*27 November 2012*

**2012 North Kaibab LiDAR, First Installment**

**Quality Assurance Results**

The purpose of this acquisition was to provide LiDAR data for portions of the Kaibab NF and Grand Canyon NP on the Kaibab Plateau, in support of ongoing studies of Northern Goshawk demographics. 3Di West, through its subcontractor Watershed Sciences Incorporated (WSI), acquired LiDAR data for over 450,000 acres in the summer of 2012. The data were to be delivered in two installments. The first installment, covered in this report, encompasses 108,745 acres and was acquired between 25 and 31 August 2012. The second installment, which has not yet been delivered, was acquired in early September and covered 336,582 acres.

The deliverables for the first installment met the contract specifications. The average pulse density for the entire study area was 11.38/m2, exceeding the target rate of 8/m2.

**Data Quality Assurance**

A thorough quality assurance assessment was conducted to determine if the lidar data deliverables met the specified Technical Specifications. The procedure for assessing the quality of the data is outlined below.

**1. Using FUSION software –**

**a. Used the catalog DOS command to assess pulses per sq. meter to determine if the dataset meets the Technical Specifications, averaged over a 100m by 100m area.\***

|  |  |  |  |
| --- | --- | --- | --- |
| **Data acquisition** | **Survey Design** | **Minimum requirements** | **Specs met?** |
| Aggregate pulse density | 8 pulses/m2 | Baring non-reflective areas (e.g. open water):   * ≥85% design pulse density for entire project area * no 100m x 100m area with <50% design pulse density (4 pulses/m2) * in areas of large terrain relief, more closely space flightlines may be necessary to meet minimum point density and double coverage | Yes. More than 86% (100%-13.90%) of the study area met the design pulse density of 8 pulses / m2. 0.92% of the study area had fewer than 4 pulses / m2, which is less than the 3% allowable. In addition, all cells with fewer than 4 pulses / m2 were along the project area perimeter (“will not be assessed”).  See Appendix A |

\*1. Cells intersecting with the project area perimeter will not be assessed

2. As defined by NHD, cells containing polygon water features (e.g. StreamRiver and LakePond) will not be assessed, however, cells containing line water features *will* be assessed in the Quality Assurance assessment.

**b. Use the catalog DOS command to flag tiles with potential elevation outliers.**

No limits on outliers were specified. However, five tiles were identified by the **catalog** command (using the switch */outlier:2*) as having minimum elevation values that were less than the average minimum elevation for all tiles in the project area, minus two standard deviations. These do not appear to be errors. The tiles were located at two steep canyons (Dog and North) in the southeast corner of the study area (see Appendix A), where elevation values drop off quickly from the plateau:

36112D1213.las

36112D1217.las

36112D1218.las

36112D1222.las

36112D1223.las

However, elevation outliers were apparent in all of the six \*.las tiles that were chosen as samples and viewed with the Fusion LDV. These isolated outliers were mostly likely birds in flight. See example in Appendix A. The output from the Fusion **catalog** command (using the 2 standard deviation multiplier) did not flag any of these tiles. Some objects were within a single standard deviation of the average maximum elevation for all tiles, so they would not have been detected even using a switch */outlier:1*. The six \*.las files that were used as samples were:

36112D1101.las

36112D1125.las

36112D4203.las

36112D4225.las

36112E4403.las

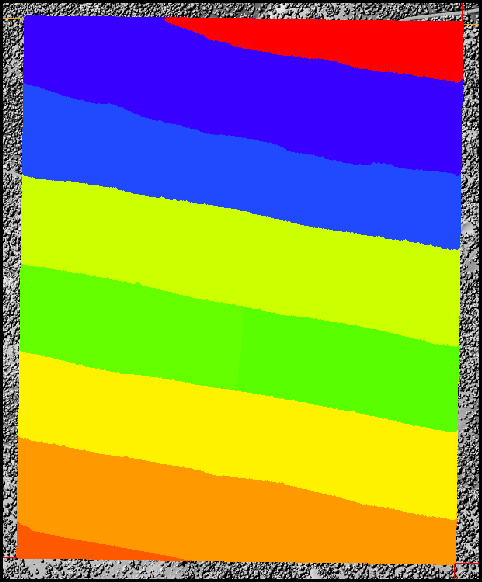
36112E4425.las

**c. Visual inspection – inspect 3D point cloud for all tiles for outliers, holes, gaps, etc.**

Visually inspected a sample of the \*.las tiles in Fusion. Also inspected the bare earth and highest hit models for the entire acquisition area (Step 2, a. and b., below).

**d. Use catalog DOS command graphical output to visually inspect flightline overlap (50% sidelap, 100% overlap) based on pulse density.**

Graphical output from the Catalog command of First Return (Pulse) Density indicated complete coverage (see Appendix A). Also displayed the GPSTime for three LAS files, using the *LidarGpsTime.esriAddIn* produced by RSAC, to visually inspect flightline overlap. See Appendix B. For example:



**2. Using ArcGIS software –**

**a. Visual inspection of Bare-earth surface model (DEM) – looking for tile boundary artifacts, gaps and holes.**

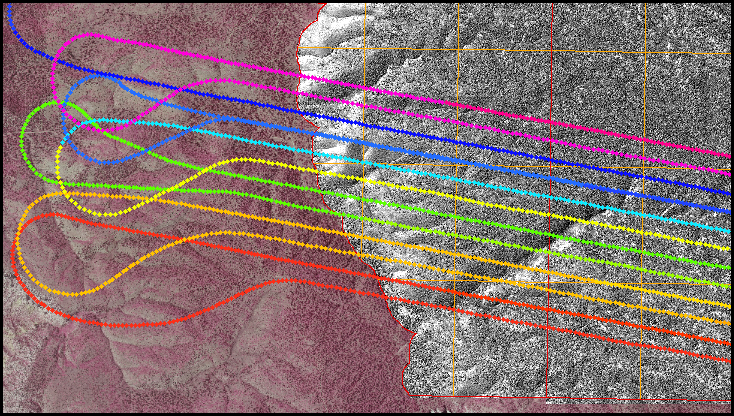
No artifacts or errors were observed during the visual inspection of the bare earth model, when displayed at a scale of 1:20,000. (See Appendix C.)

**b. Visual inspection of First-return (highest-hit) surface model (DSM) - looking for tile boundary artifacts, gaps and holes.**

No artifacts or errors were observed during the visual inspection of the highest hit model, when displayed at a resolution of 1:20,000. (See Appendix C.)

**c. Visual inspection of flightline shapefile for opposing flightline pattern.**

Visually inspected three of the Smoothed Best Estimated Trajectory (SBET) shapefiles, using a GPS\_Time field to color-code the points, to determine that adjacent flight lines were in opposing directions. (**Note** that for this delivery, as opposed to previous deliveries from 3DiWest/WSI, a GPSTime(s) field was provided as a *text* rather than a *numeric* field. A numeric GPSTime field needed to be created before its symbology could be changed using **Symbology > Quantities > Graduate colors > Value=GPS\_Time; Classes = 32**. In each case, the **Maximum Sample Size** was increased by clicking on **Classify > Sampling**.)



**d. Review shapefiles for coverage and completeness and ensure they include correct naming convention, metadata, and attributes.**

All shapefiles were displayed in ArcMap and visually inspected to confirm coverage and completeness. Metadata was included for all shapefiles.

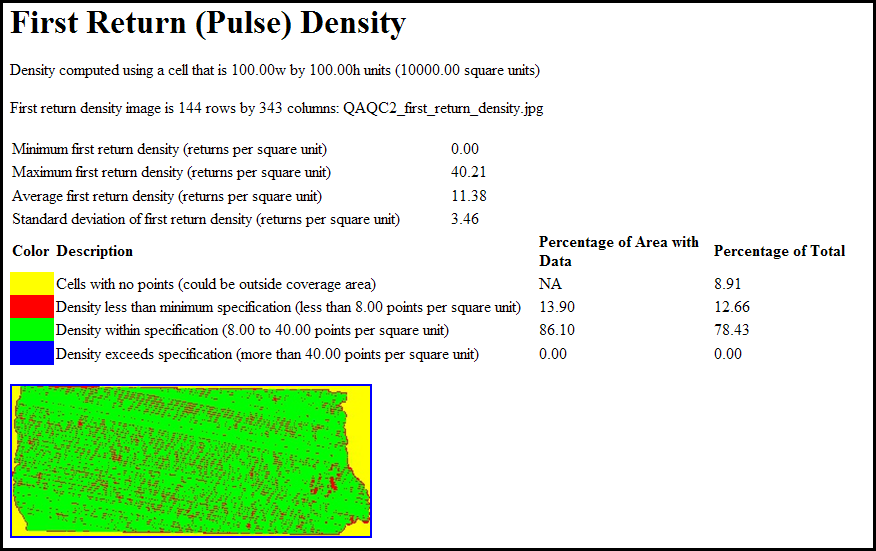
Note: The README files for both the All\_Returns and Ground\_Returns LAS files specified the UTM Zone as “11N”. These appears to be just a typo in both \*.txt files. All data appear to be in the correct Zone, 12N.

If it is determined that the acquired lidar data is insufficient based on the Quality Assurance assessment, the Contractor may be required to reprocess and/or re-fly problem areas to receive full-payment or may be asked to re-negotiate a reduced price of the lidar deliverables. Each Quality Assessment cell (100m by 100m) that does not meet the minimum Technical Specifications will cause a reduction in payment to the Contractor equivalent to the cells percentage of the total area surveyed. If 3 percent or more of the Quality Assessment cells do not meet the minimum Technical Specifications, then the Authorized Purchaser has the right to re-negotiate a reduced price of the lidar deliverables.

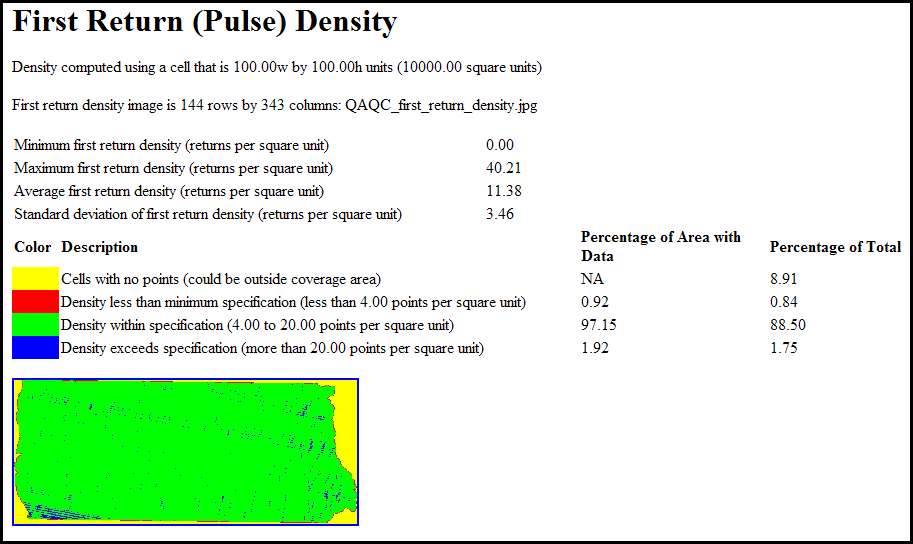
**Appendix A:**

**Aggregate Pulse Density**

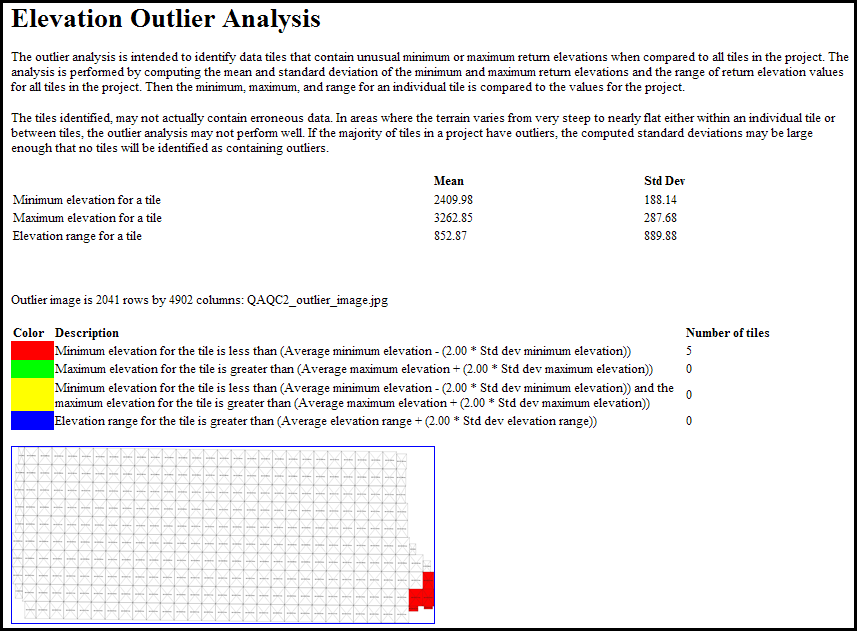
With minimum set to 8 pulses/m2 and no tiles excluded:

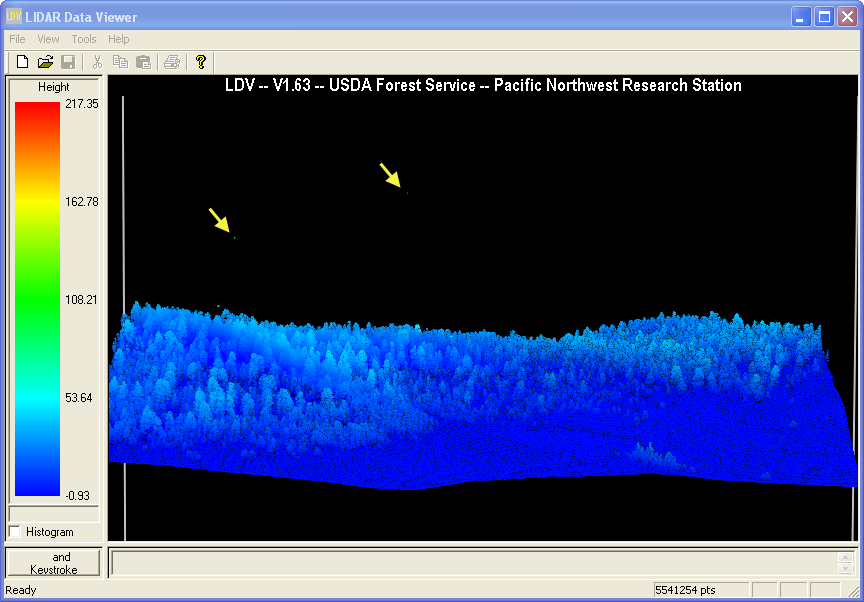


With minimum set to 4 pulses/m2 and no tiles excluded:



**Elevation Outliers**



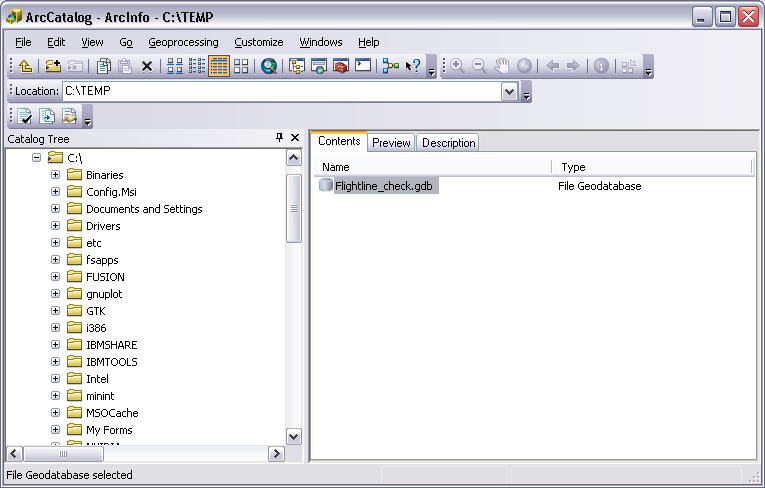
Examples of elevation outliers (possibly birds in flight) that were not detected by the catalog command when using the switch */outlier:2*. 

**Appendix B:**

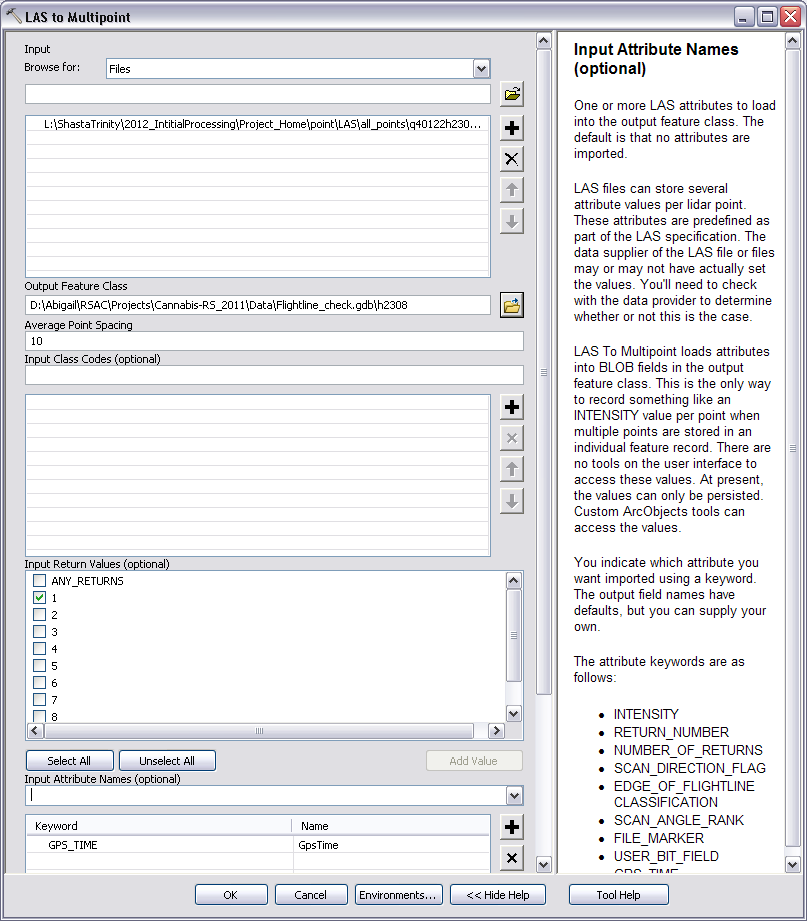
Adapted from the report *RSAC\_QA-Report\_forShastaTrinity\_Jan30\_2012.docx*.

Checking Flightline Sidelap

**Step 1:** Create **File Geodatabase**



**Step 2:** In **ArcToolbox > 3DAnalyst > Conversion > From File > LAS to Multipoint**, convert a LAS tile to multipoint (as a **Feature Class** in the newly created **File Geodatabase**). Be sure to include the **GPS\_time** attribute in the output **Feature Class**.

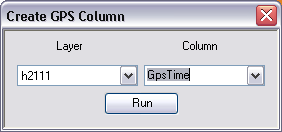
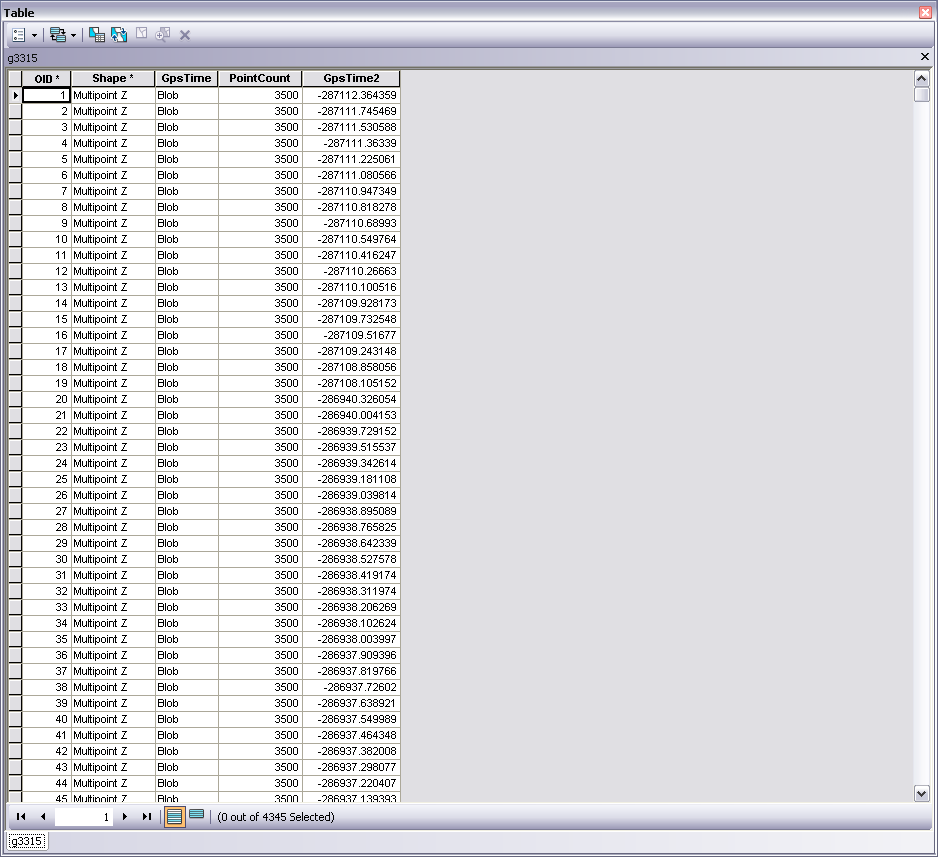


Add the new multipoint feature class to an ArcMap session. Open its attribute table, left-click on its **Table Options** and select **Turn All Fields On**. This will make the **GPSTime** field visible.

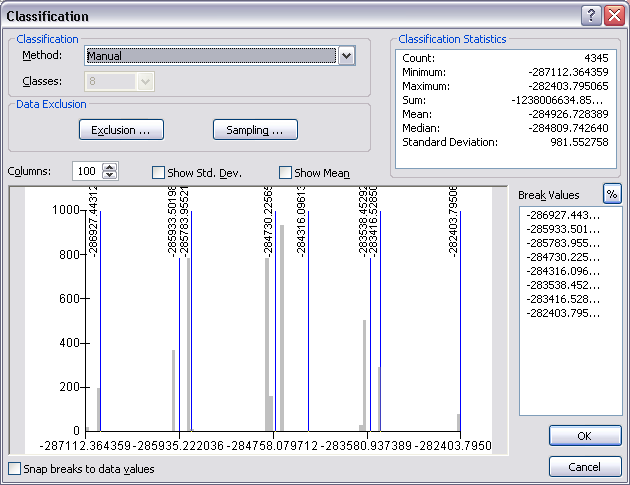
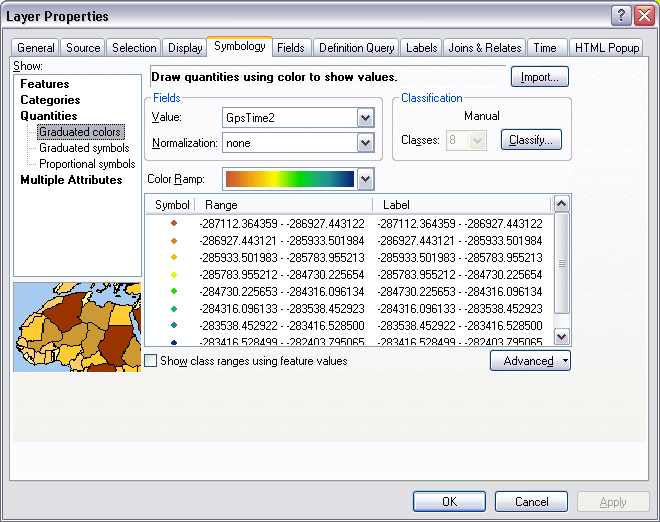
**Step 3:** Add the Lidar GPS tool AddIn (*LidarGpsTime.esriAddIn*) from the following location: [\\166.2.126.25\lidar\LAS\_AttributeConversionTool\lidarGpsTime.esriAddIn](file:///\\166.2.126.25\lidar\LAS_AttributeConversionTool\lidarGpsTime.esriAddIn)

**(NOTE:** Contact Abigail Schaaf at RSAC if you encounter problems downloading or running the tool.)

Use this tool to convert the GpsTime field to a readable field in the Attribute table (renames as GpsTime2). This GpsTime2 field is used to symbolize the lidar points and represent flightline paths.

**Step 4:** From the Symbology tab, choose Quantities and Graduated colors. Choose GpsTime2 from the Value Field and then click the Classify button to set the breaks and number of classes based on the histogram (see below). You can see where the natural breaks are for the different time chunks – each one likely corresponds to a different flight line. Make sure you have a class that captures each time chunk.

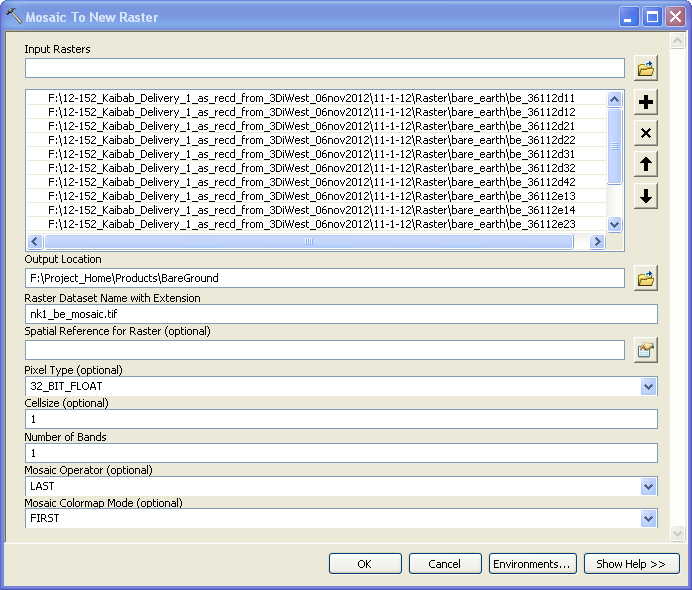
 

**Step 5:** Let the multipoint tile draw with the symbology you have given it. The flightlines should be apparent if you have symbolized it with the right number of classes and with the proper break locations. It is obvious from this rendering that there is ~50% sidelap between flightlines.

**Appendix C:**

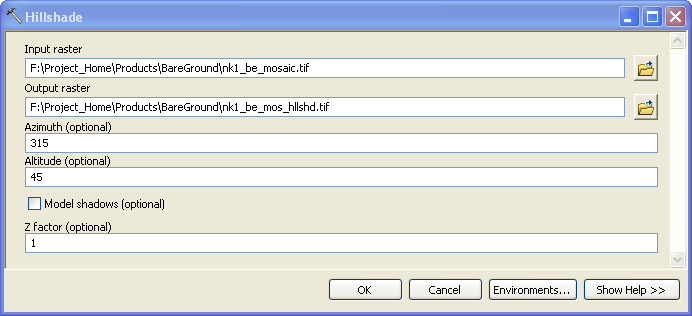
Produce mosaic of the bare earth tiles:

**ArcToolbox > Data Management Tools > Raster > Raster Dataset > Mosaic to New Raster**



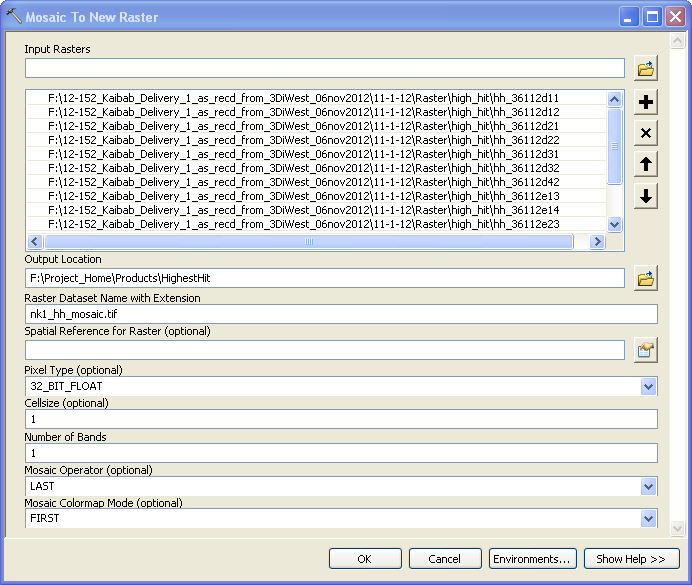
And then convert the mosaic to a hillshade version for easier visual analysis:

**ArcToolbox > Spatial Analyst Tools > Surface > Hillshade**



Produce mosaic of the highest hit tiles:

**ArcToolbox > Data Management Tools > Raster > Raster Dataset > Mosaic to New Raster**



And then convert the mosaic to a hillshade version for easier visual analysis:

**ArcToolbox > Spatial Analyst Tools > Surface > Hillshade**

