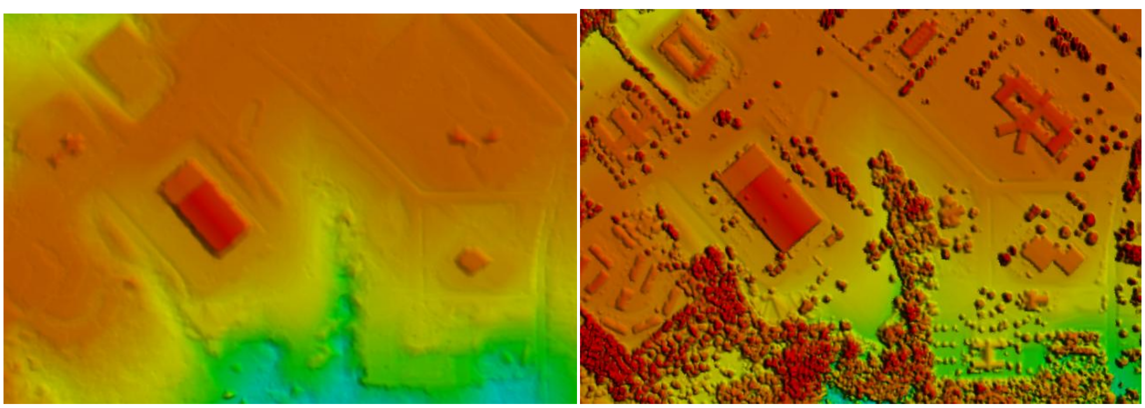


Figure 40 – Tile 42881. Left is ground image where remnants of buildings are visible. Right image is full point cloud.

Figure 41 displays an area where the vegetation removal process was not fully successful resulting in noisy data.

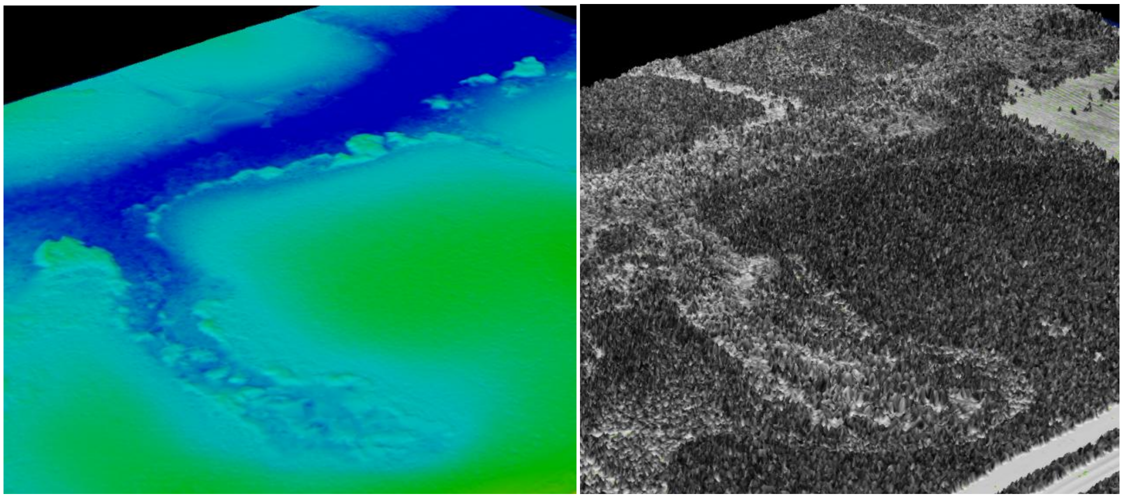


Figure 41 – Tile 45568. Left is ground image with vegetation left in. Right is full point cloud image with intensity.

5 Large Area LiDAR QAQC Review

This LiDAR dataset covered approximately 2102 square miles and includes all of Holmes County, and parts of Washington, Jackson, Calhoun, and Liberty Counties in Florida. "Large Area" was an arbitrary name given to the dataset in order to distinguish between the other LiDAR datasets collected for this project that included some of these counties. The data were acquired and processed by Merrick & Company from November 2007 to January 2008.

5.1 Vertical Accuracy Assessment

The field survey was conducted and prepared by Allen Nobles & Associates for Merrick. A total of 176 GPS checkpoints were collected throughout the project area (Appendix G – Large Area Checkpoints). In the LAS metadata Merrick states that the data exceeds the NSSDA vertical accuracy specification of 1.2 feet. In order to verify this as well as derive other useful statistics, Dewberry performed an additional accuracy check utilizing the survey checkpoints as provided by Merrick. Figure 42 shows the distribution of the checkpoints throughout the Large Area LiDAR extents.

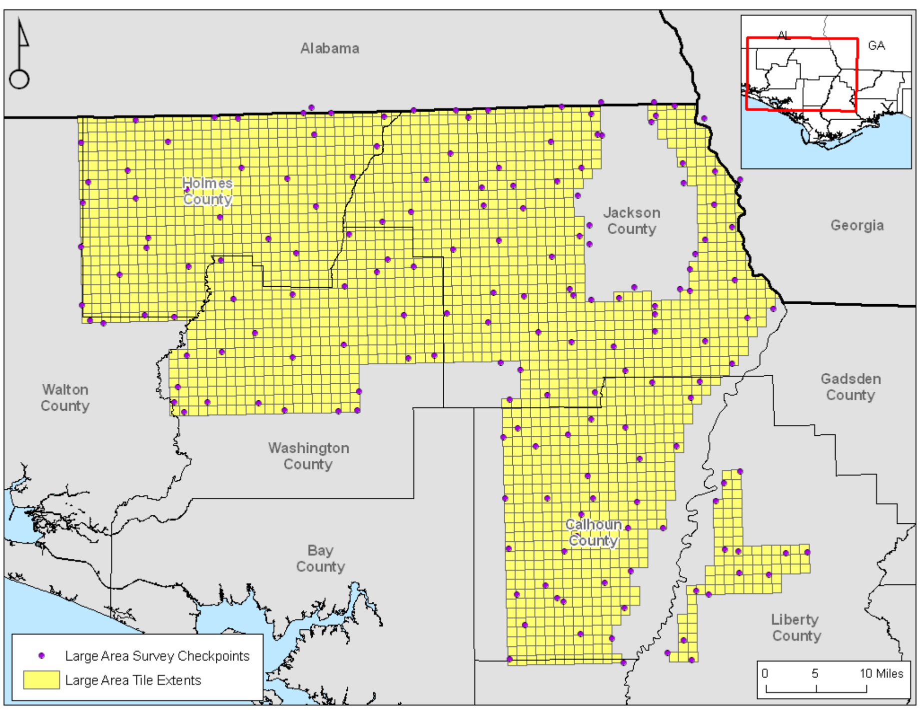


Figure 42 - Checkpoints for Merrick survey of Large Area.

Tables 10 and 11 show the complete results of the Large Area dataset run through Dewberry's RMSE process. These calculations were also completed based on consolidated values. The results proved to be well within the specified RMSE and CVA.

Table 10 – Dewberry RMSE report.

100 % of Totals	RMSE (ft) Spec=0.61ft	Mean (ft)	Median (ft)	Skew	Std Dev (ft)	# of Points	Min (ft)	Max (ft)
Consolidated	0.486	-0.052	-0.110	0.287	0.485	176	-1.250	1.310

Table 11 - Dewberry RMSE report.

Land Cover Category	# of Points	FVA — Fundamental Vertical Accuracy (RMSEz x 1.9600) Spec=1.195 ft	CVA — Consolidated Vertical Accuracy (95th Percentile) Spec=1.195 ft	SVA — Supplemental Vertical Accuracy (95th Percentile) Target=1.195 ft.
Consolidated	176		0.980	

Table 12 illustrates the distribution of the elevation differences between the LiDAR data and the surveyed points. The elevation deltas are centered around zero which indicates a normal error distribution.

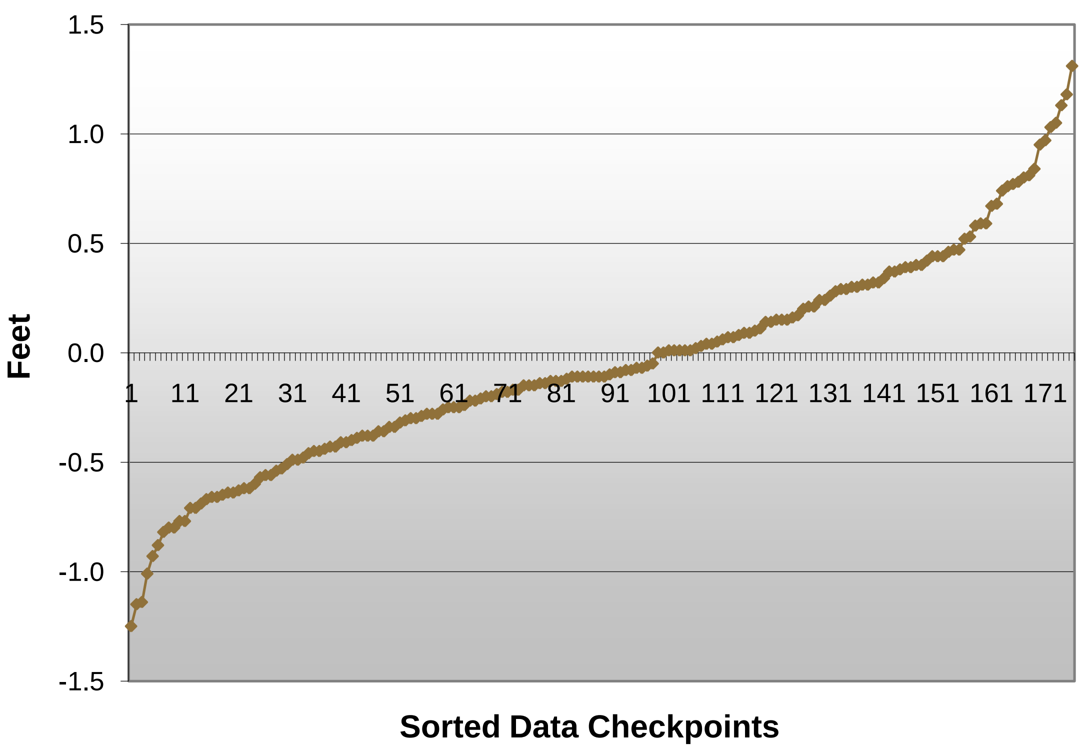


Table 12 - Sorted elevation errors for 176 survey checkpoints.

Dewberry's review of the vertical accuracy of the Large Area data confirms Merrick's statement that the dataset meets NSSDA accuracy standards.

5.2 Completeness of LiDAR Variables

A total of 2344 LAS tiles, 2344 DEM rasters in ArcGIS GRID format, and 2344 masspoint shapefiles were delivered by Merrick for the entire project overlapping all the required area (Figure 43). Dewberry verified that the data is in the correct projection and each LAS file includes the following information:

- XYZ Coordinates
- Intensity
- Return number, number of returns, GPS time
- Flightlines
- Classification
    - Class 1 for unclassified
    - Class 2 for ground

These classes are also incorrect according to NWFWMD specifications of class 2 for ground points and class 5 for canopy.

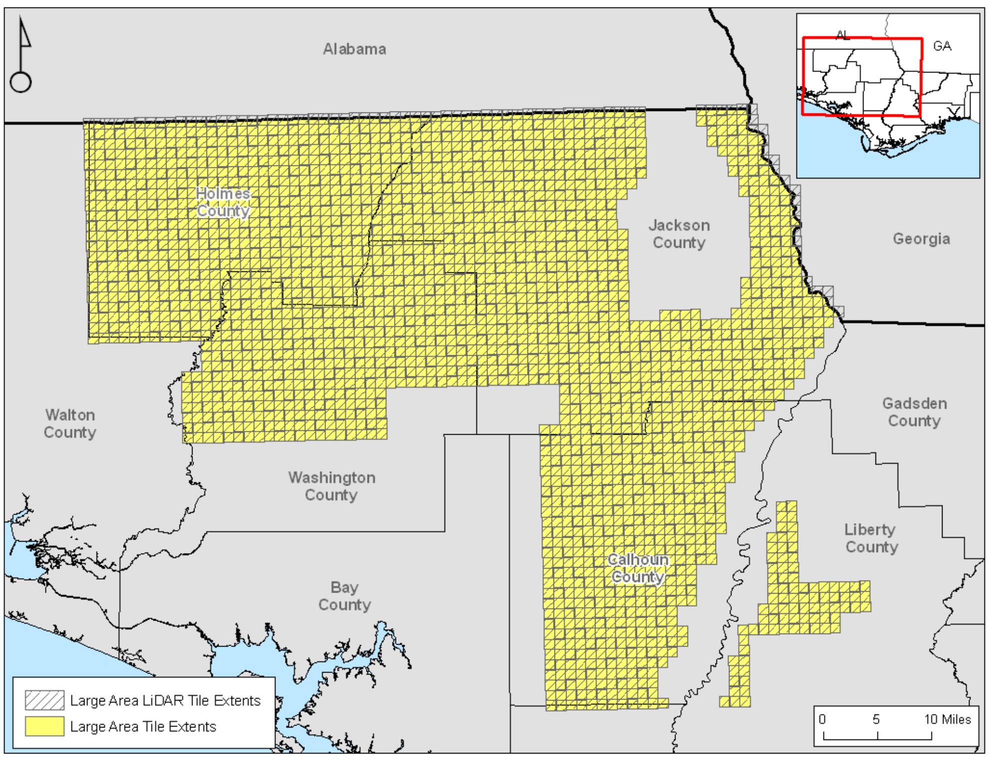


Figure 43 - Delivered LiDAR tiles - extent of LAS files.

5.2.1 Statistical Analysis of Tile Content

Each tile was queried to extract the number of LiDAR points and all tiles are within the anticipated size range.

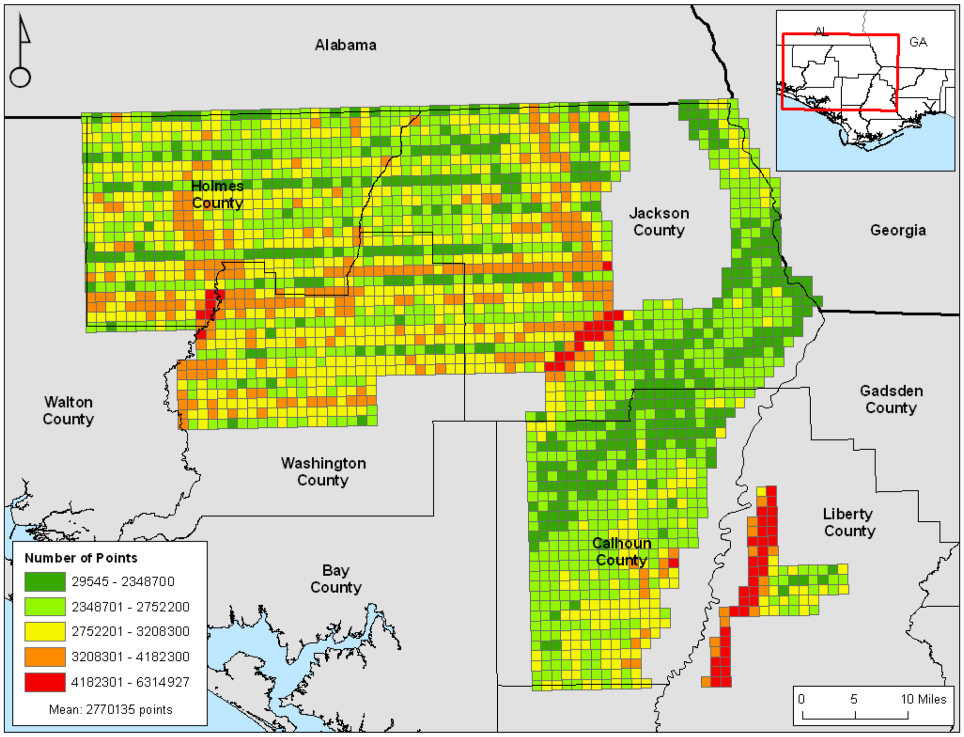


Figure 44 – Number of points per tile.

The first identify incorrect elevations, the z-minimum and z-maximum values for the ground class were reviewed. The spatial distributions of these elevations are shown in Figures 45 and 46. No noticeable anomalies were identified.

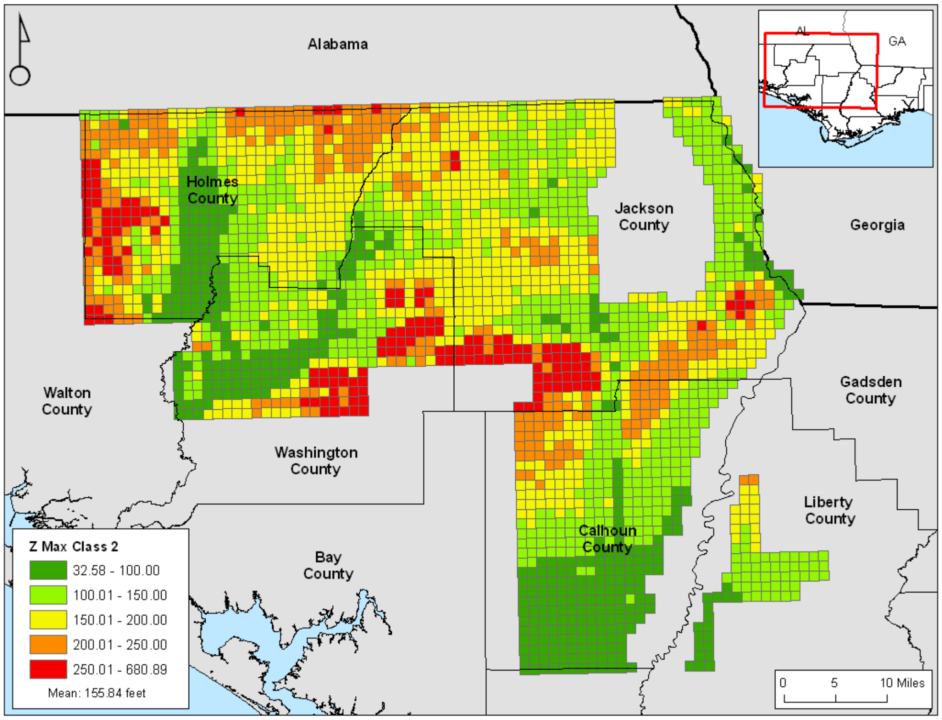


Figure 45 – Tiles classified by highest elevation in feet, class 2.

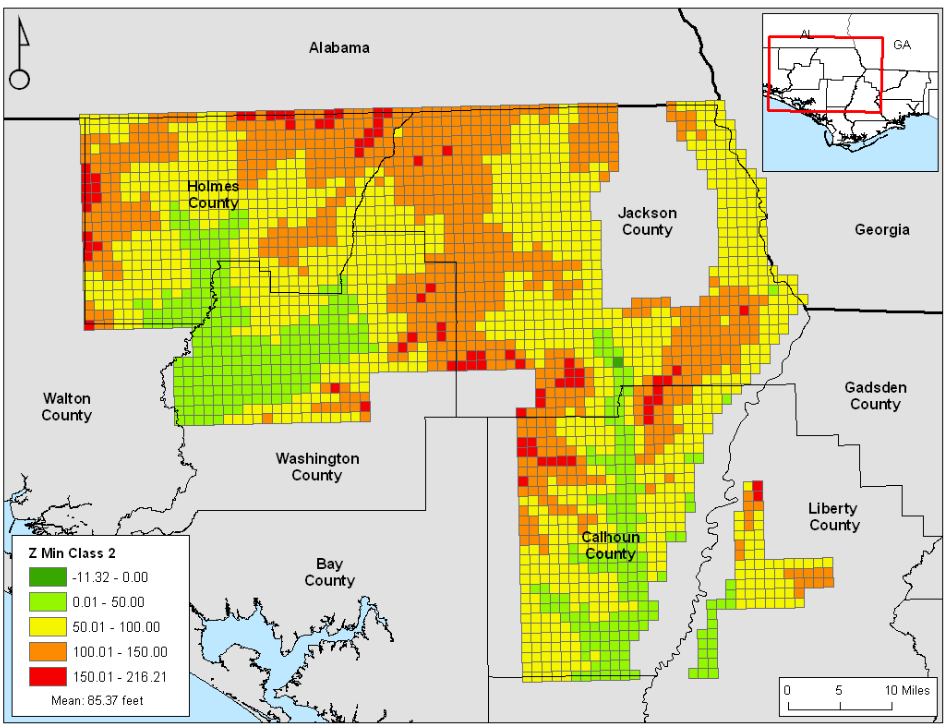


Figure 46 - Tiles classified by lowest elevation in feet, class 2.

5.3 Qualitative Assessment

Our qualitative review was to perform a macro visual inspection of all the tiles and to inspect a minimum of 30% at a micro level of detail. Additionally we reviewed 10% of the data for the scanning and flightline consistency. The Large Area LiDAR data proved to be of good quality. No major errors were found although there were a few minor issues discovered which are outlined below.

Poor Penetration

Large patches of sparse data were found. Figure 47 below displays a typical example of this problem in the Large Area dataset.

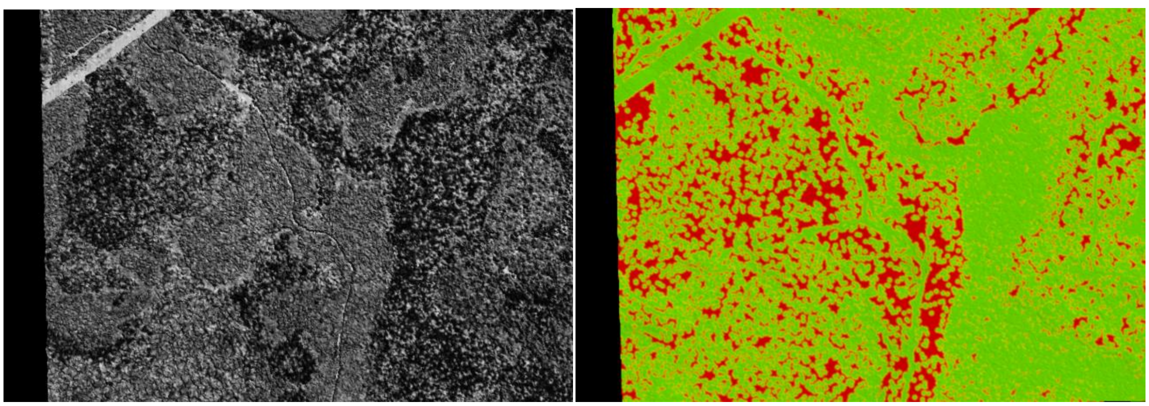


Figure 47 – Tile 34598. Left image is full point cloud image showing lots of vegetation. Right is ground density image showing areas of sparse data.

Misclassification

There were a few areas of missing ground points that seem to be the result of aggressive editing during the classification process. Figures 48 and 49 display missing patches of data within a small field. These points should not have been removed from the ground class.

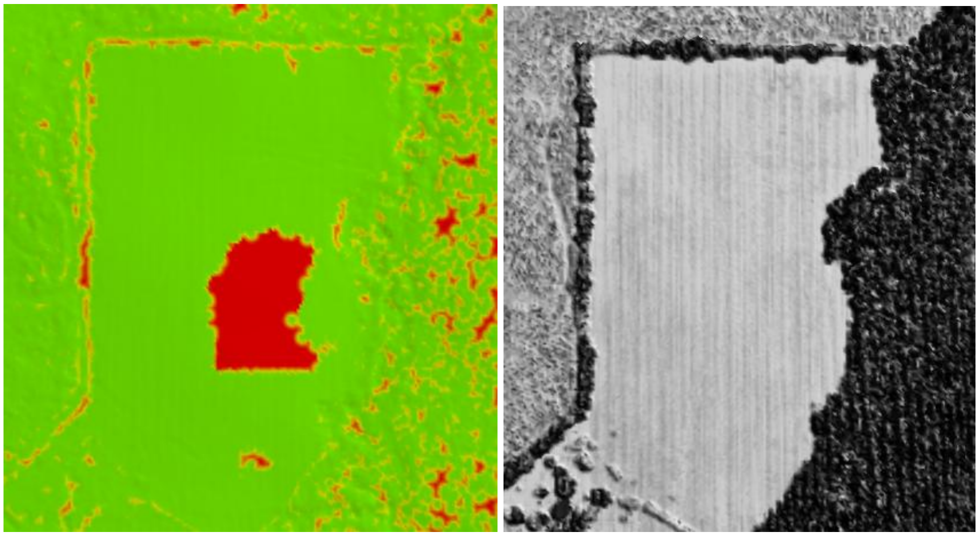


Figure 48 – Tile 27671. Left image shows area of missing data in red. Right image is full point cloud with intensity.

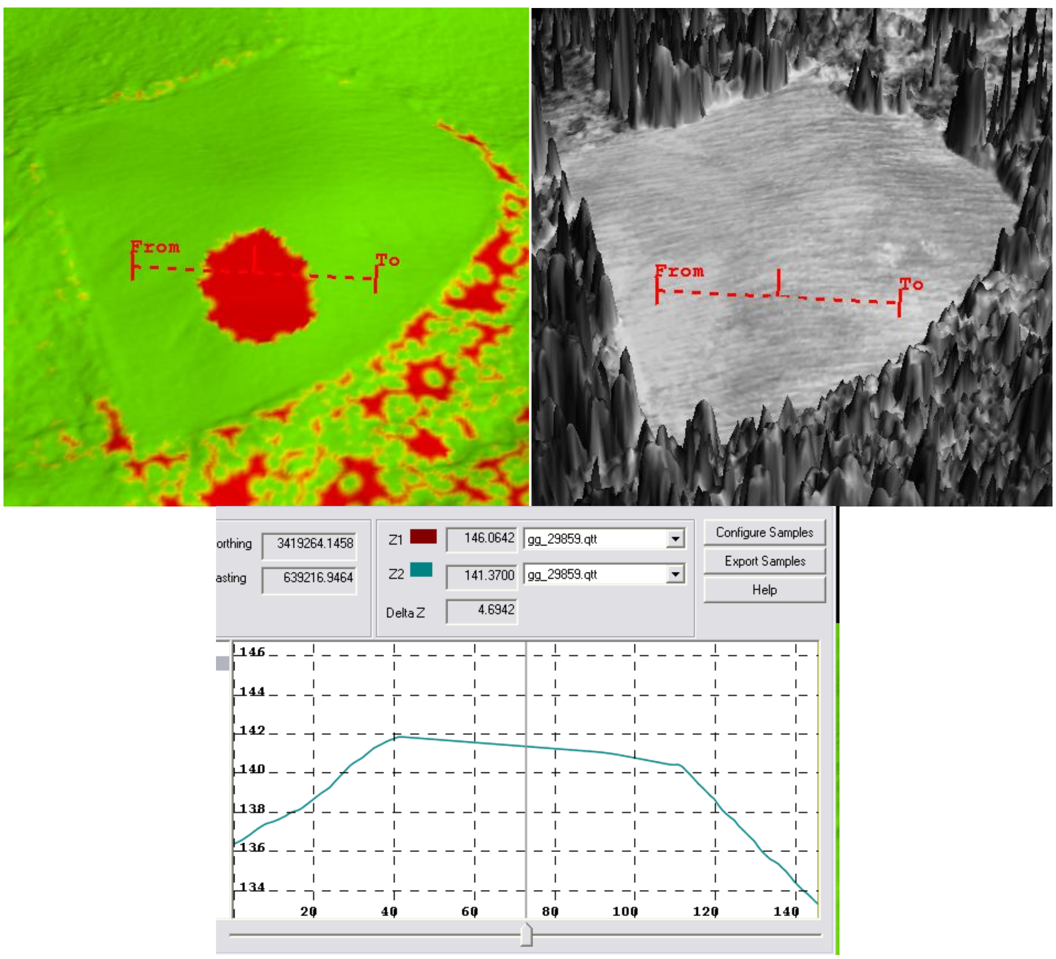


Figure 49 – Tile 29859. Top left ground density image with missing data in red. Top right full point cloud intensity (exaggeration x2) shows small field surrounded by trees. Bottom image is cross section showing a flat area where the data much jump across missing points.

6 Edgematching Between Datasets

As the four datasets were flown at different times and processed separately, it was important to take a look at the edges of each dataset to ensure that they could be effectively merged if needed. There will always be a slight difference between adjoining datasets as different parameters are used to process and classify data based on the type of terrain as well as ground conditions at the time of acquisition. In order to check this Dewberry examined 15 areas where two separate datasets met. Figure 50 shows the location of these areas in context with the LiDAR datasets extents.

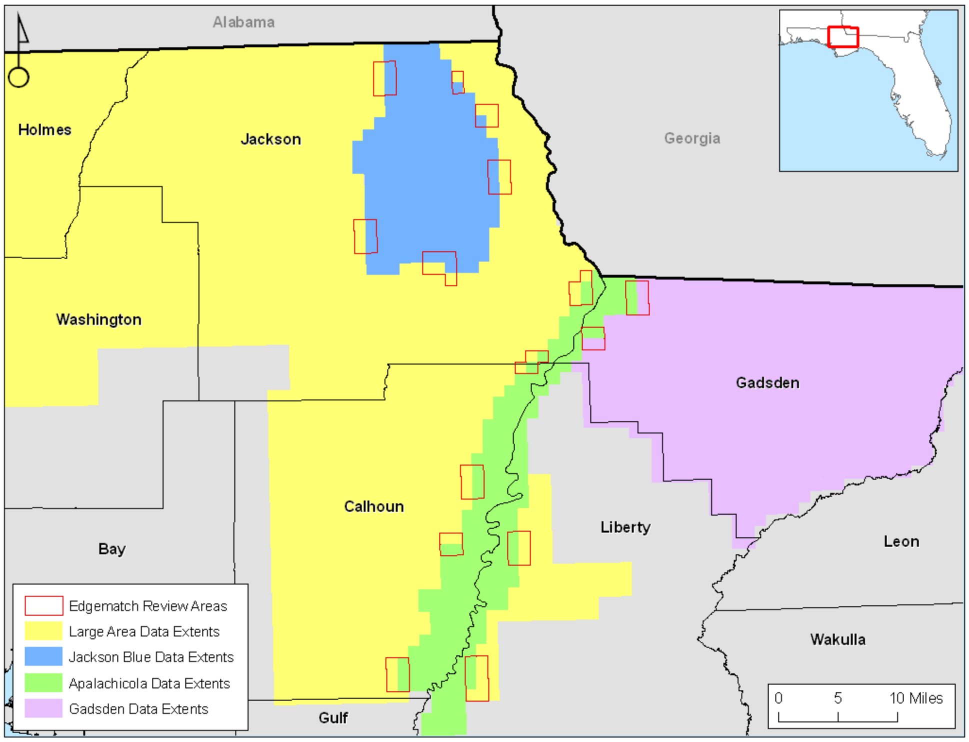


Figure 50 - Areas outlined in red were examined for potential edgematching issues.

Generally speaking, the difference between the datasets was minimal although there are a few things to be aware of when using the data across dataset lines. The biggest differences were seen between the Apalachicola data and the Large Area data and Apalachicola and Gadsden data. As discovered during the quality assessment, the Apalachicola data exhibited much better LiDAR penetration than the Large Area data and the Gadsden data. This could be a result of the time of year that each dataset was flown. The Apalachicola data was captured in March, while the other two datasets were captured in late autumn when it appears that the water levels were higher.

Figure 51 below displays an example of the penetration differences between the Gadsden data and Apalachicola data. As evidenced by the red, the Gadsden LiDAR had a tougher time penetrating to the ground than the Apalachicola.

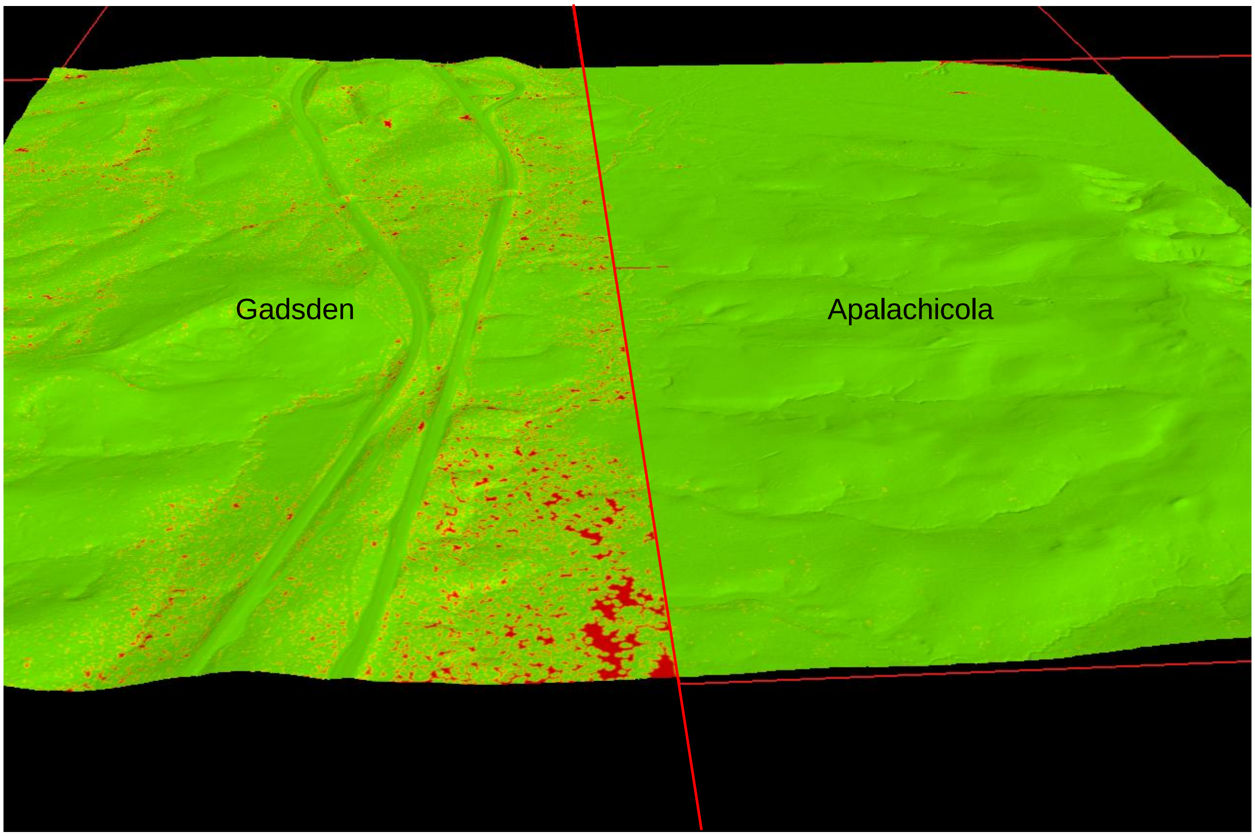


Figure 51 – Tiles 40701 and 40161. Visible change in penetration across dataset lines.

Figure 52 displays another example of the differences between the Gadsden and Apalachicola. There is a visible contrast between the noise level of the Apalachicola data (on the left side of each image) and the Gadsden data.

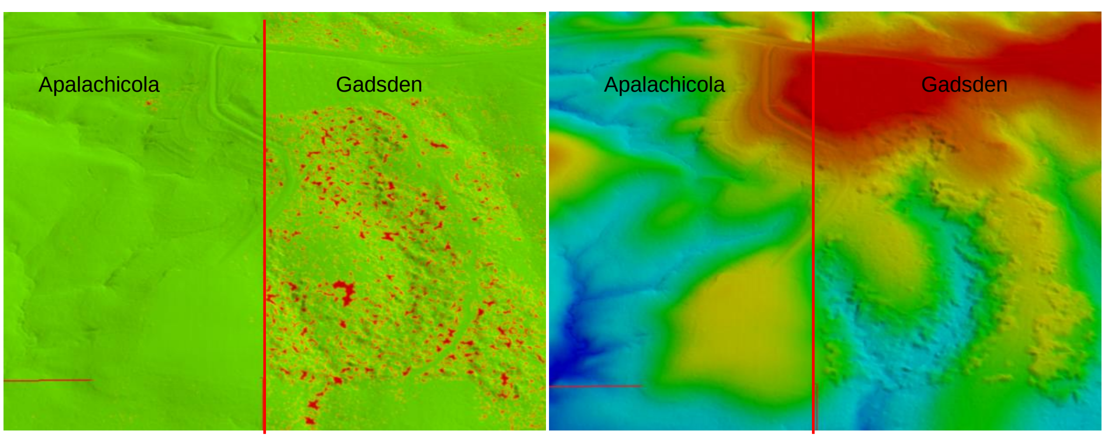


Figure 52 – Tiles 38004 and 38005. Contrast between noisy Gadsden data on right and cleaner Apalachicola data on left.

Figure 53 displays a negligible offset between the Large Area data and the Apalachicola data. Although a slight offset is clearly visible, the actual elevation difference is less than 1 foot.

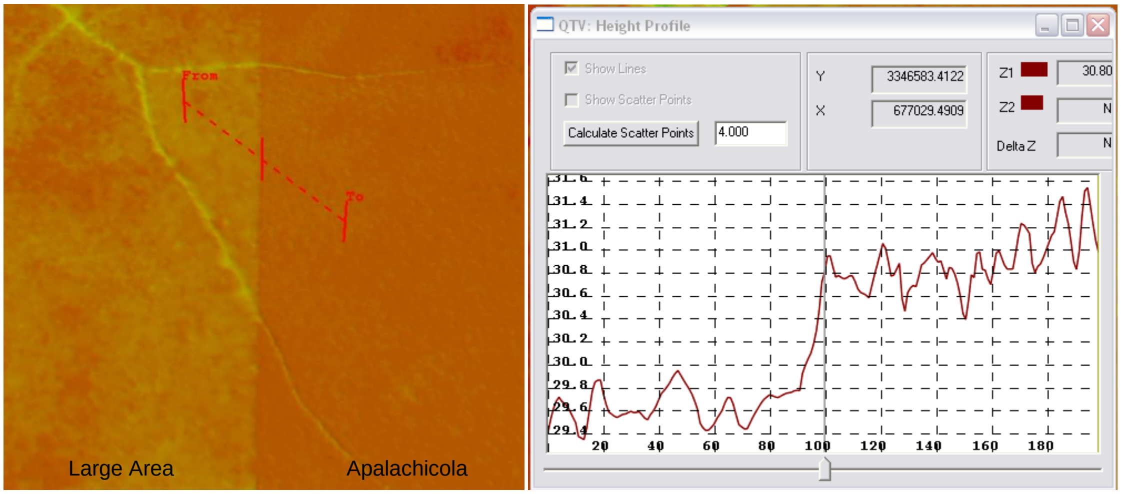


Figure 53 – Tiles 55802 and 55803. Left image is ground surface model with visible edge between Large Area LiDAR data and Apalachicola LiDAR data. Cross-section on right shows that this is approximately a 1 foot difference.

The following image displays an area along the edge of the Jackson Blue and Large Area data. Although the changes in density are visible between datasets, a cross section drawn along the road illustrates that the transition is in fact smooth.

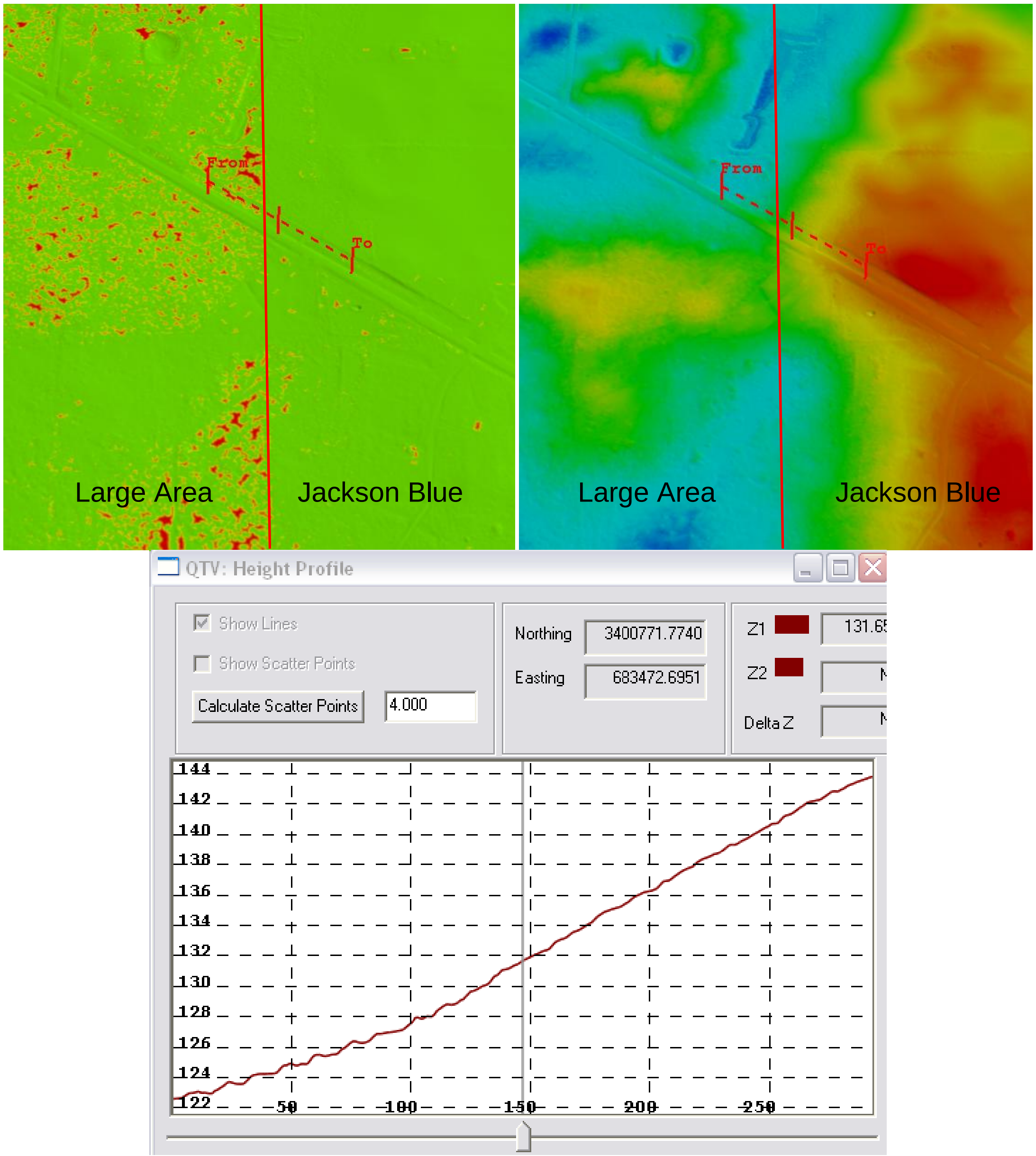


Figure 54 – Tiles 36907 and 36908. Top left is density image, right is ground surface model. The edge of each dataset is visible in both images although the cross-section does not show a difference in elevation.

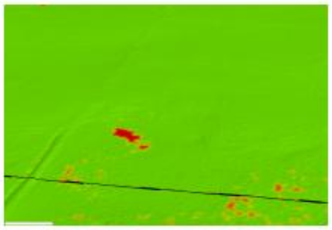
7 Conclusion

Overall the data are of good quality. The processing performed exceptionally well given the low relief and swampy terrain. No major issues were found in this data that make it unusable and most issues have minimal impact. Although there is a visible difference between the smaller datasets that were flown in the spring (Jackson Blue and Apalachicola) and the larger datasets (Large Area and Gadsden), this can be expected due to temporal changes as well as terrain differences. These data meet NSSDA standards for vertical accuracy and are sufficient to meet the needs of the Northwest Florida Water Management District.

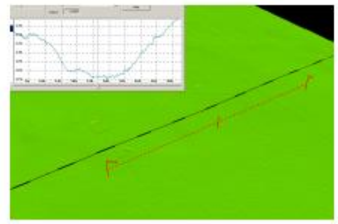
Appendix A – JacksonBlue Checkpoints

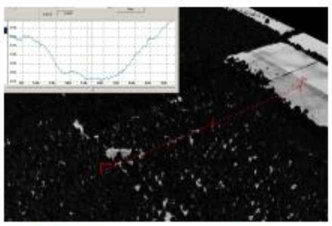
pointNo	X	Y	Z
201	675295.90	3431568.22	154.20
202	675520.91	3426369.56	141.10
203	680013.64	3427152.84	152.43
204	682002.11	3431654.32	143.70
205	684223.45	3428507.93	129.02
206	674753.64	3419821.95	136.57
207	671647.00	3416623.31	131.62
208	676936.81	3416667.66	124.30
209	688551.60	3418637.02	117.33
210	682150.29	3420265.28	125.61
211	682323.37	3415363.00	123.92
212	673441.99	3408821.01	166.90
213	673731.65	3399989.47	94.65
214	680724.28	3402032.16	156.29
215	687990.02	3401745.64	154.21
216	690379.43	3407307.92	92.91
217	681408.34	3408379.19	133.61
218	685736.70	3410999.24	109.50
219	690030.90	3412357.69	102.90

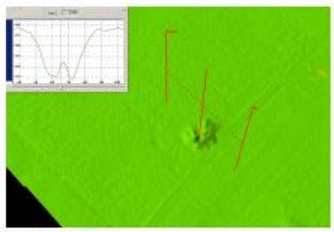
Appendix B – JacksonBlue Screenshots

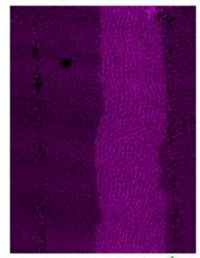

26104_PoorLidarPenetr_qttground.png

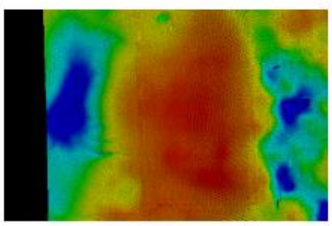

26104_PoorLidarPenetr_qttINT.png

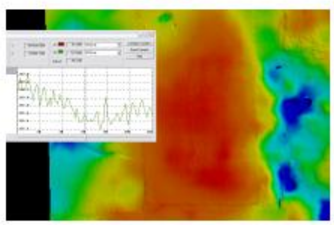

28807_Cornrows_qttground.png

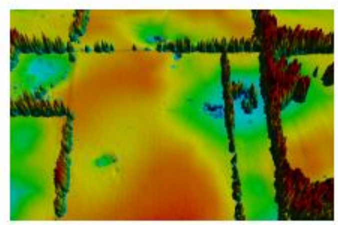

28807_Cornrows_qttINT.png

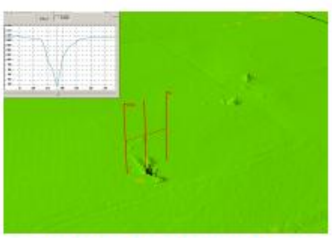

29345_PossibleDivot_qttground.png

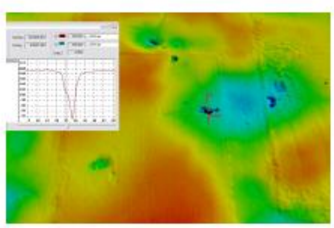

32043_cornrows_groundpoints.bmp

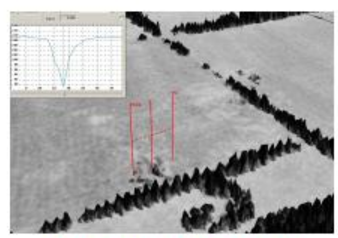

32043_cornrows_QTC.bmp

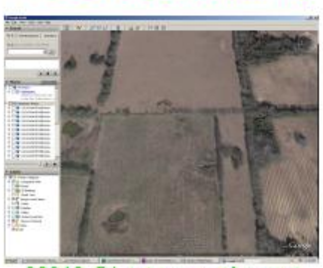

32043_cornrows_xs.bmp

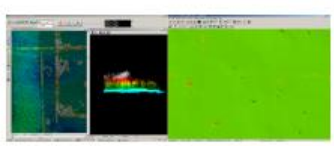

32043_divot_FPC_B.bmp

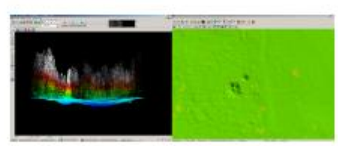

32043_Divot_qttground.png

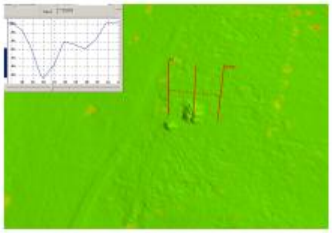

32043_divot_qttgroundB.bmp


32043_Divot_qttINT.png

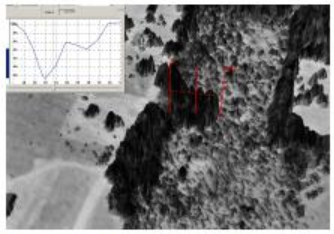

32043_Divots_google.png


32043_PossibleDivots_cloudpeak.png

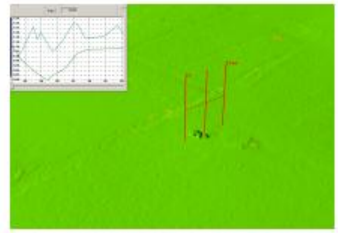

32583_PossibleDivot_cloudpeak.png



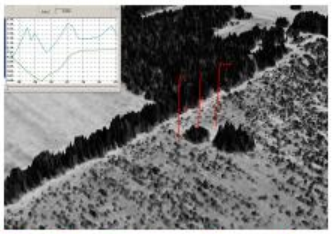
32583_PossibleDivot_qttground.png



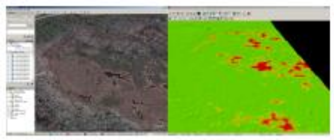
32583_PossibleDivot_qttINT.png



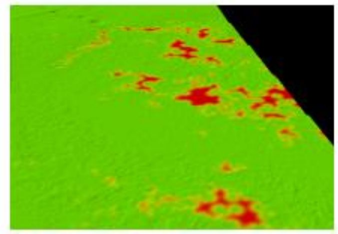
32588_PossibleAggrRemoveVeg_qttground.png



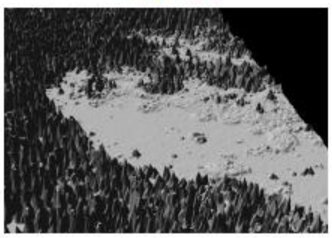
32588_PossibleAggrRemoveVeg_qttINT.png



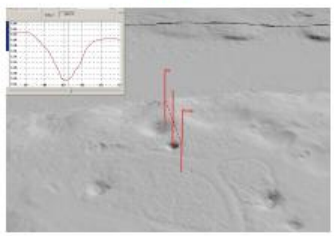
33130_PoorLidarPenetr_google.png



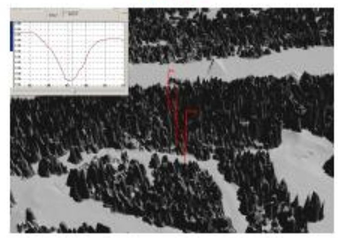
33130_PoorLidarPenetr_qttground.png



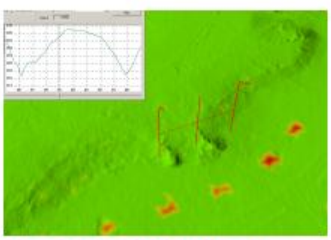
33130_PoorLidarPenetr_qttINT.png



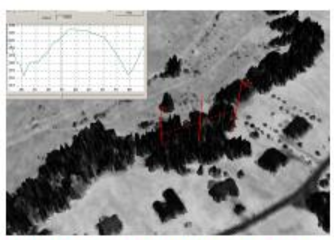
34743_PossibleDivot_qttground.png



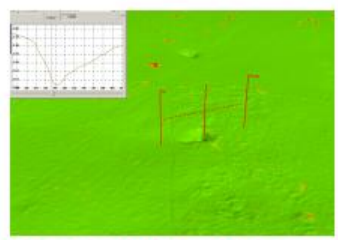
34743_PossibleDivot_qttINT.png



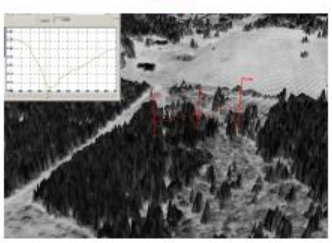
34743_PossibleDivots_qttground.png



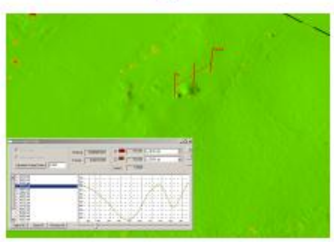
34743_PossibleDivots_qttINT.png



35283_PossibleDivot_qttground.png

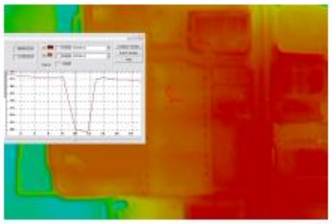


35283_PossibleDivot_qttINT.png

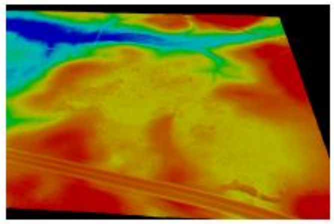


35283_PossibleDivots_qttground.png

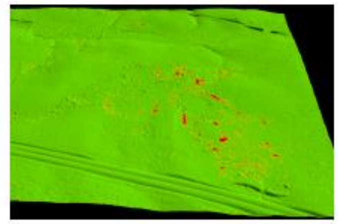
35283_PossibleDivots_qttINT and google.png



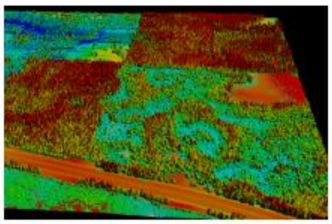
36901_divot_xs.bmp



36902_penetration_bareearth.bmp



36902_penetration_Density.bmp

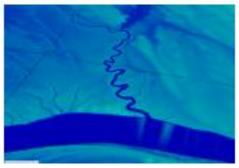


36902_penetration_FPC.bmp

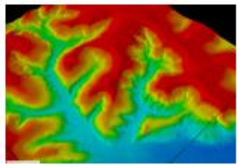
Appendix C – Apalachicola Checkpoints

pointNo	X	Y	Z
501	702505.17	3398345.17	97.80
502	707291.59	3395426.08	157.66
503	700015.35	3391210.37	76.02
504	689069.79	3379495.63	74.08
505	688087.99	3369444.53	64.78
506	694404.31	3368358.74	166.25
507	690305.84	3355212.87	54.77
508	680808.17	3354937.81	78.54
509	686842.82	3344101.82	51.37
511	686936.13	3327652.36	28.25
512	683393.83	3361855.09	69.82

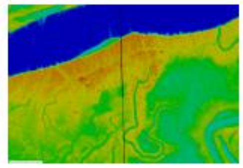
Appendix D – Apalachicola Screenshots



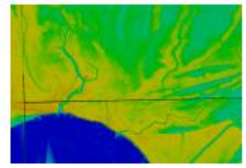
nicedata.bmp



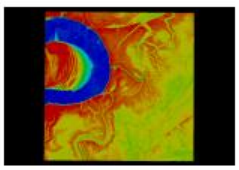
nicedata_hills.bmp



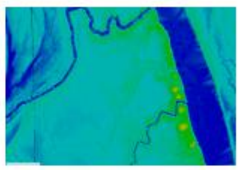
poor_penetration_49332.bmp



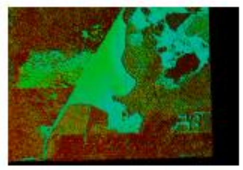
poor_penetration_49332_b.bmp



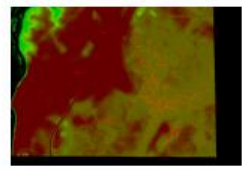
poor_penetration_49332_fulltile.bmp



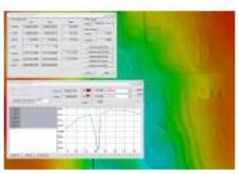
poor_penetration_53648.bmp



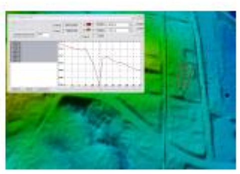
poor_penetration_57428_qttfpc.bmp



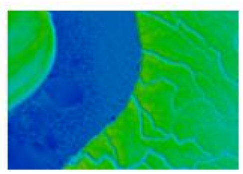
poor_penetration_57428_qttground.bmp



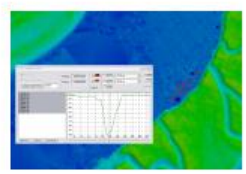
possible_divot38003.bmp



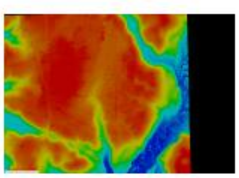
possible_divot38543.bmp



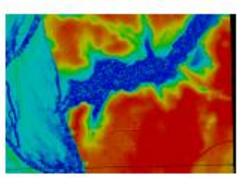
possible_divot56348.bmp



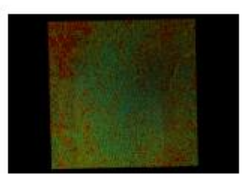
possible_divot56348_xs.bmp



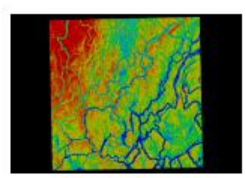
slightynoisy_59047.bmp



slightynoisy_59047_b.bmp



swampy_area_FPC_60125.bmp

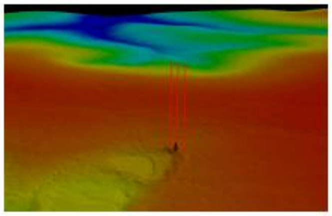


swampy_area_ground_60125.bmp

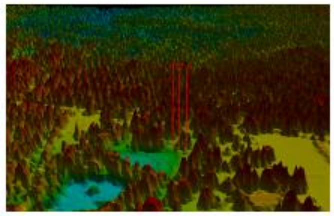
Appendix E – Gadsden Checkpoints

pointNo	easting	northing	elevation
CP439-GC	752702.05	3393789.92	229.56
CP408-GC	711734.81	3373758.48	189.21
CP427-GC	745350.23	3399620.32	179.82
CP410-GC	719716.76	3367698.30	142.59
CP415-GC	732521.69	3369756.54	83.79
CP401-GC	709579.16	3394401.59	275.59
CP412-GC	722445.03	3364104.25	90.98
CP420-GC	750944.64	3378553.25	95.18
CP426-GC	751120.13	3398164.66	269.29
CP424-GC	758201.25	3393494.75	120.21
CP421-GC	750733.79	3383589.09	86.02
CP434-GC	714590.05	3386777.03	269.75
CP430-GC	725383.55	3398946.04	283.00
CP406-GC	703165.07	3379270.75	250.13
CP432-GC	713775.77	3399603.51	275.75
CP431-GC	719356.07	3400846.68	274.84
CP440-GC	738652.13	3391258.62	254.43
CP416-GC	728559.48	3367909.96	90.06
CP414-GC	725690.80	3365973.96	87.07
CP413-GC	725386.55	3363555.10	58.50
CP437-GC	745729.19	3390179.39	242.19
CP438-GC	742232.46	3380804.50	201.51
CP435-GC	725630.25	3392435.19	286.42
CP417-GC	735397.58	3372244.23	105.64
CP445-GC	733467.66	3378667.58	216.17
CP423-GC	755521.82	3390132.83	138.88
CP422-GC	753319.08	3386092.98	133.66
CP419-GC	749355.15	3373690.27	103.77
CP411-GC	722264.83	3367072.70	144.59
CP409-GC	711834.76	3372095.74	173.49
CP418-GC	742519.03	3372974.10	123.95
CP407-GC	708946.26	3378200.62	201.31
CP433-GC	727085.01	3382616.31	239.89
CP443-GC	726516.35	3373455.29	198.06
CP404-GC	702254.42	3390748.72	143.21
CP436-GC	720230.18	3377869.88	268.83
CP428-GC	737919.17	3399345.00	292.62
CP402-GC	704941.34	3393927.04	178.58
CP405-GC	701489.82	3386843.30	243.80
CP403-GC	709469.84	3400289.09	148.95
CP429-GC	732618.85	3399520.32	281.92
CP425-GC	757092.58	3396997.01	137.63
CP442-GC	706390.75	3386209.82	289.04
CP444-GC	733289.11	3386271.72	236.09
CP441-GC	717232.39	3393795.86	257.41

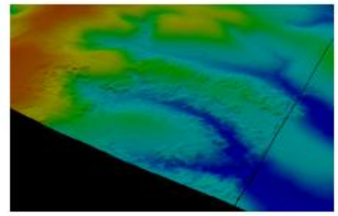
Appendix F – Gadsden Screenshots



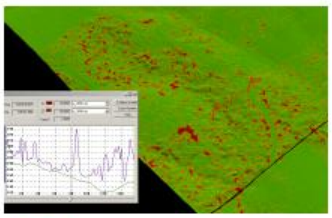
37467_vegartifact_qttground.bmp



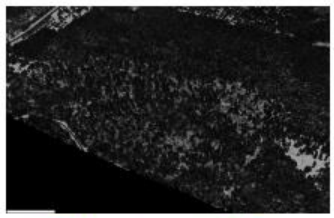
37467_vegartifact_qttINT.bmp



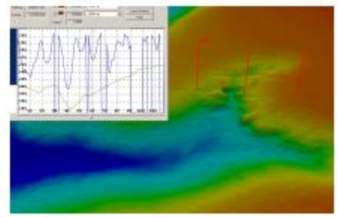
38005_noise_qttground.bmp



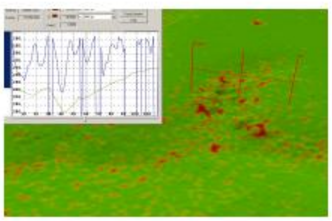
38005_noise_qttground1.bmp



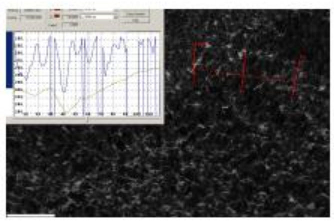
38005_noise_qttINT.bmp



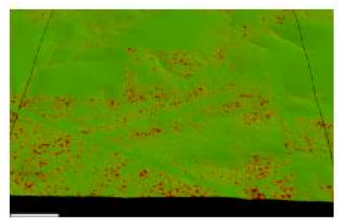
38007_streamDef_qttground.bmp



38007_streamDef_qttground1.bmp

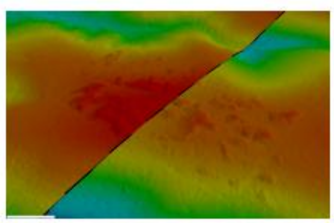


38007_streamDef_qttINt.bmp

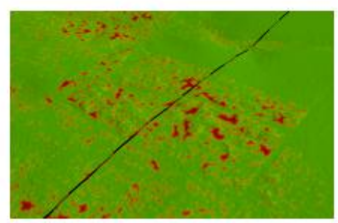


38546_poorLP_qttgroun.bmp

38546_poorLP_qttINT.bmp

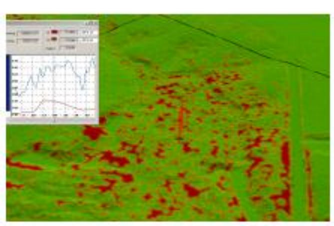


38547_noise_qttground.bmp

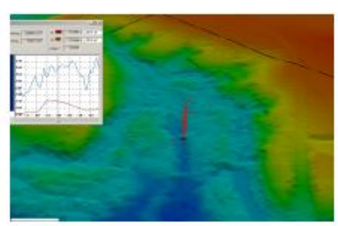


38547_noise_qttground2.bmp

38547_noise_qttINT.bmp



39101_noise_qttground.bmp



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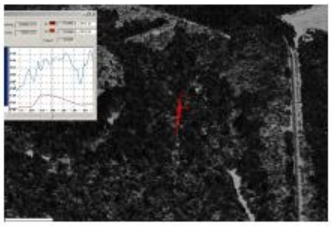
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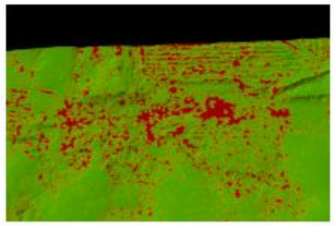
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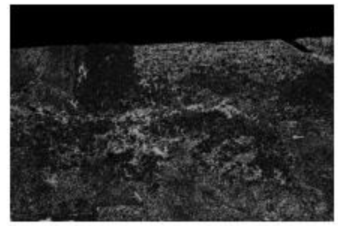
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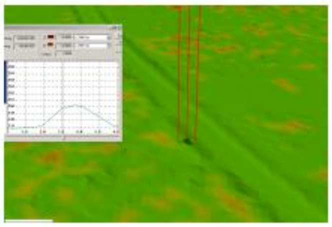
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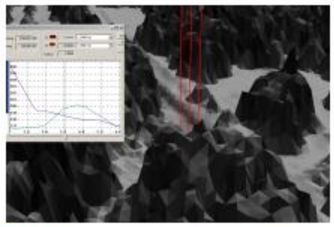
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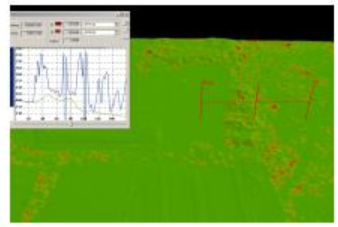
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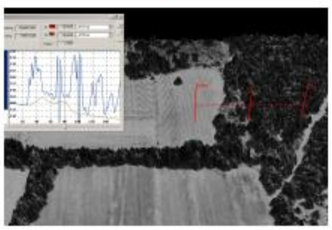
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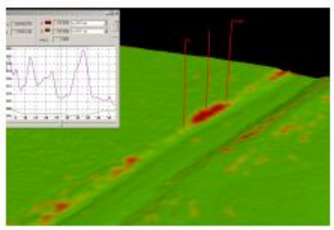
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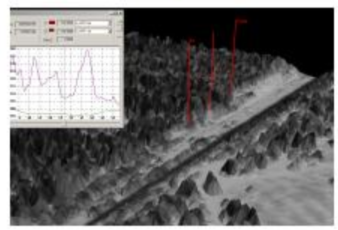
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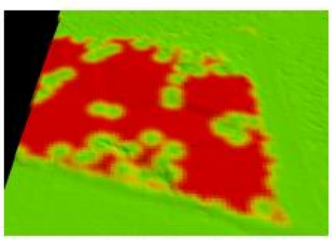
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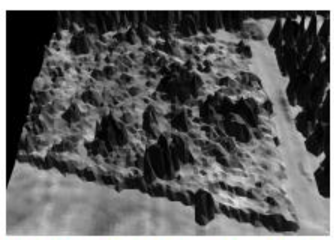
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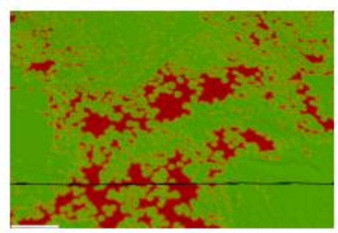
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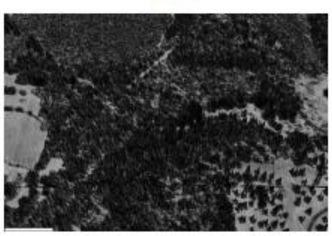
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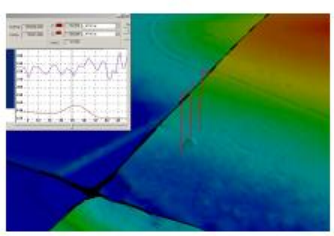
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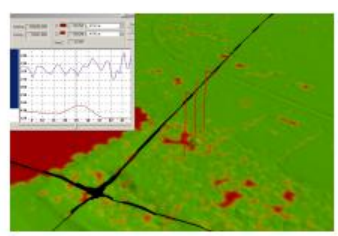
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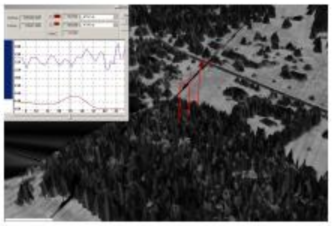
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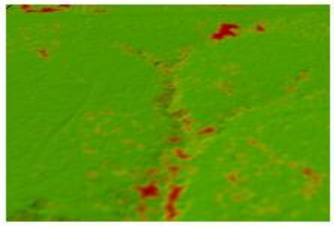
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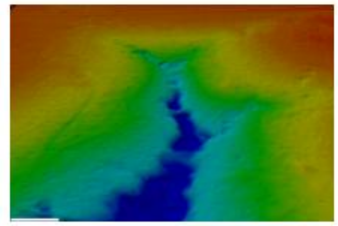
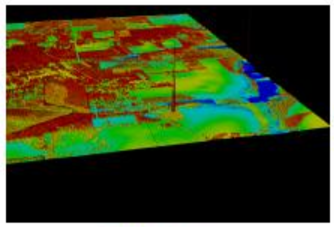
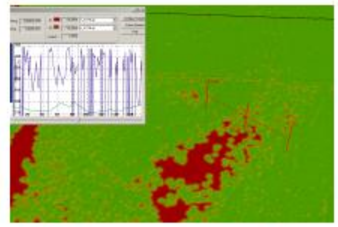

40709_streamDef_qttground2.bmp


40709_streamDef_qttINT.bmp


40713_Spikes PossibleDataholidayinFPC_qttINT.png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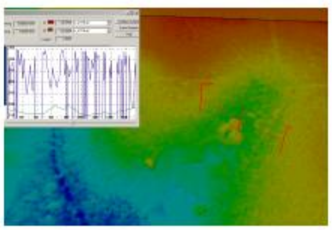
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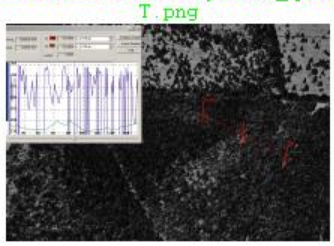
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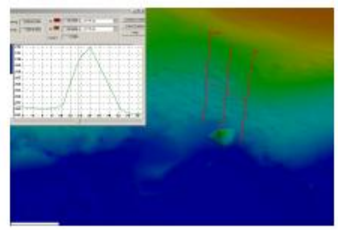
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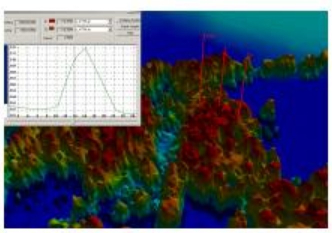
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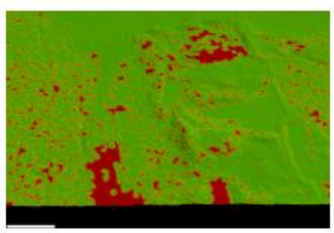
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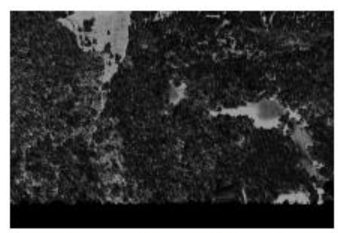
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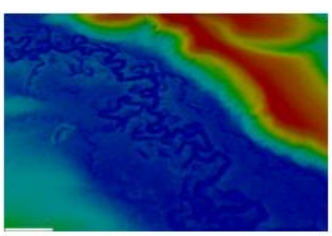
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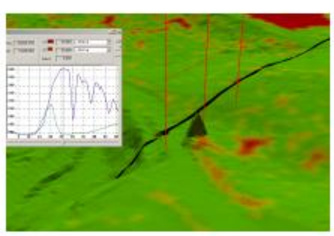
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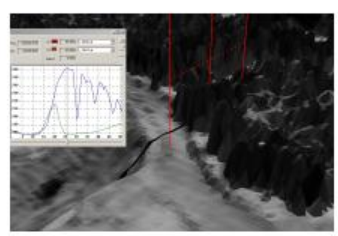
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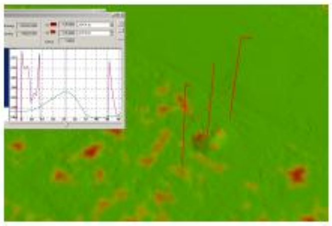

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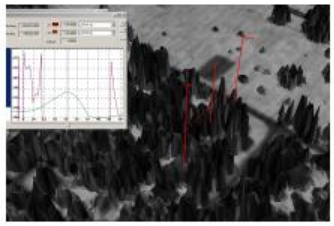

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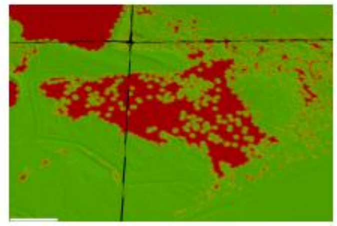
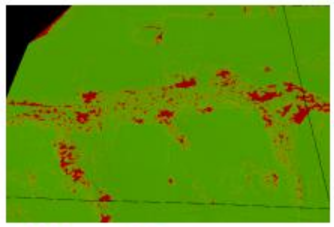


40731_poorLP_qttground.bmp

40731_poorLP_qttINT.bmp



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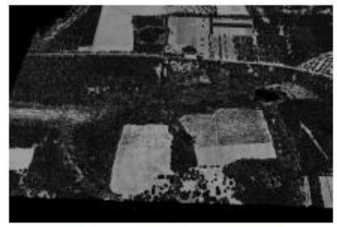

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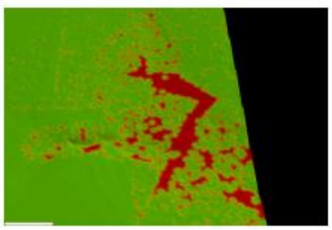

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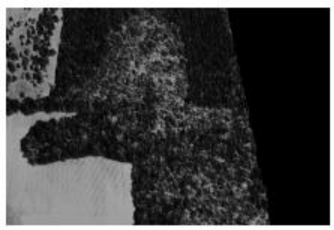

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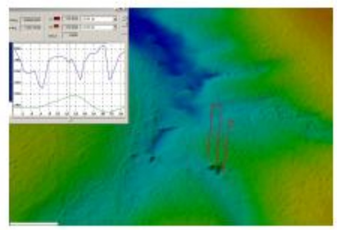
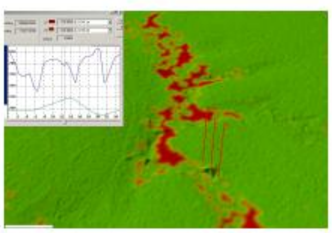


41260_vegartifact_qttground.bmp



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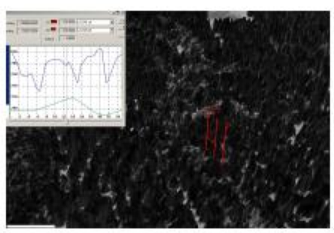

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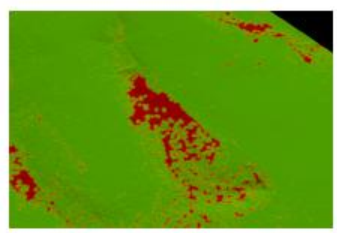

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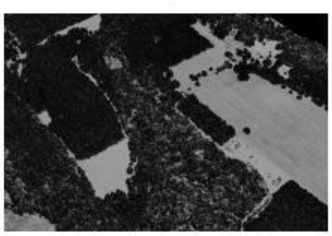

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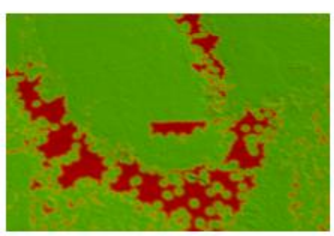
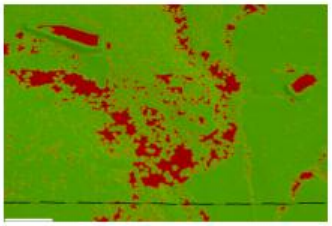


41270_missclass_Qttground.bmp

41270_missclass_QttINT.bmp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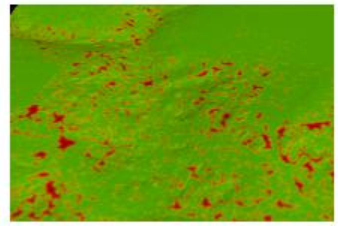
41270_poorLP_qttINT.bmp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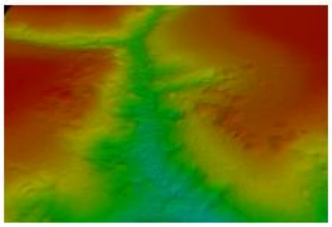
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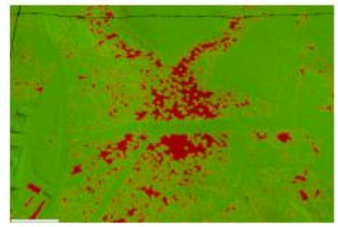
41783_noise_qttINT.bmp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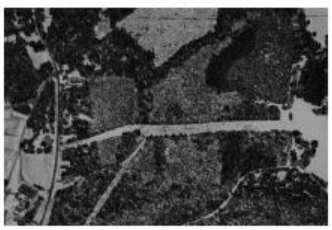
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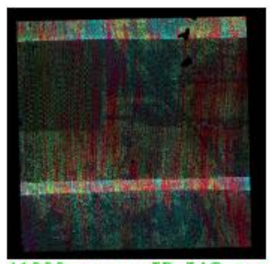
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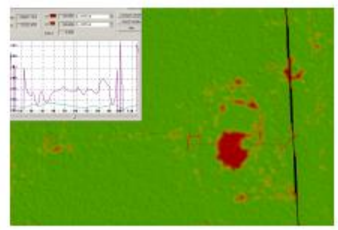
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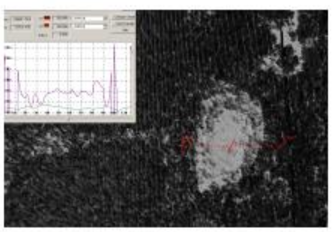
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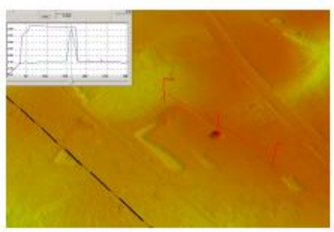
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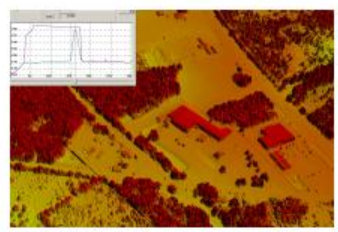
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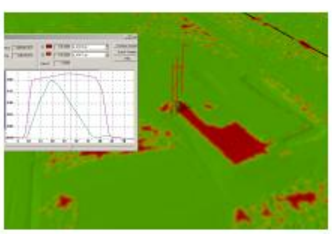
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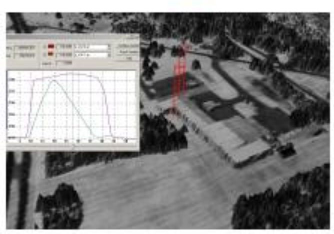
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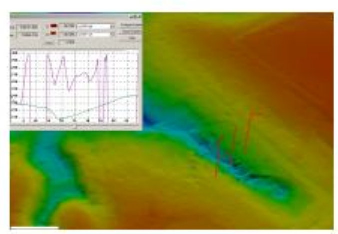
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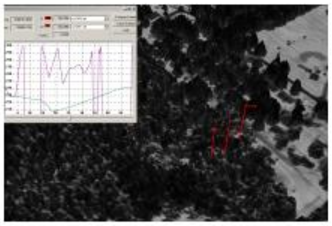

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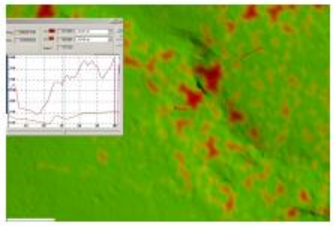

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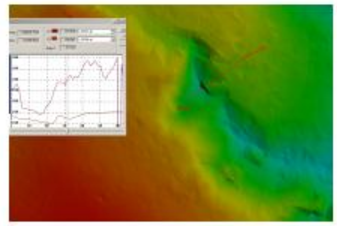

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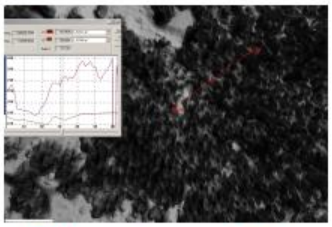

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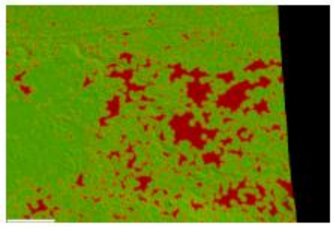
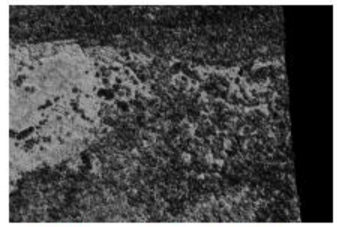


42341_poorLP_qttground.bmp



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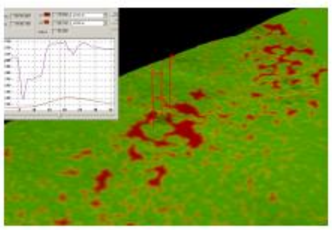

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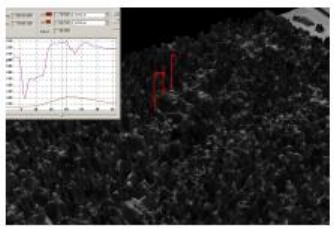

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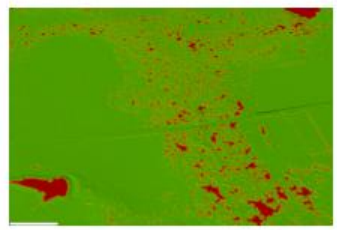
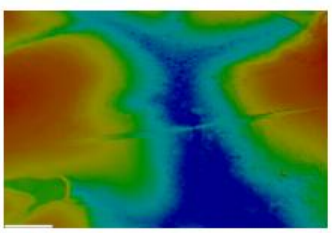


42868_noise_qttground.bmp



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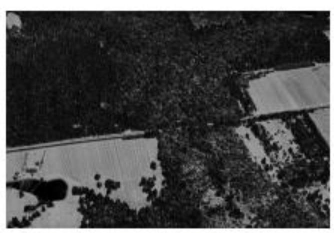
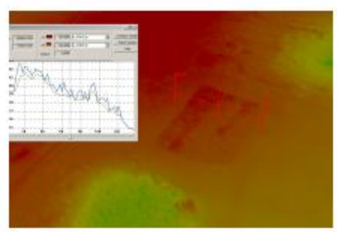


42868_noise_qttINT.bmp



42869_vegartifact_qttground.bm
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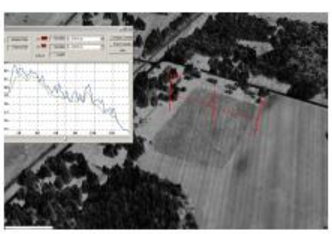
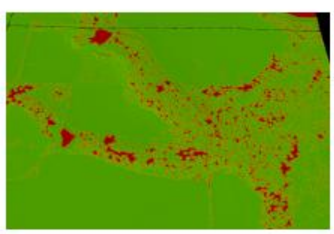
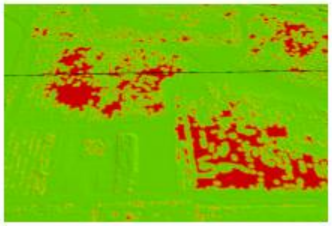


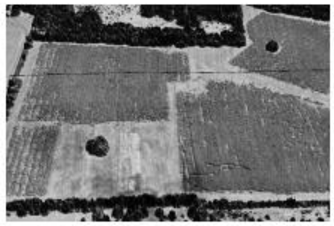
42869_vegartifact_qttINT.bmp



42870_pLp_qttground.bmp

42870_pLp_qttINT.bmp


42876_PoorLidarPenetrationField_qttground.png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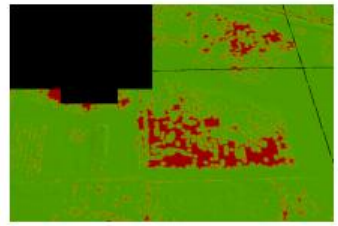
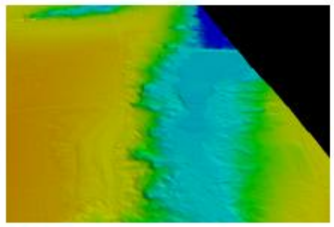
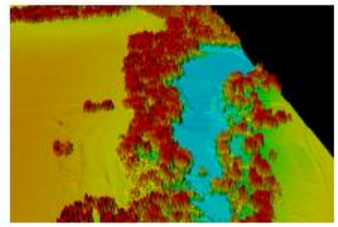

42876_poorLP_qttground.bmp


42876_poorLP_qttINT.bmp


42876_PossibleStreamDef_qttground.png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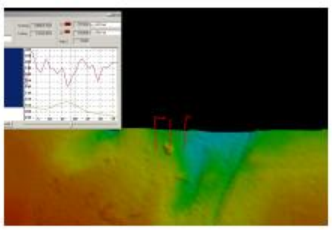
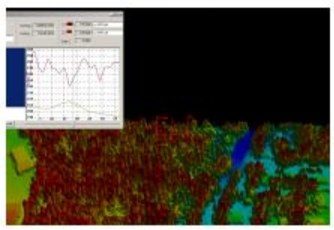
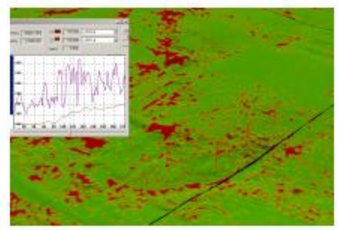
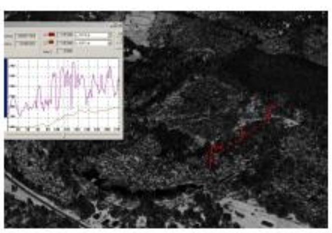
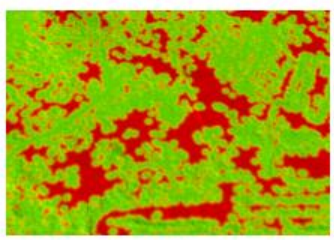
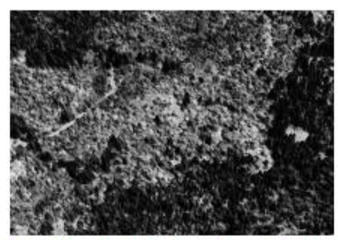

42879_vegartifact_qttground.bmp

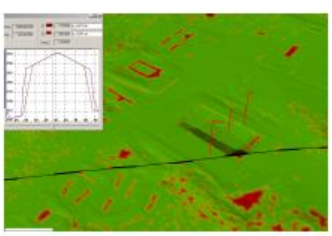

42879_vegartifact_qttINT.bmp

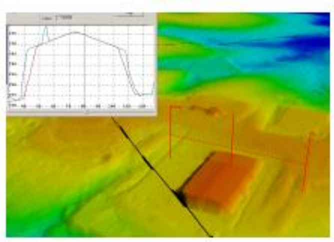

42880_noise_qttground.bmp


42880_noise_qttINT.bmp


42880_PoorLidarPenetr_qttground.png


42880_PoorLidarPenetr_qttINT.png


42881_buildingartifact_qttground.bmp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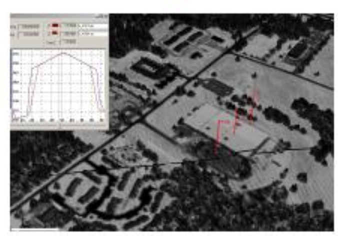
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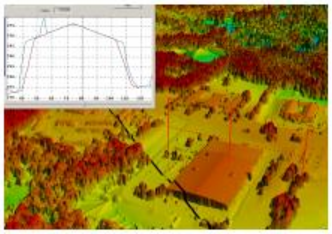
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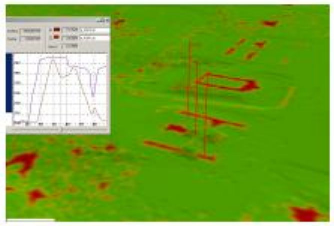
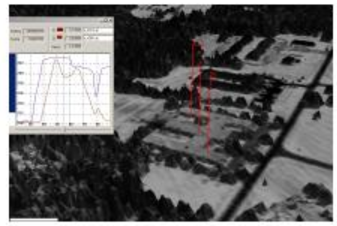
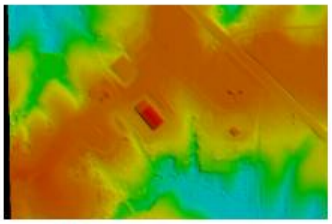

42881_buildingartifact2_qttground.bmp


42881_buildingartifact2_qttINT.bmp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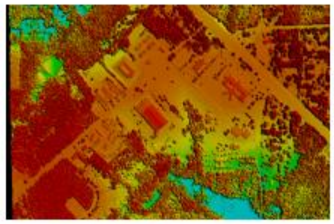
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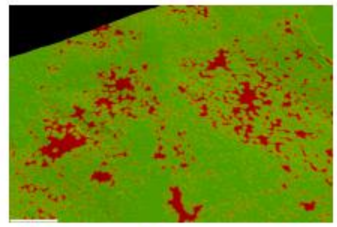
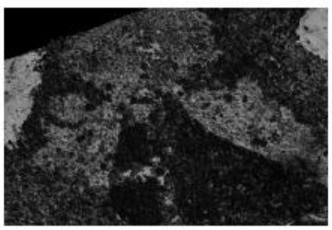
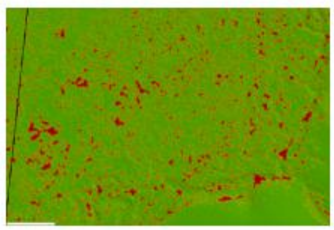
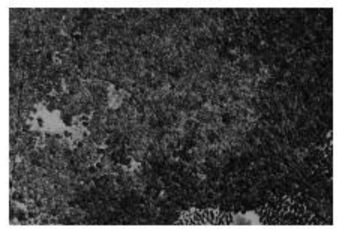
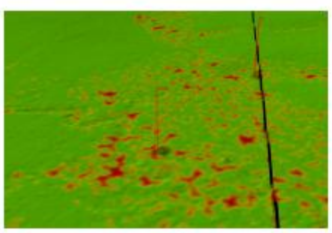
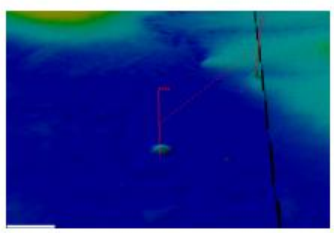

42881_poorLP_qttground.bmp

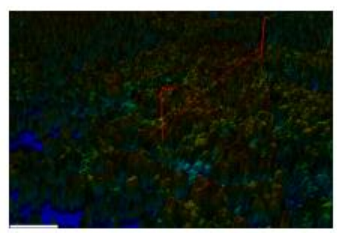

42881_poorLP_qttINT.bmp

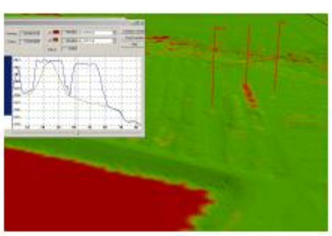

42884_poorLP_qttground.bmp

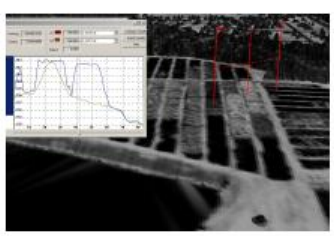

42884_poorLP_qttINT.bmp

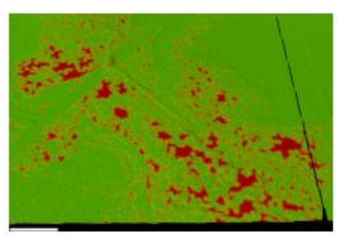

42885_artifacts_qttground.bmp


42885_artifacts_qttground2.bmp

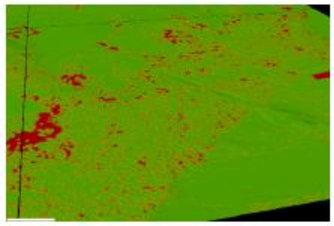

42885_artifacts_qttINT.bmp


42887_inconsistentEdit_qttground.bmp

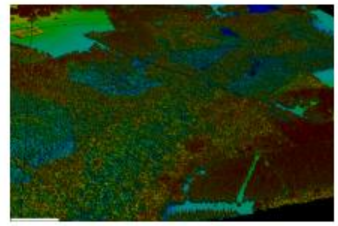

42887_inconsistentEdit_qttINT.bmp


43408_poorLP_qttground.bmp

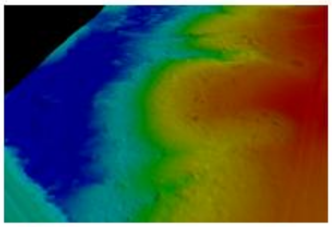
43408_poorLP_qttINT.bmp



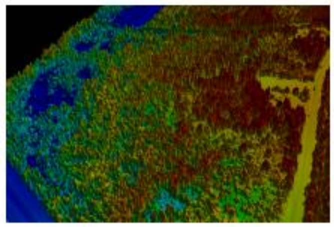
43410_poorLidarPen_qttground.bmp



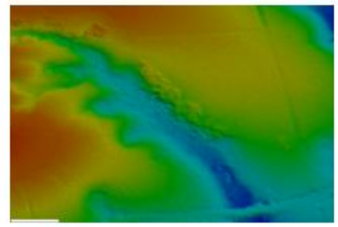
43410_poorLidarPen_qttINT.bmp



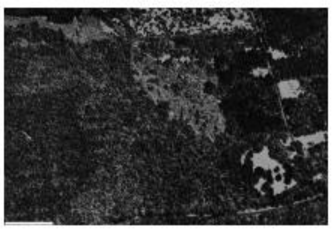
43416_noise_qttground.bmp



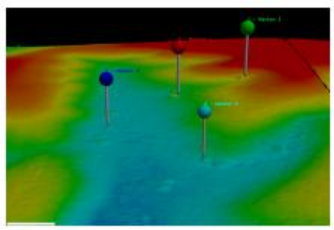
43416_noise_qttINT.bmp



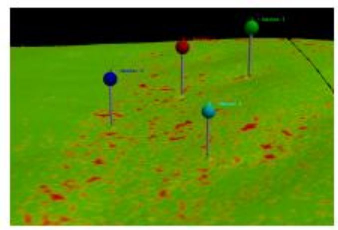
43421_noise_qttground.bmp



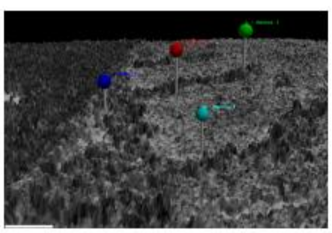
43421_noise_qttINT.bmp



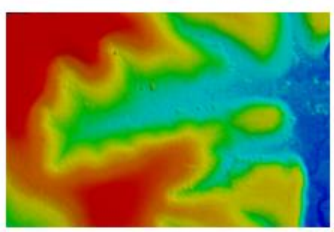
43423_artifacts_qttground.bmp



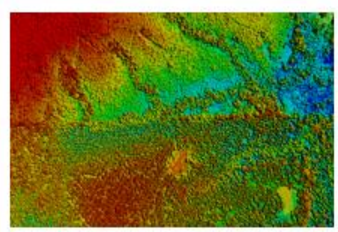
43423_artifacts_qttground2.bmp



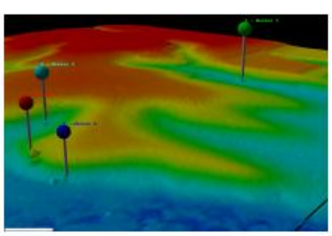
43423_artifacts_qttINT.bmp



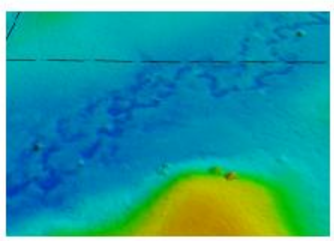
43423_vegart.bmp



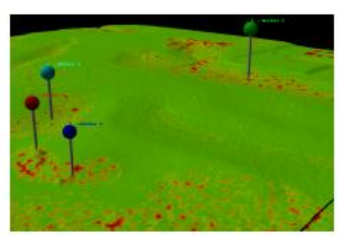
43423_vegart_fpc.bmp



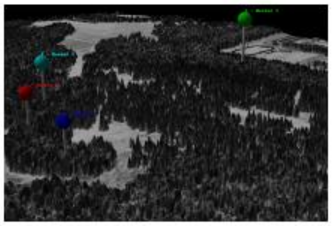
43425_artifacts_qttground.bmp



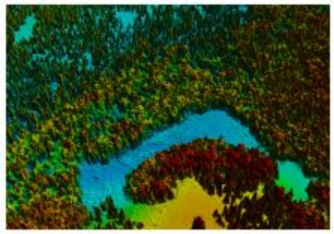
43425_Artifacts_qttground.png



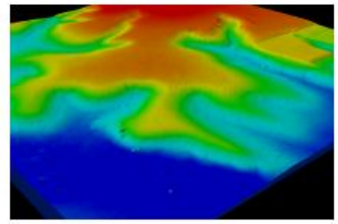
43425_artifacts_qttground2.bmp



43425_artifacts_qttINT.bmp



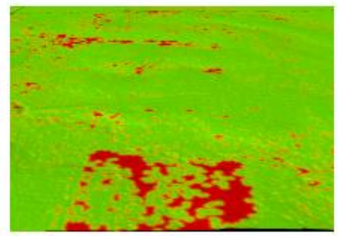
43425_Artifacts_qttINT.png



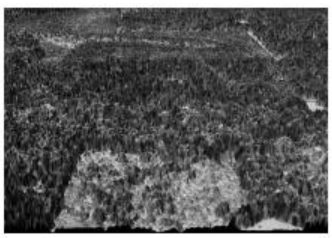
43425_vegart.bmp

43425_vegart_fpc.bmp

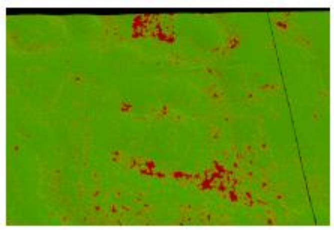
43430_PoorLidarPenetr_google.png



43430_PoorLidarPenetr_qttground.png

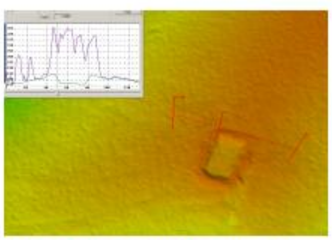


43430_PoorLidarPenetr_qttINT.png

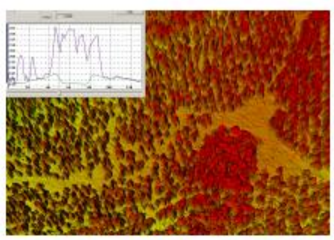


43430_poorLP_qttground.bmp

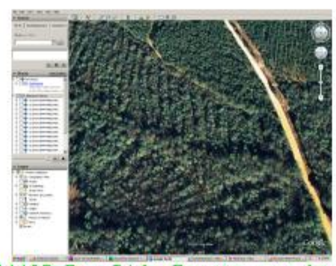
43430_poorLP_qttINT.bmp



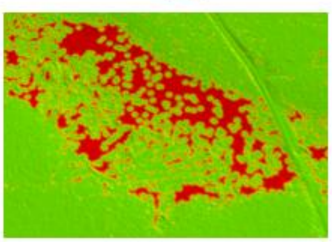
43969_AggressiveRemove_qttground.png



43969_AggressiveRemove_qttINT.png

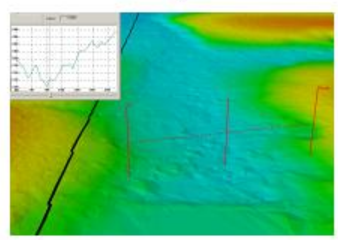


44487_PoorLidarPenetr_google.png

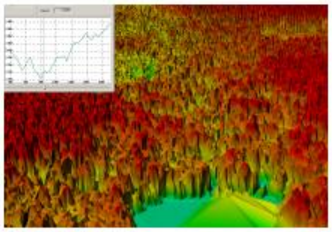


44487_PoorLidarPenetr_qttground.png

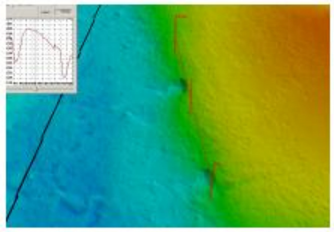
44487_PoorLidarPenetr_qttINT.png



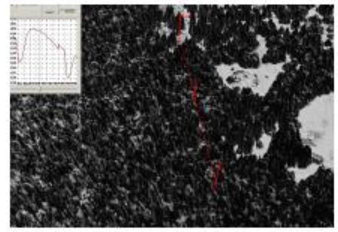
44493_Noise_qttground.png



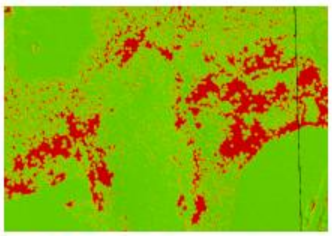
44493_Noise_qttINT.png



44494_PossibleDivots_qttground.png

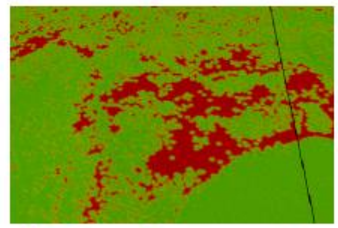


44494_PossibleDivots_qttINT.png

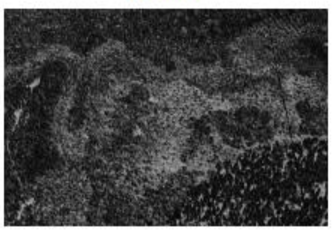


45027_PoorLidarPenetr_qttground.png

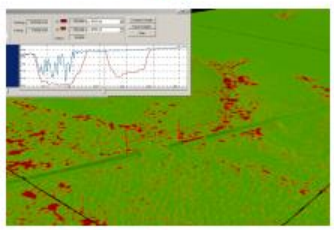
45027_PoorLidarPenetr_qttINT.png



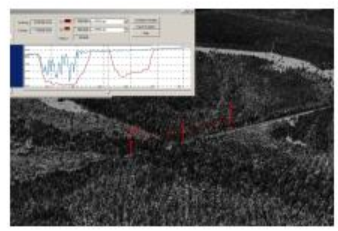
45027_poorLP_qttground.bmp



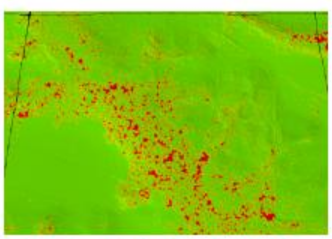
45027_poorLP_qttINT.bmp



45028_inconsistentEdit_qttground.bmp

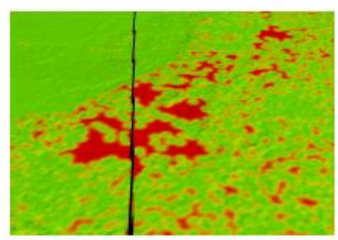


45028_inconsistentEdit_qttINT.bmp



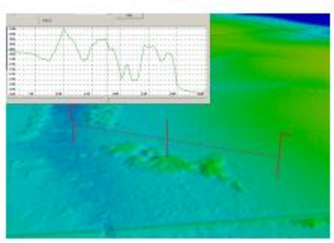
45034_PoorLidarPenetr_qttground.png

45034_PoorLidarPenetr_qttINT.png

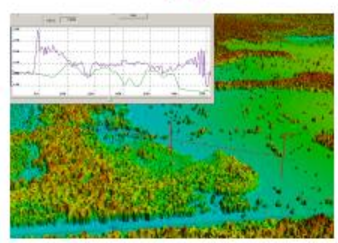


45035_PoorLidarPenetr_qttground.png

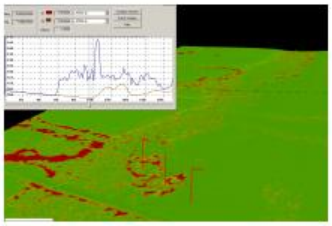
45035_PoorLidarPenetr_qttINT.png



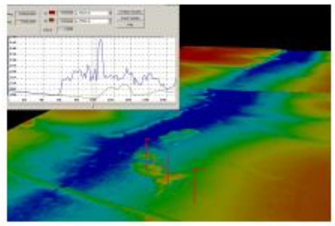
45567_Artifacts or Noise_qttground.png



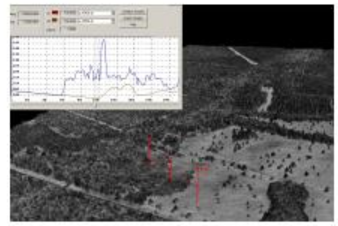
45567_Artifacts or Noise_qttINT.png



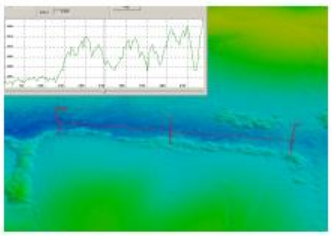
45567_artifacts_qttground.bmp



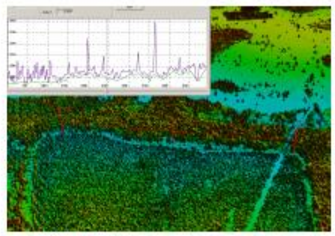
45567_artifacts_qttground2.bmp



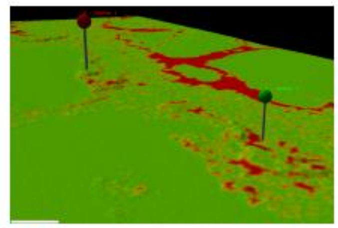
45567_artifacts_qttINT.bmp



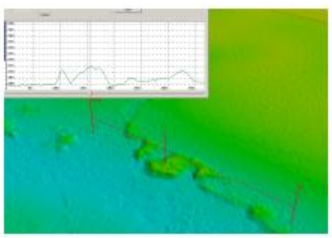
45567_Noise_qttground.png



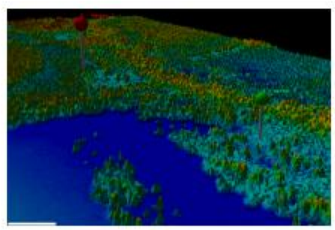
45567_Noise_qttINT.png



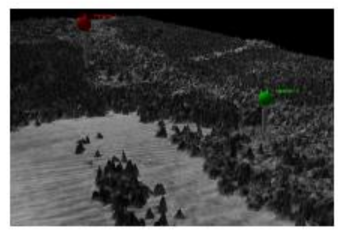
45568_artifacts_qttground.bmp



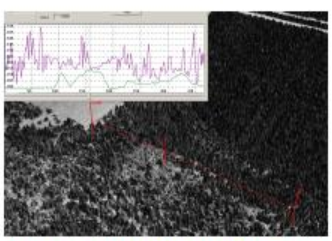
45568_Artifacts_qttground.png



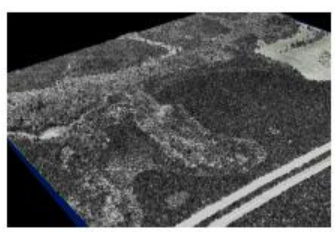
45568_artifacts_qttground2.bmp



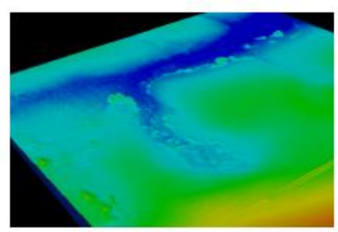
45568_artifacts_qttINT.bmp



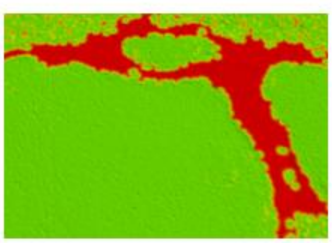
45568_Artifacts_qttINT.png



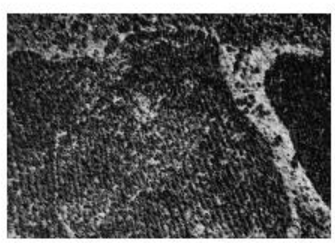
45568_fpc_intensity.bmp



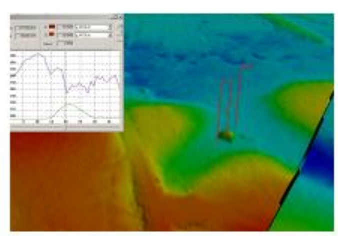
45568_groundnoise.bmp



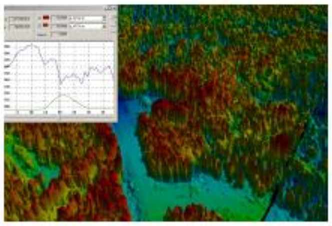
45568_PossibleMisclassLandasWater and PoorLidarPenetr_qttground.png



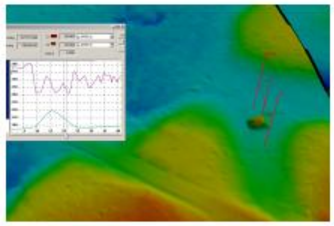
45568_PossibleMisclassLandasWater and PoorLidarPenetr_qttINT.png



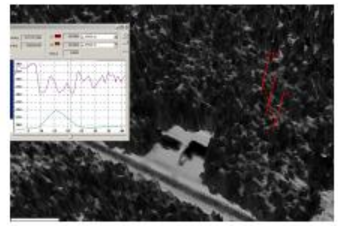
45584_artifact_qttground.bmp



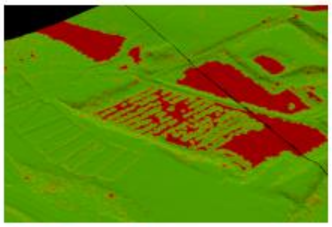
45584_artifact_qttINT.bmp



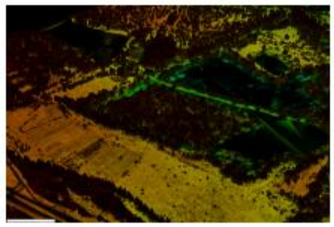
45584_vegartifact_qttground.bmp



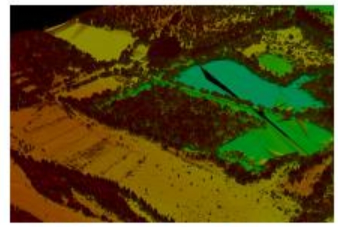
45584_vegartifact_qttINT.bmp



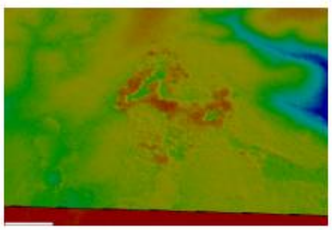
45587_poorLP_qttground.bmp



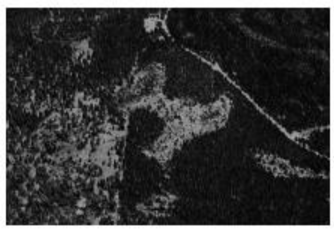
45587_poorLP_qttINT.bmp



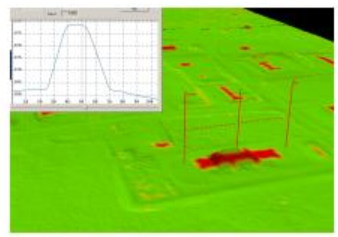
45587_poorLP_qttINT@.bmp



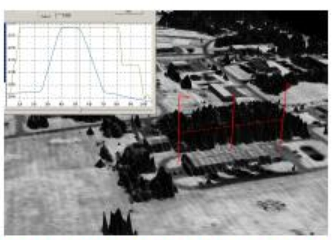
46124_noise_qttground.bmp



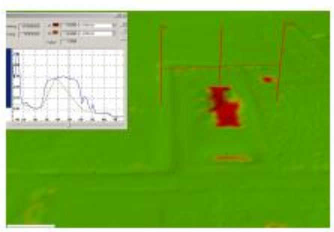
46124_noise_qttINT.bmp



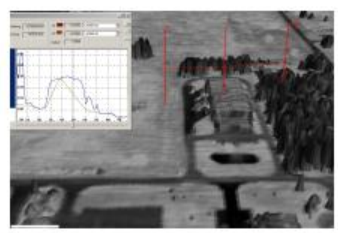
46129_ArtifactBuilding_qttground.png



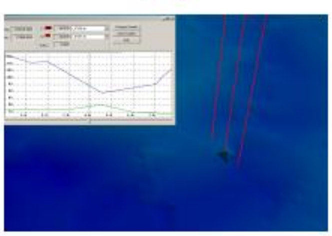
46129_ArtifactBuilding_qttINT.png



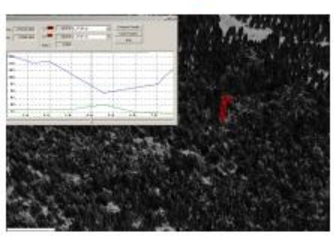
46129_buildingartifact_qttground.bmp



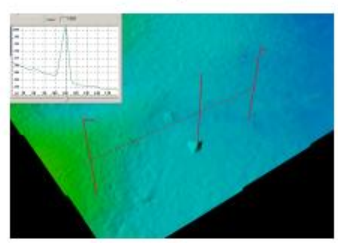
46129_buildingartifact_qttINT.bmp



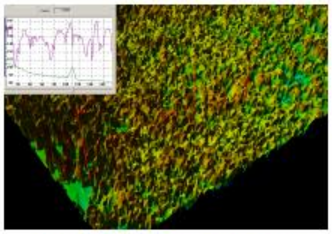
46660_artifact_qttground.bmp



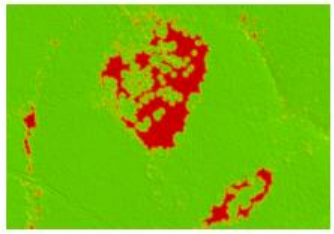
46660_artifact_qttINT.bmp



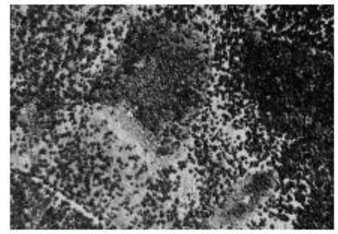
46660_Spike_qttground.png



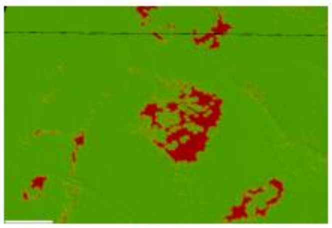
46660_Spike_qttINT.png



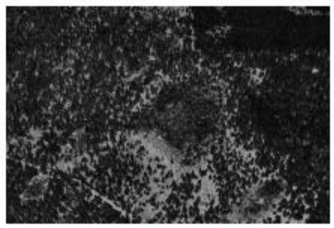
46664_PoorLidarPenetr_qttground.png



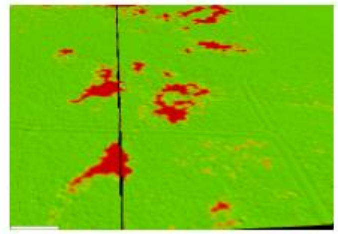
46664_PoorLidarPenetr_qttINT.png



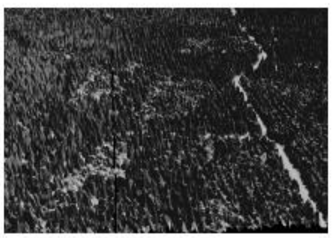
46664_poorLP_qttground.bmp



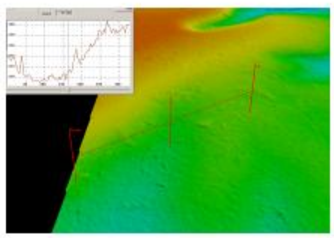
46664_poorLP_qttINT.bmp



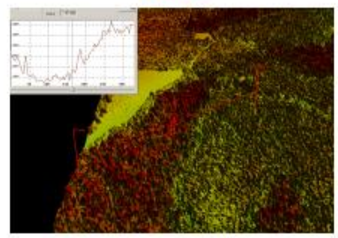
46668_PoorLidarPenetr_qttground.png



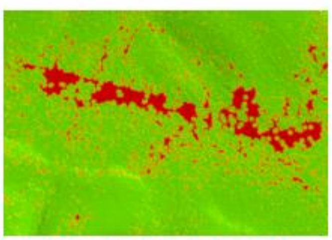
46668_PoorLidarPenetr_qttINT.png



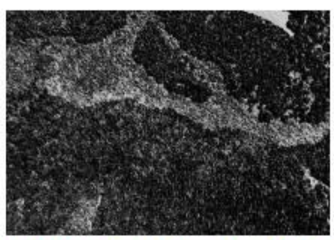
47200_Noise_qttground.png



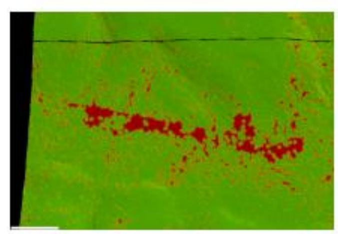
47200_Noise_qttINT.png



47200_PoorLidarPenetr_qttground.png

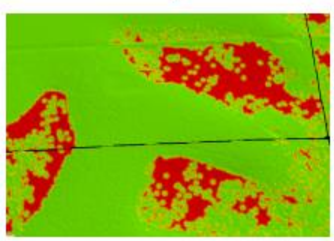


47200_PoorLidarPenetr_qttINT.png

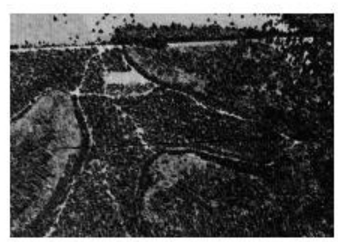


47200_poorLP_qttground.bmp

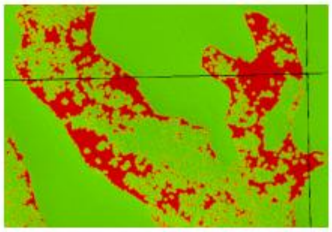
47200_poorLP_qttINT.bmp

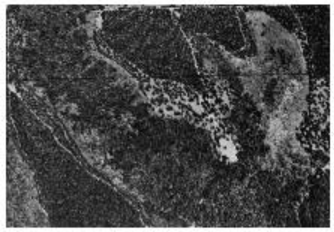


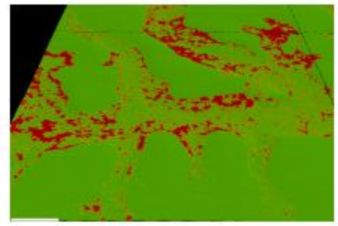
48274_PoorLidarPenetr_qttground.png

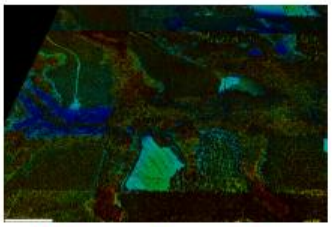


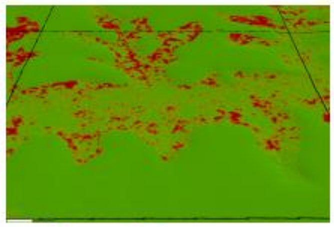
48274_PoorLidarPenetr_qttINT.png

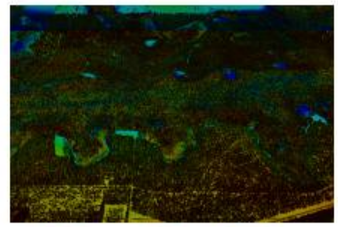

48813_PoorLidarPenetr_qttground.png

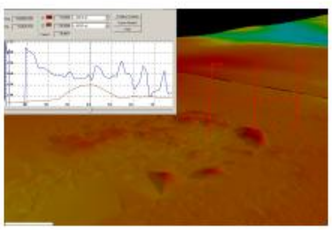

48813_PoorLidarPenetr_qttINT.png

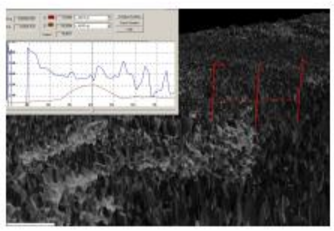

48813_poorLP_qttground.bmp

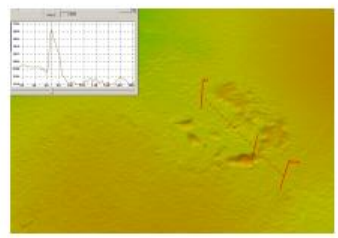

48813_poorLP_qttINT.bmp

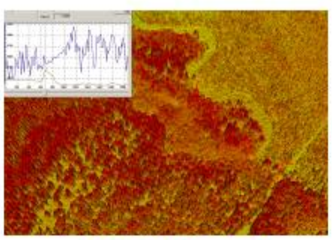

48814_poorLP_qttground.bmp

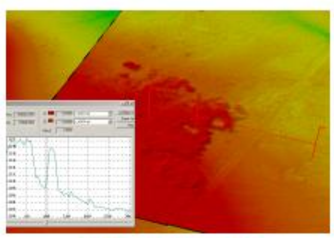

48814_poorLP_qttINT.bmp

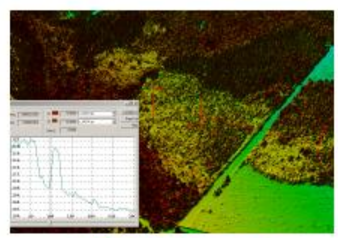

49353_artifacts_qttground.bmp

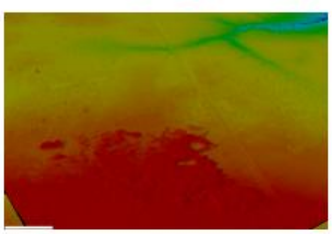

49353_artifacts_qttINT.bmp

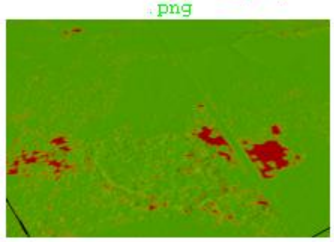

49353_Noise and PossibleSpike_qttground.png

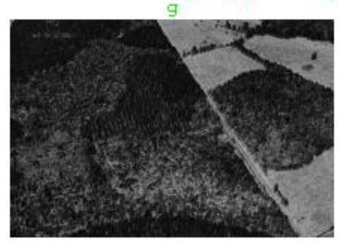

49353_Noise and PossibleSpike_qttINT.png


49355_Noise and PossibleDivotorSpike_qttground.png


49355_Noise and PossibleDivotorSpike_qttINT.png


49355_noise_qttground.bmp


49355_noise_qttground2.bmp


49355_noise_qttINT.bmp

Appendix G – Large Area Checkpoints

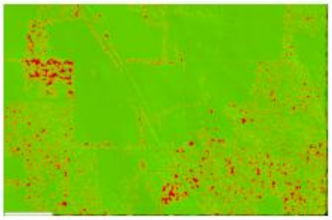
pointNo	easting	northing	elevation
WMD113	662402.56	3388674.38	228.35
WMD193	673144.74	3371814.77	126.25
WMD221	640297.41	3412487.58	91.73
WMD130	696802.19	3403113.69	105.09
WMD170	613284.03	3429142.21	99.08
WMD210	643646.84	3397502.86	165.32
WMD199	679171.57	3379556.27	174.34
WMD237	677302.42	3392452.91	96.39
WMD198	608829.53	3417641.94	74.84
WMD171	617078.99	3429018.59	215.71
WMD106	595507.79	3396266.12	265.39
WMD246	639403.10	3404372.47	126.74
WMD242	600586.99	3416275.63	119.72
WMD129	703009.34	3398473.72	90.62
WMD141	683962.54	3394888.38	129.53
WMD173	592148.80	3415463.49	284.48
WMD203	647347.87	3419297.19	181.79
GPS207	671647.07	3416623.33	131.63
WMD222	621879.24	3409810.26	123.06
WMD189	691989.30	3393275.50	184.84
WMD166	645246.50	3430319.96	168.27
WMD124	697700.53	3372535.33	190.03
WMD235	668246.26	3352164.00	81.36
WMD152	659945.38	3368126.34	154.86
WMD104	593255.34	3396641.34	285.96
GPS212	673442.01	3408821.01	166.86
WMD188	670608.08	3393216.02	98.46
WMD139	689578.33	3401422.40	122.51
WMD225	651543.39	3408092.15	136.81
WMD167	627630.90	3429883.15	167.95
GPS214	680724.28	3402032.14	156.30
WMD200	617632.16	3421189.23	142.85
WMD156	671927.20	3410193.88	116.08
WMD197	671971.54	3346364.93	69.98
WMD112	633115.99	3382150.08	165.09
WMD245	614372.96	3406253.55	65.62
WMD226	661197.72	3418289.87	111.15
WMD110	636148.37	3382243.81	203.38
GPS209	688551.70	3418636.94	117.39
WMD174	591814.24	3408418.15	237.17
WMD118	686022.94	3343397.85	46.23
DF5696	656145.10	3417914.88	157.78
WMD214	609105.28	3405238.53	71.98
WMD233	605802.16	3425272.81	183.07
WMD126	705061.53	3359408.88	118.57

WMD134	687202.27	3431001.57	132.91
WMD146	685322.16	3363426.70	64.53
WMD109	607401.96	3386007.57	34.19
WMD142	683947.10	3398928.13	133.00
WMD184	692008.73	3409635.81	88.48
WMD180	644406.52	3390565.12	107.58
WMD216	625843.30	3400860.63	95.21
GPS213	673731.63	3399989.48	94.62
WMD236	666394.73	3354201.62	76.18
WMD172	592958.45	3418764.05	287.99
WMD148	679644.79	3363436.24	97.21
WMD185	599397.62	3420688.87	125.62
WMD102	600664.33	3428771.59	194.49
WMD111	636457.07	3385354.47	267.68
WMD105	592070.93	3399167.49	244.78
WMD215	616335.42	3400111.61	122.15
BE2847	679190.91	3388646.65	219.42
WMD231	612093.74	3383531.51	33.01
WMD121	690528.45	3353398.93	55.74
WMD125	693827.50	3367785.50	165.26
WMD250	697405.17	3359602.19	109.88
WMD244	681490.75	3374538.42	117.13
WMD162	667302.29	3425320.89	122.31
WMD232	698794.99	3397025.91	100.89
WMD149	679016.40	3350658.96	39.76
WMD115	660729.76	3342454.51	62.93
WMD207	658139.88	3401103.88	143.27
WMD127	708463.01	3359581.95	118.67
WMD107	608486.44	3381963.91	67.91
BE3768	614404.30	3391605.11	99.54
WMD169	629251.53	3426429.46	193.18
WMD133	691860.88	3429085.67	105.41
WMD159	668248.73	3418949.50	95.31
BT2372	628814.86	3430744.54	232.97
WMD175	602112.41	3397573.45	58.40
WMD187	693690.37	3420612.04	116.47
GPS202	675521.04	3426369.56	141.17
BE0040	626389.15	3407422.89	152.72
47-99-C48V	673791.59	3380858.71	97.83
WMD247	662973.76	3400477.39	113.55
WMD131	697656.47	3419226.82	125.23
WMD120	688643.14	3345455.07	49.47
WMD248	662876.16	3414702.99	88.22
WMD238	619778.50	3394649.77	108.40
WMD119	689857.67	3342204.32	50.00
WMD181	648614.80	3391034.30	253.67
WMD208	665270.62	3394789.39	99.05
WMD123	695045.44	3370545.19	166.17

WMD182	696297.87	3411565.64	102.85
WMD192	669973.56	3378401.65	116.63
WMD165	640516.36	3429262.36	162.04
WMD243	664835.53	3376520.45	196.72
WMD137	688506.83	3421787.21	106.92
WMD178	620301.26	3383357.40	193.50
WMD239	672105.92	3365635.00	119.59
WMD143	696384.11	3389739.43	98.42
WMD218	645201.41	3405224.73	145.83
WMD196	666646.31	3368162.44	173.62
WMD191	683603.70	3386679.04	181.17
WMD190	674317.94	3385147.95	93.70
WMD212	625763.09	3390755.90	56.59
BE3944	673468.57	3411911.07	102.62
GPS215	687990.03	3401745.58	154.23
WMD157	667443.98	3406896.75	181.50
WMD147	681084.22	3367631.09	100.72
WMD117	677073.19	3345641.59	31.50
WMD217	634209.97	3402193.42	76.64
WMD155	670274.78	3401680.61	121.55
WMD145	687418.28	3376495.14	86.19
WMD220	644765.97	3414105.79	126.34
WMD241	651119.75	3423458.99	157.41
WMD160	673752.90	3429719.38	149.67
WMD163	657265.83	3430324.58	148.00
WMD153	660525.61	3360074.02	105.48
WMD183	695240.01	3360005.49	121.69
WMD177	606860.95	3397232.11	49.77
WMD224	629517.63	3414907.68	168.34
WMD128	702230.95	3355904.61	111.32
WMD204	658935.10	3421074.66	131.13
WMD176	608876.08	3391079.86	61.88
WMD401	675300.25	3431569.10	151.97
ANAL394	652001.17	3430291.05	152.07
DF5703	674763.96	3426407.18	148.46
WMD138	689561.34	3404848.63	119.19
WMD116	678902.93	3341845.69	28.44
WMD161	669005.29	3430965.70	125.66
WMD234	666715.02	3384688.47	141.99
WMD229	659596.46	3377876.99	201.18
DF5729	683945.67	3397629.15	121.95
WMD211	634105.74	3392821.83	98.36
BE2610	670836.85	3400746.99	118.57
WMD154	660609.03	3384026.53	250.20
BE3943	602603.43	3409945.45	200.69
WMD103	591803.61	3425149.61	139.30
WMD114	659172.47	3389850.71	286.55
WMD201	625000.73	3419356.02	97.15

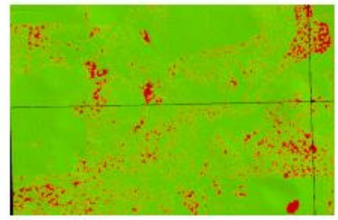
WMD168	632083.50	3429851.50	223.88
WMD150	675949.12	3354622.28	85.27
WMD132	693540.14	3415214.85	88.91
WMD144	691175.05	3386810.20	132.71
FB170P24	669283.91	3351652.88	75.49
WMD223	634863.60	3410475.19	74.77
WMD205	656469.74	3415013.84	120.34
WMD209	650602.67	3397793.36	137.73
WMD164	654031.61	3429135.16	146.88
WMD206	658951.55	3409473.35	146.39
BE3936	689668.49	3384298.22	129.26
WMD151	661876.15	3352727.08	79.56
WMD202	635535.51	3419642.03	132.41
WMD179	624554.05	3382259.44	161.55
DF5706	683373.25	3428453.92	130.94
WMD195	697518.60	3356153.86	108.43
WMD219	614213.45	3413227.12	72.74
WMD240	663072.16	3347799.16	77.00
WMD186	602307.50	3408350.76	97.64
WMD108	606852.54	3383592.88	26.84
WMD140	678292.36	3400295.33	136.81
WMD249	657271.43	3396395.83	98.42
WMD228	598029.30	3404038.23	209.71
WMD136	684186.36	3429537.67	128.81
WMD122	692650.74	3352804.65	53.35
WMD230	639362.67	3424525.28	125.43
WMD194	669488.45	3359601.03	94.91
BE3942	641094.04	3406384.46	105.91
WMD158	672226.44	3421074.40	143.01
47-01-A07G	680054.60	3356543.10	87.30
BE3524	662011.56	3379423.34	199.87
WMD135	683794.59	3431656.66	136.58
WMD416	690386.70	3407297.89	92.09
47-02-C10G	671449.23	3362047.10	97.93
GC054	674054.42	3368216.27	112.60

Appendix H – Large Area Screenshots



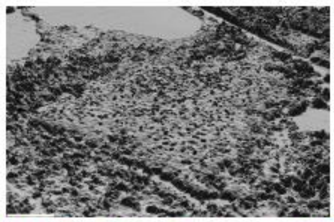
26651_PoorLidarPenetr_qttground.png

26651_PoorLidarPenetr_qttINT.png

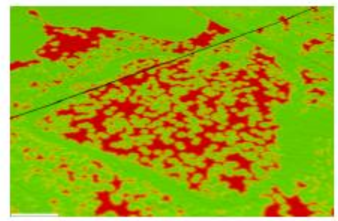


27129_Misclass and PoorLidarPenetr_qttground.png

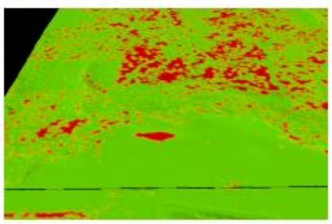
27129_Misclass and PoorLidarPenetr_qttINT.png



27130_PoorLidarPenetr_qtcINT.png

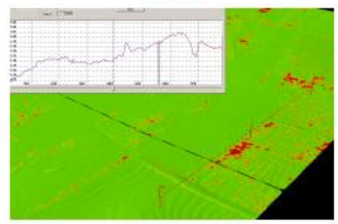


27130_PoorLidarPenetr_qttground.png

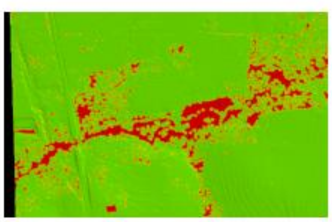


27140_PoorPenetr_qttground.png

27140_PoorPenetr_qttINT.png

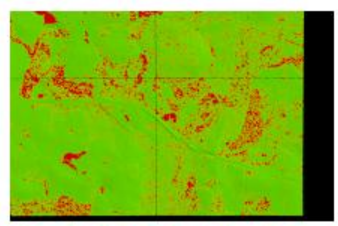


27142_Possible noise_qttground.png



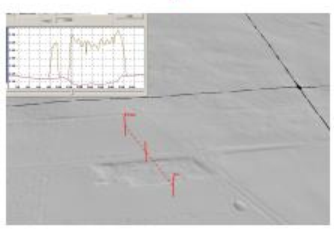
27145_PoorLidarPenetr_qttground.png

27145_PoorLidarPenetr_qttINT.png

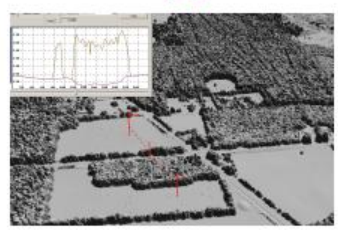


27155_PoorLidarPenetr_qttground.png

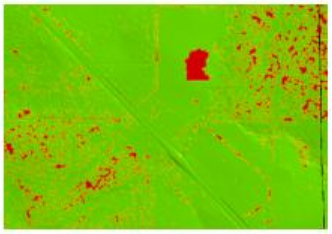
27155_PoorLidarPenetr_qttINT.png



27191_AggrRemoveVeg_qttground.png

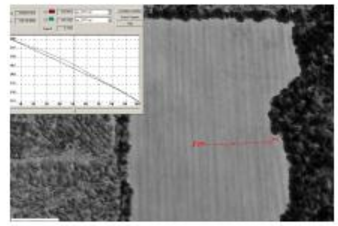


27191_AggrRemoveVeg_qttINT.png

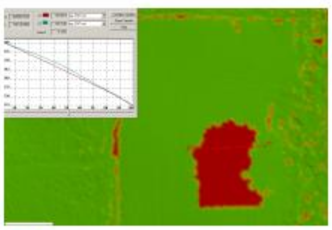


27671_Misclass and PoorLidarPenetr_qttground.png

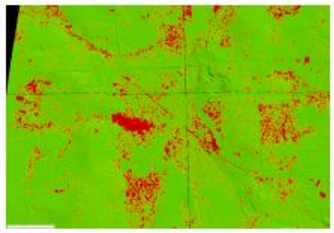
27671_Misclass and PoorLidarPenetr_qttINT.png



27671_missclass_qttgINT.bmp

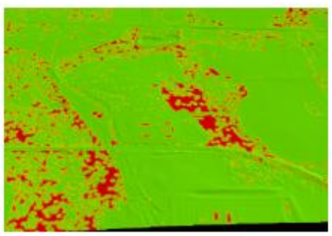


27671_missclass_qttground.bmp



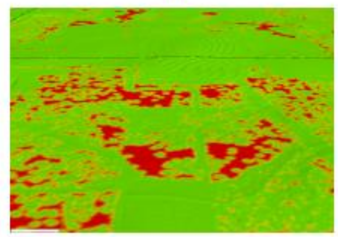
27699_PoorLidarPenetr_qttground.png

27699_PoorLidarPenetr_qttINT.png



27702_PoorLidarPenetr_qttground.png

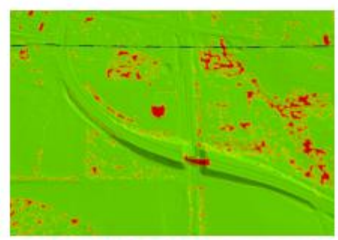
27702_PoorLidarPenetr_qttINT.png



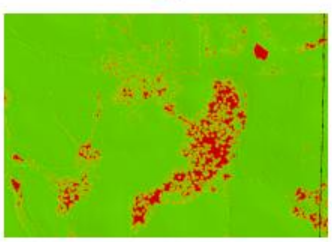
28212_PoorLidarPenetr_qttground.png

28212_PoorLidarPenetr_qttINT.png

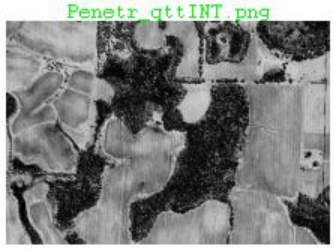
28248_BridgeArtifact and Misclass and PoorLidar Penetr_qttINT.png



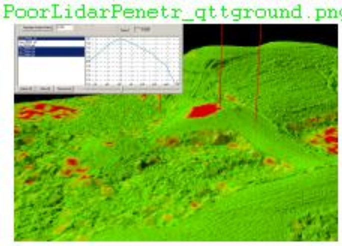
28248_BridgeArtifact and Misclass and PoorLidarPenetr_qttground.png



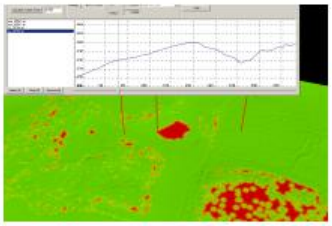
28764_Misclass and PoorLidarPenetr_qttground.png

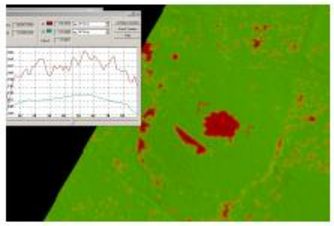


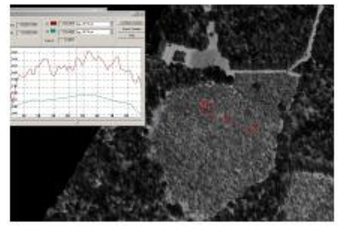
28764_Misclass and PoorLidarPenetr_qttINT.png

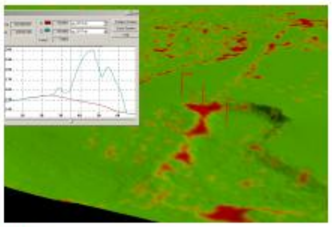


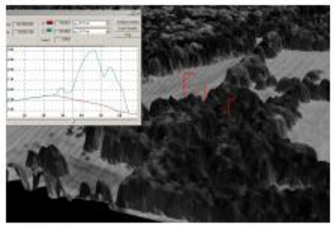
28764_MisclassMeasure_qttground elev exaggerated1.bmp

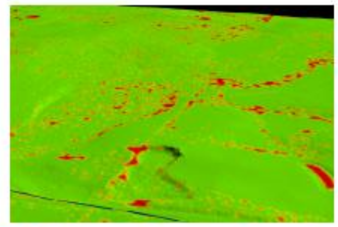

28764_MisclassMeasure1_qttground.bmp


28778_aggrclass_qttground.bmp

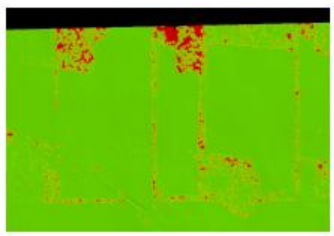

28778_aggrclass_qttINT.bmp


28778_aggrclass2_qttground.bmp

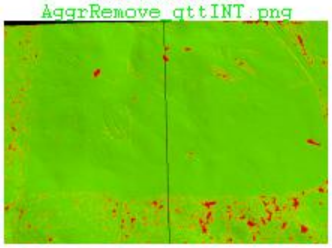

28778_aggrclass2_qttINT.bmp


28778_SparseDensityonSteepSide and Possible AggrRemove_qttground.png

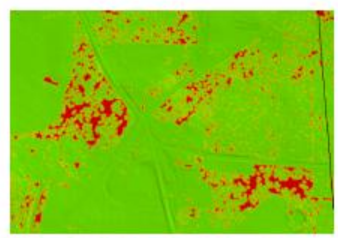

28778_SparseDensityonSteepSide and Possible AggrRemove_qttINT.png


28797_PoorLidarPenetr_qttground.png

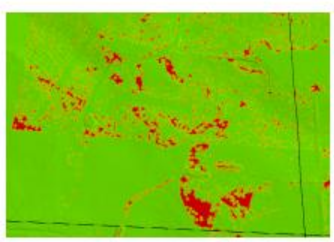

28797_PoorLidarPenetr_qttINT.png


29288_Misclass_qttground.png

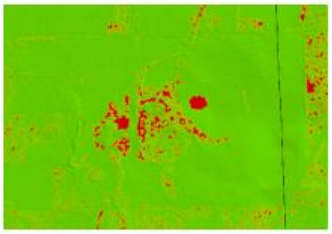

29288_Misclass_qttINT.png


29289_PoorLidarPenetr_qttground.png

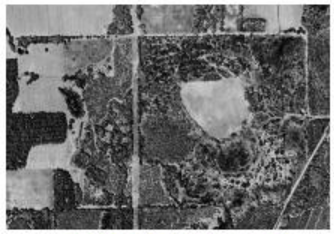

29289_PoorLidarPenetr_qttINT.png


29319_PoorLidarPenetr_qttground.png

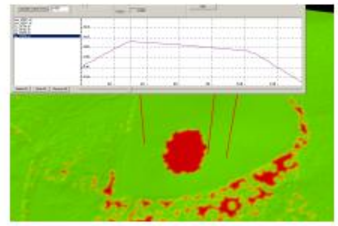

29319_PoorLidarPenetr_qttINT.png



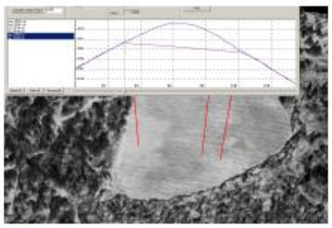
29859_Misclass and PoorLidarPenetr_qttground.png



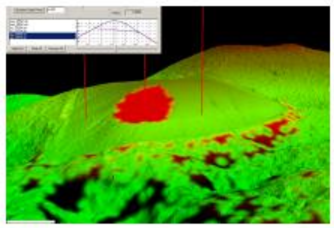
29859_Misclass and PoorLidarPenetr_qttINT.png



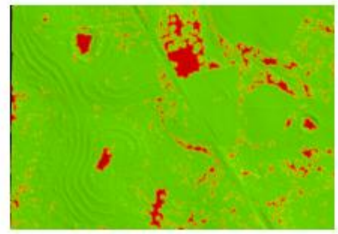
29859_MisclassMeasure_qttground.bmp



29859_MisclassMeasure_qttINTbmp.bmp

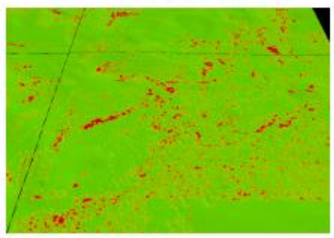


29859_MisclassMeasure_qttINTelev exaggerated1.bmp



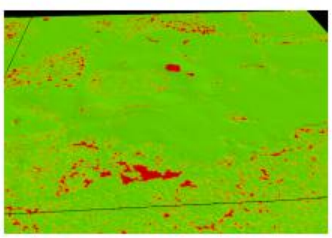
30390_Misclass and PoorLidarPenetr_qttground.png

30390_Misclass and PoorLidarPenetr_qttINT.png



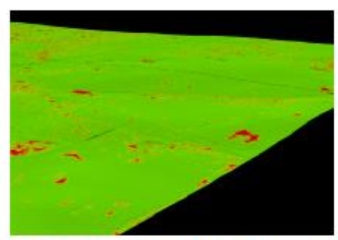
30392_PoorLidarPenetr_qttground.png

30392_PoorLidarPenetr_qttINT.png



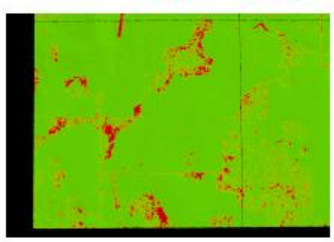
30926_Misclass and some PoorPenetr_qttground.png

30926_Misclass and some PoorPenetr_qttINT.png



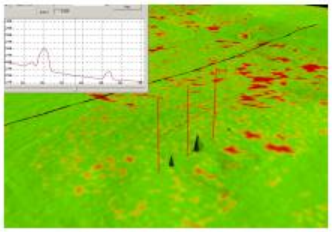
30932_MisclassLandAsWater_qttground.png

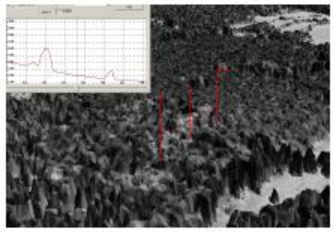
30932_MisclassLandAsWater_qttINT.png

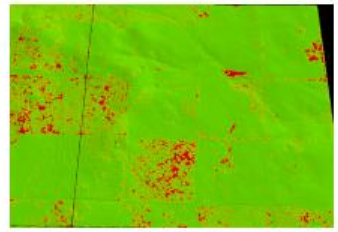


30942_PoorLidarPenetr_qttground.png

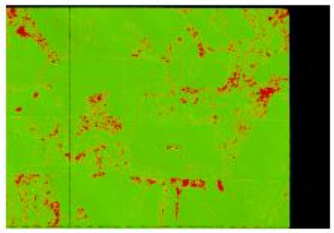
30942_PoorLidarPenetr_qttINT.png


31455_Artifact_qttground.png

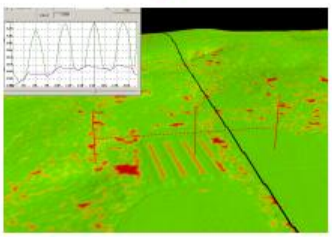

31455_Artifact_qttINT.png

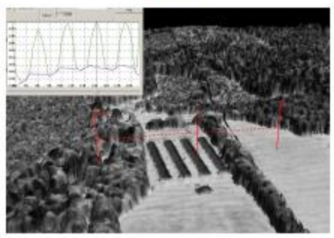

31455_PoorLidarPenetr_qttground.png

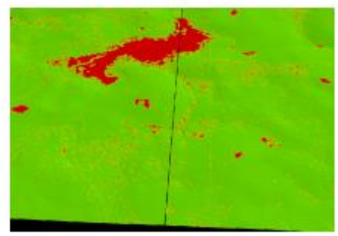

31455_PoorLidarPenetr_qttINT.png

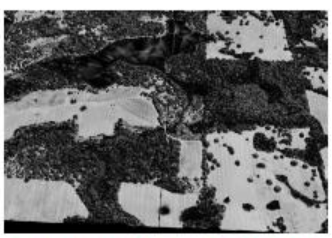

31481_PoorLidarPenetr_qttground.png

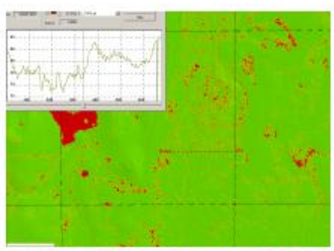

31481_PoorLidarPenetr_qttINT.png

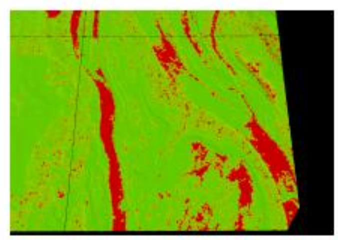

31993_Artifact_qttground.png

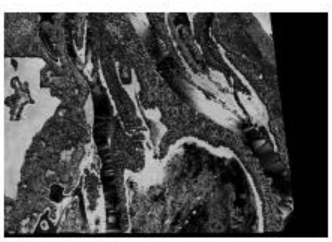

31993_Artifact_qttINT.png

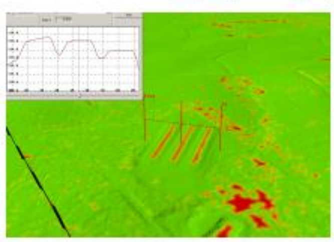

32004_Misclass_qttground.png

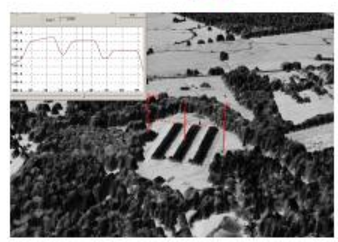

32004_Misclass_qttINT.png

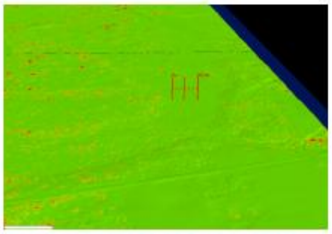

32015_Possible Noise and PoorLidarPenetr_qttground.png


32057_MisclassWaterAsLand_qttground.png

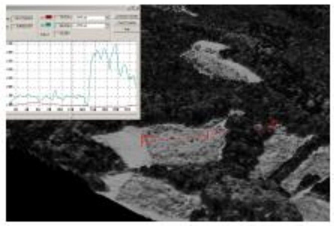

32057_MisclassWaterAsLand_qttINT.png


32533_Artifact_qttground.png

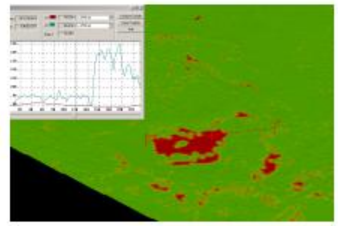

32533_Artifact_qttINT.png



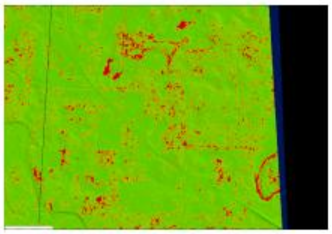
32540_Ridge_qttground.png



32556_poorLidarpen_INT.bmp

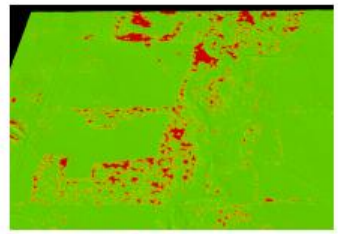


32556_poorLidarpen_qttground.bmp

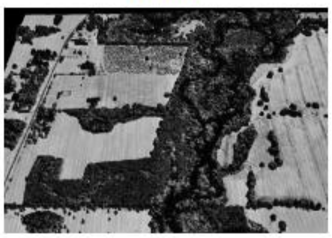


33081_PoorLidarPenetr_qttground.png

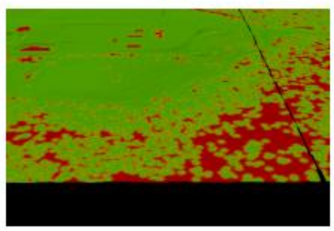
33081_PoorLidarPenetr_qttINT.png



33638_PoorLidarPenetr_qttground.png

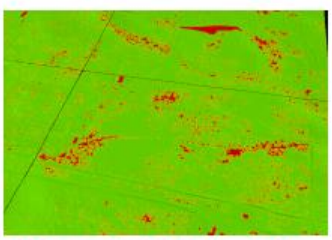


33638_PoorLidarPenetr_qttINT.png



34169_poorLP_qttground.bmp

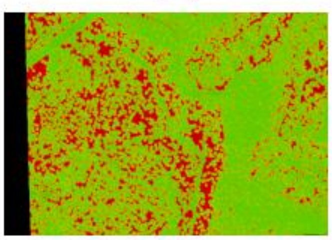
34169_poorLP_qttINT.bmp



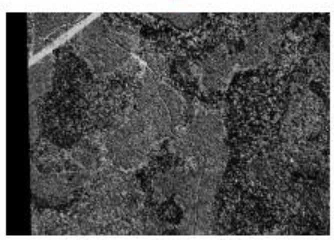
34171_poorPenetrLidar_qttground.png

34171_poorPenetrLidar_qttint.png

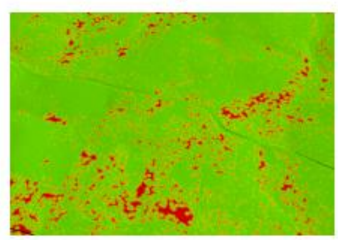
34198_PoorLidarPenetr_qttINT.png



34598_PoorLidarPenetr_qttground.png

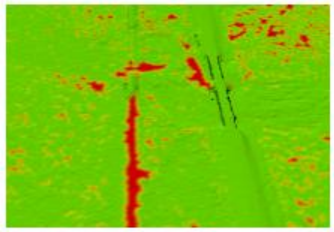


34598_PoorLidarPenetr_qttINT.png

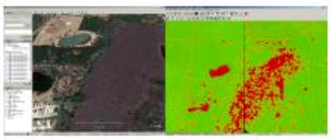


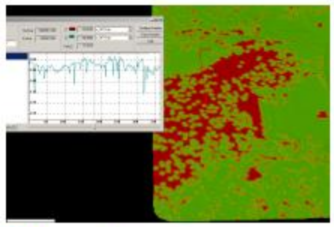
34690_PoorLidarPenetr_qttground.png

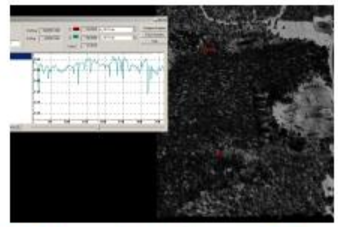

34690_PoorLidarPenetr_qttINT.png

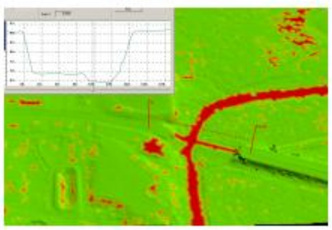

34700_Misclass and Possible Artifact_qttground.png

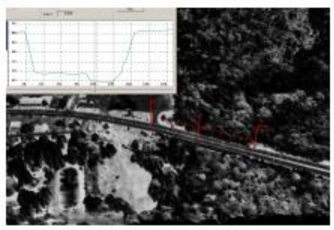

34700_Misclass and Possible Artifact_qttINT.png

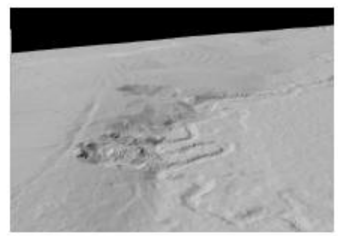

34710_Misclass_qttground and google.png

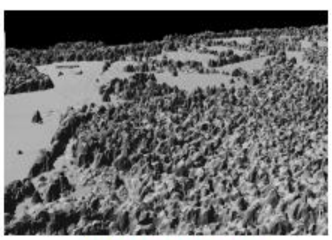

34710_poorLidarPen_qttground.bmp

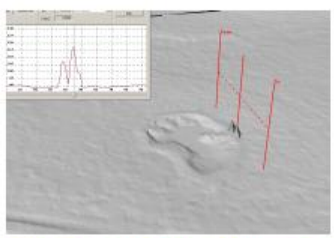

34710_poorLidarPen_qttINT.bmp

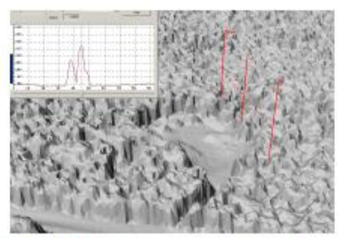

34739_ArtifactBridge_qttground.png

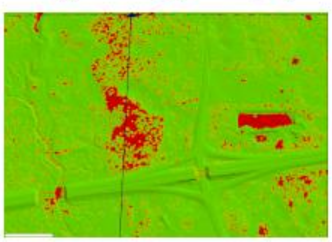

34739_ArtifactBridge_qttINT.png

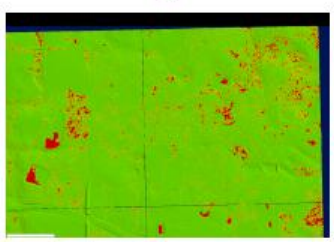

35229_Possible AggrRemove_qttground.png

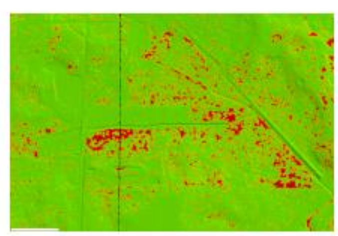

35229_Possible AggrRemove_qttINT.png


35229_VegArtifact_qttground.png

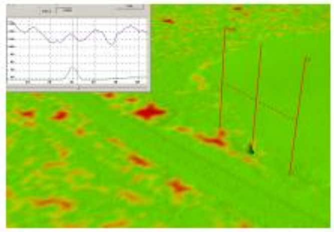

35229_VegArtifact_qttINT.png

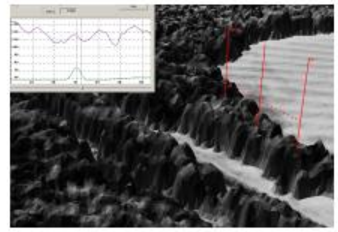

35241_PoorLidarPenetr_qttground.png

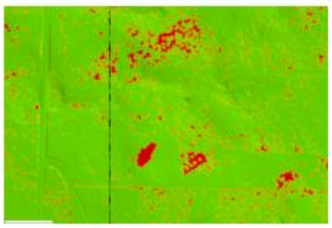

35275 and 35276_PoorLidarPenetr_qttground.png


35279_PoorLidarPenetr_qttground.png

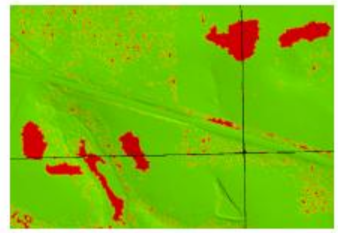

35279_PoorLidarPenetr_qttINT.png


35777_VegArtifact_qttground.png

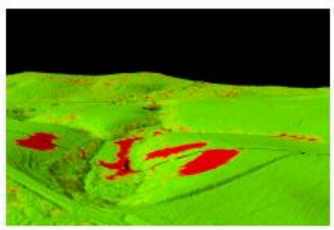

35777_VegArtifact_qttINT.png

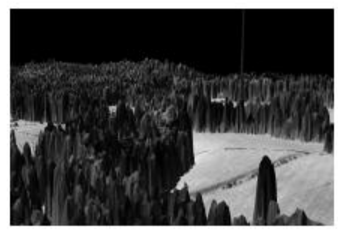

35819_Misclass and PoorLidarPenetr_qttground.png

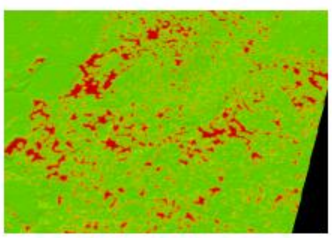

35819_Misclass and PoorLidarPenetr_qttINT.png

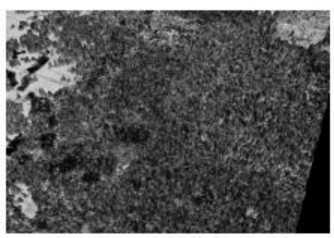

36312_Misclass_qttground.png

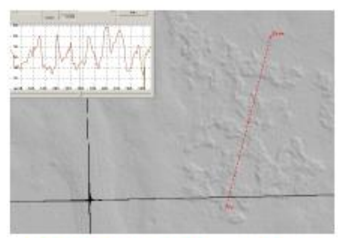

36312_Misclass_qttINT.png

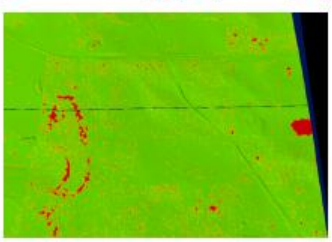

36312_MisclassMeasure_qttground elev exaggerated1.bmp

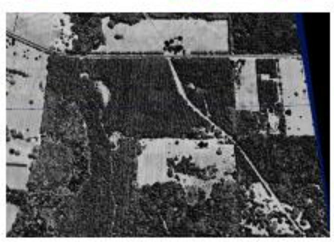

36312_MisclassMeasure_qttINT.bmp

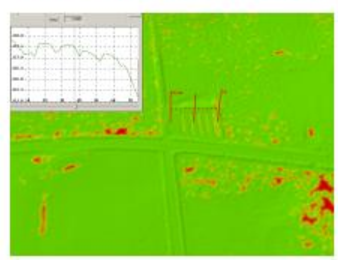

36314_PoorLidarPenetr possibleSwamp_qttground.png

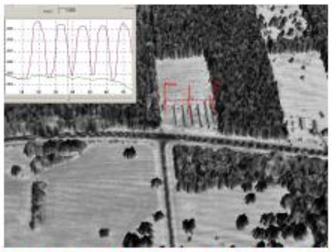

36314_PoorLidarPenetr possibleSwamp_qttINT.png


36317_Noise_qttground.png

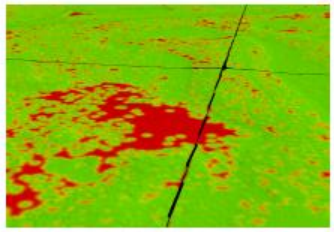

36331_Misclass_qttground.png


36331_Misclass_qttINT.png


36338_ArtifactBuilding_qttground.png

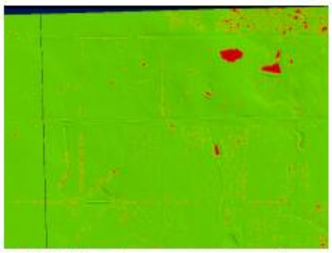


36338_ArtifactBuilding_qttINT.png

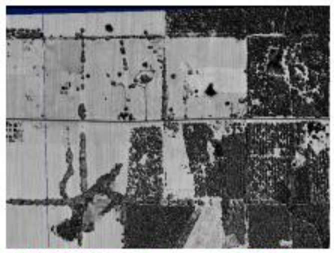


36856_PoorLidarPenetr_qttground.png

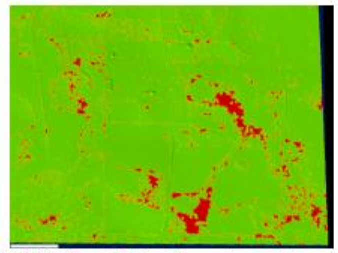
36856_PoorLidarPenetr_qttINT.png



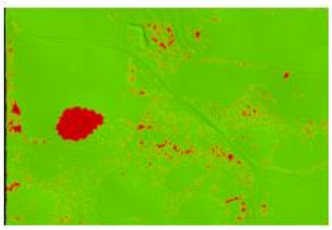
36882_Misclass_qttground.png



36882_Misclass_qttINT.png

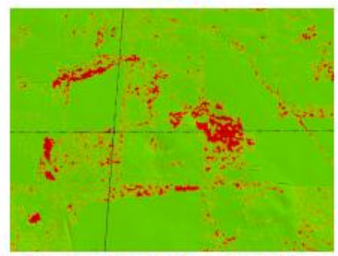


36886_PoorLidarPenetr_qttground.png



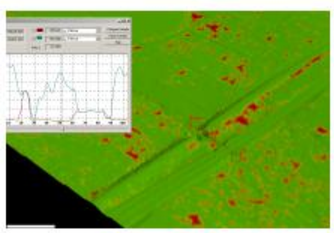
37412_Misclass_qttground.png

37412_Misclass_qttINT.png

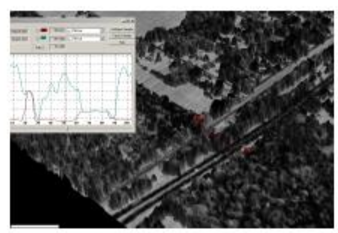


37961_PoorLidarPenetr_qttground.png

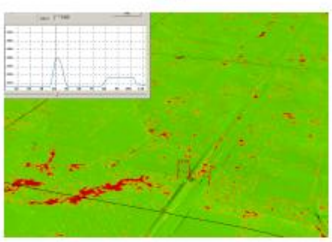
37961_PoorLidarPenetr_qttINT.png



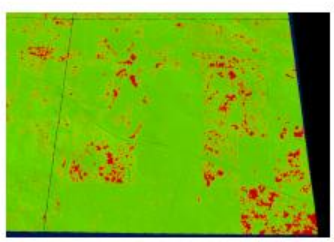
37968_bridgeart_qttground.bmp



37968_bridgeart_qttINT.bmp

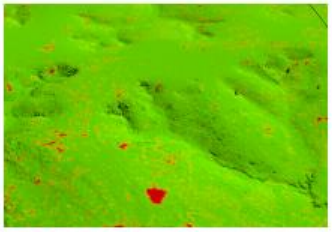


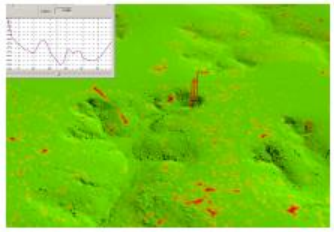
37968_BridgeArtifact and PoorLidarPenetr_qttground.png

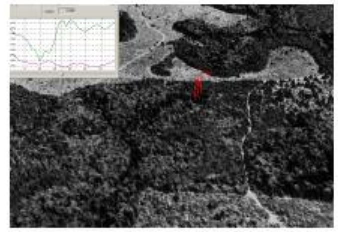


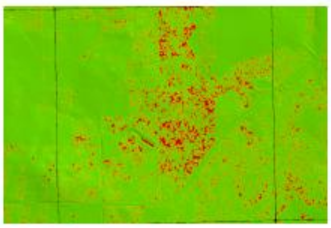
39020_PoorLidarPenetr_qttground.png

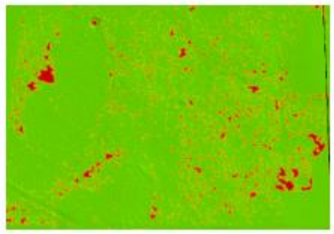
39020_PoorLidarPenetr_qttINT.png


39040_Misclass_qttground.png

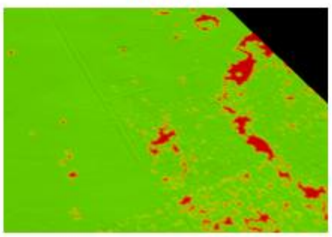

39040_VegArtifacts_qttground.png

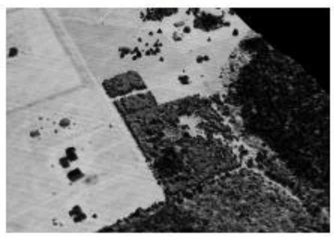

39040_VegArtifacts_qttINT.png

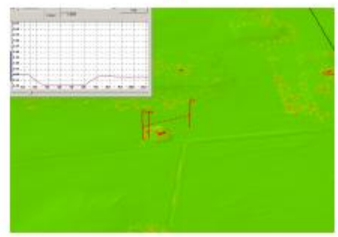

39041_PoorLidarPenetr_qqtground.png

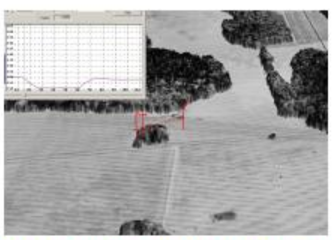

39052_PoorLidarPenetr_qttground.png

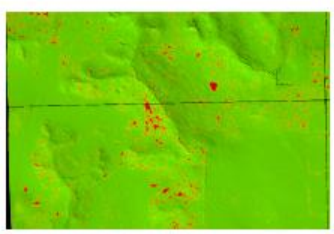

39052_PoorLidarPenetr_qttINT.png

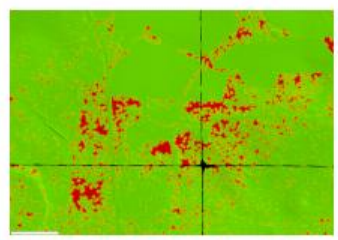

39068_PoorLidarPenetr_qttground.png

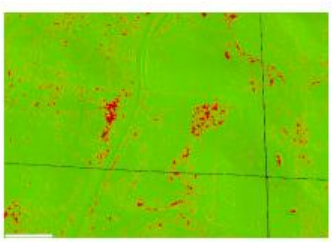

39068_PoorLidarPenetr_qttINT.png


39491_AggrRemoveVeg_qttground.png

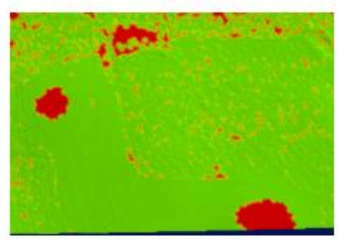

39491_AggrRemoveVeg_qttINT.png

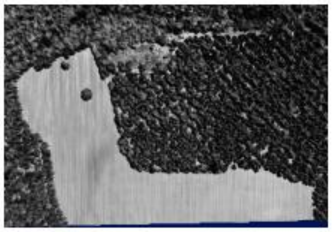

39580_PoorLidarPenetr and Misclass_qqtground.png

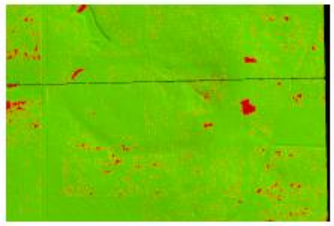

39600_PoorLidarPenetr_qttground.png


40116_PoorLidarPenetr_qttground.png

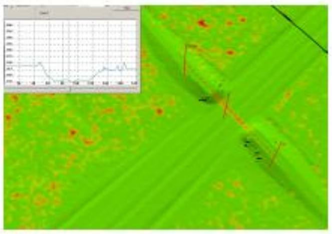

40116_PoorLidarPenetr_qttINT.png

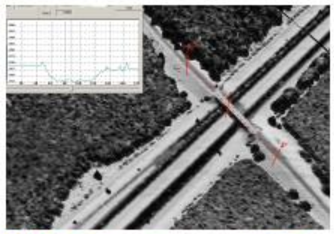

40121_Misclass_qttground.png

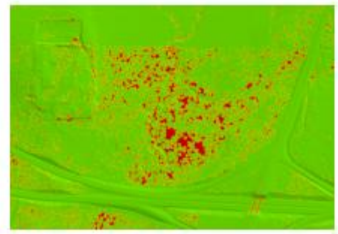

40121_Misclass_qttINT.png

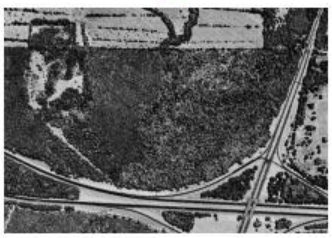

40122_Misclass_qttground.png

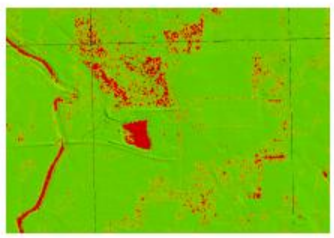

40122_Misclass_qttINT.png


40154_VegArtifacts_qttground.png

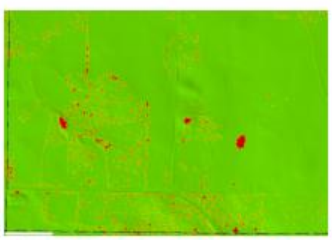

40154_VegArtifacts_qttINT.png


40156_PoorLidarPenetr_qttground.png

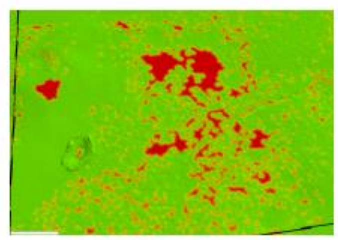

40156_PoorLidarPenetr_qttINT.png

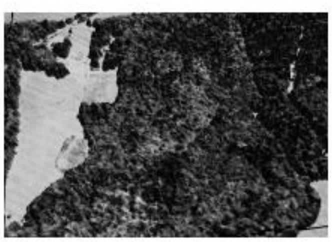

40683_PoorLidarPenetr_qttground.png

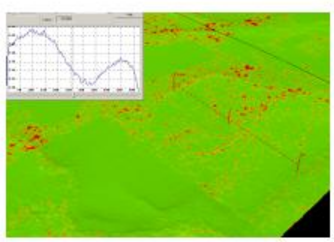

40683_PoorLidarPenetr_qttINT.png

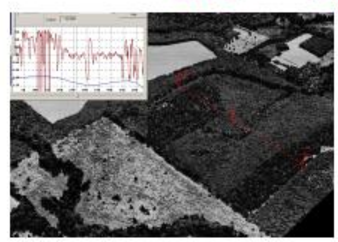

40684_Misclass_qttground.png

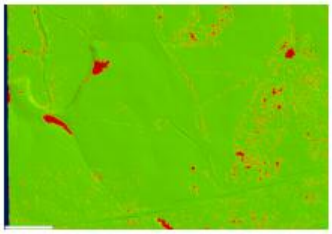

40684_Misclass_qttINT.png


40687_Misclass and PoorLidarPenetr_qttground.png

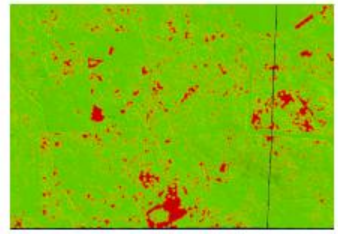

40687_Misclass and PoorLidarPenetr_qttINT.png

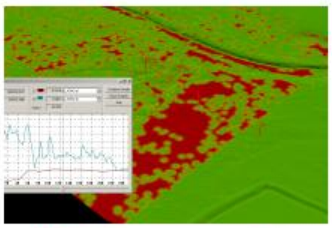

40694_Noise and PoorPenetr_qttground.png

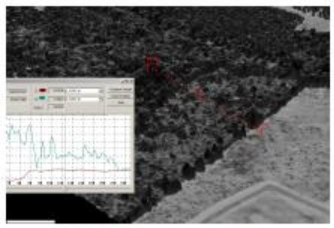

40694_Noise and PoorPenetr_qttINT.png

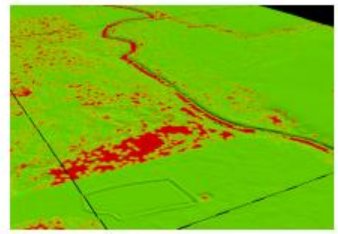

41187_Misclass_qttground.png


41187_Misclass_qttINT.png

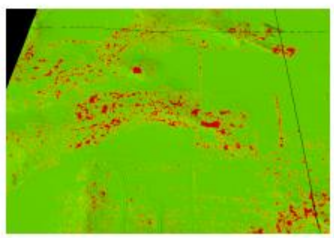

41188_PoorLidarPenetr_qttground.png

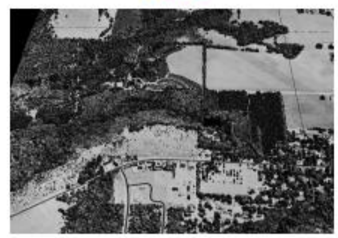

42842_pLp_qttground.bmp

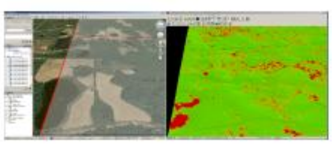

42842_pLp_qttINT.bmp

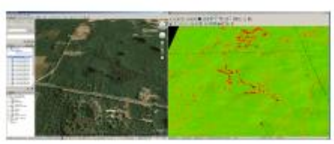

42842_PoorLidarPenetr_qttground.png

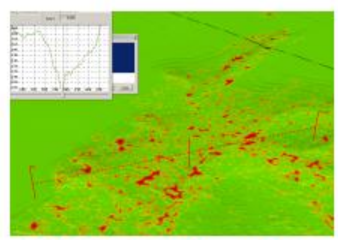

42842_PoorLidarPenetr_qttINTand google.png

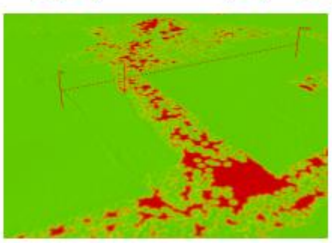

42844_PoorLidarPenetr_qttground.png


42844_PoorLidarPenetr_qttINT.png

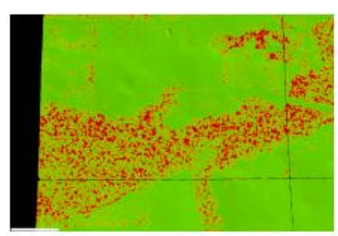

43380_MisclassWater and Soil_qttground and google.png


43381_MisclassWaterAsLand_qttground and Google.png

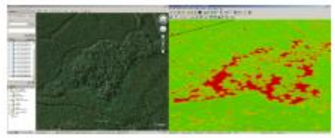

43384_Noise_qttground.png

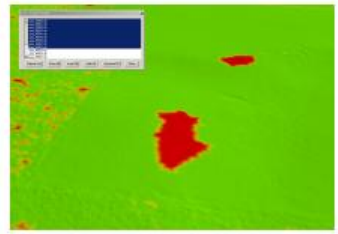

43928_PoorLidarPenetr_qttground.png


43928_PoorLidarPenetr_qttINT.png

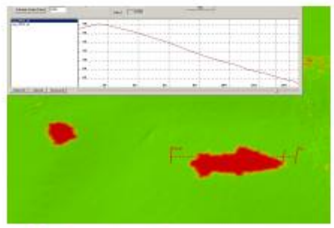

44457_PoorLidarPenetr_qttground.png

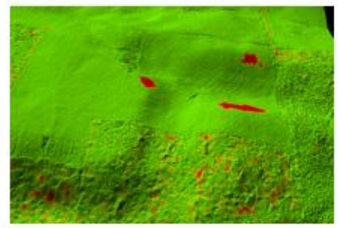

44457_PoorLidarPenetr_qttINT.png

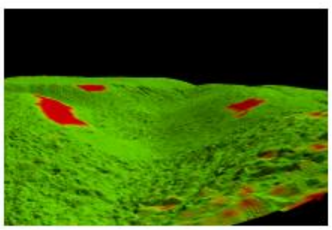

44463_PoorLidarPenetr_qttground and google.png

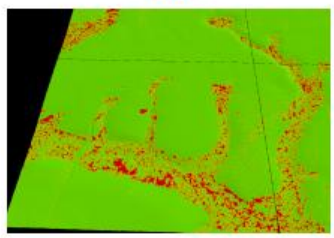

45541_misclass_qttground.png


45541_misclass_qttint.png

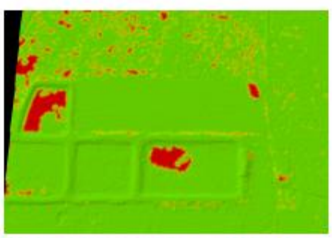

45541_MisclassMeasure_qttground.bmp

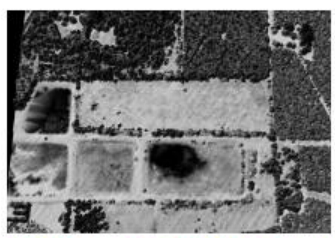

45541_MisclassMeasure_qttINTelev exaggerated1.bmp

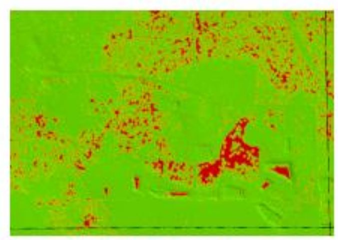

45541_MisclassMeasure_qttINTelev exaggerated2.bmp


46073_PoorLidarPenetr and Misclass_qttground.png

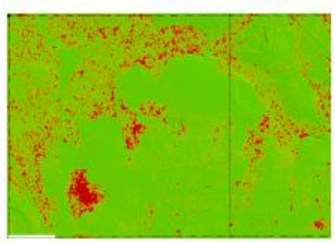

46073_PoorLidarPenetr and Misclass_qttINT.png


47167_Possible VegArtifact and Misclass_qttground.png

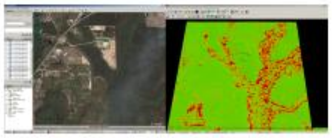

47167_Possible VegArtifact and Misclass_qttINT.png


47707_PoorLidarPenetr_qttground.png

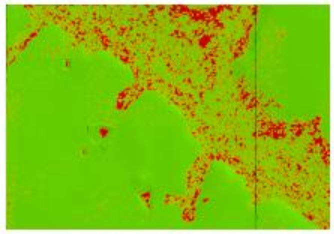

47707_PoorLidarPenetr_qttINT.png


47708_PoorLidarPenetr_qttground.png


47708_PoorLidarPenetr_qttINT.png

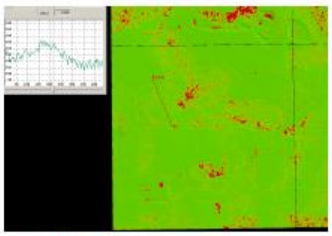


47715_PoorLidarPenetr_qttground and google.png

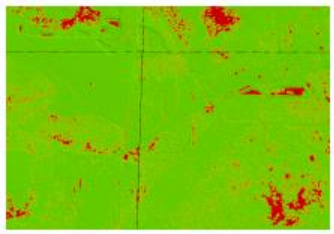


48233_PoorLidarPenetr_qttground.png

48233_PoorLidarPenetr_qttINT.png

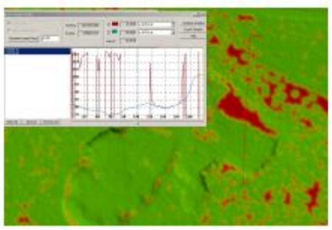


48247_Noise_qttground.png

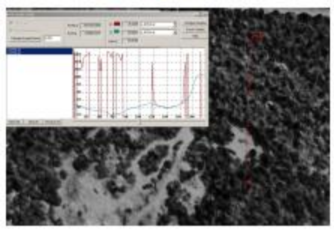


48248_PoorLidarPenetr_qttground.png

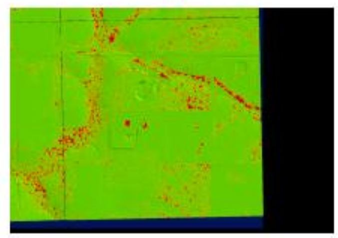
48248_PoorLidarPenetr_qttINT.png



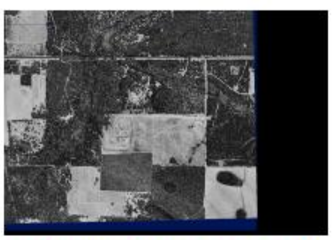
48784_poorLidarPen_qttground.bmp



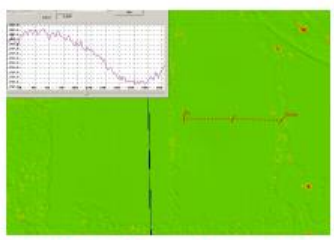
48784_poorLidarPen_qttINT..bmp



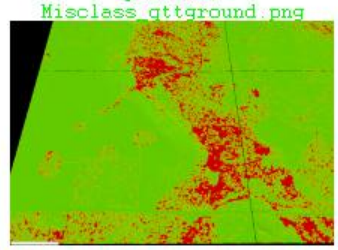
48784_PoorLidarPenetr and possible Misclass_qttground.png



48784_PoorLidarPenetr and possible Misclass_qttINT.png

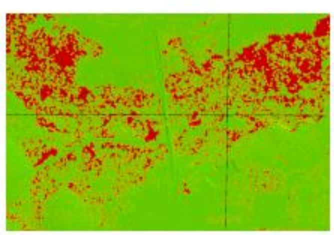


48795_PossibleCornrows_qttground.png



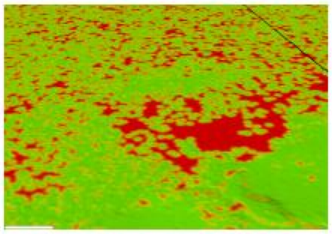
49866_PoorLidarPenetr_qttground.png

49866_PoorLidarPenetr_qttINT.png

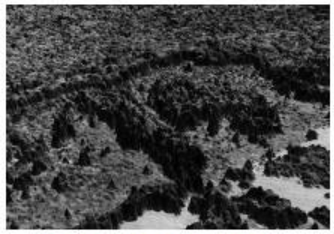


51479_PoorLidarPenetr and BridgeArtifact_qttground.png

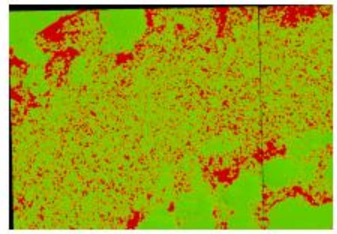
51479_PoorLidarPenetr and BridgeArtifact_qttINT.png



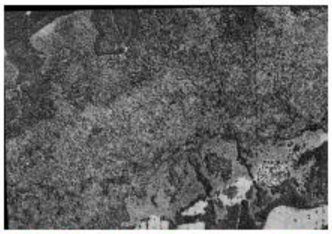
51498_PoorLidarPenetr closeup_qttground.png



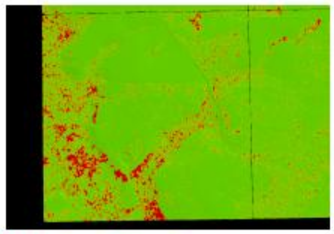
51498_PoorLidarPenetr closeup_qttINT.png



51498_PoorLidarPenetr_qttground.png

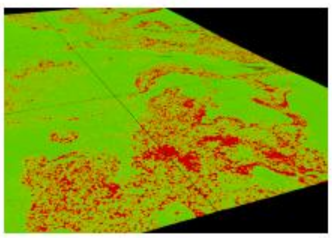


51498_PoorLidarPenetr_qttINT.png

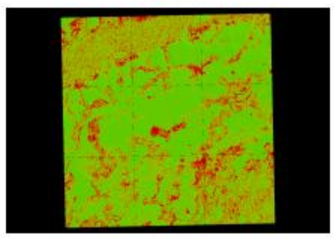


52024_PoorLidarPenetr_qttground.png

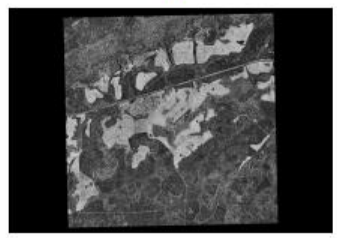
52024_PoorLidarPenetr_qttINT.png



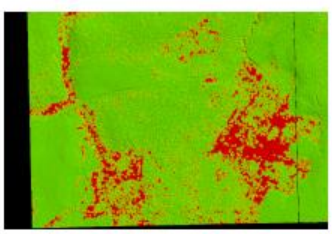
52036_PoorLidarPenetr_qttground.png



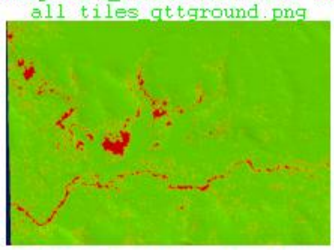
52039 and neighbors_PoorLidarPenetr on all tiles_qttground.png



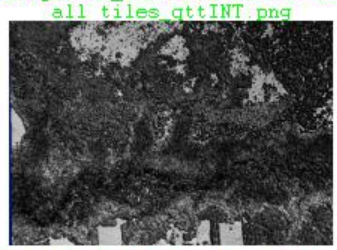
52039 and neighbors_PoorLidarPenetr on all tiles_qttINT.png



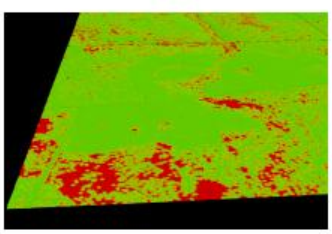
53633_PoorLidarPenetr_qttground.png



55810_PoorLidarPenetr_qttground.png

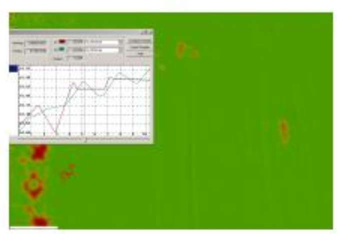


55810_PoorLidarPenetr_qttINT.png

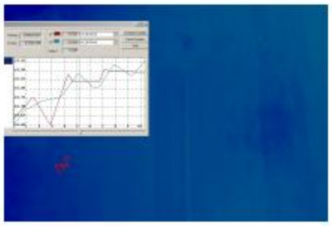


56338_PoorlidarPenetr_qttground.png

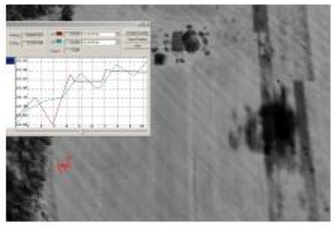
56338_PoorLidarPenetr_qttINT.png



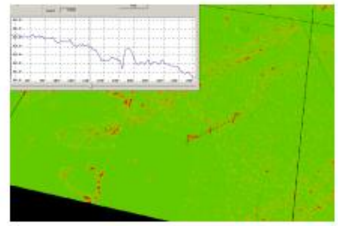
56339_neglCornrows_qttground1.bmp



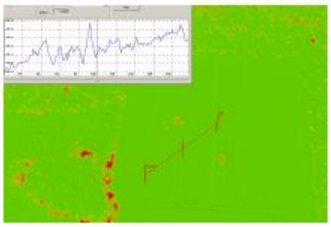
56339_neglCornrows_qttground2.bmp



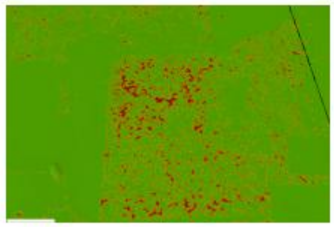
56339_neglCornrows_qttINT.bmp



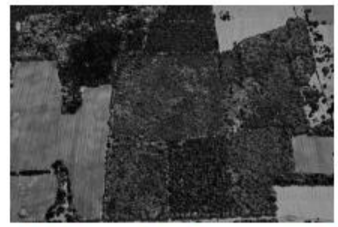
56339_Possible Cornrows extending into forest.png



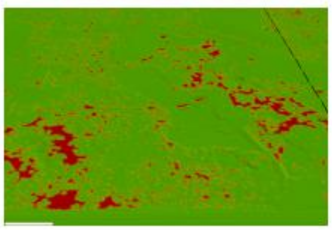
56339_Possible Cornrows_qttground.png



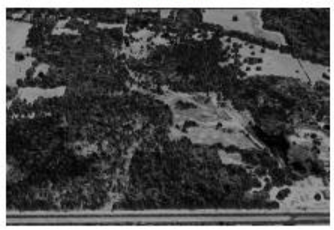
y-27181_poorLidarPentr_qttground.bmp



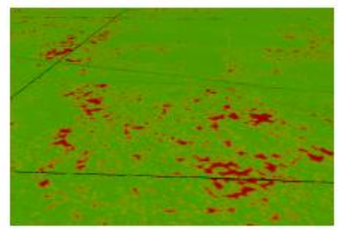
y-27181_poorLidarPentr_qttINT.bmp



z-36912_poorLidarpentr_qttground.bmp

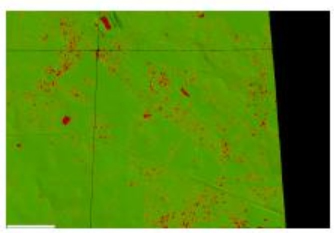


z-36912_poorLidarpentr_qttINT.bmp



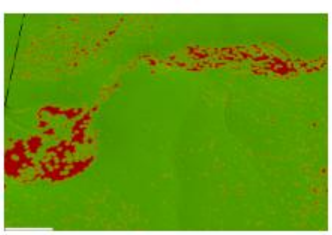
z-36913_poorLidarpentr_qttground.bmp

z-36913_poorLidarpentr_qttINT.bmp

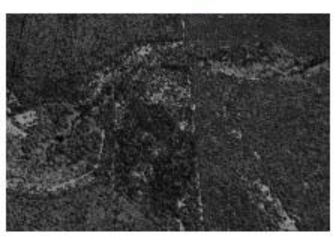


zz-34196_poorLidarpenetr_qttground.bmp

zz-34196_poorLidarpenetr_qttINT.bmp



zzz-44995_poorLidarpenetr_qttground.bmp



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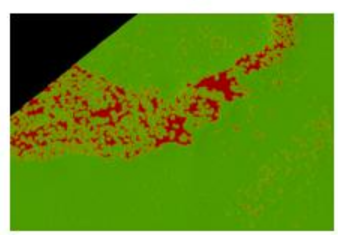

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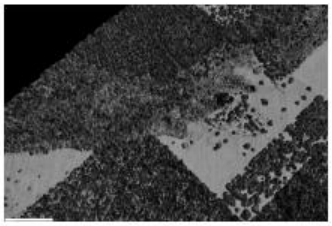

zzz-45533_poorLidarpenetr_qttINT.bmp