The Reference Library

Generating Low Confidence Polygons

GeoCue Support Team
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In the new ASPRS Positional Accuracy Standards for Digital Geospatial Data, low confidence areas within LIDAR data are defined to be where the bare earth model might not meet the overall data accuracy requirements. Generally speaking with LIDAR data this can occur where there is heavy vegetation that causes poor penetration of the pulses. If the Vegetated Vertical Accuracy (VVA) cannot be met then low confidence area polygons should be created and explained within the metadata. "For elevation data derived from LIDAR, the low confidence areas would include dense cornfields, mangrove or similar impenetrable vegetation. The low confidence area polygons are the digital equivalent to using dashed contours in past standards and practice. [1]"

There are two types of low confidence polygons. The first kind of low confidence areas are those identified in advance of the collection. These are done by the data producer and are areas where the identification of bare earth is unlikely to occur. These are typically mangroves, swamps and other wetland marshes. The second are those identified post collection, and are typically valid VVA areas, such as forests. In these areas, checkpoints should still be collected and accuracy assessments performed; however, these areas are delineated subsequent to classification and are easily identifiable by the reduced density within the bare-earth points.

The current recommendation is that low confidence areas be delivered as two-dimensional polygons. The specification is based upon the following four criteria:

1. Nominal ground point density (NGPD) – any area with ground density that are less or equal to ¼ of the recommended nominal pulse density (pulse per square meter), or twice the nominal pulse density are candidates for Low Confidence Areas.
2. Cell size for the raster analysis – recommendation is that cell size equals search radius;
3. Search radius to determine average ground point densities – recommends a search area with a radius that is equal to three times nominal pulse spacing (NPS); and
4. Minimum size area appropriate to aggregate ground point densities and show a generalized low confidence area (minimum mapping unit) - unless specifically requested by clients, structures/buildings and water should be removed from the aggregated low density polygons as these features are not true Low Confidence[2].

One method of creating low confidence polygons is by using rasters and following the guidelines set forth within the specification as shown in Figure 1. Two of the products in our product lines, LP360 and TerraScan, may be used to generate the requisite raster images.

[1] Photogrammetric Engineering & Remote Sensing Vol. 81, No. 3, March 2015, pp. A1–A26. 0099-1112/15/813–A1: http://www.asprs.org/a/society/committees/standards/Positional_Accuracy_Standards.pdf

[2] Photogrammetric Engineering & Remote Sensing Vol. 81, No. 3, March 2015, pp. A1–A26. 0099-1112/15/813–A1: http://www.asprs.org/a/society/committees/standards/Positional_Accuracy_Standards.pdf

Vertical Accuracy Class	Recommended Project Min NPD (pls/m^2) (Max NPS (m))	Recommended Low Confidence Min NGPD (pts/m^2) (Max NGPS (m))	Search Radius and Cell Size for Computing NGPD (m)	Low Confidence Polygons Min Area (acres (m^2))
1-cm	20 (0.22)	5 (0.45)	0.67	0.5 (2,000)
2.5-cm	16 (0.25)	4 (0.50)	0.75	1 (4,000)
5-cm	8 (0.35)	2 (0.71)	1.06	2 (8,000)
10-cm	2 (0.71)	0.5 (1.41)	2.12	5 (20,000)
15-cm	1 (1.0)	0.25 (2.0)	3.00	5 (20,000)
20-cm	0.5 (1.4)	0.125 (2.8)	4.24	5 (20,000)
33.3-cm	0.25 (2.0)	0.0625 (4.0)	6.0	10 (40,000)
66.7-cm	0.1 (3.2)	0.025 (6.3)	9.5	15 (60,000)
100-cm	0.05 (4.5)	0.0125 (8.9)	13.4	20 (80,000)
333.3-cm	0.01 (10.0)	0.0025 (20.0)	30.0	25 (100,000)

Figure 1 -Values for Low Confidence Area Criteria for each Vertical Accuracy Class

TerraScan

TerraScan can generate Point Density Rasters three different ways: a TerraScan macro can be created that exports a Lattice Model, Lattice Models can be exported from the project window, or Lattice Models can be output directly from the loaded points in the Main TerraScan window. If exporting Lattice Models from a macro step, or via the project window, make sure to include neighboring points to ensure gaps do not occur at tile boundaries.

Point Density Rasters for determining Low Confidence Areas generated using any of the options mentioned above should use the Ground Class during the export process as the idea behind low confidence polygons is to highlight the areas of the dataset where the penetration of returns to the ground may not allow for the stated accuracies to be obtained. The grid spacing should be determined from the information in the specifications (Figure 1). In the example shown in Figure 2 and Figure 3 the accuracy class of the data is 15cm. Thus, the maximum recommended nominal pulse spacing (NPS) is 1m, and the grid cell size for computing nominal ground pulse density (NGPD) is equal to 3m. TerraScan generates the Point Density value for each cell, hence, no categorization needs to be specified during the output process.

Figure 3 shows the resulting raster as displayed in ArcMap. The categorization of the data for display purposes is based on the recommendation that areas with ground point densities, which are less than or equal to a quarter of the nominal pulse space are good candidates for Low Confidence Areas. Specifying an interval of two and setting the lower interval limit at 0.25 meters (Red), ensures that anything that is above that lower limit is within the acceptable range (Green).

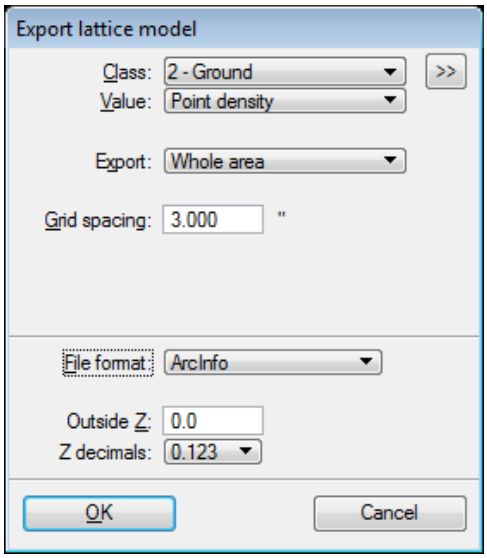

Figure 2 - Export Lattice - TerraScan Settings

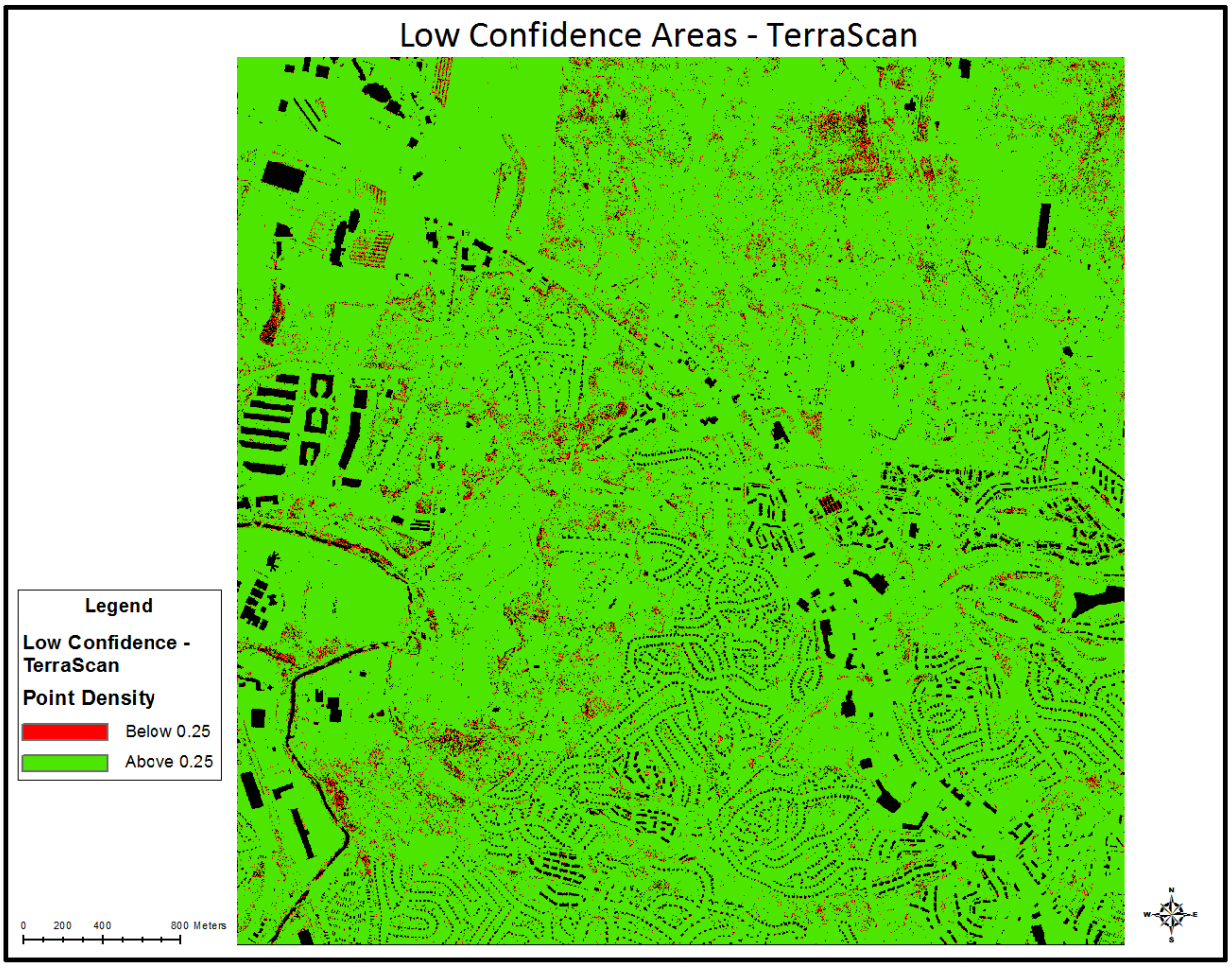

Figure 3 - Red and Black Areas in this Point Density Image represent Low Confidence Areas of Interest

LP360

In LP360, the Point Density images are generated from the active LAS Layer using the Export Wizard. The data that is being used for this example has an accuracy class of 15 cm. Thus, the maximum recommended NPS is 1m, and the grid cell size for computing nominal ground pulse density (NGPD) is equal to 3m.

The rasters are generated using the Ground Class only by using the source point filter, as the idea behind low confidence polygons is to highlight the areas of the dataset where the penetration of returns to the ground may not allow for the stated accuracies to be obtained. Figure 4 and Figure 5 represent the settings used within the Export Wizard to generate Point Density images for this example. The specification recommends that areas with ground point densities that are less than or equal to a quarter of the nominal pulse space are good candidates for Low Confidence Areas. By specifying a Point Density interval of 0.25 meters, it ensures that everything above 0.25 meters will be in the acceptable range. Using an interval range of three provides an image with four colors: black, red, yellow and green. In this instance, anything that is showing up in the TIFF image as void (black), red, or yellow are areas that would need to be evaluated to determine if they should be deemed Low Confidence areas since these are the cells that fall below the specifications recommended for low confidence minimum nominal ground point density (NGPD). Anything that is green is above the 0.25m threshold and can be considered meeting the minimum criteria.

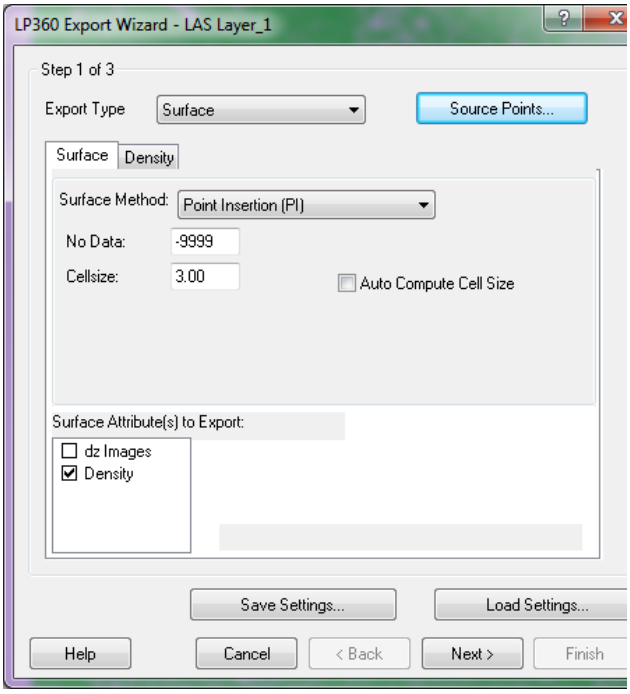

Figure 4 - Density Surface

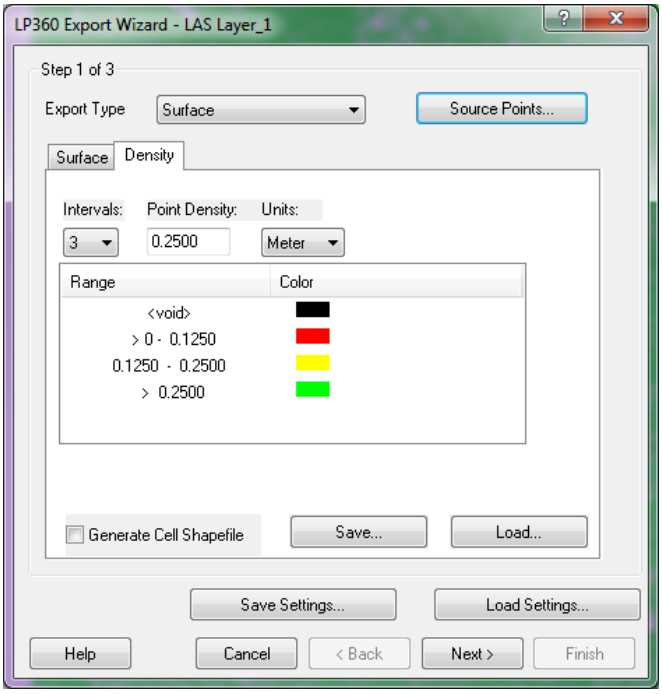

Figure 5 - Point Density Values

Generating Polygons

Once the rasters have been generated, polygons to represent the areas of Low Confidence could then be manually digitized within MicroStation, LP360 for Windows, or ArcGIS. However, ArcMap has tools available to automate the identification of areas that exceed the Low Confidence Minimum Area requirement – five acres in this example.

If we look at Figure 6 as an example of a Point Density Raster, you will see that it is colored red to show all areas less than 0.25 points per square meter, or one quarter of the NPS for the dataset. These cells along with the void areas (colored in black) are the areas of interest with respect to Low Confidence Areas.

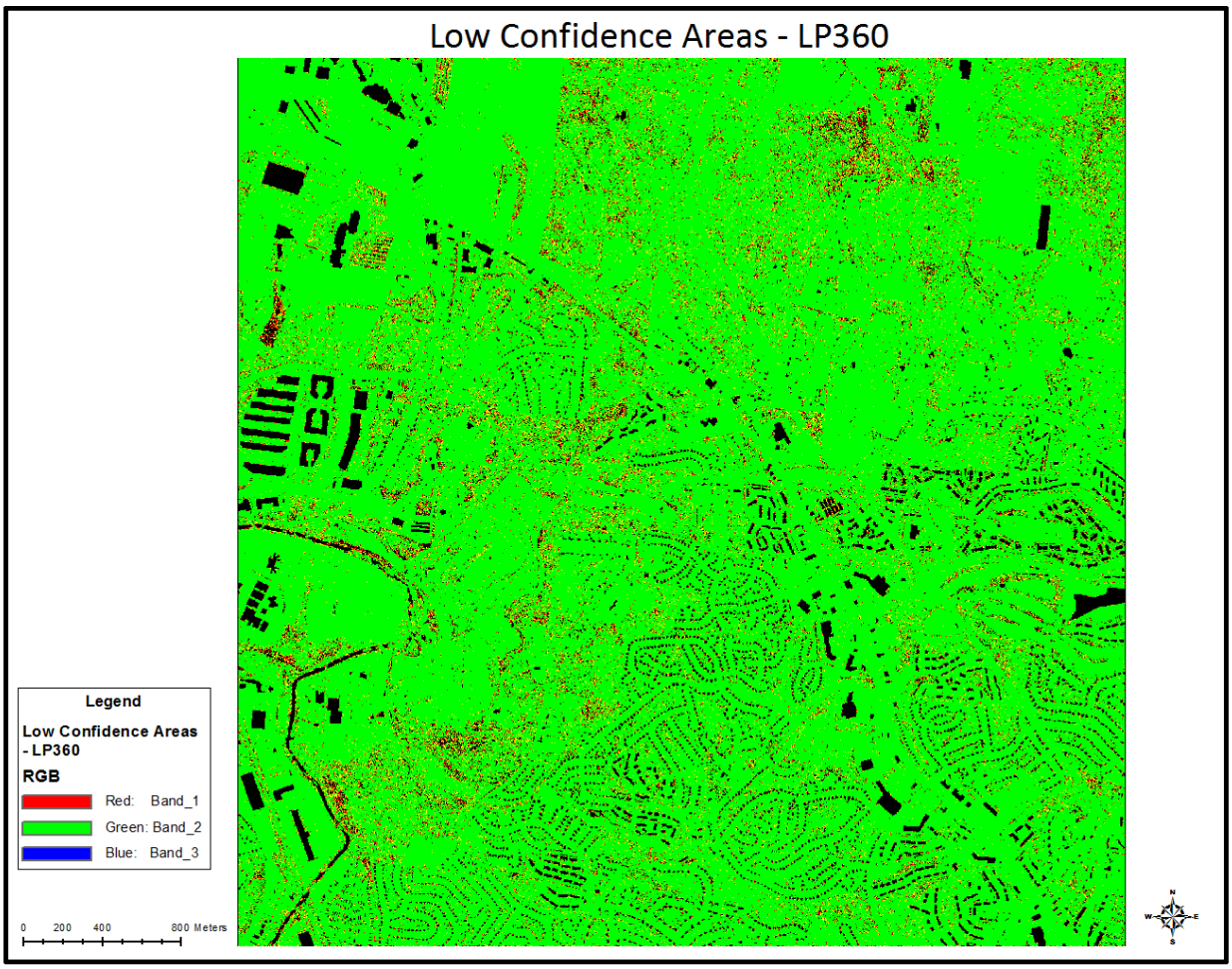

Figure 6-Red and Black Areas in Point Density Image represent potential Low Confidence Areas

Generating Low Confidence Polygons

The following is just one way that the tools within ArcMap can be used to auto-generate low confidence polygons. All the steps are accomplished using Model Builder, with the exception of the QA/QC process. The Model Builder process for the respective software products is shown in Figure 8 and Figure 9. Steps 1 and 3 in this workflow are different when working with the 3 band (RGB) image generated by LP360, versus the raster image generated by TerraScan.

1) Categorization
    a. LP360 Only: Add the three separate RGB bands to Model Builder. Use the raster calculator to add the three bands together and produce an Integer Based Raster with Grid Codes equal to 0 (Voids), 255 (Good Areas) and 510 (Areas of Interest).
    b. TerraScan Only: Use the Spatial Analyst → Reclass → Reclassify to reclassify the density classes to one class, making sure to exclude the class that represents anything above 0.25m. For instance, anything below 0.25m becomes class 1 and NoData also becomes class 1.
2) Use Conversion Tools → From Raster → Raster to Polygon
3) LP360 Only: Use Analysis Tools → Extract → Select to extract out the classes that represent the areas of interest
    a. This step can be skipped for TerraScan as it was accomplished during the Reclass step
    b. For LP360 the AOI will be the Void Areas and then the areas in Red and Yellow
4) Use Cartography Tools → Generalization → Aggregate Polygons to combine small polygons together
5) Use Data Management Tools → Features → Add Geometry Attributes to add an Area Field with units of Acres. Acres are used as the unit of measurement for the low confidence polygons as many agencies use this measurement as the mapping unit for required polygon collection.
6) Use Analysis Tools → Extract → Select to extract out any areas greater than or equal to the specified minimum area – five acres in this example.
7) The remaining polygons need to undergo a QA/QC process to determine if they meet the Low Confidence Polygon requirements. Namely, can they be removed because they represent structures/buildings and water. The attribute table of the shapefile provides a drive tool for users to select individual polygons in the table and be driven to the polygon in the map to perform this analysis. Of course, if one has hydro features or building footprint polygons for the dataset you may be able to eliminate a large number of polygons using some automated methods.

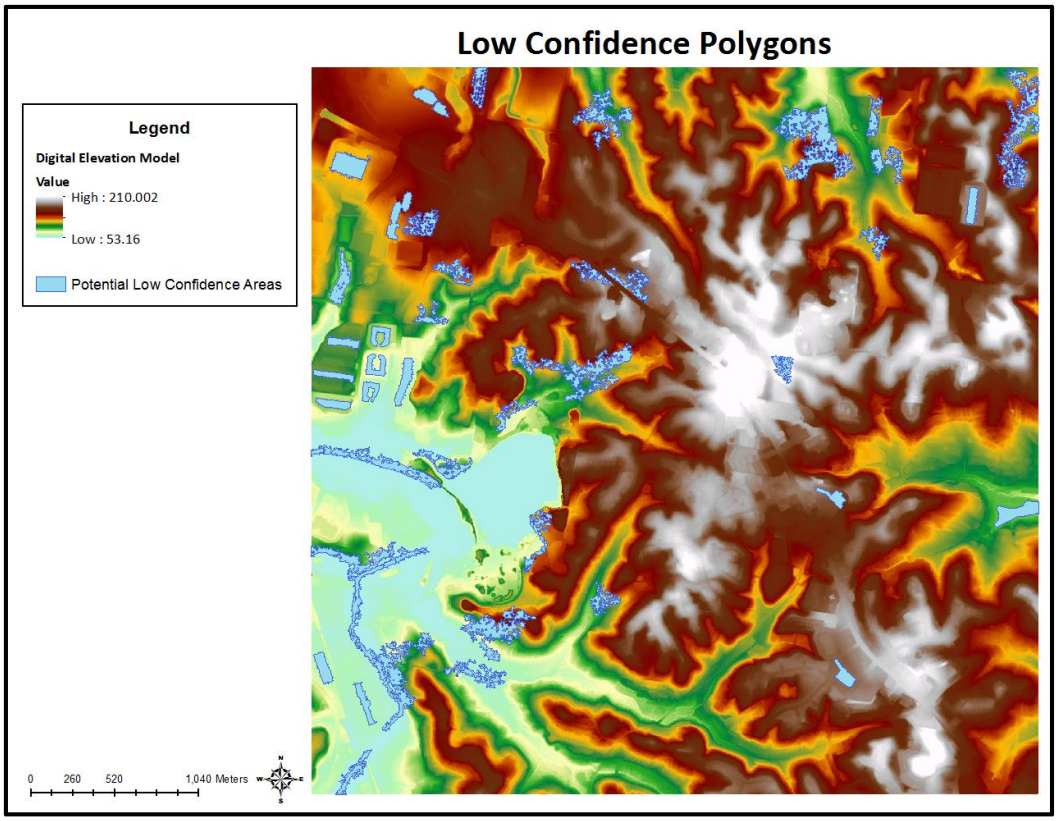

Figure 7 – Potential Low Confidence Polygons overlaid on DEM

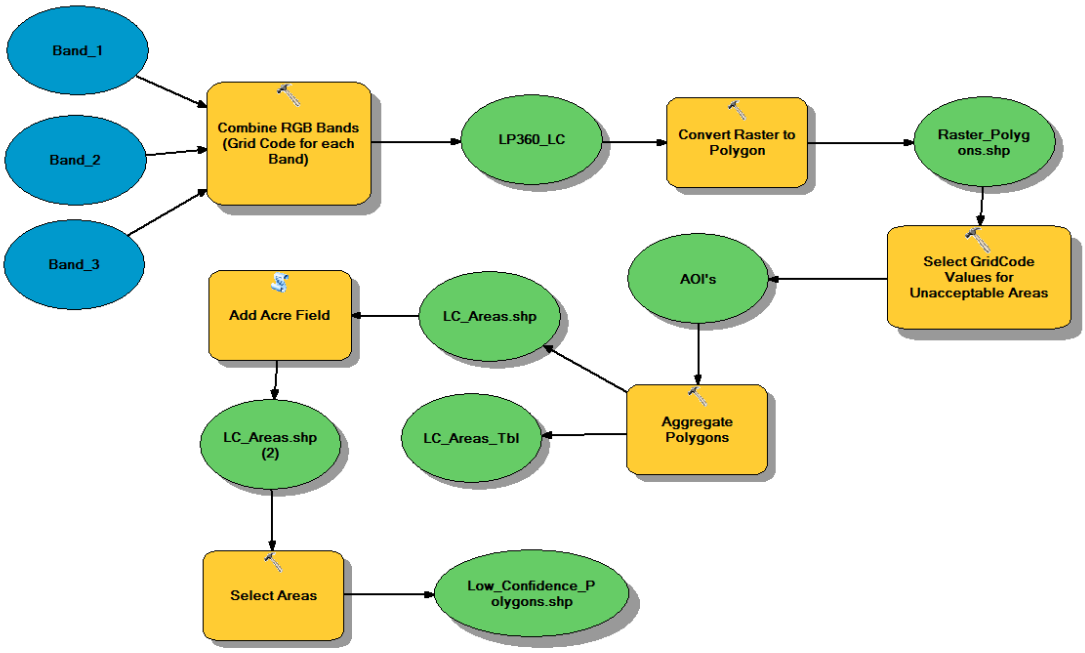

Figure 8 - Model Builder Using LP360 Generated Point Density Image

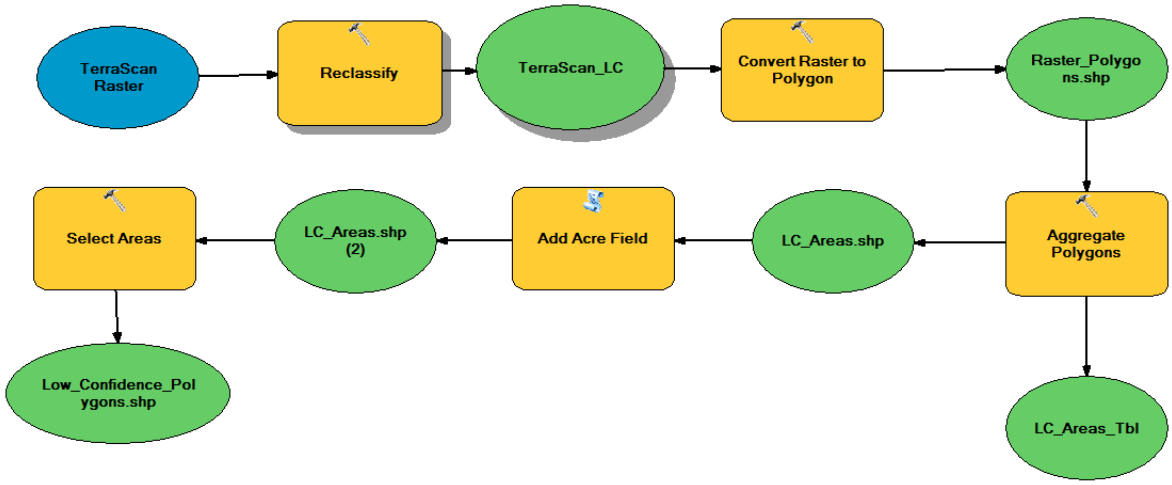

Figure 9 - Model Builder Using TerraScan Generated Point Density Image

The resulting polygon shapefile is a required deliverable as part of the metadata accompanying the LIDAR elevation dataset. Again, these polygons are only required when the bare earth model might not meet the overall data accuracy requirements, which often occurs with LIDAR data where there is heavy vegetation that results in a poor penetration of the laser pulses. We hope the provided workflows for establishing Low Confidence polygons using either LP360 or TerraScan proves beneficial. If you have any questions or comments on the workflows please comment below, or contact our GeoCue Group Support Team.