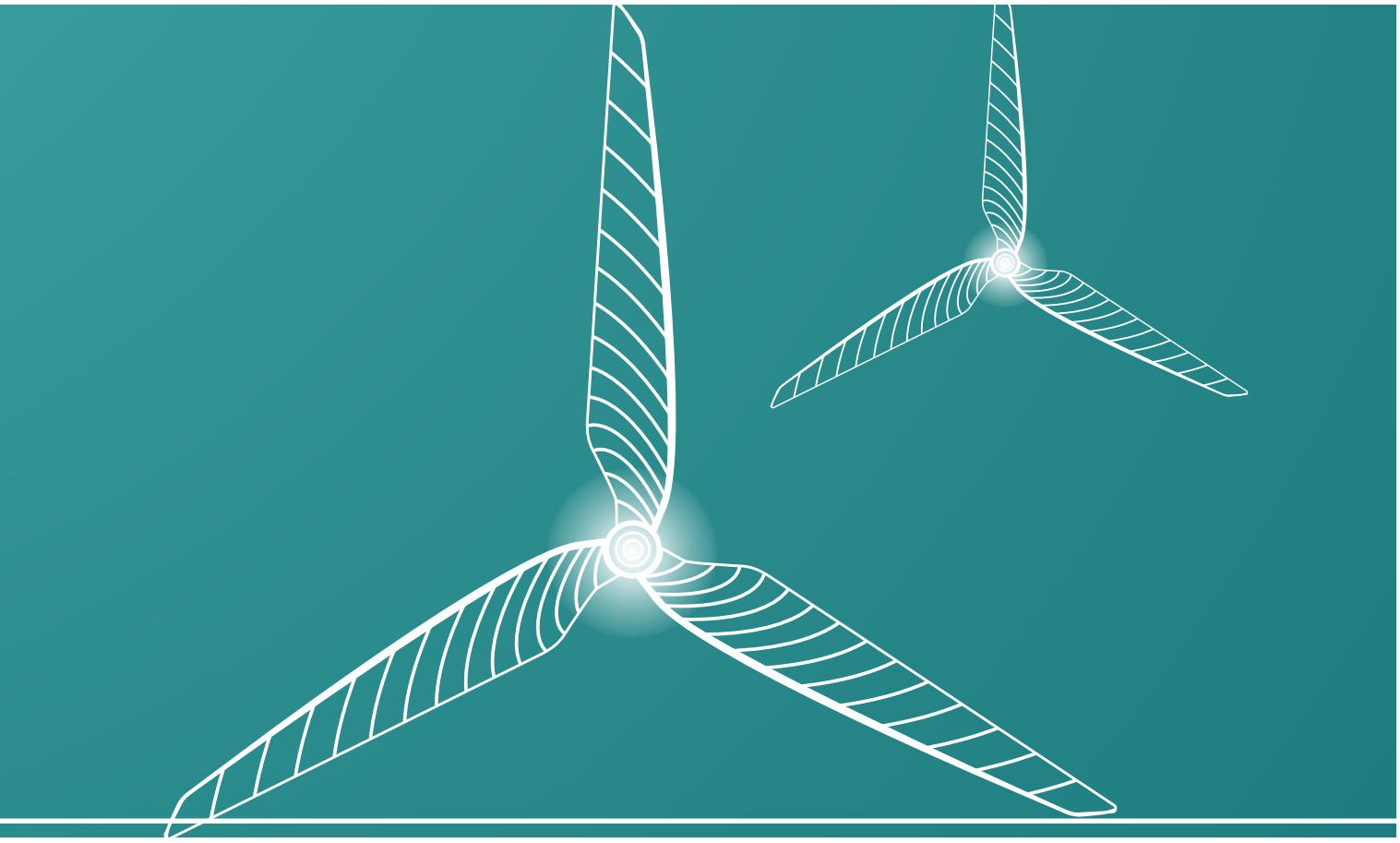
DNV·GL

TUTORIAL

WINDFARMER

WAsP

Version: 5.3
Date: April 2014
DNV GL - Energy



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None of the data contained in this tutorial have references to existing or planned wind farms

1. INTRODUCTION

The aim of this tutorial is to gain familiarity with the use of the WAsP wind flow software package which can be used to provide WindFarmer with wind climate input data.

WAsP can be controlled directly from within WindFarmer, but some users may still prefer to use it independently. In this case, WAsP is used to produce wind maps in the form of WRG (Wind Resource Grid) files or wind resources at discrete turbine locations in the form of RSF (Resource Data File).

The WAsP Map Editor tool is very useful for preparing maps of terrain and surface roughness data. It is recommended that WindFarmer users use this tool to before loading the data into WindFarmer. The process is described in chapter 2.

The main input files required for WAsP are

- a frequency table of wind speed and direction probabilities in TAB format, and
- a terrain file containing contours of height (orography) and roughness variations, in MAP format.

This tutorial comprises a series of exercises covering the preparation of files for input to WAsP and the basic processes for running WAsP. For more detailed adjustment of settings in WAsP, users should refer to the WAsP Help files, for example for handling obstacles.

WindFarmer includes a wide-ranging set of tools for the reading, cropping, converting and exporting of digital height files that can be used in conjunction with WAsP. The MCP+ Module of WindFarmer enables raw data from meteorological masts to be inspected, recalibrated and unwanted data excluded and then exported for the wind data to be analysed. The output options include TAB files from time series or through the processes of MCP correlation. These functions are described fully in the MCP+ Module Chapters of the WindFarmer User and Theory Manuals.

This tutorial is written for version 11.0 of WAsP. However, the steps are very similar with previous versions. In addition the exercises assume that the WAsP version is running in licensed mode. With an unlicensed version, you can perform most of the exercises except running calculations and saving data files.

The WAsP website www.wasp.dk provides the latest information, literature and downloads. We recommend that users regularly check the WAsP website.

2. ADDING ROUGHNESS CONTOURS WITH WASP MAP EDITOR

In this exercise you will learn how to add roughness contours by digitising in WAsP Map Editor. WAsP Map Editor is an accessory program provided with WAsP.

To work with Map Editor, WAsP must be licensed. If you are using an unlicensed version, Map Editor will run in Demo mode. You can try out the options but not save your work.

To start, you need a digital file containing height data in a contour format and a background image file indicating the types of land use. Example files are provided in a folder called 'Demodata', which can be found in Libraries\Documents\WindFarmer. Users of Windows XP can find this folder inside the WindFarmer installation directory, which is usually C:\Program Files\WindFarmer.

2.1 Loading the height contours file and background map

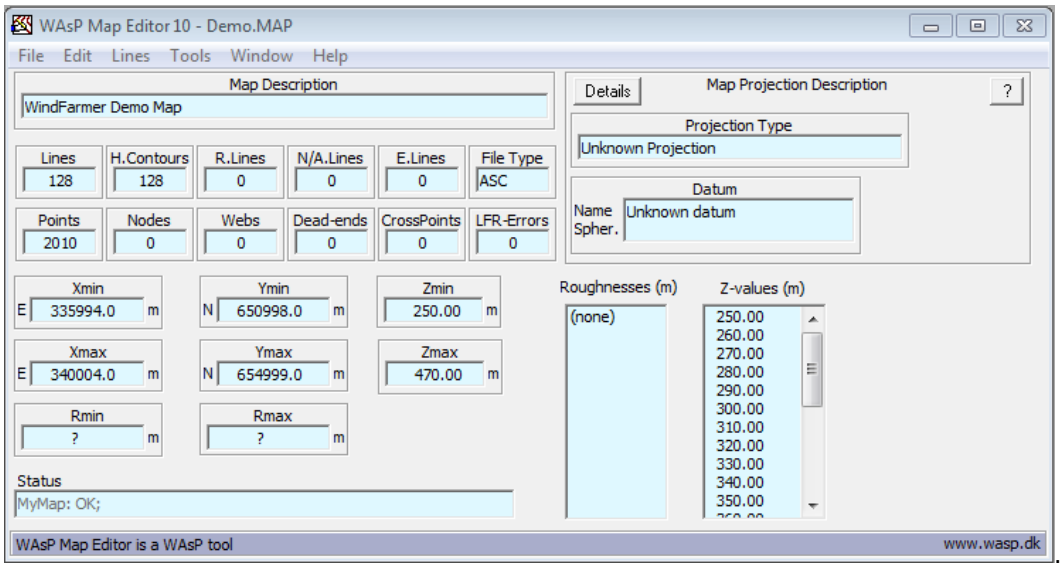
Step 1. Open WAsP Map Editor from your desktop, or from the Start > Programs menu, or from the Tools menu inside WAsP. The WAsP Map Editor window will appear.

Step 2. Click File menu > Open from the taskbar.

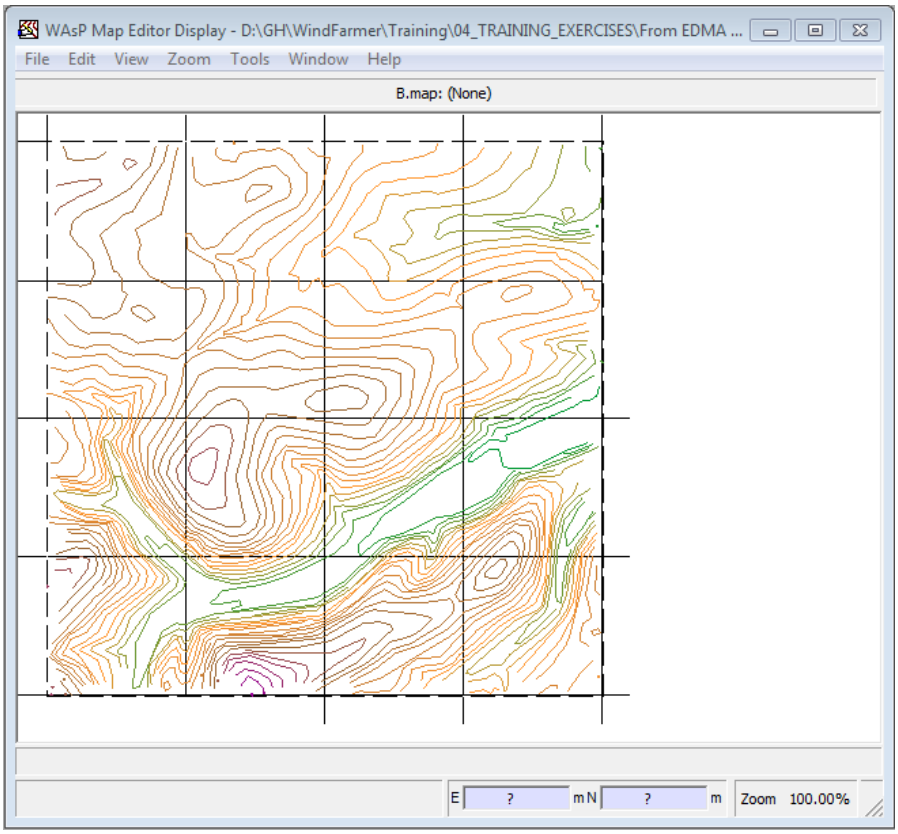
Step 3. Load the file Demo.MAP from the Demodata section of the WindFarmer installation directory. This is a 3D vector map file with the height (orography) data described as strings of X, Y coordinates with each string of points having a height attribute.

WAsP Map Editor can load a number of different international map formats. Many digital height formats that are not accepted by Map Editor can be imported into the Base Module of WindFarmer and then exported as the required MAP format. See the User Manual and Help files for more information on the map handling tools in WindFarmer.

Step 4. The Map Editor window shows the extents of the map (Xmin, Xmax etc), the height range (Zmin, Zmax), the height attributes of the contours (Z-values column) and other information. The Demo.map file contains contours at 10 metre spacing from 250m to 470m altitude.



Step 5. Select Window menu > Map Image. A WAsP Map Editor Display window opens, displaying the map contours.

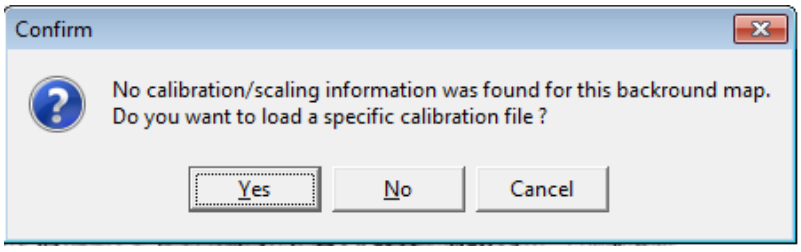


Digitisation of the roughness contours is most easily done using a background raster map or an aerial photograph where the roughness elements are identifiable.

Step 6. In the WAsP Map Editor Display box, select “File menu > Load background map”.

Step 7. Select the image file “DemoColourRefmap.BMP” from the Demodata > Refmap subfolder.

Step 8. Click OPEN to load the file. A message warns that no scaling information has been found.



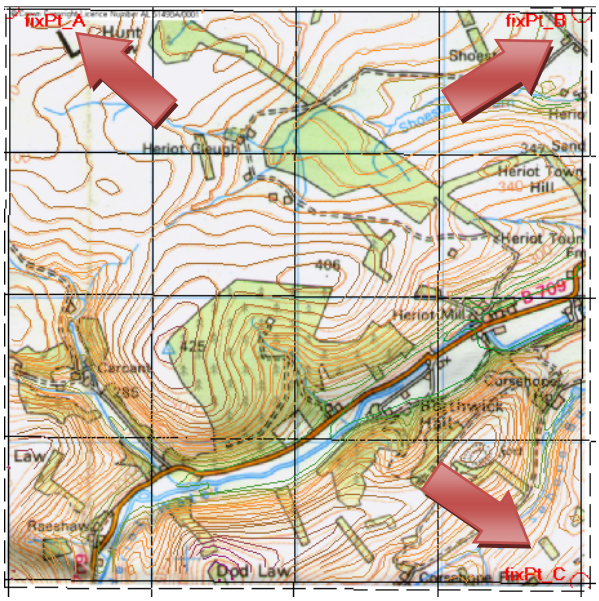
In this case press NO since no referencing file (SCL file) between the raster background map and contour map has been created.

Step 9. A warning is given before assigning the referencing between background map and MAP file. Click OK to continue. The background map with a target cursor will appear.

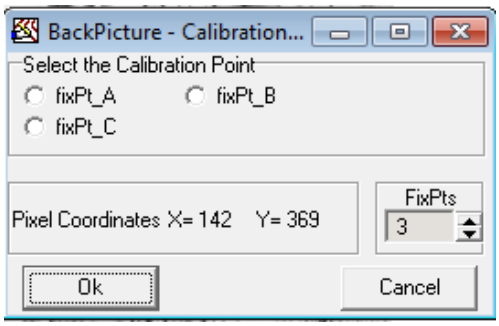
Step 10. Using left mouse click, insert 3 Fix Points on the map. In this case, choose the corners:

- FixPt A Top left corner
- FixPt B Top right corner
- FixPt C Bottom right corner

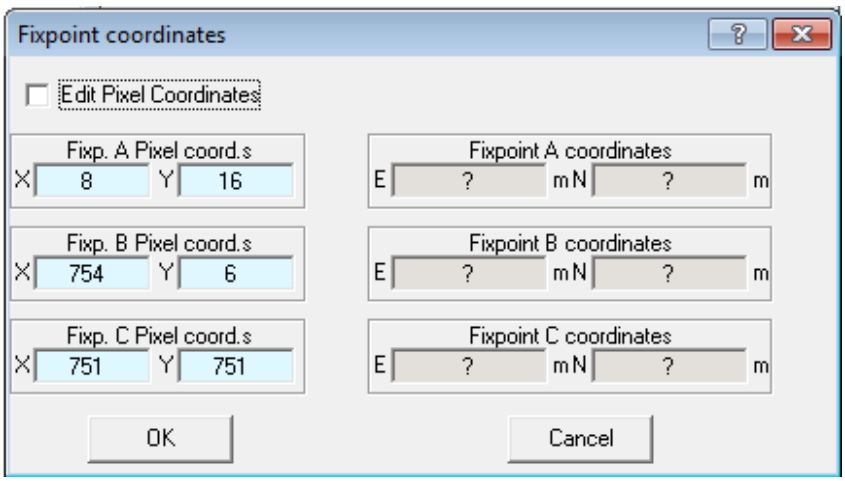
In general, Fix Points should be in a large triangle at locations with well-defined coordinates.



Step 11. As each fixpoint is inserted, the dialog box below appears. Click OK to confirm the point and insert the next.



Step 12. To reference each of these red Fix Points to specific coordinates in the map, select Tools menu > Fixpoints > Set fixpoint coordinates. The box below appears:



Step 13. Type in the coordinates for the 3 points in the cells on the right. In (Easting, Northing) these are:

- Fixpoint A (336000, 655000),
- Fixpoint B (340000, 655000) and
- Fixpoint C (340000, 651000).

Click OK to confirm the entries and close the dialog box

Step 14. Press YES to confirm the acceptance of the calibration entries. Click YES in the Confirm box that appears.

Step 15. You are prompted to save the scaling file SCL where these associations of Fix Points and their coordinates are stored. Press SAVE to store it in a directory.

If the same background image is used again in Map Editor, this SCL file can then be reloaded.

Step 16. After saving the SCL file the Display window will update as shown below.

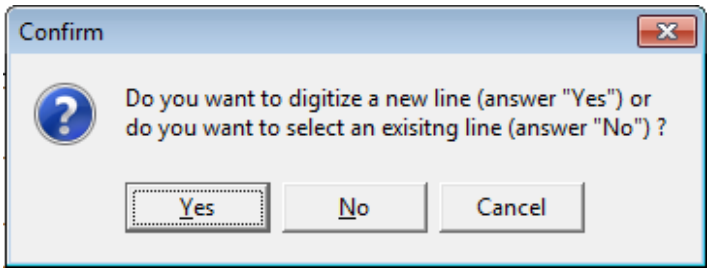
2.2 Digitising the roughness contours

For use in WAsP, areas of each roughness length must be defined by roughness contours in the same MAP file. In this exercise, you will add a roughness contour around the area of forest in the centre of the map.

Step 17. Select Zoom menu > x2 and click near the centre of the map. You can now see the map elements more easily.

Step 18. Select Tools menu > Digitise > Enable digitising. It now says “Digitise” at the foot of the Display window.

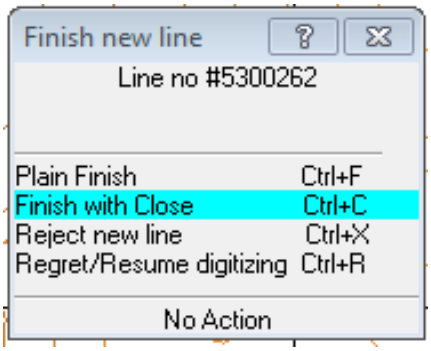
Step 19. Left mouse click at any point of the forest boundary. The dialog box below appears



Step 20. Click YES to begin digitising the forest edge using the pointer cursor.

Step 21. Left click with the mouse at each point along the forest edge. High accuracy is not generally needed.

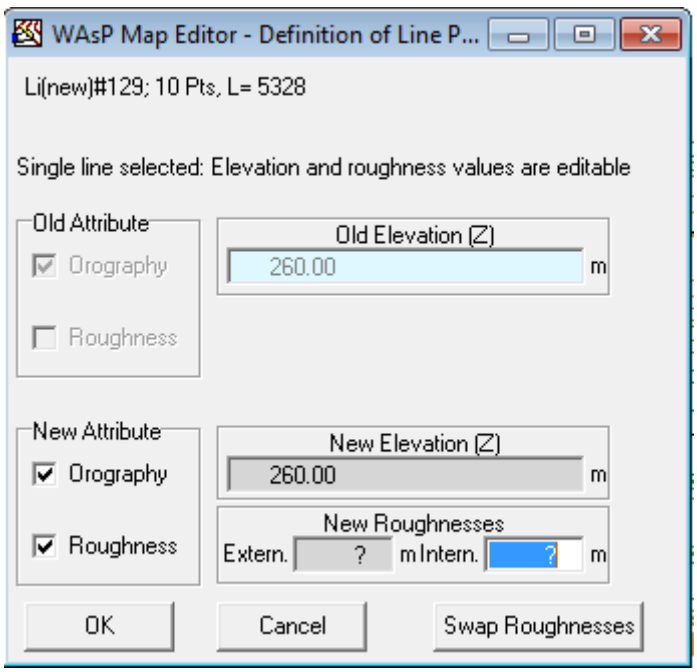
Step 22. To close the roughness contour, hit ESC on the keyboard to access the Finish new line dialog box and select “Finish with Close” .



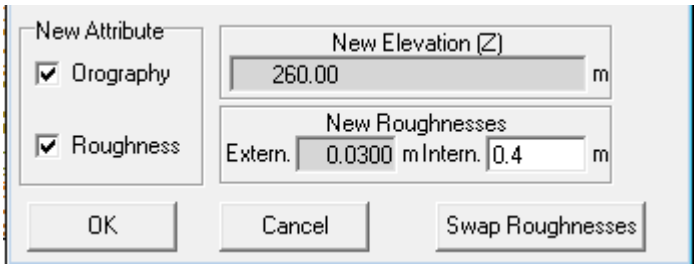
The Line Properties dialog appears. Alternatively click Ctrl+C to skip straight to Line Properties.

Map Editor can also be used to edit Orography (height) contour lines. However in this example the target is digitising roughness.

Step 23. At the bottom of the dialog box untick Orography and tick the Roughness box to allow input of new roughnesses.

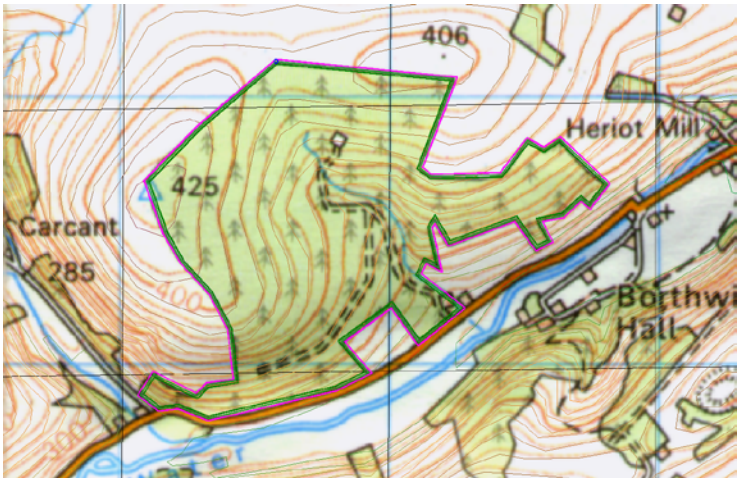


Step 24. As example, edit with 0.03 (farmland) in External and 0.4 (forestry) in Internal. Refer to theory manuals to define appropriate Zo roughness lengths for a site.

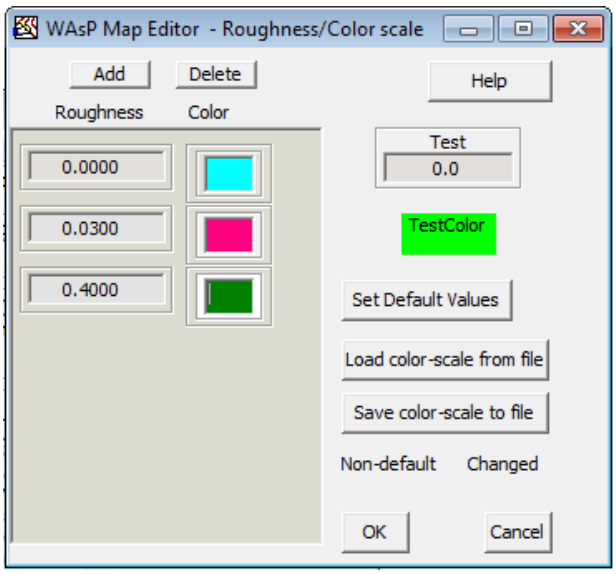


Step 25. Click OK to store these changes.

The roughness line appears as shown in the following figure. In detail, the roughness contour is the combination of three lines. The line in the middle (light green line) is what has been inserted with the pointer cursor. The internal (dark green) and external (pink) lines indicate by their colour the two roughness values that have been associated to the forestry and the surrounding farmland respectively.



Step 26. To check or change the colour associations, select Edit menu > Colour scales > Roughness. The dialog box below is displayed.



Step 27. To edit Roughness values or Colours, left click in the cells. However, in this specific example no action is required. Click OK to close this dialog box.

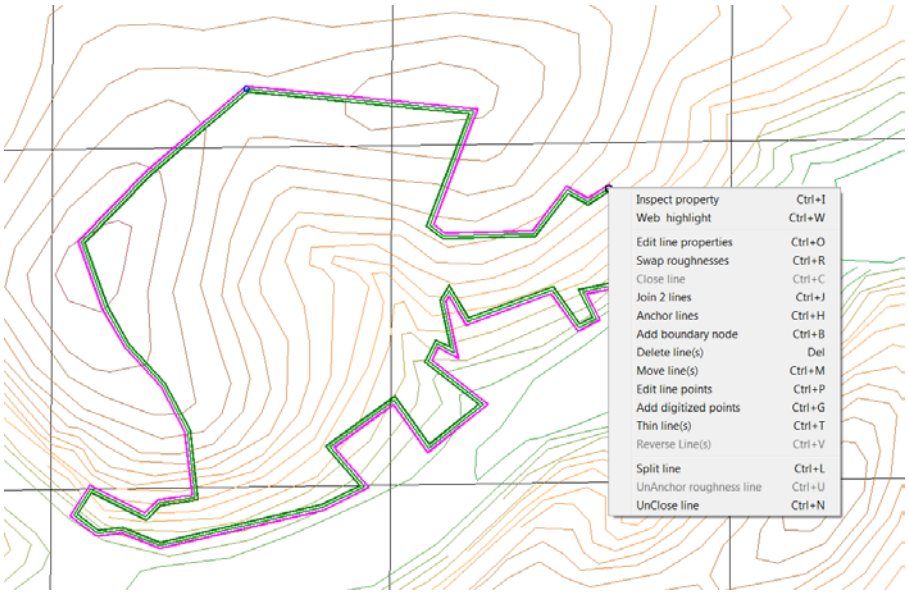
In general, follow this procedure to insert roughness lines for all the map area. Elevation lines can also be added or edited. Higher accuracy is needed for the areas close to the wind farm site. Note that roughness modelling does not replace the obstacle modelling of WAsP. WAsP Help files give details on the use of roughness and obstacles in wind flow modelling.

Step 28. Repeat to add further roughness contours as required.

Step 29. To stop digitising, select Tools menu > Digitise and untick the Enable option.

Step 30. To see the contours better in the Display window, hide the background image at View menu

Step 31. Left click on an individual contour to highlight it and show its properties at the foot of the Display window. Right click on a contour for options to edit it.



Step 32. Return to the main Map Editor window where the new list of roughness contours will be listed.

Step 33. Save the edited map file using File menu > Save As. in the taskbar of the WAsP Map Editor window or alternatively by clicking Ctrl+S on the keyboard. Give the file the name "DemoR.MAP" to indicate it includes roughness information. Save the MAP as the default format, a WAsP ASCII map file.

Note in the case of Demo.map the file is ReadOnly, therefore the file can only be saved with a different name.

Now that the MAP file contains both height and roughness information, it can be used in the main WAsP wind flow program or WindFarmer.

End of the exercise.

3. CREATION OF WRG FILES

In this exercise you will learn how to build a workbook in the main WAsP program, customise the file labelling in the workspace structure and use WAsP to create WRG wind resource grid files suitable for use in WindFarmer. It includes the creation of the single point WRG files that are needed in the optional Association method in WindFarmer.

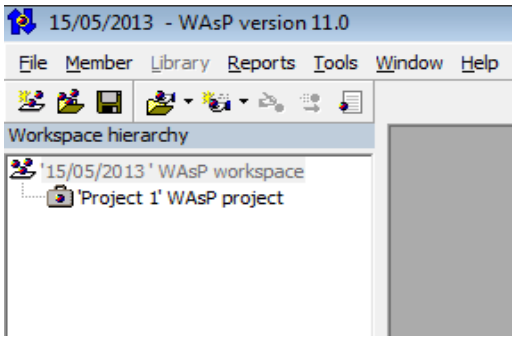
In WAsP, an empty hierarchy of related files is created, comprising either existing input data files or empty new files which will be populated in the calculation phase of WAsP. WAsP workbooks can be saved after construction and opened later to run the calculations.

If you are using an unlicensed version of WAsP, you will be able to carry out most of the exercise but not perform any calculations.

3.1 Loading the map and mast data

Step 1. Open WAsP from your desktop or from the Start > Programs menu.

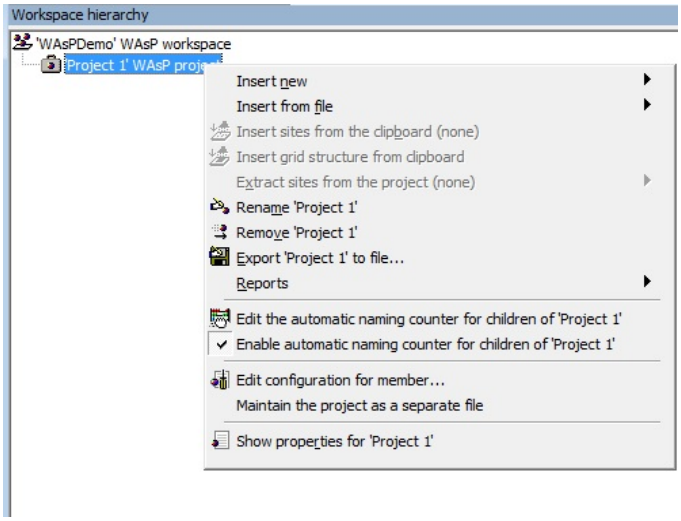
Step 2. To open a new workspace, click Select New Workspace icon  or select File menu > New Workspace. The structure shown below will appear in the top left corner of the window. If necessary, drag the grey bar down to reveal the Workspace Hierarchy.



The elements in the hierarchy will now be customised and new elements added as needed.

Step 3. Save the initial WAsP workspace, by selecting File menu > Save workspace. Save the file as WAsPDemo.wwh. The workspace name in the hierarchy automatically updates.

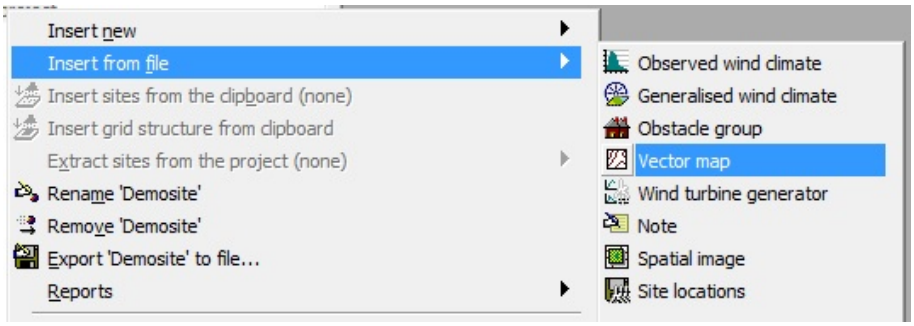
Step 4. Right click on “WAsP project 1” to show the dropdown menu.



Step 5. Left click on “Rename Project” and, in this case, type “Demosite” to rename the project in the hierarchy.

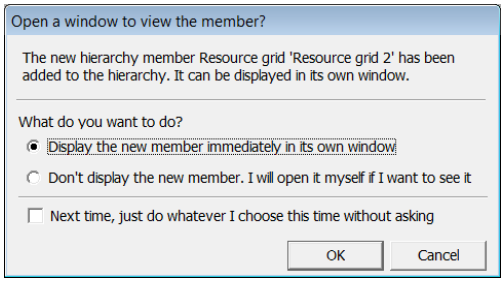
In the dropdown menu, “Insert from file” is used to load existing input data files that are needed for the calculation. The “Insert new” command is used to create empty files in the hierarchy, ready for population when the calculations are run.

Step 6. First insert the MAP file. To do this, right click on the Project, now called “Demosite”, select “Insert from file”



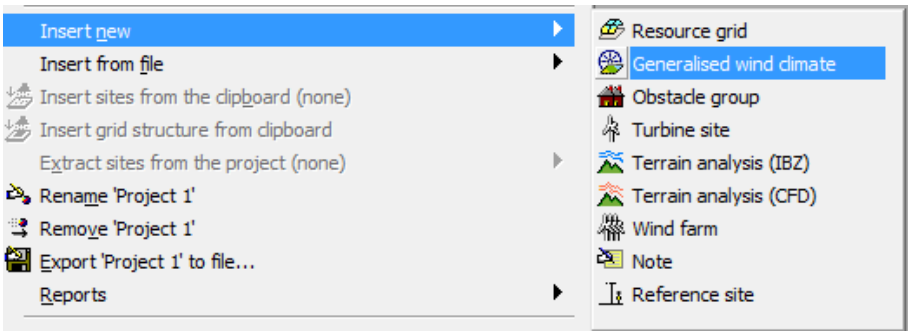
Step 7. Select “Vector map” and load the file “DemoR.map” from the previous exercise.

This MAP file should contain height and roughness contours. Alternatively, for this exercise, load the Demo.MAP from the demo data directory of WindFarmer. Click OK in the dialogue box that appears (This box will appear every time you attempt to import some data into WAsP. You can disable it by ticking the check box entitled ‘Next time, just do whatever I choose this time without asking’):



A Spatial view window appears in WAsP, displaying the map and contours.

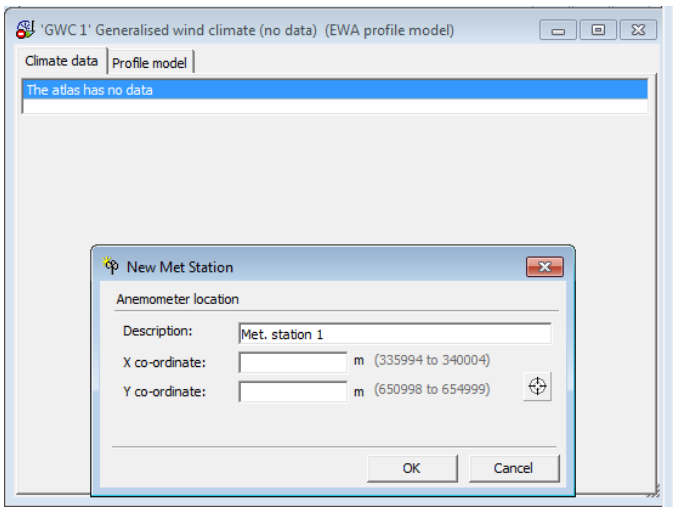
Step 8. Now set up the files for wind resource information and calculation. Right click on "Demosite" project and select "Insert new"



Select "Generalised wind climate". Two windows will open on your screen, and you will be asked to inform the mast 'Description' and position. It is essential that the location and height of the met station are entered correctly. In this example the mast height was 27m and the location was:

Easting = X co-ordinate = 337145,

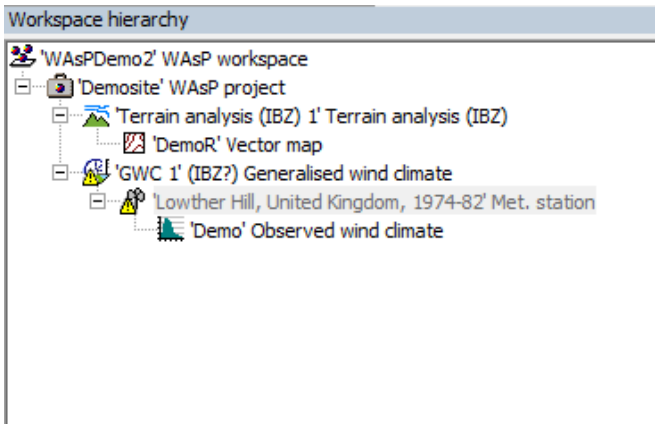
Northing = Y co-ordinate = 652387



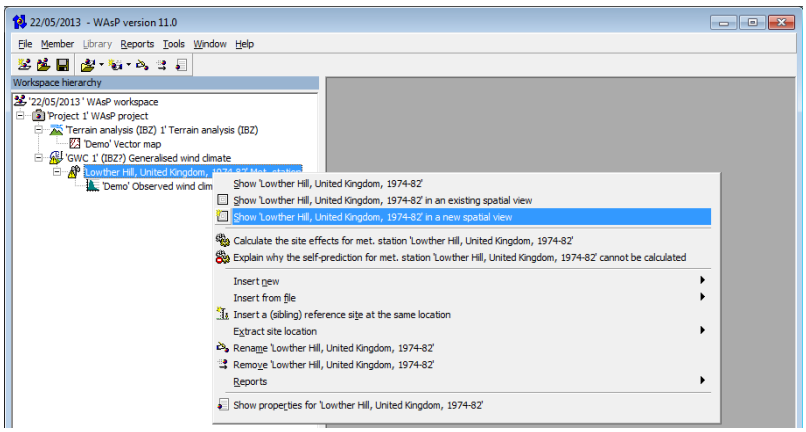
Step 9. Enter the X co-ordinate and Y co-ordinate in the empty cells. Then press OK.

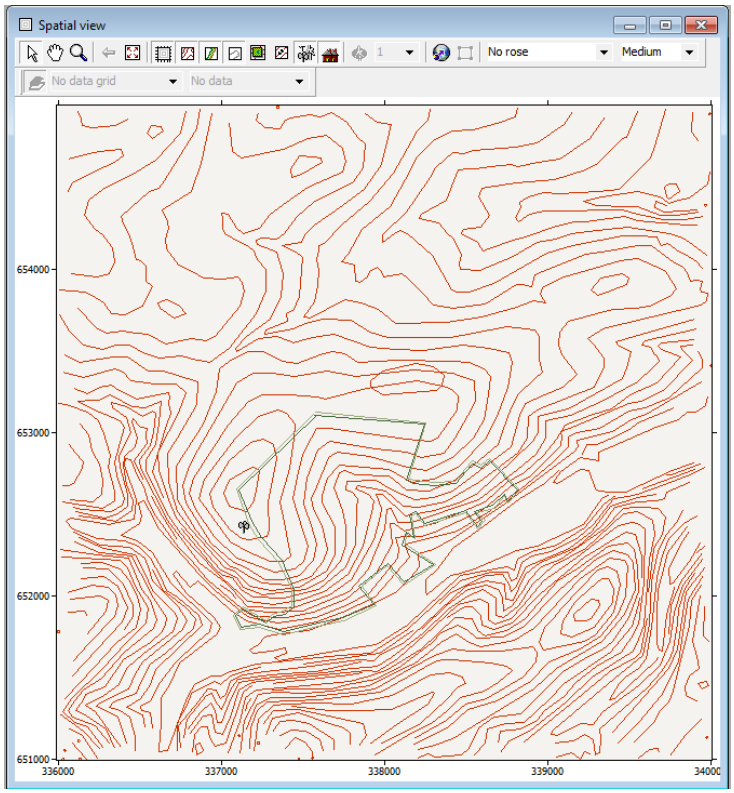
Step 10. A new window opens, 'Please select a Observed wind climate file'. Load the file "Demo.tab" from the demodata library of WindFarmer. This is the frequency table of wind data measured at the met station, then press Open.

Step 11. A Generalised wind climate, a met station and an observed wind climate appear in the hierarchy. Note that the generic met station label changes to "Lowther Hill" which is read from the top line of the TAB file.



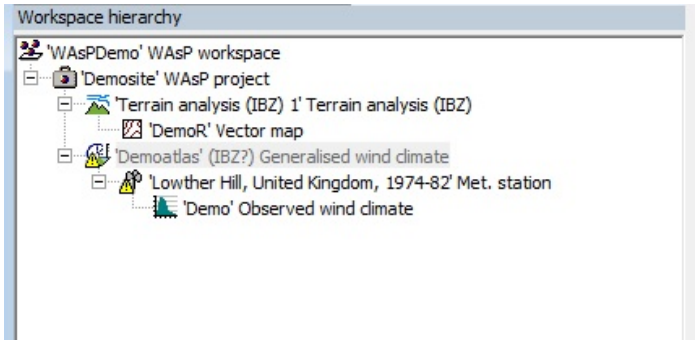
To see the met mast on the map, right click on anemometer icon in the hierarchy and select 'Show 'Lowther Hill, United Kingdom, 1974-82 in a new spatial view'. The met mast location is then displayed in the Spatial View.





Step 12. Right click on “GWC 1” in the hierarchy and rename it “Demoatlas”

The hierarchy tree now contains the MAP and TAB data inputs. The empty Wind Atlas file has a yellow marker, indicating that it does not yet contain data.



Next, empty files are needed to contain the required output wind resource calculations.

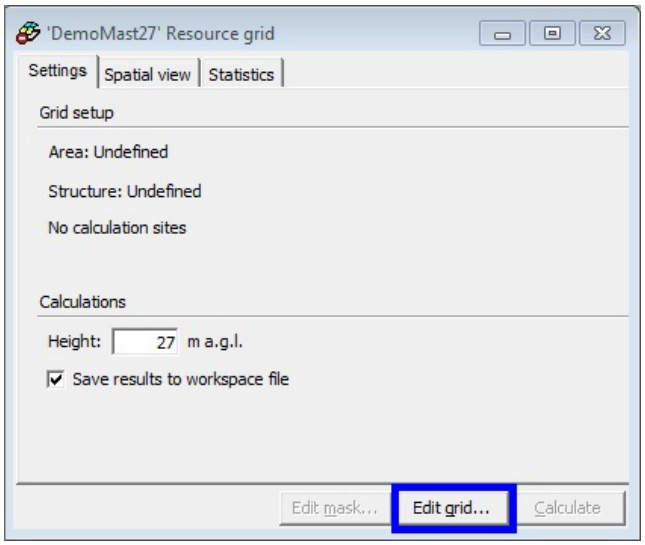
3.2 Defining the Wind Resource Grids (WRG)

First you will create an empty file for the single point WRG at the same location and height as the mast TAB data. This is required for the optional “Association” method in WindFarmer.

Step 13. Right click on “Demosite” project in the hierarchy and select “Insert new > Resource grid”

Step 14. Enter the mast height when the “hub height” is requested. Here, the mast WRG height = 27m

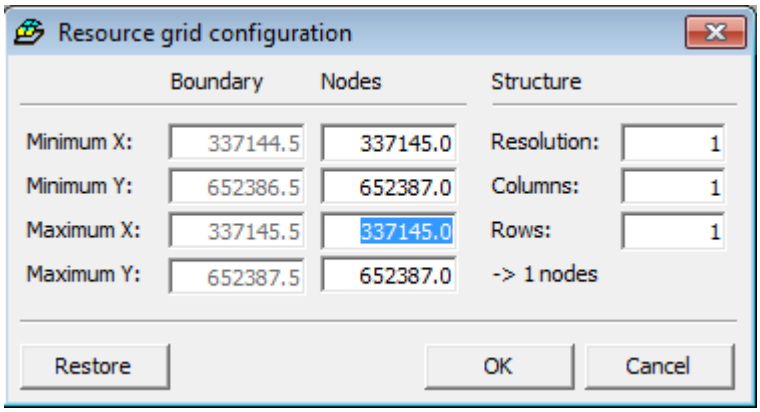
Step 15. Right click on the Resource Grid in the hierarchy and rename “Resource grid 1” as “DemoMast27m”



Step 16. In the Resource Grid dialog box, press “Edit Grid” to open the Resource Grid Configuration box.

Step 17. In the Resource Grid Configuration dialog, change the resolution to 1 as this will be a single point wind resource calculation.

Step 18. In the Nodes column, enter Xmin = Xmax = Easting of the mast. Enter Ymin = Ymax = Northing of the mast. In this case X = 337145; Y = 652387 as shown below:



Step 19. Press OK to accept and return to the main Resource Grid dialog.

The Resource Grid pages show information on the location, resolution, height and extents of the grid to be calculated, and allows them to be edited and displayed. If this dialog box has not automatically appeared, double click on the resource grid in the hierarchy.

Now set up a separate empty wind resource grid for the area of the wind farm at the hub height of the proposed turbines.

Step 20. Right click on “Demosite” project and select “Insert new > Resource grid”

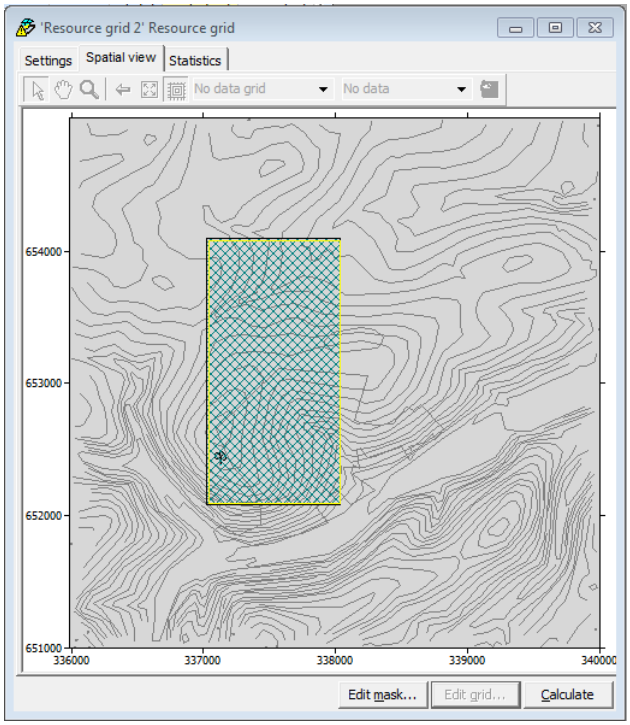
Step 21. When height above ground is requested, enter the turbine hub height. In this exercise, enter 50 m.

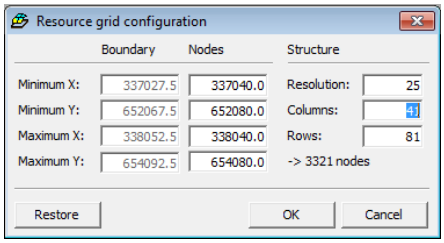
Step 22. In the hierarchy, rename “Resource grid 2” as “DemoHub50mGrid”. This WRG will be the wind map which extension will depend on the size of the wind farm.

Step 23. Open Edit Grid configuration. If necessary, double click the Resource Grid in the hierarchy to bring up the grid.

Step 24. In this case set “Resolution” to 25m, a typical value.

Step 25. In the “Nodes” column, enter the X and Y ranges for the grid area required. For this example, fill in with the coordinates in the image below, in the configuration as shown, to give a grid covering 1 km by 2 km:

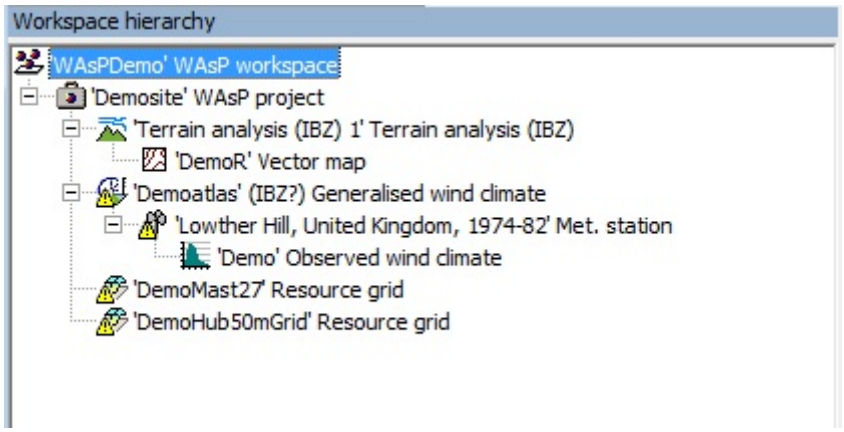




The number of nodes to be calculated appears automatically in the configuration dialog and the grid extents are displayed in the spatial view.

Step 26. Press OK to store the changes

Now all the inputs are set for a simple site with one mast 27 m high and for considering a layout of turbines with 50 m hub height within the rectangular WRG area shown in the Spatial view.



Notice that

- A yellow warning symbol appears if there is enough information but the calculation has not yet been performed
- A red no-go symbol appears in the hierarchy and in dialog boxes if more information is still required.

WAsP has not performed any calculations at this point. If edits are still needed, click the Edit Grid button in the Resource Grid dialog. To remove elements from the hierarchy, right click on the element and select “Remove name”

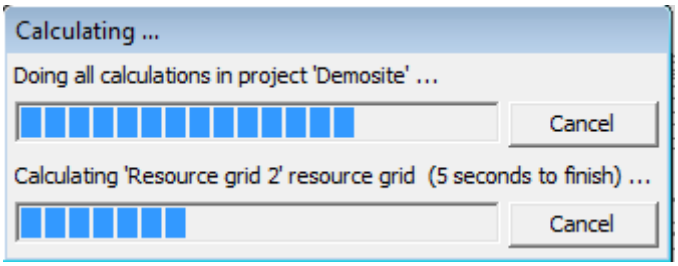
Step 27. To save the WAsP workspace, select File menu > Save Workspace as.

3.3 Running calculations of Wind Atlas and WRG

Calculations in WAsP can be run either singly or as a batch. Here you will calculate all feasible calculations in the Demosite WAsP project at the same time.

Step 28. Using the workspace just constructed, right click on "Demosite" project in the hierarchy and select "Do all feasible calculations for all project members"

A progress box indicates the approximate running time of the displayed calculation. The calculation can be interrupted at any time.



Step 29. After completion, export the WRGs produced: In the hierarchy, right click on the WRG "Demomast27m" resource grid", and select "Export Demomast27m to file…"

Step 30. Save the file with WRG extension for later use in WindFarmer.

Step 31. Repeat the operation of exporting with the "DemoHub50mGrid.WRG"

Step 32. Save the WAsP workspace by File menu > Save Workspace.

The wind resource files Demomast.WRG and DemoHub50mGrid.WRG are now ready for use in WindFarmer, together with the Demo.TAB file.

End of the exercise.

Further notes:

- If the Association method is not going to be used in WindFarmer, the single point WRG at the mast is not needed. Only the Grid.WRG file covering the wind farm at hub height needs to be calculated in WAsP.
- Several WRGs of different heights or covering different areas can be set up and calculated in the same project in WAsP.
- Several projects can be handled within the same WAsP workspace (WWH file). However, there must be no more than one wind atlas in each project. Otherwise the WRG does not recognise which Wind Atlas should be used as initiation.
- If you have a project with multiple masts, create one project for each mast. Then within each project, calculate the WRGs initiated from that mast.
- To remove or replace any file a WAsP workbook, right click on the file in the hierarchy and select "Remove". Then select "Insert New" to replace the file.
- Details of constituent files can be checked by right click on the hierarchy element and selecting "Show Properties for …".
- The construction of the hierarchy does not have to follow a particular sequence, regarding the map, wind atlas and the required WRGs. However loading the MAP file first provides the spatial views for the other elements and WRG extents.

4. CREATION OF RSF FILES

The calculation of WRG wind resource grid files by WAsP can sometimes take several hours if the wind farm covers a large area and the WRGs are needed in detailed spatial resolution. For wind farm analyses where the wind turbine locations are already known, a faster alternative is to calculate an RSF wind resource file in which the wind resource is predicted only at discrete turbine locations.

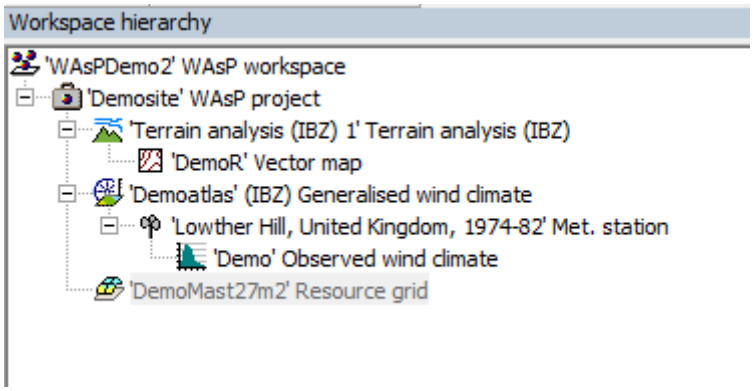
In this exercise you will learn how to use WAsP to create discrete RSF files for use in WindFarmer.

4.1 Defining the single point WRG files

If the Association method is to be used with the RSF file in WindFarmer, 2 single point WRG files need to be also calculated in WAsP. These WRGs are needed at the mast location: at the mast height and at the turbine hub height.

Step 1. Set up the WAsP workspace according to section 3.1 in the previous exercise.

Step 2. Insert the single point Demomast27m.WRG file, as described previously, obtaining the hierarchy below.



Step 3. To insert the second single point WRG, right click on “Demosite” project and select “Insert new > Resource grid”

Step 4. Enter the height above ground as 50 m, assuming that the turbine to be used has hub height of 50m

Step 5. Rename the file “Resource grid 2” as “Demomast50m”

Step 6. Select Edit Grid and in the Grid Configuration, enter the X and Y coordinates for the mast location, and Resolution of 1. In this case X = 337145; Y = 652387.

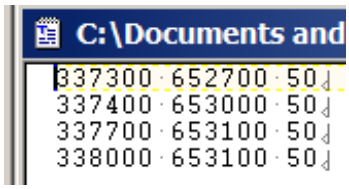
4.2 Defining the RSF wind farm file

Step 7. To set up the RSF calculation, in the hierarchy right click on the “Demosite” project , and select Insert New > Wind Farm

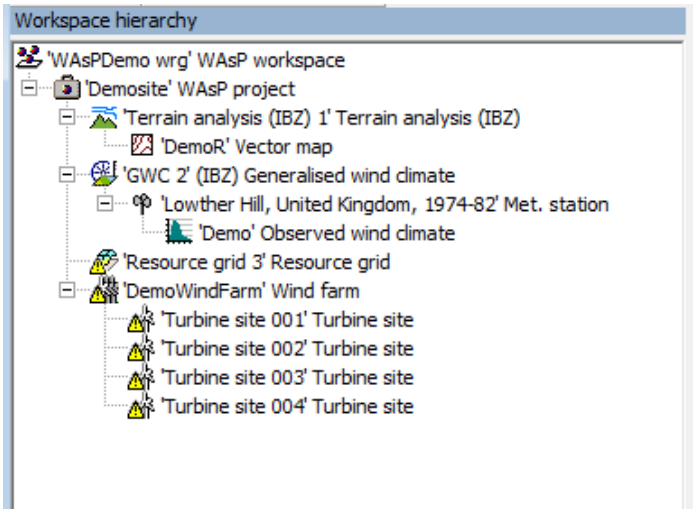
The wind farm element in WAsP is used only to calculate the wind resources at specified locations. Functions regarding turbines and turbine interactions are not relevant here.

Step 8. Rename “Wind Farm 1” as “DemoWindFarm”

Step 9. Assume that the wind farm has 4 turbines with known coordinates. Prepare outside WAsP a text file with the Eastings, Northings and Hub Heights shown. Tools such as Notepad, Textpad or Excel can be used. Save the file with TXT extension. All the turbines must have the same hub height.



Step 10. Right click in the WAsP hierarchy on "DemoWindFarm" > Insert from file > Site Locations. On the 'Open file' window, select to show 'All files', then load the file TXT containing the 4 turbine sites.



Alternatively turbines can be added by right click on "DemoWindFarm" > Insert new > Turbine site. If necessary, double left clicking at the turbine opens its properties window. Hub height and turbine location can be edited in the Settings page.

4.3 Running the WAsP calculations

Step 11. To calculate the wind resources, right click on "Demosite" project and select "Do any feasible calculations for the project members".

Step 12. Export "Demomast27m.WRG" and "Demomast50mWRG" from the workspace by clicking on each and selecting "Export", then choosing WRG option.

Step 13. Export "DemoWindFarm.RSF" from the workspace by clicking and selecting "Export", then choosing RSF option.

The three wind resource files together with the initiating TAB file are now ready for use in WindFarmer.

5. USING WASP CFD

This final section gives a brief overview of using the WasP Computational Fluid Dynamics (CFD) tool and explains how to import the results into WindFarmer. The Wasp CFD tool needs to be operated from within WAsP directly, rather than through the WindFarmer interface.

For more details, please refer to the WasP documentation which can be found at: http://wasp.dk/Products/WAsP%20CFD/QuickGuide.aspx.

The basic steps for making CFD simulations are as follows:

Step 1. Purchase CFD „Calculation credits“ from DTU (http://www.wasp.dk/Products/WAsP%20CFD/HowToOrder.aspx)

Step 2. Build a new workspace hierarchy.

a. If you are building a new workspace (as described in section 3 in this Tutorial), when you have to insert the terrain information (*.MAP file) right click on your project and select Insert new > ‘Terrain Analysis (CFD)’, then you will be asked to load your .MAP file.

b. If you are using a CFD in an existing project, you can convert your IBZ file by right clicking on it and select ‘Convert IBZ terrain analysis to CFD’.

Step 3. Double click on ‘Terrain analysis (CFD)’ in the hierarchy and specify one or more 2km x 2km squares or “tiles”. These will be the areas from your project that you will send information about to WAsP CFD.

Step 4. Select ‘Save request’ and select a suitable location for the request file(s).

Step 5. Start the ‘WAsP CFD Calculation Tool’ by going to Tools>CFD Calculation Manager.

Step 6. Click on ‘Add session’ and then select one or all of your request files.

Step 7. Select ‘Add job’ to send the request files for CFD simulation.

Step 8. The file is converted into a CFD calculation and the resulting tile is saved to your “result file”.

Step 9. Once you get the result files from the CFD calculation, double click on ‘Terrain Analysis (CFD)’ in the hierarchy and select ‘Import’ to import the CFD results into WAsP. An importing box will appear, and you should load your files from the location where they were saved. After loading you will be able to visualise the tiles imported on your screen as green squares.

Step 10. After you load the ‘result files’, right click on your workspace and select ‘Do all feasible calculations’.

You can now follow the steps as outlined in sections 3.2, 3.3 and 4 to create the required mast and hub height WRGs or RSF.