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Dewberry Response to USGS Review of the FEMA IX - Orange County, CA LiDAR Processing Project

Produced for U.S. Geological Survey

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Executive Summary

The primary purpose of this project was to develop a consistent and accurate surface elevation dataset derived from high-accuracy Light Detection and Ranging (LiDAR) technology for the USGS FEMA IX Orange County, California Project Area.

The LiDAR data were processed to a bare-earth digital terrain model (DTM). Detailed breaklines and bare-earth Digital Elevation Models (DEMs) were produced for the project area. .

Deliverables for this project included raw point cloud data, classified point cloud data, bare earth digital elevation models, intensity images, breaklines, control points, metadata, project report, and project extent shapefiles.

The USGS review of these deliverables resulted in one call to deliver intensity ortho metadata, one call regarding the location of the swath accuracy testing results, one call to include missing checkpoint from the forested and fully grown land cover class in the accuracy testing, two calls to redeliver unreadable LAS tiles, ten calls to remove buildings from ground, four calls to remove vegetation artifacts from ground, two bridge removal calls, four calls to modify breaklines, and four calls regarding data voids or missing data.

PROJECT AREA

Data was formatted according to tiles with each tile covering an area of 1500m by 1500m. A total of 868 tiles were produced for the project encompassing an area of approximately 681 sq. miles.

Figure 1: Project Map

Edit Calls

METADATA

All metadata has been redelivered in addition to the intensity metadata due to the effect of the additional checkpoint.

ACCURACY TESTING

The missing checkpoint for the Forested and Fully Grown land cover class was located and added to the LiDAR and DEM dataset testing. This additional point changed the LiDAR dataset SVA for the Forested and Fully Grown land cover category by 0.01m. This additional point did not significantly impact the DEM dataset SVA. There was a slight change to the overall CVA for both the DEM and LiDAR datasets but it was less than 0.001m. The final report and metadata were updated to reflect these changes.

LAS TILES

USGS was unable to load two LAS tiles. These two LAS tiles have been redelivered. USGS identified artifacts and missing water features in the delivered data. These calls resulted in the modification of twelve LAS tiles. The twelve modified LAS tiles have also been redelivered.

BUILDINGS AND STRUCTURES

There were eleven locations where comments were made to remove structure related artifacts. The DEM surface models are created from terrains. Terrain models create continuous surfaces from the inputs, in this instance LiDAR ground points. The surface model must make a continuous model and in order to do so, points are connected through interpolation. This can cause visual artifacts in areas where the ground elevation is higher on one side of the building than the other. This is common throughout California where many homes are built into hillsides. As these "artifacts" are only visual and do not exist in the LiDAR points, no modifications were made to the LAS or DEMs in 10 of these areas. Modifications were made to 1 area where highpoints could be removed from the ground to create a cleaner surface model. Examples are shown below.

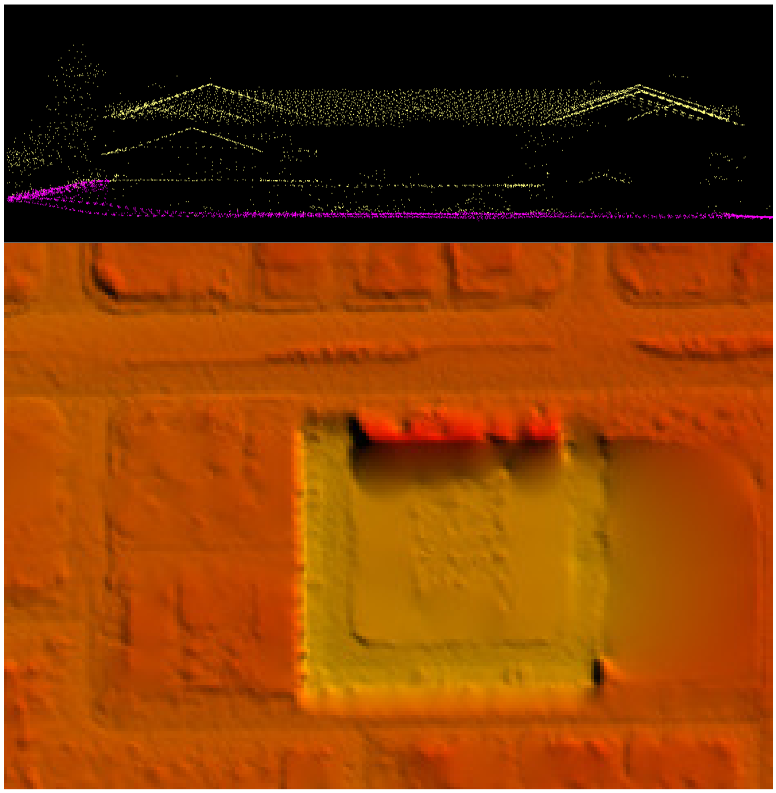

Figure 2 - Tile 11SMT096435. The DEM in the bottom view shows a visual artifact because the surface model is interpolating between the available ground points on either side of the building points that were removed. The profile in the top view shows the LiDAR points of this particular feature colored by class. All building points have been removed from ground (pink) and are unclassified (yellow). There are no ground points that can be modified to correct this visual artifact.

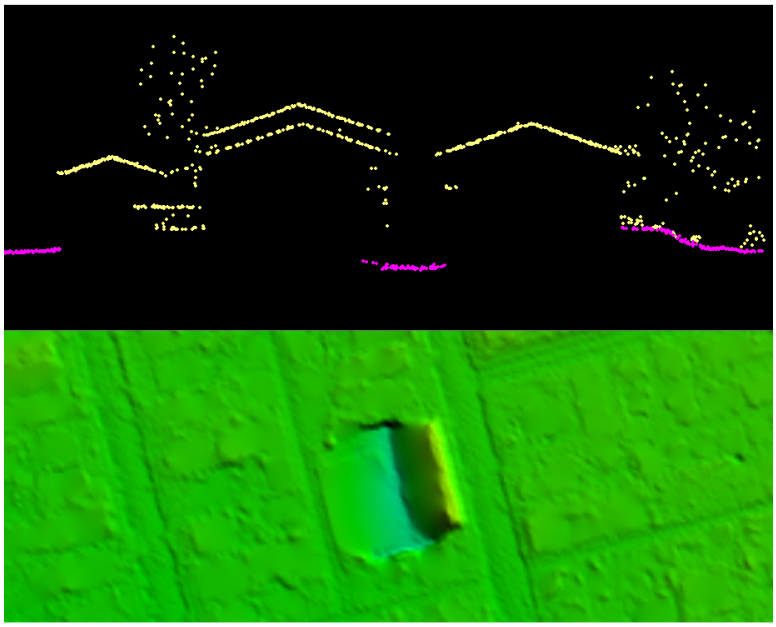

Figure 3 - Tile 11SMT141435. The DEM in the bottom view shows a visual artifact because the surface model is interpolating between the available ground points on either side of the building points that were removed. The profile in the top view shows the LiDAR points of this particular feature colored by class. All building points have been removed from ground (pink) and are unclassified (yellow). There are no ground points that can be modified to correct this visual artifact.

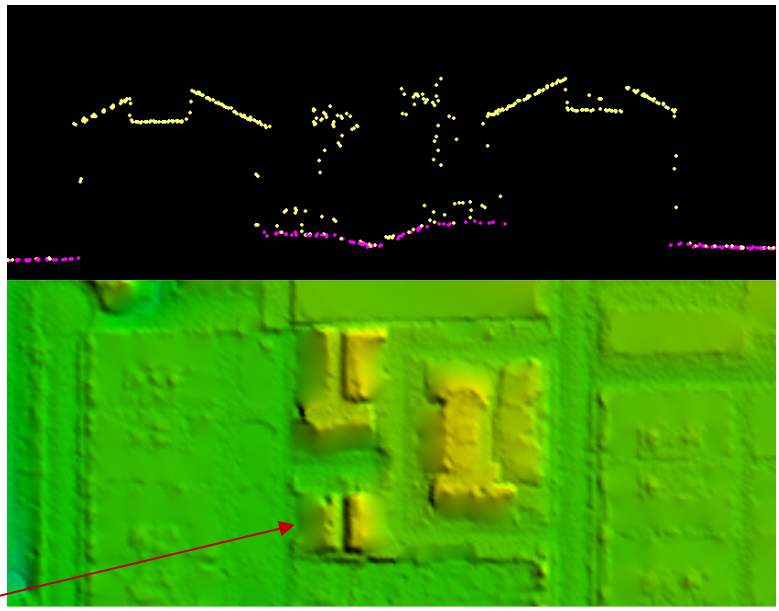

Figure 4 - Tile 11SMT066435. The DEM in the bottom view shows a visual artifact because the surface model is interpolating between the available ground points on either side of two apartment buildings separated by a courtyard. The profile in the top view shows the LiDAR points of this particular feature colored by class. All building points have been removed from ground (pink) and are unclassified (yellow). There are no ground points that can be modified to correct this visual artifact.

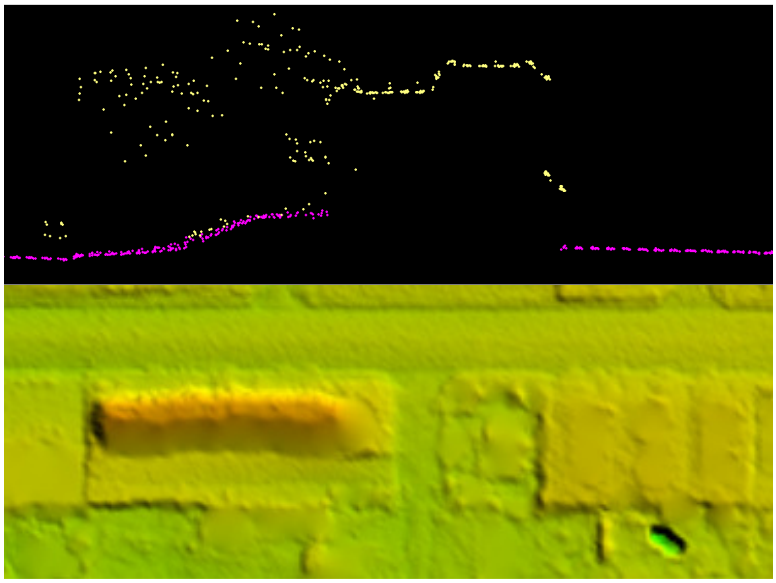

Figure 5 - Tile 11SMT081390. The DEM in the bottom view shows a visual artifact because the surface model is interpolating between the available ground points on either side of the building points that were removed. The profile in the top view shows the LiDAR points of this particular feature colored by class. All building points have been removed from ground (pink) and are unclassified (yellow). There are no ground points that can be modified to correct this visual artifact.

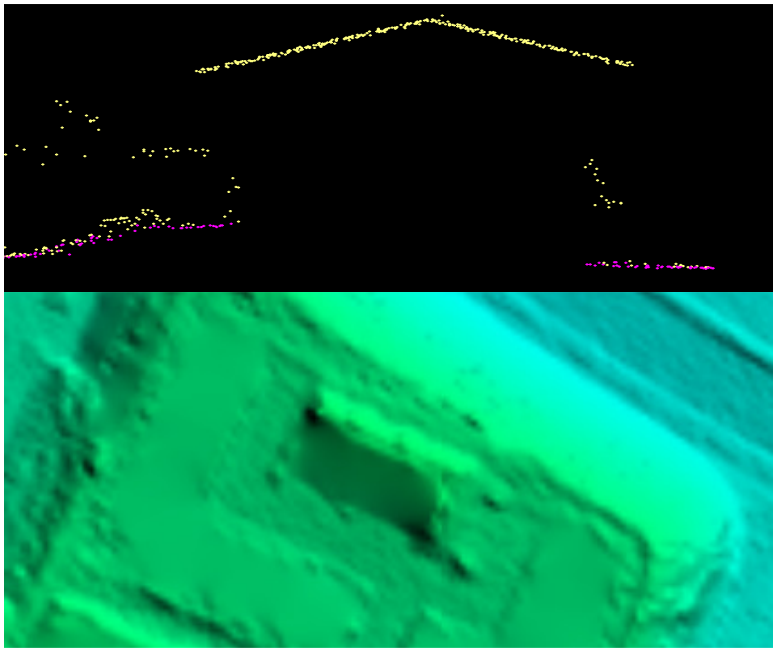

Figure 6 - Tiles 11SMT261225 and 11SMT276225. The DEM in the bottom view shows a visual artifact because the surface model is interpolating between the available ground points on either side of the building points that were removed. The profile in the top view shows the LiDAR points of this particular feature colored by class. All building points have been removed from ground (pink) and are unclassified (yellow). There are no ground points that can be modified to correct this visual artifact.

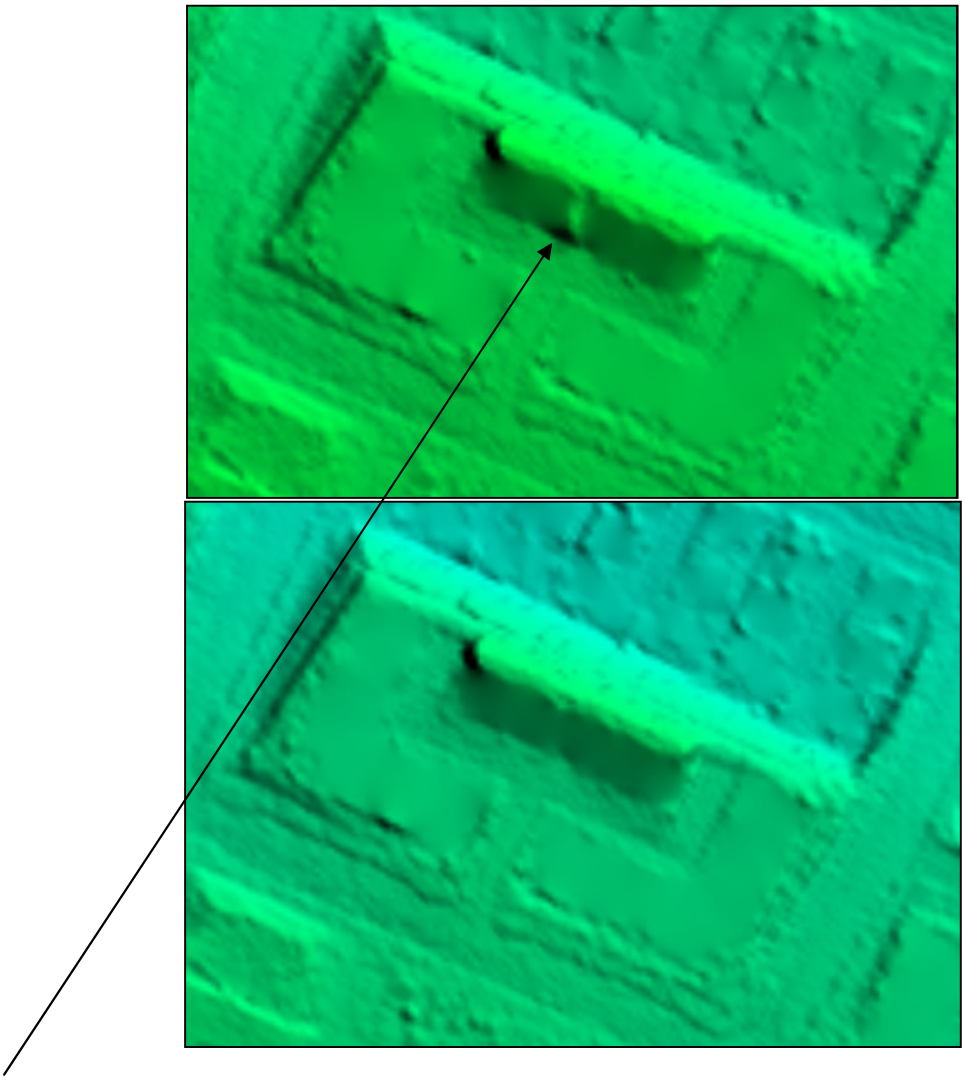

Figure 7 –Tile 11SMT276225. The DEM in the top view is similar to the previous calls but some high points are present that can be modified. These high points were removed from class 2 ground. The impact to the DEM is minor and a visual artifact is still present in the redelivered DEM shown in the bottom view because the surface model is interpolating between the available ground points on either side of the building points that were removed. All building points have been removed from ground.

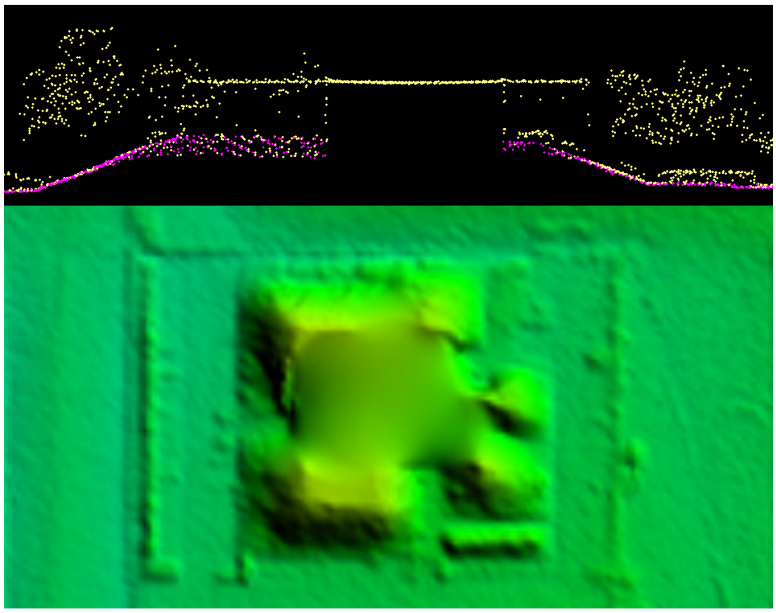

Figure 8 - Tile 11SMT096450. The DEM in the bottom view shows a visual artifact because the surface model is interpolating between the available ground points on either side of the medical center building points that were removed. This looks odd due to the hills included in the landscaping surrounding the building. The profile in the top view shows the LiDAR points of this particular feature colored by class. All building points have been removed from ground (pink) and are unclassified (yellow). There are no ground points that can be modified to correct this visual artifact.

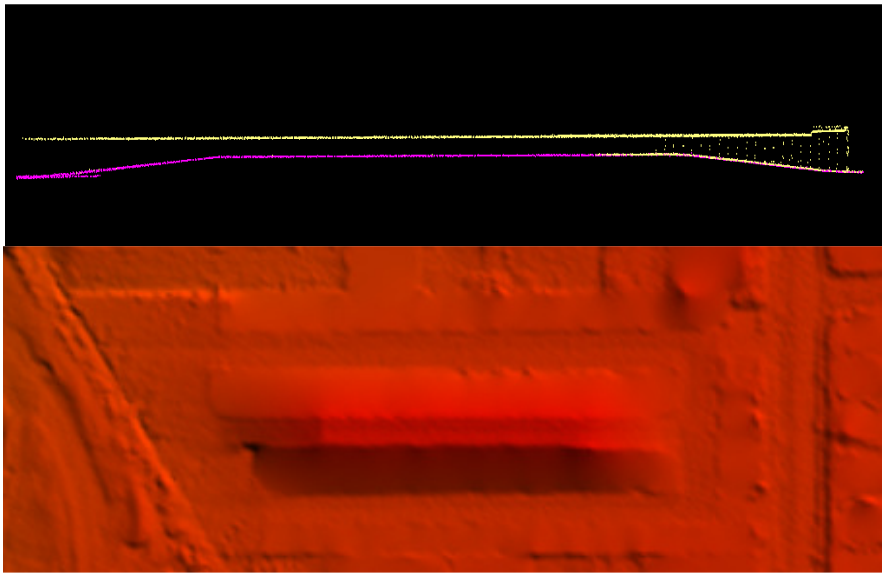

Figure 9 - Tiles 11SMT111210 and 11SMT126210. The DEM in the bottom view shows a visual artifact because the surface model is interpolating between the available ground points on either side of storage facility units that are separated by built up ground forming a raised ramp like feature. The profile in the top view shows the LiDAR points of this particular feature colored by class. All building points have been removed from ground (pink) and are unclassified (yellow). There are no ground points that can be modified to correct this visual artifact.

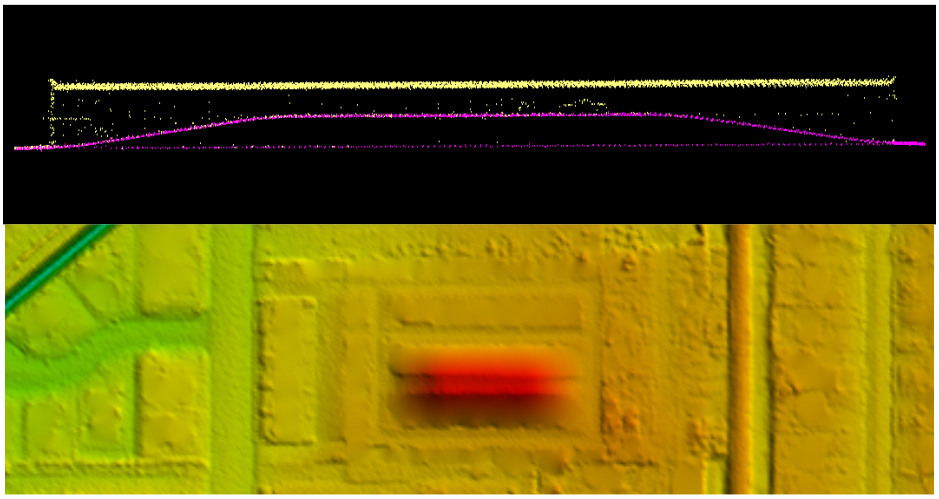

Figure 10 - Tile 11SMT066390. The DEM in the bottom view shows a visual artifact because the surface model is interpolating between the available ground points on either side of more storage facility units that are separated by built up ground forming a raised ramp like feature. The profile in the top view shows the LiDAR points of this particular feature colored by class. All building points have been removed from ground (pink) and are unclassified (yellow). There are no ground points that can be modified to correct this visual artifact.

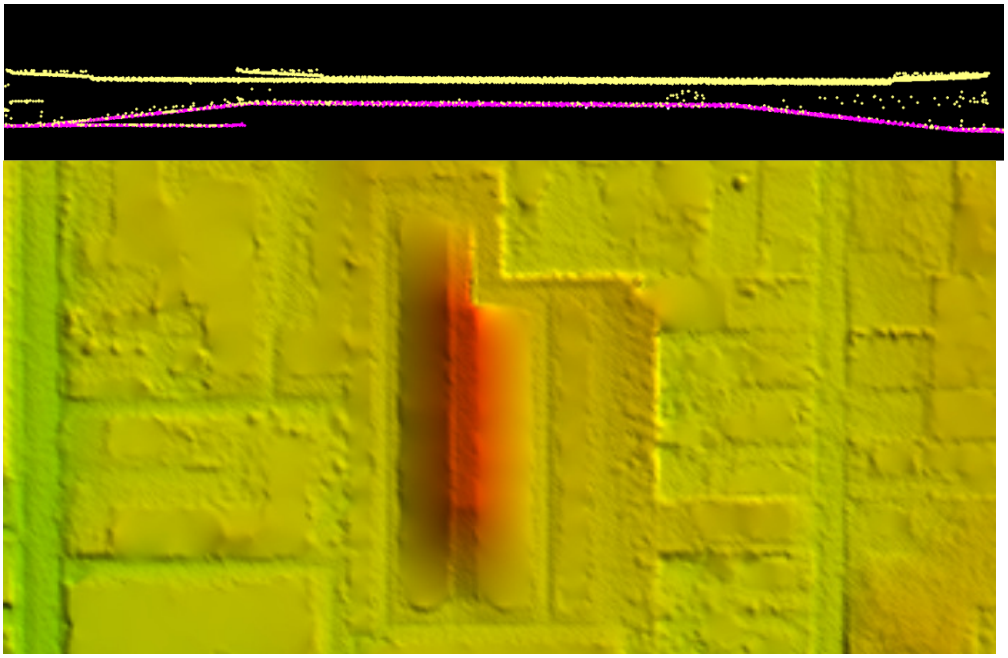

Figure 11 - Tile 11SMT006435. The DEM in the bottom view shows a visual artifact because the surface model is interpolating between the available ground points on either side of more storage facility units that are separated by built up ground forming a raised ramp like feature. The profile in the top view shows the LiDAR points of this particular feature colored by class. All building points have been removed from ground (pink) and are unclassified (yellow). There are no ground points that can be modified to correct this visual artifact.

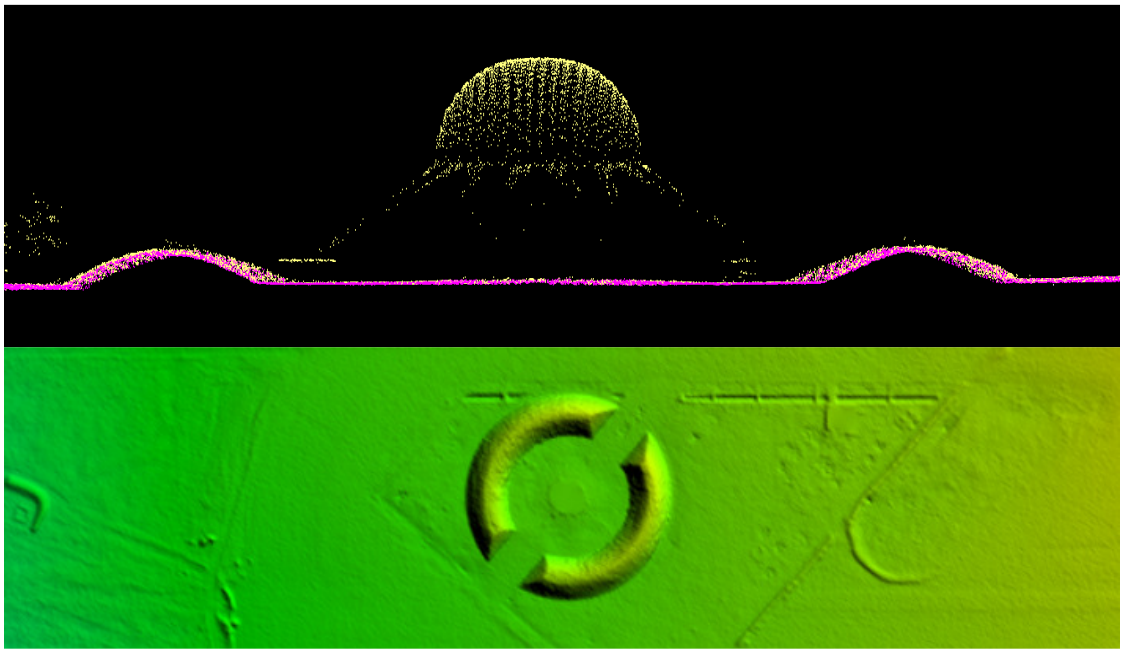

Figure 12 - Tile 11SMT306255. In ground structures exist within the project area. In the example above, earthen mounds have been formed around an area. These features are correctly included in the ground classification.

ARTIFACTS

There were three calls to remove features from the ground surface. Dewberry removed the identified features as requested by USGS. Examples are shown below.

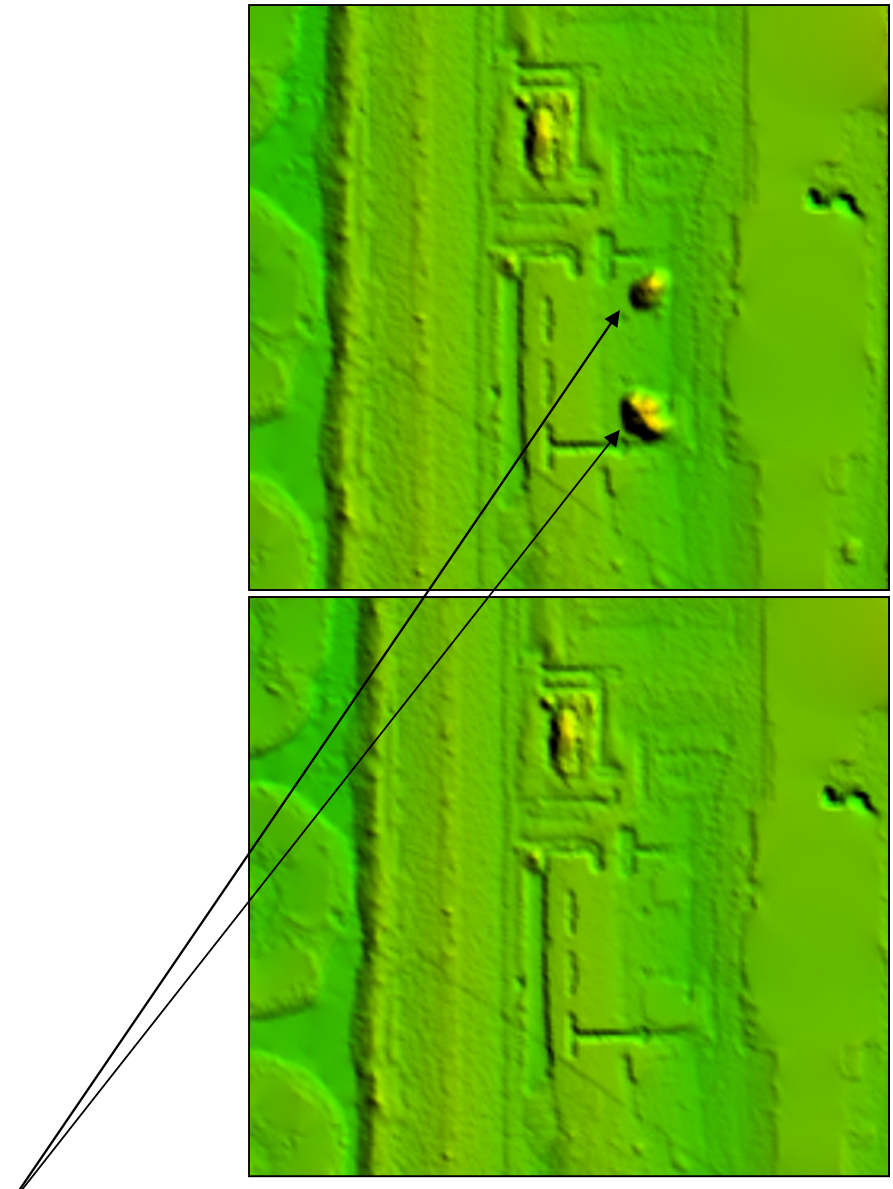

Figure 13 - Tile 11SMT081240. At the time of LiDAR acquisition, this area was under construction and dirt hills were present as shown in the top view. At the request of USGS, these hills have been removed from the ground as shown in the redelivered DEM in the bottom view.

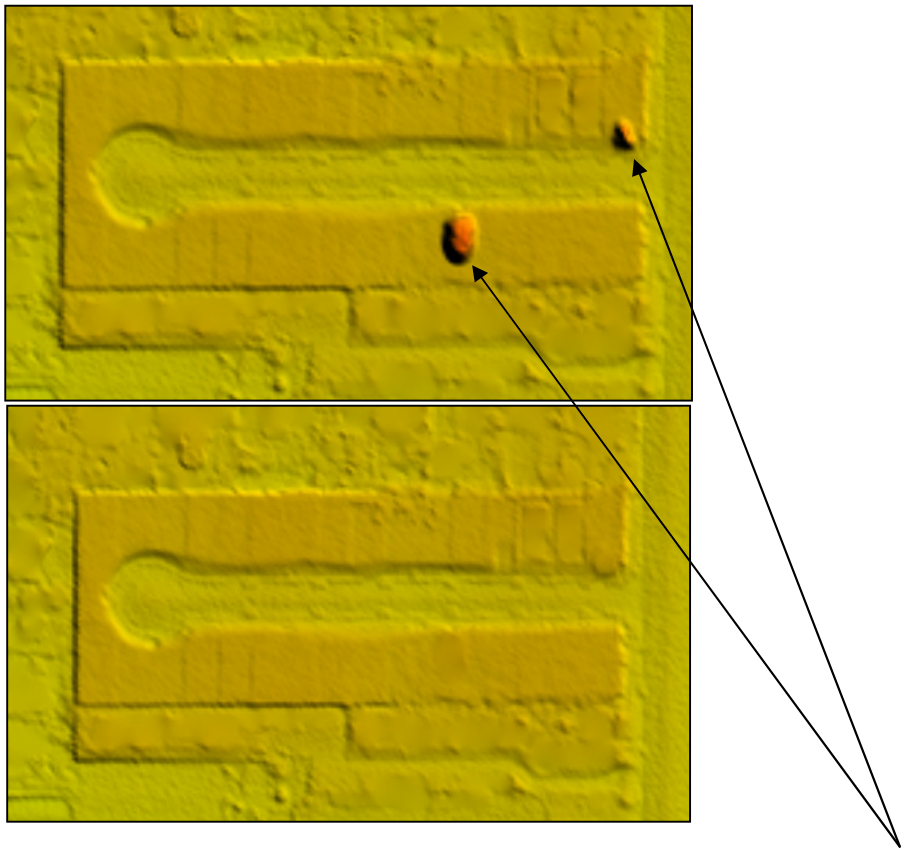

Figure 14 - Tile 11SMT066420. At the time of LiDAR acquisition, this area was under construction and dirt hills were present as shown in the top view. At the request of USGS, these hills have been removed from the ground as shown in the redelivered DEM in the bottom view.

BRIDGE REMOVAL

There were two locations where Dewberry interpreted a feature as a culvert and included it in the ground surface. USGS identified these features as bridges, not culverts. Dewberry has modified the points and removed these features from the ground surface. Examples are shown below.

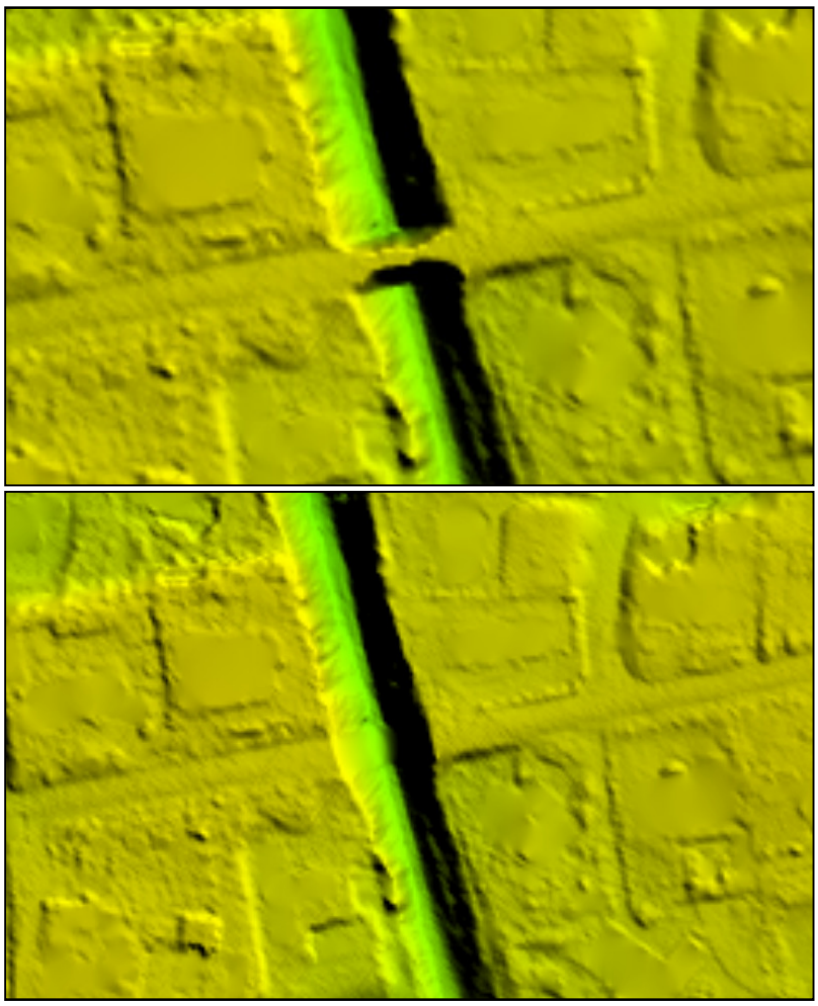

Figure 15 - Tile 11SMT126525. The feature identified was originally interpreted as a culvert and included in the ground surface as shown in the top view. USGS identified this feature as a bridge. The LAS and DEM have been corrected by removing this feature from the ground surface as shown in the bottom view.

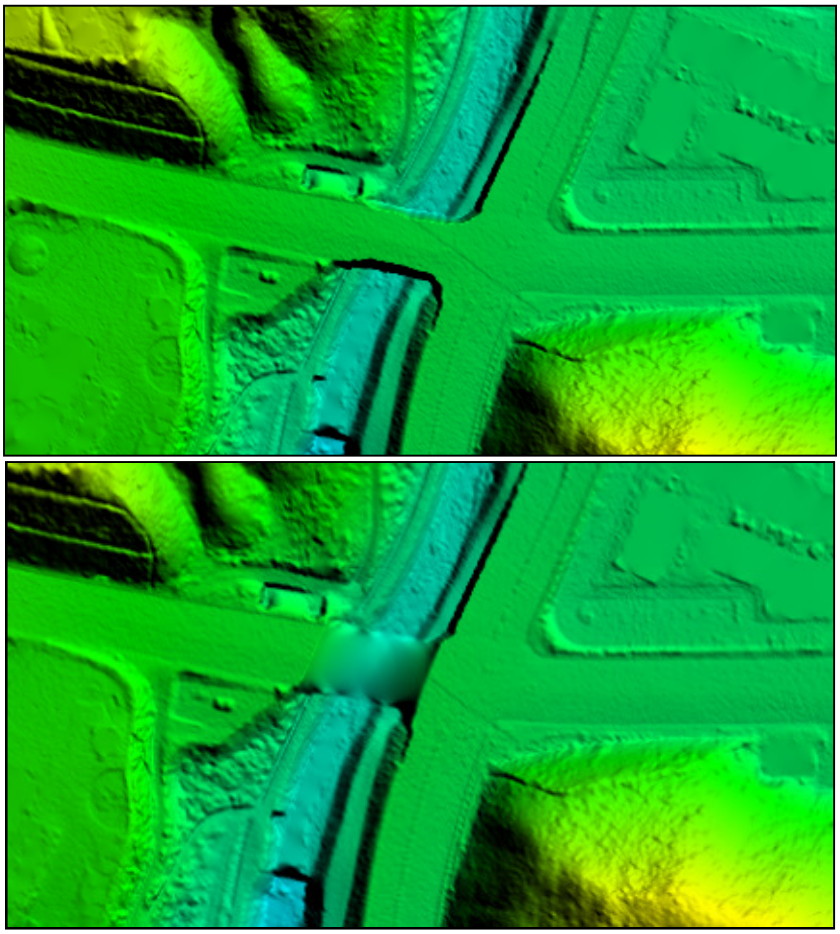

Figure 16 - Tile 11SMT321120. The feature identified was originally interpreted as a culvert and included in the ground surface as shown in the top view. USGS identified this feature as a bridge. The LAS and DEM have been corrected by removing this feature from the ground surface as shown in the bottom view.

BREAKLINE ADJUSTMENTS

There were four locations where USGS identified areas of water that were not included in the collected breaklines. While the interpretation of the feature may be questionable in the intensity imagery, Dewberry agrees with three of the calls after reviewing color imagery and the available LiDAR points. There is one location called out by USGS where, after reviewing the LiDAR, Dewberry confirmed that the breaklines accurately capture the existing water and no changes were necessary. Examples are shown below.

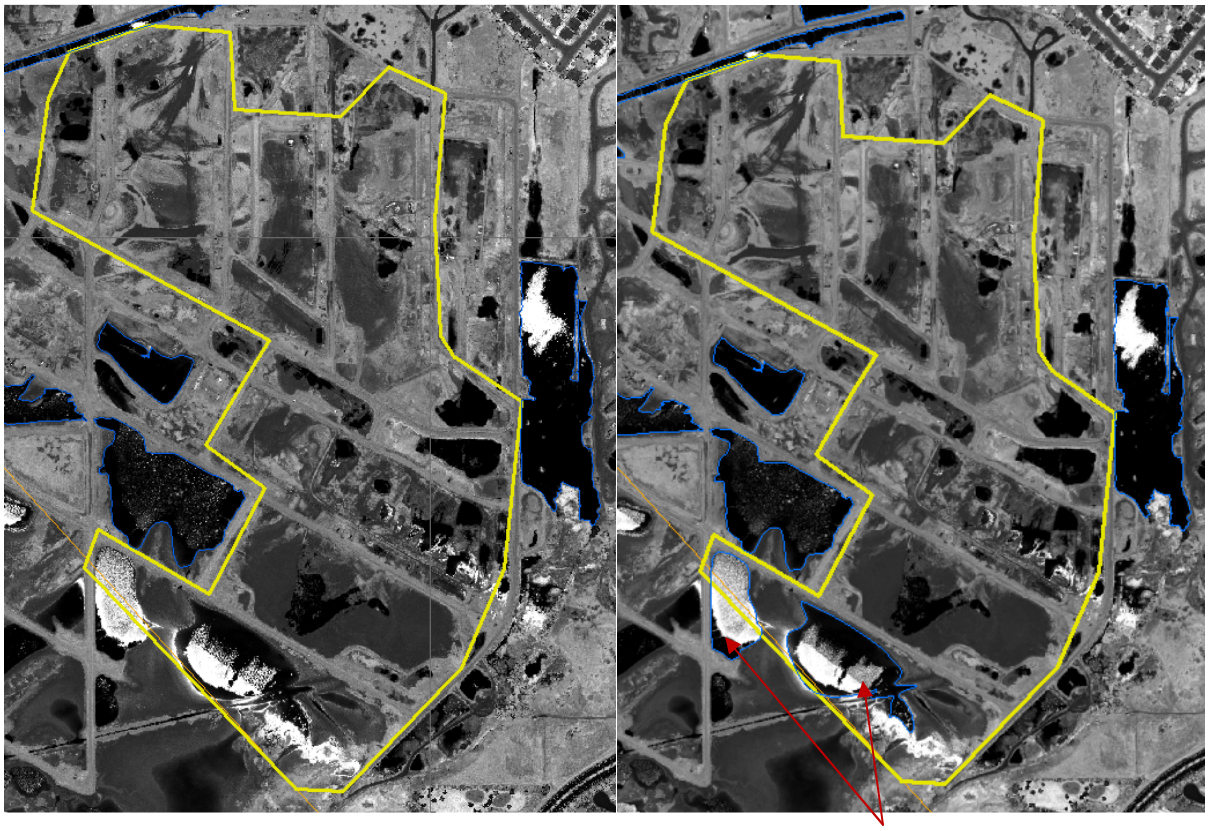

Figure 17 - Tiles 11SMT036270, 11SMT051270, 11SMT036285, and 11SMT051285: The intensity image showing the collected breaklines from the first delivery is on the left. The modified breaklines from this delivery are shown in the intensity image on the right. Dewberry added two ponds to the delivered breaklines. The LAS and DEMs have been corrected to reflect the addition of these features.

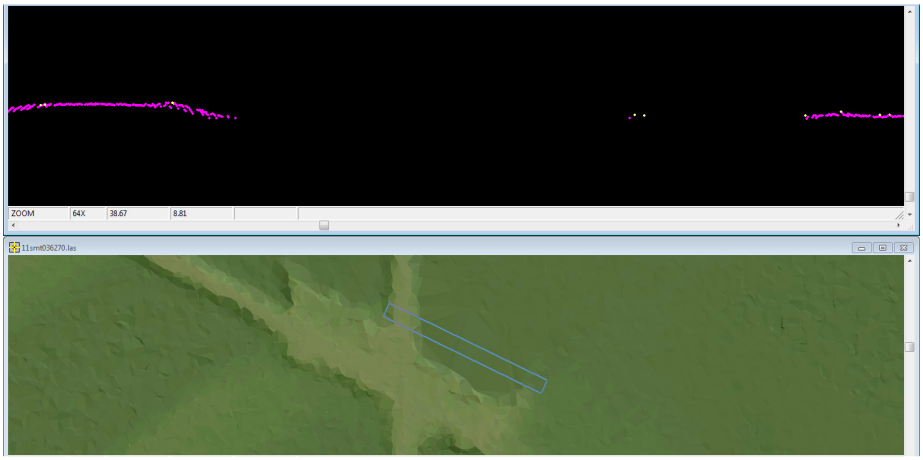

Figure 18 - Tiles 11SMT036270, 11SMT051270, 11SMT036285, and 11SMT051285: The LiDAR points shown above confirm that the breaklines delivered to USGS should be modified to include additional water bodies. The black areas are where no points were returned due to the presence of water. The black areas that are 2 acres or greater and have been confirmed to be water have been added to the breaklines and the LAS and DEMs have been modified to reflect these changes.

Figure 19 - Tile 11SMT201465. As the intensity imagery shows, the breaklines delivered to USGS correctly capture the water bodies in the area that are 2 acres or greater.

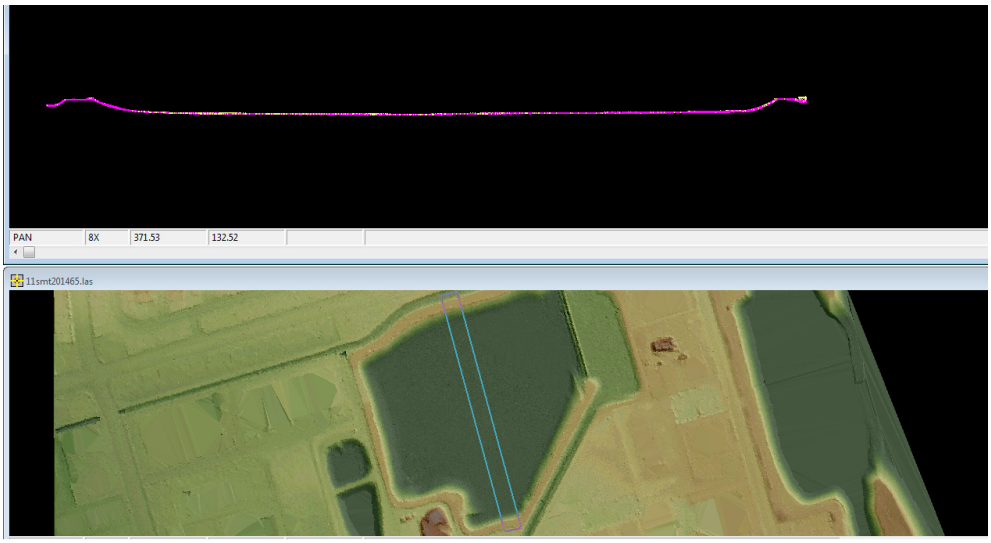

Figure 20 - Tile 11SMT201465. The LiDAR points shown above confirm that the breaklines delivered to USGS correctly capture the water bodies in the area that are greater than 2 acres. Within the identified area, several points were returned indicating the presence of ground. These points have been correctly classified as ground (shown in pink) and the area was not hydro flattened in the delivered DEM. Had there been water present, a black area would show where very few or no points were returned due to the presence of water. It is likely that this area was dry during the time of the mission.

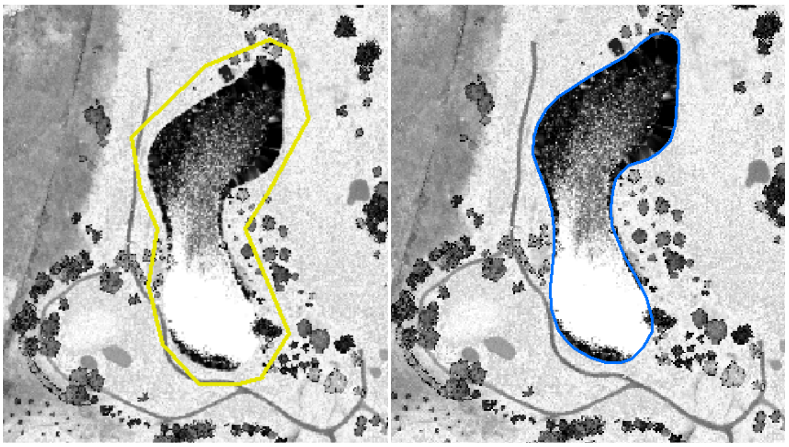

Figure 21 - Tile 11SMT021390. The intensity image showing the collected breaklines from the first delivery is on the left. The modified breaklines from this delivery are shown in the intensity image on the right. Dewberry added one pond to the delivered breaklines. The LAS and DEMs have been corrected to reflect the addition of these features.

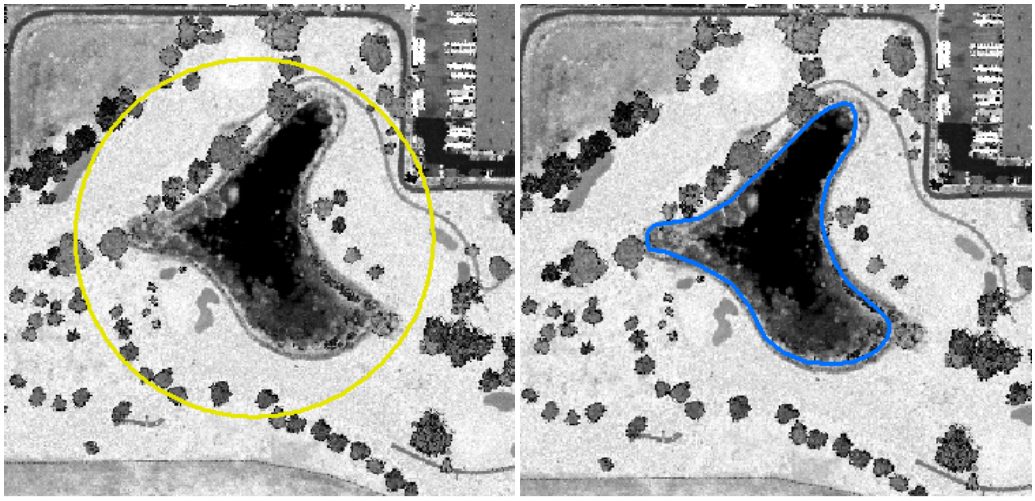

Figure 22 - Tile 11SMT036390. The intensity image showing the collected breaklines from the first delivery is on the left. The modified breaklines from this delivery are shown in the intensity image on the right. Dewberry added one pond to the delivered breaklines. The LAS and DEMs have been corrected to reflect the addition of these features.

MISSING DATA

There were four locations called out by USGS for data voids or missing data. Fortunately, there were no true data density, data voids. The gaps identified were due to processing errors that occurred with the partial tiles along the project boundary. The twenty-one tiles where this error occurred have been reprocessed and redelivered.

Summary of Edit Calls

- There was one call to deliver intensity ortho metadata.
  - Intensity ortho metadata has been creates and delivered.

- There was one call to deliver the swath calibration points.
  - The swath calibration points have been included in this delivery.

- There was one call regarding the location of the swath accuracy testing results.
  - The swath accuracy results were included in the swath metadata but a small section has been added to the project report to provide additional clarity.

- There was one call to include a missing checkpoint from the forested and fully grown land cover class in the accuracy testing.
  - This checkpoint has been included, in the accuracy testing of the swaths, classified LAS and DEMs and the new values have been updated in the report and corresponding metadata.

- There were two calls to redeliver unreadable LAS tiles.
  - These two tiles have been redelivered.

- There were eleven calls to remove buildings from ground.
  - Ten of these issues have been corrected.
  - There was one call where no changes were necessary.

- There were three calls to remove artifacts from ground.
  - All three of these issues have been corrected.

- There were two bridge removal calls.
  - Both of these issues have been corrected.

- There were four calls to modify breaklines.
  - Three of these issues have been corrected.
  - There was one call where no changes were necessary.

- There were four areas with calls regarding data voids or missing data.
  - The twenty-one affected DEM tiles were reprocessed and redelivered.