

National Network of Regional Coastal Monitoring Programmes of England

Quality Control of Lidar Data

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Introduction

An important driver for the Regional Coastal Monitoring Programmes is that all data collected and made freely available should be quality-controlled in a thorough and consistent manner, to ensure that the data meets the Specification, with the result that the data can be used subsequently with confidence for a wide variety of coastal engineering and management tasks.

This document describes the procedures used by the National Network of Regional Coastal Monitoring Programmes to quality-control lidar data, and can be used at three different levels:

- A summary of QC tests, for those users who just want a brief overview of the generic quality control
- Details of the quality control process including:
 - Workflow process *i.e.* the checks to be made and the most suitable order in which they are carried out. This section includes mandatory checks plus some optional checks depending on the landscape captured *e.g.* high cliffs, or on the deliverables in the Brief.
 - The methods used to carry out the checks, including the thresholds used. This section includes clear examples of what is and what is not acceptable.
- Sample procedures for undertaking the checks. Those undertaking quality control may use any software or methods they wish, providing the QC standards are met. However, since most of the data quality control tests are expected to be done in a GIS, an example of a suitable procedure using ArcGIS (Standard licence, Spatial Analyst and 3D Analyst extensions) is given (Appendix B). The methods given here should also work in other GIS software¹.

Appendix A is a diagram summarising the quality control workflow

Appendix B provides a procedure for ArcMap which can be used to complete the QC checks

Appendix C provides a sample template to record the QC process

Summary of QC tests

The quality control tests fall broadly into two categories:

- Data quality
 - Reached required depth at seaward limit
 - Water removal
 - Gaps
 - No striping/pocking
 - Removal of spikes *e.g.* flocks of birds, pylon cables
 - Polygon coverage
 - Structures included in DSM, excluded in DTM
 - Vertical accuracy
 - *Flight lines (optional)*
 - *Point density (optional)*
 - *Profiles (optional)*

¹ Point clouds cannot be loaded in QGIS but other software can be used to view *e.g.* Cloudcompare.

- Data management (final deliverables)
 - Correct number of tiles received in all required formats *e.g.* *.asc and *.txt
 - Correct file names
 - Correct file formatting
 - No duplicated filenames
 - All deliverables delivered

Workflow for data quality checks

Viewing scale

The scale at which the lidar should be viewed for quality control depends on the resolution of the data. For example, viewing 1 m resolution data at a scale of 1:2400 means that 1 cm represents 24 pixels *i.e.* 24 metres, which leaves too much margin for error when digitising. Accordingly, for 1 m resolution lidar, the recommended scale for QC is 1:2000 when going through the tiles and 1:1500 for editing.

Datasets

- Elevation rasters as mosaics or 1 km tiles
- LAS point cloud - exclude Tie lines and use last returns only
- Aerial photography/base maps²
- Watermask (if provided)
- Tile index shapefile

Derived datasets

- Hillshade raster
- MLWS contours
- Intensity raster (can be created from intensity values of LAS Point cloud)

Step 0 Copy data

Copy the data for QC to your local machine or to a Hard Drive. Avoid working from a network drive as this can be slow and progress could be lost if the connection drops out.

Step 1 Filtered, unfiltered or both?

Lidar data can be delivered as unfiltered and/or filtered rasters (as defined by the Brief). The route through the QC checks is slightly different depending on the deliverables.

The unfiltered Digital Surface Model (DSM) is created from the last return of the lidar pulses and contains trees, buildings, structures *etc.* The filtered Digital Terrain Model (DTM) is a “bare-earth” dataset where buildings, cars, trees *etc.* have been removed (filtered) from the data.

Data may be delivered as DSM, DTM or both. The only difference in terms of quality control is the presence or absence of structures (see below). Unfiltered and filtered rasters are created from the same point cloud so if both types are delivered, start by carrying out all checks on the unfiltered data. Any issues concerning water removal, spikes, gaps, polygon coverage, and seaward limit will be the

² Use aerial photography as an aid only, especially when it was collected at a different date from the lidar data. If the aerial photography is on the coastalmonitoring.org website, it can be accessed as a WMS layer in Arc or in QGIS.

same for the filtered data. Then load the filtered data (mosaic and hillshade) and check if structures have been removed in accordance with the Brief. Clearly, if only one type of data is delivered, all data quality checks are carried out on the delivered datatype.

Use Appendix A to see which QC route to follow.

Step 2 Watermask and elevation mosaic

The easiest way to QC is to use a watermask polygon, together with a mosaic of the elevation rasters provided by the Contractor. The watermask is a shapefile indicating where water will be removed from the data. Everything outside the watermask polygon or in gaps in it will be removed from the final dataset.

If watermasks are provided by the Contractor, make a copy and edit them directly for issues concerning water removal and seaward limit. If a dataset was flown on multiple dates, multiple elevation mosaics and watermasks may have been delivered by the Contractor. In this case, create a single raster from the delivered elevation mosaics. If the preliminary data is delivered without watermasks, create a mosaic from the OS 1 km tiles (see Appendix A and B).

If it is apparent at this stage that the data has been delivered in millimetres or integers, halt QC and ask the Contractor to re-deliver the data in metres.

Step 3 Create derived datasets and load other data

- Create a hillshade raster and Mean Low Water Springs (MLWS) contours from the mosaic, and load them in the GIS
- Create LAS datasets and intensity rasters and add them to the map
- Add other supporting layers to the map (*e.g.* survey polygon, index shapefile, aerial photography). Display any polygon datasets as an outline only
- Label the index shapefile with the tile name
- Set symbologies as desired and order the layers in the table of contents (see Appendix B)
- Check that the tiles in the index file are named with the correct OS tile name. Check a few tiles of the index polygon against the OSGB grid information layer on the website or a shapefile with the 1k OSGB tiles to verify this

Step 4 Vertical accuracy check

Check that the vertical accuracy of the data is acceptable by comparing samples against areas that have been surveyed on the ground (minimum accuracy in processed data should be +/- 0.10m RMSE). If there is more difference than is acceptable between the surveys, halt QC and inform the Contractor before proceeding with the rest of the QC. Checking vertical accuracy might be impractical in areas where there are no suitable reference areas to check the lidar data against – *e.g.* extensive dunes or soft cliffs – or where no data is available to compare the lidar against.

Step 5 Optional additional checks

Flight lines

If the frontage has cliffs, dunes or other features that might cause shadowing, check the flight paths were appropriate to capture them. These landforms usually require a minimum of 2 flight lines, one to seaward and one to landward of the feature. Where only one flight line is used, it should be seaward of Mean High Water (MHW). Load the “smoothed best estimate of trajectory” shapefile (SBET) (containing time, original position and attitude data, as captured during the flight in its attribute table)

and assess if they are appropriate or compare them to the runs proposed by the Contractor before flying. Record the result in the spreadsheet.

Point density

Depending on the desired output resolution, the point cloud data should be collected at a minimum density of 1 point per m² for an output of 1x1m cells and 4 points per m² for a grid with a cell size of 0.5x0.5m. In ArcMap you can use the LAS Point Statistics as Raster tool to create a raster from a LAS dataset that describes the number of returns per cell. The method should be pulse_count and the sampling value (= cell size of the output grid) should be about 4 times the size of the resolution of the delivered data (so 4 for a 1m resolution grid, 2 for a 0.5m resolution grid) – this reduces the processing time and avoids creating a huge dataset. The value of each cell in the output grid is the number of LAS points recorded for that grid. Check the statistics in the “source” tab of the properties of the raster. Divide the mean by the value you put in the sampling value in the tool. The result is the point density. So a mean value of >16 is good for a lidar grid with a 1m resolution. Record the result in the spreadsheet.

Profiles³

If profiles are part of the deliverables, check for the following:

- the profiles coincide with profile line shapefiles
- profiles start at the required starting point
- profiles reach the required depth and that they cover the raster to its seaward extent
- there are no points where there is no lidar data available *e.g.* through runnels
- the data file contains the correct columns of data

Step 6 Error polygons and watermask editing

The quickest way to highlight any issues is to generate a polygon shapefile indicating the type of issue *e.g.* gap, spike, water removal (see Appendix B for how to create a shapefile with a dropdown box to pick QC issues). Add polygons to the shapefile as you encounter errors, and if watermasks are delivered edit the watermask copies for any seaward limit and water removal-related issues (Appendix B). Be careful when editing watermasks: it is very easy to accidentally “drag” part of the mask slightly. The contractor uses the amended watermask to create the final dataset so if it’s “dragged” slightly, the polygon won’t be covered properly.

If both filtered and unfiltered data are delivered, check the unfiltered data first. Then load the filtered data and check it for issues with structure removal only. All other issues should be the same.

Step 7 Record issues

- Use a quality control spreadsheet *e.g.* Lidar_QC_YYYY_YYYY.xlsx (where YYYY indicates the winter flying season the surveys were carried out) to keep track of general issues with the data (Appendix C, Table 1)
- Export the index shapefile as an excel file (see Appendix B) and copy the OS tile column to a separate tab in the spreadsheet (named with the Work Package name). Use this list of all the

³ Note that profile checks should be done only after all other quality issues have been addressed, to ensure that they are generated from quality-controlled data. Consider discussing with the Contractor to delay production of profiles until the data quality has been accepted.

tiles in the Work Package as a guide when going through the data (sort it alphabetically first). This makes sure that no tiles are skipped and helps to keep track when QC spans multiple days. Use this worksheet as well to highlight any issues with individual tiles (Appendix C, Table 2).

- Send both the edited watermark and the QC shapefile to the Contractor (see Appendix B on how to export the QC shapefile from the geodatabase to a shapefile)

Workflow for data management checks (on final deliverables)

QC issues addressed

- Load the corrected data in the GIS and check that the issues that have been sent to the Contractor have been addressed.
- Use the QC shapefile as a guide and make a note in the “Fixed” column of the Work Package worksheet whether the highlighted issues have been rectified.
- Record any comments briefly on the corrections in the Master worksheet as well.

Overlapping polygon/duplicate tile name checks

- Load the final delivered index shapefile in Arc and label it with the file name
- Check that there are no tiles labelled twice or more (indicating that multiple files have been delivered for the same OS tile), see page 13 for exceptions and further details

General checks

Check that metadata, report, survey polygon and flight index are correct and present, as well as any other deliverables requested in the Brief.

Check that filenames for data delivered in polygons (*.asc mosaics) are based on the Work Package polygon number, survey date and data type (see Appendix C, Table 1). It is important to remember that these mosaics are processed but without removing the water, to allow users to modify the data themselves. If a final water-free DSM and/or DTM mosaic is required, it should be created from the 1k tiles after the survey is accepted.

XYZ files

- Check that the same number of *.asc and *.txt files is delivered and that they have been named correctly, using the correct file extension
- Check file names and extensions and make sure all data is dated with the same correct date (see further for detailed description)

Completion of quality control

Acceptance of survey

- Inform the Contractor that the survey has been accepted and fill out the “Survey Accepted” and “Raster Created” columns in the spreadsheet
- When the survey is accepted, delete any temporary QC files that are not needed anymore
- Create water-free DSM and DTM mosaics from the final 1 km DSM and/or DTM tiles and save in a MOSAICS folder in the root folder of each Work Package
- Create hillshade rasters from the final mosaics and save in the same folder

Upload data to www.coastalmonitoring.org website

Usually only one report covering the whole area flown is delivered after all the Work Packages have been QC'd. Make copies of the final report and put a copy in each work package folder, since the data

will be uploaded to the website in survey polygons. Change the report name to match each work package name and flying date (use the latest flying date if multiple dates were used to fly a polygon). Make sure the report name in the metadata form matches the names of the report copies.

Upload data to the FTP for subsequent uploading to the website by CCO. Upload work packages in separate folders and only include unfiltered and filtered tiles (XYZ and ASCII), metadata, report and profiles (if delivered and if they need to be uploaded to the website) and let CCO know when finished. Fill out the “Loaded to FTP for Website” column in the QC spreadsheet.

Methods

1. Data quality

Not integer

When first loading the elevation data, check that it is delivered as floating point in metres, not as mm and integers. Do this by looking at the “High” and “Low” values of the mosaic raster in the table of contents in ArcMap. If they are decimal numbers that look like a sensible range of values for the area, they are ok. If they are in mm, the values are usually in the thousands.

Fill out the spreadsheet.

Full polygon coverage

When going through each tile, make sure that the collected data covers the entire polygon on the landward side. If it is not fully covered, add a polygon to the QC shapefile and fill out the spreadsheet. Note that polygon coverage issues are different from “gaps”; polygon coverage issues are areas where no data was collected over part of the polygon. Gaps are parts of the dataset where data was collected, but not included in the final dataset.

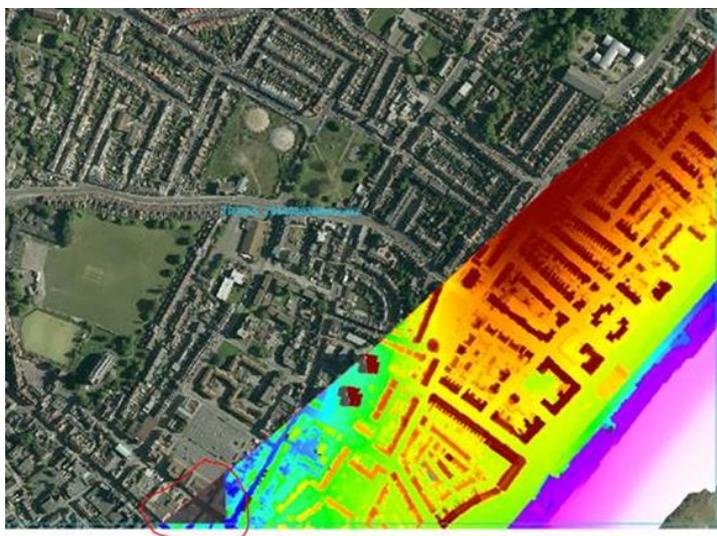


Figure 1: Polygon not completely covered

Seaward limit reached

Check that the data reaches the specified seaward limit by forcing MLWS contours (in Ordnance Datum) through the raster (see Appendix B). For locations in between tidal stations, estimate or interpolate the MLWS level based on the nearest tidal stations. If the data has reached the required depth, an unbroken contour should be produced. When using watermarks, the contour should fall completely within the watermark boundary. Amend the watermark if it doesn't.

If the data fails to reach depth, check that flights have been conducted at appropriate times on appropriate tides. If flights were carried out on an appropriate tide, make a note on the Master spreadsheet that the seaward limit wasn't reached but that the flight was carried out in an appropriate window. Where tidal stations are far up tidal rivers and in harbours, MLWS may not be reached, even though the flight was carried out within an appropriate tidal window.

If MLWS is not reached, make sure that as much dry land as possible is included in the watermask/in the data. If there is more dry land available outside the watermask, amend it to include the dry land (Figure 2). When not using watermasks, use the water-containing mosaics that are delivered with the preliminary data to check if more dry land is available and add the missing area to the QC shapefile. Use the symbology settings of the elevation raster, the LAS point cloud and the Intensity raster to help decide where the water line is (see Appendix B on how to create these datasets, and the next section on water removal for examples).

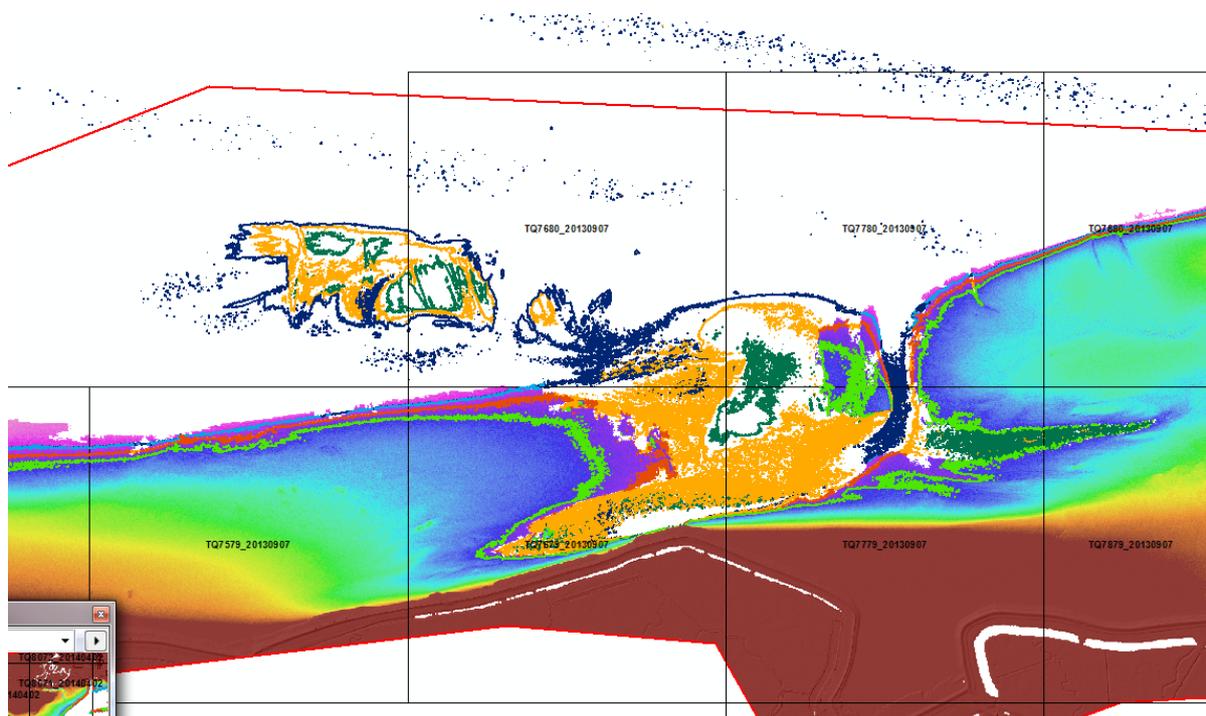


Figure 2: Contours showing there is dry land available that wasn't delivered in the 1k tiles.

Figure 2 shows an example of seaward limit checks of preliminary data that wasn't delivered with watermasks. The contours were drawn from the water-containing mosaic and overlaid on the mosaic that was created from the 1 km tiles. This showed that there was a lot more dry land available than was delivered.

If watermasks have been delivered, amend them as required. If working without watermasks, add a polygon that covers the area that needs to be included to the QC shapefile.

Water removal

On the open coast there should be no areas containing tidal water included in the watermask polygon, although small patches of standing water *e.g.* in runnels or beach creeks are acceptable, as is estuarine water. Large water bodies like ponds, lakes and lagoons should be excluded from the watermask as well as water areas that are ≥ 10 m in width. Swimming pools, small ponds and narrow creeks and rivers may be left in.

Use the Intensity rasters to help identify areas with water (exclude tie lines, and only use last return). The intensity value is an indication of the reflectivity of the surface and can make the difference between different types of surfaces and between land and water clearer. It is a relative value so will be different from flight to flight.

“Patterns” in the elevation raster can also indicate water (waves are sometimes visible in the data). Play around with the colour ramp and stretch settings to maximise information from the data (see Appendix B). You can also use the closest available aerial photography but be careful when using aerial photography from a different flying date/time when looking at water courses in mobile sediment.

Contours can help to show up water as well (see Appendix B on how to draw quick contours).

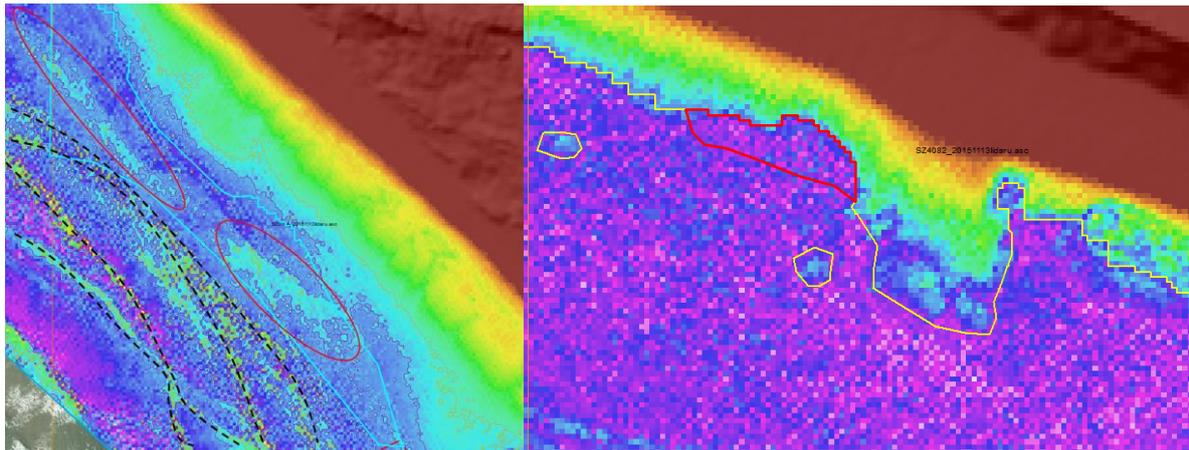


Figure 3: How to recognise water in the raster

In Figure 3, the turquoise blobs in the red ovals on the left are probably foam at the top of the waves; the dashed lines indicate the crests of incoming waves. The image on the right shows how the pattern of the elevation raster can give an indication of which areas are water or land. In this case the red polygon has the same colour/pattern as the more seaward areas so it is probably water.

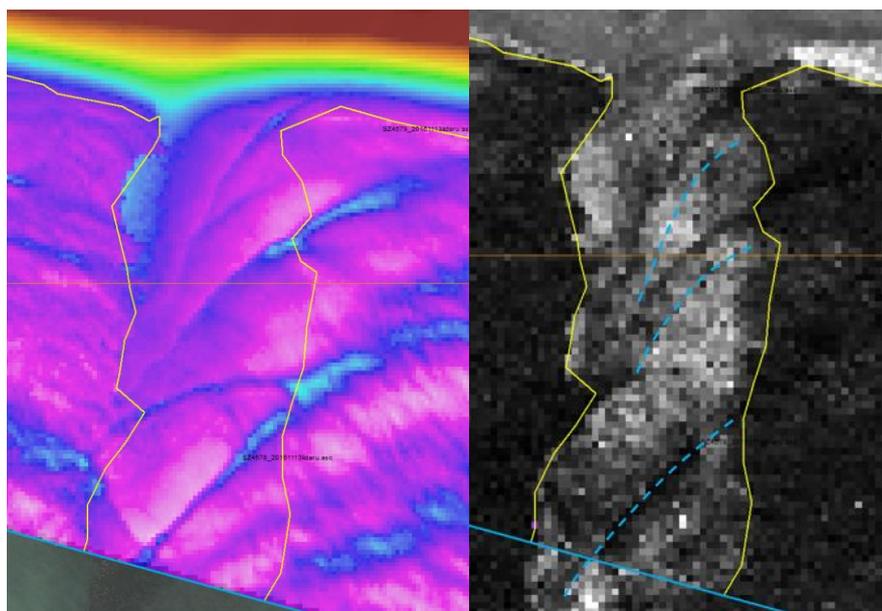


Figure 4: Waves in the elevation raster and the intensity raster

Figure 4 also gives an example of what waves look like in lidar. In this case they have not been removed from the watermark (yellow line). The black and white image below shows the Intensity raster for the

same area. The original watermark follows the lighter shade of intensity but frothy water can give this return as well. There are some darker lines visible cutting through the light area, these take the shape of the wave crests (blue dashed lines).

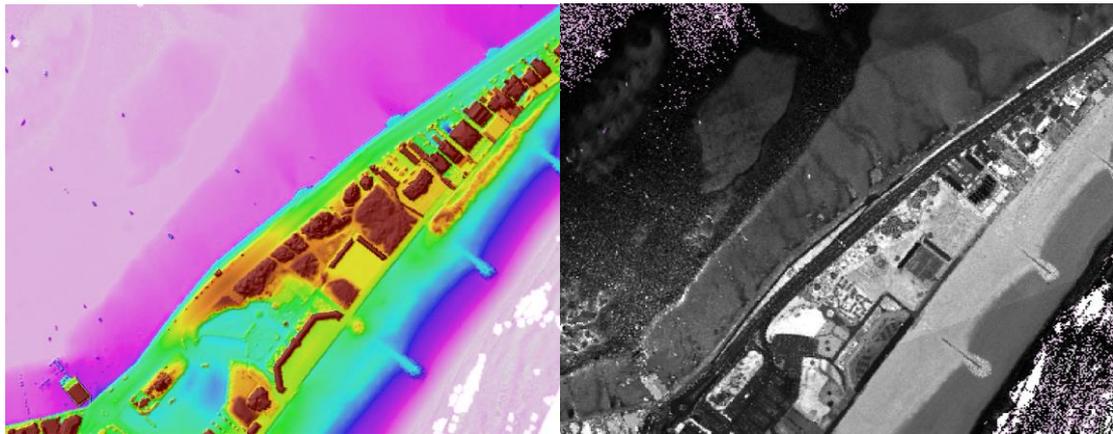


Figure 5: Elevation raster on the left, intensity on the right

Figure 5 shows clearly how the intensity raster displays different surface types. The islands in the top left corner are defined much clearer in the intensity raster and the boundary between the beach and the water in the bottom right corner is very clear in the intensity raster.

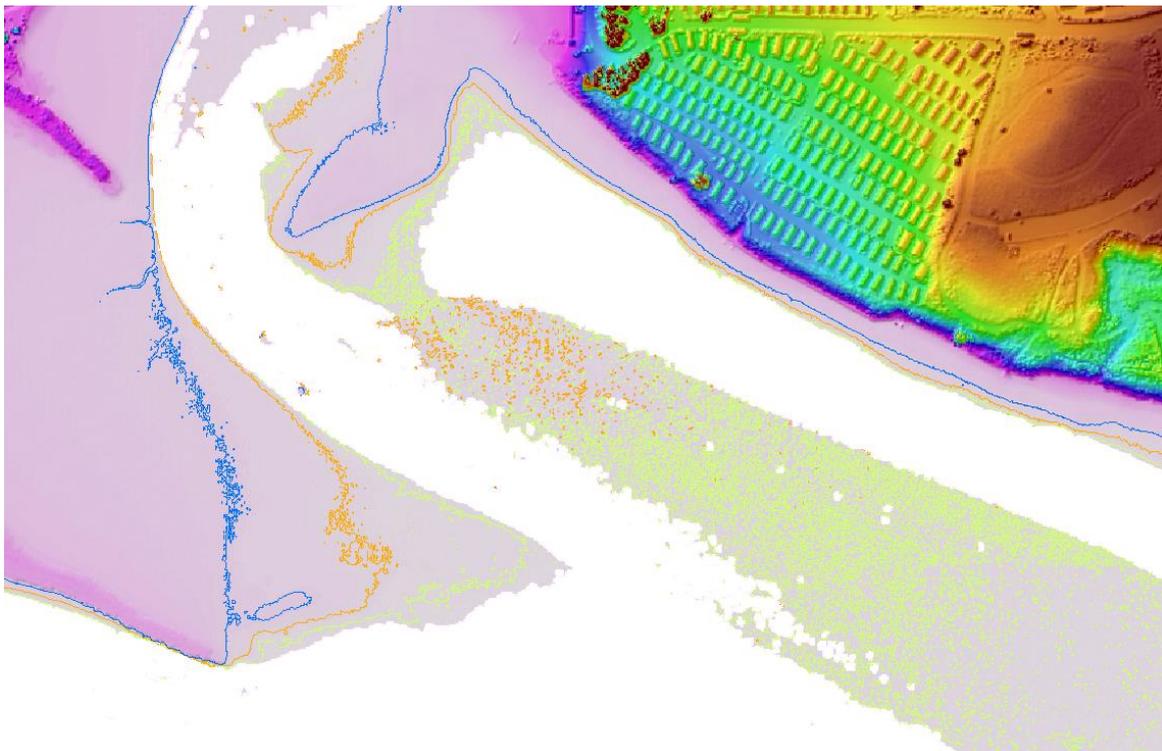


Figure 6: Contour behaviour on still water and land

Figure 6 illustrates how contours can make clear where land ends and water begins. Contours also help clarifying the topography of areas that appear flat or slope very gently. On dry sloping land the contours are clear defined lines. Where it becomes flatter, they might appear a little bit messy, but it is still possible to follow a “line”. On still water, they become very dappled and can cover the entire surface (yellow and orange from the middle to the bottom right).

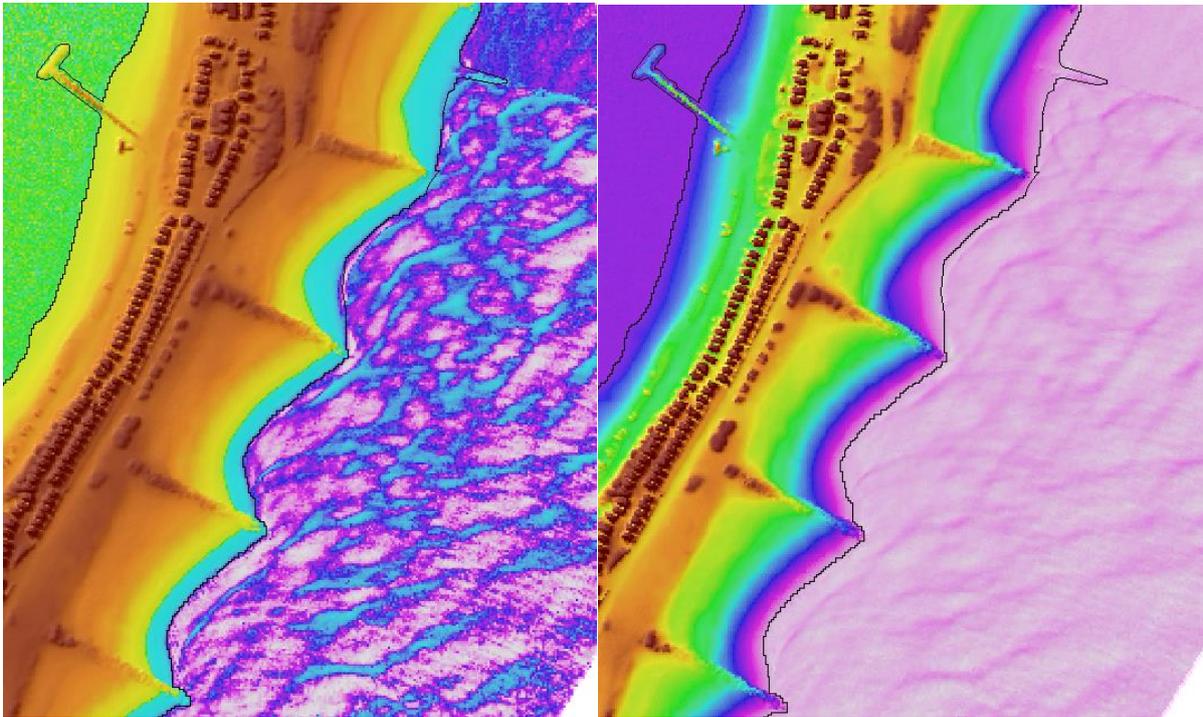


Figure 7: Histogram equalize stretch on the left, percent clip stretch on the right. Waterline is indicated by the black line

Figure 7 shows another example of how the symbology settings of the elevation raster can highlight the water/land boundary.

Amend the watermask or add a polygon to the QC shapefile where water needs removing. Where water needs to be removed from a large pond or lake a “donut” hole might have to be created in the watermask (see Appendix B).

Gaps

Check that there are no gaps in the raster where data is missing or has been accidentally filtered out. Gaps are parts of the dataset where data was collected, but not included in the final dataset. Use the LAS point cloud to check if data points are available. Make sure to use only the last return points (see Appendix B). If there are no points in a gap, it should not be flagged. The point clouds are quite large to load, so you can just check the Intensity raster as an initial check. The Intensity raster is made from the LAS points, so if there is a gap in the Intensity raster, it means that there were no data points available and the gap is a real gap. If there is no gap in the intensity raster, check the point cloud.

When using the Intensity raster or point cloud, **make sure you use the one that has the same date as the tile you are checking**. Sometimes two flying dates have covered the same area, but only the point cloud of the date in the tile name will have been used to make the elevation raster.

Explanation for acceptable gaps:

- Last return data is used to generate the output and where there is an absence of a recorded last return pulse(s) on a bridge/structure (*i.e.* the first returns hit the bridge but the last return was from the terrain below) there will be gaps.
- Where very dark/black material is present on the roof, laser pulse energy can be absorbed by the surface and not received back by the sensor resulting in no data. Where the area of no data is beyond the interpolation threshold for the surface there will be a data gap.

- There can occasionally be gaps on along cliffs caused by shadowing of the cliff face and the foot of the cliff as seen by one swathe and the overlap of the neighbouring swathe not covering that area. This is especially the case where the cliff is towards the centre of the landward swathe. There can also be gaps in the dataset due to shadowing of the ground by another structure, especially in dense urban areas with high buildings and narrow streets.
- Cliff overhangs may also cause issues as the grid cell can only contain one Z value *i.e.* you cannot have the top of the cliff and the bottom of the cliff represented in the same cell.

Add a polygon to the QC shapefile where there are gaps in the data.

Data Spikes

Check for spikes in the raster, spurious points caused by flying birds, power cables *etc.* (Figure 9). Points from people on the beach, wrecks and boats resting on dry land, vehicles, large pylons... are all acceptable and should not be recorded as spikes. Where the laser passes through glass roofs and Velux windows the signal can be reflected off surfaces inside the building before returning to the sensor, making the elevation of the point lower than the surrounding points, resulting in messy buildings. This does not need correcting (Figure 8).

Make sure that spikes will show up in the symbology settings you are using for the raster (if the top and bottom 5 per cent values of the dataset are set to be the same colour, spikes on the lowest beaches and highest cliffs might not be visible).

Add a polygon for any spikes to the QC shapefile.

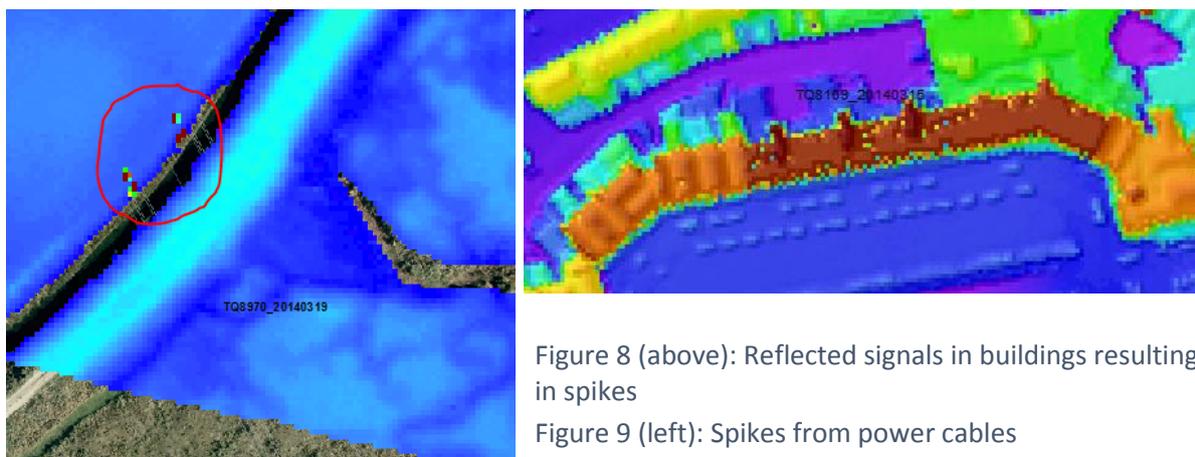


Figure 8 (above): Reflected signals in buildings resulting in spikes

Figure 9 (left): Spikes from power cables

Data stripes/pocking

These do not occur very often but they may appear in the data where there have been changes in surface elevation between flight lines within a tidal window – these are within-system QC tolerances and details of data checks will be provided in the end of project report (Figure 10, Figure 11). Where these are due to calibration error beyond the system specification they should be addressed in data processing.

Check also that structures in the sea are georeferenced properly. Use the aerial photography to check if they are in the correct place, or use an Ordnance Survey basemap (OS open data is available in ArcGIS as a standard basemap).

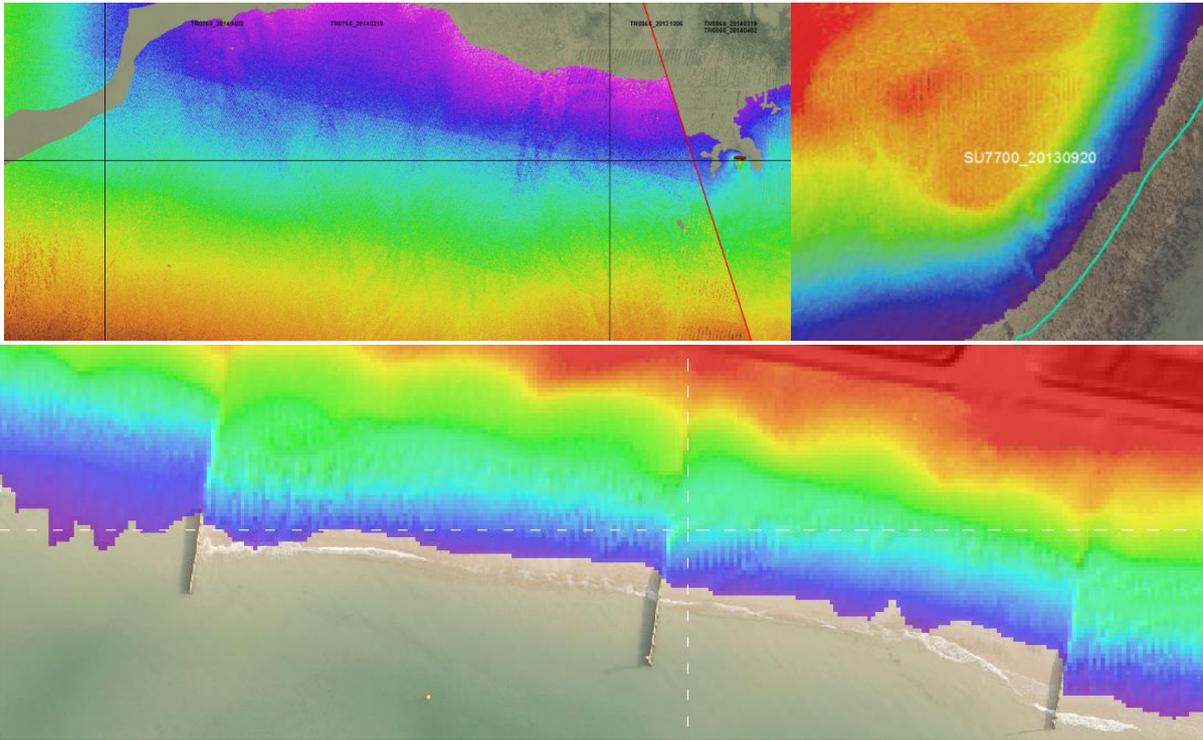


Figure 10: examples of stripes that are within QC tolerances

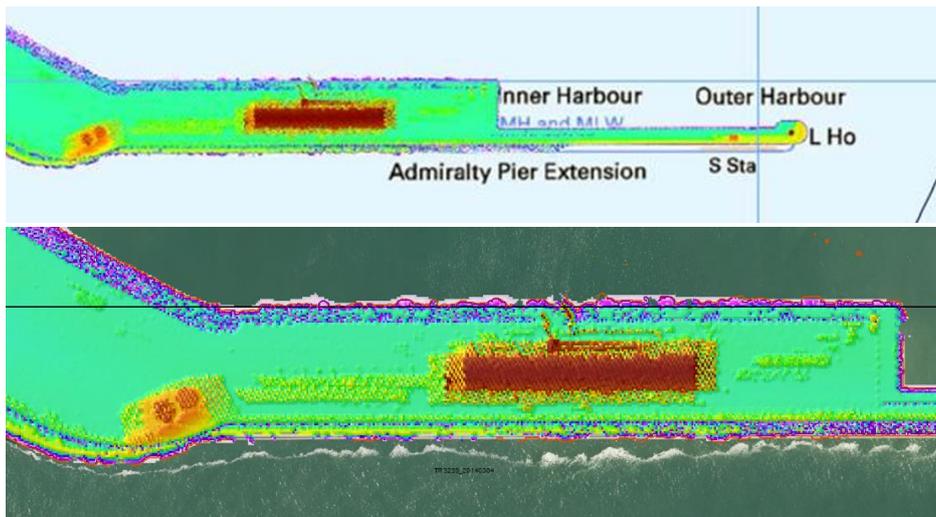


Figure 11: Harbour pier not aligned with OS basemap, one of the flight lines was not georeferenced correctly

Add a polygon to the QC shapefile for any striping issues. It might be worth sending a screenshot to the contractor when sending the QC shapefile.

Structures

DSM (unfiltered data) - the digital surface model should include all features and structures that are attached to the ground (bridges, piers, trees, wrecks, boats resting on dry land, houses, vehicles, large pylons, people wandering around). Check that such structures haven't been removed from the dataset. Add any missing structures to the QC shapefile (Structures Unfiltered). Floating pontoons, jetties and boats should be removed.

DTM (filtered data) - the digital terrain model has structures and features removed ("filtered") from the data so check that structures have been removed **as detailed in the Brief**. Beach structures such

as groynes, breakwaters and harbour walls might have to be included while piers, beach huts or ephemeral features might have to be filtered out. Add a polygon for structures that need removing to the QC shapefile (Structures Filtered).

2. Final Deliverables – Quality checks

Overlapping polygon/duplicated file names

Duplicate file names should be avoided at all cost as these cause problems when uploading data to the website. Duplicate file names can occur where work packages or subpolygon boundaries meet. Therefore it is best practice to choose adjoining work packages so that boundaries coincide with OS tile boundaries where possible.

Where work packages consist of several subpolygons whose boundaries go through an OS tile over land, a single tile should be produced using the later survey date in the tile name. Where the subpolygon boundary goes through a harbour or a river or a similar water feature, multiple rasters for the same OS tile are allowed if the subpolygons were flown more than a week apart, as long as they have different flying dates in their file names. If they were flown on the same day or only a few days apart, a single tile should be delivered using the latest flying date in the tile name.

Work package boundaries as decided by the client should be respected, even if they are not on an OS tile boundary. However if two adjoining work packages are flown on the same day, or only a few days apart, the tile on the boundary should be delivered as a single tile in one of the two work packages.

In the cases where delivery of multiple tiles from different flying dates for the same OS tile is allowed there should be no data overlap between the tiles. Each tile should cover a different section of the OS tile.

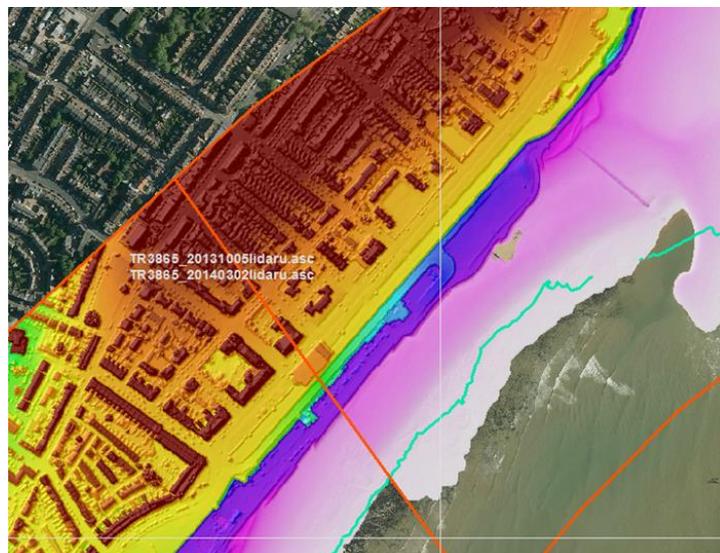


Figure 12: 2 tiles delivered instead of 1 OS tile. In this case 1 tiles should be delivered in the final dataset, named TR3865_20140302lidaru.asc. It would be better to change to polygon boundary to coincide with the OS tile boundary

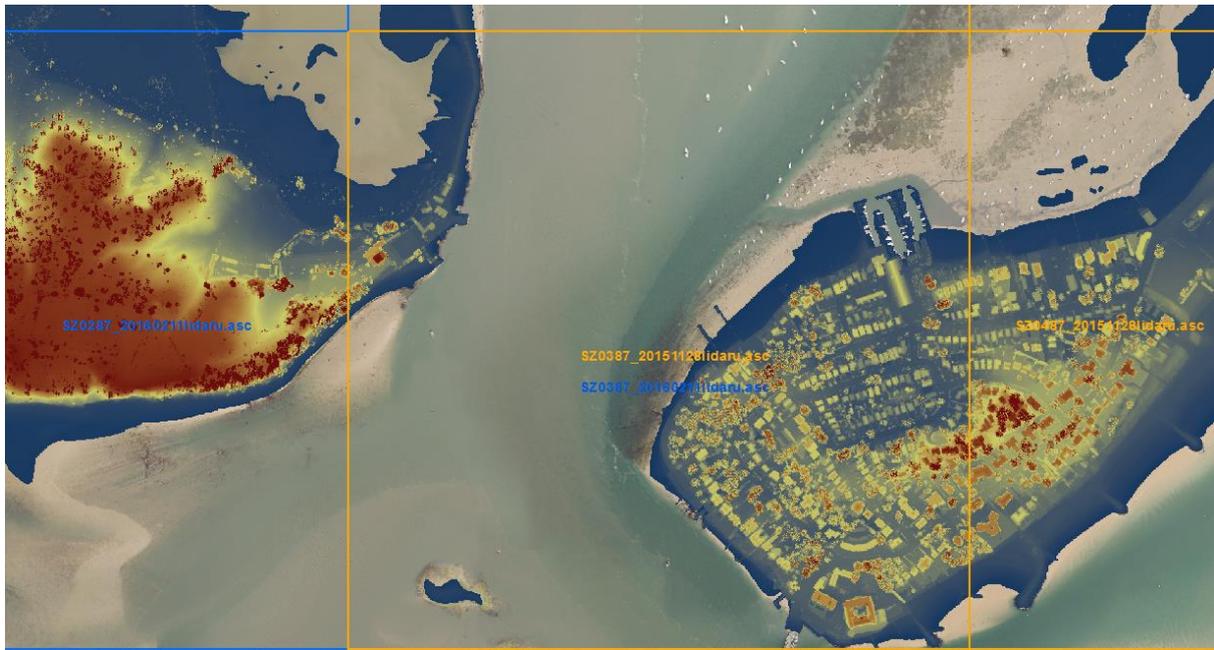


Figure 13: Tile SZ0387 was covered on different flying dates. The boundary goes between Brownsea Island on the left and Sandbanks on the right. Tile SZ0387_20151128lidaru.asc only contains the right part of the tile, tile SZ0387_20160211 only contains the left part of the tile. This is OK.

Profile checks (optional)

Profiles are delivered as points in text files. Check that 7 columns of data and 1 header row have been delivered.

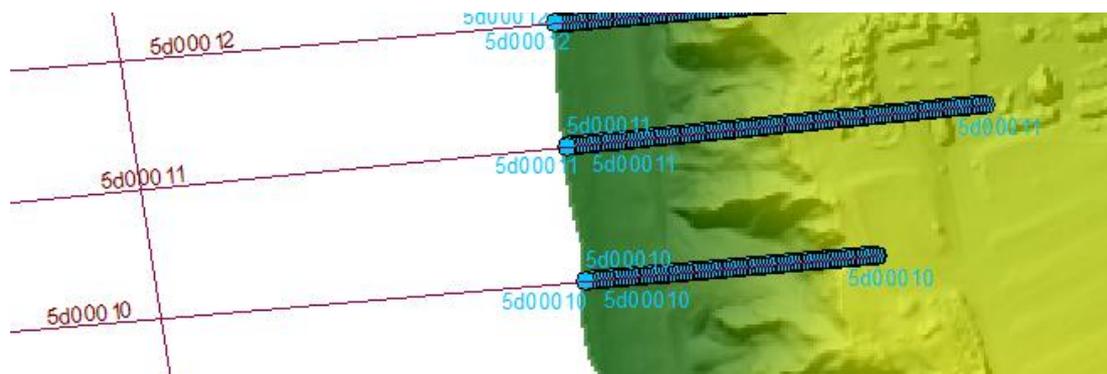
Example:

Easting	Northing	Elevation_OD	Chainage	FC	Profile	Reg_ID
484955.63	92411.06	0.76	171.00	ZZ	CHI166	5a00001
484955.01	92410.27	-0.790	172.00	ZZ	CHI166	5a00001
484954.40	92409.48	-0.790	163.00	ZZ	CHI167	5a00002

Profile is the local name of the profile, Reg_ID is the Regional line name. FC refers to the Feature Code (for sediment type), which is 'ZZ' for all lidar surveys, since sediment type is not derived.

Load the delivered profile points in ArcMap and convert them to shapefiles (see Appendix B). Load a shapefile of the profile lines. Label the points and the profile lines with the local profile line name and make sure they match. Then label them with the regional profile name and make sure they match again. Check the points are on top of the lines and start in the correct position.

Use a mosaic of the final delivered tiles and check that the points extend to the full seaward extent of the raster, but not beyond the waterline.



Make also sure no points have been delivered where no data was recorded. Convert the raster to a polygon shapefile and use a “select by location” approach to identify any points that are not in the polygon (See Appendix B). Feed back to the contractor if any errors are encountered (make a note of the profile name, Survey Unit, Easting, Northing and include a screenshot).

3. Final Deliverables – Data Management checks

Data labelling (optional)

The medium (CD/DVD) on which the data is delivered should be labelled as follows:

Label:

LiDAR
Survey area
Polygon ID
YYYYMMDD
Disk number
Contractor

Data labelling does not apply to data delivered on hard drives or through FTP software.

Data file names

The data filenames must be in the correct format and case so that it can be loaded to the website. OS tiles and _SANDS should be in uppercase, file extensions and the type of data (u or f) in lowercase.

1k tiles: **OSOSOS_YYYYMMDDLidarxx**

where: OSOSOS is the Ordnance Survey 1km Tile Name – 6 digits (uppercase)

YYYY is the year of survey

MM is the month of survey

DD is the day of survey

lidarxx is the type of data (lowercase) - replace xx with u for DSM and f for DTM

Make sure the correct tile name is used.

Examples: [SX6639_20070331lidaru.asc](#)

[SX6639_20070331lidarf.txt](#)

Profiles: **CCUUU_YYYYMMDDLidarxxp.txt**

where: C is the Coastal Process Sub-Cell (2 digits) e.g. 6a (lowercase)

UUU is the Survey Unit (variable number of digits) e.g. SU16

YYYY is the year of survey (4 digits)

MM is the month of the survey (2 digits)

DD is the day of the survey (2 digits)

lidarxx is the type of data (lowercase) – replace xx with u for DSM and f for DTM

SANDS files should be named as above with _SANDS inserted following lidarxxp

Examples: [7eMU15-4_20090210lidarup.txt](#)

[7eMU15-4_20090210lidarfp_SANDS.txt](#)

Data delivered in polygons

Data delivered in polygons (*.asc, *.txt mosaic) should be based on the Work Package polygon number, survey date and data type:

WPNN_PP_YYYYMMDD*.*

where: WP is the Work Package name (variable number of characters/digits)
 PP is the polygon number (2 digits)

Examples: LSW01_01_20111027lidarf.asc
 LSW02_04_20111027lidaru.txt

Point clouds

The las point cloud names should be based on the Work Package polygon number, survey date and data type, with addition of Line number (L*) or Tie Line number (T*) as appropriate:

Examples: LSE01_01_20111027_L1lidaru.las
 LSE05_04_20121202_T3lidaru.las

Check all data is dated with the same date and that the date is correct. The correct date is the date the survey was completed. This should be supplied in the report. If a work package was flown over 2 or 3 contiguous days, the date used for the 1km tile names should be the last date of the survey. Where tiles within a survey area were collected more than a week apart, files should be named with separate dates.

Metadata

Check that the metadata form is present and named and dated correctly.

Meta_lidar_WPNN_YYYYMMDD

Where: WP is the Work Package name (variable number of characters/digits)
 YYYY is the year of survey (4 digits)
 MM is the month of the survey (2 digits)
 DD is the day of the survey (2 digits)

Check that the relevant fields are filled in and that the start and end dates and the name of the survey report are correct. The metadata form should be named with the end date of the survey.

Example Metadata Form

General Information	
Name of LIDAR instruments manufacturer:	OPTECH
Instrument model:	GEMINI
Average flight height (metres):	700mAGL (approximate)
Swath width (metres):	800.00
Grid size (metres)	0.50
Units of elevation reading for ASCII grid file:	mAOD
Units of elevation reading for text file:	mAOD
Start Date (dd/mm/yyyy):	17/09/2009
End Date (dd/mm/yyyy):	17/09/2009
Distance of elevation readings along profile (metres):	N/A
Quality Information	
Estimated accuracy of dataset:	positional accuracy +/-40cm elevational accuracy +/-15cm
Explanation of accuracy estimate:	
Metadata Information	
Data has been collected by:	Environment Agency - Geomatics Group
Comments:	Contact Alison Matthews

Survey Report

Check the survey report is present and is named in the correct format and case and dated correctly.

Report_lidar_SurveyAreaNameWPNN_YYYYMMDD

where: WP is the Work Package name (variable number of characters/digits)
YYYY is the year of survey (4 digits)
MM is the month of the survey (2 digits)
DD is the day of the survey (2 digits)

Check that the report contains the correct dates in the flight information report and that the correct flight logs are included.

Lidar Index

Check the index is present and is named in the correct format and case and dated correctly.

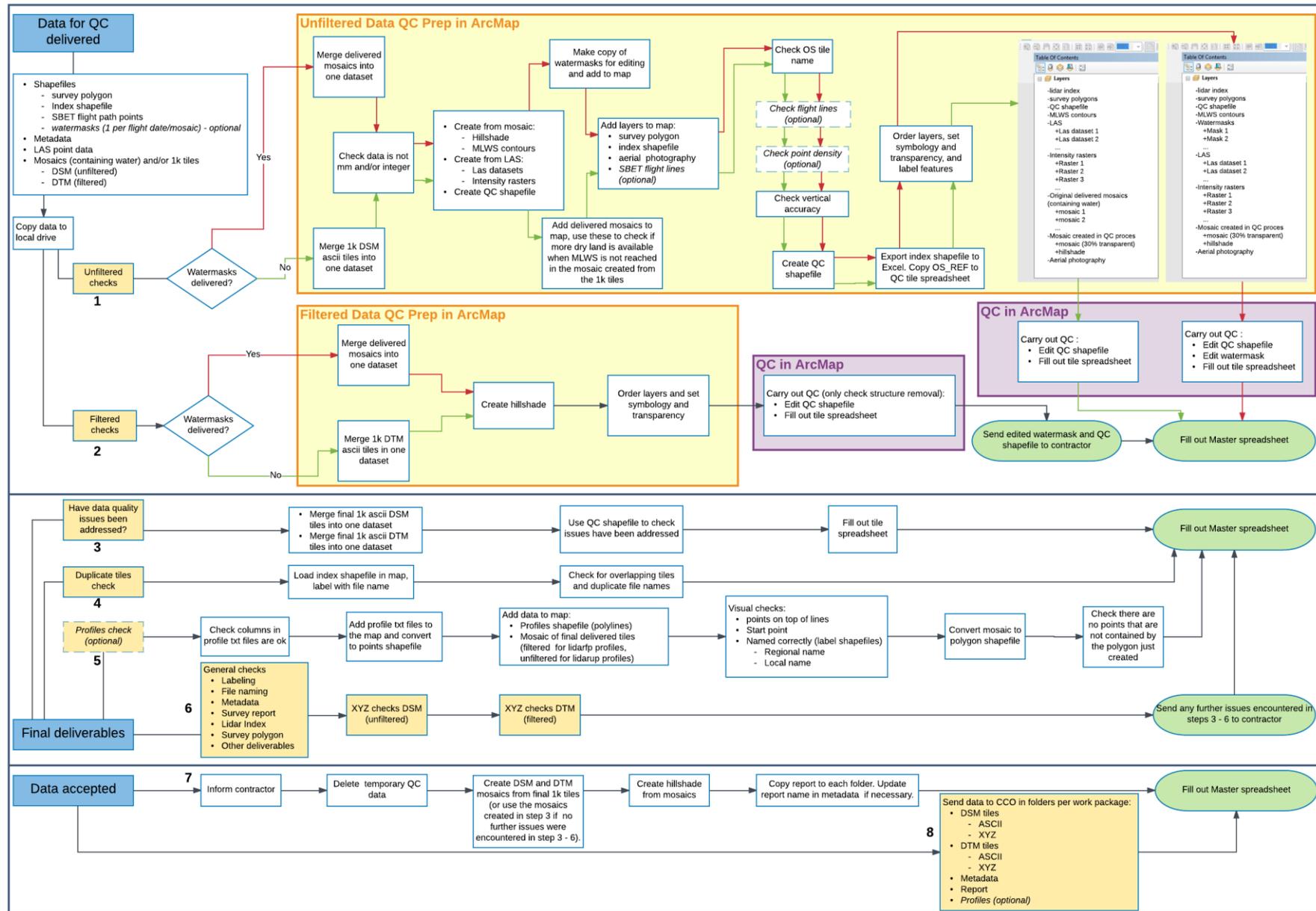
Lidar_index_WPNN_YYYYMMDD

where: WP is the Work Package name (variable number of characters/digits)
YYYY is the year of survey (4 digits)
MM is the month of the survey (2 digits)
DD is the day of the survey (2 digits)

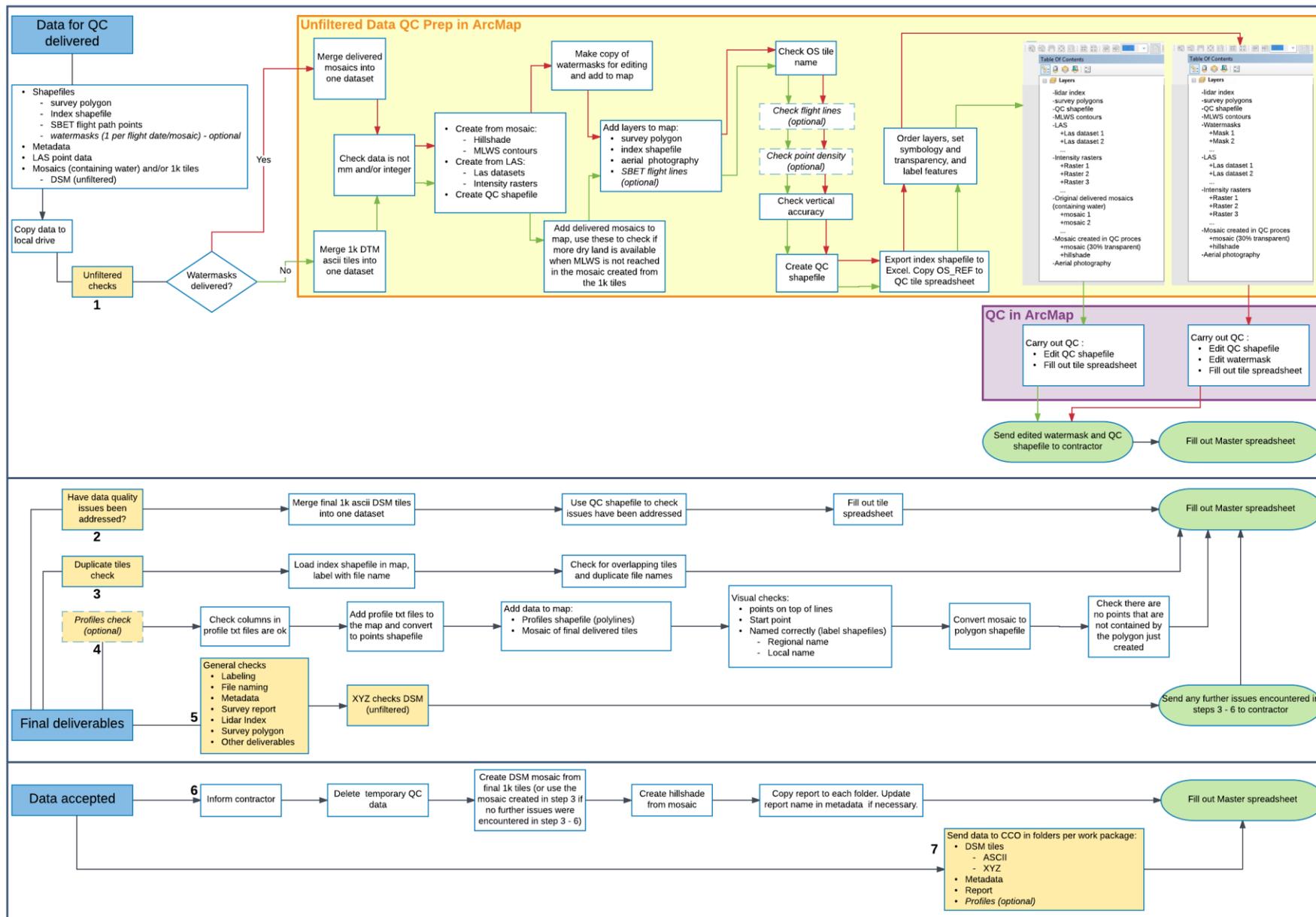
Check that it covers the correct area and that the dates in the attribute table match the dates in the report, metadata and file names.

Appendix A – Workflows in Arc

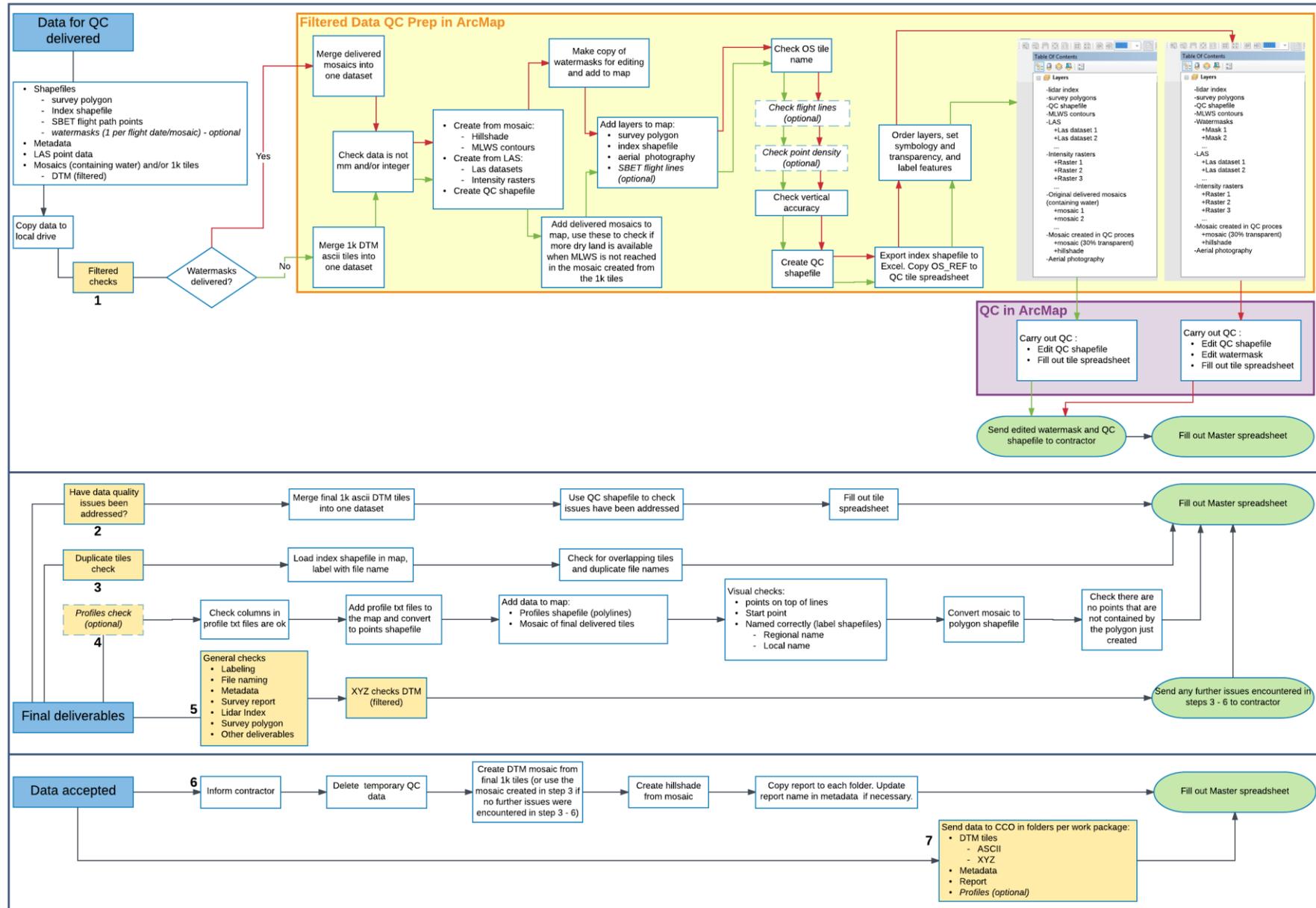
Unfiltered DSM and Filtered DTM Checks



Unfiltered DSM Checks



Filtered DTM Checks



Appendix B – Procedures in Arc

1. Creating a mosaic from 1k tiles

Use the search function to find the “Mosaic to New Raster Tool” (or go to Data Management Tools>Raster>Raster Dataset> Mosaic To New Raster)

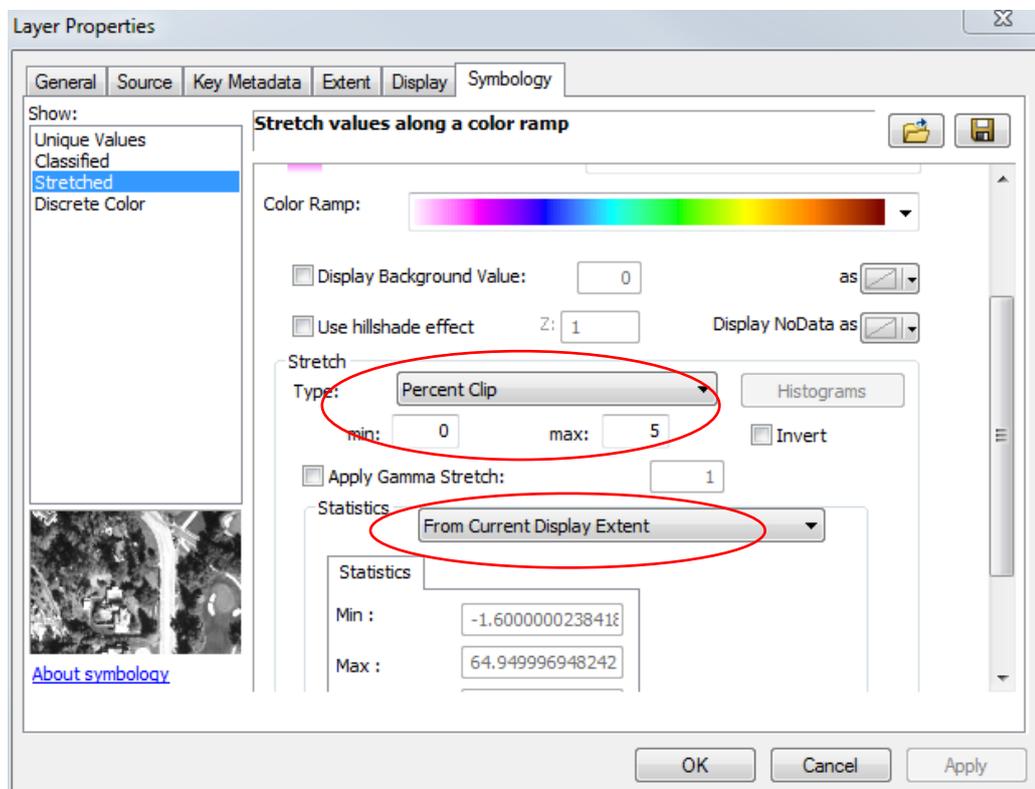
Select all the 1k rasters, choose an output location and give the output raster a name (use a name ≤13 characters and no extension to use the default Arc grid).

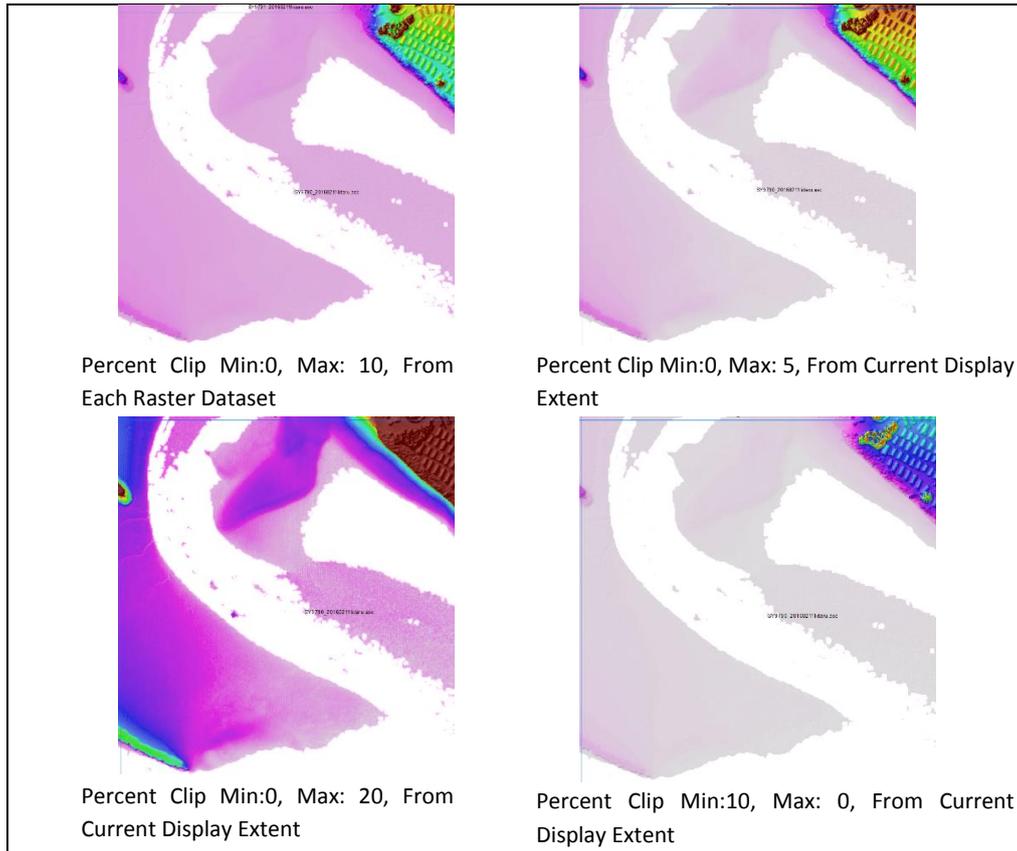
Other parameters to use:

- Spatial reference = British National Grid
- Pixel type = 32_BIT_FLOAT
- Cell size =1 (if data is 1m resolution, otherwise use other value)
- Number of Bands = 1

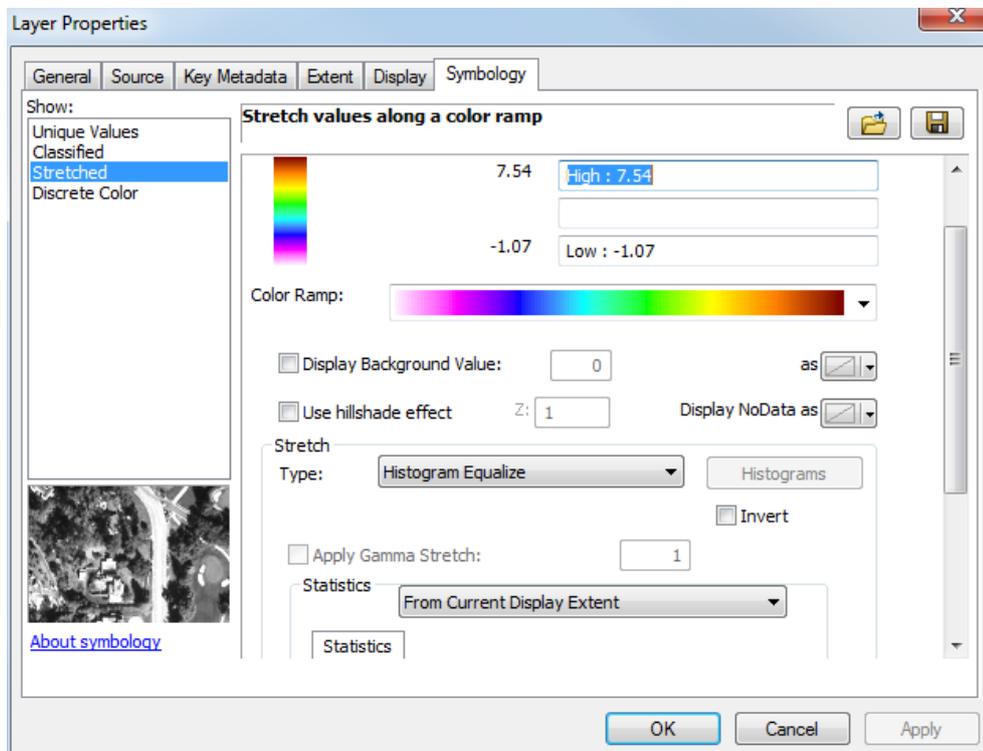
2. Setting symbology

In the layer properties, go to the symbology tab and choose a colour ramp that will show up elevation differences well. Set the stretch type to Percent clip and play around with the values of the max percent until you find values that work for the display you’re currently looking at. Set the Min value to 0, otherwise the lowest values (the beach) will be coloured the same flat colour. You can also change the Statistics dropdown to use “From Current Display Extent” as this will stretch the colours of your chosen colour ramp on the part of the dataset that is currently visible. If you then also change the Max value of the percent clip to a higher percentage, the colours will be pushed into the lower values, giving more elevation detail on flat beaches (see example below). When using a higher value for percent clip, spikes are easily missed so make sure to change it to lower values when looking for spikes.





The Histogram Equalize stretch in combination with the From Current Display Extent statistics can also show up features really clearly.



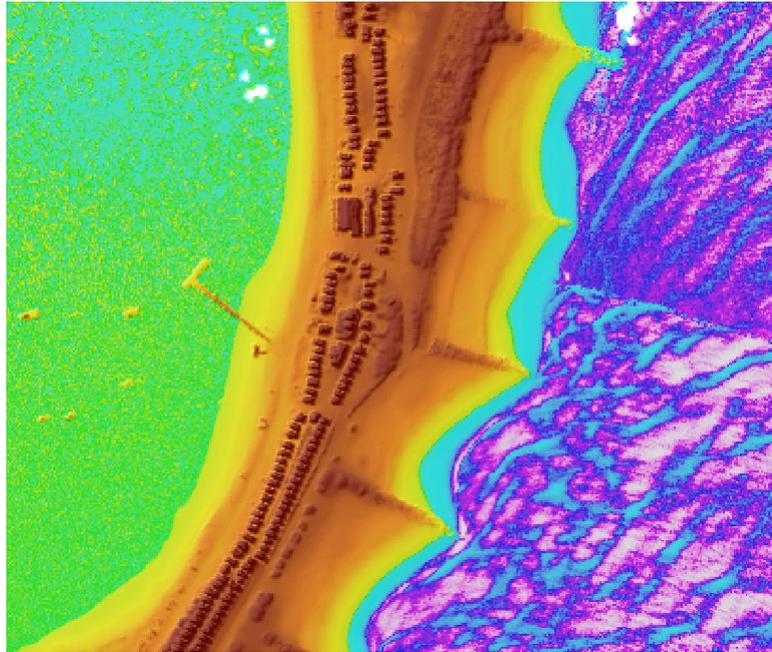
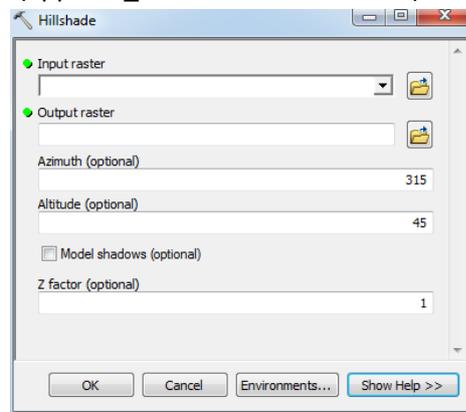


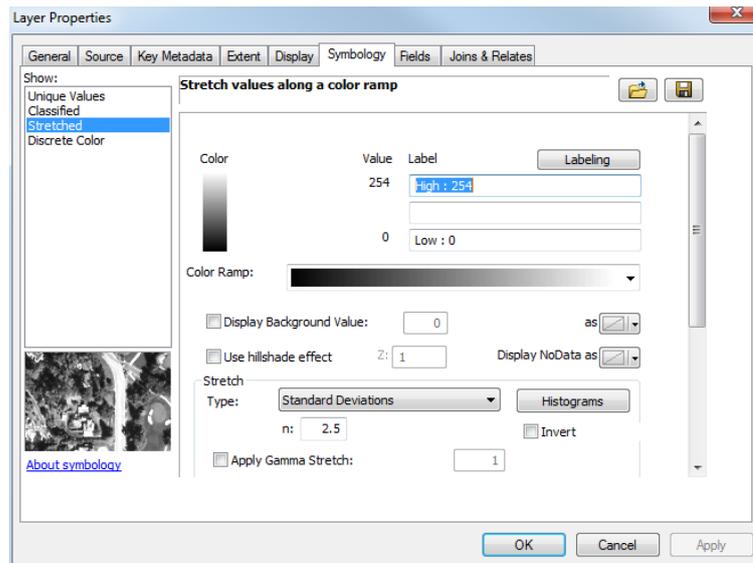
Figure B1: Histogram equalize

3. Creating a hillshade from the mosaic

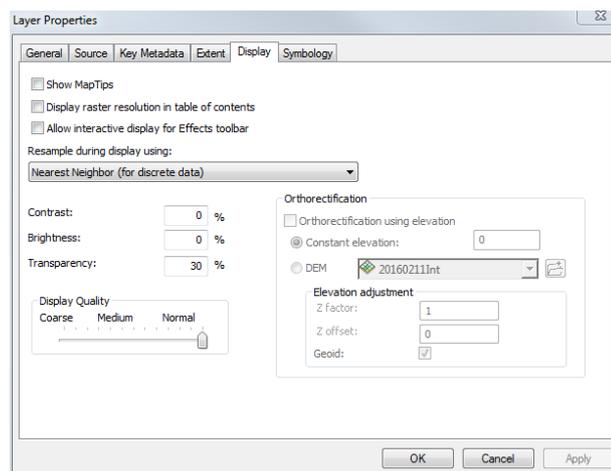
Use Hillshade (3D Analyst or Spatial Analyst). Use the Elevation raster as the input and choose an output folder and name (append _hsh to the raster name) and click OK.



Put the Hillshade raster below the mosaic in the table of contents. In the layer properties of the Hillshade, go to the symbology tab and change the stretch type to standard deviations and click OK.

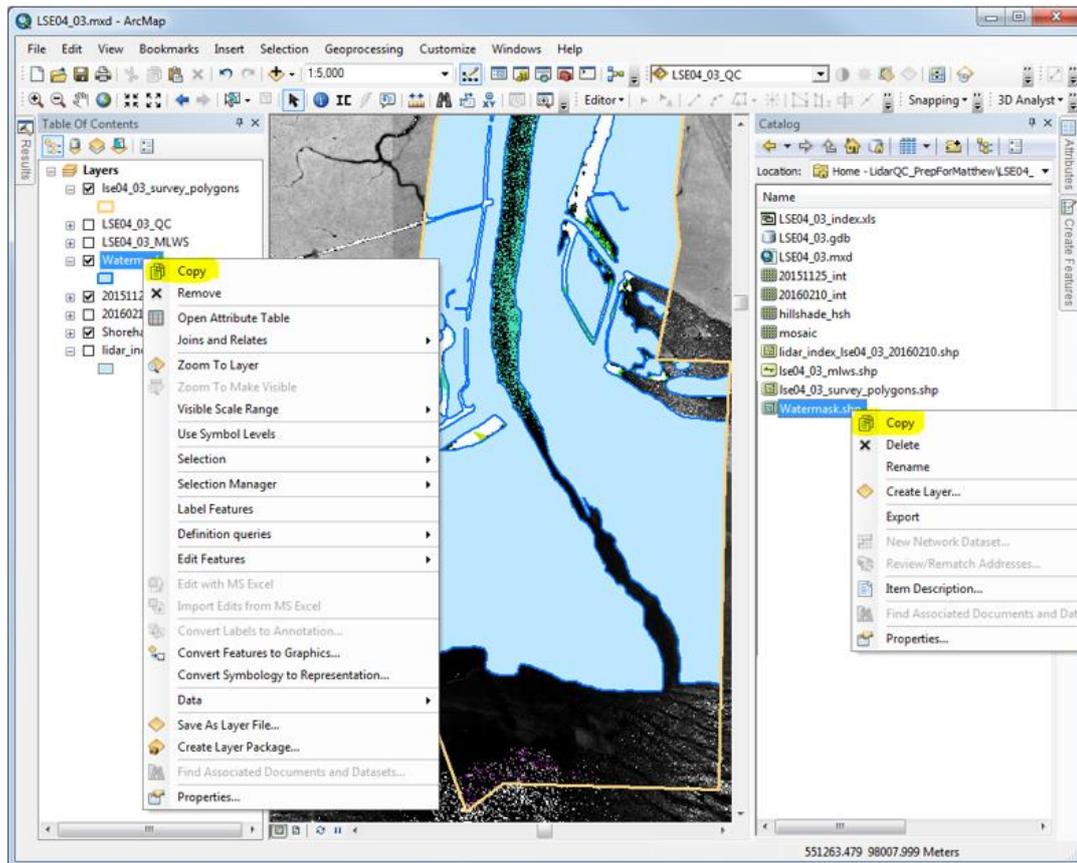


Group the mosaic and hillshade together in the table of contents (select both and right click -> choose Group), with the mosaic on top. Change the symbology of the mosaic as desired and set the transparency to 30%.



4. Copying datasets (watermask)

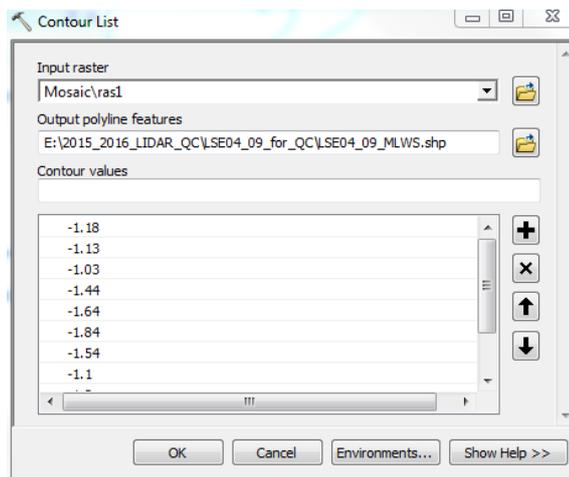
When copying the watermark for editing, make sure to copy it in the Catalog window (on the right of the image below) or through Arc Catalog and then add it to the map. Copying and pasting layers in the Table of Contents section of ArcMap (on the left) just duplicates the layer but doesn't create a copy on your drive. Both layers will be pointing to the same dataset on the drive. You can check this by looking at the source tab of the layer properties. Likewise when you change the name of a layer in the table of contents, it doesn't change the name of the file. You can rename datasets in ArcCatalog or in the Catalog window in ArcMap.



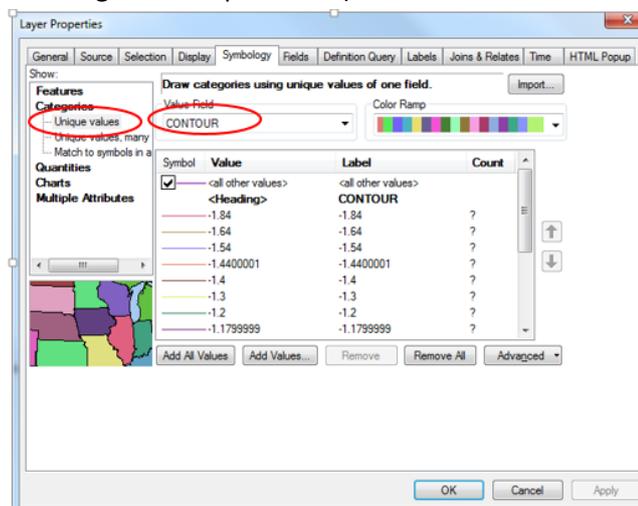
5. Create MLWS contours in Arc

Use the search function to find the “Contour List” tool or go to ‘3D Analyst’ > ‘Raster Surface’ > ‘Contour List’ or ‘Spatial Analyst’ > ‘Surface’ > ‘Contour List’.

Make sure the correct raster is selected as the input surface. Add MLWS levels for all tidal stations in the survey polygon as the contour values (click the ‘+’ after every value you type in). You can use <https://www.tidetimes.org.uk/> to check which tidal stations are available. Add a few intermediate values as well if the values are far apart. Save the output somewhere in the project folder.



Once the shapefile is created, change the symbology in the layer properties to colour the lines by contour value (Use Categories-unique values).



6. Use Las data in arc and make raster from the intensity values of the points

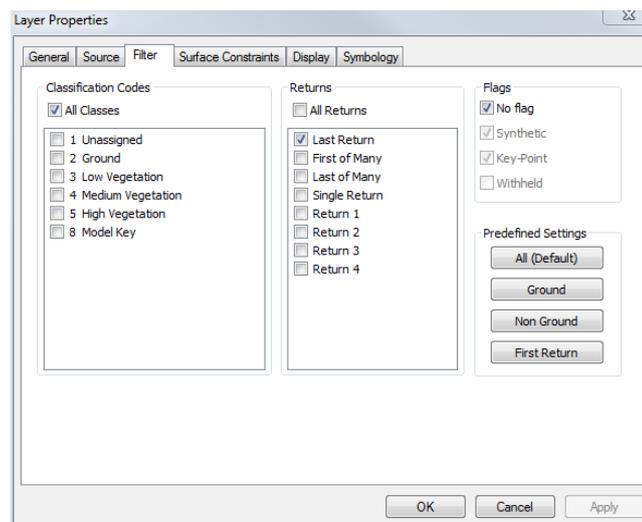
The las files are usually organised in polygon folders that match the tide station. To work with las files in arcmap, you need to create a las dataset first, then add the las files to the empty dataset. Create a las dataset for each flying date in the LAS_Point_Data folder by right-clicking the LAS_Point_Data folder in the ArcCatalog window. Select “New” and “Las Dataset”. Name the LAS dataset something like this: LSE04_09_20160113.las.

Repeat for each flying date

Right-click one of the new las datasets and click “Properties”. Go to the LAS files tab. Use the “Add Files” buttons to add the relevant las files to the dataset (don’t add the files that have a “T” in their filename). Go to the statistics tab and click the Calculate Statistics button. On the XY Coordinate System tab, pick British National Grid.

Repeat for each flying date

You can now bring in the point clouds in Arc by adding the las dataset to the table of contents. You can also load them in ArcScene to look at them in 3D. When bringing the data into Arc, open the layer properties and go to the filter tab. Check Last Return to only display the last return points.



7. Create an intensity raster for each las dataset

Make an intensity raster for each las dataset with the “Las Dataset to Raster (Conversion)” tool (use the Search button to find the tool or go to Conversion Tools>To Raster> LAS Dataset to Raster)

Use the following parameters:

- Value Field = intensity
- Cell Assignment = Average
- Void Fill Method = NONE
- Output Data Type = Float
- Sampling Type = Cellsize

- Sampling Value = 1.5 (Make sure to change this one! This means the output cells will be 1.5x1.5m, a bit bigger than the raster to avoid gaps where point density isn't that high)

Save the output rasters in the same folder as the las datasets, name them something like 20151113_Int (no extension, don't use more than 13 characters). Change the symbology to standard deviations between 1.5 and 2.5, you can change it to statistics of current display extent as well to make different materials show up better when QC'ing. Very low intensity values (black) tend to be water or non-reflective surfaces like roads.

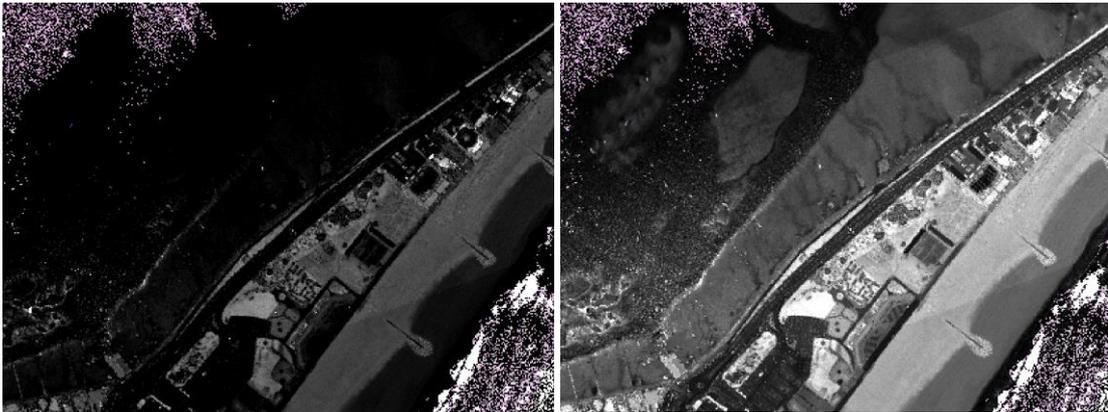
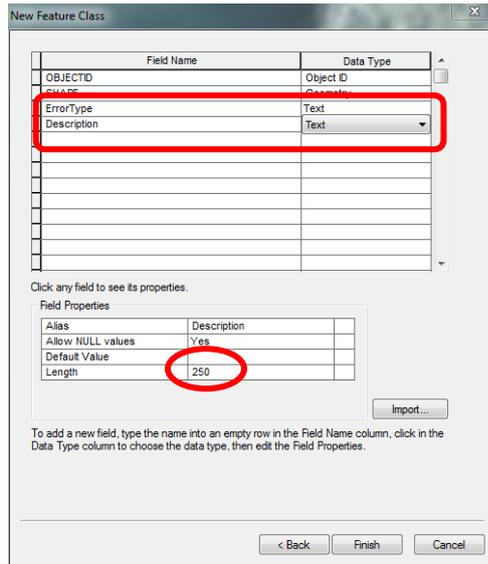


Figure B2: The same intensity raster, on the left with the default 0.5 min and max percent clip settings, on the right with a 2.5 standard deviations stretch.

8. Create QC shapefile with dropdown menu for the types of QC issue

This will create a dropdown menu so the same values won't have to be typed every time

- In the root folder, create a new file geodatabase (right-click root folder, select "New" and "File Geodatabase". Name it QC LSE04_09 or something similar
- Right-click the geodatabase and choose "New" -> "Feature Class". Give it a name like QC_LSE04_09. Leave the type as Polygon features.
- On the following screen, choose "British National Grid" as the coordinate system
- On the following 2 screens, keep the default settings
- On the screen with the field name and data type, Add a field called ErrorType (Data type Text) and a field Description (Data Type text). Change the Length of the Description field to 250 characters:

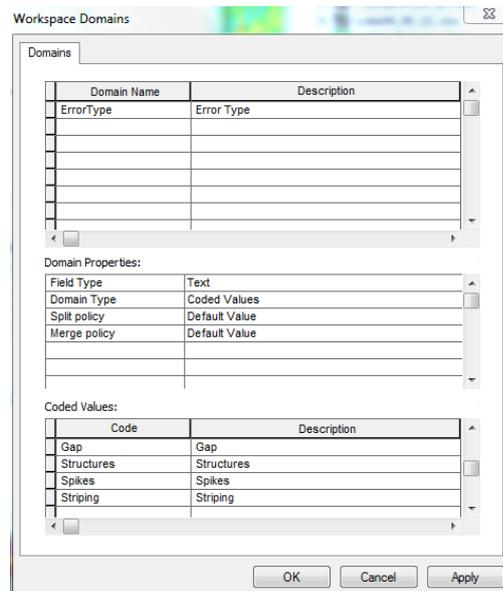


Click "Finish"

- In the catalog window right-click the new feature class you've just created and open the Properties.
- Go to the "Subtypes tab" and Click the "Domains" button at the bottom.
- In the top table, Type "ErrorType" in the Domain name column, and Error Type in the Description column. Under the Domain Properties in the middle, change the Field Type to "Text"
- Fill out the Coded Values table as follows:

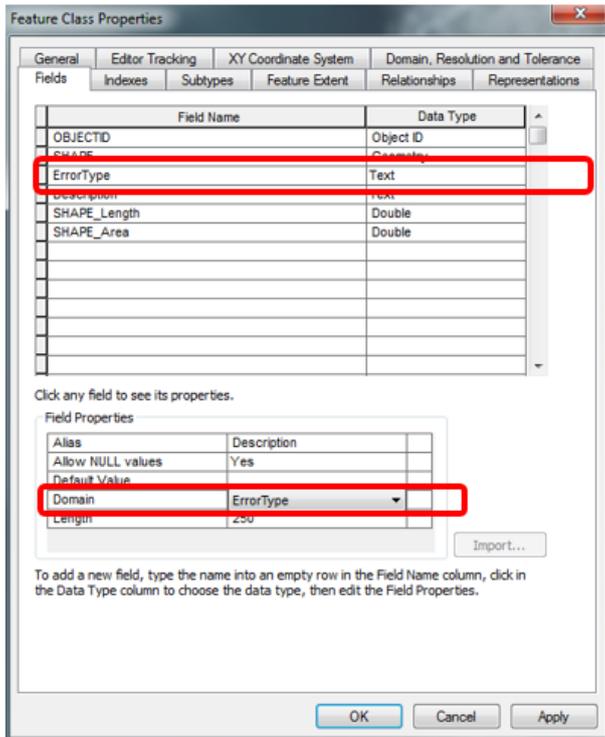
Seaward Limit	Seaward Limit
Polygon Coverage	Polygon Coverage
Water Removal	Water Removal
Gap	Gap
Structures U	Structures Unfiltered
Structures F	Structures Filtered
Spikes	Spikes
Striping	Striping

(When using watermarks, you don't need the Seaward Limit and Water Removal categories)



Click OK

- Go to the “Fields” tab, Select the Field Name called “ErrorType”. Then click the box next to “Domain” under the field properties and select “ErrorType”.



Click OK

- Add the shapefile to the map, right-click it and choose start editing. Click the create features icon on the editing toolbar:



Choose polygon and start creating polygons for each error that you encounter

Double-click or hit F2 to finish a polygon.

Open the attribute table and pick the error type for each polygon you create. Add a comment in the description field.

QC_LSE04_08						
	OBJECTID *	SHAPE *	ErrorType	Description	SHAPE_Length	SHAPE_Area
	22	Polygon	Water Removal	Remove more water	53.099773	112.961022
	23	Polygon	Water Remov	Remove more water	32.369403	35.473181
	24	Polygon	<Null>	Remove more water	15.656854	12
	25	Polygon	Seaward Limit	Remove more water	107.784845	190.116483
	26	Polygon	Polygon Coverage	include more data	658.407497	7483.329922
	27	Polygon	Water Removal	include more data	156.058869	1101.524335
	28	Polygon	Gap	include more data	680.07839	8470.924178
	29	Polygon	Structures	include more data	41.565389	83.042566
	30	Polygon	Spikes	include more data	143.368527	397.379087
	33	Polygon	Striping	include more data	38.720588	90.795718
	34	Polygon	Gap	include island	26.535203	41.922998
	35	Polygon	Gap	can be included in final data	156.702278	342.743793
	37	Polygon	Gap	include more data	50.225598	98.288076

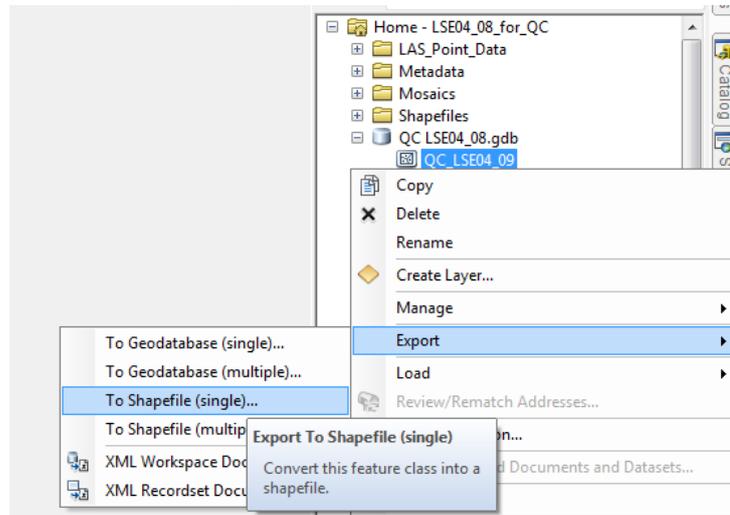
Important: on the editing toolbar, frequently click “Editor” > “Save Edits”.

At the end of the QC session, click “Editor” > “Save Edits” and then “Editor” > “Stop Editing”

9. Exporting QC shapefile from geodatabase to shapefile

Save edits and stop editing.

Right-click the QC shapefile in the geodatabase, choose “Export” and “To Shapefile (single)...”



Choose an output location (folder) and give the shapefile a name in Output Feature Class box + “.shp” as extension.

Click OK.

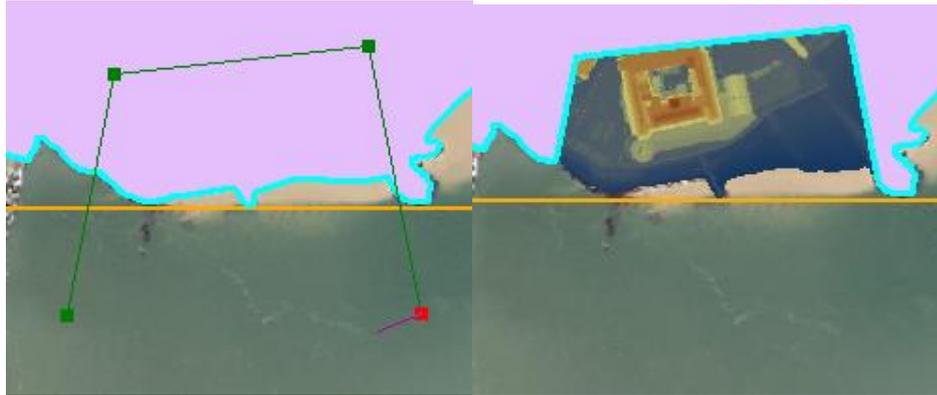
You can now zip the shapefile (made up of 7 files with the same name) and add it to an email. If you don’t zip it, some of the file extensions might be seen as a threat and will be removed by some mail servers.

10. Edit the watermark

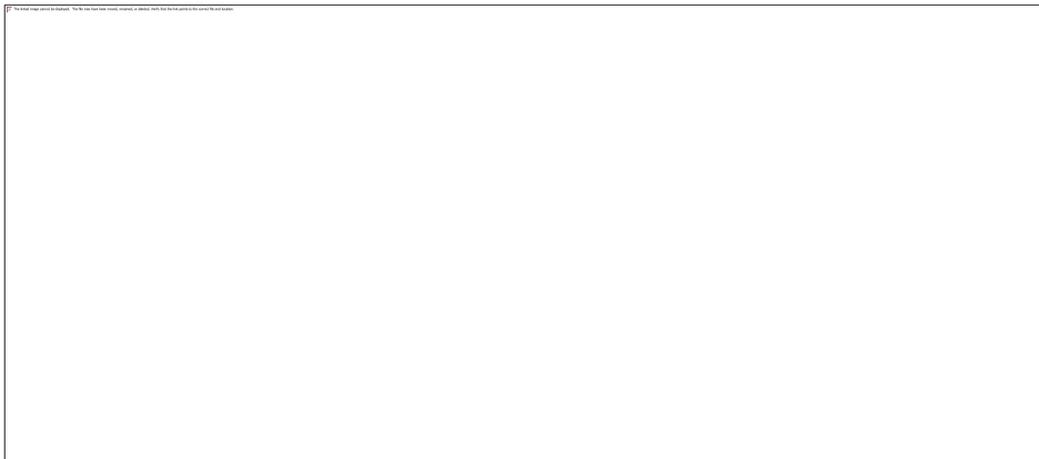
- Use the “Reshape Features” tool on the editing toolbar :
- Start and end inside the watermark to extend it:



- Start and end outside the watermark to remove parts:



- Don't forget to save edits
- Be careful when editing watermarks: it is very easy to accidentally “drag” part of the mask slightly. The contractor uses the amended watermark to create the final dataset so if it's “dragged” slightly, the polygon won't be covered properly. In the image below the black outline is the original watermark, the light purple polygon is the edited one and the pale line at the top left is the survey polygon. The edited watermark has shifted to the right, while the original watermark coincides with the survey polygon boundary on the left.

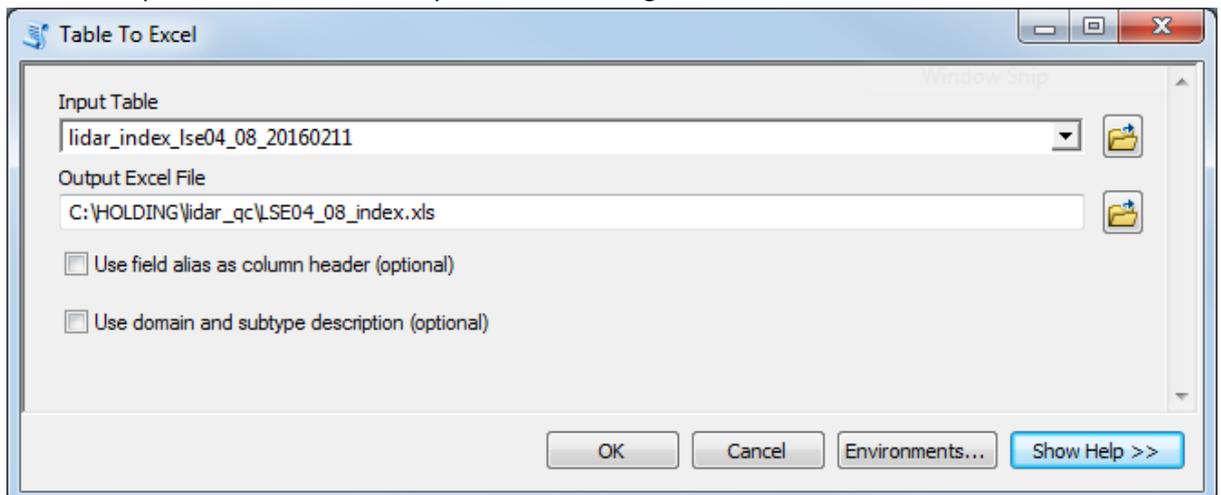


11. Cutting holes in polygons (donut holes)

- Start editing the polygon.
- Ensure point snapping is enabled. If it is not, click **Point Snapping**  on the **Snapping** toolbar. (right-click in the toolbars area and select “Snapping” to display the snapping toolbar).
- Click the **Snapping** menu on the **Snapping** toolbar and click **Snap To Sketch**.
- With edit sketch snapping, you can better construct a closed boundary defining the area you want to remove.
- Click the **Cut Polygons** tool  on the **Editor** toolbar.
- Sketch the area you want to remove. Make sure the end vertex snaps to the first one, so you end up with a closed polygon.
- Right-click anywhere on the map and click **Finish Sketch**.
- You now have two polygons. Select only the inner polygon and press the DELETE key.

12. Export index shapefile to Excel spreadsheet

- Use the “Table To Excel” tool
- Select the index shapefile as the input
- Put the output somewhere with all your QC files and give it a name



- Copy the OS_REF column to the QC spreadsheet
- You can delete the exported excel file now

13. Drawing quick contours in Arc

To draw a quick contour at a specified location, use the 3D Analyst toolbar (right-click in the toolbar area and add it, if it's not there).



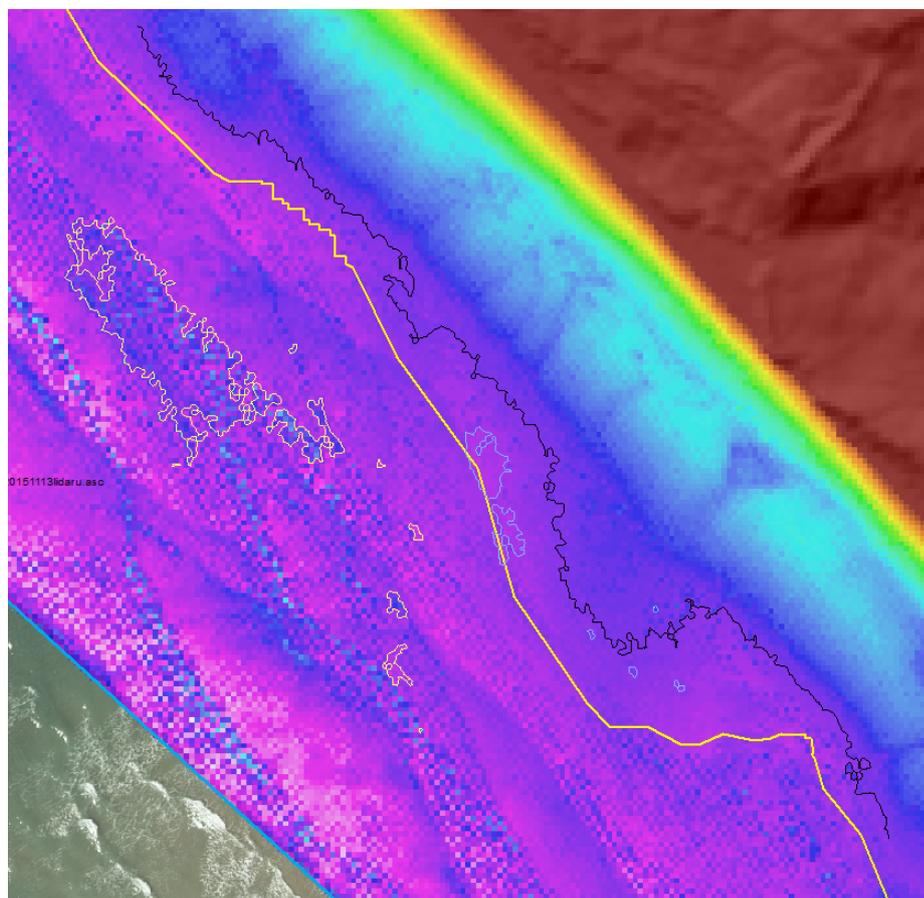
3D analyst needs to be enabled to use this toolbar. If the buttons are greyed out, Click Customize -> Extensions... -> and select 3D analyst.

In the drop-down menu choose the raster you want to draw contours on, then click the contour button to the right of the drop-down menu. If you click somewhere on the raster a contour will be drawn following the height of the pixel you clicked. This contour is not stored as a shapefile but as a “graphic” and will only go as far as the extent of the window you’re

looking at. To select the contour to change the colour or delete it, use the arrow on the **drawing** toolbar, not the arrow from the editor toolbar.



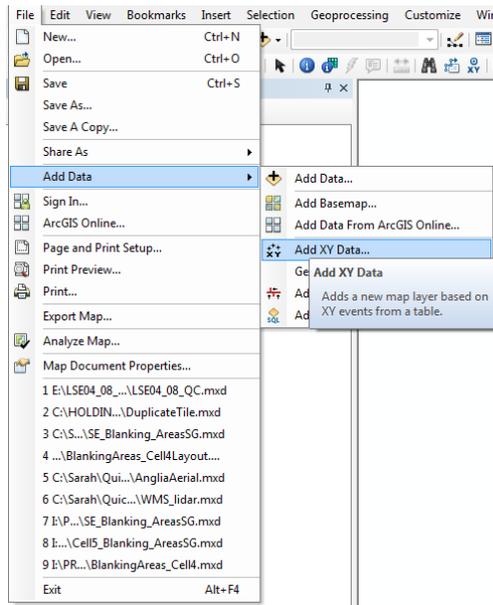
You can change the colour of the new contour by selecting the drawing arrow, right clicking the contour, then choosing properties. You can use this feature to find where the land ends and the sea begins. On land, the contours should be quite long and continuous. You might have to click around a bit to find a long contour. On the image below, the black contour is a “land” contour, the small blue contours are places where the tool couldn’t find many adjoining pixels of the same value. The light coloured contour in the sea is a typical water contour, it is an enclosed contour of a very irregular shape. Be aware that it is possible to have enclosed contours on land, if there is a mound or a dune or something similar.



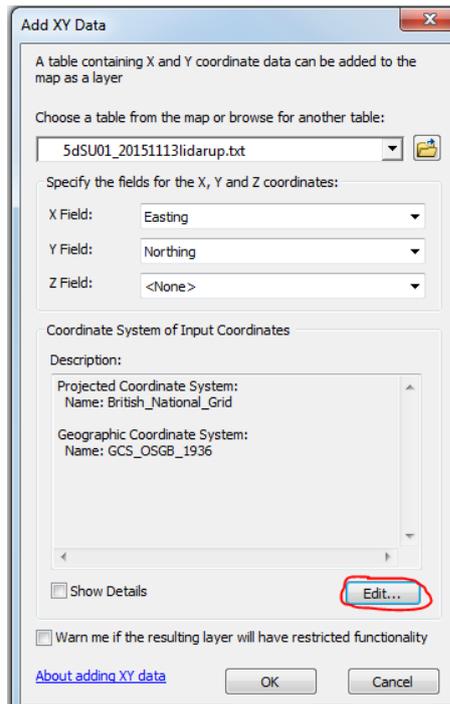
When deleting a contour, **make sure the Drawing arrow is highlighted**, if the editor arrow is highlighted and you press delete, one of the features in the shapefile you’re editing could get deleted! If this happens, you can use the “undo” button at the top left. If you hover over it and it says “Undo Delete Elements” it has deleted the contour graphics which is fine. If it says “Undo Delete Features” it has deleted something from a shapefile or feature class. You don’t want this to happen unless you want to delete a feature.

14. Add profile text files to Arc

- In ArcMap click, File > Add Data > Add XY Data



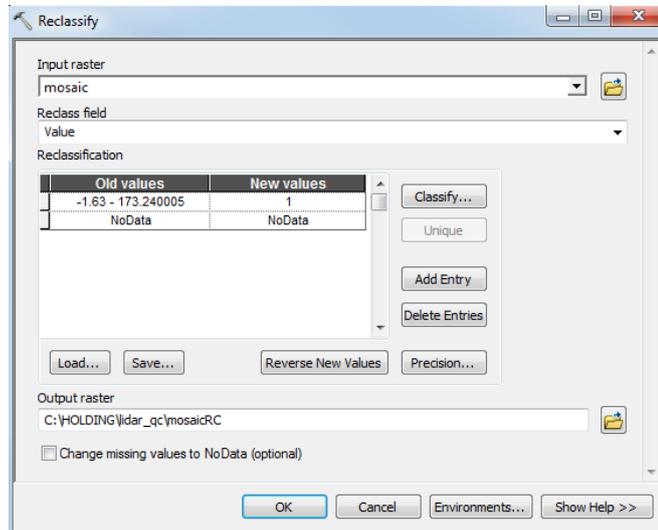
- Navigate to the text file, set the X Field to Easting and the Y field to Northing
- Don't forget to Edit the Coordinate System to British National Grid



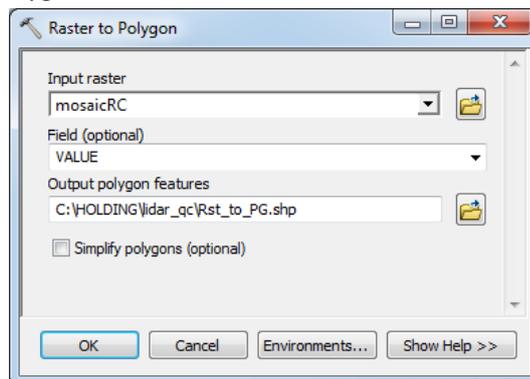
- Click OK
- In the table of contents, right-click the Events layer and then choose "Data" > "Export Data..."
- Use the layer's source coordinate system and choose an output name and location
- Label the resulting points shapefile with the profile names (Profile or Reg_ID). Use the Labels tab in the properties of the points shapefile.
- Load a shapefile with the profile lines and label them with the profile name
- Compare the start points and labels and make sure they match

15. Convert raster to extent shapefile and check which profile points fall outside the extent

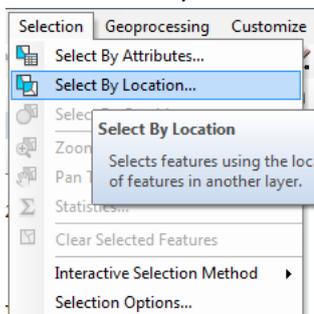
- Use the reclassify tool to create a constant raster with the exact extent of the final dataset
- Use the mosaic of the final 1k tiles as the input raster
- Click the “Classify” button and change the number of classes to 1
- Save the output raster somewhere and give it a name and Click OK



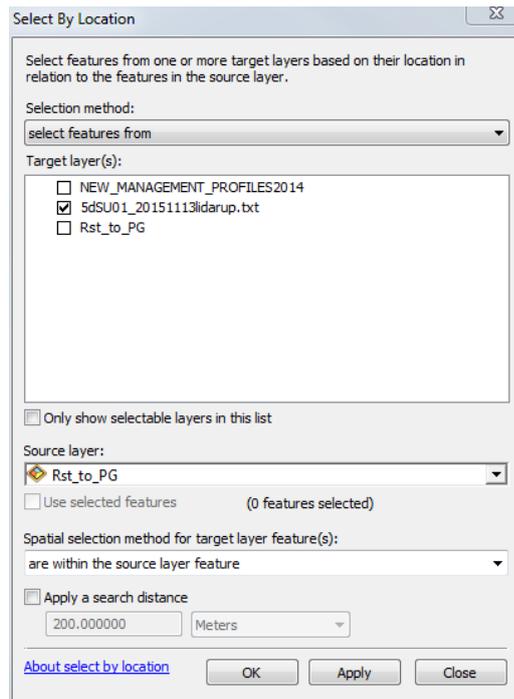
- Use the Raster to Polygon tool to convert the raster to a polygon
- Use the constant raster as the input, and choose a folder and name for the output polygon
- Uncheck the “Simplify polygons” box



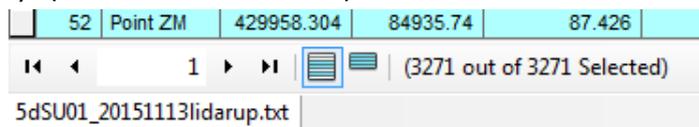
- You now have a polygon with the exact same extent as the final raster
- Go to the “Selection” menu and select “Select By Location...”



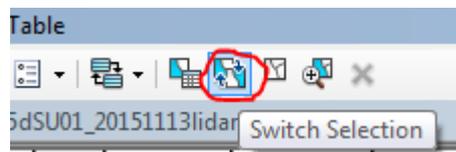
- Select features from the points shapefile you created earlier. The source layer is the polygon you just created. The selection method is “are within the source layer feature”
- Click OK



- All points should be selected
- Verify this by opening the attribute table of the points shapefile and look at the bottom of the table. It should say “(XXX out of XXX Selected)” where XXX is the same number



- If it's not the same number, use the switch selection button at the top. The selection will now be flipped



- Then use the “show selected records button at the bottom to only display the selected points in the attribute table. These are points that are over areas with noData, or where elevations over water have been included



- Take screenshots and make a note of the survey unit, profile, easting and northing and feed back to the contractor.

Appendix C – QC spreadsheet template

Lidar_QC_YYYY_YYYY.xlsx where YYYY indicate the winter flying season the surveys were carried out. This spreadsheet should contain one “Master” tab to record checks for all delivered work packages and a tab per work package (LSE01_01 for example) that lists every tile in that work package.

Work Package	<i>e.g.</i> LSE04_01
Polygon Number	<i>e.g.</i> P_7055 if subpolygons are being used
Area	<i>e.g.</i> Herne Bay to Dover
Date of completion of Survey	
Date received	
Data Quality - Unfiltered Data Checks	
Flight Lines - Optional	Check flight line position is appropriate to minimize shadowing
Point Density - Optional	Check point density is appropriate for delivered raster resolution
Not Integer	Check that data is delivered as floating point in metres, not as mm and integers.
Full Polygon Coverage	Check that the raster covers the entire polygon.
Reach Seaward Limit	<p>Check that the data reaches the specified seaward limit by using MLWS contours.</p> <p>If the data fails to reach depth check that flights have been conducted at appropriate times on appropriate tides. If flights were carried out on an appropriate tide, make a note in this column that the seaward limit wasn't reached but that the flight was carried out in an appropriate window.</p> <p>N.B: These contours are not kept after QC is complete, so delete the files when qc is complete.</p>
Water Removed	Check that all the water has been removed from the data. It is especially important to check whether rivers, lakes and lagoons have been properly removed. Areas with water that are approximately 10m or more in width should be removed.
No Gaps in Raster	Check that there are no gaps in the raster where data is missing or has been accidentally filtered out. Use the Las point cloud to check if data points are available. Make sure to only use the <u>last return</u> points. If there are no points in a gap, it shouldn't be flagged.
Data Spikes	Check for any spikes in the raster. Make sure that spikes will show up in the symbology settings you're using for the raster (if the top and bottom 5 percent values of the dataset are set to be the same colour, spikes on the lowest beaches and highest cliffs might not be visible).
Data Stripes/Pocking	Check for stripes (pocking) in the data. This should be fairly apparent, especially when looking at beach areas. These don't occur very often. They may appear in the data where there have been changes in surface elevation between flight lines within a tidal window – these are within system QC tolerances and details of data checks will be provided in the end of project report. Where these are due to calibration error beyond the system specification they should be addressed.
Structures Included	Check that fixed structures have not been removed. Floating pontoons, jetties and boats should be removed.
Date Checked	

By	Initials of who checked the section
Data Quality - Filtered Data Checks (if applicable)	
Flight Lines - Optional	Only fill out if unfiltered data is not delivered.
Point Density - Optional	Only fill out if unfiltered data is not delivered.
Full Polygon Coverage	Only fill out if unfiltered data is not delivered.
Reach Seaward Limit	Only fill out if unfiltered data is not delivered.
Water Removed	Only fill out if unfiltered data is not delivered.
No Gaps in Raster	Only fill out if unfiltered data is not delivered.
Data Spikes	Only fill out if unfiltered data is not delivered.
Data Stripes / Pocking	Only fill out if unfiltered data is not delivered.
Correct Structures Removed	Check that structures have been removed according to the brief. Beach structures such as groynes, breakwaters and harbour walls might have to be included in the filtered data.
Date Checked	
By	Initials of who checked the section
Initial QC Summary	
Corrections Required?	Yes or No
Corrections Reported (Date)	Date of sending QC shapefile to the contractor
Corrections received (Date)	Date of receiving corrections from the contractor.
Comments	Any comments on the received corrections.
Overlapping Polygon Data Checks	
Duplicated Filenames with Adjacent Polygons	Check using the index shapefile that tiles don't overlap with other polygons. Label the index tiles with their file names. Tiles will be labelled twice if there is overlap. If there is an overlap, check that the tiles have different dates. Filenames should not be duplicated!
Date Checked	
By	Initials of who checked the section
Profile Data Checks (if applicable)	
Lie on correct profile lines	Add the text file to ArcMap using the add xyz data tool. Bring in a shapefile of the profile lines and check that the points from the text file are positioned on the profile lines.
Attributes	Check that profiles have 7 columns of data and 1 header row.
Reach Seaward Limit	Check that the profiles reach the required depth by using the 'Select by Attributes' tool in ArcMap or by colouring the points by elevation.

Extend Seaward to Full Extent of Data	Check that the profiles extend to cover the raster data to its seaward extent.
Start in correct position	Check that the profiles start at the required starting point (same as profiles shapefile or according to other requirements)
No Data	Check that there are no points included where there is no lidar data available.
Date Checked	
By	
General Checks	
Data Labelling – if applicable	Check that the medium on which the data is delivered is labelled correctly (only for CDs/DVDs)
Data Filename	Make sure the data filenames are be in the correct format and case so that it can be loaded to the website:
Metadata	Check that the metadata form is present and is named in the correct format and case and dated correctly.
Survey Report	Check the survey report is present and is named in the correct format and case and dated correctly.
Lidar Index	Check the index is present and is named in the correct format and case and dated correctly. Check that it covers the correct area and that the dates in the attribute table match the dates in the report, metadata and file names.
Survey Polygon	Check that the correct survey polygon has been delivered. Open the polygon in ArcMap and check that it covers the correct area.
Date Checked	
By	Initials of who checked the section
Unfiltered XYZ Data Checks	
Matching Number of Tiles with Unfiltered asc Tiles	Check that the same number of asc and txt files is delivered. This check can only be done after the final data has been delivered.
Check File Extensions = .txt	Check that the file extension is txt. This check can only be done after the final data has been delivered.
Date Checked	
By	Initials of who checked the section
Filtered XYZ Data Checks (if applicable)	
Matching Number of Tiles with Filtered asc Tiles	Check that the same number of asc and txt files is delivered. This check can only be done after the final data has been delivered.
Check File Extension = .txt	Check that the file extension is txt. This check can only be done after the final data has been delivered.

Date Checked	
By	Initials of who checked the section
QC summary – Final Deliverables	
Corrections Required?	Any corrections required on final deliverables? Yes or No
Corrections Reported (Date)	Date of reporting issues with final deliverables to the contractor.
Corrections received (Date)	Date of receiving corrections made by contractor.
Comments	Any comments on the received corrections.
Survey Accepted	
Date	
Name	Initials of who checked the section
Raster Created	Create a water-free mosaic raster from the 1k DSM and/or DTM tiles and a hillshade raster for each mosaic.
Name	Initials of who created the raster
Date	
Loaded to FTP for Website	
Date	
Name	
Comments	General comments on encountered issues and relevant feedback from contractor

Table 1: Master QC worksheet – detailed explanation per column

Tile	Corr_Req?	Gaps	Water Removal	striping/ pocking	structures (unfiltered)	structures (filtered)	MLWS reached	polygon covered	seaward limit	spikes	Fixed
SZ2884			x				no				ok
SZ2984			x				no		x		ok
SZ2985	no						no				ok
SZ3084		x	x				no				ok
SZ3085			x				no		x		ok
SZ3086	no						no				ok
SZ3184	no						no				ok
SZ3185	no										ok
SZ3186	no						no				ok
SZ3284	no						no				ok
SZ3285					harbour wall not included	some buildings not removed	no		x		ok

Table 2: Worksheet to check individual tiles per work package. X's or comments indicates issue with tile.