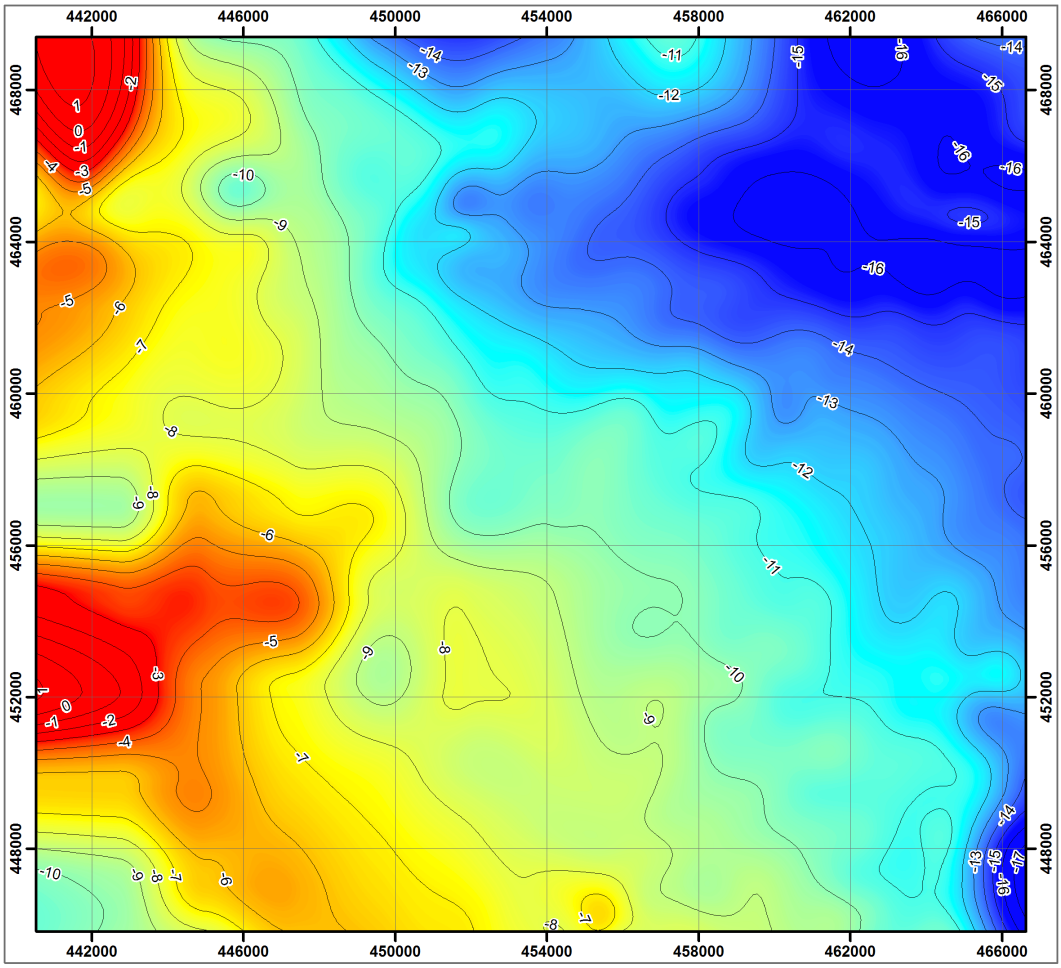
Introduction to GIS with ArcGIS

for
Geophysicists, Meteorologists and Environmental Scientists



© Clare Gordon
School of Earth & Environment,
University of Leeds

For ArcGIS version 10.4
12th November 2019

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QGIS Development Team, 2019. QGIS Geographic Information System. Open Source Geospatial Foundation Project. http://qgis.osgeo.org

Font: Clear Sans

Contents

How to use this workbook

If you need this workbook in a different format, e.g. large print or a different font, please contact me - details at the end of this section.

It is worth reading through each little section before you start to follow the instructions. Certainly if you get stuck read the section fully to check that you haven't missed something!

The following conventions are used in this workbook to show things that you need to do:-

Tip boxes
Some handy tips and definitions have been put in tables through out the workbook. Check these for more information. You can find a list of these in the List of Tables at the beginning of the booklet.

Table 1: Tip boxes

Video Clip available in Minerva - Using the measure tool in ArcMap.
Direct link: `http://bit.ly/2h5ir8u`

This icon indicates that there is a video clip available for this task. The text next to the icon will explain where to find the video clip - either a web link or in Minerva. Note that many of the video clips have sound - **on cluster machines these will require that you plug in your own headphones. Computers in clusters do not have speakers.**

Menu items are formatted as "buttons" so the following statement -

File » New... » Blank Document indicates that you should click on the **File** command on the toolbar, then click on **New...** then select **Blank Document**.

Keys that you should press are shown as follows: Esc means press the **Escape** key on the keyboard.

Where tool names in programs are mentioned these can usually be found by hovering over the buttons in Arc to activate **tool tips**.

Question 0.1. Questions that you need to answer or exercises that you need to do on your own are in boxes in large font. If a question is numbered, then a possible answer will be given in the answers section at the back of the workbook (check the contents list). If there is an empty box below use it as a space in which to record your answers.

Write your answer here!

Techniques that are covered in earlier chapters of the workbook will not be repeated in later chapters, but will be referred back to, so remember to bring the workbook to each practical so that you can refer back to it. The workbook will remain available in Minerva, but further printed copies will not be provided.

Contact Details

For further information about the contents of this booklet contact: Clare Gordon (Email: c.e.gordon@leeds.ac.uk) Room 10.140b, School of Earth and Environment, University of Leeds

Chapter 1

Introduction to GIS: exploring the software

1.1 Learning outcomes

When you have completed this chapter of the workbook you should be able to

- demonstrate how to open a map in ArcMap
- select appropriate tools to navigate in a map document
- use layers to organise and display information on a map
- understand the basic principles of file management for GIS

1.2 Obtaining data

You will download the data for this exercise from Minerva as a zip file, but when you create maps for your own areas you will need to download your own map layers. We will cover downloading data for the UK in a separate session.

- Download **NorthWalesData.zip** from Minerva.
- Unzip the files to a folder called **gis** either on your M: drive (recommended) or on a USB memory device. **You'll need a total of about 170MB free space to complete the following exercises.**

You should end up with a folder structure something like the one in figure 1.1.

1.3 Opening a map in ArcMap

- Open ArcMap by search for **ArcMap** in the start menu and clicking on it. Be patient! Arc can take a while to open.
- From the Getting Started dialog select to Browse for maps... . If you don't have the Getting Started dialog then use File > Open
- Navigate to the folder in which you unzipped the downloaded file and open `NorthWales.mxd`

Unzipping files
Zipping files is a way of compressing them to save space and make it easier to store and download them. You'll frequently need to extract or unzip files during this module. Zip files may have extensions of either `.zip` or `.7z`, both will extract or unzip if you use the instructions here. • In **My Computer** right-click on the zip file. • 7-Zip » Extract files... select the location to save the files to OK Right-click and **Extract all** (which is the unzip utility provided by Windows) will usually work on `.zip` files, but occasionally doesn't extract **all** of the files in the archive. 7-zip seems to be more reliable and works for `.7z` too. 7-zip is also open-source so if you want to install a copy on your own computer you can - just download it from `http://www.7-zip.org/`

Table 1.1: Unzipping files

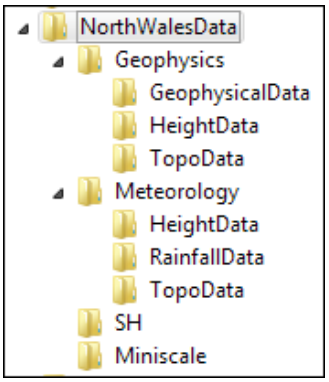

Figure 1.1: Folder structure of data from VLE

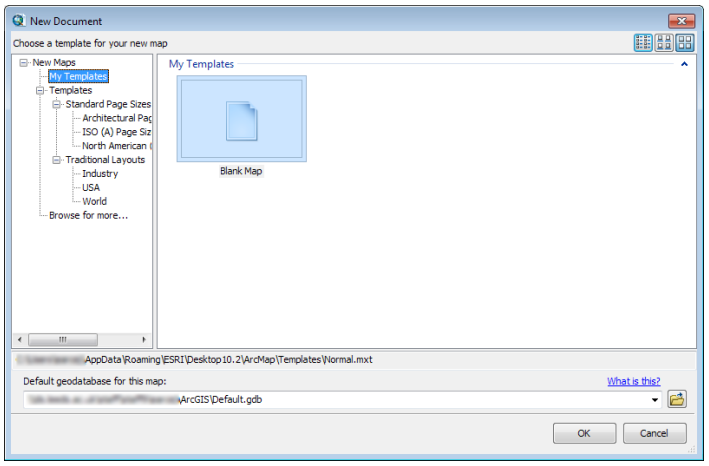

Figure 1.2: ArcMap when it is first opened - with splash screen

1.4 ArcMap window

Figure 1.3 on page 3 shows the main features of the ArcMap view and how it will look when you first open it. Note that not all of the items labelled may be visible when you first open Arc.

1.4.1 Navigation

The Tools toolbar (figure 1.4) gives you the tools to move around your maps and zoom in and out.

If the Tools toolbar isn't visible open it by going to Customize » Toolbars and click on **Tools** to tick it.

Hover over the buttons to see short tool tips that explain what each button will do.

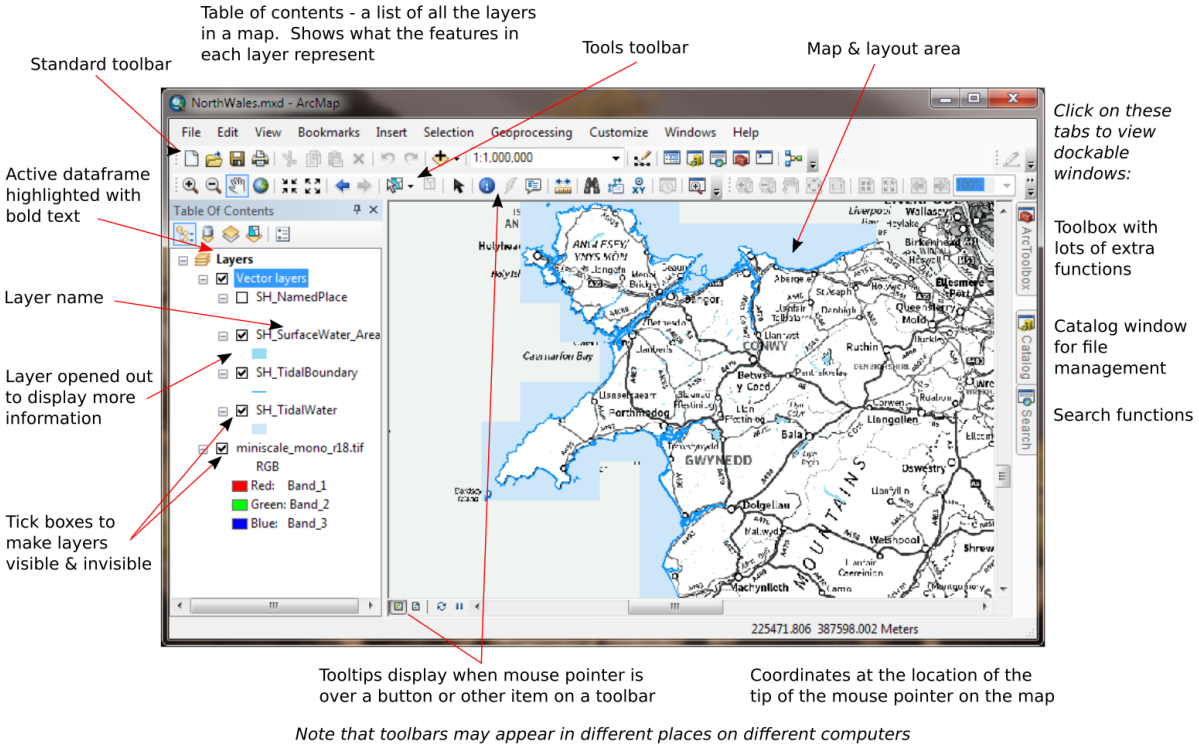

Figure 1.3: The ArcMap screen. (Esri software graphical user interfaces are the intellectual property of Esri and are reproduced herein by permission. All rights reserved.)

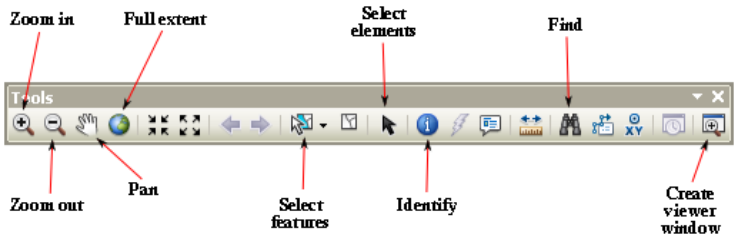

Figure 1.4: ArcMap tools toolbar

Question 1.1. Try out each tool in turn and see what it does. Make notes for yourself in table 1.2 on page 3.

Possible answers to questions in the text which are numbered, like this one, are in appendix C on page 126 so that you can check your understanding.

Table 1.2: Navigation tools in ArcMap

Tool	**What it does**
Zoom in (also try using the mouse wheel to zoom in and out)	
Zoom out	

Full extent	
Zoom to layer (this one isn't on the tools toolbar. Right-click on the title of a layer in the table of contents Zoom to layer)[1]	
Pan (also try holding down the mouse wheel and panning - useful when you're using another tool)	
Select features (try clicking on the map, and click and hold then drag and let go)	
Identify	
Find (try searching for **Llanbedr** in the **Features** tab. Once you have a result, right-click a record and have a go with the commands from the menu, e.g. **Flash**)	

Video Clip available in Minerva - Using the "Find" button to find features in ArcMap. Direct link: `http://bit.ly/2h5hWeC`

1.5 Working with map layers in ArcMap

Layers are an essential part of any GIS. Each layer is a reference to a particular data source. In this project file the layers so far include

- SH_NamedPlace
- SH_SurfaceWater_Area
- SH_TidalBoundary
- SH_TidalWater
- miniscale_mono_r18.tif

The table of contents panel on the left hand side of the window shows all the layers that are in your map and allows you to control their visibility.

[1] **Zoom to layer** is a very useful tool. It can be particularly useful if you have zoomed in or out too far and can no longer see your map properly. Zoom to layer and you'll usually be able to see enough to find the bit of the map that you really want to see.

Video Clip available in Minerva - Working with layers in ArcMap.
Direct link: `http://bit.ly/2ttzfdJ`

1.5.1 Viewing contents of layers

If you have added vector data, such as the `SurfaceWater_Area` and `TidalBoundary` layers, you will also be able to refer to the table of contents as a key to your symbols. This is particularly useful if a particular layer has multiple symbols.

- Click on the little minus symbol next to the `SH_SurfaceWater_Area` layer - the blue box beneath the layer title should fold away (close)
- Now click on the little plus symbol next to the same layer. The symbol for that layer should reappear (open).

1.5.2 Turning layers on and off

Click in the little box next to one of the layers (figure 1.5). The tick will disappear and so will that layer in your map. Click again to make the layer visible once more.

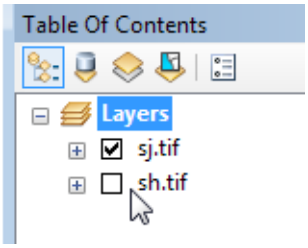

Figure 1.5: Turning layers on and off without removing them

> ***The*** `SH_NamedPlace` ***layer is drawing slowly because it has so many labels. Try turning that off so that your map draws much faster. You can always turn it on again later if you need it.***

1.5.3 Adding layers to ArcMap

GIS data generally falls into two data types, raster and vector. You'll find out more about these types as you work through this course. You'll start by adding raster images as a background map.

Adding tif or jpg files to view

You can add more than one tile of data at a time. This makes it possible to create an apparently "seamless" map and print across tile boundaries, just follow the instructions and select all of your required tif or jpg files at once.

You will add the two topographic map tiles that you downloaded as part of NorthWalesData.zip - see below for instructions on which to add.

Video Clip available in Minerva - Adding new layers to ArcMap from a local disk and Connect to Folder. Direct link: `http://bit.ly/2sueGtH`

- File ▸ Add data... or click on the **Add data button** (figure 1.6).
- Alternatively simply find the file you want in the Catalog panel (click on the Catalog tab on the right of the map window or go to Windows ▸ Catalog) and drag and drop it onto the map area

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Geophysics Select **sh52.tif** and **sh62** from the `Geophysics▸TopoData` folder and Add

Meteorology Select **sh.tif** and **sj.tif** from the `Meteorology▸TopoData` folder and Add

Figure 1.6: The Add Data button

- When you add tif or jpg files to ArcMap it will ask you whether you want to create pyramids. It's your choice! Pyramids can save time when you are zooming in and out of your map but take a while to create when you first load the file.[2]
- Ignore any error message about not being able to project data - just click OK to get rid of it (it isn't always a good idea to ignore this error message, but in this case it will be OK).

Connecting to a folder
If you can't see your M:/ drive or USB device in the list of folders when adding data or viewing the catalog you need to **Connect to folder**. • Click on the **Connect Folder icon** (figure 1.7) and select your top level gis folder then click OK. • Now select your files from the folders that you can see. On cluster machines you'll probably find that you have to repeat this each time you start work in Arc, unfortunately.

Table 1.3: Connecting to a folder

Figure 1.7: Connect to Folder button

IMPORTANT NOTES

[2] If you want more information about how pyramids work search for **raster pyramids** in the Desktop Help.

Video Clip available in Minerva - Connect to Folder. Direct link:
`http://bit.ly/2sp6mA3`

- Keep the name of the tif or jpg file you want to add to ArcGIS the same as the tfw or jgw file that came with it and keep them both in the same folder.
- It's not really a good idea to edit the file separately but if you do -
  - don't resize the tif or jpg file
  - make sure that you don't compress the tif file when you save it
- Make sure that the file extension for tiff files remains as .tif (with a single 'f') otherwise ArcMap will probably not recognise it. **This can be a particular problem when downloading using Internet Explorer** - so make sure that you check.

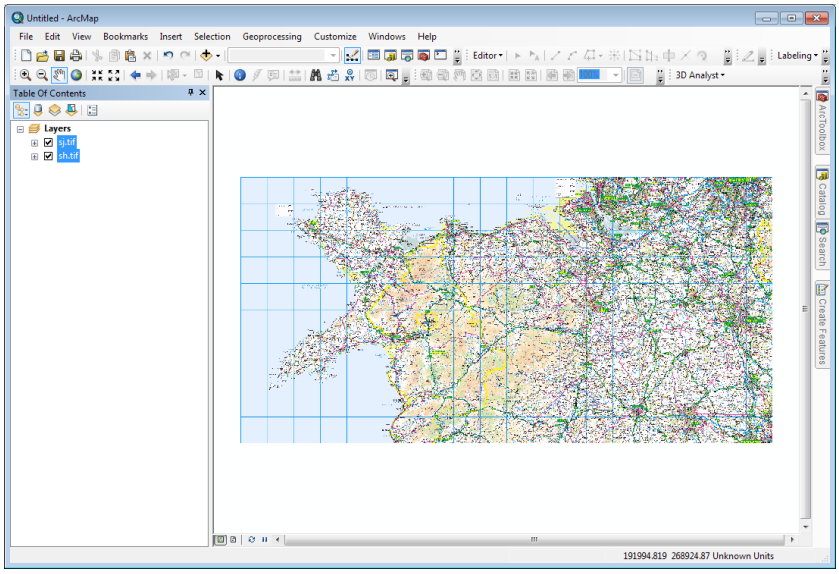


Figure 1.8: The map in Arc when you have added tif files (Meteorology version - geophysicists will have a smaller area of more detailed data)

Adding shapefiles to ArcMap

Shapefiles are a vector type file format. You'll add a layer showing the major roads and the railways of North Wales and have a brief look at the data.

Again, just like with the raster files, you can add more than one shapefile at a time.

- File > Add data... or click on the **Add Data button** (figure 1.6 on page 6)
- Alternatively use the **Catalog** panel which should be available on the right-hand side of your map[3]. Find the file that you want to add to your map and simply drag and drop it into the map window.
- Add files from the `SH` folder - `SH_Road` and `SH_RailwayTrack`

[3] If there isn't a tab for the catalog panel on the right-hand side of your map, go to Windows > Catalog to open it.

The layers should appear in the table of contents on the left of your map. Arc will have given them random colours and added the layers to your map. Figure 1.9 shows the resulting map with the raster layers switched off as in section 1.5.2 on page 5. I've also switched off the `SH_NamedPlace` layer so that the place names aren't covering everything.

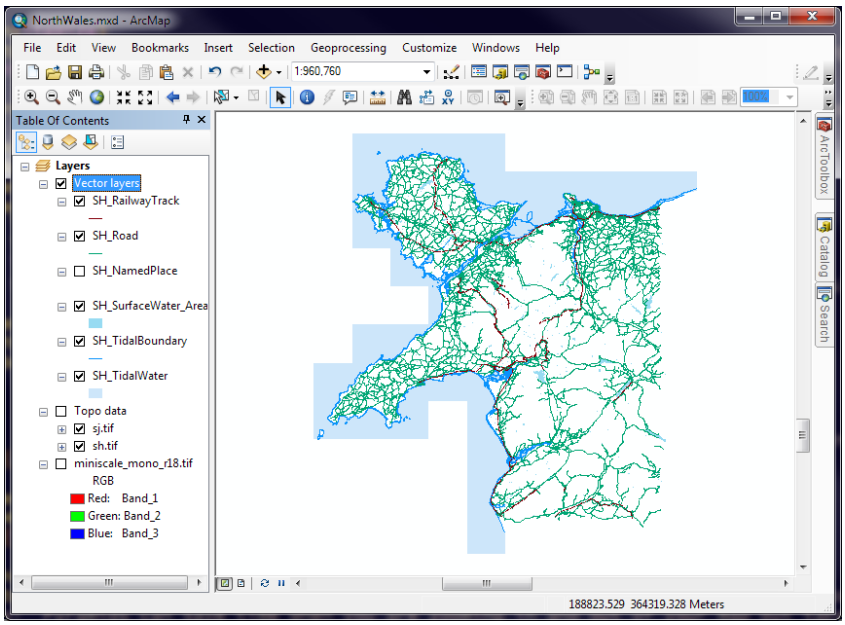


Figure 1.9: ArcMap once you have added vector shapefile layers (raster tif layers, and the place names have been switched off)

1.6 Checking and setting the coordinate system

The coordinate system is an important property which tells Arc where data is on the surface of the Earth and what measurement system is used for your datasets. It is important to have this set correctly or the layers in your map will not display properly.

Video Clip available - For more background information about why coordinate systems exist view the YouTube video "Why all World maps are wrong" at `https://youtu.be/kIID5FDi2JQ`

Check whether the coordinate system is set to "British National Grid" as follows:

- Right-click on **Layers** in the table of contents on the left.
- Properties > Coordinate System

This should show you what the current coordinate system is set to - see figure 1.10.

Your properties may not look the same as this. The data frame takes its coordinate system from the first data file added, if the information is available. Tif files don't have this information. If you have other types of files, such as shapefiles, or geodatabase feature classes, adding those first ensures that the coordinate system is set. Otherwise, as in this case it may say **Unknown** or **No Coordinate System** and you will need to add the coordinate system manually.

If you need to set the coordinate system:

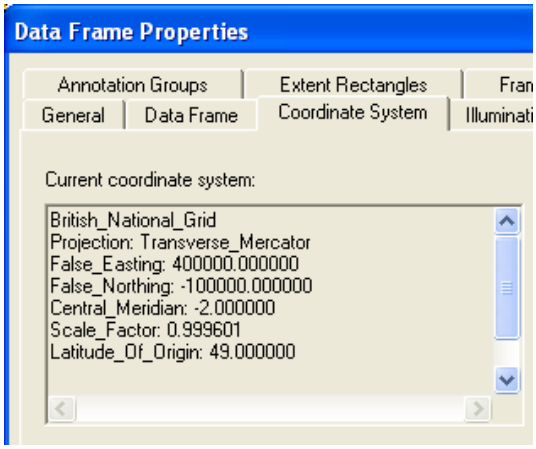


Figure 1.10: Current coordinate system details in the Data Frame Properties

Figure 1.11: Scale dropdown box on the standard toolbar

- From the **Coordinate System** window (figure 1.10)
- Projected Coordinate Systems › National Grids › Europe › British National Grid › OK.

Now it should be possible to scale your view using the scale drop down on the standard toolbar (figure 1.11). To change to a particular scale just use the dropdown, but you can also type a scale in this box, particularly if the scale that you want isn't in the list, e.g. **25000** (note no punctuation), and it will change when you press **return**.

If this is either greyed out or shows scales such as 1:1,566,900,333 and won't display at scales such as 1:10 000 then there may be a problem with the coordinate system. Try setting it again and ask for help if it still doesn't work.

1.7 *****Warnings about file management*****

Boring, but **essential!**

You don't want to spend lots of time creating a map only to find that it won't open when you come to print it, or that you can't find the files that go to make up your map. A lot of students have wasted a lot of time because they didn't follow the file management rules which are laid out in table 1.4 on page 10.

The table summarises the rules, more detailed information was given in the lecture segment. See the slides and the video in Minerva.

Video Clip available in Minerva - File management for ArcGIS. Direct link: `http://bit.ly/2gNqFBN`

1.7.1 Relative paths in ArcMap: links between maps and datafiles

ArcMap layers reference datasets rather than contain them. By default layers link to datasets through their source property using ***absolute*** paths. This means that if you save a map file to

Summary of file management rules - ignore at your peril!

If you have problems with a project in ArcGIS check that you have followed the rules below before you ask for help.

- Keep your files organised - create a folder for each project and keep all the files for that project in that folder. Make sure that you remember where you are saving files. If you forget you'll probably have to waste time downloading the files and processing them again.
- Don't use spaces or non-standard characters in folder or file names - these can cause problems for ArcGIS. Stick to alpha-numeric characters.
- Keep file paths short but informative - that is the whole list of folders and the file name. The total should be less than 256 characters. Make sure you use names that mean something to you for future reference!
- If you have problems opening / moving / unzipping files - check disk space! Remember GIS data needs a lot of space and can quickly fill your M:/ drive.
- Don't save files to **My Documents** or **Documents and Settings** because of the spaces in their pathnames. On the University system start at the root of your M:/ drive (your username rather than your full name) and navigate from there.
- Don't save files to the **Desktop, the harddisk of a cluster machine** or any **temp or temporary** folder. The files will have disappeared by the next time you look for them.
- Don't save zip files to a temp or temporary folder or open them without saving them first - you may be refused permission to unzip them.
- Use ArcCatalog or the Catalog window in ArcMap to move and delete gis files, not Windows Explorer or My Computer. ArcCatalog is specially set up to handle gis files with more than one part without breaking them.
- If you are having trouble carrying out an operation in ArcMap check that ArcCatalog is not open too - and the reverse if you are having problems in ArcCatalog.
- Keep a backup copy. Arc does crash and can damage datafiles as well as your map.

Table 1.4: Summary of file management rules

a drive, e.g. your M: drive, if you then move the folder containing all of your files to a different location you will lose the links to your data. It is advisable to change paths to ***relative*** before you start creating a map, then as long as your files remain in the same relationship to each other between folders it doesn't matter if the drive letter changes.

- Customize » ArcMap Options » General then tick next to Make relative paths the default for new map documents » OK.

Now check that the setting is correct for this map

- File » Map Document Properties » General check that **Store relative pathnames to datasources** has a tick next to it then OK.

When you save a new map, it will automatically be given a **.mxd** extension. It is always a good idea to use a file name that makes it clear to you in future what the map is.

If you do break the paths by moving files around then you need to repair the broken file links (tip box 1.5) before you can see the layers in your map.

Repairing broken file links

If you use absolute file paths and you have to move the files from one location to another you will find that the broken links are marked by a red exclamation mark next to the layer name (as in figure 1.12).
To check the file name and repair the links

- Open the layer properties and go to the Source tab
- Under **Data Source** you will see which file Arc is looking for
- To repair the link click on Set Data Source... and look for the missing file - which won't be in the location that is listed
- Once you find it, select it and click Add and then OK

If you are really lucky any other missing layers will appear too, but if not, repeat as necessary.
If you already know which files you need to look for, do the following to repair the links:

- Right-click on the layer
- Data > Repair Data Source...
- Navigate to the file Add > OK.

Table 1.5: Repairing broken file links

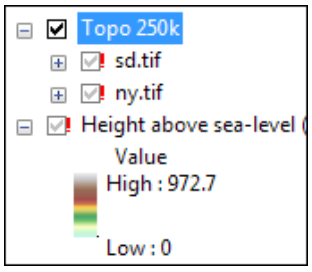


Figure 1.12: The red exclamation mark showing that the links to the data for these layers is broken

Video Clip available in Minerva - Repairing broken file links. Direct link: `http://bit.ly/2h2X1J3`

1.8 Saving and backing up

Save your map files at regular intervals. You will be doing a lot of work on them and can lose a lot of time if you have to redo your work because the program has crashed.

Make back up copies of your map files to a separate location. It is also a good idea to have back up copies of your data files. Particularly once you start editing, problems can corrupt the whole file, so make a copy of your gis folder on a separate disk/drive/memory stick before you start editing and then at regular intervals during the process.

1.9 Removing layers

You'll want to try and keep the table of contents tidy, and this means that you will want to be able to remove layers that you no longer need.

- Right-click on the **SH_NamedPlace** layer in the table of contents - Remove

You won't need any of the other vector layers for the rest of the exercises in this module so also remove:

- **SH_RailwayTrack**
- **SH_Road**
- **SH_SurfaceWater_Area**
- **SH_TidalBoundary**
- **SH_TidalWater**

Note that this doesn't remove or delete the data from your disk, it just removes the link to it from your map.

In addition make sure that the raster map layers from the `TopoData` folder are in your map and switched on (you should have added these in section 1.5.3 on page 5).

When you've finished exploring **save your map and then close ArcMap**. You'll be using this base map again in chapter 5 so make sure that you can remember where you have saved it to.

Chapter 2

Digimap

2.1 Introduction

Digimap is a service provided to Higher Education in the U.K. by EDINA at Edinburgh University. Digimap provides a front end to digital maps and data of Great Britain from the Ordnance Survey and the British Geological Survey. As a member of the University of Leeds you have access to maps and data for use as part of your studies.

2.2 Learning outcomes

When you have finished this workbook you will

- be aware of the UK data available to you through the Digimap service
- understand how to use the Roam browser in the Digimap Collections to make a digital map displaying a selection of features
- know how to download images and pdf maps from the Digimap Collections for printing and use in other programs
- know how to use Data Download to download data from Digimap Collections for use in GIS programs

2.3 Logging in to Digimap

2.3.1 Registering

If you have not used Digimap before you will need to register using your University id, that is the username and password that you use to access University systems. Full instructions for registering and logging in are on the Digimap help pages at

`http://bit.ly/1yQusPx`

Start by selecting **University of Leeds** and logging in with your usual University username and password. Please do not use any other email address to register - it will only cause you problems when it comes to obtaining data later.

You need to register for each collection separately, but can do it in one go. For this workbook you won't need to use all collections, but it is worth registering for all that are available to you so that you can explore them for yourself. The University of Leeds does not subscribe to Marine or Global Digimap[1].

In the **Purpose** dropdown select **Academic Works (coursework, projects, dissertations etc.)**

[1] as of September 2018

2.3.2 Logging in

To log in go to the Digimap Collections page (figure 2.1) at

`http://digimap.edina.ac.uk`

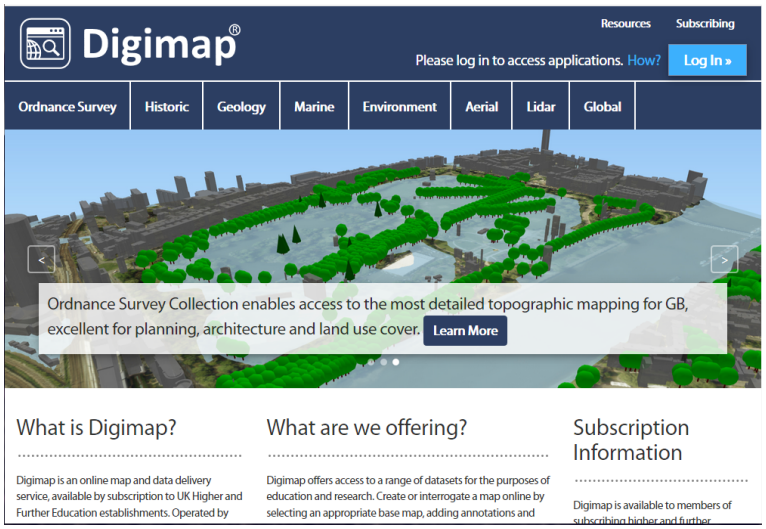


Figure 2.1: Digimap initial page

- Click the **Login** button at the top right of the screen and type **Leeds** in to the box and select the **University of Leeds** from the list of available institutions
- You should get the familiar University of Leeds login page, so type your **University username and password** into the appropriate boxes and then click the **Log in** button. If you are already logged in to Minerva you may find that you don't have to enter your login details again.

You should be taken to the Digimap initial page again (figure 2.2), but this time with your name at the top right.

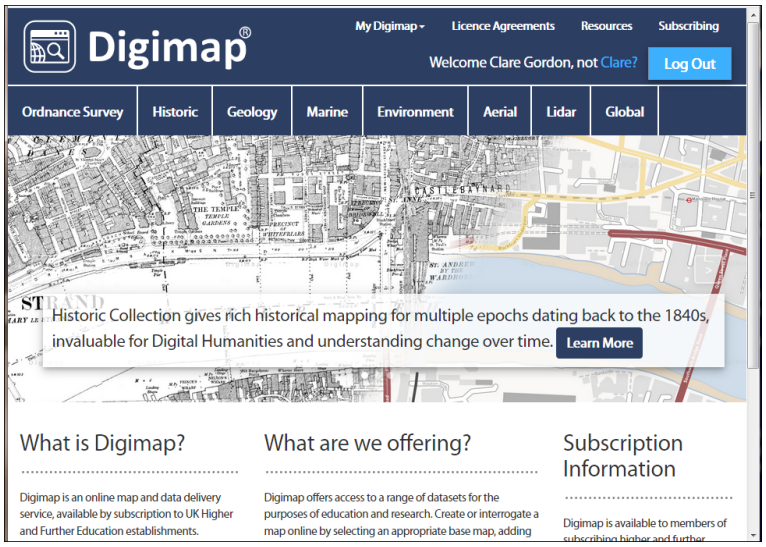


Figure 2.2: Choosing a data collection

The list includes options for a large number of collections. In this workbook we'll only be looking at the collections that are most relevant for creating the maps you'll need during your course, but if you are interested in any of the others feel free to explore them. Edina have worked to make all of the tools similar across each collection so just have a go!

2.4 Ordnance Survey Collection

We are going to start by looking at the **Digimap - Ordnance Survey Collection**. (Figure 2.3.) Click on the Ordnance Survey heading at the top of the screen and you'll be shown which services are available to you and information about the collection.

Figure 2.3: Ordnance Survey Collection

The list includes links to **Roam** and **Data Download**. We'll look at both of these in the sections below.

Roam and Download are fairly standard across all collections in Digimap (making allowances for the differences in the data) so once you've used them in the OS Collection you'll have a good idea of how they are likely to work for Geology, Aerial etc.

2.4.1 Digimap Roam

In this section you will learn how to use Roam to view and create maps using Ordnance Survey data.

- Click on the **Roam** heading.
- You may be presented with the copyright statement page.
- Read the copyright notice carefully and click on the **copyright terms and conditions link**. This launches the "Digimap: Ordnance Survey Data Sub-licence Agreement" page which shows the full terms and conditions. You signed up to these terms and conditions when you registered so make sure that you follow them. Click your browser's **back** button to return to the copyright notice, then click on the green button to acknowledge your agreement to the copyright statement.

Video Clip available - The Digimap video on Digimap Roam is available at `https://youtu.be/kSdO-2lnRGc` (this video has sound). Note that this video shows the beta version of Roam so there may be some differences.

Overview

Digimap Roam enables you to view and print maps using Ordnance Survey data at various predefined scales. PDF prints can be created in A4 or A3 size and landscape or portrait orientation. See figure 2.4 for an annotated overview of the Roam window.

Figure 2.4: The Digimap Roam window

The service is being actively developed at the moment so keep an eye open for new buttons or headings and try them out.

1. = **Map window** - Where the maps are displayed
2. = **Home** - return to the Digimap home page
3. = **Search** - enter a place name, postcode or map coordinates here to search for them
4. = **Print** - produce a printable PDF file of your map
5. = **2 up** - open a second map window - allows you to look at two different maps of the same area side-by-side
6. = **Click and drag to zoom in** - as it says!
7. = **Zoom slider** - use to zoom in and out
8. = **Zoom to max extent** - Click to zoom out to full G.B. view
9. = **current view** and **scale bar** - shows current view type and the scale on the map
10. = **Overview map** - when you're zoomed in use this to show where in the country you are
11. = **Map content** - view map legend and customise map content when possible

12. = **My Maps** - previously saved map views and content
13. = **Overlays** - Enables hill shading at certain levels of zoom
14. = **Drawing tools** - Tools to create annotations, import your own data, or export data in various formats
15. = **Measurement tools** - Tools to measure distance and area
16. = **Map information** - current map product, data licence, date of map and other essential information
17. = **Basemaps** - Enables different map styles at certain levels of zoom
18. = **Opacity** - slider to change the transparency of the basemap

Searching for a location

You can search for a location in Roam by using a place name, postcode or grid reference.

To search using a **place name**:

- Type the place name (for this example type **Leeds**) in the search box and press Enter or click on the magnifying glass button.
- If there is more than one match for your place name the search results will be displayed below the search box - see figure 2.5. Click the place name that you are interested in to view it in the map window - in this case click on **Leeds (Leeds)**.

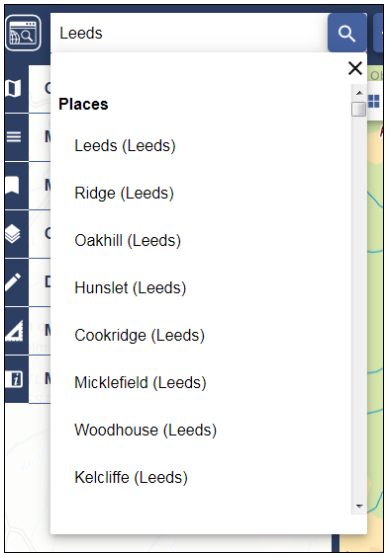


Figure 2.5: Search box and results of a search for “Leeds”

You’ll need to click on the cross on the search results to close the list but when you do you’ll lose the marker showing the centre of your search area.

To search using a **full postcode**:

- Try searching for the University postcode - **LS2 9JT**. Roam should take you straight to the centre of this postcode area.

To search using a **Grid Reference**:

- Type the grid reference, e.g. **SE4435** in the **Grid Reference** box and click **Find**. Roam will automatically navigate to that location.

Navigating in Roam

You can navigate in Roam by panning (moving the map in any direction by dragging it with the mouse) and by zooming in and out of the map.

To zoom in/out of the map you can:

- Double click to zoom in
- Use the zoom slider bar to zoom in or out either by clicking on the **+** and **-** signs or dragging the blue marker on the bar.
- Or click anywhere on the slider bar to zoom to that scale.

Map views

Roam has at least 13 pre-defined map scales, called **views**. The views consist of different Ordnance Survey map products which are appropriate for each view's scale (e.g. the Street view uses the VML (VectorMap Local) raster). once you have found your location of interest you can zoom in and out to find the appropriate view for your map.

The name of the view you are looking at appears in the bottom right of the map window, e.g. **City view**.

Search for the postcode LS2 9JT (The University).
Question 2.1. What view does Roam take you to when you click on "Find"?

Zoom in and out and notice the way that the map content changes between views. Pan around and explore an area of your choice.

Controlling map content and basemaps

In some of the views in Roam it is possible to customise which features are displayed on the map - e.g. display only A class roads and/or railways.

To customise the map view:

- Zoom to **Neighbourhood view** - the type of view is shown in the bottom right of the map.
- Click on **Basemaps** (top left of the map window) and select **VML Streetview**[2] See figure 2.6
- Click the **Map Content** tab in the task menu panel. The map content panel contains a list of the feature types that are included in the map so it can also function as a key.
- Switch features or groups of features (such as all roads) on and off by checking or unchecking the tick box next to the feature name.
- All features can be switched off by unchecking the **Clear/select all layers** tick box. **N**B: clearing all layers will result in a blank map, so remember to switch at least one layer back on!

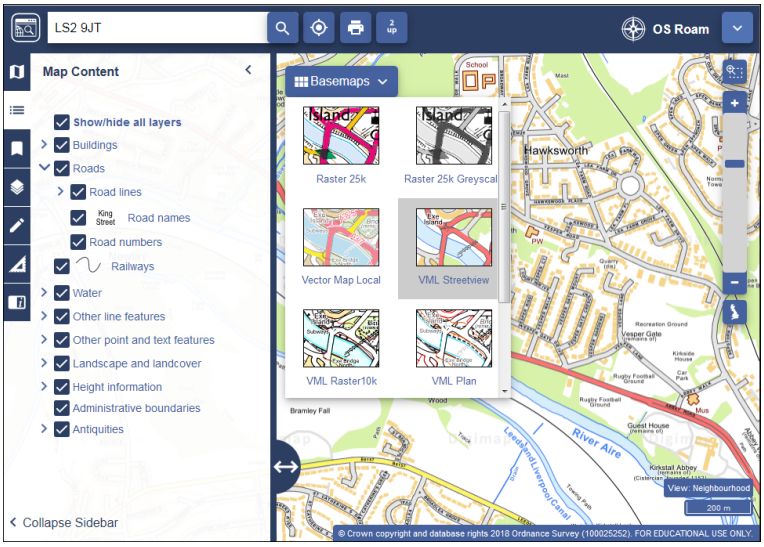


Figure 2.6: Choosing a basemap in Neighbourhood view in Roam. Note the tickboxes next to the features for the VML Streetview basemap.

Note: Many other views cannot be customised because the Ordnance Survey data used in these views are in raster data format which do not allow selection of features. You will still be able to see the features listed in the map content control panel but there won't be tick boxes next to them.

Question 2.2. Name some other view and basemap combinations besides Neighbourhood >> VML Streetview that allow you to select content?

Using the measuring tools

Roam provides tools for measuring distance and area.

- Click on Measurement Tools on the sidebar to open them (figure 2.7).
- Click on the first button - **Measure Distance**.
- Click on the map to start measuring, click for each corner, then double-click to stop measuring. The measurement in metres will appear on the toolbar as well as on an overlay on the map.

Question 2.3. Use the Measure Distance tool to measure your route to the University. How far away do you live?

[2]VML stands for VectorMap Local and refers to a particular Ordnance Survey product which is used in many of their web mapping applications.

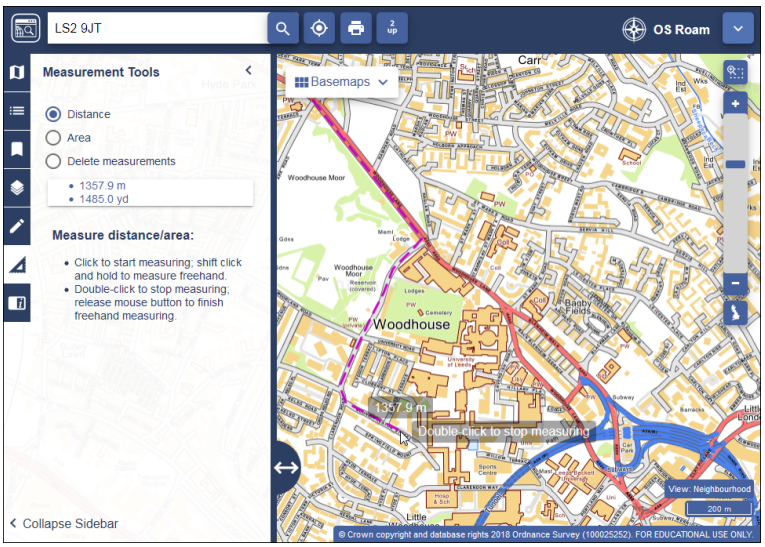


Figure 2.7: Measurement tools - click on the map to start measuring, double-click to stop

In a similar way try out the **Measure Area** tool.

Try very roughly to measure the area of Woodhouse Cemetery (now disused and known as St George's Fields) which is just north of us here in Earth and Environment.

Question 2.4. What is the area of Woodhouse Cemetery?

Using the drawing tools

Roam has a set of drawing tools that allow you to draw on a map and add labels. This is particularly useful for marking up maps for reports or to show people where you are working.

Video Clip available - The Digimap video on Annotating maps with Roam is available at `https://youtu.be/GeFa2Er1Z9M` (this video has sound)

- Click on Drawing Tools on the sidebar - the Drawing Tools panel should open (figure 2.8).
- Explore the tools and scribble all over your map! There is a **Delete All** button so you can clear everything when you have finished, or you can toggle visibility so that you can turn the annotations off without losing them.

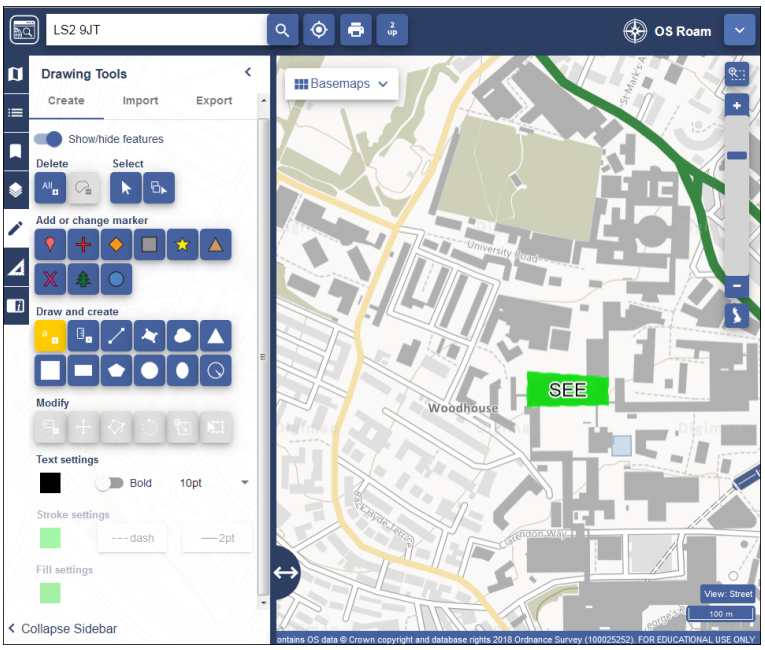


Figure 2.8: The Drawing Tools panel

Return to the University (LS2 9JT) and check that the view is set to Street View.

Use the drawing tools to draw a box with a red line around the Earth and Environment building (i.e. this building!) and label it "SEE" in bright green.

Exporting annotations

It is possible to save your annotations or drawings to file. This is particularly useful as one of the options is Shapefile which can be directly opened in ArcGIS, and another is kml which can be opened in Google Earth.

- Click on Export on the Drawing Tools panel, (figure 2.9) give your file a name that will help you identify it again later and select a file format:
  - **Shapefiles** can be opened in most GIS software
  - **KML** will open in Google Earth
- Then click on Export to save the file to disk

Printing from Roam

Roam allows you to create printable PDF (Portable Document Format) maps or export jpg or png images in A4 to A0 size and in portrait or landscape layout. The image formats make it possible to import maps into Word or Powerpoint.

You won't be printing directly from Roam, really this is more of an **export** function.

Using the map that you were looking at in the previous exercise create a pdf map which you'll save to your M:/ drive. You don't need to print it unless you particularly wish to.

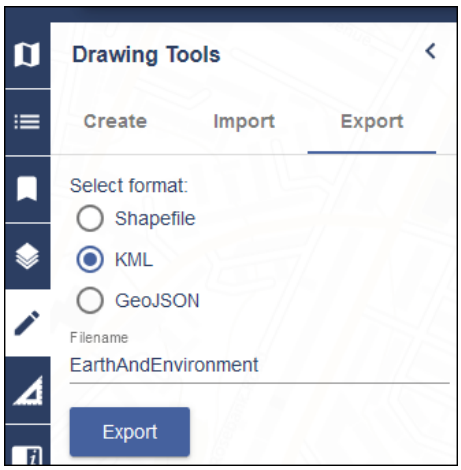


Figure 2.9: Saving annotations to file in Roam

Video Clip available - The Digimap video on Printing Roam maps is available from `https://youtu.be/mPZOyGp75h0` (this video has sound)

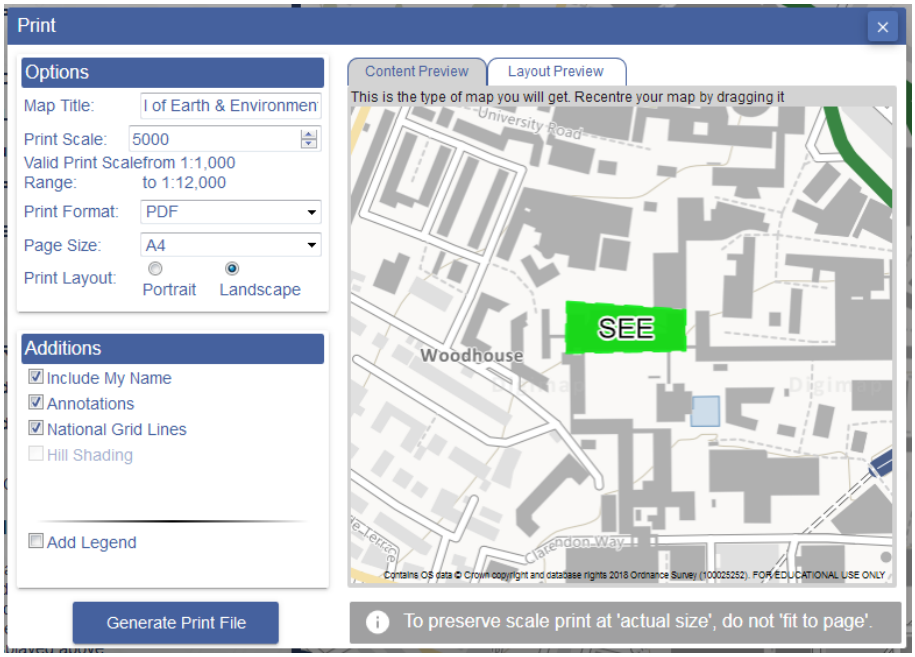


Figure 2.10: Printing to pdf or image file from Roam

- Click the **Print icon** at the top right to open the print options in a new browser window (figure 2.10).
- Enter a map title in the appropriate box.
- Click to add National Grid Lines.
- Select the page size and layout using the drop down menus.
- Look at the **Layout Preview** tab to check that the area that you want will be printed and move the map, or rescale it if you need to
- Click **Generate Print File**, depending on your choice this will either produce a PDF file which

you can save or print, or an image file that you can include within other documents.

See section 2.7 on page 36 for information on how to print and edit PDF files.

Saving map views for future use

Once you have set up a view and, maybe, added annotations, Roam allows you to bookmark it so that you can go back to it later.

- Click on My Maps on the sidebar
- Click on Save and give your map a name that will help you to identify the map later then click Save on this screen.
- Next time you want to use that map click on Open and open it from the list that appears there - figure 2.11.

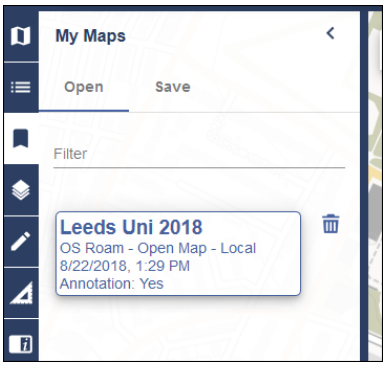


Figure 2.11: My Maps

2.4.2 Data Download

Data Download is a tool for downloading Ordnance Survey data for use in GIS or CAD software. The format that the data is delivered in will determine whether you will be able to open it directly in a software package or whether you will need to convert it.

We'll be using data from Digimap in ArcGIS later in the module so you need to know your way around this section. Instructions for converting, importing and viewing file types that need it will be given during the ArcGIS part of the course.

Selecting your Ordnance Survey data

- Go to the Digimap home page
- Click on **Ordnance Survey** in the menu at the top of the page
- From the Ordnance Survey page choose **Data Download** (Figure 2.12.)

Data download takes you to a map that looks very similar to Digimap Roam but with some important differences.

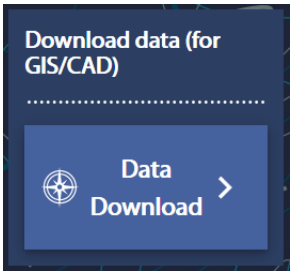


Figure 2.12: Data Download

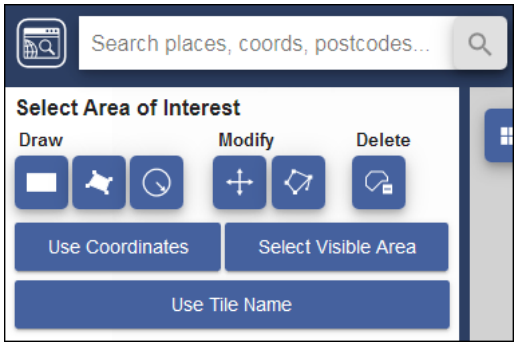


Figure 2.13: Search for & select an area

Selecting an area

On the left there is a menu panel with options for selecting an area with a search box above it (figure 2.13).

- Click in the **Search** box and type **University Road, Leeds**, then press Enter or click on the magnifying glass to search.
- When you get the results click on **Roads (100+)** then select **University Road (University - Leeds)** to zoom in then close the search results.
- Under **Draw** click on the rectangle and use the mouse to draw a box around part of the University, clicking to start and finish the box. (Figure 2.14)

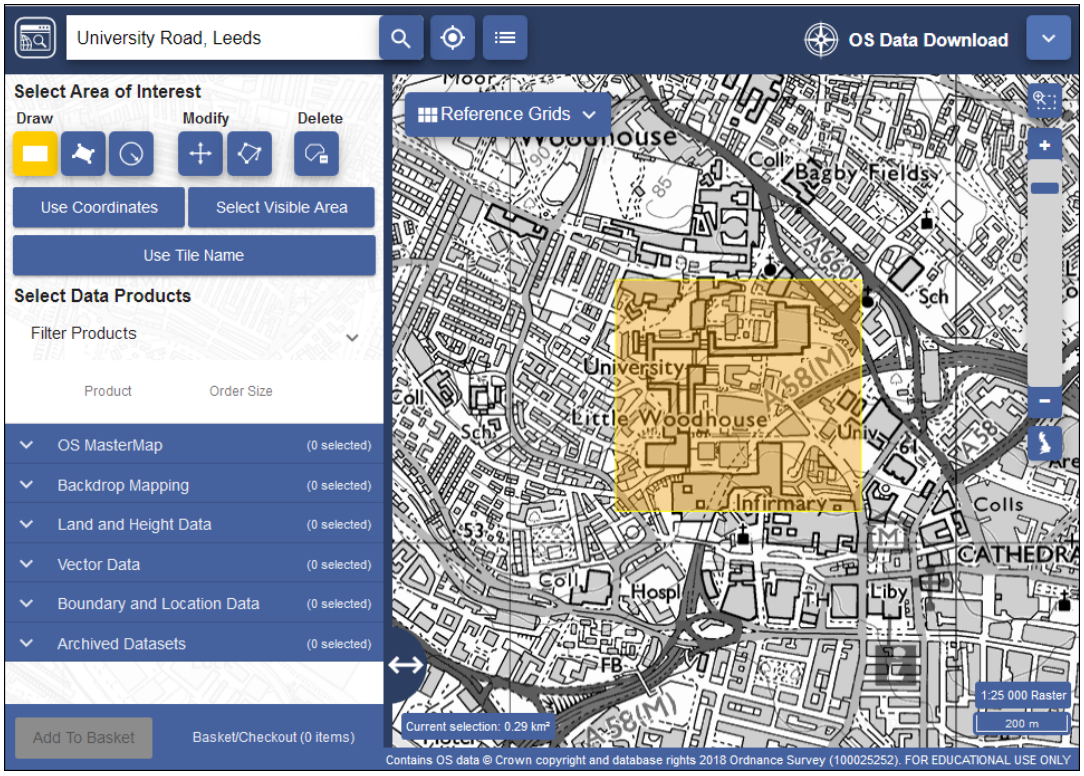


Figure 2.14: Selecting an area in Digimap Download

Note: The map that you see on the screen only shows the area that you will be downloading data for, **not** the actual data that you'll be downloading. You'll select the data separately so don't worry what it looks like for now.

Selecting data sets

Now that you've selected an area you have to select the data that you need.

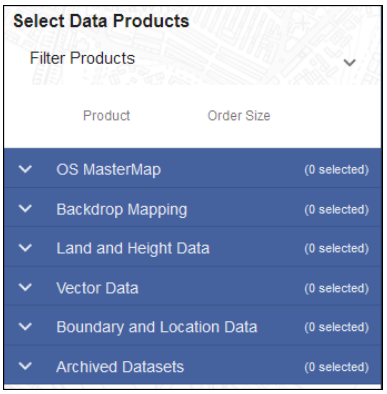


Figure 2.15: Select products from the list

- Back in the panel on the left, under **Select Data Products**, drop down each of the headings in turn. (Figure 2.15.)
- There are a lot of different data sets here and most of them won't mean anything to you. For now select the following datasets when you find them by putting a tick in the box next to them.

> ***Backdrop mapping: VectorMap Local Raster***
> ***Land and Height data: OS Terrain 5 Contours***

You can get more information about the datasets by clicking on the arrow next to them. This includes information on licences.

The figure on the right in brackets under **Order Size** shows how many tiles your selected area uses out of the maximum downloadable number.

- When you have selected the data you require click on **Add to Basket**. (Don't worry - despite the Shopping Basket and Checkout you won't be charged. The University has already paid the subscription!)

Your basket should appear with details of your order. (Figure 2.16.)

- Some datasets will give you an option to change the format (highlighted in yellow). In this case click on **Select Format** next to the contours. The choices are **Shape**, **GML3** or **DWG**. Choose **Shape** in this case.
- You may also need to select a theme - for the VectorMap Local Raster there is a choice of themes - pick whichever one you like this time!

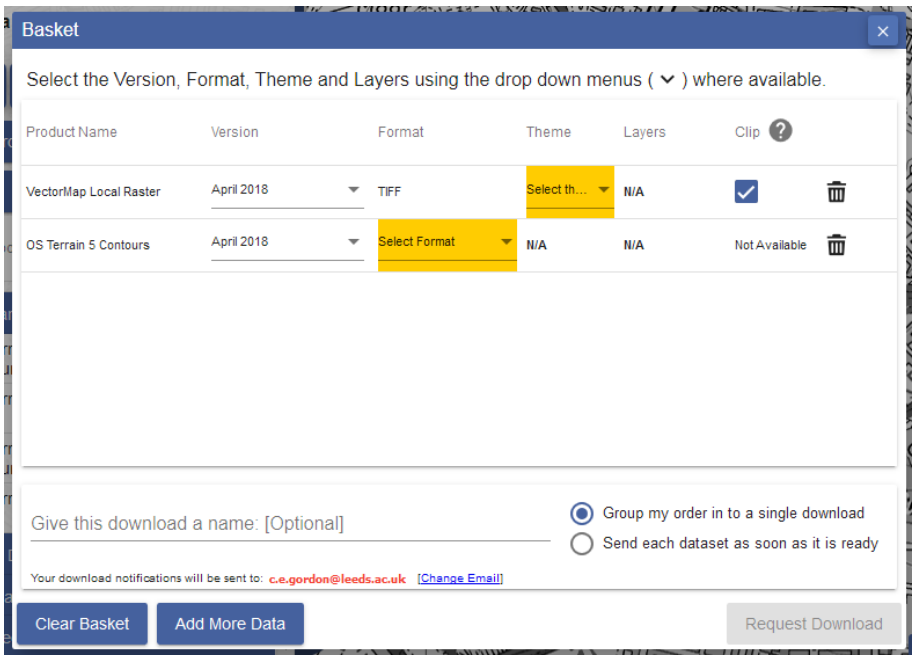


Figure 2.16: Details of your order in the Basket

- Some items will have a **Clip** option. This means that the data will be sent to you clipped to the area outline that you requested. If you are really short of disk space this could be useful, but it doesn't usually hurt to have extra data around the outside of your study area. I prefer to untick this box and download full map tiles.
- Give the order a name, e.g. **Leeds**. This will be part of the file name of the zip file that you download so try to make it short but helpful!
- Click on **Request Download**.

Downloading your data

You'll receive an email confirming your order, then another with a download link. Make sure that you are still logged on to Digimap before you click on the download link (figure 2.17).

Figure 2.17: The download link in the email - click on this not on any of the other links in your email!

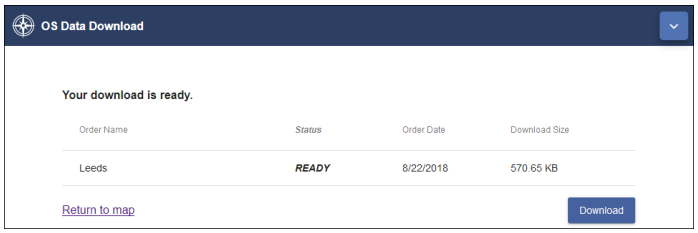


Figure 2.18: Order ready to download

Once you have clicked on the link a window should open telling you that your order is ready to download (figure 2.18).

- Click on **Download**.
- You'll download a zip file. **NOTE:** Don't run or open the file directly from your browser, and make sure that you **DON'T** save your zip file to a **temp** folder where you will probably be unable to unzip it.

Make sure that you remember where you have saved the zip file.

Now open **My Computer** and navigate to the location where you saved the zip file. Right-click on the compressed map data file that you downloaded and choose 7-zip ⟩ Extract files... . Select where you want to save the extracted files, and make a note of where you save them to. You should end up with a folder for each dataset that you requested.

Viewing your data

In this case the files that you have downloaded are either tiff graphics files or shapefiles. Navigate to the downloaded folder called something like `vml-raster_746810▸se` (your order number will be different) and look at the contents. Open one of the .tif files from the VectorMap Local Raster download by double-clicking on it. These files should open in a graphics program. In future classes we'll be using these in our own maps. Try opening one of the .shp files too. It's unlikely that you will be able to. These are a specific format for use in Arc and other GIS programs and we'll look at that in the ArcGIS sessions[3].

The download facility includes a lot of different formats and products, but the basic method of download is the same for all of them. The challenge tends to be in knowing how to use them once you have downloaded them and you'll be looking at that in future sessions.

2.5 Geology Digimap

Geology Digimap gives you access to British Geological Survey (BGS) data, if you use Geology Roam it is on a background Ordnance Survey maps.

2.5.1 Geology Roam

Geology Roam works in a similar way to the Digimap Ordnance Survey Roam so you may find that some of this seems familiar.

Video Clip available - The Digimap video on Geology Roam is available at `http://bit.ly/1y191L7` (this video has sound). Note that this refers to an older version of Geology Roam.

If you are already in the Ordnance Survey section find the **Digimap home page** by clicking on **Digimap Home** at the top left of the screen.

From the Digimap home page click on the Geology heading and click on **Geology Roam**.

The Geology Roam map window (figure 2.19) is basically the same as the Ordnance Survey Roam window.

Geology Roam is very similar in functionality to the Ordnance Survey Roam, so the buttons and task menu should be familiar to you from the previous sections.

- Open the **Search** menu and enter the University of Leeds postcode - **LS2 9JT** - into the postcode search box, then click on **Find**.

[3] Note that there may also be other files in the VectorMap Local folder with a **.tfw** extension. These won't open in any program but, if present, are essential for using the tif file in GIS programs such as ArcGIS, so make sure that you keep this together with the tif file.

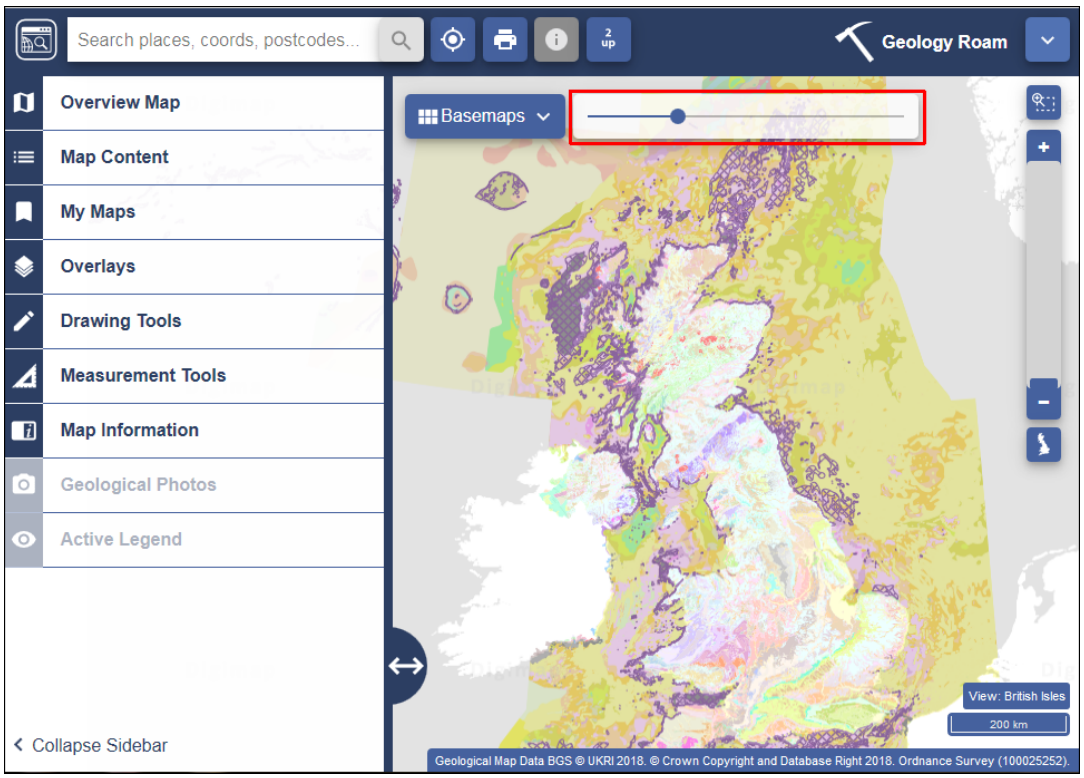


Figure 2.19: Geology Roam map window

- As in OS Roam use the controls to change scale and level of detail.
- One feature that is different from OS Roam is the slider at the top of the map window (outlined in red in figure 2.19). Try sliding it and see its effect on the transparency of the geology over the topography.
- use the Basemaps menu to load different geology layers, for example, in the more zoomed in views try changing the 1:50 000 geology so that it shows **rock types** instead of **rock units**.

Controlling map content

- Once you have a geological map of the area you require click on the **Map Content Control** tab (figure 2.20). This will give you a key to the area shown in the current map and a way to control the visible layers.
- Try turning off the **Superficial Deposits** by unticking the box next to that heading and see what difference it makes to the map. You may have to be patient if you can't see the geology at all for a minute or so - it should return eventually! Try the same with **Artificial Ground**
- To find out what geology is present in a particular area click on the button for the **Feature Information** tool on the toolbar at the top...
- ...then click on the unit on the map that you want to find out more about. A box will appear showing basic details for all of the layers underneath the cursor (figure 2.21), plus the National Grid coordinates. The features selected in the list at the left of the box will be outlined on the map.

Question 2.5. What is the Bedrock geology underneath the School of Earth and Environment?

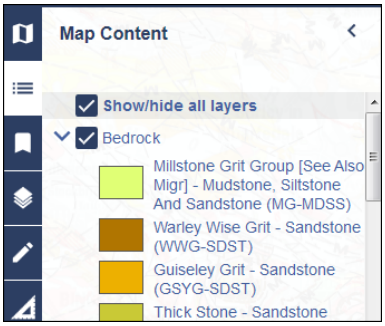


Figure 2.20: Map Content Control

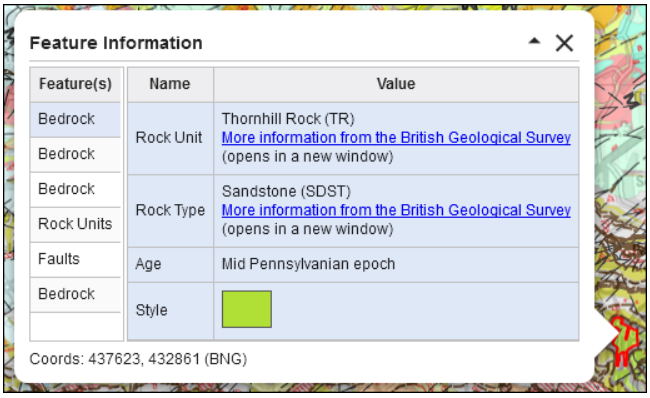


Figure 2.21: Feature information

Geological photographs

The geological photos panel adds icons that open photographs from the BGS photo archive. These include a caption with information about the geological features that they show.

Currently there are no geological photos available for the Leeds area. Search for and go to **Malham Cove** on the map and then click on Geological Photos in the side panel.

You should see lots of “camera” icons appearing on your map - figure 2.22.

Click on one of the icons to see a thumbnail. Click on that to see the large photo and more details (you may need to scroll down to see explanatory text).

Alternatively open out the **Geological Photos** list on the left-hand side of the screen and click on items in the list there.

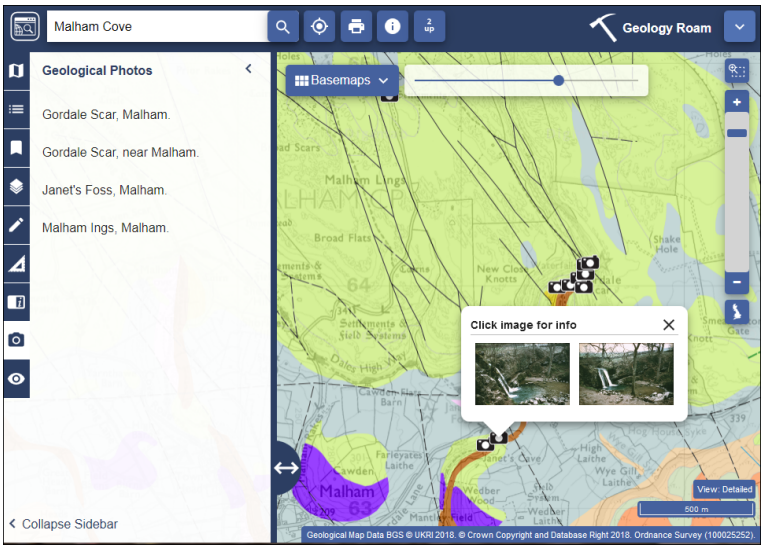


Figure 2.22: Viewing geological photographs

Printing from Geology Roam

Printing from Geology Roam means that you produce a file which you can save to print later if you wish, or include in another document.

- Click on the **Print** icon. The print dialog will open in a new window (figure 2.23).
- Fill in a map title
- Select the **print format** that you require - pdf for printing, png or jpg for importing into other documents - and whether you want to print in portrait or landscape format.
- Select the **Page Size** that you require.
- Note that the extent shown on the preview will not necessarily correspond with the extent that will actually print out - you can check that on the **Layout Preview** tab.
- Select whether you wish to include **National Grid lines** or **Rock Code Labels** (the labels are useful if you add a legend, but are rather obvious on the map).
- Select **Add Legend** if you want to generate a separate legend. If you choose this then your output will be two files inside a zip file.
- Click on **Generate Print File**, this will produce a file which you can then save or print.
- See section 2.7 on page 36 for information on how to print and edit PDF files.

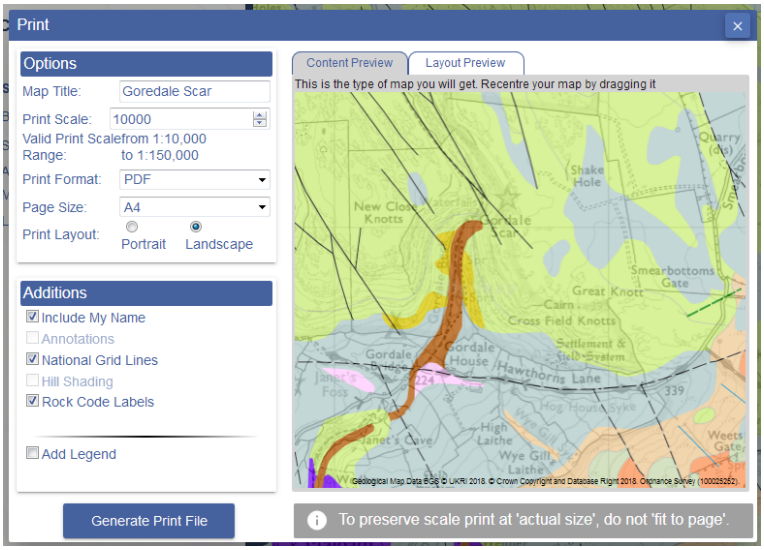


Figure 2.23: Geology print dialog

Other features of Geology Roam

In addition to the features listed above Geology Roam allows you to make annotations, measure distance and area, save and open maps, and save annotations to file in exactly the same way as Ordnance Survey Roam. See the notes in section 2.4.1 from page 15 for more information.

2.5.2 Geology Download

Geology Digimap also gives you the opportunity to download tiles of geological data to add to your own maps. We'll download some data now, but it is delivered in a format that has to be opened in a GIS program and you'll find out how to do that later in the workbook.

Video Clip available - The Digimap video on Geology Download is at `http://bit.ly/1xssnUC` (this video has sound), again, this refers to the older version.

- Click on the **Home** button in the top left-hand corner of the screen to return to the Digimap home page.
- Click on **Geology** in the menu at the top, then on **Geology Data Download** to bring up the map for selecting downloads.

Geology Download works in the same way as Ordnance Survey download, but of course, you have a different selection of layers to download. So start by selecting the area you require - using **search** and then the rectangle tool under **Draw** to outline the correct area.

Search for "Malham Cove" and outline a small area around that.

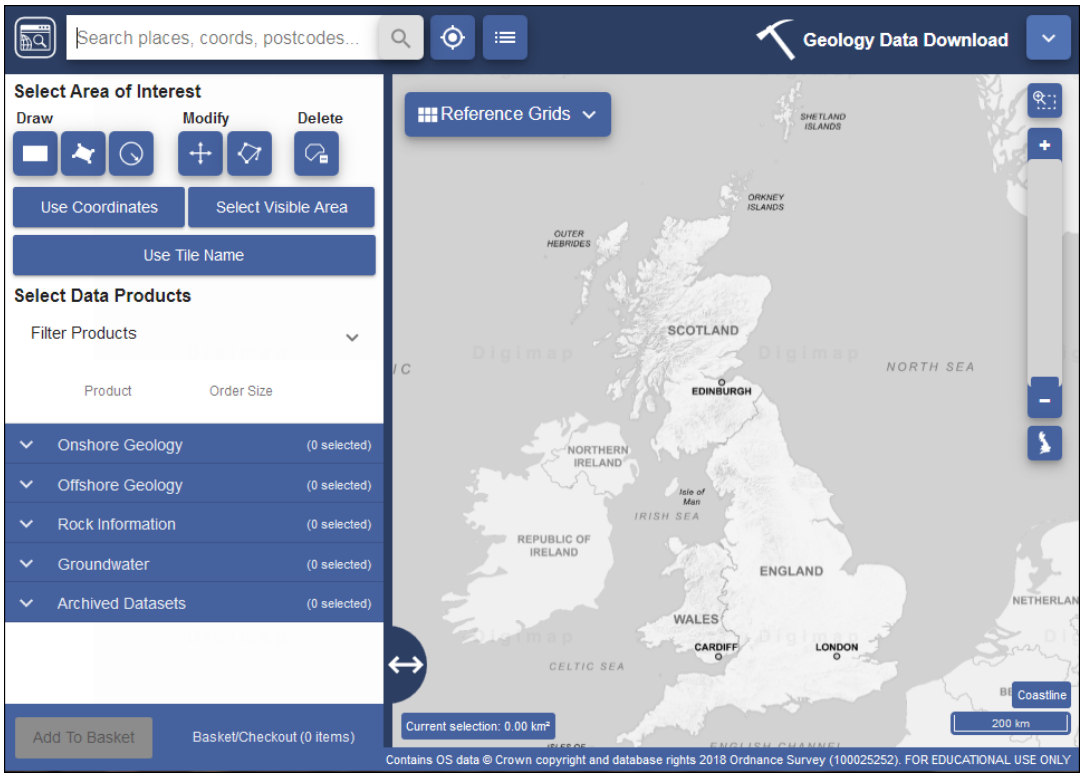


Figure 2.24: The Geology Download interface

You then need to select the data sets that you are interested in from the panel on the left. Usually you'll want layers from the **Onshore Geology** section.

To find out whether there is 1:10 000 or 1:25 000 coverage of the area that you are interested in click on the grid symbol next to the layer in the Selection panel.

If there is data available the tiles will then be highlighted and you'll be able to see the tile names too. If you've zoomed to Malham Cove there won't be anything visible.

Click on the grid icon next to 1:50 000 Geology, then zoom out. You should reach a point where you can see the outlines of the tiles of data.

Question 2.6. What is the Tile Name for 1:50 000 data at this location?

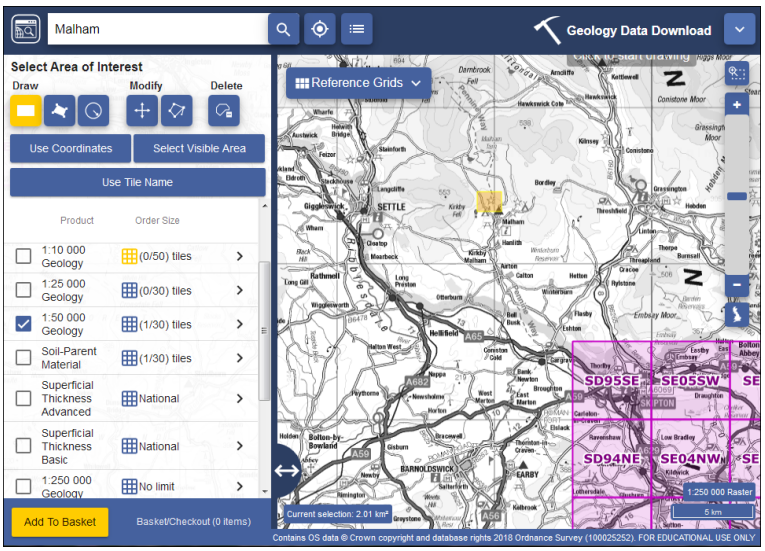


Figure 2.25: Finding out the availability of geological data: the shaded areas in the south east of the area around Skipton show 1:10 000 tiles which are available for this area. There is by no means full coverage of either 1:10 000 or 1:25 000

In this case

Select 1:50 000 Onshore data and don't forget to add it to your Basket. Once you've done that go to Checkout where you will be able to choose the format for your data, and when appropriate, the layers (figure 2.26).

The format choices will be either **SHAPE**, **MIFMID** or **TAB**. Shapefiles are opened in ArcGIS (and many other GIS programs) so once you have completed the rest of this module you will have the knowledge to open the downloaded files in Arc, but for now just be aware that the data is available. Mid/mif format opens in MapInfo - another GIS program which is also available within the university but which we won't be covering here.

2.5.3 Geological maps in the School of Earth and Environment

The geological maps that are available through Digimap are also available in paper form by speaking to Clare Gordon in the Kennedy Library (C.E.Gordon@leeds.ac.uk).

The paper geological maps still provide more information than the digital service, such as cleavage and bedding, and complete legends.

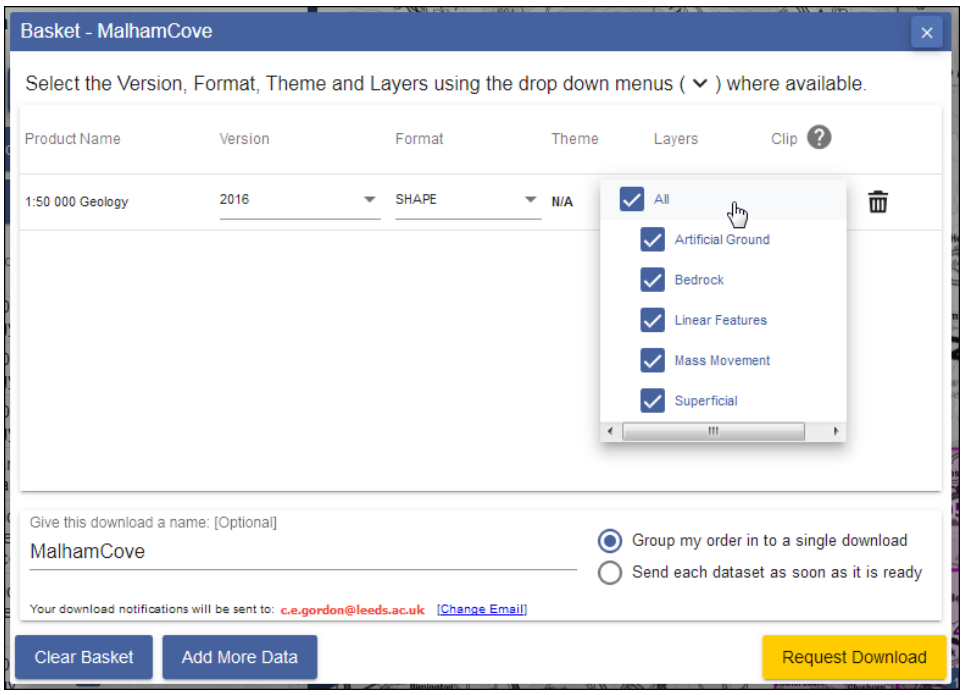


Figure 2.26: Format and layer options for downloading geological data

2.6 Aerial Digimap

Since 2016/2017 Digimap has given access to 25cm resolution aerial imagery from Getmapping. This is a fantastic resource and enables you to see a great deal of detail. It's well worth downloading imagery for your field areas. As in other collections in Digimap, you have a choice of Roam or Data Download and these work in a similar way, so refer back to the previous sections if you need a reminder, but there are inevitably some differences because of the different nature of the data.

2.6.1 Aerial Roam

From the Digimap home page click on the **Aerial** heading and then on **Aerial Roam**

The Aerial Roam map window is basically the same as the Ordnance Survey Roam window and the functionality is very similar so I won't go through it all here.

- Open the **Search...** menu and enter the University of Leeds postcode - **LS2 9JT** then click on **Search**
- You should be taken to a view which looks something like figure 2.27

Note that the imagery isn't available to browse at all zoom levels. Look at the bar on the right of the window (figure 2.27) and you'll see that the most zoomed out levels are labelled **OS**. As you zoom in closer the map will change to imagery.

Zoom in and out and move around the map to see what is available.

Opacity and viewing place names and roads

You can use the opacity slider at the top of the screen (above the zoom control) to allow the map to be shown through the aerial photograph.

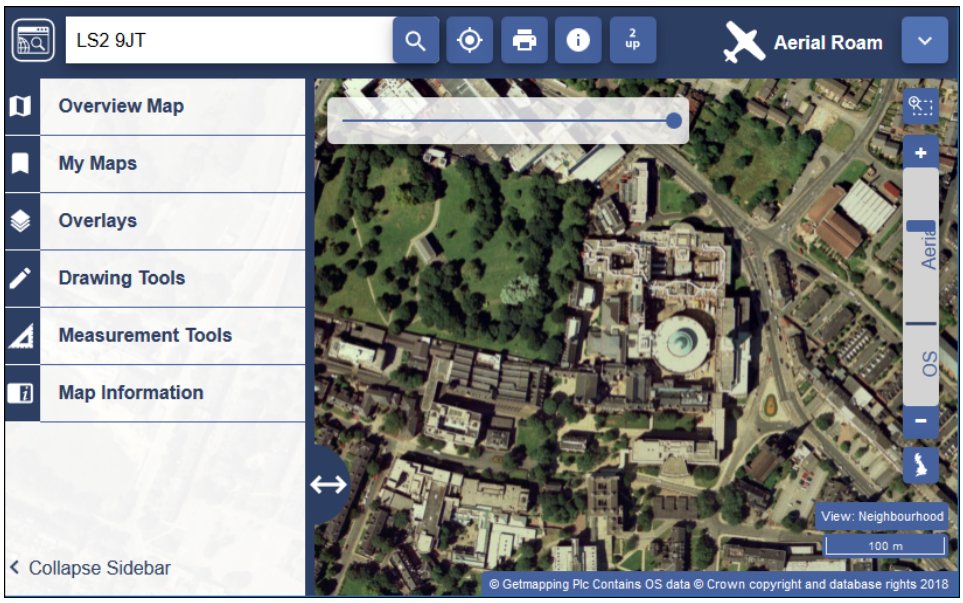


Figure 2.27: The Aerial Roam window

If you don't want to make the aerial layer transparent, but do want to be able to see the names of places and the roads, click on Overlays > Road/Place names in the sidebar. This is a toggle, so do the same again to switch the names off.

Finding the date of the imagery

If you have searched for **LS2 9JT** and are looking at a view of the University, move the map so that you can see the SEE building. There is a lot of building work going on around the University so it would be useful to know when the imagery was taken to have some idea of how much is likely to have changed since. To find out the date it was flown do the following:

- Click on the **i** for information button at the top of the screen (next to the Overlays)
- Now click somewhere on the map, close to the SEE building.
- You should be shown a panel with the Tile name, Date Flown and the eastings and northings of the location that you clicked - see figure 2.28

In 2000 the company Getmapping flew aerial imagery for the whole of the UK - which is extremely impressive given that they were obtaining high resolution, cloud-free data. For how many days in the year is the UK completely cloud free?

Most of the data available in Aerial Digimap has been flown much more recently.

Note that when you click on the map for information you are also shown a red outline for the tile that you have clicked on. You may need to zoom out and move the Tile Name dialog out of the way to see this.

Search for the following British National Grid easting and northing using the search box:

- ***289576, 812418***

Question 2.7. What is the Tile Name at this location, and on what date was the aerial imagery at this location flown? As a bonus, what town is this point within?

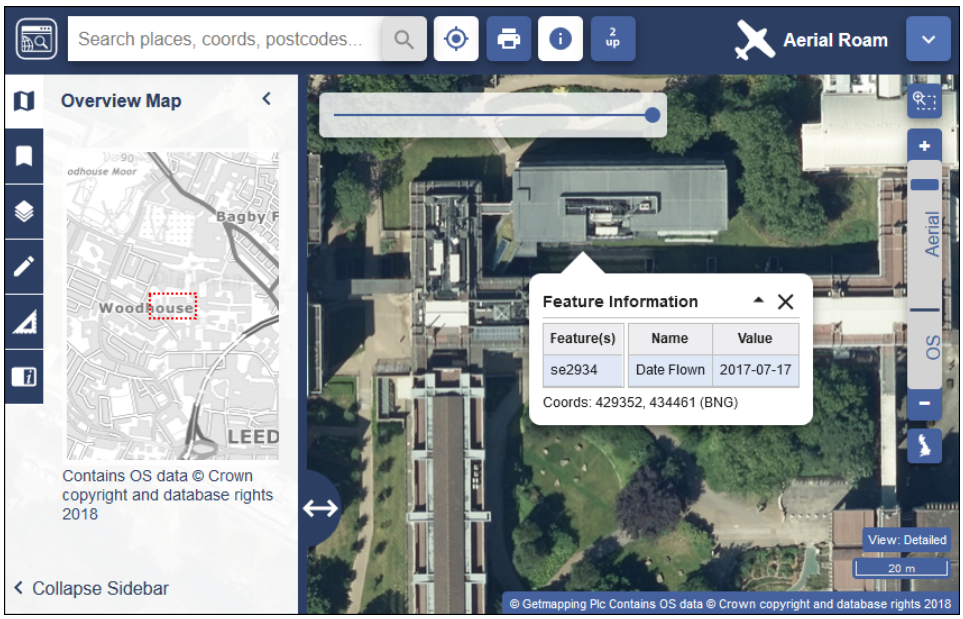


Figure 2.28: Information about the tile of aerial imagery, including the date that it was flown

2.6.2 Aerial Download

Return to **Digimap Home** and now select

- **Aerial** and **Aerial Data Download**

As with the other download interfaces the map that you see on the screen is only an indicator of the area that you will be downloading, it is not the actual data.

Use **Search** to go to British National Grid coordinates **254042, 271408**. You'll see that this is a coastal area of Wales with a rocky foreshore. Use the **Rectangle** tool to draw a rectangle around a small part of the rocky coast. These imagery downloads can be very large so for now just pick a very small area, at the bottom right of the map you can see the size of your current selection in km^2, try to go for something of about 0.25 km^2.

- Go to **Aerial Imagery (Latest)** in the panel on the left and put a tick in the box next to **High Resolution (25cm)**
- The number in brackets after this shows how many tiles you have selected to download out of the maximum of 100. If you have selected to download more than 4 files then I'd suggest that you outline a smaller area just for the purposes of this exercise.
- If you click on the arrow next to the dataset you are given more information about it, including the recommended copyright acknowledgement. Make a note of this and add it to any document or map that you create with this data.
- Now click on **Add To Basket** and give your download a name, then **Request Download**

This works in exactly the same way as OS and Geology download, so having requested the data you need to wait for an email which contains the download link. Once you have this, download the data, move it to your M: drive and **unzip it** (Right-click on the zip file - 7-zip > Extract here).

View the files in ArcGIS

You can open the jpg files in a graphics editor if you want a quick look at them, but for our purposes it makes more sense to add them to a map.

- Open ArcGIS, set up a new map and add the jpg file(s) that you have downloaded.
- You should be able to zoom in on an area of the rocky coast and have a look at the amount of detail that is available
- The files are georeferenced so can be used alongside map tiles from Digimap Ordnance Survey download
- If you are using this in a map for coursework or your dissertation, or indeed for showing to anyone else, don't forget to add the correct copyright acknowledgement.

Using aerial imagery for fieldwork

If you are setting up a map for geological fieldwork in an area of the UK it is well worth downloading this data and creating a set of aerial images too. Data may be available for other countries but it won't be downloadable via Digimap. If you can't find any aerial imagery for your area try searching for **World Imagery** in ArcGIS Online or the basemaps and add that to your map. It won't be as detailed as 25cm resolution, but will be better than nothing.

2.7 Printing and editing PDF files

2.7.1 To print

PDF files can be viewed and printed in any PDF reader, such as Adobe Acrobat Reader.

- From **My Computer** double-click on the pdf file and it should open automatically in the default reader.

For your own computer there are a lot of different programs that will read PDF files. See the list at

`http://en.wikipedia.org/wiki/List_of_PDF_software#Viewers_4`[4]

2.7.2 To edit

PDF files can be edited in Adobe software such as Photoshop and Illustrator, and in CorelDraw. It is also possible to edit files in Inkscape. Open the file as follows -

- File > Open > OK.

[4] Last accessed: 17th September 2019.

2.8 Copyright acknowledgements for Digimap data

Copyright is important. Remember that most data providers ask you to sign up to conditions that include an obligation to add a copyright acknowledgement to your map. Check what that copyright statement is and add it.

e.g. when you signed up to use the Digimap collections you agreed to add copyright acknowledgements whenever you created a map with the data. These do change from time to time so it's worth knowing how to check it for yourself.

- To find these copyright acknowledgements go to the **Digimap Resource Centre** (**Resources** at the top of the main Digimap page)
- Look for a link to **Digimap Licence Agreements** and click on it.
- Click on the End User or Sub-licence agreement for the data that you've used
- then look for the information under **In return, you must:** - that gives you the acknowledgement text.

For example, as of April 2019 when you use Ordnance Survey data obtained from Digimap you are expected to add the following text to your map.

> ***© Crown copyright and database rights*** `year`***. Ordnance Survey (100025252).***

Where *year* is replaced by the current year.

Remember that you do have to acknowledge each different dataset that you use and will have signed up to that when you registered.

Adding the copyright symbol to your text

To add the **copyright symbol** - ©- to your text

- check that the Num lock is on on the keyboard
- hold down the Alt key
- use the number pad to type 0 + 1 + 6 + 9
- release the Alt key

Table 2.1: Adding the copyright symbol to your text

If you are *not* using U.K. Ordnance Survey data this is **not** the correct copyright acknowledgement to use, for example if you are using data for Spain or the United States, or indeed UK data that you haven't downloaded from Digimap. You'll need to find the correct copyright acknowledgement for yourself. The web page[5] at `http://bit.ly/1ZSifnd` gives some information about how to cite GIS materials - including the software as well as the data. Have a look at that and follow the suggestions to cite non-Digimap data.

Advice on citing Digimap data, as opposed to the copyright acknowledgement is at `https://digimap.edina.ac.uk/webhelp/resources/citation/services.html`

[5] Last viewed: 18th September 2018

2.9 Further help with Digimap

2.9.1 Additional Digimap collections

This booklet has only covered the basic collections from Digimap. The University of Leeds also subscribes to Geology, Aerial, Historic and Environment collections.

All of the collections have a Roam and a Data Download interface which work in a similar way to the examples you have used.

You have access to all of these collections, feel free to have a look at what is available and make use of any of the data or maps in your work.

2.9.2 Digimap Collections online help

Digimap help is available from both the Digimap Ordnance Survey and Geology home pages. Click on the links in the left hand menu for more information about how to use the services and file formats.

Alternatively use the Help links from within Roam or Download or use the videos that Edina have uploaded to YouTube at -

`http://www.youtube.com/user/EDINADigimap`[6]

If you want more detailed information Edina provide e-learning units which are linked from the main Digimap home page.

2.9.3 School of Earth and Environment

Clare Gordon can provide help and advice on using Digimap. Contact her in room 10.140b at the back of the Kennedy Library or on **c.e.gordon@leeds.ac.uk**.

The most up to date edition of this workbook will be available in Minerva for those modules on which it has been used.

[6] Last accessed: 29th August 2019

Chapter 3

Creating data for GIS: Point data and GPS

3.1 Learning outcomes

When you have completed this section you should be able to

- collect your own spatial data for use in GIS
- discuss the problems that can affect data for GIS
- suggest ways in which to minimize error and uncertainty in spatial data

3.2 Introduction

The previous chapters should have given you some idea of the variety of data that is available for you to use, but there is nothing to replace going out and collecting your own data and it is very likely that you will be using GPS units for fieldwork at some point.

In this chapter you will collect waypoints using a GPS unit. Once you have collected waypoints you will look at how to import the data from the GPS units into ArcMap.

Waypoints collected using a GPS receiver can be downloaded and opened in ArcGIS in a variety of ways depending on the software provided with your receiver. Instructions in this section will of necessity be vague in places as it is impossible to know about every combination of hardware and software. You may need to use instruction booklets and help files provided with your setup.

If you are new to GPS and would like to find out more about the background and technology there are beginners guides at:

Garmin:

`http://www8.garmin.com/aboutGPS/index.html`[1]

Ordnance Survey:

`http://bit.ly/1cPJkCw`[2]

3.3 Prerequisites

- GPS receiver with cables to connect to computer
- **OR** GPS enabled mobile device either with cables to download data or wifi connection.
- Base map - these instructions will show you how to use ArcGIS Online as a base, but use the most suitable base map for your area.

[1] Last visited: 18th September 2018
[2] Last visited: 18th September 2018

3.4 Collecting data with a GPS

You will be divided into small groups. Each group will have a GPS unit (probably a Garmin eTrex 10), a brief quick start guide and a fieldslip (see section 3.12). The official Quick Start manual for the Garmin eTrex 10 is available online[3] at

`http://static.garmincdn.com/pumac/etrex_10_QSM_EN.pdf`

3.4.1 Setting up the GPS

This is best done once you are outside and the gps can find satellite signals. Wait for me at the location I tell you, and we will check that you all have a gps which works, and know how to do the basics before you continue with the exercise.

You will be given a quick reference sheet which you can take outside with you to use during the exercise.

Take a short while to familiarise yourself with the GPS and work out how to add waypoints (use the quick reference leaflet to see how to do the basics). Please ask if you can't work anything out.

- Start by turning the GPS on!
- Use the thumbstick to navigate the menu. Press it to select.
- Use the **Waypoint manager** to delete all existing waypoints (hint: use the **Menu** button!)
- Use the **Track manager** to clear the current track
- For this exercise go to Setup » Position Format and check that the format is as follows:
  - **Position format:** British Grid
  - **Map Datum:** Ord Srvy GB
  - **Map Spheroid:** Airy
- If the position format isn't correct, reset it.[4]
- Check that you know how to record a **Waypoint**

Now you should be ready to go.

3.4.2 Collecting data: warnings

Accuracy

It is possible check how many satellites your GPS receiver can see (**Satellite** in the initial menu). The more satellites there are within view, the more accurate your readings will be.

When you get outside, keep an eye on this from time to time.

[3] Last visited: 18th September 2018

[4] It is often best to have the coordinate system set to the same as a paper map that you are using in the field. If this isn't possible set the format to WGS84, which is a standard geographic coordinate system and can be **transformed** into another system later:

- **Position format:** hddd.ddddd degrees
- **Map Datum:** WGS84
- **Map Spheroid:** WGS84

Figure 3.1 shows the satellite information screen on the eTrex 10. In this case it is showing that it has picked up four of the satellites that it is expecting, although it only has a full-strength signal from three of them. The accuracy is +/- 34 m, hopefully yours will be better than that!

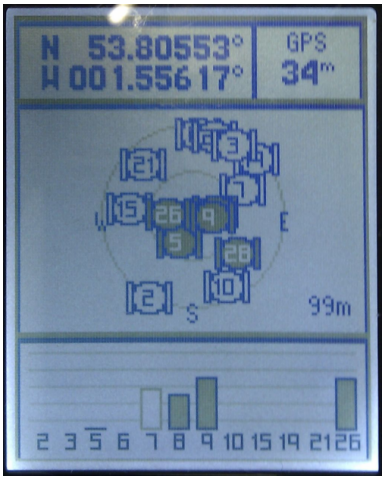


Figure 3.1: Garmin eTrex 10 satellite information screen

Make a note on your sheet of the number of satellites that there are in view when you first switch on the GPS and of the stated level of accuracy which should be in metres (ask for help if it is in feet).

The general advice is to turn on your GPS well in advance of starting to work, and leave it on for the whole of the working day. This gives it a chance to find and track the maximum number of satellites. Even under ideal conditions, when your receiver has found several satellites, due to the nature of the system accuracy still won't be 100%. Under **Satellite** you should be able to find out what the current level of accuracy is - it will be a measurement in metres. Be aware of this when using the readings. According to the O.S. website "Positional accuracy with a single receiver, to civilian users approximately equals 5 m to 10 m, 95% of the time." [5]

It is particularly worth noting that GPS data can give an *illusion* of extreme accuracy. The readings tend to show figures with lots of decimal points which could lead you to assume that a reading is accurate to 1 m or less. Given the statement above that is very unlikely to be the case.

For this reason it is still important to know how to locate yourself accurately on a paper map without the use of GPS, and most navigation experts will say that with practice you can be far more reliable and accurate than a GPS unit. Not least, you should have the intelligence to recognise when the point where you are standing is at the top of a cliff, not off it!

Elevation

Don't use elevation measurements from your GPS. For various reasons obtaining accurate height readings with GPS is much more difficult than obtaining accurate horizontal readings. The OS website has an explanation of how best to do this, but it involves specific equipment and readings taken over at least 24 hours.

3.4.3 Data to collect

Go out to the area indicated in the class (probably Chancellors Court or St Georges Fields) taking a copy of the data sheet or map with you and collect a series of point readings. You will be

[5] `http://bit.ly/1cPJkCw` [Last accessed: 18th September 2018]

given a time limit - try quickly to collect points which are spread out across a fairly wide area. When you are doing field work you will collect data in your field notebook and/or on a field slip but for now mark items on the field slip provided.

Suggested features to take a reading for are: Trees; Seats; Rocks; Rubbish bins; Memorials; Sign posts; Planters; Maps. But add any other features that you think are appropriate.

Fill in the fieldslip with the number of the waypoint, and the type of feature, e.g. seat.[6]

Make sure that every member of the group has a turn with the GPS and try to work quickly and efficiently.

Once you have at least the recommended number of points, return to the computer cluster and continue following these instructions to download the data.

3.5 Downloading files from the GPS

Start from here once you get back into the cluster from collecting data.

To download data directly from the GPS unit you will have a USB lead (if you're in class you should sign one out from the demonstrator).

- Connect the USB lead to a USB port on the computer.
- Lift the "weather cap" from the port near the top of the back of the gps unit and plug the other end of the USB lead in to that
- The gps unit should appear as a removable drive in **My Computer**
- navigate to `Garmin`▸`GPX` and download the gpx (gps exchange format) file - `Waypoints_`*`current_date`*`.gpx`

You won't be able to open the file directly, but **copy it to your working folder** so that you don't lose it when you remove the gps.

Make sure that every member of your group has a copy of the gpx file on their own drive so that you can all work through the remaining exercises independently.

When you've finished make sure that the gps is turned off - the batteries are not rechargeable!

3.6 Converting gps files for ArcGIS

Before you start this exercise check that you have set the links from ArcMap to datafiles to relative - see section 1.7.1 on page 9 for a reminder on this and how to deal with broken links (the little red exclamation mark).

Video Clip available in Minerva - Converting gps files to display in ArcMap. Direct link:`http://bit.ly/2fY3bd7`

3.6.1 Converting with the Conversion tools

Methods of converting gpx files in Arc appear to change with each version. This method should work with version 10.4 and above. If it doesn't, or if you are on version 10.3 or another lower version try the instructions in section 3.6.2 on page 44 instead.

The simplest way to convert gpx to feature class is to use the **From GPS** tool.

- Open ArcMap and begin by having a look at the properties of the gpx file in the Catalog panel - right-click on the file and select Properties
- In particular check the XY Coordinate System and make a note of how it is set in the box below.

gpx file coordinate system:

If the XY coordinate system is `<unknown>`, which it probably is, you'll need to work out what the coordinate system actually is.

Open the gpx file in a text editor such as Notepad or Notepad++ (right-click on the file in the windows file explorer and Open with... . You may need to set the text to wrap around if the whole thing appears on a single line - in Notepad++ go to View > Word wrap.

It will look rather confusing - this is a form of xml - but don't panic! Look for a line that begins `<wpt lat= ...` (see figure 3.2). This line shows the **latitude** and **longitude** of a waypoint and demonstrates that, even if your gps unit was set to British National Grid, for example, a gps unit will still **store** the data in a coordinate system called **WGS84**.

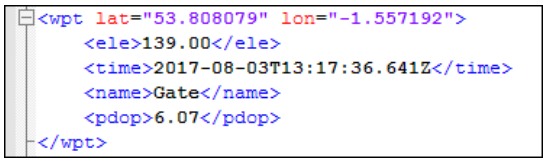


Figure 3.2: This is how a waypoint looks in Notepad++ - note the line beginning **<wpt lat=** . Also note that the coordinates will be in lat and long even if you had the GPS unit set to British National Grid.

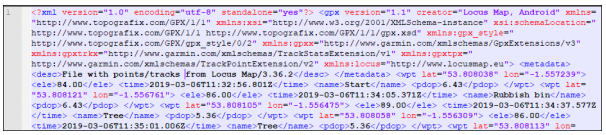


Figure 3.3: This is the same file as figure 3.2 but with all of the data on one line. It's harder to see what is happening, but the information is the same. Just look for **<wpt lat =** still.

So if the coordinate system of your file was `<unknown>`, write **WGS84** in the box above where you wrote the gpx file coordinate system previously.

You'll use one of the tools in **ArcToolbox** to convert the gpx file. ArcToolbox gives you the opportunity to do a lot of very advanced processing tasks without needing to use a command-line interface.

[6] It is possible to use the GPS unit to add notes, such as the type of feature, to each waypoint, but the GPS doesn't have a touch keyboard and entering text is very long-winded and fiddly. It is much easier to collect the points on the GPS, make notes on paper, then add the notes to the data on computer.

- If the toolbox isn't already open find it by going to Geoprocessing > ArcToolbox. Be patient, it can be slow to open - it should look something like figure 3.4 once it does.
- Open Conversion Tools > From GPS and double-click on GPX to Features to open the tool (figure 3.5).
- Fill in your **Input GPX File** and then click on the folder symbol next to **Output Feature class** (remember - never try to save to the Default geodatabase - it almost always crashes)
- You can either just navigate to your folder and then type in a name such as `Waypoints` or you can add the data to an existing geodatabase
- Click Save > OK

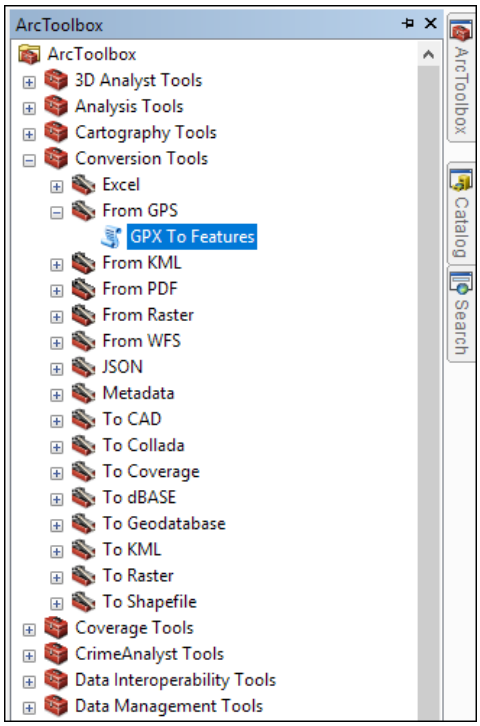


Figure 3.4: ArcToolbox - showing GPS to Features selected

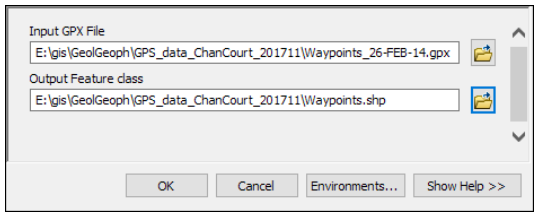


Figure 3.5: The filled in GPS To Features tool

The tool should run and add a point feature class to your blank map.

3.6.2 Converting with the Data Interoperability tools

> ***If you have already converted your gpx files in section 3.6.1 on page 43 go straight to section 3.7 on page 46.***

Methods of converting gpx files in Arc appear to change with each version. This method should work with version 10.3.1. If it doesn't, or if you are on version 10.4.1 try the instructions in section 3.6.1 on page 43 instead.

The simplest way to convert gpx to feature class is to use the **Data Interoperability Quick Import tool**.

- Open ArcMap and begin by having a look at the properties of the gpx file in the Catalog panel - right-click on the file and select Properties
- In particular check the XY Coordinate System and make a note of how it is set in the box below.

gpx file coordinate system:

NOTE: If the XY coordinate system is actually `<unknown>` you'll need to know the system that the gps was set to - in this case it should be **WGS1984** as that is standard for gps files.

You'll use one of the tools in **ArcToolbox** to convert the gpx file. ArcToolbox gives you the opportunity to do a lot of very advanced processing tasks without needing to use a command-line interface.

- If the toolbox isn't already open find it by going to Geoprocessing > ArcToolbox
- Once in the toolbox double-click on Data Interoperability Tools > Quick Import
- Click on … next to **Input Dataset:**
  - Set format to gpx by clicking on … next to **Format** and searching for **gpx** in the box at the bottom left, then selecting **GPS eXchange Format(GPX)**.
  - Click on … next to **Dataset:** to navigate to your gpx file and open it
  - Click on … next to **Coord. System** to set it to WGS84 (or whatever coordinate system your gps was set to - see the note you made above) - For WGS84 look for Geographic Coordinate System > World > WGS1984
  - OK - see figure 3.6
- OK
- Now click on the folder symbol next to **Output Staging Database** to set where you want to save your data. **Don't save it to the default location as it will almost inevitably crash!**

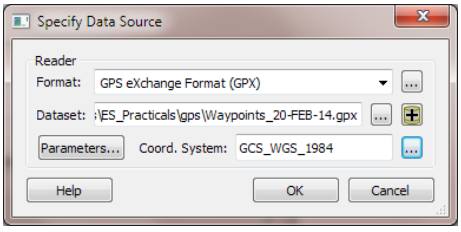


Figure 3.6: Selecting the data source to import

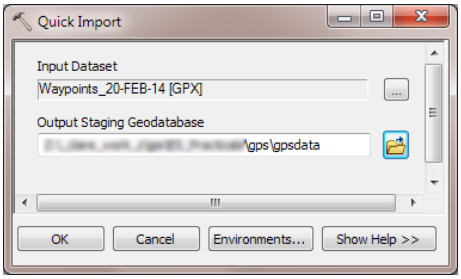


Figure 3.7: The Quick Import dialog

Your input dialog should look something like figure 3.7.

- Click OK to run the conversion.

Check in the Catalog panel to make sure that you have a new geodatabase with the name that you gave it under **Output Staging Database**, and which contains a feature class which will probably be called something like **Waypoints**.

3.7 Add waypoint data to ArcMap

Before adding your data to a map you need to stop and think about coordinate systems - the coordinate system of your data needs to match the coordinate system of your map.

If you followed the instructions for converting your gpx file with the Conversion tools or the Data Interoperability tools then the coordinate system will be **WGS1984** (you should have made a note of it in section 3.6.2 on page 44). We'll start by adding the data to a map with that coordinate system.

- Add your converted Waypoints feature class to the map, if it hasn't been added automatically.
- Check the coordinate system of the data frame (double-click on the data frame title (usually **Layers**) to open the properties, then go to the **Coordinate System** tab) - it should be WGS84. If it isn't, set it to that now (`Geographic Coordinate Systems▸World▸WGS84`)
- also check that the waypoints are set to WGS84 by going to the layer properties and looking for the **Geographic Coordinate System** heading under **Source**. If that says `<unknown>` you'll need to set the projection:
  - use the toolbox to **Define** the projection of the Waypoints feature class to WGS84. (Toolbox ⟩ Data Management Tools ⟩ Projections and Transformations ⟩ Define Projection and set the **Coordinate System** to `Geographic Coordinate Systems▸World▸WGS84`)

3.7.1 Adding a background map from ArcGIS Online

As a quick way of setting up a background map we'll use a dataset provided by ArcGIS Online. There are a lot of maps available this way and although they have some limitations it can be a useful way of creating a map.

Warning: adding online data can slow Arc down significantly, or cause it to crash completely. If you are having trouble with a map try removing any online layers.

Video Clip available in Minerva - Adding data from ArcGIS Online.
Direct link: `http://bit.ly/2sp41oY`

- File ⟩ ArcGIS Online…
- Search for **Imagery** in the box at the top and from the layers that appear choose **World Imagery**. Make sure that you choose the layer package (see figure 3.8) - if the button for the layer says Open rather than Add then look for another similar layer! **Add** the layer to your map.

Be patient while the layer loads. If it won't load and complains of lack of memory you will need to close ArcMap and open it again - the previous operations will have been fairly memory intensive!

Because the map uses the coordinate system WGS84, which is also the coordinate system for data in ArcGIS Online, you shouldn't get any error messages or warnings.

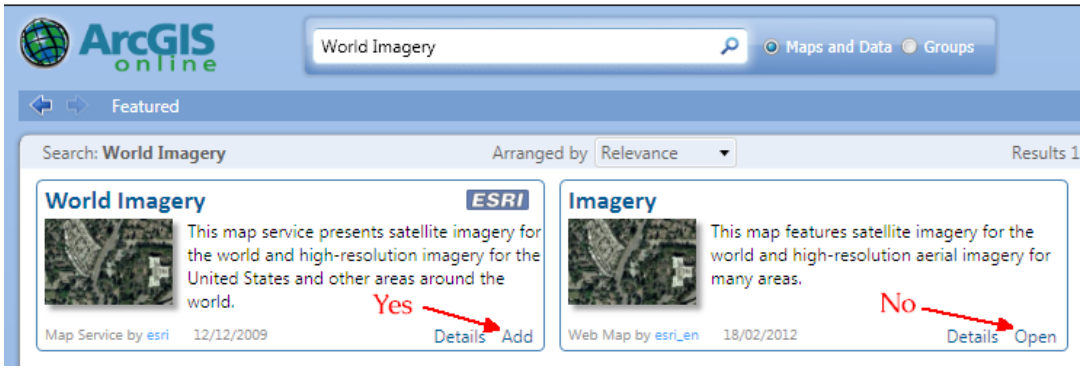


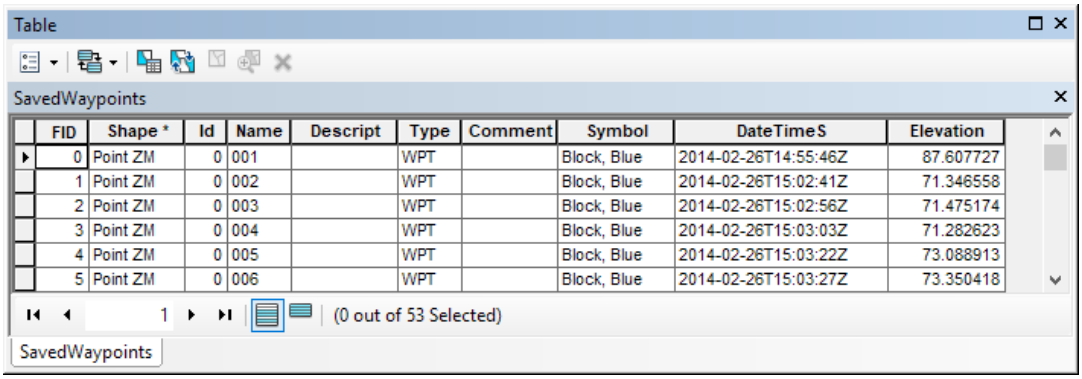
Figure 3.8: Adding imagery from an ArcGIS Online layer package

Have a look at your map and zoom in and out a bit. Take particular note of where your gps points are. How accurate do you think the locations are? What problems can you spot based on your memory of collecting the data? How do you think you could increase accuracy of data collection?

3.7.2 Adding extra data to feature classes

Have a look at the attribute table of the new layer

- right-click on the layer in the table of contents
- select Open Attribute Table. It should look something like figure 3.9



FID	Shape *	Id	Name	Descript	Type	Comment	Symbol	DateTimeS	Elevation
0	Point ZM	0	001		WPT		Block, Blue	2014-02-26T14:55:46Z	87.607727
1	Point ZM	0	002		WPT		Block, Blue	2014-02-26T15:02:41Z	71.346558
2	Point ZM	0	003		WPT		Block, Blue	2014-02-26T15:02:56Z	71.475174
3	Point ZM	0	004		WPT		Block, Blue	2014-02-26T15:03:03Z	71.282623
4	Point ZM	0	005		WPT		Block, Blue	2014-02-26T15:03:22Z	73.088913
5	Point ZM	0	006		WPT		Block, Blue	2014-02-26T15:03:27Z	73.350418

Figure 3.9: The attribute table for the converted gps data

Amongst many other attributes there should be one for **Name** which should include the label or name of each waypoint as stored by the GPS unit. There is a set of important information missing from this file, though. What do you think it is?

Hopefully you spotted that you still need to add the details of each feature to the shapefile, i.e. what type of feature it is, such as seat or signpost. You should still have a copy of this information. This is the point at which you add that information to the attribute table but first you need to add a new field.

Adding a new field to a feature class

This can also be referred to as adding a new column or a new attribute field.

Video Clip available in Minerva - Adding a new field to a feature class.
Direct link: `http://bit.ly/2fYVbZE`

- Within ArcMap, with editing off and ArcCatalog closed...
- Right-click on the layer title - e.g. **Waypoints**.
- Open Attribute Table click on the Table Options button in the top left of the attribute table window Add Field...
- Fill in the form (see figure 3.10) by typing **FType** in the **Name** field[7]; change the **Type** to **text**; change the **Length** to 75 OK
- Close the attribute table.

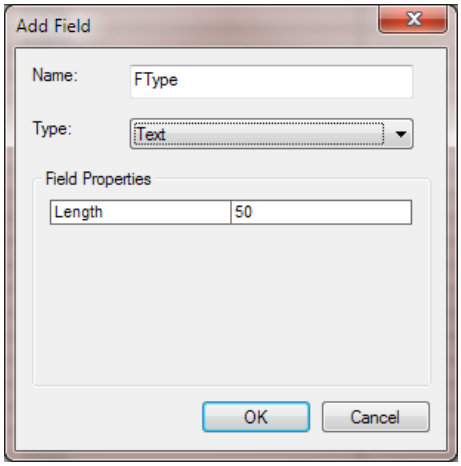


Figure 3.10: Add Field dialog

Problems with adding fields to feature classes crop up rather regularly, usually it is possible to get around them by using the tips in table 3.1 on page 49.

3.7.3 Adding feature attributes to a feature class

Now you're ready to add information, or **attributes**, to your new field.

- Start an edit session by doing the following
  - open the Editor toolbar by going to Customize Toolbars and clicking so that there is a tick next to **Editor**
  - right-click on the waypoints layer in the Table of Contents and select Edit Features Start Editing
- Open the attribute table for the waypoints feature layer (right-click on the layer then Open Attribute Table)

[7] Field names are restricted to 8 characters and cannot have any spaces. `FType` is a contraction of `Feature Type`

Getting around problems when adding fields to feature classes
Sometimes when you try to add a field to a feature class you'll get an error message saying that the field is already in use. This will prevent you adding a field. The first thing to check is that you are not in an edit session. If you are sure that you are not and it still isn't working, try the following: • If you are using the Catalog Panel in ArcMap then close ArcMap completely. • Open ArcCatalog and go to the feature class to which you want to add a field. • Right-click and open **Properties** • Go to the **Fields** tab. • Use the boxes there to add as many new fields as you need to add. If you are having problems with creating fields in ArcCatalog, then do the reverse - close ArcCatalog, Open ArcMap, and use the Catalog panel to add new fields.

Table 3.1: Getting around problems with adding fields to feature classes

- Click in the first box - check that the `Name` field matches the number in your notes, and add the type of feature. Try to be consistent, so all features of the same type have exactly the same text - check spelling and if you use upper case to start one, use it for all.
- go through the list and add all the feature types, see figure 3.11.
- then save your edits and close the edit session - using the Editor toolbar Editor > Save Edits then Editor > Stop Editing.

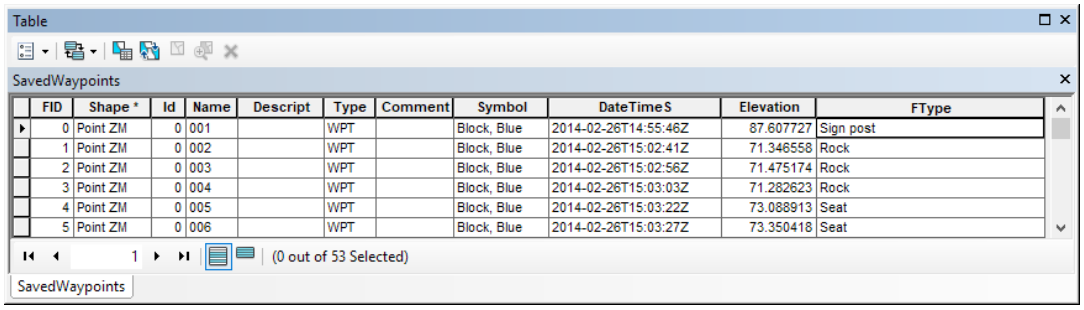


Figure 3.11: The attribute table for the converted gps data with the feature type added manually

Video Clip available in Minerva - Adding feature attributes to a feature class. Direct link: `http://bit.ly/2fYFMZ5`

3.8 Symbolising a layer

So far you have a single coloured dot representing every point. Your map would be much more informative if each type of feature had it's own symbol.

Open the attribute table for your new point feature layer again and have another look at the data that it contains. In the previous section you created a column called **FType** or something

similar and added attributes to show what type of feature each record contained. In Arc it is easy to colour, or **symbolise** the features so that you can differentiate what they refer to.

- Close the attribute table.
- Right-click on your point layer and click on **Properties**
- Go to the **Symbology** tab

Video Clip available in Minerva - Symbolising a layer by categories in ArcMap. Direct link: `http://bit.ly/2ePRqVG`

At the moment the layer is symbolised as a single symbol - a single random colour which is used for all features.

- Select **Categories** in the list on the left of the properties dialog
- then select **Unique Values**
- in the **Value Field** box that appears select **FType** - or whatever you called the field that you added attributes to.
- click on Add All Values

You should find that you get a list of the values of FType to which Arc will have assigned random coloured symbols - figure 3.12.

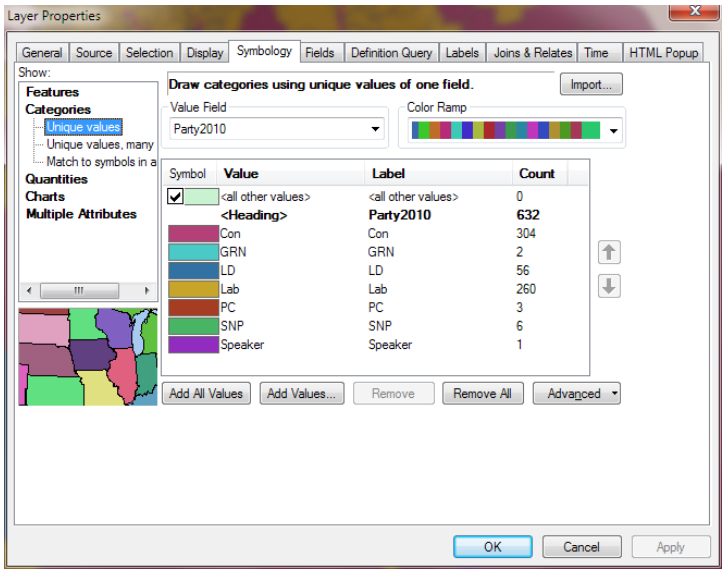


Figure 3.12: Setting symbols for a layer with multiple categories

- You can change the symbols by double-clicking on each symbol in turn - have a go now. If you search through the possible symbols in the symbol selector you may find appropriate symbols for rocks, plants etc.[8] Use the Style References button to add further selections of symbols.
- Click on Apply to see the result and OK when you are happy with it.
- You may find it easier to see what you are doing if you turn off the base map layers.

[8] Note that the search facility doesn't always work in cluster machines - you may have to browse the possibilities instead.

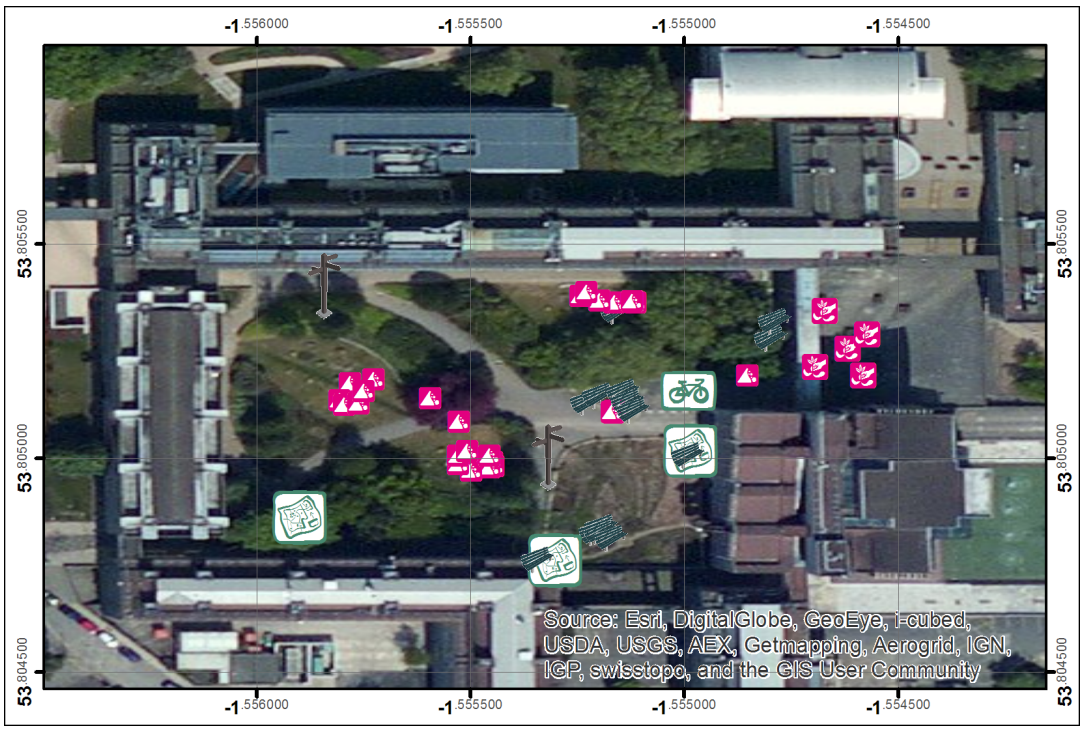


Figure 3.13: An example of symbolised waypoints for Chancellors Court (WGS84 coordinate system)

3.9 Data frame reference scale

When you print your map you will want the symbols and labels to be a particular size at a particular scale. If you set a **data frame reference scale** to the scale at which you are intending to print the map then you can set the size of the symbols and labels at this scale.

Question 3.1. Zoom in to 1:500 and then zoom out to 1:25 000. What happens to the size of the symbols you have just created when you zoom in very close or zoom out?

- Scale the map to the scale that you will be printing it at by using the **scale drop down** on the standard toolbar. In this case set the scale to **1:1 000** (you can just type **1000** into the box).
- Right-click on the **data frame title** (Layers) in the table of contents.
- Reference Scale > Set reference scale. Arc will set the reference scale to the current map scale.

Question 3.2. Zoom in to 1:500 again - what happens to the size of the labels now? And what happens to them when you zoom out to 1:25 000?

When you use the symbology settings to set the size of your symbols now, you will be setting the size that they print out at your reference scale. You may find that you do need to resize the symbols so that they don't look to crowded once you have set this.

- To remove the reference scale completely use Reference Scale > Clear Reference Scale.
- To change a reference scale set your map to the correct scale then use Reference Scale > Set Reference Scale again.

3.10 Changing the coordinate system of data

The GPS data that you have collected is in the WGS84 geographic coordinate system, but often you will need to use the data in a local projected coordinate system. The obvious example is if you are using Ordnance Survey maps from Digimap in the same project. This is the example that we'll use now, but the same situation can arise if you are, for example, mapping in Spain or Eire.[9]

- Open a new blank map in ArcMap and add the **LocationBNG** shapefile that you can download from Minerva as **GPS_data_GPMet.7z**. Remember that the first layer that you add to a data frame automatically sets the coordinate system.
- Save your new map as **UniversityBNG** - the "BNG" indicates that it is in **B**ritish **N**ational **G**rid.
- Add the **se2934.tif** layer from the downloaded data to your map.
- Now try adding your **Waypoints** layer. What happens?

You should get a warning which looks something like figure 3.14.

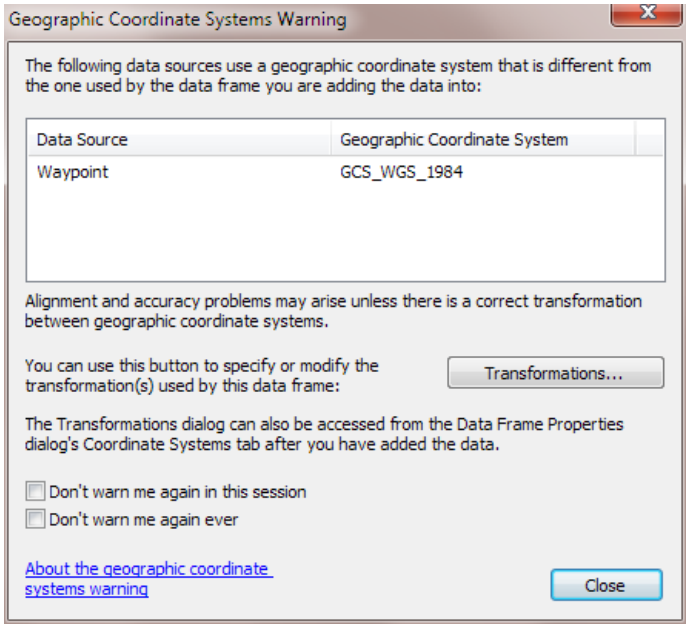


Figure 3.14: Geographic Coordinate System Warning

This is telling you that the data that you are adding to the map is not in the same coordinate system as your map, so Arc can't add it in the correct location without some extra information

Video Clip available in Minerva - Transforming the projection of data "on-the-fly". Direct link: `http://bit.ly/2fYQtLg`

from you. You need to tell ArcGIS that you want to **project on-the-fly** so that the WGS layer appears in the same space as the map and data that has already been projected to British National Grid.

- Click on Transformations...
- Set the Transformations dialog so that your selections are as in figure 3.15 with the top box being the GCS to convert from[10].
  - **Convert from:** GCS_WGS_1984
  - **Into:** GCS_OSGB_1936
  - **Using:** OSGB_1936_To_WGS_1984_Petroleum
- OK > Close

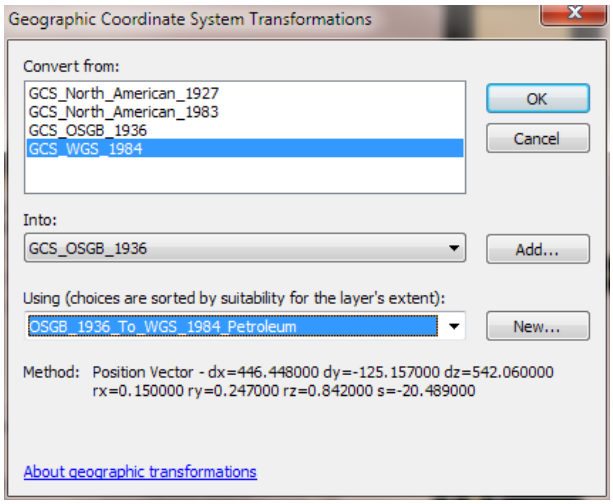


Figure 3.15: Transformations dialog

Even if you don't get a warning, don't assume that all is well! The **Location** feature class should outline an area around where you collected data. If it doesn't you need to check that transformations are set up correctly.

The layer should be added to your map and appear in the correct position. This method of projecting a layer is only temporary.

- Open the data frame properties
- Go to the **Coordinate System** tab and click on the Transformations... button
- from there select to transform WGS84 to OSGB1936 using the Petroleum option as in the previous instructions.

[9] If you want to find out more about coordinate systems and projections have a look at Heywood (2006) pp. 44-51 for a general introduction. The books in the Coordinate systems and projections section of the module reading list give more detailed information.

[10] If you want more information about what you are doing here try clicking on the **About geographic transformations** link at the bottom of the dialog.

If you want to project a layer permanently, particularly if you want to do analysis on it, you have to use the **Project** tool which you find from Toolbox > Data Management Tools > Projections and Transformations. There are separate tools for feature classes and raster layers, in this case you would select Feature > Project

Video Clip available in Minerva - Reprojecting a feature class with the toolbox. Direct link: `http://bit.ly/2fYCPYv`

3.10.1 Adding data from ArcGIS Online

Once again add an Imagery layer from ArcGIS Online as you did in section 3.7.1 on page 46. You should find that you get the Geographic Coordinate System warning again, and again you'll need to **Transform** the layer to British National Grid to be able to use it on your map.

Be aware that adding layers from ArcGIS Online can slow ArcGIS down a lot. If Arc crashes because of this all you can do is remove the ArcGIS Online layer. In this case - speak to staff or demonstrators to obtain an alternative dataset.

Look at both maps in turn and it should become obvious that changing the projection doesn't just have an effect on how your layers line up with each other, but also on the "shape" of your data.

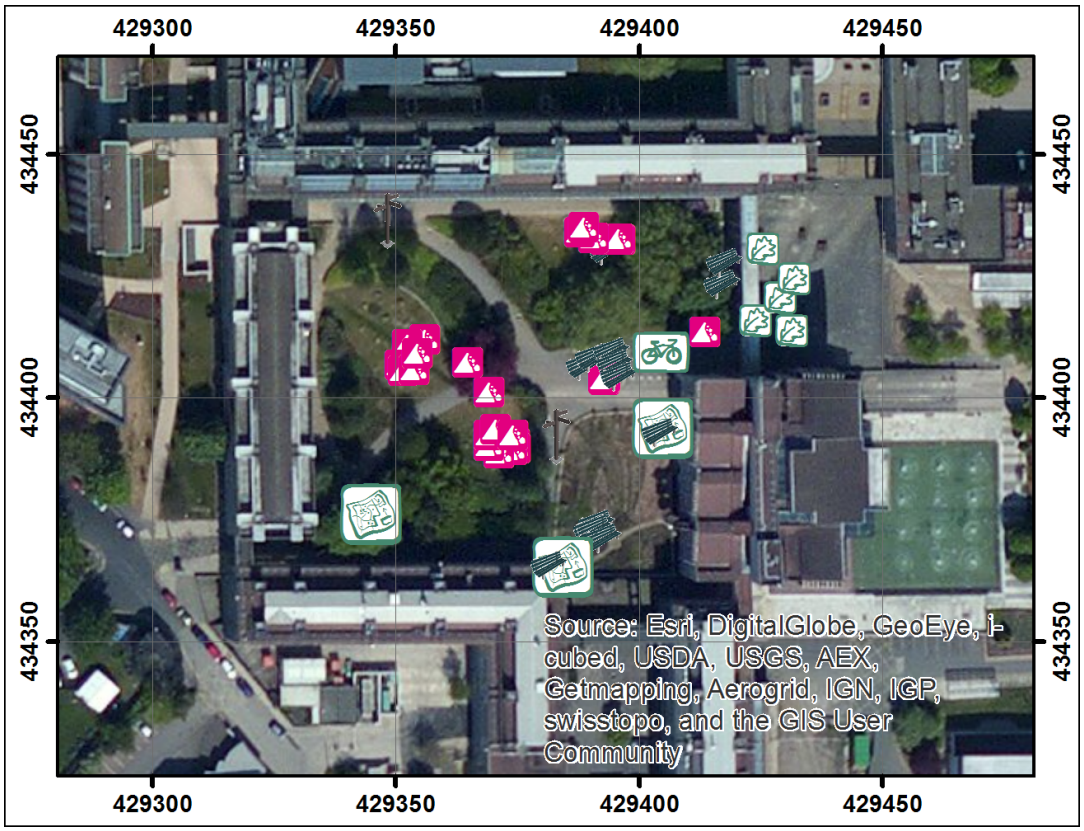


Figure 3.16: An example of symbolised waypoints for Chancellors Court (British National Grid coordinate system)

3.11 Finally...

Question 3.3. Have another close look at the gps layer. How accurate do you think the locations of the points are? What problems can you spot based on your memory of collecting the data? Compare the points you collected with the base imagery that you've added. How do you think that you could increase accuracy of data input?

When you are mapping in the field you can use a gps receiver to locate your measurements and keep a record in your field note book. But remember the issues with accuracy (section 3.4.2 on page 40) and make sure that you can also locate yourself accurately using a paper map. The advice of professional mappers is often to check the location given by your gps unit against a map every time that you take a reading!

3.12 Recommended reading: collecting data with GPS

For more detailed information have a look at the following references from the module reading list[11].

Chang (2016), Section 5.4. on creating new data includes information on GPS.

The Ordnance Survey has a lot of information about GPS on their website[12], including a Beginners Guide to GPS. Start at `http://bit.ly/1C5XMST`

Heywood, I. (2011), Chapter 10 covers data quality issues, including accuracy.

[11] Reading list available from Minerva and from the module catalogue at `http://webprod3.leeds.ac.uk/banner/dynmodules.asp?M=SOEE-2650`

[12] Last visited: 18th September 2018

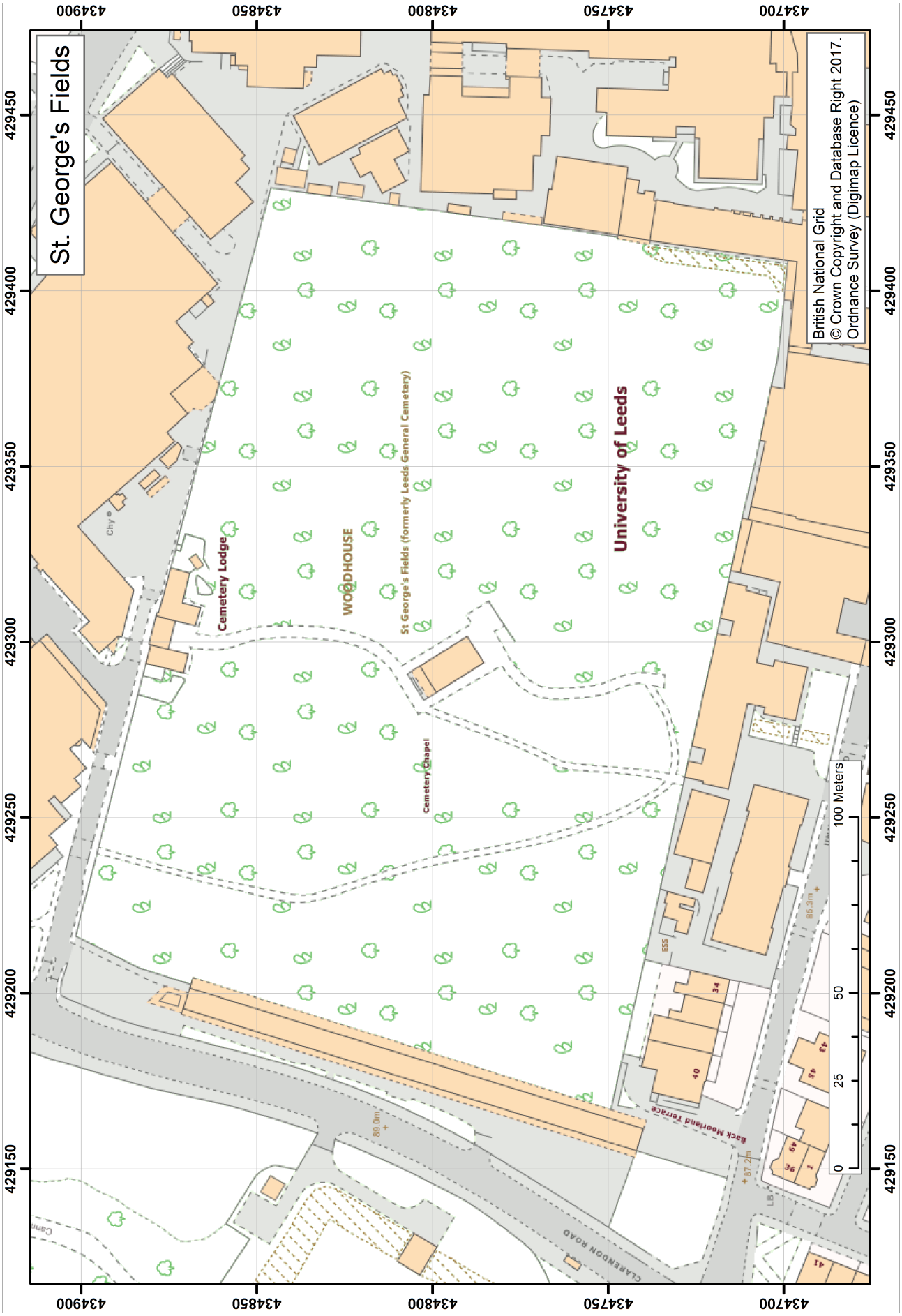


Figure 3.17: Field slip for St George's Fields

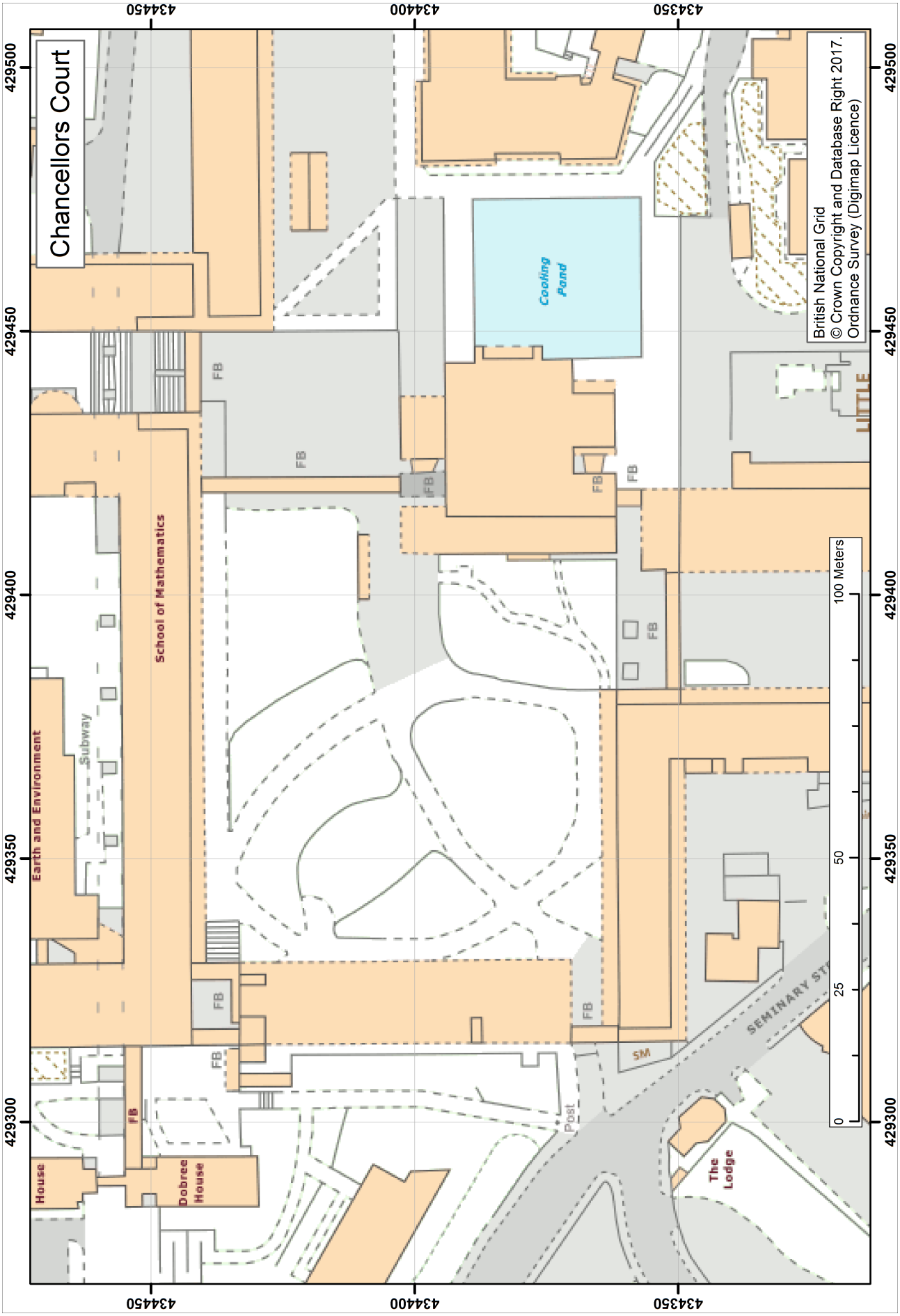


Figure 3.18: Field slip for Chancellors Court

Chapter 4

Creating data for GIS: Digitising

4.1 Introduction

Digitising or tracing data manually in Arc involves having a background map which shows the locations that you wish to digitise, and then using the editing tools to draw vector polygons, lines and points. In this exercise you will produce a map of Chancellors Court showing the outlines of the buildings, the paths, and other features such as seats and signposts.

Even if you never actually need to digitise a map it is extremely useful to know how to set up your own feature classes and how to add features by editing. Sometimes you just need to outline your study area, or add a point to show where something specific is, or as input to one of the tools provided in Arc.

This is a very brief overview of the tools for digitising in ArcMap as we are limited for time - if you need to do anything more complex then you should be able to find plenty more information in the ArcGIS Desktop Help.

Video Clip available - If you feel that you are still not clear about the difference between **raster** and **vector** GIS data it would be worth having a look at the video "Learn more about raster and vector map data" by the Ordnance Survey which is available at `https://youtu.be/hb0Gp51nYGI`

4.2 Obtaining the background data

If you closed your map at the end of chapter 3 reopen it now in ArcMap, otherwise continue working in the same map - **UniversityBNG.mxd**

You should have a map in British National Grid showing an aerial view of part of the University with your gps points on top.

4.3 Setting up a geodatabase to store your data

A geodatabase is a container that holds lots of other datasets or feature classes. You'll set one up and then use it to store the data that you create by digitising features.

Note that we will be using the Catalog panel in ArcMap for these steps, but all will work in ArcCatalog too.

Video Clip available - The YouTube video at `http://bit.ly/1zR2WBY` shows the process of creating a geodatabase, feature dataset and feature class. It also carries on to show how to add data to a feature class - we'll cover this later. (This video has sound)

- In the catalog panel on the right-hand side of ArcMap select the folder in which you want to set up your file geodatabase.
- Right-click on the folder New > File Geodatabase.
- Give your geodatabase a name, e.g. **Leeds**.

Things to check if you have problems setting up geodatabases
• Make sure that you are in a folder, not directly on the root of a drive, e.g. in the C: drive. • Check your disk space!

Table 4.1: Things to check if you have problems setting up geodatabases

You should end up with a new entry in the catalog that has an icon like a small grey tin (figure 4.1).

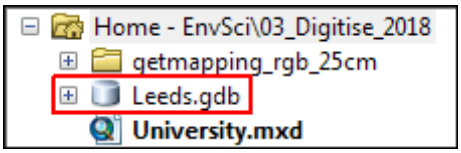


Figure 4.1: A file geodatabase in the catalog panel

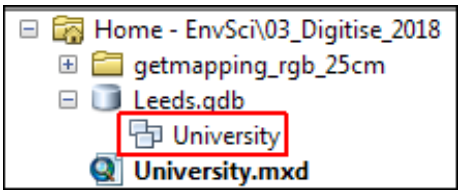


Figure 4.2: The file geodatabase now includes a feature dataset

4.3.1 Set up a feature dataset

Still in the catalog panel or ArcCatalog

- Right-click on your geodatabase
- New > Feature Dataset...
- Enter a name that describes the information that it will contain, in this example it could be **University**.
- Click Next.
- Set your projection - in this case British National Grid so select Projected Coordinate Systems > National Grids > Europe > British National Grid.

Getting around problems with adding feature datasets and feature classes to a geodatabase
Sometimes when you try to add feature datasets or feature classes to a geodatabase you'll get an error message saying that the database is already in use or is locked. This will prevent you adding anything else. The first thing to check is that you are not in an edit session. If you are sure that you are not and it still isn't working, try the following. • If you are using the Catalog Panel in ArcMap then close ArcMap completely. • Open ArcCatalog and, in the table of contents, go to the geodatabse to which you want to add a feature dataset or feature class. • Right-click and add the feature dataset or feature class here If you are having problems with creating feature datasets and feature classes in ArcCatalog, then do the reverse - close ArcCatalog, Open ArcMap, and use the Catalog panel to add new datasets or classes.

Table 4.2: Getting around problems with adding feature datasets and feature classes to a geodatabase

- Next » Next » Finish.

You should end up with a new entry in the catalog that has an icon like three small grey boxes (figure 4.2) (you may need to click on a + sign next to the geodatabase icon to see the feature dataset.)

4.3.2 Set up a feature class

Still in the catalog panel or ArcCatalog

- Right-click on the feature dataset in the geodatabase (e.g. in this example the feature dataset is **University**) New » Feature class...
- Give your feature class a name that describes what it's contents will be, e.g. **Buildings** and an alias, e.g. **University buildings**. The alias will be a readable name that will appear in ArcMap etc., so it can include spaces. Note that the name of the feature class should not contain any spaces or symbols.
- Select the type of feature class to be stored - for this class it will be **Polygon Features**.
- Next » Next.
- In the next dialog you can add extra fields to your feature class, in this case click in the first blank space in the **Field Name** column and type `Label` then check that the **Data Type** is `Text` and change the **Length** to `100`
- Finish

Arc should create the new feature class and add it to the current map. Note the icon for the Building feature class in the Catalog, this shows you that it holds polygon features (see figure 4.3).

In the same way, inside the feature dataset, create a feature class called Paths with a feature type of Line Features.

And create a feature class called Trees with a feature type of Point Features.

Note that if you forget to change the feature type when you are creating a feature class it can't be changed later. All you can do is delete the feature class and create a new one.

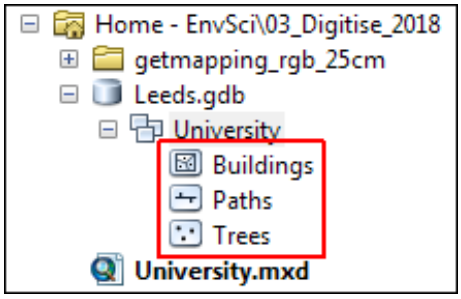


Figure 4.3: Examples of polygon, line and point feature classes within a feature dataset in a geodatabase.

Arc should have automatically added the new feature classes to your table of contents. If it hasn't add them now.

4.4 Digitising in ArcMap

You should already have an aerial view as a background for your map. For these exercises you'll be **digitising** polygons and lines by tracing over features on this view.

4.4.1 Open the Editor toolbar

All of your creating and editing will take place within an **Edit Session**. The drawing tools will create an **edit sketch** which will modify the feature in the feature class when you stop editing.

- Open the **Editor toolbar** (figure 4.4) (if it isn't already open) - Customize > Toolbars > Editor.

Figure 4.4: The Editor Toolbar

4.4.2 Check your features are available to edit

Sometimes when you create a feature class it appears in the table of contents, but doesn't appear in the list of layers that you can edit. Check that as follows -

- Start an edit session by right-clicking on the **Buildings** layer in the table of contents and selecting Edit Features > Start Editing

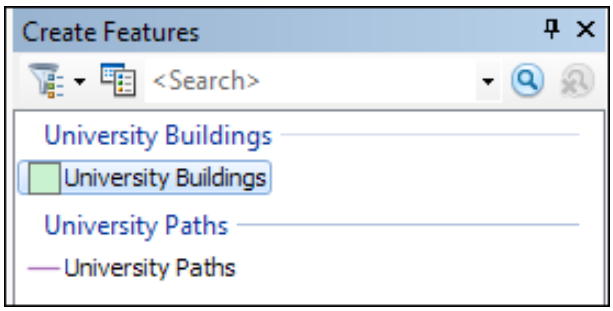


Figure 4.5: The Create Features panel with feature templates for two feature classes

- The **Create Features** panel (figure 4.5) should open on the right-hand side of the window. If it doesn't, click on the right-most icon on the **Editor** toolbar to open it.

If you created a feature class but it doesn't appear in the Create Features panel there are two things to check:

1. Have you selected the correct feature class? Stop editing (Editor > Stop Editing) and start editing again, being very careful to select the correct feature class.
2. If the feature class or feature still isn't visible you need to set up **feature templates** - see the next section.

4.4.3 Feature templates

If you can see the features that you want to edit, don't worry about carrying out the instructions this section. It's worth reading this section, though, as being aware of feature templates may be useful to you in the future. Start following again from section 4.4.4 on page 63.

Feature templates show the symbology of the layers that you are editing. Usually they are created automatically when you add a layer, but in some circumstances they are not. In that case you need to create them manually.

Figure 4.6: The organize templates button

- Open an edit session and select the correct geodatabase or shapefile folder.
- Click on the Organize Templates button on the **Create Features** panel (figure 4.6).
- In the **Organize Feature Templates** dialog box click on **New Template**.
- Tick the check boxes next to the layers that you need to create templates for Finish.
- There should be a symbol for each of the layers that were missing. Click to Close.

Your feature classes or features should now appear in the **Create Features** list and you should be able to select that layer to edit.

If you have set symbology categories for a layer, you can also add the symbology as templates in exactly the same way and select them directly when you are editing and creating data.

4.4.4 Digitizing a polygon

Video Clip available in Minerva - Digitising in ArcMap Part 1: Starting and finishing, and creating polygon features. Direct link: `http://bit.ly/2gNhDVw`

We'll digitise the School of Earth and Environment (SEE) building by drawing a polygon around the outline.

- If you haven't already, start an edit session by right-clicking on the **Building** layer Edit Features > Start Editing.
- In the **Create Features** area which should open to the right of your window, make sure that the **Building** layer is selected.
- In the area below select the correct **Construction Tool**, e.g. **polygon**.

Figure 4.7: Straight Segment tool

- The **Straight Segment** tool (figure 4.7) should automatically select on the Editor toolbar, if it doesn't then click on it now. Alternatively you can select another tool at this stage.
- Click on the map to start drawing a polygon. Trace along the edges of the SEE building by clicking each time you want to change direction.
- Each click creates a **vertex**, which is similar to a node in a drawing package such as CorelDraw.
- If you want to **undo** the last vertex that you drew, press Ctrl + z.
- Double-click when you finish your polygon, or press F2. If you don't do this you will find that your polygon just disappears when you start doing something else.

You can easily delete features within an edit session, so just have a go and don't worry if your shapes don't work the first time.

- **IMPORTANT:** Save your edits at regular intervals - Editor > Save Edits.
- To stop editing - Editor > Stop Editing.

You should have created a solid polygon which covers the School of Earth and Environment (figure 4.8).

Stop and think about the digitizing that you have just done. Can you think of any potential issues with the data that you have created in this way?

- ***What scale did you digitize at? What effect will this have on the amount of detail that you included? What recommendation would you make about viewing the data on a map?***
- ***How accurate were you when you were placing the vertices?***
- ***How clear were the edges of the building that you were digitizing? What did you do when there were trees overlapping? What about shadows?***

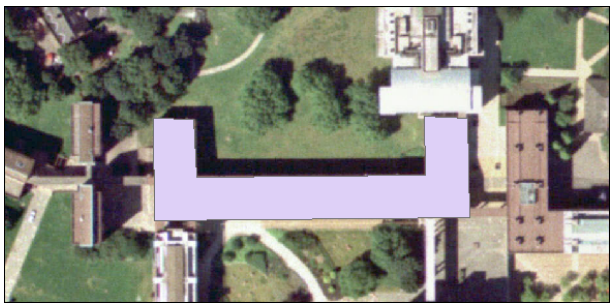


Figure 4.8: The digitised School of Earth and Environment (yours probably won't be the same colour as mine)

4.4.5 Editing features

If you want to edit a polygon or line to change it once you have created it, start by using the black arrow, i.e. the **edit tool**, from the Editor Toolbar to select the feature that you want to edit...

Video Clip available in Minerva - Selection tools and stopping layers from being selectable. It can be useful to prevent other layers from being selectable as if more than one feature is selected you won't be able to make the changes. Direct link `http://bit.ly/2fbGgee`

Video Clip available in Minerva - Digitising in ArcMap Part 4: Editing features after creation. Direct link: `http://bit.ly/2gNddyO` (watch Digitising in ArcMap Part 1 for general information about digitising.)

Figure 4.9: Edit Vertices button

- click on the **Edit Vertices** (figure 4.9) button on the Editor toolbar.
- You can then move the existing vertices, or use the small toolbar that appears to add or remove a vertex.
- You'll be editing the **Edit sketch**, not the actual line or edge, so the feature itself won't change until you finish editing by clicking F2 on your keyboard.

4.4.6 Transparency

Don't forget that you can make layers transparent. As you draw your building polygons you'll gradually be covering up the layers underneath and it can be useful to see through the top layers. Instructions for transparency are in section 6.2.2 on page 76.

4.4.7 Adding feature attributes to a feature class

Next you'll add some extra information to your new feature. It would be useful to be able to label the SEE building with its name so we'll add that to the feature class.

(Note: if you didn't create a text field called **Label** when you were setting up your buildings feature class then do so now by following the instructions in section 3.7.2 on page 47.)

- Start an edit session
- Click on the **attributes** button on the Editor toolbar (see figure 4.10). This will open the **Attributes** panel.
- Use the black arrow on the Editor toolbar to click on the digitised building and select it, the attributes panel will show the current layer and the fields (properties) available - figure 4.11.
- Enter an appropriate label in the **Label** field that you've set up. In this case enter **School of Earth & Environment**. Later we'll set this up so that it shows on the map.
- Save your edit and stop editing.

Figure 4.10: The attributes button

OBJECTID	1
Label	School of Earth & Environme
SHAPE_Length	479.234949
SHAPE_Area	3617.559244

Figure 4.11: The attributes panel

4.4.8 Labelling features

Now that you have label text in your attribute table you can label the features on your map.

- Right-click on the **Building** layer in the table of contents Properties > Labels
- Click to put a tick in the **Label features in this layer** box and set the **Label** field to Label
- If you wish to, change the text symbol and colour.
- Apply to see what it looks like and OK when you are happy with your label.

The name of the building should appear on top of the polygon.

Digitise the other buildings that surround Chancellors Court. The Roger Stephens to the south east; Garstang Building to the south; and Priestley Building to the the west. Give labels to all of the buildings.

Video Clip available in Minerva - How to add labels to layers in Arc. Direct link: `http://bit.ly/2h2vtDs`

4.4.9 Digitising line features

Digitising line features is very similar to digitising polygons, except you don't have to "close" a line.

You should already have the paths layer added to your map.

- Open an edit session and select this layer to edit.
- Add lines for the paths across Chancellors Court
- save your edits and end the edit session

You don't need to add any labels for the lines layer in this case.

Video Clip available in Minerva - Digitising in ArcMap Part 2: Creating line features. Direct link: `http://bit.ly/2gNchJY` (watch Digitising in ArcMap Part 1 for general information about digitising.)

Again, think about the problems that you encounter as you edit. Do you draw the edges of the paths, or just the centre line? How can you be sure of what happens underneath trees? How easy is it to be accurate with the drawing tools? Think about the implications for future use of the map at different scales.

4.4.10 Digitising point features

Again, digitising point features is very similar to digitising lines, except you only have to click once for each feature.

You should already have the trees layer added to your map.

- Open an edit session and select this layer to edit.
- Add points for the trees that you can see in Chancellors Court by clicking once for each one
- then save your edits and end the edit session.

Video Clip available in Minerva - Digitising in ArcMap Part 3: Creating point features. Direct link: `http://bit.ly/2gNlHoI` (watch Digitising in ArcMap Part 1 for general information about digitising.)

You don't need to add any labels for the points layer in this case.

Again, think about the problems that you encounter as you edit. How easy is it to decide where you should add a point to represent a tree? How easy is it to be accurate with the drawing tools? Think about the implications for future use of the map at different scales.

4.5 Finally...

Finish digitising the buildings around Chancellors Court and the paths across it. Check that all of the layers that you have created - the points, lines and polygons, have all been symbolised appropriately and are labelled where necessary.

Then create a layout showing all of your data without the background imagery layer. Add any extra content that you think your map needs, such as a scale bar, a key, a measured grid and a title. This map isn't assessed, but this is good practice for when you need to produce a map for a report or exercise, though the layout chapter (chapter 8) does cover this in much more detail.

Your map should look different from the possible layout in figure 4.12, but this will give you an idea of what it could look like. You will have made different decisions when digitising and symbolising data.

4.6 Recommended reading: digitising

For more detailed information have a look at the following references from the module reading list[1].

Chang (2016), Section 5.4. on creating new data includes information on various ways of digitising.

Kennedy, M. (2013), Chapter 5 includes information and exercises which look at data storage structures and digitising.

For help with specific tools don't forget to search in Arc Desktop Help - there is a lot of helpful information in there.

There are a lot of videos on YouTube which may help you - just do a search on **digitising**. For example, have a look at the video at `http://bit.ly/1CasAjt`

[1] Reading list available from Minerva and from the library by searching for *SOEE2650* at `http://lib5.leeds.ac.uk/rlists/index.php`

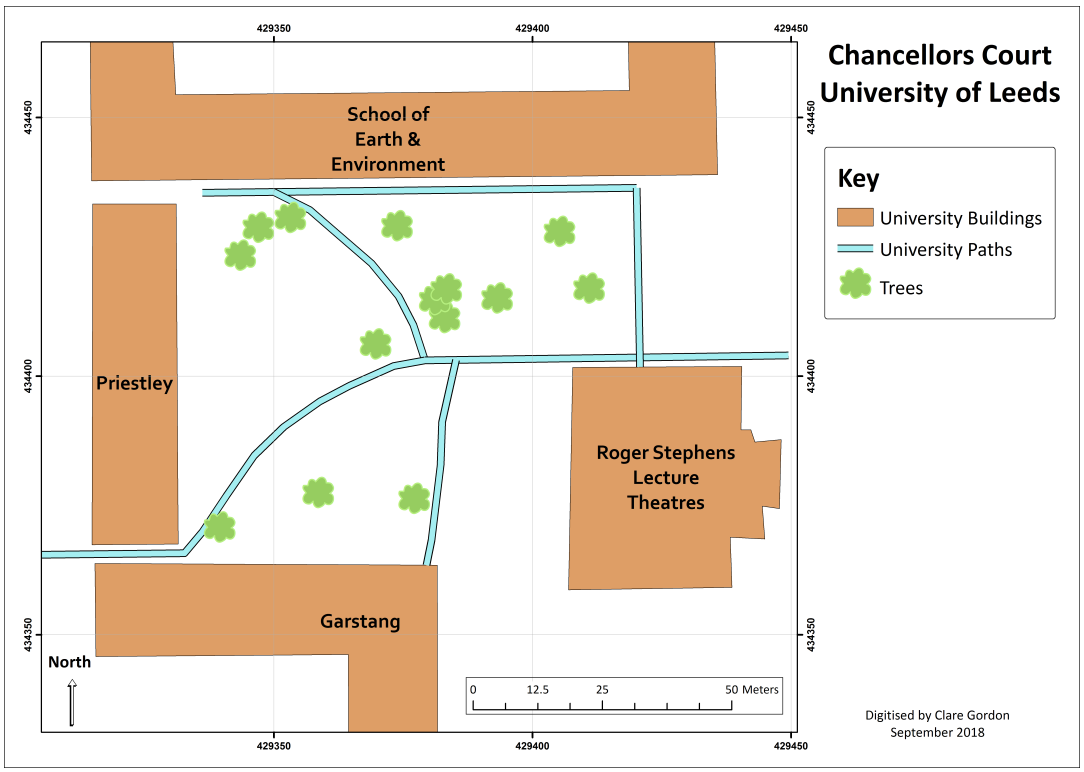


Figure 4.12: Possible final layout for digitised map of Chancellors Court

Chapter 5

Creating point data from xyz files

The data that you collected using GPS and converted to shapefile for importing to Arc, shows you one way of adding point data. You will probably also come across point data as an Excel file or as a text file. If these contain x and y coordinates then they can easily be added to Arc.

For the rest of these exercises return to the map of Llanbedr or North Wales which you started working with in chapter 1. The map should just contain two raster tiles forming a background map either of the whole of North Wales (Meteorology) or the Llanbedr area (Geophysics).

5.1 Creating xyz files

Xyz files can be either comma separated value text files, or Excel spreadsheets. They contain point data which includes coordinates for a geographic location either in two dimensions (x and y) or three (x, y and z).

Video Clip available in Minerva - Importing points from Excel or csv to ArcMap. Direct link: `http://bit.ly/2hk1ffk`

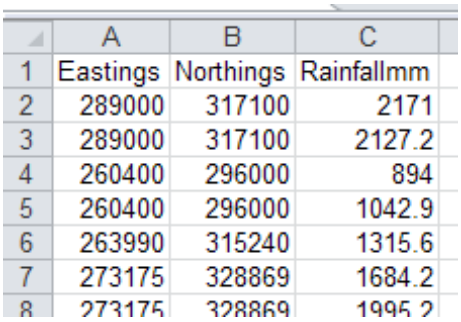
Geophysics	**Meteorology**
In Excel open the **LlanbedrGravity.xls** file from the `Geophysics▸Gravity` folder that you downloaded from Minerva.	In Excel open the **rainfall_2009_Gwynedd.xls** file from the `Meteorology▸RainfallData` folder that you downloaded from Minerva.

Have a look at the data (Figure 5.1). Your file will either show the gravity of an area around Llanbedr in North Wales, or the total measured rainfall at particular points in North Wales in 2009. You're using gravity or rainfall data, but the same techniques will apply to any point data, such as lead concentrations in soil samples, average temperature etc.

Note that Arc doesn't appear to open files from the latest versions of Excel so make sure that if you are creating your own files you save them as Excel 97-2007 and that they have an **xls** extension rather than **xlsx**.

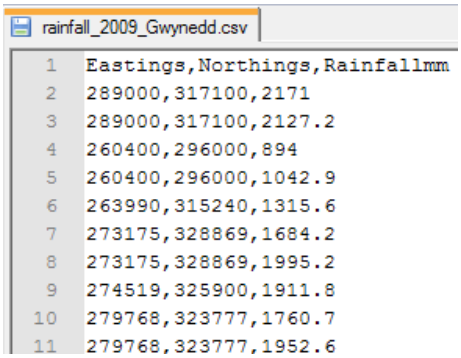
Arc can also import xyz data from **.csv** (comma-separated value) files either saved from Excel or created in a text editor such as Notepad++ (Not Word!) see figure 5.2. If your Excel file doesn't work in Arc, open it in Excel and save it as **.csv**

NOTE: Column headings in both Excel and csv must be short and contain no spaces or non-standard characters - so text and numbers only.



	A	B	C
1	Eastings	Northings	Rainfallmm
2	289000	317100	2171
3	289000	317100	2127.2
4	260400	296000	894
5	260400	296000	1042.9
6	263990	315240	1315.6
7	273175	328869	1684.2
8	273175	328869	1995.2

Figure 5.1: Excel file containing x and y point data - open in Excel



rainfall_2009_Gwynedd.csv

```
1  Eastings,Northings,Rainfallmm
2  289000,317100,2171
3  289000,317100,2127.2
4  260400,296000,894
5  260400,296000,1042.9
6  263990,315240,1315.6
7  273175,328869,1684.2
8  273175,328869,1995.2
9  274519,325900,1911.8
10 279768,323777,1760.7
11 279768,323777,1952.6
```

Figure 5.2: The same file containing x and y point data, this time saved as .csv and opened in a text editor

---

Note the **Eastings** and **Northings** columns - in effect x and y. These are in **British National Grid 1m coordinates** (The grid numbers such as SH or SJ have been replaced with numbers - 22 and 23. See appendix A for more information on how this works). Other numerical columns can be used for the z values / data. In this case we'll be using **CorrBA** (Corrected Bouguer Anomaly in mGal) or **rainfallmm** (Annual rainfall in mm) as the z values.

5.2 Import points from xyz file to ArcMap

Open your map of North Wales in ArcMap.

Converting .xls or csv to a feature class

In the Catalog panel in ArcMap:

For an Excel spreadsheet (if you are using a csv file use the instructions below) -

- click on the plus sign next to the Excel file to show the contents (figure 5.3)
- You should be able to see a layer with a name which ends with with a **$** sign.
- right-click on that layer (if you can see more than one use the first in this case) and click to Create Feature Class > From XY Table... (figure 5.4)
- Fill in the X and Y Fields using the spreadsheet columns which show the coordinates in British National Grid
- Click on Coordinate System of Input Coordinates... and select **British National Grid**
- Choose a location and name for the output, then OK

This also works for csv (**c**omma-**s**eparated **v**alue) files. Indeed, **if you are having trouble loading an Excel file**, try saving it as csv in Excel[1], then import it to Arc using the instructions below. It often works much better than the Excel file.

For a csv file -

[1] Save from Excel to csv as follows: File > Save As choose a location then under **Save as type:** choose **CSV (Comma delimited) (*.csv)**.

- just right-click on the file name, it won't have a plus sign like the Excel file does
- select Create Feature Class > From XY Table... .
- Fill in the X and Y Fields using the spreadsheet columns which show the coordinates in British National Grid
- Click on Coordinate System of Input Coordinates... and select **British National Grid**
- Choose a location and name for the output, then OK

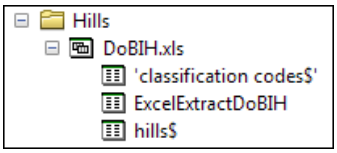


Figure 5.3: Excel file in Catalog opened out to show contents

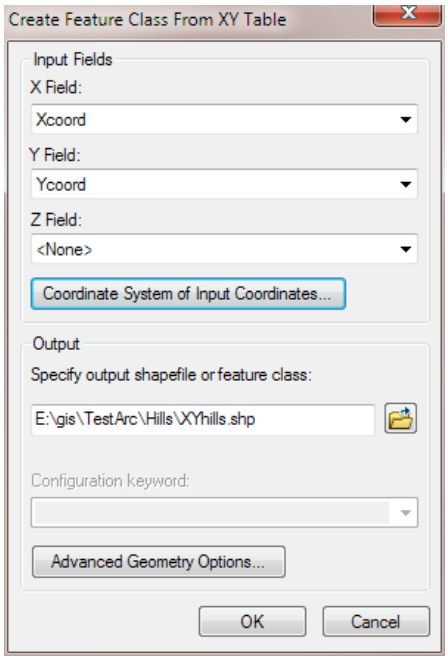


Figure 5.4: Creating a feature class from an XY Table (your field and file names probably won't be the same as this)

The output shapefile should appear in Catalog in the location that you chose to save it. Add it to your map in the usual way.

Your points should appear as dots on your map - **Zoom to Layer** on your new layer to check. The points will probably look rather small when zoomed in - just look carefully for them. You should find that you have a layer with dots which cover the area (or part of the area) of your base map (figure 5.5 shows the gravity points).

Do the following to have a look at how the fields in your spreadsheet have been imported -

- Right-click on the layer in the table of contents
- **Open attribute table...** and compare with the Excel file that you originally opened. It should look basically the same except for a couple of columns that Arc has added - maybe FID and Shape*.

Close the attribute table and don't forget to save the changes to your map.

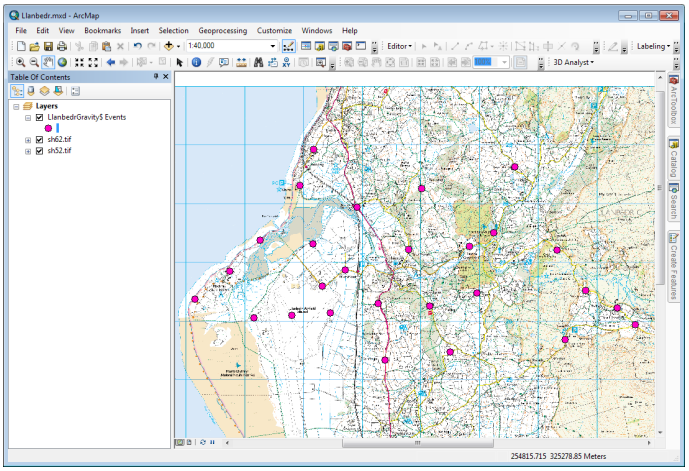


Figure 5.5: Map showing gravity points imported into ArcMap as xyz data from Excel

5.3 The Catalog panel

The Catalog panel in ArcMap should be available from a tab to the right of the map window. If it isn't there, go to Windows > Catalog.

- Click on the **Catalog** tab.
- The Catalog panel should open out (figure 5.6). In the panel click on the folder that says **Home**. You should be able to see all of the files and folders for your project.
- Navigate to the folder in which you saved the data. You may need to go to **Folder Connections** for this, or **Connect to Folder** (see tip box 1.3 on page 6 for a reminder of this). Now look at the points file - it should have an icon with points on it, and you should only be able to see one file.
- now open the usual Windows file browser (My Computer), navigate to the same location and have a look at the same file.

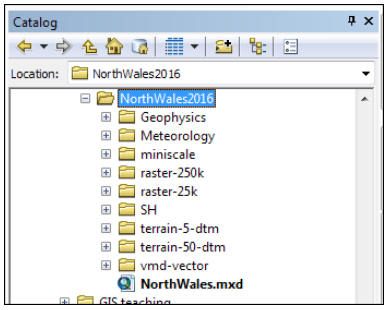


Figure 5.6: The Catalog panel in ArcMap

Question 5.1. question

What is the main difference that you notice between the shapefile that you see in the Catalog panel and the same shapefile that you see in My Computer?

Notice that there are several files with the same name in My Computer – a shapefile basically consists of all of these files and you should never use Computer or Windows Explorer to move shapefiles or delete parts of them. ArcCatalog or the Catalog window in ArcMap are the Arc equivalent of Computer and are specially designed to handle multipart GIS files.

If you delete or rename this file using Catalog (which I don't recommend doing at the moment!) then Arc would keep your disk tidy by deleting or renaming all of the individual parts too.

You should finish this chapter with a map document containing the points imported from Excel with a couple of raster tiles providing a background map. In the next chapter you'll look at how you can process the points further and display them in different ways.

Chapter 6

Viewing point data with 3D Analyst

The Arc 3D Analyst extension allows you to visualise point data in 3D as an interpolated surface. The extension works in either ArcMap or ArcScene but we'll just use it in ArcMap to start with.

6.1 Set up the 3D Analyst extension

- Start with the map containing your gravity or rainfall data open in ArcMap.
- Enable the 3D Analyst extension - Customize > Extensions... tick the box next to 3D Analyst > Close. *If 3D Analyst isn't on your list then your licence does not include this extension. Speak to IT for more information.*
- Open the 3D Analyst toolbar (figure 6.1) - Customize > Toolbars > 3D Analyst

Figure 6.1: The 3D Analyst toolbar

6.2 Creating a surface from your point data

3D Analyst can create a surface in grid format derived from point data. This will show z values for the spaces between the observed points which Arc will have worked out from available data - a process known as **interpolation**. Inevitably the accuracy of the surface will increase if you have more data points in a particular area, but it still works if your points are widely spaced.

There are several different methods of interpolation available in Arc. The instructions below use Spline as an example, but try Inverse Distance Weighted and Kriging too, and have a look at the differences. Different methods work best for different data.

There is more information in ArcGIS Desktop Help - search for **Raster Interpolation**. Also see ArcUser for a useful article freely available online -

`http://www.esri.com/news/arcuser/0704/files/interpolating.pdf` [1]

- Open ArcToolbox by clicking on the tab at the right-hand side of the ArcMap window (figure 6.2)

Video Clip available in Minerva - Interpolating surfaces from point data. Direct link: `http://bit.ly/2h39mN9`

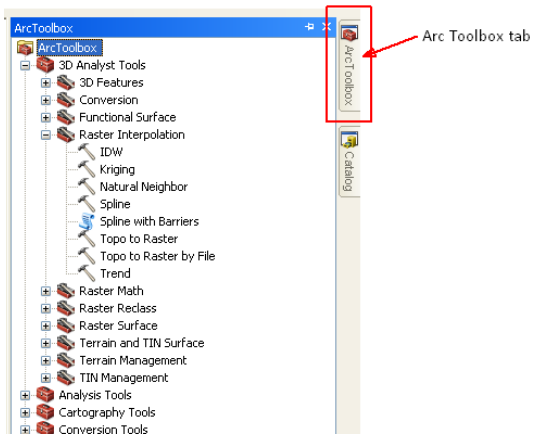


Figure 6.2: The Arc Toolbox

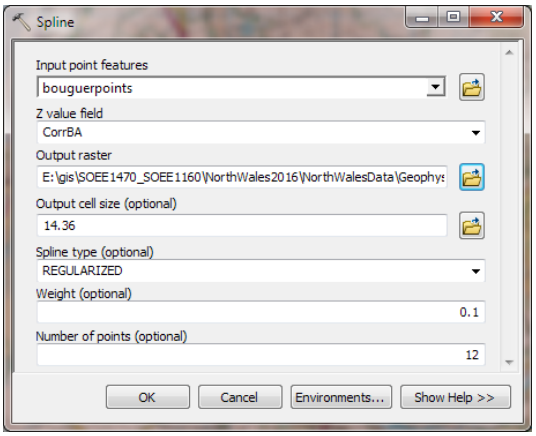


Figure 6.3: Spline dialog box

- If the tab isn't visible on the right of ArcMap open it by going to Geoprocessing » ArcToolbox.
- In the toolbox open out - 3D Analyst Tools » Raster Interpolation then double-click on **Spline**.

- A dialog box should open (figure 6.3)
- Under **Input points** select your point layer (or drag and drop it from the table of contents).
- Under **Z-value field** select the title of your z value column, in this case **CorrBA** (Corrected Bouguer Anomaly) for gravity or **rainfallmm** for total rainfall.
- Click the browse button next to **Output raster** to select where you want to save your new surface - the default will be in a default geodatabase on your M: drive, but it would be better to save it with the rest of your project data, so browse to select the folder in which you want to save your data. (Note that on the University network tools usually fail if you try to save output to the default geodatabase.)
- Give your surface a name - with a maximum of 13 characters and no spaces. Preferably make this name something that you'll still know the meaning of if you come back to it in a few months time.
- Save » OK

ArcMap will interpolate the surface from your data points and add it to the map. You should end up with something similar, but probably not identical, to figure 6.4 or figure 6.5.

6.2.1 Change the symbology of the surface

The surface is divided into discrete units at the moment.

[1] Last visited: 3rd November 2016.

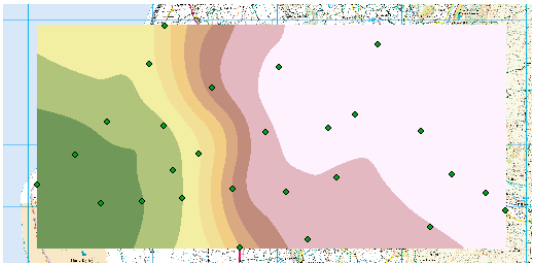


Figure 6.4: Interpolation of corrected gravity anomaly

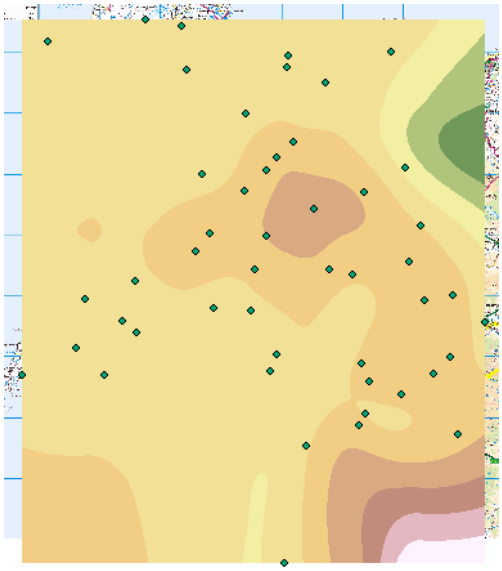


Figure 6.5: Interpolation of rainfall data

Question 6.1. Use the identify tool from the tools toolbar to click on various points within one colour band. What do you notice about the readings for the interpolated layer?

The automatically generated symbology is not the best for this data and should be changed so that the colours are **stretched** rather than classified in separate bands.

- Right-click on the new surface layer in the table of contents and go to Properties > Symbology.
- Check that **Show** is set to **Stretched**.
- Right-click the **Color Ramp drop-down** and click **Graphic View** so that you have a list of names instead of the colour ramps. From the list select a suitable colour ramp, e.g. **Spectrum - full bright**. Click on the **Invert** tick box to reverse the colour order so that low is blue and high is red (the "expected" direction). See figure 6.6
- OK

6.2.2 Transparency

At the moment your surface covers up everything underneath it, to allow the layers below to be visible through it you need to set transparency.

- Right-click on the layer you wish to make transparent Properties > Display type a value such as **40** into the **transparency** box Apply.
- Once you are happy with the transparency click on OK.

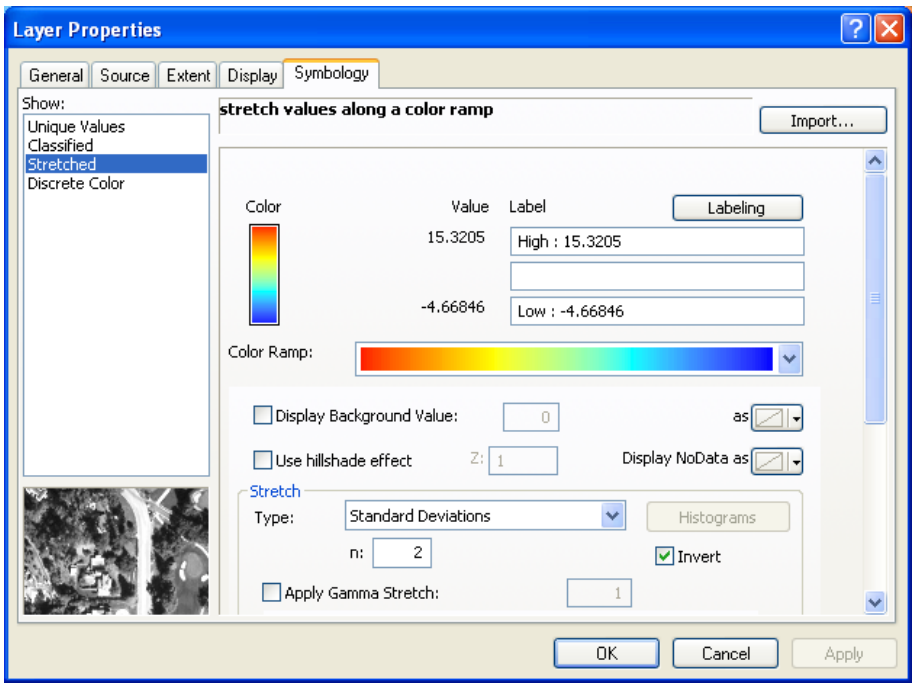


Figure 6.6: Symbolising a surface as stretched

6.3 Comparing types of surfaces

Repeat the section above twice more from 6.2 on page 74, but this time select the **IDW tool** and then the **kriging tool**. You'll end up with three different surfaces on your map. Have a look at each of them and look at the information in Desktop Help and the information on page 34 of the article at

`http://www.esri.com/news/arcuser/0704/files/interpolating.pdf`

Question 6.2. Which surface do you think is the most appropriate for this data and why? Make notes below, then use the surface that you have chosen as the most appropriate to carry out the tasks in the following sections. You will also be asked to include this answer as part of your assessment submission.

6.4 Deriving contours from a surface

Once you have created a surface you can use 3D Analyst to derive contours to display the surface in 2D.

- Toolbox > 3D Analyst Tools > Raster Surface > Contour. (Figure 6.7)

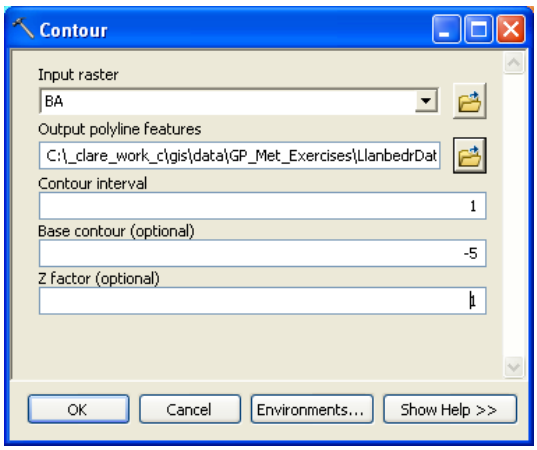


Figure 6.7: The Contour tool

- Set **Input raster** to the surface from which you want to derive contours.
- Browse to save **Output polyline features** in your data folder. If you save this to a folder it will be saved as a shapefile, if you save it to a geodatabase it will be a polyline feature class within that database. Either should be fine.
- Set the **Contour interval** appropriately depending on your input surface.
- Supply a **Base contour** if required, that is the lowest contour that will be generated. Check the lowest value in your data in the table of contents.
- The **z-factor** is optional. It is used to adjust the units of the data. So a z-factor of 3.28 would convert data in meters to a result in feet. Leave it as **1** here.
- OK

Arc should generate contours and then add them as a layer to your map (figure 6.8).

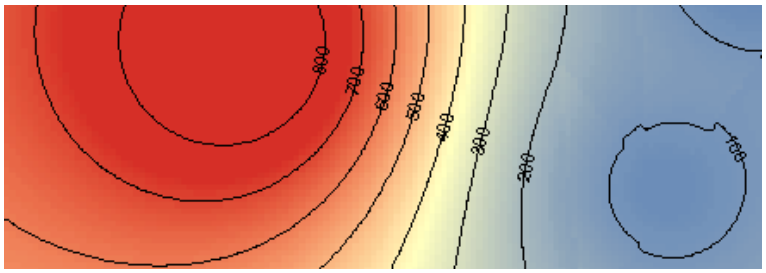


Figure 6.8: Labelled contours overlying symbolised 3D surface in ArcMap - section 6.4.1 shows how to label them

6.4.1 Adding labels

Contours don't help much if you don't know the value of each of them. Arc is able to label features in a map with any field from the attribute table.

Right-click on your contours layer in the table of contents and select to *Open Attribute Table*. ***This will show the information, or attributes, about the features in your feature class in the form of a table. What is the name of the field that shows the height of each contour?***

To add labels to your contours do the following:

- Right-click on your contours layer in the table of contents Properties › Labels tab.
- Click in the box next to **Label features in this layer**.
- Set **Label field** to the field that shows the height of each contour - it's easy to forget to do this so double-check you have!
- Click on Placement properties... and on the **Label Position** tab drop down the box under **General** and select **Contour Placement**
- OK › Apply to check the result. OK when you are satisfied with the labels.
- Try out some of the other options and see what happens to your labels.

Video Clip available in Minerva - How to add labels to layers. Direct link: `http://bit.ly/2h2vtDs`

You could also try labelling your data points, if you think that it would be useful to someone else looking at your map.

Don't forget to use a data frame reference scale so that the labels print at a suitable size - see section 3.9 on page 51 for a reminder of how to do this.

6.4.2 Changing the colour of your contours

Arc will have created your contours in a random colour and you will probably want to change it, particularly if it is a colour that doesn't show up against your background. Changing the colour or the style involves **symbolising** your data.

- Right-click on your contours layer in the table of contents Properties › Symbology tab.
- Click on the button with the current symbol (line) on it and select a new colour and width, if required. OK › OK.

You can use the same technique to symbolise your datapoints and make them clearer.

Video Clip available in Minerva - Symbolising layers as single symbols in ArcMap. Direct link: `http://bit.ly/2imXnaH`

6.5 Using 3D Analyst to create an outline profile

3D Analyst enables you to draw an outline profile across your map using z values in your surface grid files or heights above sea level. We will start by obtaining height data from Digimap and converting it to the correct format for ArcMap to be able to use it.

6.5.1 Download DTM files from Digimap

DTM stands for Digital Terrain Model[2]. These are raster files which contain points with height data for the land surface.

For gravity maps

If you are creating a rainfall map use the download location in the next section, not this one.

> ***Use Digimap O.S. Data Download to search for "Llanbedr" and download Land and Height Data OS Terrain 5 DTM files in Asc format (you may have to change the file type in your basket). Save them to your /Llanbedr/HeightData/ folder. Remember to unzip them or Arc won't be able to see the files. See figure 6.9 for the approximate area to download.***

Figure 6.9: If you are working on the gravity map download DTM data in ASC format for at least the area in orange on this map

Now continue to section 6.5.2 on page 81.

For rainfall maps

If you are creating a gravity map use the download location in the previous section, not this one.

> ***Use Digimap O.S. Data Download to search for "Llanbedr" and download Land and Height Data - OS Terrain 50 - DTM files in Asc format (you may have to change the file type in your basket). Save them to your /Llanbedr/HeightData/ folder. Remember to unzip them or Arc won't be able to see the files. See figure 6.10 for the approximate area to download.***

Now continue to section 6.5.2 on page 81.

[2]You may also see **DEM** which stands for Digital Elevation Model. There are differences in the data, but both can be treated in the same way.

Figure 6.10: If you are working on the rainfall map download DTM data in ASC format for at least the area in orange on this map

6.5.2 Producing "seamless" datasets from more than one tile of dtm data

If you are using more than one tile of dtm data follow the instructions below to combine the multiple files into one "seamless" dataset, a process that involves creating a mosaic. This will make it possible to use the files as a continuous surface in maps and 3D scenes. During this process we will also convert the multiple ascii or tiff files into one single **Grid** file.

This will work with various formats of dtm files including tiff and asc.[3]

On the University system be VERY CAREFUL that you add your files by navigating from the M:/ drive (your username) rather than via My Documents (your full name). The mosaic will almost inevitably fail if you use the wrong path.

Video Clip available in Minerva - Creating a seamless mosaic from multiple DEM tiles. Direct link: `http://bit.ly/2stVzQn`

- If ArcMap isn't already open, open it now.
- Ensure that the Spatial Analyst extension is installed by going to Customize » Extensions... and checking that **Spatial Analyst** has a tick next to it. If it doesn't, then tick it.
- Now set the extent for carrying out geoprocessing operations - Geoprocessing » Environments... » Processing Extent set to Union of Inputs » OK.

[3] Otherwise, if you have downloaded a single dtm file, use the Toolbox to convert the file to a Grid without needing to mosaic (Toolbox » Conversion Tools » To Raster » Raster to Other Format (multiple)).

- Then use the toolbox to open the correct tool - ArcToolbox » Data Management » Raster » Raster Dataset » Mosaic to New Raster.

Fill in the dialog that opens as shown in figure 6.11.

- Select all of your ascii dtm tiles under **Input Rasters** (you may need to look for them in more than one folder if your area covers parts of more than one 100km grid square)
- The **Output Location** is a folder or a geodatabase NOT a file name.
- Under **Raster Dataset Name with Extension** enter a file name without an extension to create an ESRI grid. Make sure you call it something that means something to you, e.g. *mosaicdtm*.
- Set the **Spatial Reference for Raster** to the one that applies to the original files using the button to the right of the field. (You can check this in the properties of one of the original files if you need to). If your final map needs to be a different coordinate system you will set this later - see section 6.5.3 on page 82.
- **Pixel Type** should be set to the same as the original files - have a look at the properties if you need to check
  - For properties right-click on a file in either the Catalog or the Table of Contents and select Properties...
    * From the Catalog the information you need will be on the **General** tab.
    * From the Table of Contents it will be on the **Source** tab.
    * You need to make a note of the **Pixel Type** and the **Pixel Depth**
  - For OS Terrain 5 and OS Terrain 50 files from Digimap this should work out as **32_BIT_FLOAT** from the list under **Pixel Type** in the tool.
  - Even though this is labelled optional, it isn't!
- Cellsize can be left blank, alternatively check this in the properties for your data.
- **Number of Bands** should be **1** to create a monochrome raster.
- OK

ArcToolbox should process your tiles, then add the result to your map. You should have a single tile which is coloured continuously rather than as a separate section for each individual tile (figure 6.12 - yours will look different to this one).

6.5.3 Define spatial reference for output mosaic

If you set the spatial reference when merging your files **then you can ignore this section**, otherwise you need to define the spatial reference of the output before you go any further. It is probably worth checking that your output mosaic does have a spatial reference - check in the properties.

If the spatial reference is **Undefined**:

- Open the toolbox and select Toolbox » Data Management Tools » Projections and Transformations » Define Projection
- Add the mosaic (you can drag it from the catalog into the appropriate box on the dialog)
- Select... and choose the coordinate system that your original data was in.

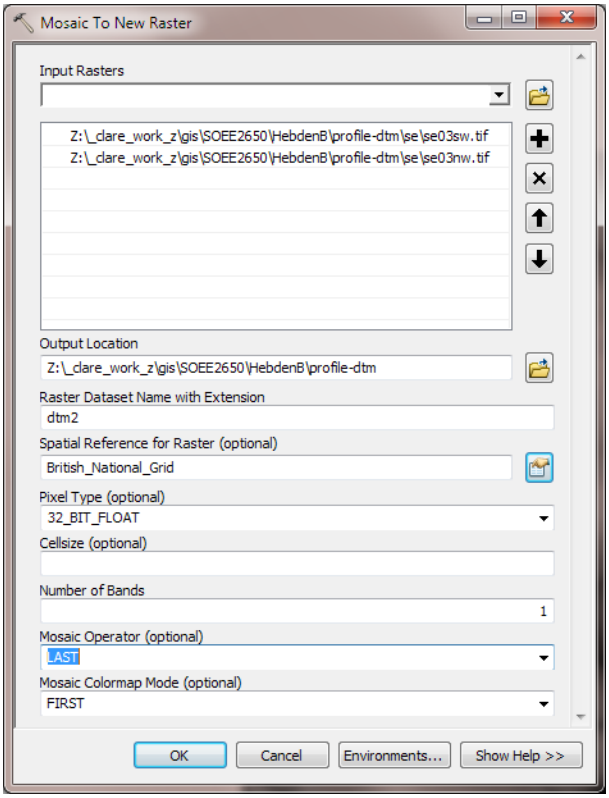


Figure 6.11: The Mosaic to New Raster tool. Note that the details for your data may be different to those shown here.

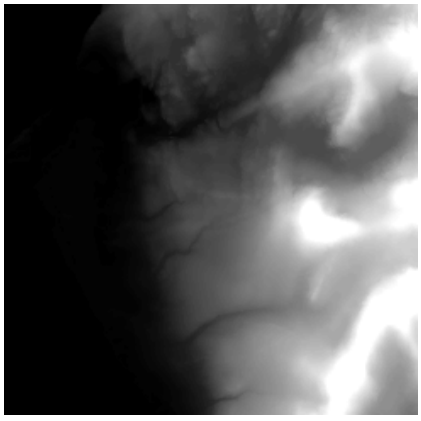


Figure 6.12: Grid file mosaic made by combining smaller tiles

6.5.4 Changing spatial reference for output mosaic

If the spatial reference of your original files is not the same as your map project then you need to change the coordinate system.

- Open the toolbox and select Toolbox › Data Management Tools › Projections and Transformations › Raster › Project Raster
- Add the mosaic (you can drag it from the catalog into the appropriate box on the dialog)
- Select... and choose the coordinate system that your final map project needs to be in, e.g. British National Grid.
- Arc will probably set the **Transformation** automatically if necessary, but if it doesn't select one from the drop-down list. e.g. WGS84 to British National Grid is usually **OSGB_1936_To_WGS_1984_P**

6.5.5 Create a profile graph

Now you can use the topographic grid layer and the gravity or rainfall surface that you created earlier to create profiles and compare them.

- If the **3D Analyst Toolbar** isn't already open, open it now (section 6.1 on page 74). See figure 6.13 for the buttons that you'll need when creating a profile graph.

Video Clip available in Minerva - Profile graphs with 3D Analyst.
Direct link: `http://bit.ly/2imsnrB`

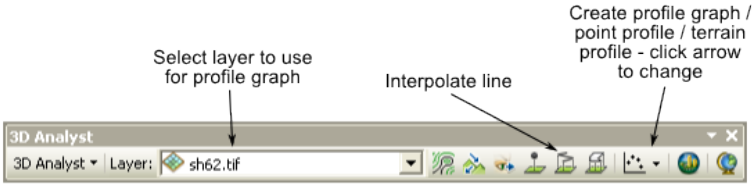


Figure 6.13: The 3D Analyst toolbar showing buttons for creating a profile graph

- Make sure that the interpolated surface that you created by raster interpolation in section 6.2 on page 74, and that you chose to use for the rest of the exercise, is present as a layer in ArcMap.
- Add the **mosaic dtm** file that you created.
- Move the dtm layer to the bottom of the data frame layers and make it invisible (so it doesn't slow things down by redrawing all the time!)
- Click on the layer drop-down arrow on the 3D Analyst toolbar and select the interpolated surface.
- Click the **Interpolate line** button (see figure 6.13 remember that you can hover over buttons to see what they are).
- **For the gravity map:** click on the map and draw a line from left to right across the CorrectedBA surface which passes through Llanbedr. Double-click to stop editing.
- **For the rainfall map:** click on the map and draw a line from left to right across the rainfall surface which passes through the area of highest rainfall. Double-click to stop editing.
- Right-click on the line Properties... > Symbol change the colour then click OK. This will help you to identify the correct profile later.
- Click on the layer drop-down arrow on the 3D Analyst Toolbar again and this time select the seamless dtm file that you created by mosaicing in section 6.5.2.
- Click the Interpolate line button.
- Click on the map and draw another line on top of the first line. Double-click to stop editing. Again, change the colour if you wish to - this time to a different colour to your first line.
- Select both lines by using the **Select elements** tool (black arrow) from the tools toolbar to draw a box around both lines on the map.
- Click on the **Create Profile Graph** button on the 3D Analyst toolbar. This should produce your profile in a new window - see figure 6.14.

6.5.6 Change profile graph properties

The default profile graph gives you the two lines and some general titles and other settings. You'll need to change the properties to make the graph more informative.

- Right-click on the title bar of the profile Properties. When the properties dialog (figure 6.15) opens move it so that you can still see the graph.

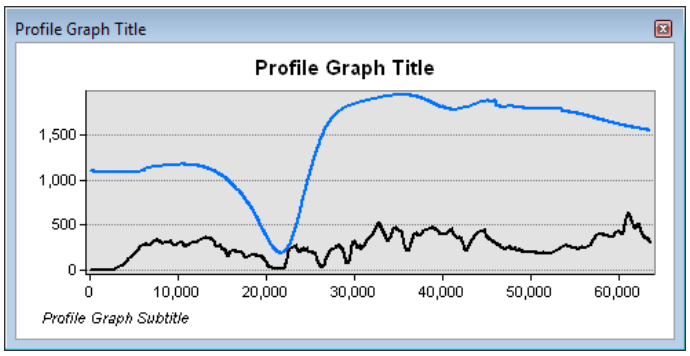


Figure 6.14: Profile graph with terrain and data lines, before the graph properties have been edited to make the purpose of the graph clear

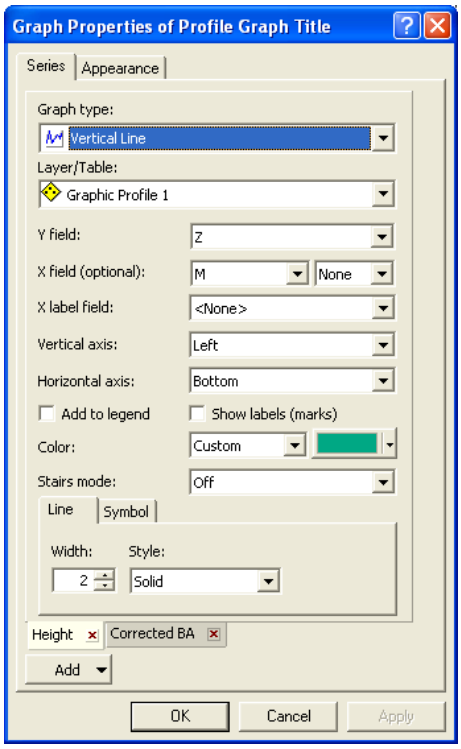


Figure 6.15: The graph properties dialog - Series tab

Set the properties as follows -

- On the **Appearance tab** change the title to something more descriptive of the purpose of the graph. Delete the subtitle. Apply.
- Click on the **Series** tab.
  - Click on each of the tabs at the bottom in turn and name them according to which data series they refer to. This is where having changed the colours of your lines will be useful.
  - Set the vertical axis of **Height** to **Left**
  - Set the vertical axis of your data surface (Corrected BA or Rainfall) to **Right**
  - Apply
- Use **Axis Properties** on the **Appearance** tab to label the left hand axis **meters** and the right hand axis in mGals which are the units of the Corrected BA or mm which are the units of the rainfall.

- OK

Continue to experiment with the settings to get a clear and informative profile graph **with a legend**. Don't worry if you make a mess of it, you can always close it, select the lines on the map again and have another go.

Once you are happy with the graph just close it using the cross at the top right.

If you want to open a graph again once you have closed it use View > Graphs and select it from the list there.

Chapter 7

Using BGS geology shapefiles downloaded from Digimap

7.1 Introduction

It is possible to download shapefiles containing British Geological Survey (BGS) data at various scales from the Digimap service. These can be added to a map in ArcMap in the usual way. Once data has been added to ArcGIS symbolising the data can be an issue. These notes give some suggestions for how to display the data. Please refer to the Digimap chapter of your workbook for more information about downloading data from Geology Digimap.

IMPORTANT: Please note that the information in this section is written so that it can be used with a variety of BGS datasets. Take care to follow the sections that apply to the data that is suitable for your map. If you are not sure about this, please ask.

For example: if you are a geophysicist following the exercises which use gravity data for Llanbedr then download 1:50 000 data and go to section 7.3 on page 88 for instructions on what to do next.

If you are a meteorologist following the exercises which use rainfall data for North Wales then download 1:250 000 data and go to section 7.2 on page 87.

Log in to Digimap and download tiles of geological data in shapefile format. Choose data to cover your area at an appropriate scale. For example, the scale at which you are intending to print your map. Note that 1:25 000 and 1:10 000 data are not available for all areas of the UK.

Unzip the layers that you download.

- ***If you have downloaded 1:250 000 data go to section 7.2 on page 87.***
- ***If you have downloaded 1:50 000; 1:25 000 or 1:10 000 data go to section 7.3 on page 88.***

7.2 Styling shapefiles with an ArcView legend file

If you have downloaded 1:50 000; 1:25 000 or 1:10 000 data go to section 7.3 on page 88 for information on using layer files to style data.

The 1:250 000 shapefiles provided by Digimap have an ArcView legend file (.avl) with them which can be used to apply BGS standard symbology.

Video Clip available in Minerva - Symbolising a layer with an ArcView legend file (.avl). Direct link: `http://bit.ly/2sY8QUI`

- Start by adding the 1:250 000 shapefiles to ArcMap in the usual way
- In the table of contents, select the layer to symbolise, e.g. Bedrock.
- Right-click on the layer Properties » Symbology
- Click on Import...
- Click on **Import symbology definition from an ArcVIew legend file (*.avl):** (figure 7.1
- Click on the folder button next to the **Legend file:** box and navigate to the location of your shapefiles. There should be an avl file there with the same name as the layer you have selected.
- Click on the avl file then Open » OK
- For a polygon layer, such as bedrock, make sure that **LEX_ROCK** is the selected **value field** in the **Import Symbology Matching Dialog**. For a polyline or line layer it should be **FEATURE**.
- OK » Apply » OK

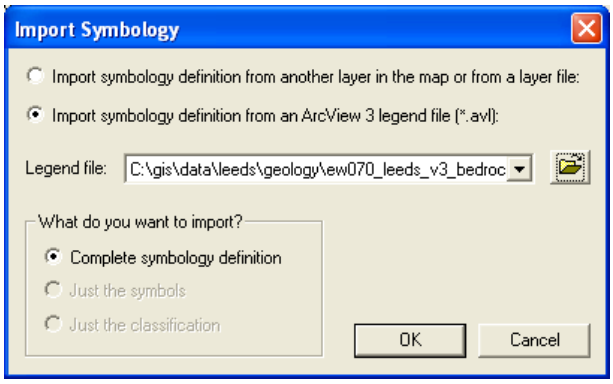


Figure 7.1: Import Symbology

You should then see the data in the layer symbolised according to BGS categories.

You may find that the symbology for line layers in the legend files is not very helpful, in this case you will need to categorise the line layers on **FEATURE** and then apply your own symbology.

7.3 Styling shapefiles with a layer file

If you have downloaded 1:250 000 data go to section 7.2 on page 87 for information on using layer files to style data.

The 1:50 000 shapefiles have a layer file with the extension .lyr associated with them when you unzip them.

The 1:10 000 and 1:25 000 shapefiles provided by Digimap have another zipped file within the download which contains layer files. These layer files can be used to apply BGS standard symbology.

For the 1:25 000 and 1:10 000 data start by unzipping the layer files:

- for 1:10 000 scale data unzip `Geology_10k_Layer_Files.zip` to your local drive.
- for 1:25 000 scale data unzip `Geology_25k_Layer_Files.zip` to your local drive.

There are two possible ways to use layer files to symbolise the shapefiles and it is your choice which one you use. Both will give the same final result.

Video Clip available in Minerva - Symbolising a layer with a layer file (.lyr). Direct link `http://bit.ly/2tx6ePi`

7.3.1 Add the layer file first

- Open ArcMap and add data as usual, but this time add the layer files (.lyr extension - see figure 7.2) to your map rather than the shapefiles

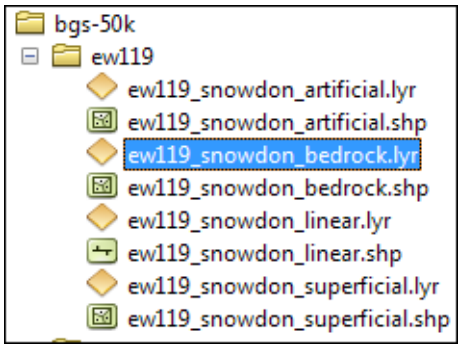


Figure 7.2: The bedrock layer file is selected here. Add this to your map rather than the shapefile

You'll probably find that you can see the layer title in your table of contents but it has the "dreaded" red exclamation mark next to it (figure 7.3) and you can't see the geology on your map. This is because the layer file is still trying to find the data in the place it was on the computer of the person who originally set up the file, so you need to tell it where to find the data on **your** computer.

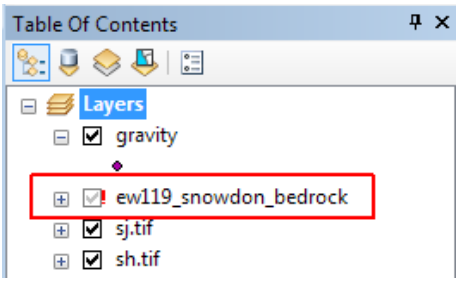


Figure 7.3: The red exclamation mark showing that the layer file can't find the associated data

If it works immediately and you can see the geology on your map that's a bonus and you don't need to repair the data source!

- Right-click on the layer and Data > Repair Data Source...[1]

[1] Alternatively open the layer properties, go to the **Source** tab and click on the Set Data Source... button

- navigate to where you saved the data, either the original tile or the merged tile and add the matching data tile, e.g. bedrock.
- then click Add to style the data.

The layer should appear on your map symbolised according to BGS categories as in figure 7.5.

7.3.2 Add the data layer first

An alternative to the previous section is to add the data layer first -

- Add a shapefile to your map as usual. It will appear but will be all one colour (figure 7.4).
- Open the layer properties and go to the **Symbology** tab
- Click on the Import... button and select to **Import symbology definition from another layer in the map or from a layer file:**
- Click on the folder button next to the **Layer:** drop down and navigate to the location of your layer files. There should be a layer file with a similar name to your shapefile, e.g. `gb_10k_bedrock.lyr`
- click on the lyr file and Open > OK
- For a polygon layer such as bedrock, make sure that the selection in the drop down for the **Value field** in the **Import Symbology Matching Dialog** matches.
- OK > Apply > OK

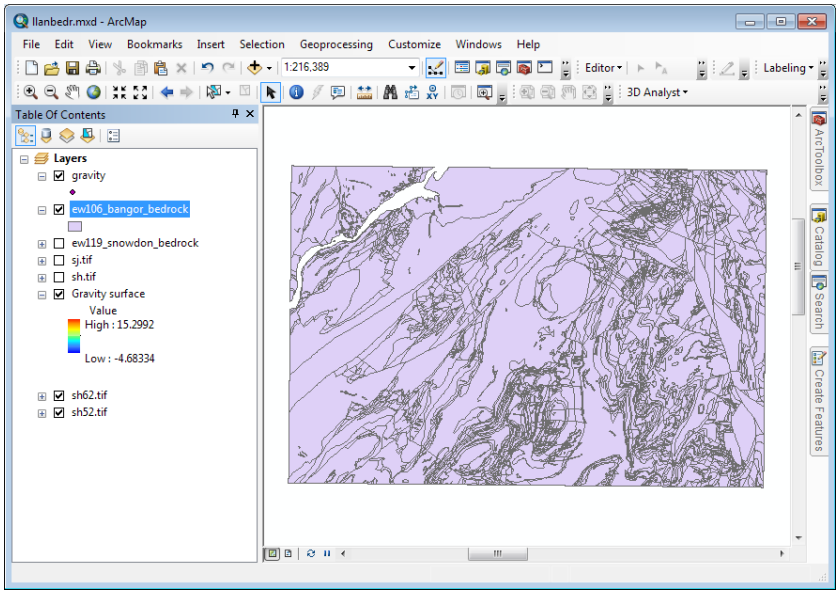


Figure 7.4: BGS geology shapefile with no symbology

The data should now be symbolised according to BGS categories as in figure 7.5.

7.4 Merging vector data files

NOTE: The layer files for the 1:50 000 data are specific for the tile so don't merge multiple 1:50 000 tiles. You'll have to symbolise each of these separately. Merging is useful for 1:25 000 and 1:10 000 data, though.

If you have multiple tiles of data you may find it a good idea to **merge** the tiles first.

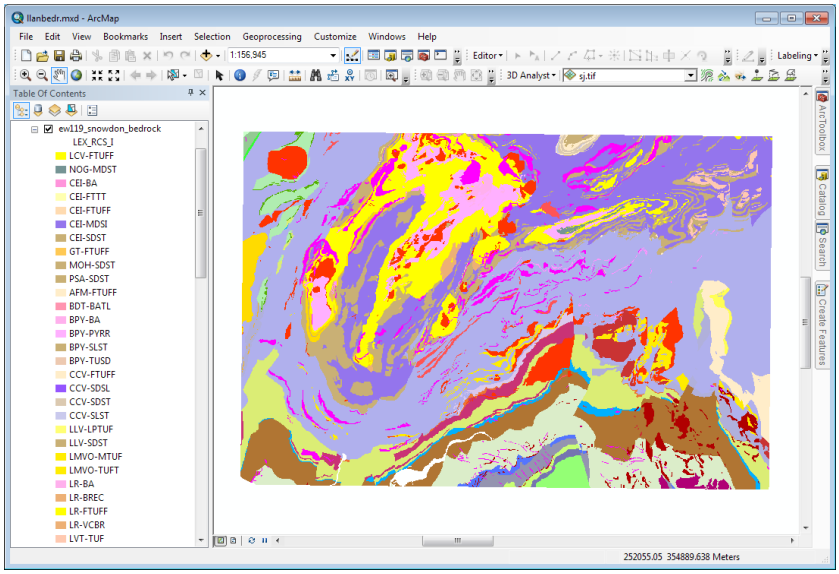


Figure 7.5: BGS geology shapefile with symbology, also showing the classification in the table of contents

- Geoprocessing » Merge
- In the tool dialog that opens add the tiles that you want to merge. Note that these need to be of the same data type, e.g. polygons. In this example choose all of the bedrock tiles.
- Choose a location for the output, and give it a name, then select OK to merge the tiles.

Once you have a single tile of data for each type of geology that you want to add to your map, you can choose one of the following two methods:

7.5 Restricting a layer to a subset of features

If you are only creating a map for a small part of a BGS tile and using a layer file or an ArcView Legend file to apply symbology, you may find that your legend includes a lot of values that are not actually visible on your map. With a bit of extra effort you can tidy up your legend by removing the unused features.

Note that you do not have to do this, it is only if you think it would be useful…If you are following the gravity or rainfall exercises then don't worry about it now, but just remember that it is possible to do!

7.5.1 Select features and use to create a new layer

Arc allows you to select a subset of the features on a layer and then export them as a new layer.

- Start by zooming the map to the extent for which you wish to export data.
- Right-click on the layer Data » Export Data…
- In the dialog that opens (figure 7.6) select to export **All features in View Extent** and use the folder button to select a location and the name of the output.
- OK then select to Add data to map

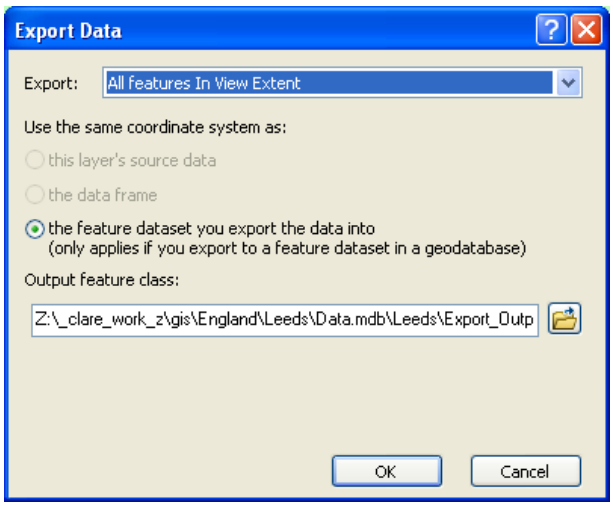


Figure 7.6: Exporting data from the view extent

You should have a layer that includes all features that either completely or partially appear in the view area.

To symbolise the layer follow the instructions above, use the layer file (section 7.3) or the ArcView legend file (section 7.2) from the original layer to provide the symbols. Once you have done that you can remove the legend items that are not being used by your selection.

- Open the **Layer Properties** for your new layer and select the **Symbology** tab.
- Click on the **Count** column heading

ArcMap will count how often each category is used in that layer and will display the result (figure 7.7).

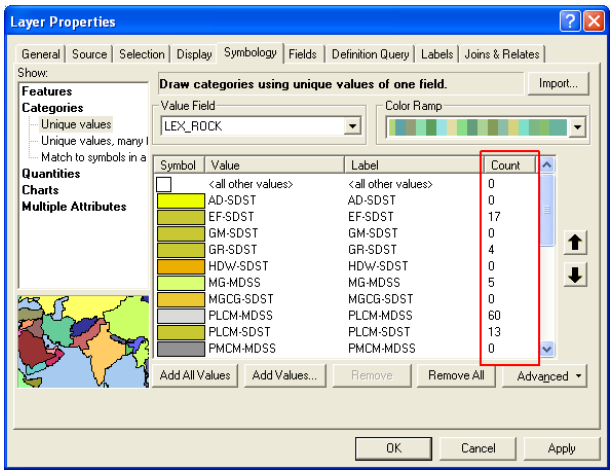


Figure 7.7: Counting categories used in a layer

- You now need to go down the list of values and delete all those that have a count of **0** by selecting the row and clicking on Remove. (Yes, there are rather a lot of rows to delete...)
- When you have finished click OK.

You should now have a much shorter and more manageable list of categories both in your table of contents, and in any legend you create.

7.6 Copyright notice

All maps produced from BGS data downloaded from Digimap must carry the following copyright acknowledgement:

Geological Map Data BGS © UKRI 20(yy)

Where (yy) is replaced by the current year.

Maps that also include OS data must **in addition** carry the OS copyright acknowledgement[2].

© Crown Copyright and Database Right 20(yy). Ordnance Survey (Digimap Licence).

Create a geological map of your area using the geological data that you processed above and an Ordnance Survey base map at a suitable scale. You'll need to set transparency[a] for the geology so that the topography is visible underneath to give location information.

The examples above all show just the bedrock geology, try adding and symbolising the other layers provided too, particularly the linear features (fold axes, faults etc).

[a] Check the workbook index for **Transparency** if you need a reminder of how to do this.

[2] Note that the text for this copyright acknowledgement changed in October 2014

Chapter 8

Layout and presentation

Once you've put in all of the hard work to produce a map of your field area or project, it is worth making the extra effort to ensure that you lay it out clearly and print it, or export it in a professional fashion. Make sure that you allow the time to do this. Care and patience can make the difference between a scruffy, unimpressive map that loses you marks, and a clear, professional map that gives a good first impression.

Don't underestimate the time that the final details can take and don't leave this until the last hour before a deadline!

You won't need to use all of the elements and features outlined here for every map. Equally, this is not an exhaustive list of possible elements. You should already have some idea of what elements are useful, and should be able to make a decision for each case based on your existing knowledge of maps. If you think that you need to add something that is not listed here, e.g. a report based on a table, then use the extra information available in the bibliography, further information and on-line to find out how to add it.

This chapter also includes some information on map evaluation and a useful checklist which should help you to think about how maps are used and what needs to be included.

So this chapter isn't necessarily for working through in order. Make sure that you are aware of the contents and of what Arc is able to do, and then make your own decisions and further investigations.

8.1 Learning outcomes

When you have completed this section of the workbook you should be able to

- layout a map in such a way that it effectively communicates the content and purpose of your work to a user
- select map elements to include in a layout and set their properties to match the requirements of your map
- print or export your map to show it to it's best advantage
- evaluate your maps and maps by other people or organisations based on a checklist

8.2 Viewing a map layout

In ArcMap **Layout view** allows you to control the format and scale at which you print your map, and lay out additional elements to complete the final product.

- Open the map that you created in the previous chapter in ArcMap
- Go to layout view by clicking on View > Layout View or by clicking on the Layout view button - see figure 8.1

In this view you will see your map laid out as it will be when it is finally printed or exported with the page outlined on screen and the content on top of it - figure 8.1.

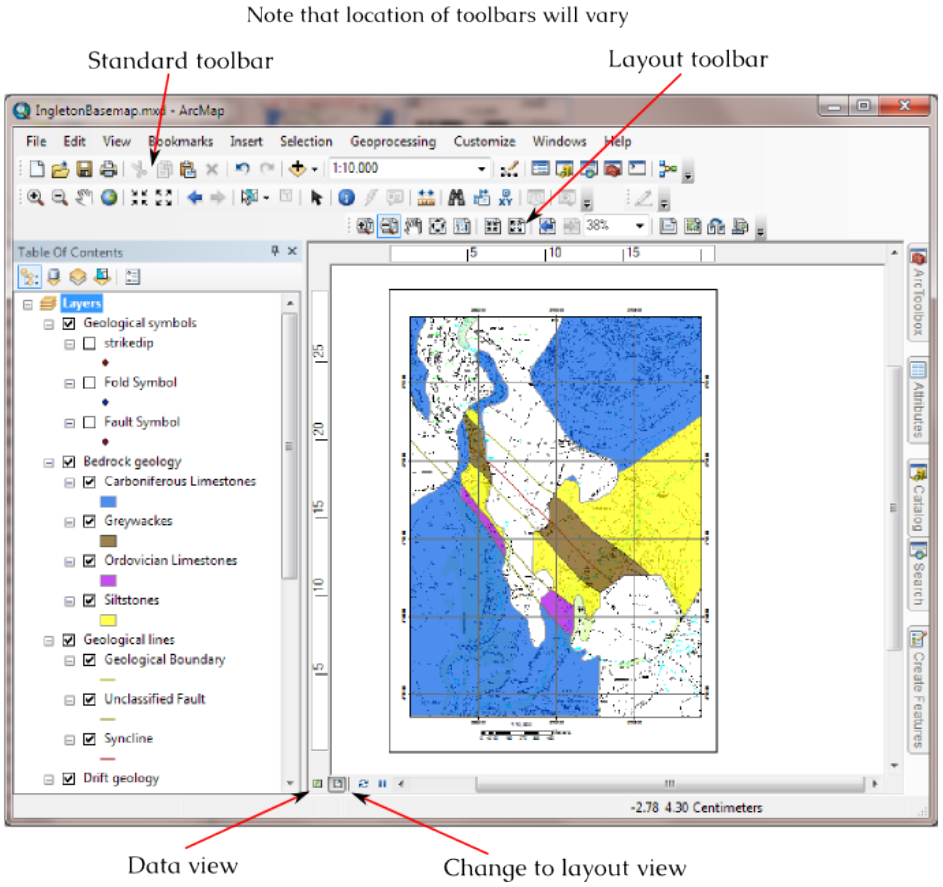


Figure 8.1: Layout view

8.3 Size and scale of a layout

8.3.1 Page size and scale

Changing the size of the page can also change the scale, so each time you alter this check the scale of your map again!

Video Clip available in Minerva - Setting the size and scale of a map layout. Direct link: `http://bit.ly/2h33WSu`

- File > Page and Print Setup... - see figure 8.2.

- Check whether **Use Printer Paper Settings** is ticked or not.
  - If it is the settings used are those in the **Paper** area above
  - If it isn't then the settings used are those in the **Page** area below.
- If you want a standard paper size such as A0 or A4
  - Select the size in the dropdown list in the **Page** or **Paper** area
  - Select the correct orientation (portrait or landscape)
- If you need a non-standard paper size
  - Choose **Custom** in the dropdown box
  - type your required measurements into the **width** and **height** boxes
  - select the orientation if necessary (portrait or landscape)

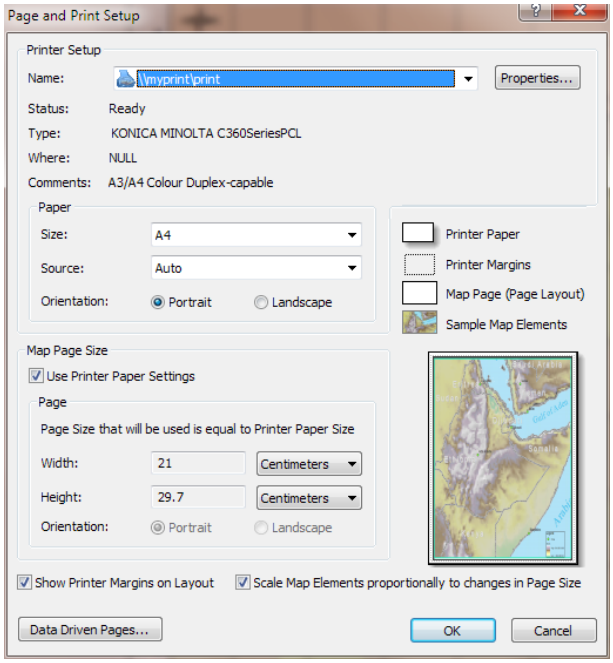


Figure 8.2: Page and Print setup: Choosing page size

Start with the paper size as A4 in Page and Print setup; set the map scale to 1:25 000. Next set the paper size to A3 and tick the Scale Map Elements proportionally to changes in Page Size box. Now click ***OK***
Now what scale is your map?

The scale will probably change almost every time you change anything else! **KEEP CHECKING AND RESETTING IT!**

Repeat the above steps as necessary until the layout looks right and is at the correct scale.

8.3.2 Resizing the data frame in a layout

When you first change to layout view the area of the map that you see in the data frame will not necessarily be the area that you want to show. Changing the size of the data frame is easy, but can take a little experimentation. You will also need to look at this in conjunction with the instructions on changing paper size in the previous section.

Video Clip available in Minerva - Resizing the data frame in a layout.
Direct link: `http://bit.ly/2h2YQWp`

- Click once on the data frame (that is the main map area)
- When the data frame is selected you should be able to see that it is outlined by a dashed line with small turquoise boxes at the corners and on each side - see figure 8.3.
- Use the boxes as "handles" to resize the data frame by dragging
- Keep an eye on the scale dropdown! You may need to put this back to your required scale and then resize the data frame again
- Remember that you can use the pan tool on the layout toolbar to move your map within the data frame.
- Keep repeating this until the size/extent and scale of your map are correct

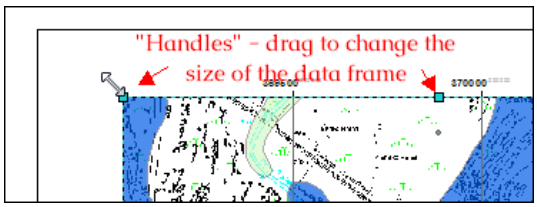


Figure 8.3: Using the "handles" to resize a data frame in layout view

Printing a map at the correct page size, area and scale
Printing a map at the correct page size, area and scale can be a bit like "juggling jelly". You just have to keep trying and change it a little bit at a time until it looks right. • Start by setting the correct paper size • Then use the black arrow tool to set the data frame to the size you want compared to the paper size • Now check the scale of your map and change it if necessary • Check the coverage - does your map show the area you need? • keep repeating these steps (sometimes several times) until your map shows the right area at the right scale, and fits on the page!

Table 8.1: Printing a map at the correct page size, area and scale

8.3.3 Setting a fixed extent

It is possible to set the view to show a particular extent, but be warned that if you do this it then becomes impossible to change the scale of your map in either map or layout view, and you won't be able to resize the data frame in layout view or pan your map in map view. If you've been asked to produce a map at a particular scale this won't be a good idea!

- Go to Data Frame Properties > Data Frame
- Under **Extent** use the dropdown box to select Fixed Extent
- Enter the coordinates you require in the boxes or click on Specify Extent... to choose a layer or view.
- Apply > OK
- If you wish to undo this just set Extent back to Automatic

It is also possible to set the dropdown to Fixed Scale, which can be useful, but does mean that if you are still working on your map it isn't possible to zoom in and work on details.

8.4 Adding elements to a layout

The information below includes details on adding many different elements to a layout. Not all of these will be appropriate to every layout, it is up to you to decide which elements to use depending on the purpose and audience of your map and any guidelines specified for assessments or reports.

Remember that **Arc Desktop Help** will provide you with plenty of extra information on how to add map elements to a layout.

Most elements are added to a layout in a similar way to each other using the Insert menu. In most cases you'll then be presented with a properties dialog which allows you to make changes to the element.

Once they have been inserted you can move the elements around. If you need to change properties then double-click on an element.

Video Clip available in Minerva - Adding a scalebar, title and text to a layout. Direct link: `http://bit.ly/2s9iMYO`

8.4.1 Scale bar and text

Some indication of scale should always be added to both printed and screen maps. A scale bar is a useful convention for both. Scale text (e.g. 1:50 000 or 1cm = 1km) is only relevant for printed maps, not for maps on screen where someone can zoom to any scale.

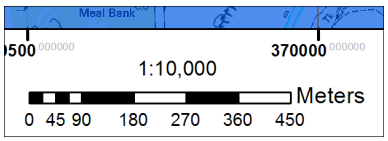


Figure 8.4: Scale bar and scale text on a map layout

8.4.2 Title and text

Adding a title

Maps need an informative title so that people looking at them know what they are supposed to show. You can add a title by going to Insert > Title. This gives you a dialog in which to add the title which will then appear on your map. If you want to change the font size etc double-click on the title then click on Change Symbol... . Doing it this way sets the title in the **Map Document Properties** for the whole map - change the title text by going to File > Map Document Properties.

Adding text

You should use the insert text command to add further text, such as your name (or for an assessment your student ID) as creator of the map, a copyright statement, acknowledgements, and further explanation.

Copyright acknowledgements Copyright is important. Remember that most data providers ask you to sign up to conditions that include an obligation to add a copyright acknowledgement to your map. Check what that copyright statement is and add it.

e.g. when you signed up to use the Digimap collections you agreed to add copyright acknowledgements whenever you created a map with the data. These do change from time to time so it's worth knowing how to check it for yourself.

- To find these copyright acknowledgements go to the **Digimap Resource Centre** (**Resources** at the top of the main Digimap page)
- Look for a link to **Digimap Licence Agreements** and click on it.
- Click on the End User or Sub-licence agreement for the data that you've used
- then look for the information under **In return, you must:** - that gives you the acknowledgement text.

For example, as of April 2019 when you use Ordnance Survey data obtained from Digimap you are expected to add the following text to your map.

> ***© Crown copyright and database rights*** `year`***. Ordnance Survey (100025252).***

Where *year* is replaced by the current year.

Remember that you do have to acknowledge each different dataset that you use and will have signed up to that when you registered.

If you are *not* using U.K. Ordnance Survey data this is **not** the correct copyright acknowledgement to use, for example if you are using data for Spain or the United States, or indeed UK data that you

Adding the copyright symbol to your text
To add the **copyright symbol** - ©- to your text • check that the Num lock is on on the keyboard • hold down the Alt key • use the number pad to type 0 + 1 + 6 + 9 • release the Alt key

Table 8.2: Adding the copyright symbol to your text

haven't downloaded from Digimap. You'll need to find the correct copyright acknowledgement for yourself. The web page[1] at `http://bit.ly/1ZSifnd` gives some information about how to cite GIS materials - including the software as well as the data. Have a look at that and follow the suggestions to cite non-Digimap data.

Advice on citing Digimap data, as opposed to the copyright acknowledgement is at `https://digimap.edina.ac.uk/webhelp/resources/citation/services.html`

If you want to add formatted text try adding it via a Word document using the instructions in section 8.4.9 on page 108.

8.4.3 Adding a key / legend to your layout

You'll have added various data to your map, and it is necessary for you to explain to anyone looking at your map what those layers and symbols show. To do this you'll need to add a legend or key.

Start by using the default options to create a legend. Once you have the basic legend it is possible to make alterations later

Video Clip available in Minerva - Adding and editing a map legend.
Direct link: `http://bit.ly/2urgYuF`

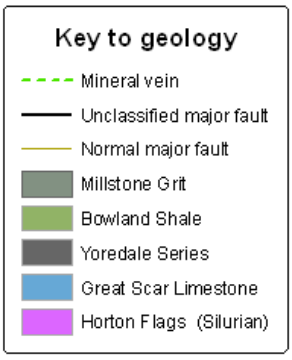


Figure 8.5: An example of a basic legend or key

[1] Last viewed: 18th September 2018

- In layout view - Insert > Legend...
- The Legend Wizard should open. ArcMap will probably add all of your layers to the right-hand box automatically. Use the arrow buttons to remove and add layers and to order them as you want them to appear - referring back to the list that you just made.
- Next then change the legend title if you wish and click Next again
- Decide whether you want to add a background or border to your legend then Next > Next > Finish
- Move your legend to an appropriate position on your map.

You can double-click on the legend to change its properties and settings. At this stage if you make changes to the layers in the table of contents, those changes will automatically be reflected in the legend.

As an aside - the ESRI blog has a short discussion at `http://arcg.is/2eD2Kk2` about the use of singular and plural nouns for legend items which you might find informative.[2]

It is very likely that you will want to change the legend in some way to make it clearer. Once you have all the basic information in your legend you can convert it to a graphic and you will have more flexibility to rearrange items. Note that once you have converted a legend to a graphic it will no longer change automatically if you change symbology or layers on your map, you will have to generate a new legend. So leave this step until you are happy with everything else on your map.

Converting a legend into a graphic

- In Layout view use the **Select elements** tool (black arrow) to select the legend.
- Right-click on the legend Convert to Graphics.
- Right-click on the legend again Ungroup.
- Repeat the last step again

Now you should be able to select individual parts of your legend and move them around or delete them.

> ***For example if you have lines with symbols that have been added as points: in your legend move the point symbol so that it is positioned on top of the appropriate line then delete any text that was associated with the symbol.***

Use the tools on the **Draw** toolbar (figure 8.6) to add extra text.

Figure 8.6: The Draw toolbar

> ***The default legend styles in Arc will not necessarily group features in a way that is most helpful for your map. You can add headings yourself using the Text tool and then rearrange the entries under those headings manually.***

[2] Last viewed: 18th September 2018.

Make sure that your key covers all of the information that you have added to your map, but doesn't include any symbology that doesn't appear on your map. (Do you want a viewer to sit there wondering where that symbol is on your map?)

8.4.4 Adding a measured grid

Measured grids add labelled grid lines to a layout. If you are using Ordnance Survey or other UK data projected in British National Grid then you can easily add National Grid lines and numbers to your map. The O.S. raster tiff files already have grid lines marked, but adding a measured grid allows you to include coordinates around the edge of your map - making it possible to read grid references.

Video Clip available in Minerva - Adding a measured grid to a map.
Direct link: `http://bit.ly/2uruf6q`

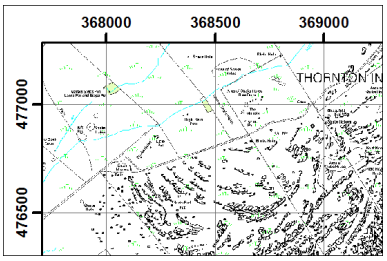


Figure 8.7: A map with a measured grid that shows British National Grid references on a 500 m grid

- View > Data Frame Properties > Grids > New Grid > Measured Grid
- Choose the style that you want. Check that the coordinate system is set to **Same as data frame**, and check that the intervals are suitable to the scale of the map, e.g. 500 meters for a 1:10 000 scale map. *Note that being able to set this relies on having the correct co-ordinate system set for your data frame.*
- Next > Next > Finish > OK

Once you have set the grid up you can make further changes to the properties by going to View > Data Frame Properties > Grids and double-clicking on the grid that you have already created.

Note that the grid that Arc adds is fully numeric, you may be more used to seeing grid letters for 100 km grid squares, e.g. our current grid reference is similar to SE 2934 3444, our current grid coordinates are similar to 42934 43444. It is the latter that will appear on a measured grid generated by Arc. For more information on this and a diagram to help you to change from one to the other, see section A on page 120.

8.4.5 Adding north arrows

Before adding a north arrow to your layout stop and think about how you need to indicate north on your map. If you look at the technical information on an Ordnance Survey Landranger (1:50

000) map you'll see a diagram showing Grid north, True north and Magnetic north. The information given there shows how to plot the difference of magnetic north from grid north. Adding this to your own maps can also be useful.

If you are taking strike and dip measurements in the field you should have corrected your compass-clino for declination (the horizontal angular difference between true north and magnetic north) anyway. When you plot the measurements on your map it isn't worth worrying too much about whether you are plotting against grid or true north as the difference on any grid, not just the British National Grid, is unlikely to be that big. Figure 8.8 shows the different types of north and the declination.

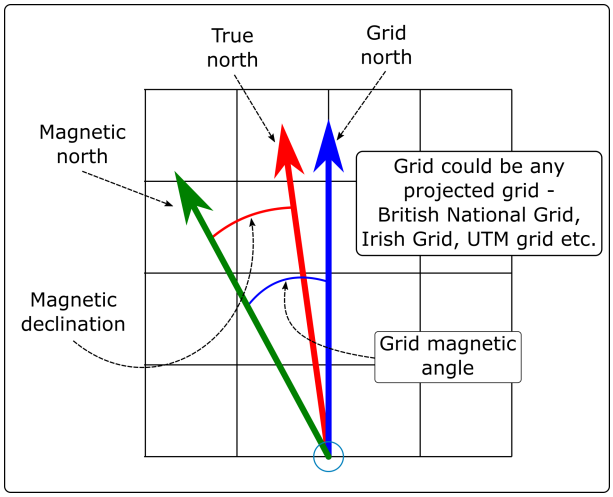


Figure 8.8: The different types of North that you'll find on a map set to a projected coordinate system, such as British National Grid

If you add north arrows to your layout do remember to label them in some way which shows which version of north each one is showing.

Video Clip available in Minerva - Adding north arrows to a layout.
Direct link: `http://bit.ly/2hohEQa`

North arrow: Grid north

If a map is in a projected coordinate system ArcMap will automatically lay it out aligned with the grid. So for example, any map set to British National Grid will be aligned to grid north.

In this case it isn't strictly necessary to add a north arrow to show grid north if you also include a measured grid on your map, but it doesn't hurt.

In layout view:

- Insert > North Arrow...
- select an arrow style (it's usually better not to go for something too fancy!)
- Click on Properties... and check that **Align To:** is set to **Data Frame Rotation**
- OK > OK

If you check this against your measured grid lines you should find that it matches exactly.

North arrow: True north

True north is the direction from the area of your map to the North Pole. In the east/west centre of a grid, such as that set for the British National Grid, it may well be the same as grid north, e.g. in Leeds the difference is extremely slight. As you go further east or west towards the edges of an area covered by a grid the difference becomes more noticeable, e.g. at Lands End in Cornwall, or in Norfolk.

In layout view:

- Insert > North Arrow...
- select an arrow style (it's usually better not to go for something too fancy!)
- Click on Properties... and check that **Align To:** is set to **True North**
- OK > OK

If you check this north arrow against your measured grid lines you may well find that the north arrow is slightly tilted.

North arrow: Magnetic north

Magnetic north is the direction from the area of your map to the magnetic North Pole. This changes with time so the first thing you need to do is to find out what the **declination** is in your area at the moment[3]. To do this you can use the page provided by the BGS Geomagnetism Group at `http://bit.ly/2uGMfdp`[4]

Use the map to select your area and click to retrieve the data. Make a note of the figure shown as **degrees east** and round it to the nearest whole number. The key to the table you are given is underneath the map.

In layout view:

- Insert > North Arrow...
- select an arrow style (it's usually better not to go for something too fancy!)
- Click on Properties... and check that **Align To:** is set to **True North**
- Set the **Calibration Angle** to the figure you found above. The arrow on the preview should change to reflect this (see figure 8.9).
- OK > OK

This magnetic north arrow should now appear tilted the appropriate number of degrees from the true north arrow that you added above. It would be useful to also add text to your layout (Insert > Text...) showing the date that you added magnetic north, and the declination figure.

8.4.6 Adding extra data frames

It can be very useful to be able to place more than one map or map view on a single layout, either so that you can show a different area, or a different zoom level for the same area. You can also use this to set up an automatic extent indicator which marks your study area on a larger map. To do all of this you need to add extra data frames.

[3] **Declination** is the angle between true north and magnetic north at a particular location. **Grid Magnetic Angle** is the angle between north on the grid and magnetic north. To find Grid magnetic angle for Great Britain use the calculator at `http://www.geomag.bgs.ac.uk/data_service/models_compass/gma_calc.html` on the BGS pages. This is the number that is given on the corner of OS maps and the one you need for setting your compass-clino in the field so it would be worth making a note of this on your map too.

[4] This should work for anywhere in the world.

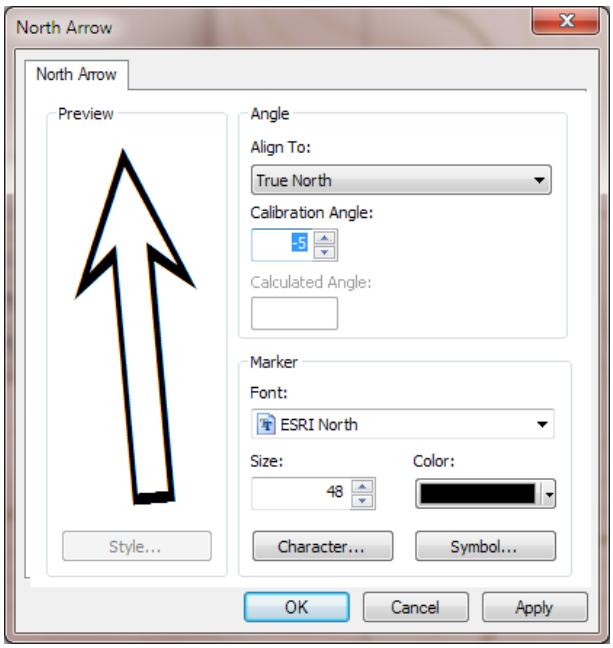


Figure 8.9: The properties for a north arrow to show magnetic north

Video Clip available in Minerva - Adding extra data frames to a layout. Direct link: `http://bit.ly/2spjXqZ`

Create a new data frame

- In either data or layout view Insert > Data frame
- A new data frame should appear in your table of contents and the map area will become blank if you are in data view, or show a new data frame on the page if you are in layout view (see figure 8.10). If the new data frame doesn't appear in layout view, use the cursor to drag the data frame title from the table of contents to the layout.
- Make sure that the data frame title in the table of contents is bold - that means that it is **active** (see figure 8.11). If you need to make a data frame active right-click on it and select **Activate**.

Add data and set the projection

- Add map data to the new data frame, either by adding it from the Catalog, or by dragging and dropping it from an existing data frame.[5]
- You may need to alter the data frame properties to set the Coordinate System - don't forget to check that it has been set correctly! Note that it is possible for data frames within the same map to have different coordinate systems.
  - Right-click on the data frame title (probably **New data frame**) in the table of contents

[5] Occasionally if you are dragging and dropping from another data frame Arc will lose the link to some layers and you'll see the dreaded red exclamation mark. If this happens just follow the instructions in table 1.5 on page 11 to repair the links.

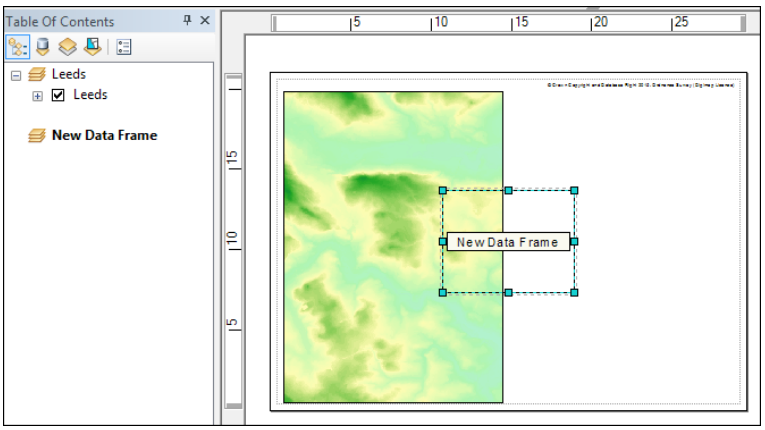


Figure 8.10: Layout view showing the newly added data frame. You can now move and resize this as you wish, and add data to it as required

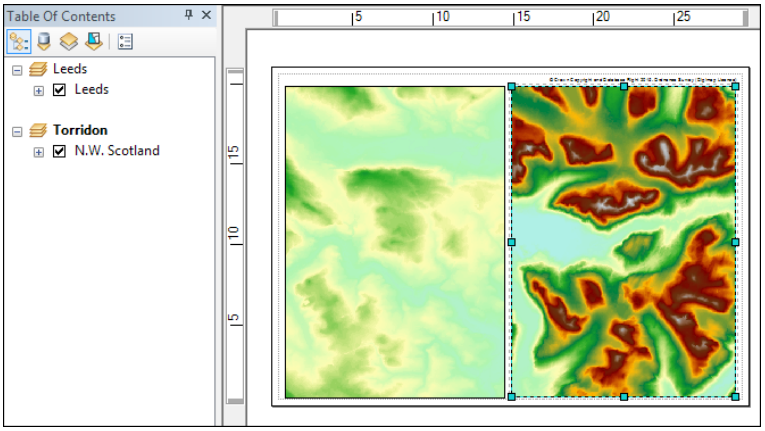


Figure 8.11: Layout view showing the activated data frame - note the data frame title in bold in the table of contents, and the selection lines around the data frame on the layout

– If it hasn't already been set, set the coordinate system as required by your map, e.g. for British National Grid - Properties... > Coordinate System > Projected Coordinate Systems > National Grids > Europe > British National Grid > OK

8.4.7 Adding an extent indicator

For some maps, particularly large scale maps of very small areas, it is useful to show a small scale map of the general area with the area of the main map marked (see figure 8.12). To do this you need to obtain small scale data and then add it to a second data frame in ArcMap. For Great Britain investigate the more general scale basemaps from Digimap, such as MiniScale or GB Overview, or use the national outlines from the boundary layers. It's up to you to select data which is readable/clear at the scale you are going to display it.

For areas outside of Great Britain you may need to search for suitable data, or use data from Natural Earth[6].

Note that using a screenshot from Google Maps or Google Earth (or similar) with a marker on it doesn't look good, and should be avoided.

Start by adding a new data frame to your map as shown in section 8.4.6 on page 104 and add your choice of map layers to the new data frame.

[6]Download from `https://www.naturalearthdata.com/` Last visited: 16th May 2019.

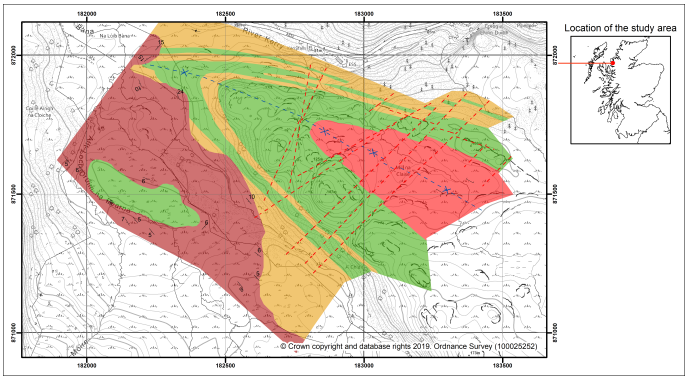


Figure 8.12: An extent indicator on a layout: using a smaller map to show the general area of the main map

Set up the extent indicator

- Resize and relocate the data frame and set it to an appropriate scale (e.g. start with 1:1 000 000) and the area around the location of your main map.
- Right-click on the data frame title in the table of contents Properties > Extent Indicators add the main data frame (probably called "**layers**" to the right-hand box and tick the **Show Leader** box then click OK.

You should now have a map with a red box showing the outline of the area covered by your main map and with a line leading to it as in figure 8.12 on page 107.

> ***Try moving and rescaling both maps - the box should resize and relocate to reflect your changes.***

You can change the style of the box and the leader line by going back into the **data frame properties**.

8.4.8 Showing a profile on a layout

If you have created a profile graph for your map you may wish to include it in the final layout.

- If the profile that you created earlier is still open:
  - Right-click on the graph Add to Layout
- If the profile is closed - whilst in layout view:
  - Views > Graphs > Manage... right-click on your graph in the list Add to layout
- Once your profile graph is on the layout:
  - Move the graph to the required permission
  - Change properties by selecting the graph, right-clicking and going to **Properties**

8.4.9 Adding sections, diagrams and photographs to a map layout

You will probably want to add extra items to your map layout, in particular cross sections and diagrams created in vector drawing packages such as Inkscape, CorelDraw or Adobe Illustrator and maybe some photographs.

When it comes to creating a full map presentation, such as the Geological Sciences A0 dissertation map, which includes elements other than just a map, you have a choice:

- You can either use ArcMap to set up the full layout by importing photographs and also sections, diagrams, etc created in other programs such as Inkscape or CorelDraw - **instructions for importing elements from other programs are in this section**.
- *or* you can export your completed map (and other map elements) from ArcMap and import them into Inkscape, CorelDraw or a similar vector package. (Word, Powerpoint etc are **not** recommended for creating a full layout.) **In this case go to section 8.6.3 on page 111 and look at the instructions for exporting a layout from ArcMap.**

Video Clip available in Minerva - Adding diagrams, images and formatted text to a layout. Direct link: `http://bit.ly/2t8CHbs`

Adding objects: CorelDraw diagrams and Word documents

You should use these instructions to include any text and CorelDraw diagrams that you need to include in your layout. These instructions also work for Excel spreadsheets. Inkscape diagrams should be exported to png and then imported to ArcMap as images - see section 36 below.

Note that CorelDraw files may not display correctly if you have gradient fills. You may find that you have to export images from CorelDraw as png (Portable Network Graphics format) and then insert them into Arc as images - see section 36 below.

- In Layout view - Insert > Object... to open the dialog (figure 8.13)
- Click to **Create from File** and browse to find the file that you want to insert
- Check that Display as icon isn't checked
- then click OK
- Move and resize the file on the page as required.
- If you wish you can right-click on the object to get a dialog that allows you to add a background or border.

If you are likely to want to make changes to your diagram or document later then you can click so that you **link** the file rather than insert it, but that does mean that you need to keep it in the same location relative to your Arc mxd file. This is particularly useful if you want to add formatted text as the tools are so limited in Arc. Write your text in Word and then include it as an object and you can still edit it by double-clicking on the object in Arc.

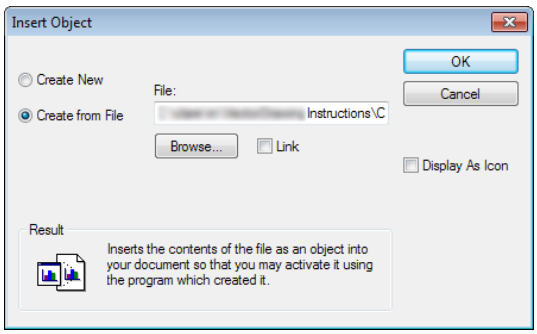


Figure 8.13: Inserting an object such as a CorelDraw file into a layout

Inserting photographs and images

Very similar to above but use this method for including jpg, bmp, png etc files in your layout.

Following some experimentation I would recommend that if you are including diagrams produced in either CorelDraw or Inkscape you **export/save as...** your diagram as **png** format and then insert the result into Arc. It may not look quite right on screen (gradients can be a bit odd and the image can look very pixelated/blurry) but looks fine when actually printed. Jpg files tended to have problems with colours changing when they are exported from CorelDraw.

- In Layout view... Insert > Picture... and browse for the image you require OK
- Move the image as required. Try not to resize it unless you absolutely have to. You'll get better quality if you resize vector images in Inkscape/CorelDraw before you export them, rather than resizing them in Arc once they've been saved as rasters.

Remember, if the image doesn't look quite right, try exporting to pdf or printing a copy before you worry about it (see section 8.5.1 on page 110). What you see on screen isn't always how the final result will look.

NOTE: double-check that images inserted in this way print! If they don't then, if all else fails, it is possible to add them to a Word document then insert the Word document as an object - see section 36 above.

8.5 Checking your map

A very important stage but one that can easily be forgotten if you are in a hurry!

In addition to the points below have a look at Darkes (2017) which gives lots of quick tips on map layout and presentation. On pages 92 and 93 Darkes includes a section with quick wins for improving your map before publication if you have 5, 15 or 50 minutes. In addition, check the reading list for other references - there is plenty of information available to help you to present better maps.

- ***Check spelling. Even better - get a helpful (and reliable!) friend to proof-read your text for spelling mistakes. It's very easy to miss something obvious in your own work. In particular check geological and geographical names and any technical terms.***
- ***Check that you have included everything that you need to include - if this is an assignment reread the instructions and check that you haven't forgotten to do anything.***
- ***Check that your map doesn't include anything that you don't want to include! Did you add some experimental polygons when you were editing, then forgot to delete them? Have you clicked on the Add text button too many times, but then not removed the resulting text?***
- ***Look at the article on the ESRI blog at*** `http://bit.ly/SZyDiC` [a]***. Read about what makes a map great, then click on the link to the checklist and use the questions there to evaluate your own map. Have you included everything you need to include, or do you have a good reason if something is not on your map? Have you taken care with your presentation?***

[a] Last viewed: 18th September 2018

8.5.1 Printing a copy to pdf to check

Inevitably you'll notice something not quite right with your map after you have printed it. To minimize the chances of this happening when the (expensive) big version is printed it is a good idea to print your map at A3 and have a close look at it first! (This isn't such an issue if your map is only A3 or A4 when full size.)

- Export your map as a pdf file following the instructions in section 8.6.2 on page 111.
- Open your pdf map file in Acrobat reader, or your usual pdf program (instructions below are for Acrobat).
- File » Print...
- Choose your printer and use the printer properties to set the paper size to A3 then choose to print in colour.
- In the **Page Handling** section set **Page Scaling** to **Fit to Printable Area**. In Acrobat this should show you a small preview of how your file will print.
- When you are happy with the settings - OK

8.6 Printing and exporting maps from ArcMap

When you have finished creating your map in ArcGIS you will usually need to export it to pdf for printing. The following instructions should help to ensure that your map is the correct size and scale.

8.6.1 Printing a map from ArcMap

The best quality output is obtained by printing directly from ArcMap, though this isn't always possible. If it is, print as follows:

- Start by checking that the page size and scale are correct in **Page and Print Setup...** (section 8.3 on page 95)
- Whilst in Layout view - File > Print...
- Select your printer with the Setup... button and choose paper size and colour printing as you usually would (this is system specific so I can't include exact instructions here)
- Set **Output Image Quality** to **Best**
- Click on OK to print

8.6.2 Exporting a map for printing

These instructions show you how to export the map to pdf - the format that is usually required by print shops etc. There are other options in the dropdown list if you need to export an image or another format and the instructions are very similar.

- From within layout view - File > Export Map...
- Select **PDF(*.pdf)** in the **Save as** type. **(Do not select the 'Production PDF' option, if you have it - it causes all sorts of problems.)**
- Set the resolution - minimum 300dpi for printing. Higher is better, but too high and it will be impossible to export the file, particularly if it is a large map.
- Set **Output Image Quality** to **Best**.
- Give your file a name and choose where to save it (checking first that you have enough disk space - some exported maps can be very large[7]).
- Save - be patient! For a large map this can take a long time.

Important note on printing your final copy

If you are printing your final copy from pdf double-check that the **Page Scaling** or **Zoom** is set to **Actual Size...** or **None** (the actual terminology depends on which pdf application you are printing from). This is important to ensure that your map is printed at the scale at which you intend it to be printed. Major problems can be caused by the tiny amount that your map will be reduced by otherwise.

8.6.3 Exporting a map to import to other programs

As explained in section 8.4.9 on page 108 you can either import items into an ArcMap layout, or export the ArcMap layout to include in programs such as Inkscape, CorelDraw, Word or Powerpoint. The instructions here show how to do the latter.

- To start with set up your ArcMap layout as required
  - check that the page size, and the scale/size of the data frame are correct - you'll lose quality if you resize them outside of Arc
  - If you want to include a legend in the final layout it is a good idea to create it in Arc and export it with the map as then the colours and sizes of the symbols will match the map.

[7] If you think that you may be short of disk space you can save the export to the c: drive or the desktop of the computer in the first place, but do make sure that you then move the file to your m: drive or a USB stick. Forget and you'll lose it.

  - add a measured grid and a scale bar
  - optionally add an automatically generated extent diagram

- File > Export Map...
- Choose the appropriate output format (see below) and set the resolution - to **600 dpi** if you have the disk space
- Choose a location then Save

If you basically want a good quality image to import into Word, Powerpoint, CorelDraw, Inkscape etc, then **png** or **jpg** are both fine. Be aware that if you import png or jpg and then resize them you are likely to end up with blurred final result - double-check before printing.

You can also import **pdf** or **svg** into Inkscape and CorelDraw and do some limited further editing.

Whichever format you choose, if your map is going to be part of a bigger presentation where scale is important, such as the Geological Sciences final dissertation map, import to either Inkscape or CorelDraw without changing scale/size/proportions (check instructions for those programs) and then double-check the scale of the main map by drawing a horizontal line of known length and checking it against the lines of the measured grid. For example, for a map at 1:10 000, a line of 10 cm will be the same length as the space between the 1000 m (1 km) grid lines.

8.7 Recommended reading: layout and presentation

The module reading list[8] includes a full section on layout and presentation. In particular have a look at "Designing better maps" by Cynthia Brewer, but for a quick overview look at the article by Frye (2001) or the small book by Darkes and Spence (2017). For examples and ideas look at Brewer (2008) and the ESRI Map Book Gallery.

[8] Reading list available from Minerva and from the module catalogue at `http://webprod3.leeds.ac.uk/banner/dynmodules.asp?M=SOEE-2650`

Chapter 9

Viewing your data in 3D in ArcScene

Once you have created features and data in Arc you can use them in almost exactly the same way in ArcScene, another component of the ArcGIS suite. You can then view the map in 3D and see how your data relates to the topography. You'll be able to export images from ArcScene to include in other reports and layouts.

9.1 Learning outcomes

When you have completed this section of the workbook you will

- be able to export the layers from a map and open them in ArcScene
- be able to view and explore the map in 3D
- save the view and add it to a map layout

9.2 Using 3D Analyst and ArcScene to view 3D topography

3D Analyst and **ArcScene** enable you to view your data in three dimensions using z values in surface grid files or heights above sea level.

You should already have a DEM or DTM layer which you downloaded to use in earlier exercises. This is the one that you used for height data, and probably mosaicked in section 6.5.2 on page 81.

9.2.1 Adding data and setting base heights in ArcScene

Once you have your DEM/DTM you need to load all of your data into ArcScene and then tell Arc to apply the heights from the DEM to each layer that you want to show in 3D.

- Open ArcScene (from the button on the 3D Analyst toolbar in ArcMap or from the Windows Start menu). It will look something like figure 9.1.

The interface should look familiar from ArcMap. Notice that you still have the Catalog available, just as in ArcMap, and can explore, and drag and drop data from there.

- Add your mosaicked DEM grid file for the height data

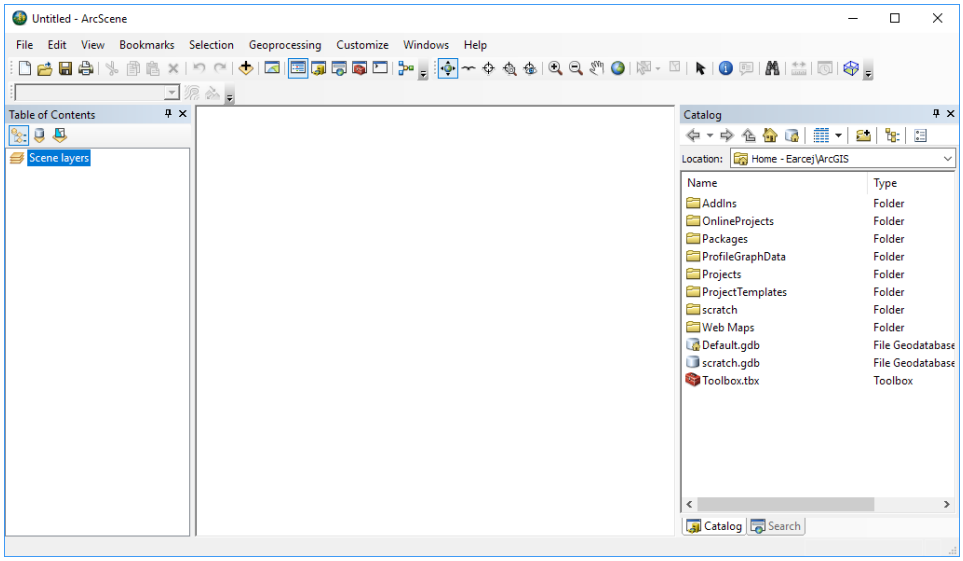


Figure 9.1: The blank ArcScene window.

- Add the background tif files, e.g. VectorMapLocal Raster; 1:25 000 Raster; 1:250 000 raster etc. Don't worry if the map looks rather strange when you first add data.
- Move the DEM file to the bottom of the table of contents and turn it off - it doesn't need to be visible for this exercise.
- Check that the coordinate system of the data frame is correctly set to British National Grid, if not set it now.
  - to check, right-click on **Scene layers** in the Table of Contents and go to Scene Properties
  - click on the **Coordinate System** tab and check the **Current Coordinate System**
  - If it isn't **British_National_Grid** reset it by clicking on Projected Coordinate Systems › National Grids › Europe › British National Grid in the top box.
  - Click OK

Base heights for topography

When you have all of your data in ArcScene you can start to turn it into a 3D view by setting base heights for various layers.

Set the dtm layer as the base heights for the topography as follows:

- Go to the layer properties of each background map tif file in turn and go to the Base Heights tab
- click next to Obtain Heights for Layer from Surface and ensure that your raster DTM grid layer is selected in the box - figure 9.2
- then click on the Raster Resolution button and have a look at the **Base Surface** resolution compared with the **Original surface**. You may find that there is quite a difference - as in figure 9.3
  - The raster surface resolution controls how smooth the shape of your 3D surface will look
  - you can change **Cellsize X** and **Cellsize Y** to a higher resolution, but it's a good idea to start with something that isn't too detailed. For the example shown I might change it to **250**. The units are the map units which are metres in this case. You may get a message warning you about system resources - click OK for now. But if things do slow down or stop, you may need to set the raster resolution to a higher number.

– Click OK

- Go to the **Rendering** tab and set a rudimentary form of hill shading by clicking the option to **Shade areal features relative to the scene's light position**. This makes the 3D effect a bit more obvious - as in figure 9.4.
- Click OK

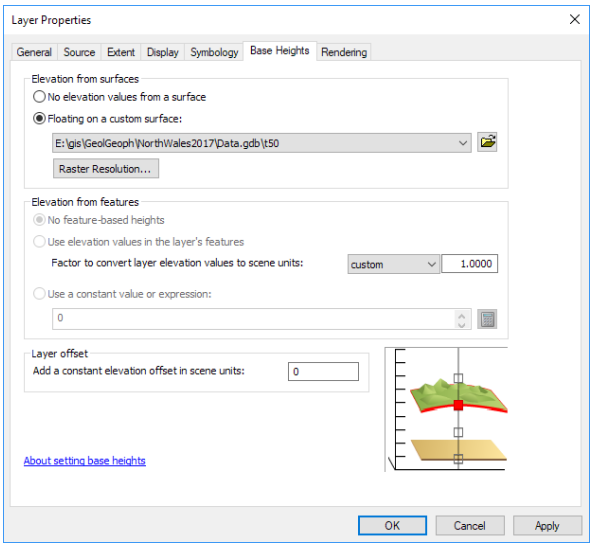


Figure 9.2: Setting the base height for a raster layer

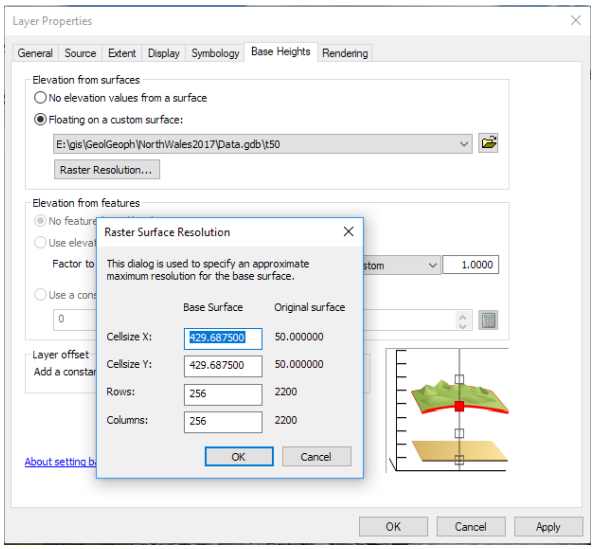


Figure 9.3: Checking and setting the raster surface resolution - don't make it too detailed to start with

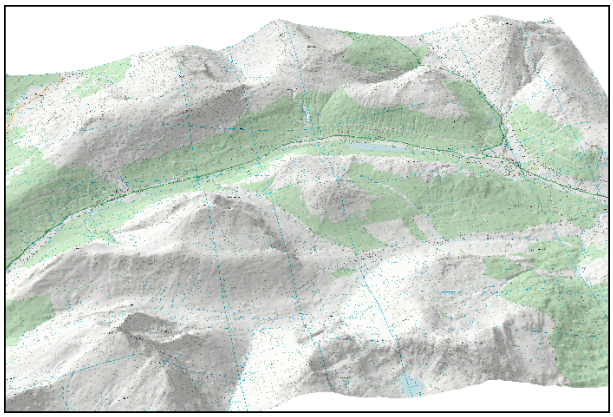


Figure 9.4: Topographic map raster tiles with base height and shading

The tif files should each in turn appear in 3D. The quality of the tif files probably won't be very good, but don't worry, you can sort that out later.

Try navigating around your scene using the tools on the toolbar at the top of the ArcScene window (figure 9.5). They don't work quite the same as Google Earth, but it's worth trying various tools and mouse buttons.

Figure 9.5: The ArcScene toolbar with navigation tools highlighted

Base heights and extrusion for point layer

If you have a vector layer with a field which could be used to **extrude** the data then you can display that in ArcScene too. Examples could include a point layer with lead or other chemical concentrations; a point layer with gravity or rainfall data; point data for depths of water wells; a polygon layer with building outlines and heights. The field with data such as height, or concentration, or depth is known as **z** data.

Add your layer that contains the data to be extruded to ArcScene and **zoom to layer**. The points will be hidden by the topography layer at the moment as the base heights haven't been set yet.

- Open the vector layer properties and go to the **Extrusion** tab. Tick to **Extrude Features in Layer**.
- Click on the **Calculator** button next to the **Extrusion value or expression:** box. Enter the name of your **z** data in the calculator by double clicking on it and click on OK
- Make sure that you select to Apply Extrusion by adding it to each feature's base height > OK. The dialog should look something like figure 9.6.
- Now set the base height in the same way that you did for the tif files.
- OK.

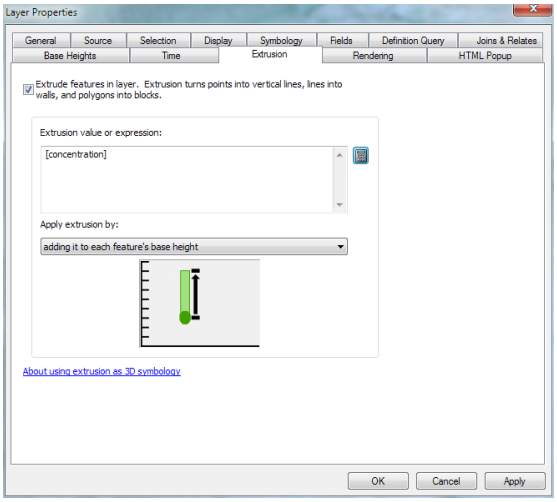


Figure 9.6: Extruding point features

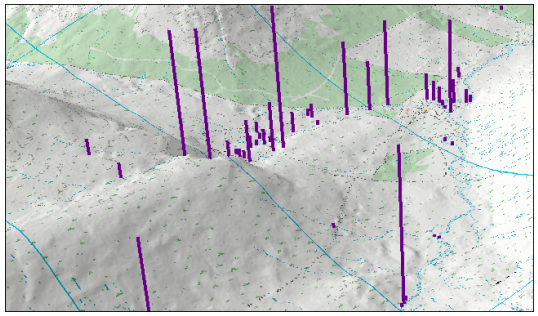


Figure 9.7: Extruded point features standing up above the terrain

You should be able to see the features now (figure 9.7). Move the scene around and have a look at how the points have been symbolised in relation to the level of the terrain.

9.2.2 Adding and offsetting a raster surface

You can also add a raster surface, such as the interpolation surface that you created earlier. This could be a lead concentration layer; interpolated gravity; interpolated rainfall. Any continuous surface will work with this.

- Add the surface that you created by interpolation in a previous chapter and symbolise it as you did in ArcMap.
- Set the base heights to the dtm layer again.

You will probably find that it appears on top of the topography but looks rather blotchy or vague, as in figure 9.8. This is because it is trying to occupy the same space as the tif files. You need to tell Arc which layers should be drawn on top, there are two possible ways to do this.

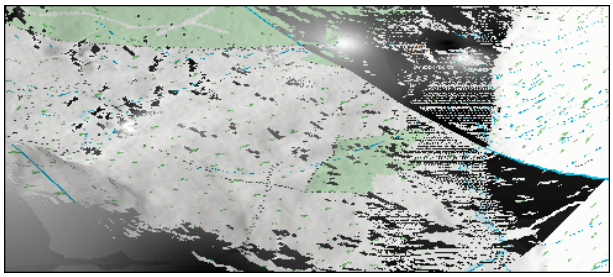


Figure 9.8: The interpolated layer trying to occupy the same space as the topography tiles

- On the **Rendering** tab of the raster topography map tiles set the **drawing priority of areal features...** to 5 or above. This tells Arc that these layers have a lower priority than the interpolated surface.
- On the **Base Heights** tab of the interpolated surface set the **Offset** to **20**. The quality of the surface should improve but you may need to fiddle around with the offset to get the best result. Be careful, though. If you set it too high the offset becomes obvious. Try setting it to **250** and navigate around the scene. Suddenly you can see exactly what offsetting is doing! Unfortunately setting transparency can also cause problems with this option.

9.2.3 Quality enhancement for raster images

You'll probably find that your tif files appear to be very bad quality and may even be unreadable. This is partly as a result of the zoom level and will improve if you zoom in close, but is also due to the way that Arc conserves memory by decreasing the quality of rasters. The following tip improves the rendered quality of raster images, such as O.S. tif files, but does slow down rendering quite dramatically by using more computer memory. If you put the slider too high Arc may crash. Increase quality with care.

- Open the layer properties for one of the tif files and go to the **Rendering** tab.
- Move the slider next to **Quality enhancement for raster images** depending on the quality you require.
- Click Apply to try it out and OK to accept the result.

9.3 Exporting your 3D scene as an image

When you have set up all of your data and want to export a view to include in a report or map layout, do the following.

- Navigate to a view that shows your data clearly.

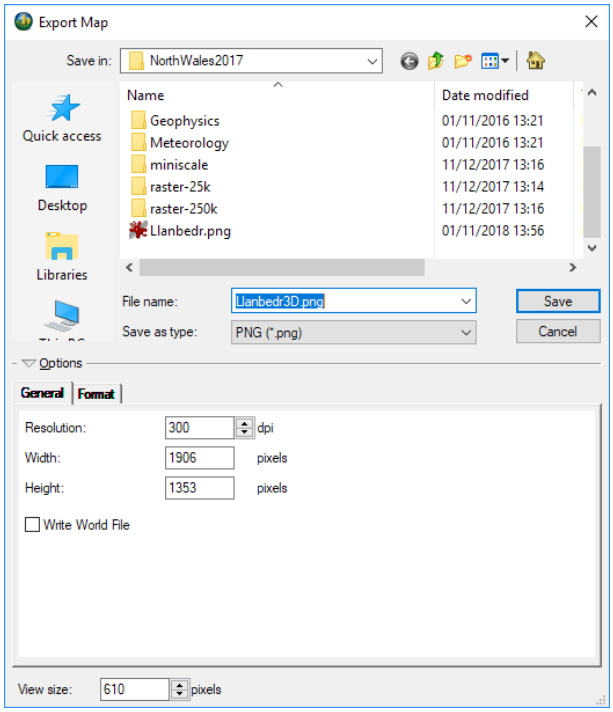


Figure 9.9: The Export dialog for ArcScene

- Now **Export** your file as an image by going to File > Export Scene > 2D... and selecting a format such as jpg, png or tiff.
- Choose where you want to save the output, and the file name that you want to save it as
- Check the **Resolution** on the **General** tab. If you are printing a layout you want this to be at least `300 dpi`, if not `600`. The dialog should look something like figure 9.9
- Save

You should end up with an image file which can be imported into other programs, e.g. ArcMap to include in a map layout, e.g. figure 9.10, Word to include in a report, or Powerpoint to include in a presentation.

9.3.1 Exporting as 3D

You may have noticed that there is also an option to export to 3D. It's easy to export, but you are creating a format called VMRL (Virtual Reality Markup Language) which doesn't open in most of the software we use.

If you feel like trying this out, there is a very light-weight viewer called **qiew** which will open the resulting `.wrl` file. You can download qiew from `http://www.qiew.org/`. The binary version for Windows is a zip file and once you've unzipped it you can just double click on the `.exe` file, then open the `.wrl` exported from ArcScene in the program.

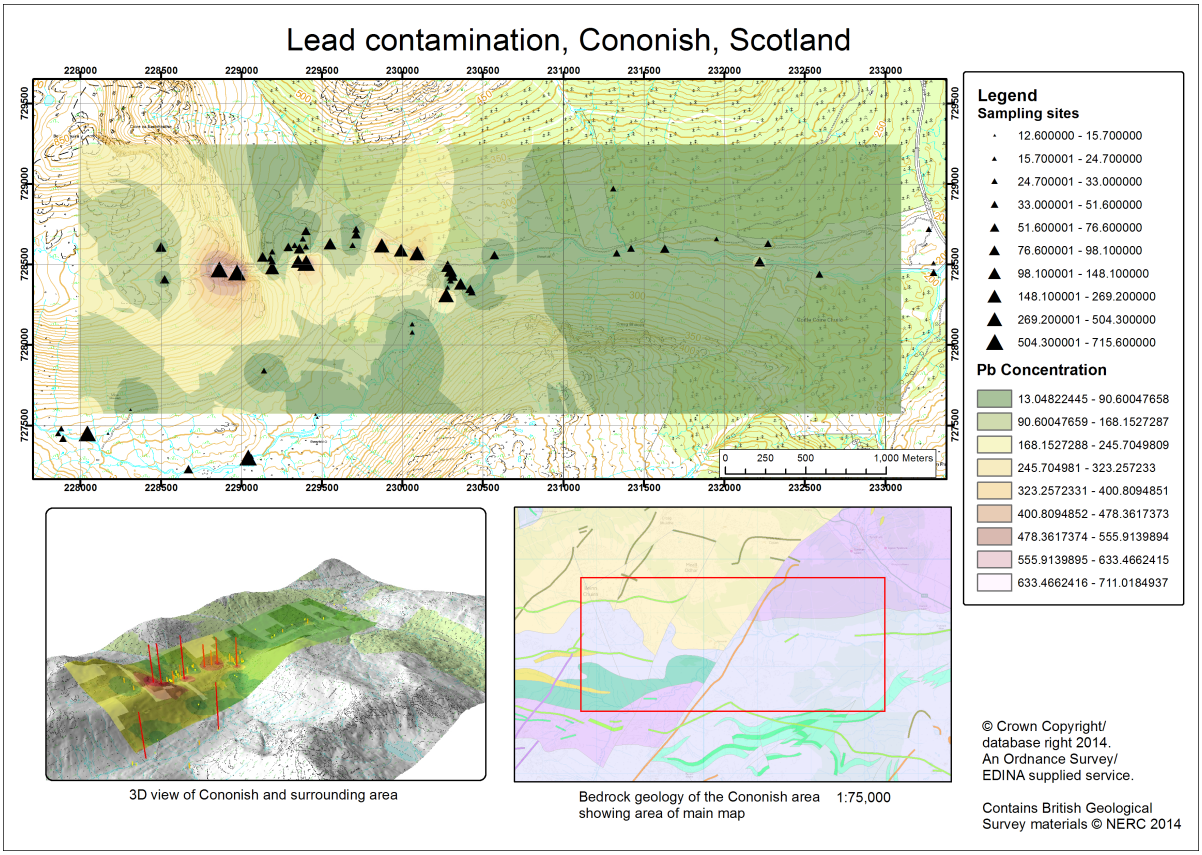


Figure 9.10: Example of a map layout which includes a 2D image exported from ArcScene

Appendix A

British National Grid 100 km squares

A.1 Introduction

British National Grid references are most commonly given in the form NN60052674, with grid **letters** at the start to give the 100 km grid square. These letters need to be replaced by numbers if the grid references are to be read by ArcGIS.

If you use GIS regularly you may also find that you need to replace grid numbers from GIS with grid letters in order to give grid references to other people.

If you are given a reference that does not include the grid letters but consists entirely of numbers it is worth checking whether the grid numbers make sense. Of course, it may just mean that the person who created the references forgot about the letters, in this case the reference could refer to any of the 100 km squares covering the UK - not helpful!

A.1.1 Replacing grid letters with numbers

To replace grid letters with numbers as is required when importing British National Grid references into Arc:

Using the example **NN 6005 2674** (This is not necessarily on your current map!)

- find the number of the line **to the left** of the grid square (i.e. one of the numbers from the line at the bottom) in figure A.1 - for **NN** this is "2".
- This number will apply to all of the references in the eastings column of the spreadsheet.
- then the number of the line **below** the grid square (i.e. one of the numbers to the left) - in this case "7".
- This number will apply to all of the references in the northings column of the spreadsheet.
- So in this example, grid reference **NN 6005 2674** would become **26005 72674**.
- In addition, x and y numbers all need to be six figures to appear in the correct place in Arc, so if, as in the example, there are fewer digits then add zeros to the end of each so make it correct. Finally the grid reference above will become **260050 726740** and at this point will be ready to enter into Arc.

Question A.1. Starting from a grid reference NG 344 576 what will be the grid reference with NG converted to figures?

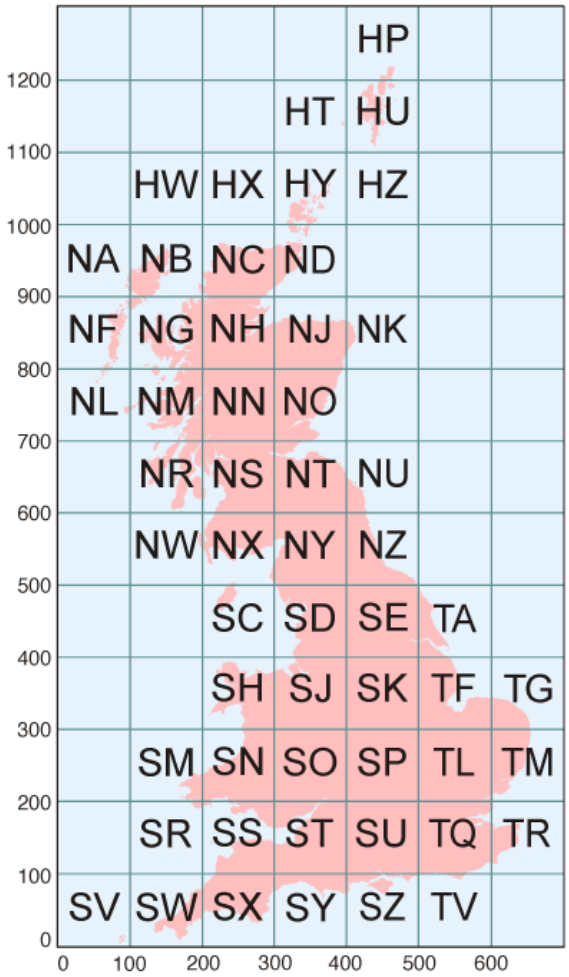


Figure A.1: British National Grid 100 km squares

If you look at the corners of a published hardcopy Ordnance Survey map such as the Landranger (pink covers) or Explorer (orange covers) series you'll be able to see these numbers as small figures on the labels of the grid lines - only at the corners, though, not right around the edges. The grid letters will appear in the corner of the published maps too.

A.1.2 Replacing grid numbers with letters

Try doing a similar exercise in reverse:

Question A.2. Starting with grid coordinates 5433 2433 what will be the grid reference with the figures converted to letters?

Appendix B

GIS: Bibliography

GIS basics

Heywood, I., Cornelius, S. & Carver, S. (2011) *An Introduction to Geographical Information Systems.* 4th ed. Harlow, Essex, Prentice Hall. (available online)

A good general guide which isn't tied to one particular GIS application. Data for these exercises is available on the book's website and there are also questions to test your understanding.

Longley, P.A. et al. (2015) *Geographic Information Science & Systems*, 4th ed. Chichester: Wiley. (Available online)

Another useful general book about GIS.

Chang, K. (2016) *Introduction to Geographic Information Systems*, New York, USA: McGrawHill, 8th edition.

General book that goes into more detail than some of the others. Sets tasks which run in ArcGIS.

Kennedy, M. (2013) *Introducing Geographic Information Systems with ArcGIS*. 3rd ed. New Jersey, Wiley. (available online)

A detailed work book rather than a straightforward reference guide - intended to be a complete course. Useful if you want to get more involved in GIS.

Newsletters

ArcUser - `https://www.esri.com/about/newsroom/arcuser/`

Freely accessible on-line magazine from ESRI with articles and examples on how to use ArcGIS.

ArcNews - `https://www.esri.com/about/newsroom/arcnews/`

Freely accessible on-line magazine. Lots of technical articles giving real-world examples of the use of ArcGIS.

Journals

I haven't listed specific articles here, but all of the following journals are available online through the University Library and if you browse the latest articles in any of them you will see how GIS is being used by scientists in a range of disciplines. These are just suggestions, there are plenty of other GIS and cartography journals out there, and plenty of GIS-related articles in discipline-specific journals.

- Cartography and geographic information science
- GIScience & Remote Sensing
- International Journal of Digital Earth

GIS for geology and environmental science

Note that some of these books will also include useful basic information about GIS in general.

Tian, Bai. (2016) *GIS Technology Applications in Environmental and Earth Sciences*, Boca Raton, Fla: CRC Press.

Available online via the University Library. Includes lots of relevant case-studies and examples of how environmental and earth scientists can use GIS.

Scally, R. (2006) *GIS for Environmental Management*, Redlands, California: ESRI Press.

A book of case-studies, e.g. wetland preservation; habitat conservation; reclaiming industrial land.

ESRI (2011) ESRI Conservation Map Book `http://www.esri.com/library/books/conservation_mapbook.pdf` (Last viewed: 20th July 2016)

Another book of case-studies and example maps.

Brimicombe, A. (2010) *GIS, environmental modeling and engineering*, Boca Raton, Fla; London: CRC Press. 2nd edition. (available online)

Uses environmental examples. Shows in detail the process of planning a project as well as basic information about GIS.

Bonham-Carter, G. (1994) *Geographic Information Systems for Geoscientists: Modelling with GIS*. New York, Pergamon.

Uses geological examples but plenty of ideas on how GIS can be used in a scientific context. Probably too much detail but gives an impression of what is possible!

Bettinger, P. and Wing, M.G. (2004) *Geographic Information Systems: Applications in Forestry and Natural Resources Management*, New York, USA: McGrawHill Higher Education.

Basic GIS techniques and information applied to a specific area.

Most articles demonstrating the use of GIS are in other subject-specific journals rather than specific GIS journals. Try searching Scopus (`http://search.library.leeds.ac.uk/iii/encore/record/C__Rb3205248`) or Web of Knowledge (`http://search.library.leeds.ac.uk/iii/encore/record/C__Re1000528`) using the keyword **GIS** and other keywords for your specific interest.

Layout and presentation: or How to draw a better map!

As well as the technical skills involved in creating a map you should have some awareness of the principles necessary to produce a map that communicates information to your viewers in the best way possible, otherwise known as cartography. The references below will give you some ideas to start you off.

Darkes, G. & Spence, M. (2017) *Cartography: an introduction.* 2nd edition. London, The British Cartographic Society.

Short guide to basic principles. Available from the British Cartographic Society at `http://www.cartography.org.uk/product/cartography-an-introduction-second-edition-2017/` for £12.99 (plus £2 postage). (Last viewed: 24th January 2018).

Frye, C. (2001) Making maps that communicate. *ArcUser*, (October - December), pp.38-43.

A brief but useful guide to how to communicate with maps. Well worth a look if you want to pick up some ideas quickly. Available on-line at `http://www.esri.com/news/arcuser/1001/files/bettermaps.pdf`. (Last viewed: 15th January 2015)

Peterson, Gretchen N. (2009) *GIS cartography: a guide to effective map design*, Boca Raton, Fla. : CRC Press. (available online)

More detailed guide to cartography and design which is very accessibly written. Possible to download pdf of the book and keep it handy for reference.

Brewer, Cynthia A. (2016) *Designing better maps: a guide for GIS users*, Woodlands, California: ESRI Press. 2nd edition.

The classic book on cartography for GIS. A lot of information but very clearly presented.

Brewer, Cynthia A. (2008) *Designed maps: a sourcebook for GIS users*, Woodlands, California: ESRI Press.

Lots of examples of maps with comments about how they were designed.

ESRI Map Book Gallery at `http://www.esri.com/mapmuseum` (Last viewed: August 2019)

Examples of maps produced with ArcGIS - from volume 28 Transforming Our World, the books are fully available on-line. Have a browse and see examples of maps that ESRI considers are “best practice”. If you would rather have a look at a printed copy I have some editions in my office, just come and ask.

ESRI UK has an online showcase of “Maps we love” at `http://www.esriuk.com/products/maps-we-love` where they also suggest the steps to reproduce some of the maps.

Coordinate Systems and Projections

Maher, M.M. (2013) *Lining up data in ArcGIS: A guide to map projections*. 2nd ed. Redlands, California: ESRI Press.

A practical guide to coordinate systems and projections in ArcGIS. As well as background information it gives step-by-step instructions for how to identify unknown coordinate systems and how to solve problems in Arc. In addition to the copies in the Edward Boyle Library there is a copy of the first edition available for reference in room 10.140b in SEE. See Clare Gordon if you wish to consult it.

Snyder, J.P. (1983) *Map projections used by the U.S. Geological Survey*. U.S. Geological Survey Bulletin 1532, Washington D.C., U.S.A.; U.S.G.S. 2nd edition. Available online from: `http://pubs.er.usgs.gov/publication/pp1395`

A classic! Anyone who works regularly with map projections will know this book. Detailed, but has useful information about map projections in general; the terminology; and specific map projections.

Monmonier, Mark. (2004) *Rhumb lines and map wars: A social history of the Mercator Projection*, Chicago; London: The University of Chicago Press.

A readable look at map projections taking the "war" between the Mercator and Peters projections as a starting point.

Raster surface models and 3D Analyst

Kennedy, K.H. (2010) *Introduction to 3D data : modeling with ArcGIS 3D Analyst and Google Earth*, Hoboken, N.J. : Wiley. (available online)

Clear information on the use of ArcGIS and Google Earth for exploring data in 3D. A how-to guide.

Appendix C

Answers to questions in text

These are suggested answers to the questions asked in the text. Check your answers against them but be aware that in many cases there is more than one correct answer. If you don't understand why a particular answer has been given please ask module staff or demonstrators for more information.

Chapter 1: Introduction to ArcMap

Question 1.1: Try out each tool in the tools toolbar in turn and see what it does.

Tool	What it does
Zoom in	*Moves the view closer in to the map so that you are viewing a smaller area in more detail*
Zoom out	*Moves the view out from the map so that you are viewing a larger area in less detail*
Full extent	*Zooms right out so that all of the data in your map is visible.*
Zoom to layer (this one isn't on the tools toolbar. Right-click on the title of a layer in the table of contents zoom to layer)	*Zooms to the extent of the data in the layer you clicked on*
Pan	*Move the area of the map that you are viewing by dragging it*
Select features	*Select particular features, or items from the selected layer by clicking on them.*
Identify	*Find out more information about the features at a particular point on the map.*
Find (try searching for **Llanbedr** in the **Features** tab. Once you have a result, right-click a record and have a go with the commands from the menu, e.g. **Flash**)	*Search for features that match a particular term and view the features in the map.*

Chapter 2: Digimap

Question 2.1: What view does Roam take you to when you click on "Find"?

Street View - look in the bottom right of the map view to see which view you are looking at.

Question 2.2: Name some other view and basemap combinations besides **Neighbourhood** >> **VML Streetview** that allow you to select content?

Possible combinations include the following:

- Street >> Vector Map Local
- Street >> VML Plan
- Detailed >> Full Colour
- District >> Mid-scale (2016)
- City >> Strategi (2016)

There are other combinations which also allow you select. Note that none of the basemaps marked as Raster allow you to select, neither do the most zoomed out Views.

Question 2.2: Use the Measure Distance tool to measure your route to the University. How far away do you live?

Of course, I can't tell you the answer to this one. Make sure that you include the units of the measurement in your answer - which should be either metres or kilometres.

Question 2.4: What is the area of Woodhouse Cemetery?

The area is approximately 36450 m^2

Question 2.5: What is the bedrock geology underneath the School of Earth and Environment?.

You'll probably need to click on the Bedrock tab to see that the bedrock unit is Pennine Lower Coal Measures Formation, and the rock type is Mudstone, Siltstone and Sandstone. The Age is listed as Langsettian Sub-Age.

Question 2.6: What is the Tile Name for 1:50 000 data at this location?

Once you've zoomed out a fair way, you should be able to see that Malham Cove is covered by a tile called "EW060". This means that it is covered by the map sheet for England and Wales with the number 60 - which matches the paper maps produced by the British Geological Survey.

Question 2.7: What is the Tile Name at this location, and on what date was the aerial imagery at this location flown? As a bonus, what town is this point within?

*This point is in Aviemore (switch on Overlays - Road/Place Names to be able to see this) and the Tile Name is **nh8912**. The date that the imagery was obtained was **2015-10-01** (as of 1st August 2018).*

Chapter 3: Creating data for GIS: Point data and GPS

Question 3.1: What happens to the size of the symbols when you zoom in to 1:500 and then out to 1:25 000?

You should be able to see that the text and symbols stay the same size on the screen, which means as you zoom out they look larger in comparison to the rest of the map. This means that at a smaller scale the symbols overlap.

Question 3.2: Once you've set a data frame reference scale, what happens to the size of the symbols when you zoom in to 1:500 and then out to 1:25 000?

This time you should be able to see that the text and symbols become larger or smaller on the screen depending on the zoom, but they remain in the same proportion to each other - and don't overlap more at a smaller scale than they do at a larger.

Question 3.3: How accurate do you think the locations of the points are? What problems can you spot based on your memory of collecting the data? How do you think that you could increase the accuracy of data input?

Your results may be very different to mine, but based on the readings that I took I would say that the accuracy is variable. The data sheet should enable you to quantify this for each point. In relation to the base imagery my points vary between very accurate and up to a couple of meters away.

Ways to increase accuracy include using GPS in areas with a clear view of the sky, so away from buildings, trees, mountains, etc. Turn on your GPS well before you start to use it and give it plenty of time to connect to multiple satellites. Read the instructions for your GPS! Some models have additional ways of increasing accuracy.

Chapter 5: Creating point data from xyz files

Question 5.1: What is the main difference that you notice between the shapefile that you see in the Catalog panel and the same shapefile that you see in My Computer?

The main difference should be that in Catalog you can only see one version of each file and that has a file extension of .shp. In My Computer there are multiple versions of each file with different file extensions.

Chapter 6: Viewing point data with 3D Analyst

Question 6.1: Use the **identify** tool from the tools toolbar to click on various points within one colour band. What do you notice about the readings for the interpolated layer?

*Hopefully it is fairly easy to spot that different points within one colour band actually have different readings. The data is **continuous** rather than discrete for each colour band.*

Question 6.2: Which surface do you think is the most appropriate for this data and why?

Don't forget to use the suggested article to arrive at your conclusion. You will be using the answer to this question as part of your assessment so do keep a record of it.

Appendix A: British National Grid 100 km squares

Question A.1: Starting from a grid reference **NG 344 576** what will be the grid coordinates with NG converted to figures?

The grid coordinates will be 1344 8576

Question A.2: Starting with grid coordinates **5433 2433** what will be the grid reference with the figures converted to letters?

The grid reference will be TL 433 433

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