Workshop set up: QGIS project

Download and extract the zip file:

NatureBasedSolutionsForWater_ViridianLogic.zip

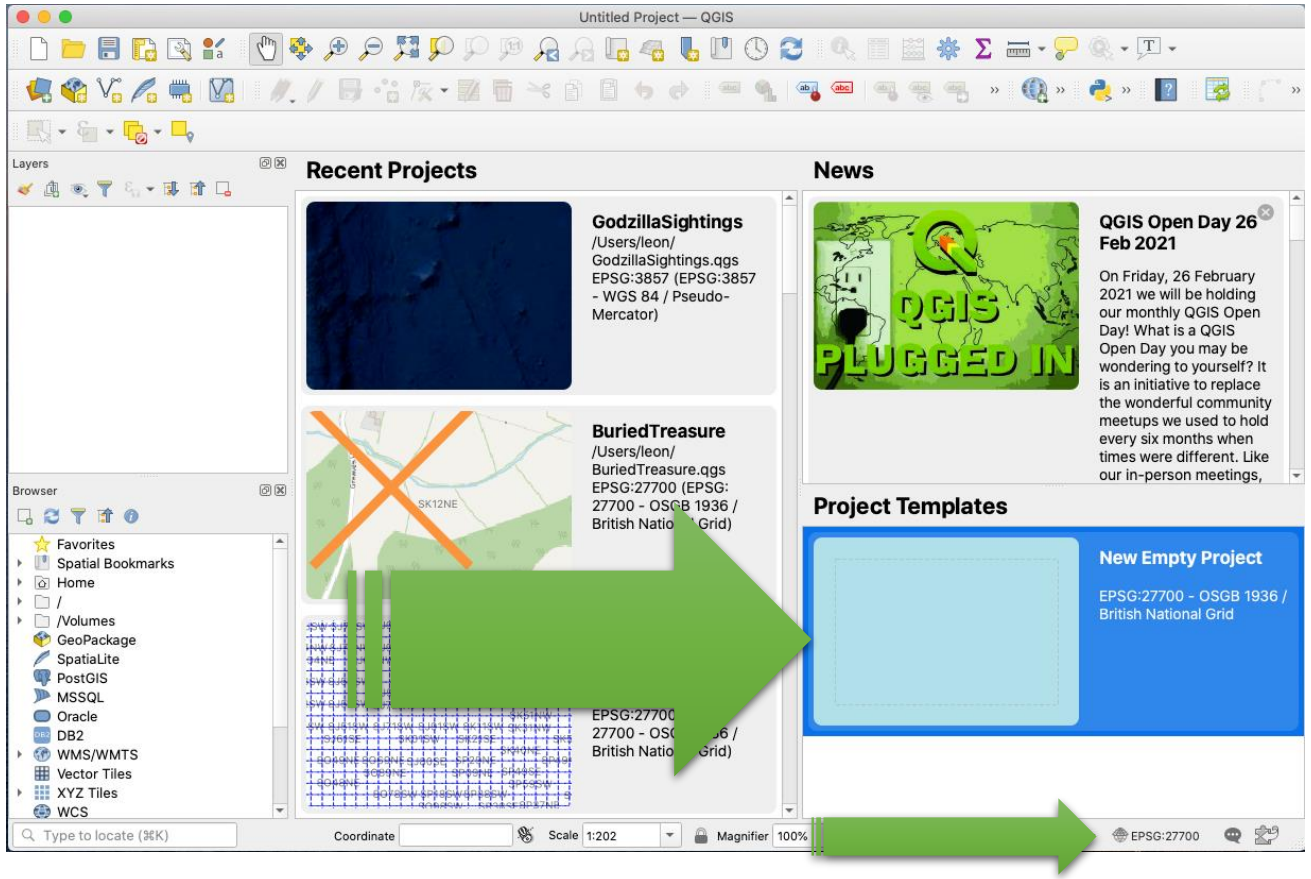
The link to this zip file is in the pre-course email sent on Friday 19th March 2021

Open up **QGIS** (this workshop is based on version 3.16.4)

Set the projection to

EPSG:27700

Open up a **New Empty Project**



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10-DAY CHALLENGE

11 – 24 March 2021

Events and activities for
naturally-smarter businesses

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Get involved in The We Value Nature 10-Day Challenge

- Complete **daily challenges**. Each challenge can be completed in around 10 –15 minutes and will help you take the next step on your nature journey.

- Register for practical, interactive **sessions**.

wevaluenature.eu/10-day-challenge

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Supporting

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 821303

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@WeValueNature

A practical workshop on modelling nature-based solutions for water

Dr Leon Baruah
leon@viridianlogic.com

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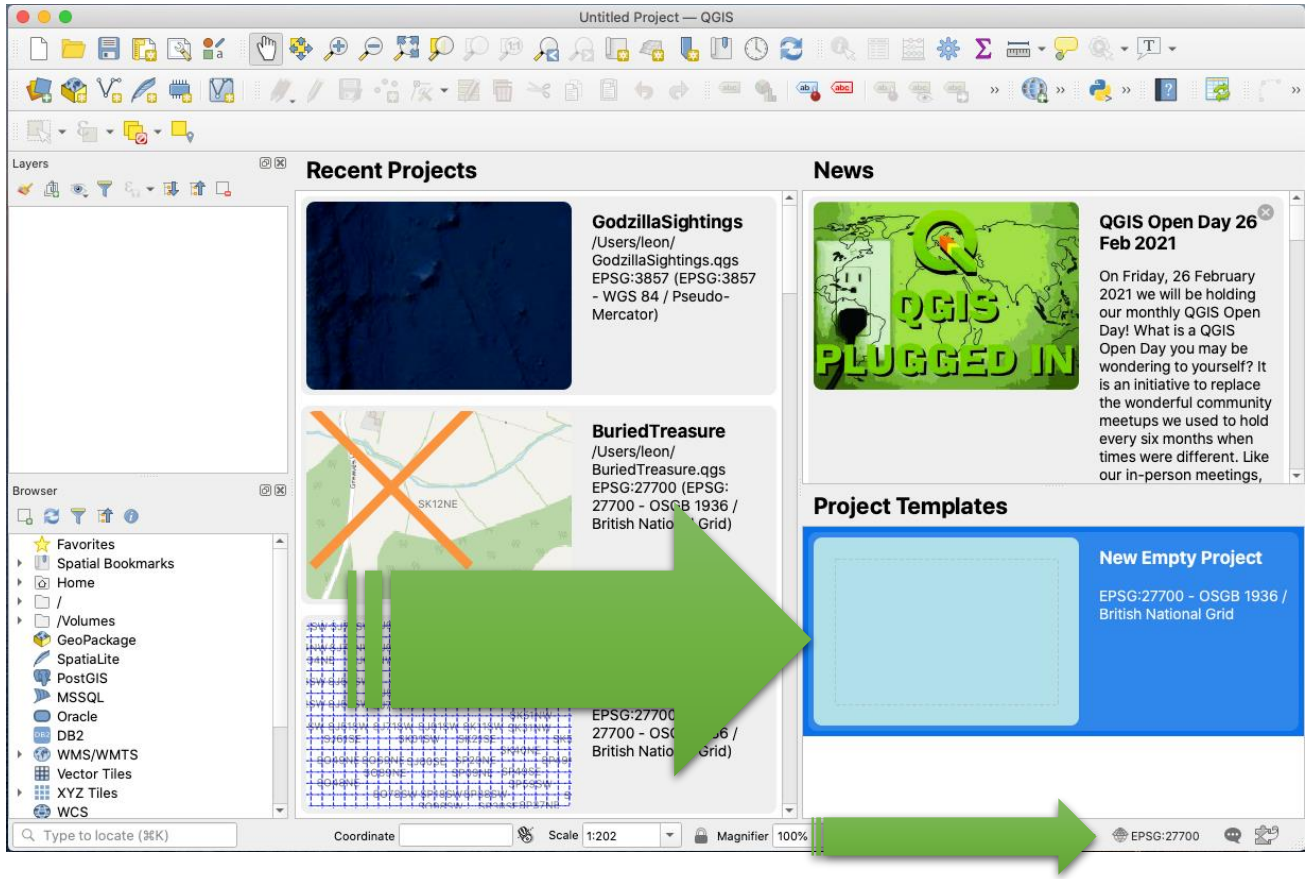

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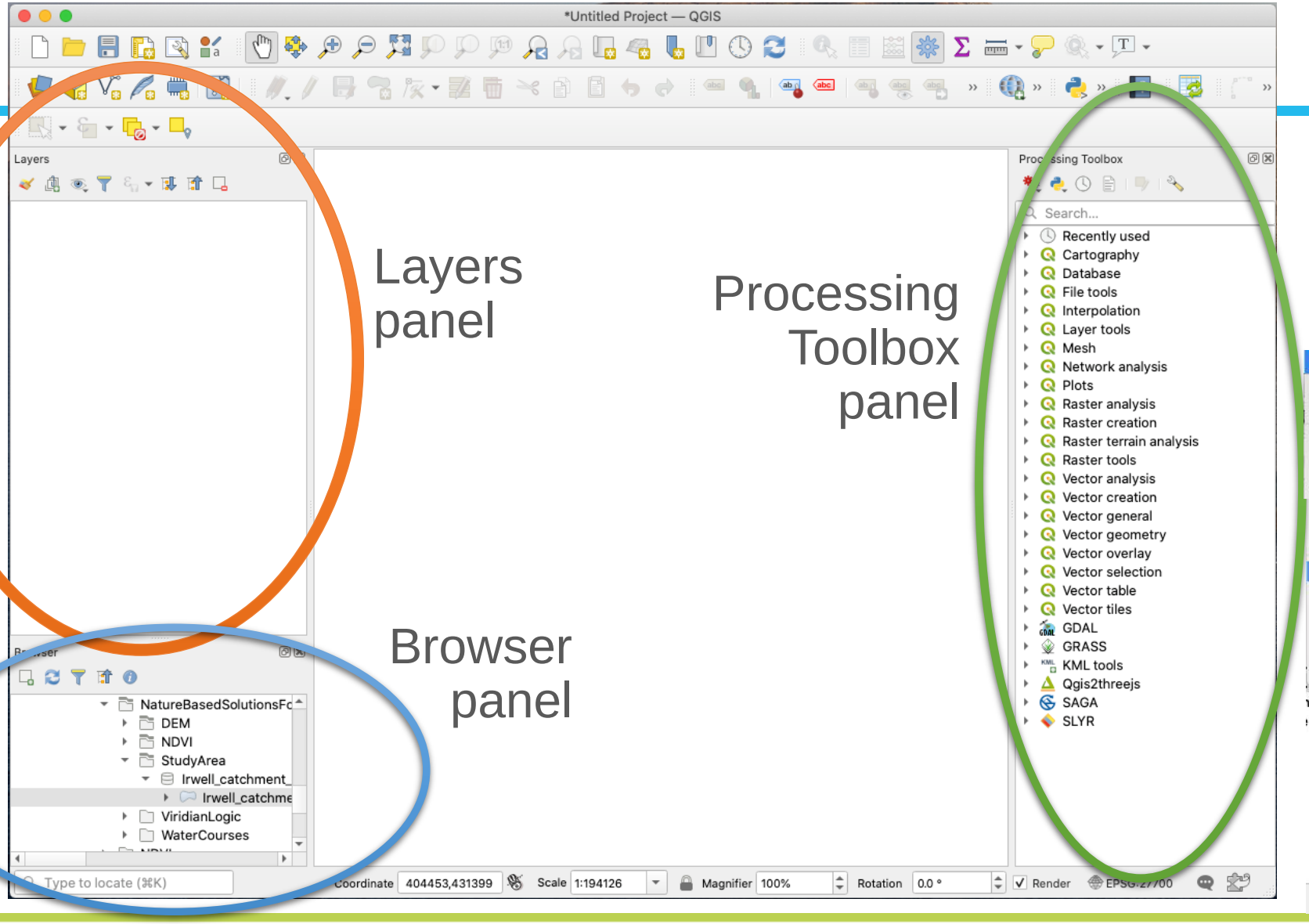
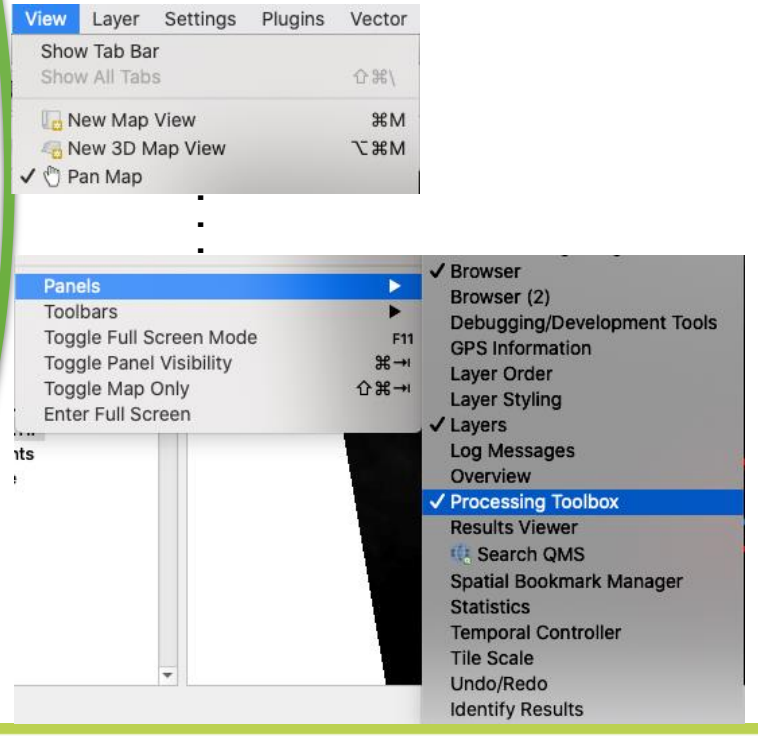


Panels are activated through the **View** top menu under the **Panels** sub menu



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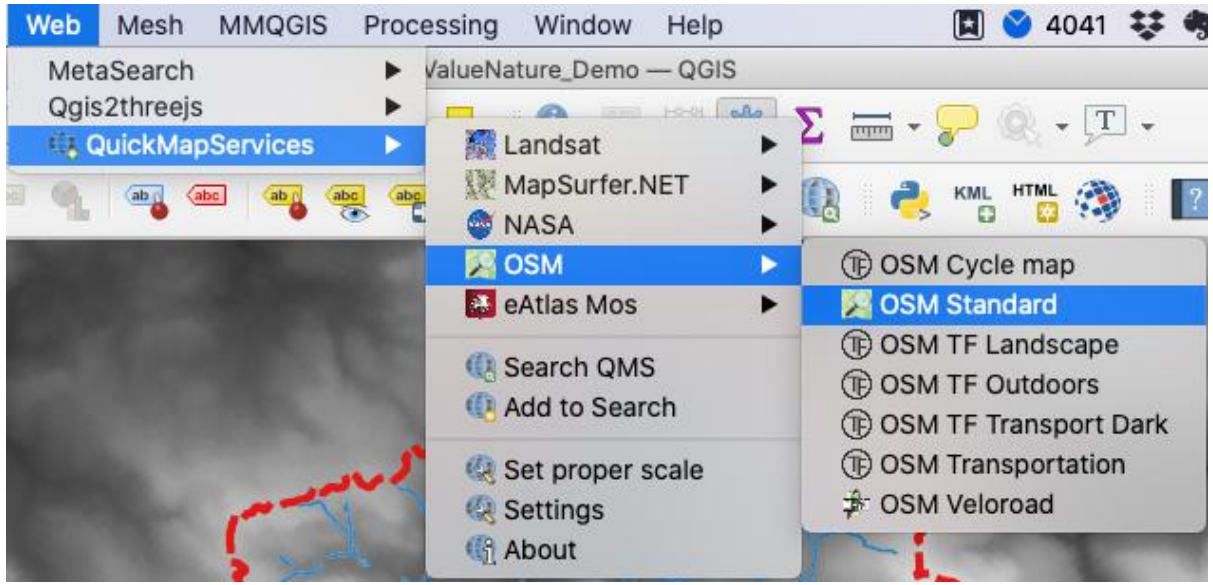
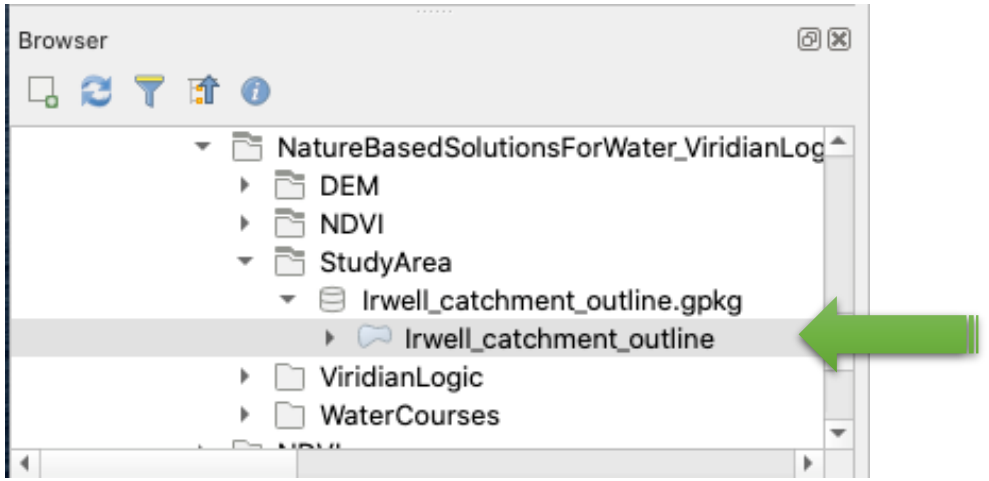
Workshop set up: QGIS project

Open **QuickMapServices** through the **Web** top menu

Load **OSM Standard**





Navigate to where you unzipped the workshop data & add the catchment outline from the **StudyArea** folder

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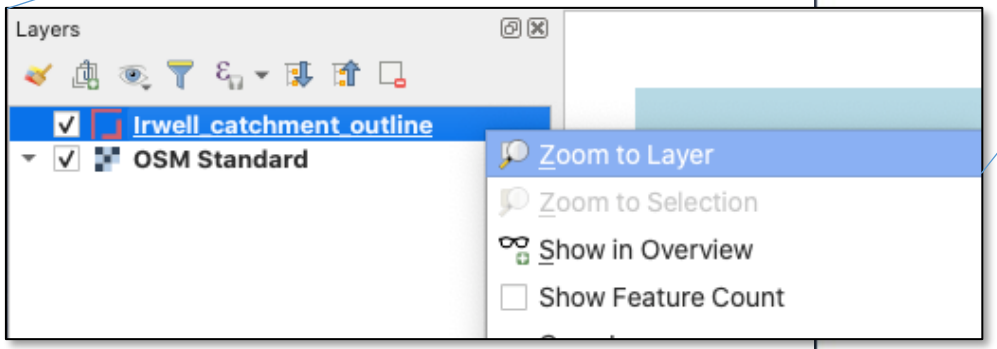
Workshop set up



Right click
Irwell_catchment_outline
and select **Zoom to Layer**

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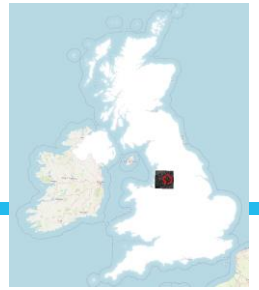
Irwell - background



Press release

Natural flood management project to begin at Greater Manchester beauty spot

A project designed to implement natural flood risk management (NFM), techniques for communities that lie within the catchment of the River Irwell will commence in the coming weeks.

From: Environment Agency
Published: 9 September 2020

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NDVI

Normalized Difference Vegetation Index

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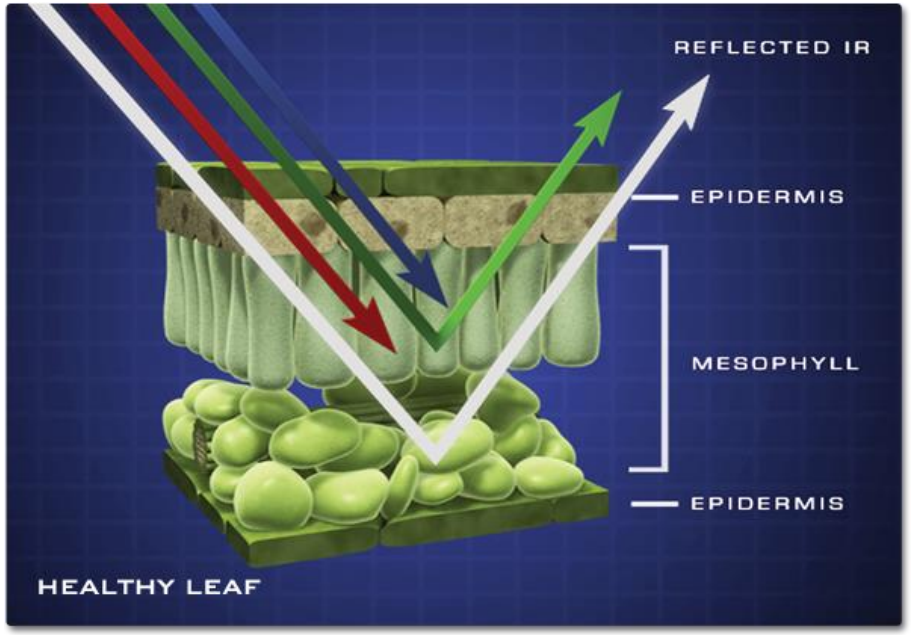
NDVI (Normalised Difference Vegetation Index)

- NDVI is a way of measuring vegetation "**greenness**" by looking at the relative reflectiveness of photosynthesizing plant material.
- This is done typically using red and infrared bands from remote sensing data. Areas that are not reflective (i.e., dark) in the red area of the spectrum, where chlorophyll absorbs light, but bright in the infrared.



Source: nasa.gov

- NDVI values mathematically range from -1 to +1, although most vegetated land will have positive NDVI values, whilst water will typically have small or negative NDVI values.

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NDVI data sources

In this workshop we will be using Sentinel 2 data dating from April 2020 (selected for minimal amount of cloud cover).

Data here was downloaded from eos.com/landviewer/

Data is openly available from a number of platforms such as

- Copernicus Open Access Hub scihub.copernicus.eu
- Earth Explorer earthexplorer.usgs.gov

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Sentinel 2 data

The calculation we are going to undertake use the infrared and red bands, which are the Sentinel 2A bands 4 (red) and 8 (infrared).

Band number	Band name	Sentinel-2A		Sentinel-2B		Resolution (meters)
		Central wavelength (nm)	Bandwidth (nm)	Central wavelength (nm)	Bandwidth (nm)	
1	Coastal aerosol	443.9	20	442.3	20	60
2	Blue	496.6	65	492.1	65	10
3	Green	560.0	35	559	35	10
4	Red	664.5	30	665	30	10
5	Vegetation Red Edge	703.9	15	703.8	15	20
6	Vegetation Red Edge	740.2	15	739.1	15	20
7	Vegetation Red Edge	782.5	20	779.7	20	20
8	NIR	835.1	115	833	115	10
8b	Narrow NIR	864.8	20	864	20	20
9	Water vapour	945.0	20	943.2	20	60
10	SWIR – Cirrus	1373.5	30	1376.9	30	60
11	SWIR	1613.7	90	1610.4	90	20
12	SWIR	2202.4	180	2185.7	180	20

Source: eos.com

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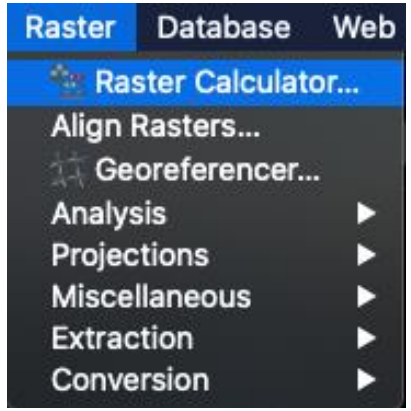
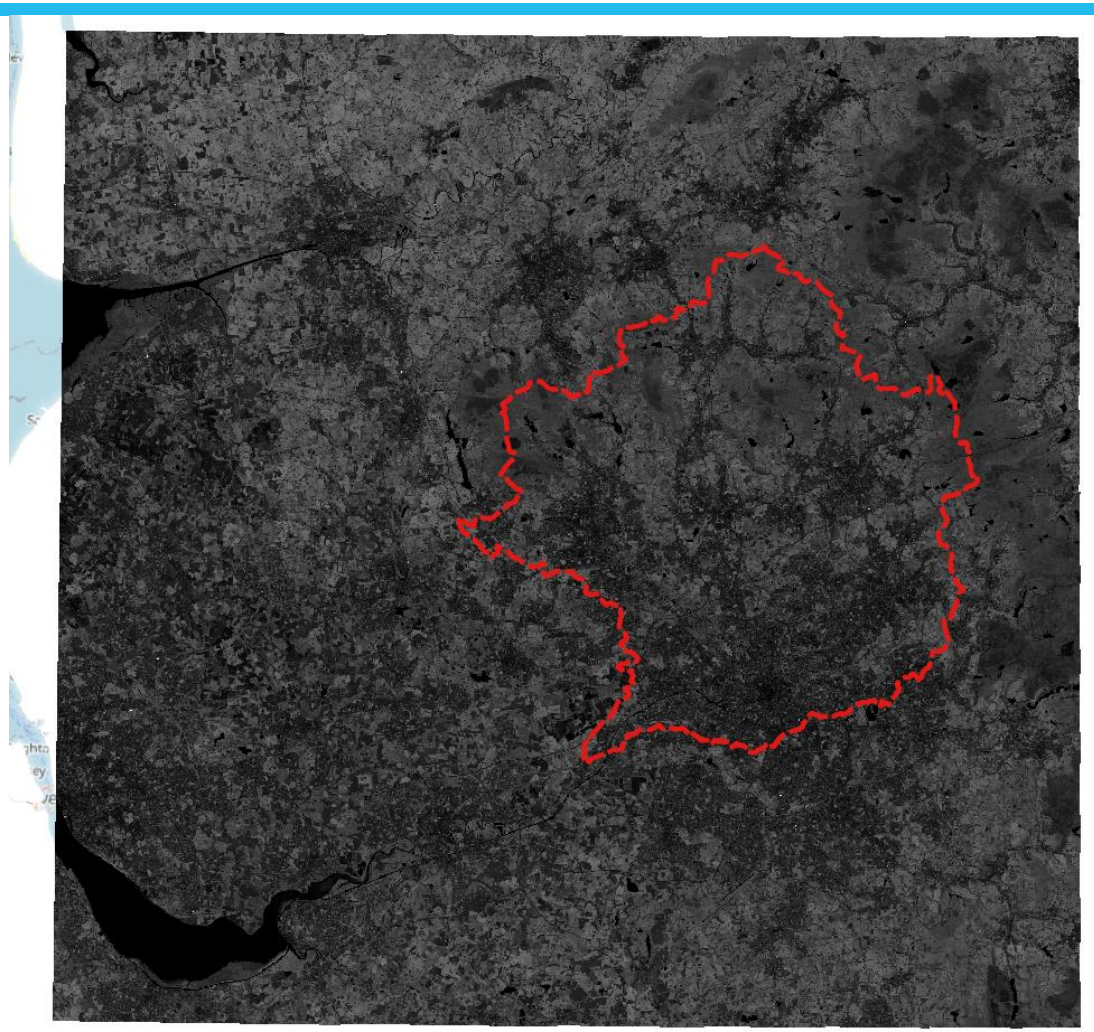
Workshop exercise: NDVI

- With the **Browser Panel,** drag the Sentinel tiles (named **S2B…tif**) into QGIS
- Since the data are monochromatic, they should appear as simple black/grey/white tiles



- Next, open **Raster Calculator** by selecting it from the **Raster** top menu



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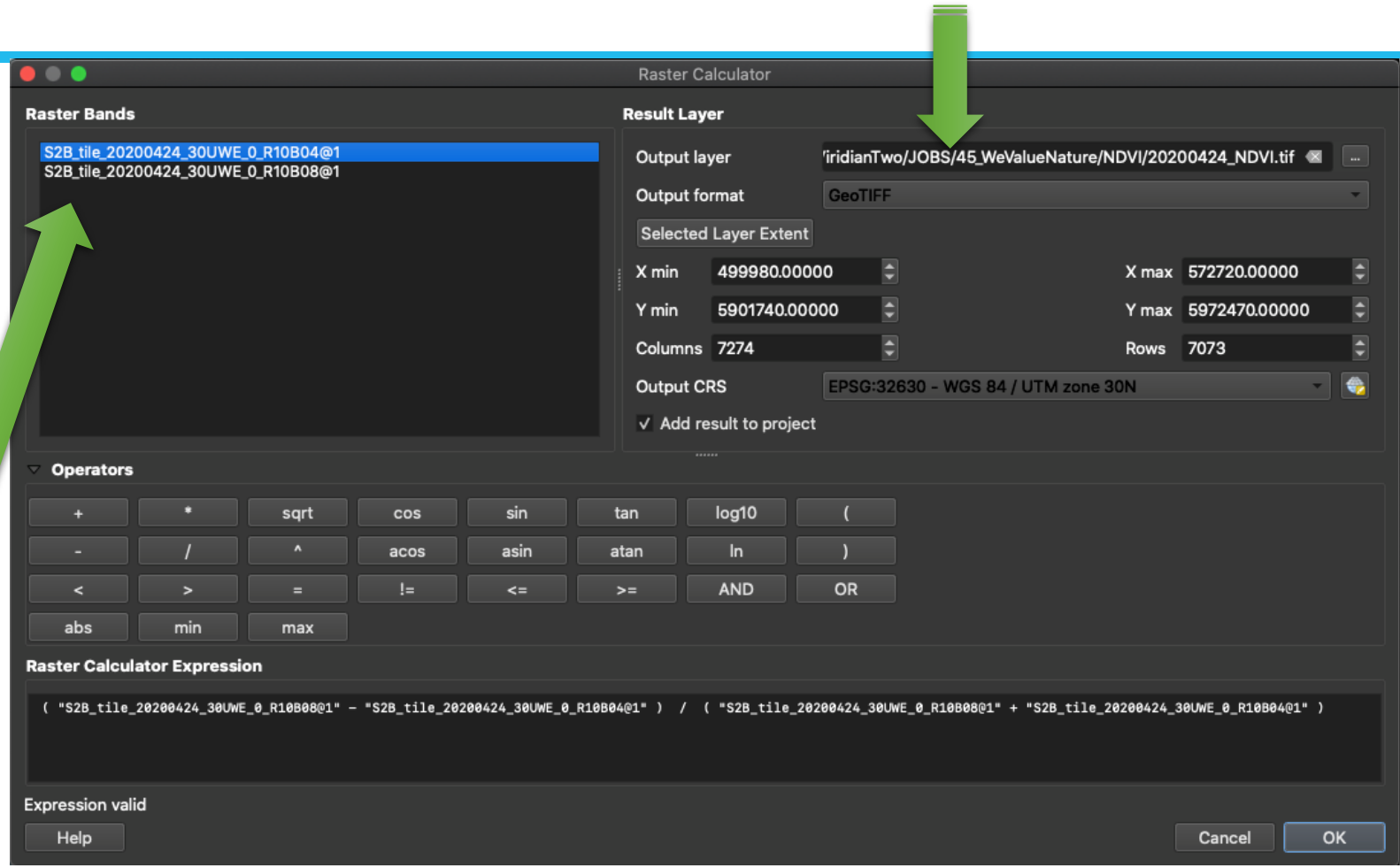
Workshop exercise: NDVI

- NDVI is calculated with the following formula:

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

- The expression can be built by clicking the buttons & the layers in the top panel

- Set an output file name



("S2B_tile_20200424_30UWE_0_R10B08@1" - "S2B_tile_20200424_30UWE_0_R10B04@1") / ("S2B_tile_20200424_30UWE_0_R10B08@1" + "S2B_tile_20200424_30UWE_0_R10B04@1")

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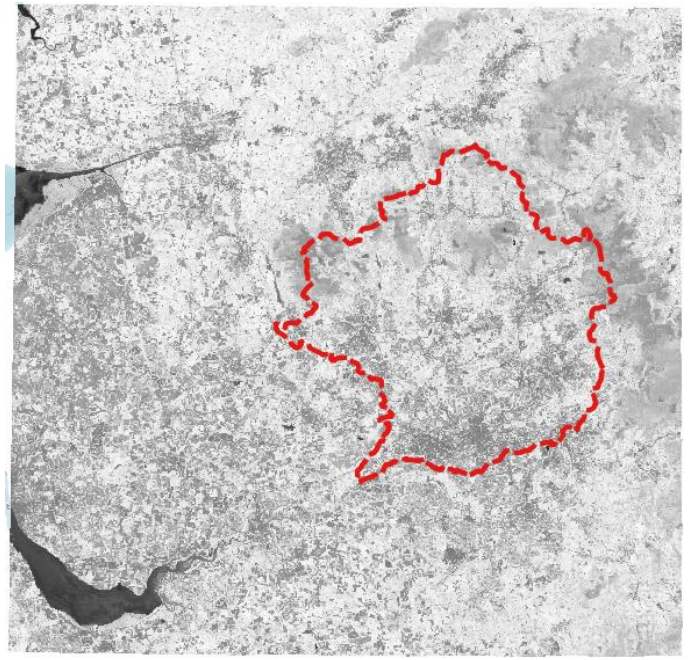
Workshop exercise: NDVI

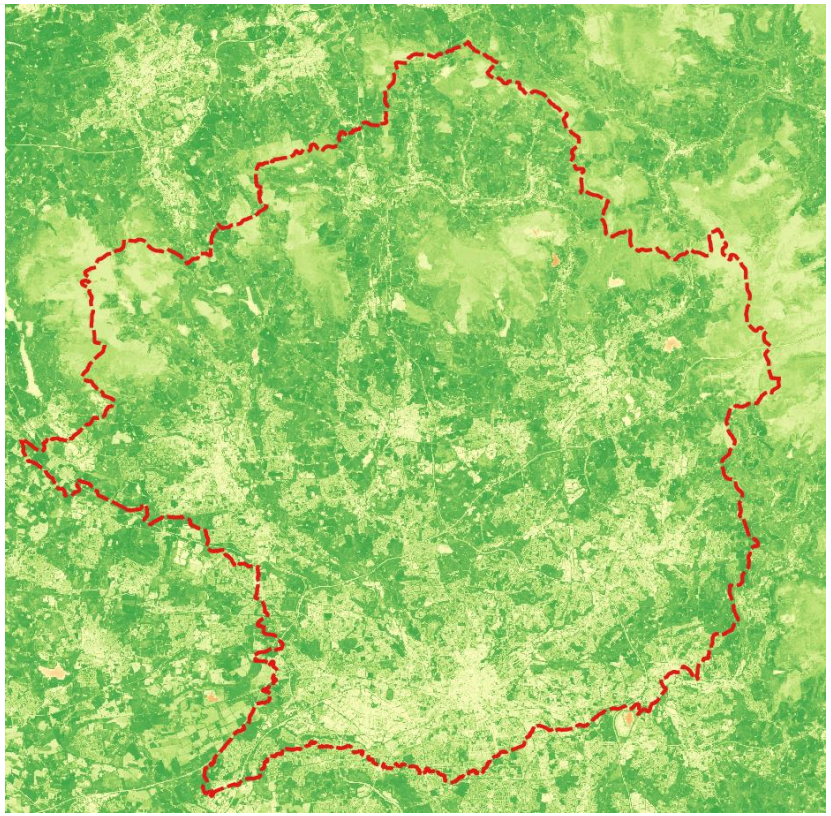
$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

- The output will match the **20200424_NDVI.tif** file in the **NDVI** folder.



- QGIS style file **20200424_NDVI.qml** can be applied to your output.

- Note that QGIS will automatically applies style files that are in the same folder as the file they apply to, if they are named the same.



("S2B_tile_20200424_30UWE_0_R10B08@1" - "S2B_tile_20200424_30UWE_0_R10B04@1") / ("S2B_tile_20200424_30UWE_0_R10B08@1" + "S2B_tile_20200424_30UWE_0_R10B04@1")

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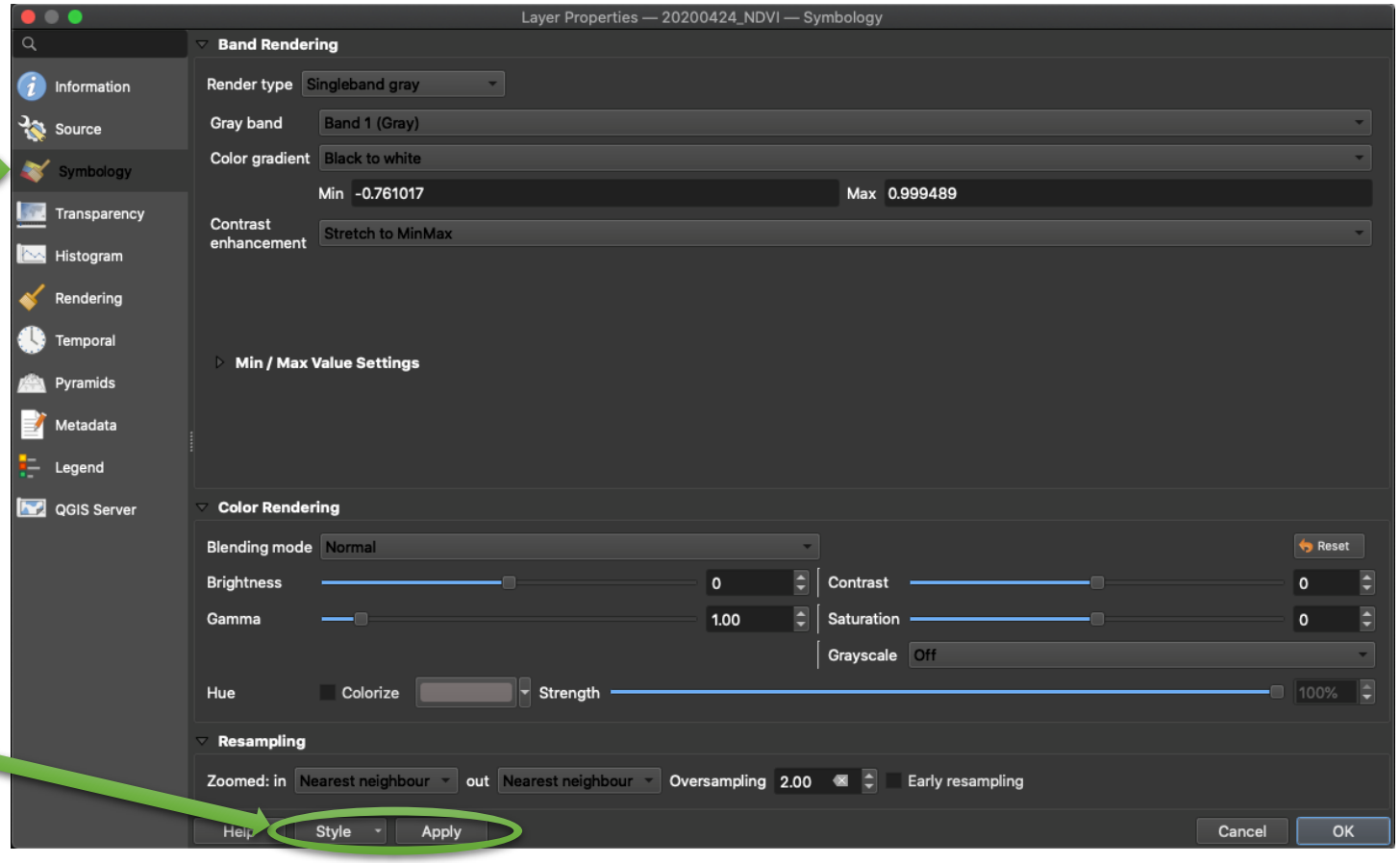
Workshop exercise: NDVI

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

- To apply a QGIS style file, right-click the NDVI layer in the **Layers** panel and click **Properties**.
- The **Symbology** tab on the left is where styling is changed.
- Click the **Style** button on the bottom, select **Load Style…** navigate to **20200424_NDVI.qml** and press **Apply**



("S2B_tile_20200424_30UWE_0_R10B08@1" - "S2B_tile_20200424_30UWE_0_R10B04@1") / ("S2B_tile_20200424_30UWE_0_R10B08@1" + "S2B_tile_20200424_30UWE_0_R10B04@1")

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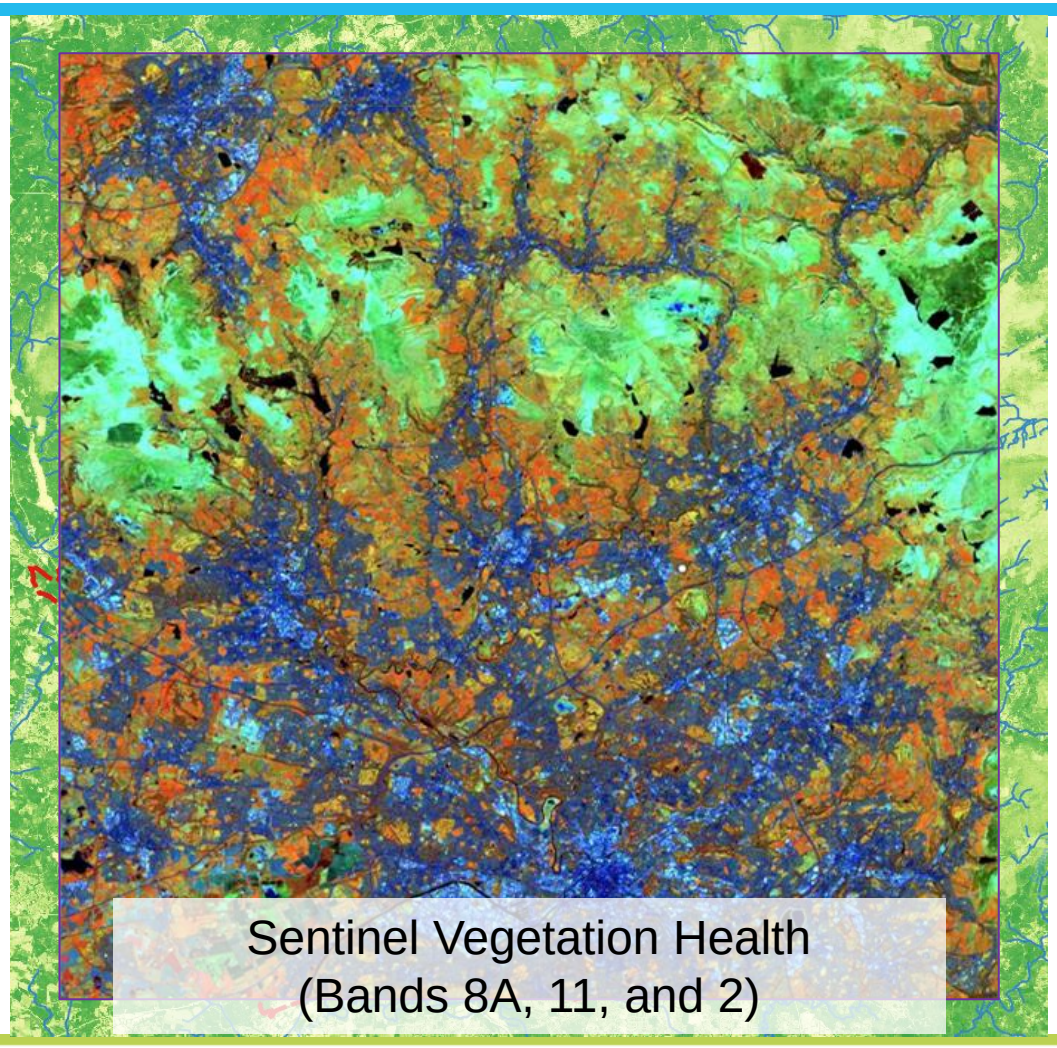
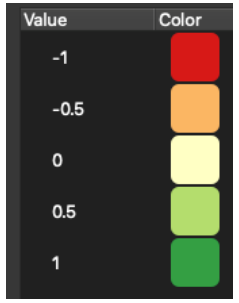
NDVI discussion

$$\mathbf{NDVI} = \frac{(\mathbf{NIR} - \mathbf{Red})}{(\mathbf{NIR} + \mathbf{Red})}$$

N.B. Image contains **WatercourseLink.gpkg** from **Watercourses** folder



Sentinel Vegetation Health
(Bands 8A, 11, and 2)



Referencing the NDVI formula, more positive values show a greater abundance of vegetation.

- Comparison to the river network reveals where there are opportunities for more vegetative cover in the landscape
- Comparison with other indicators can lead to a deeper understanding of opportunities
- However, without knowing how overland flows reach the river network, these areas of opportunity may not impact downstream water problems

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Hydrologic modelling

Surface flow of water over the topography of the land

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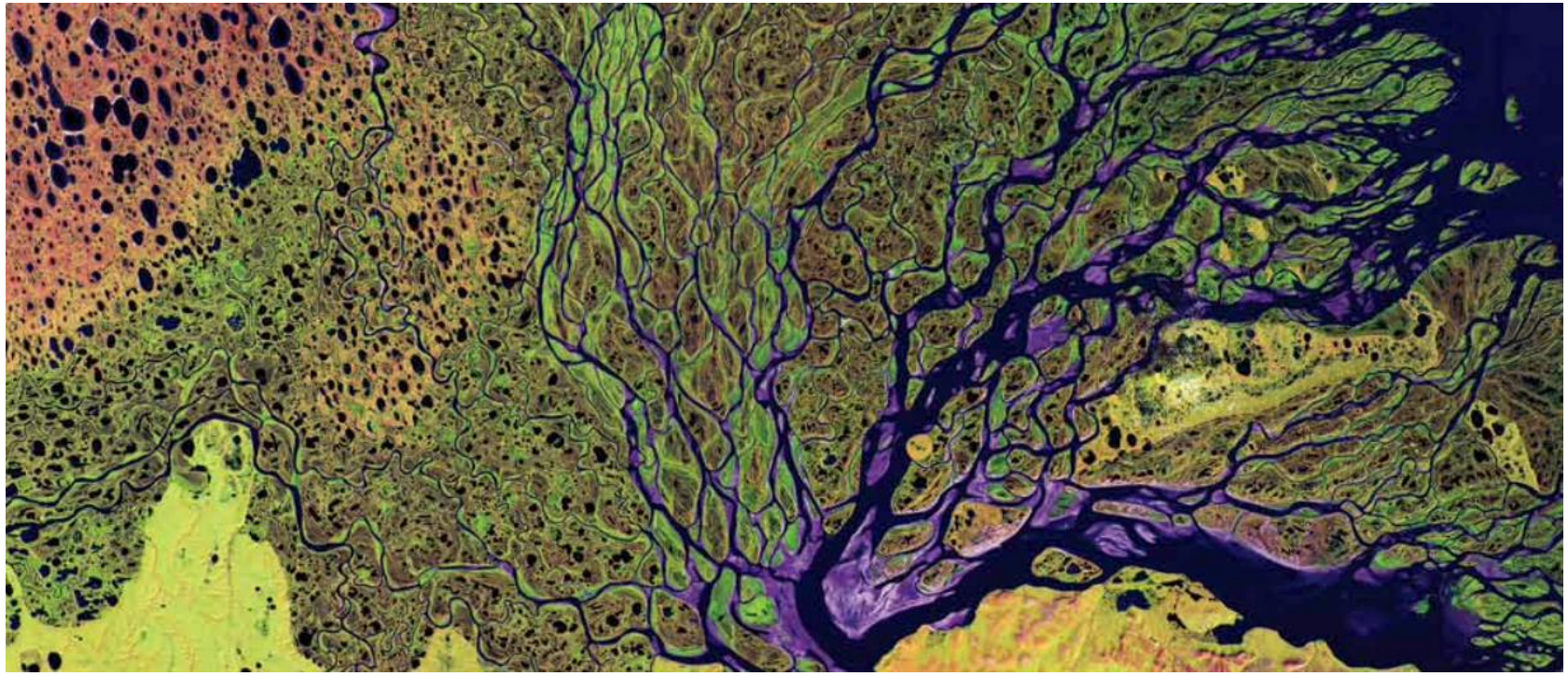
Hydrologic modelling

- Knowing where water flows over the landscape gives an indication of where to best place nature-based solutions to slow overland flows that feed the river network.



Source: nasa.gov

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Hydrologic modelling data sources

For this workshop, we will produce a basic flow accumulation raster, which simply requires a DEM (Digital Elevation Model).

We will be using the 25m resolution EU DEM v1.1, which is an open data product from Copernicus.

https://land.copernicus.eu/imagery-in-situ/eu-dem/eu-dem-v1.1

Each EU DEM tile covers 10º x 10º and can be several gigabytes in size. A small portion has been clipped from this large tile to use for analyses: **eu_dem_v11_lrwell500m.tif** in the **DEM** folder.

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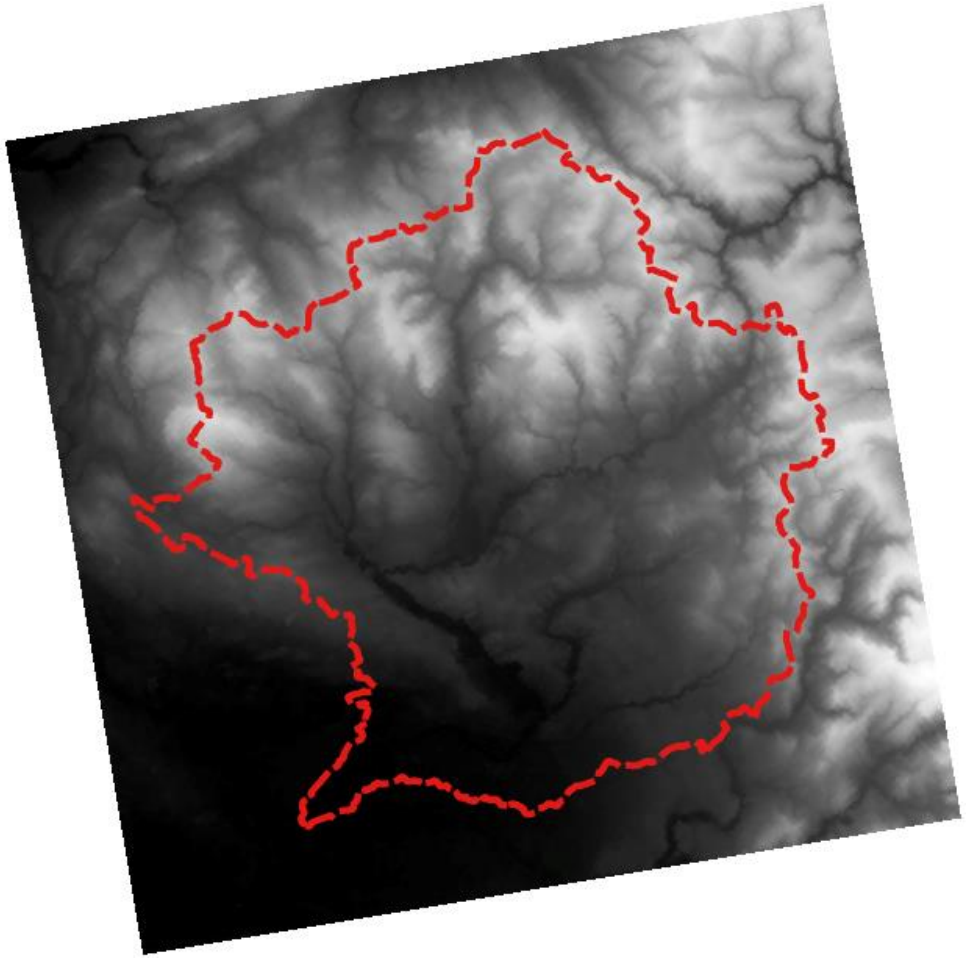
Workshop exercise: Hydrologic modelling

- Load **eu_dem_v11_Irwell500m.tif** from the **DEM** folder into QGIS. The DEM is typical of any landscape with hills valleys and dips
- The first two steps of this process are *pit filling* and calculating *flow direction*
- *Pit filling* is necessary because hydrologic algorithms are simple in understanding landscapes and flows that channel into dips never flow out
- *Flow direction* determines the preferred downhill direction of flows in the DEM



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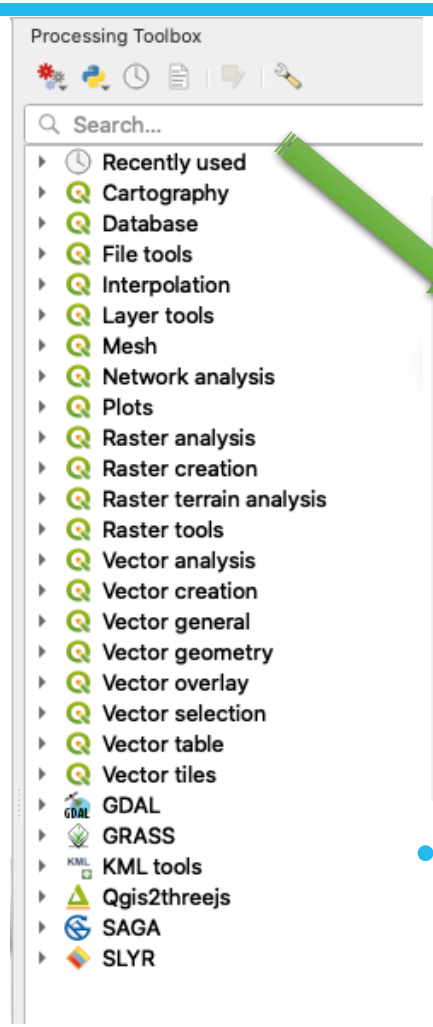
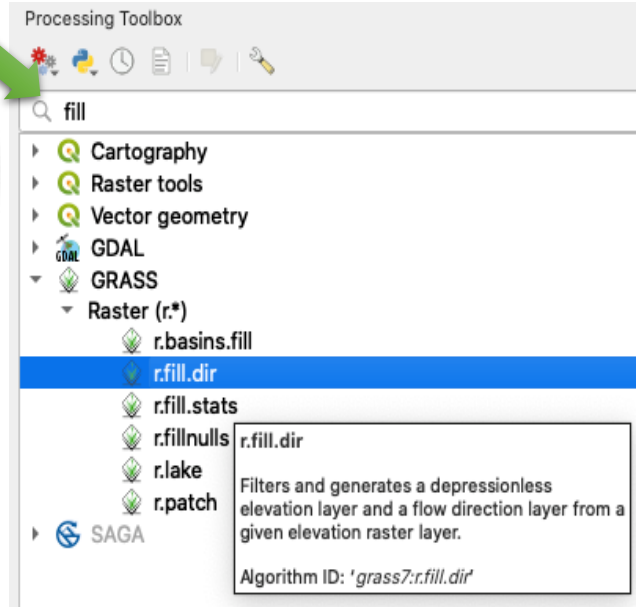
Workshop exercise: Hydrologic modelling

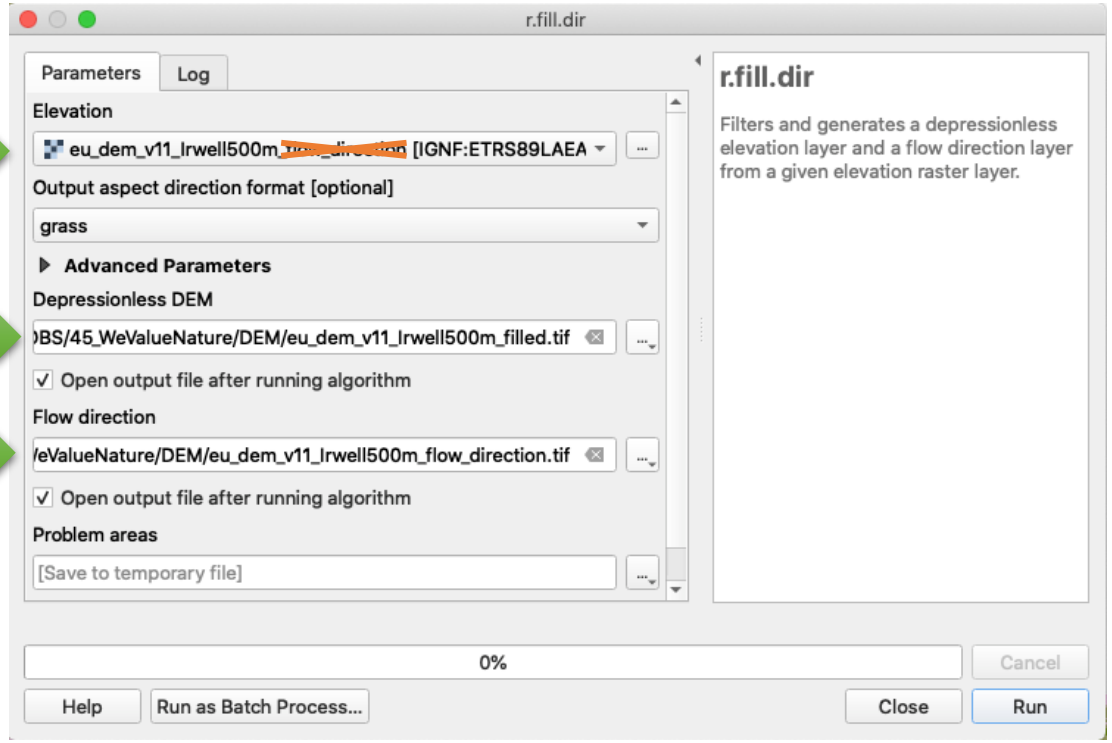


- Pit filling and flow direction are calculated in one step using the **r.fill.dir** tool in the **Raster** tools of the **GRASS** package



- Set to DEM

- Set output **.tif** files



- Use the Search bar in the Processing Toolbox panel to locate **r.fill.dir** quickly

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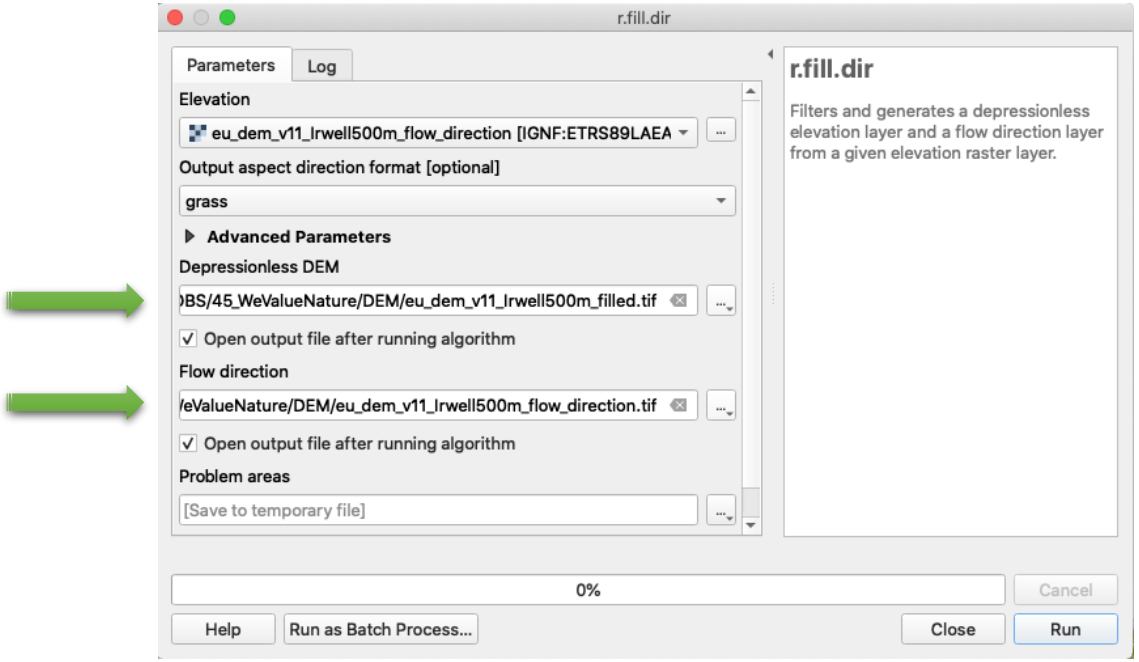
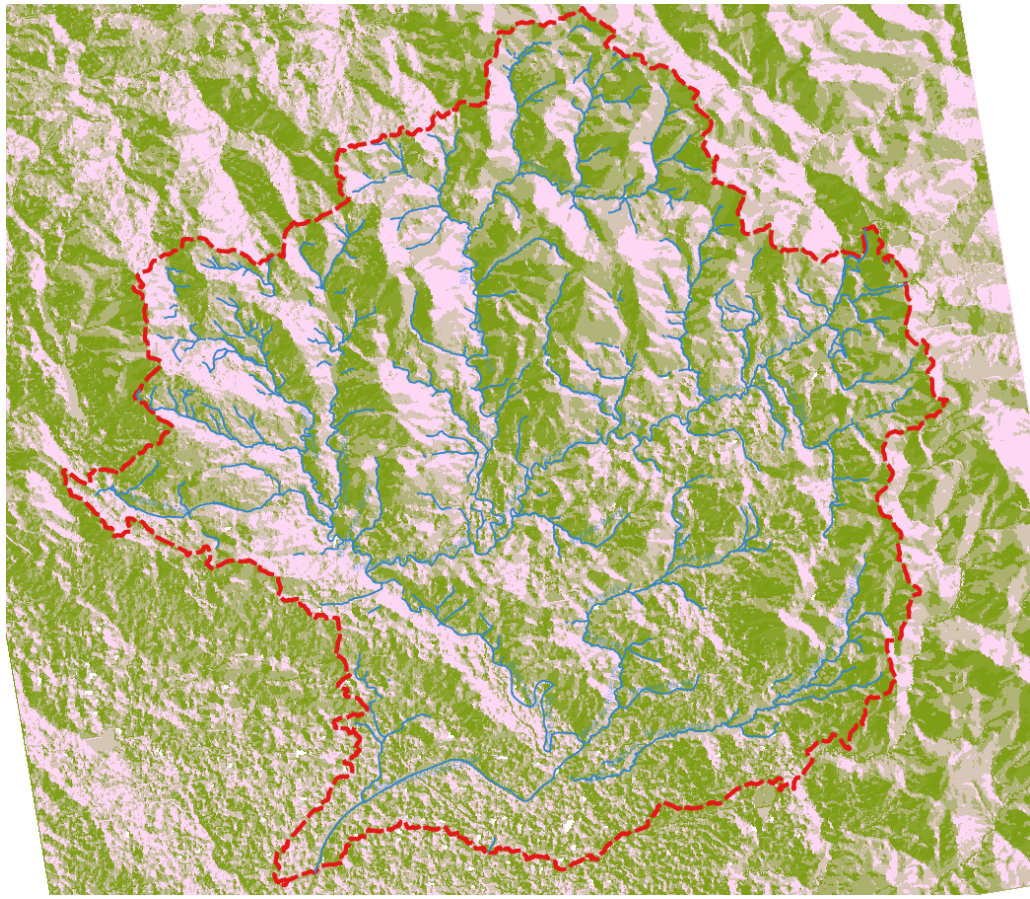
Workshop exercise: Hydrologic modelling

- Optionally fill in paths to the **Depressionless DEM** and **Flow direction** parameters, then click **Run**





- Apply the flow direction style file to the output **eu_dem_v11_lrwell500m_flow_direction.qml**

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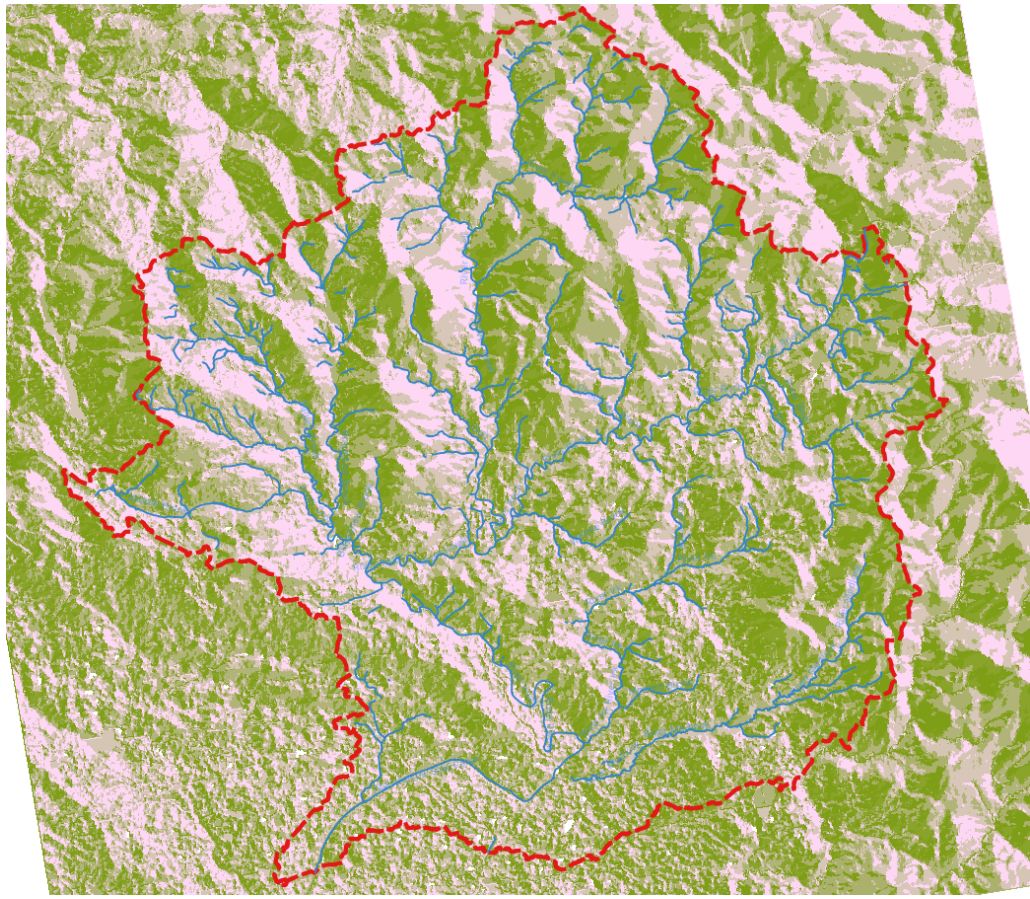
Workshop exercise: Hydrologic modelling

- Loading **WatercourseLink.gpkg** data from the **Watercourses** folder, we can see how the styled flow direction data generally* lead toward the river network



* The river network data and DEM data are from independent sources and derived for different scales, and so may disagree at finer detail

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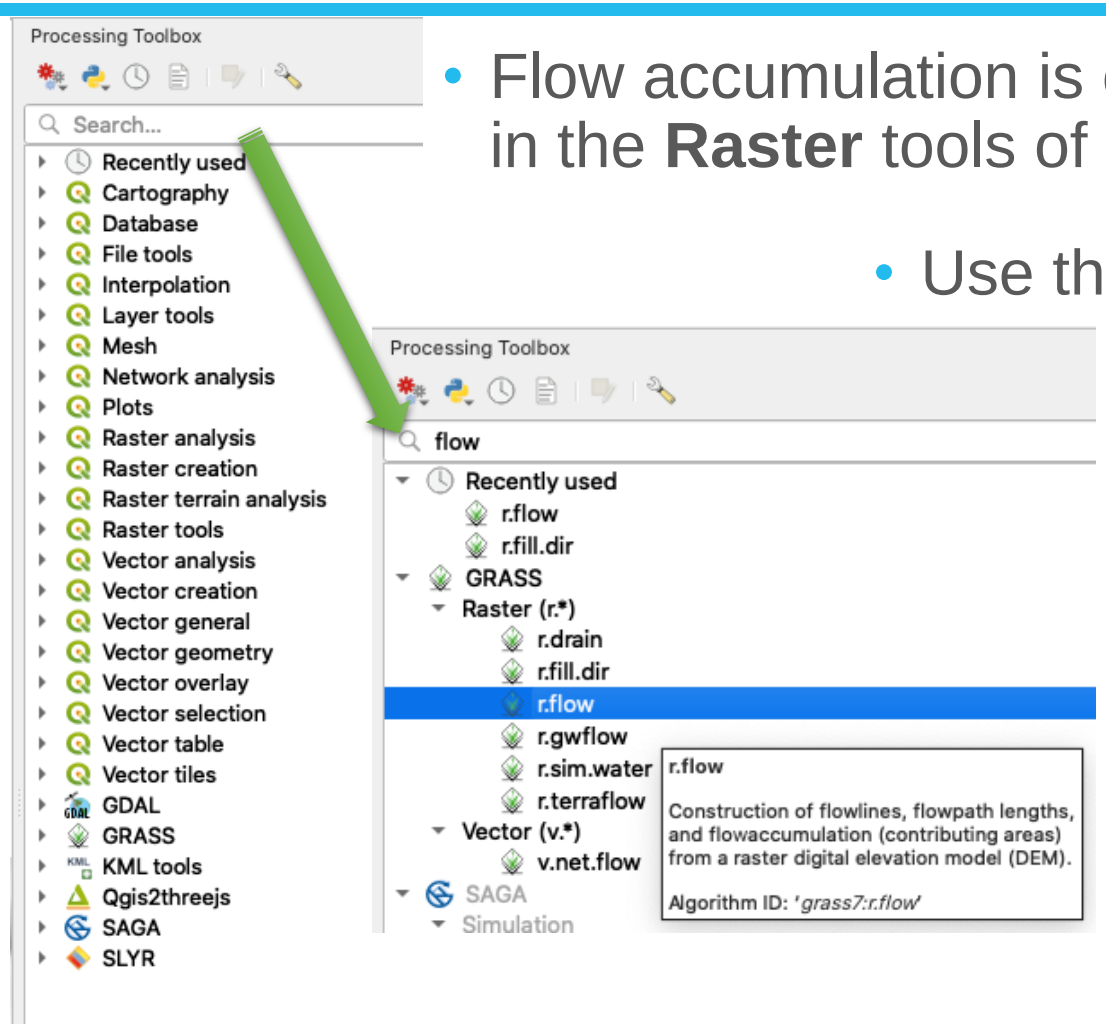
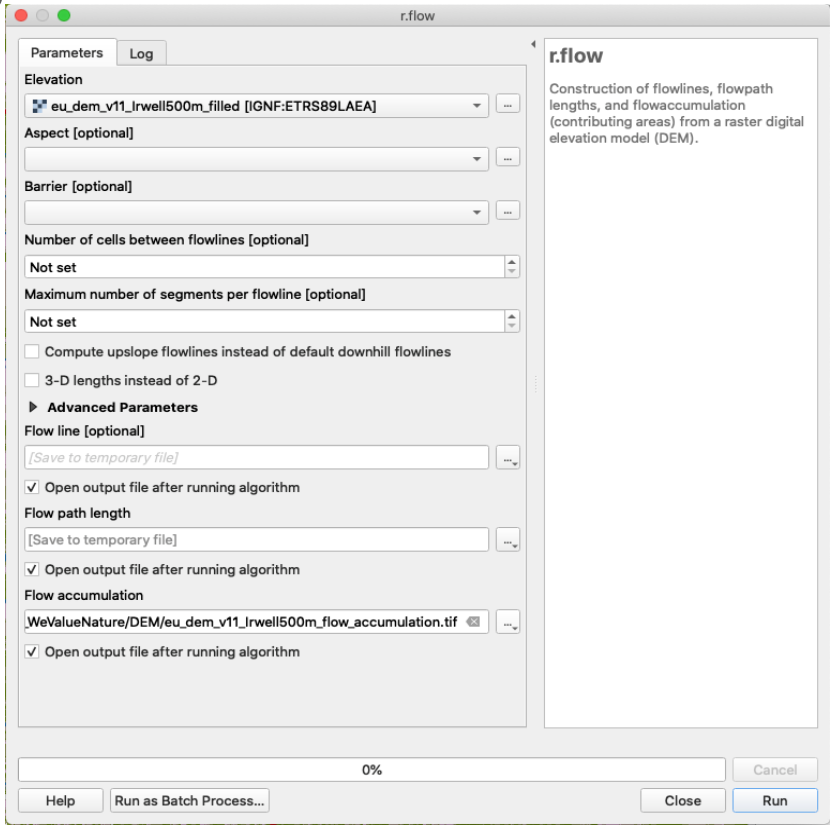
Workshop exercise: Hydrologic modelling

- Flow accumulation is calculated in one step using the **r.flow** tool in the **Raster** tools of the **GRASS** package
  - Use the filled DEM
  - Set an output **.tif** file





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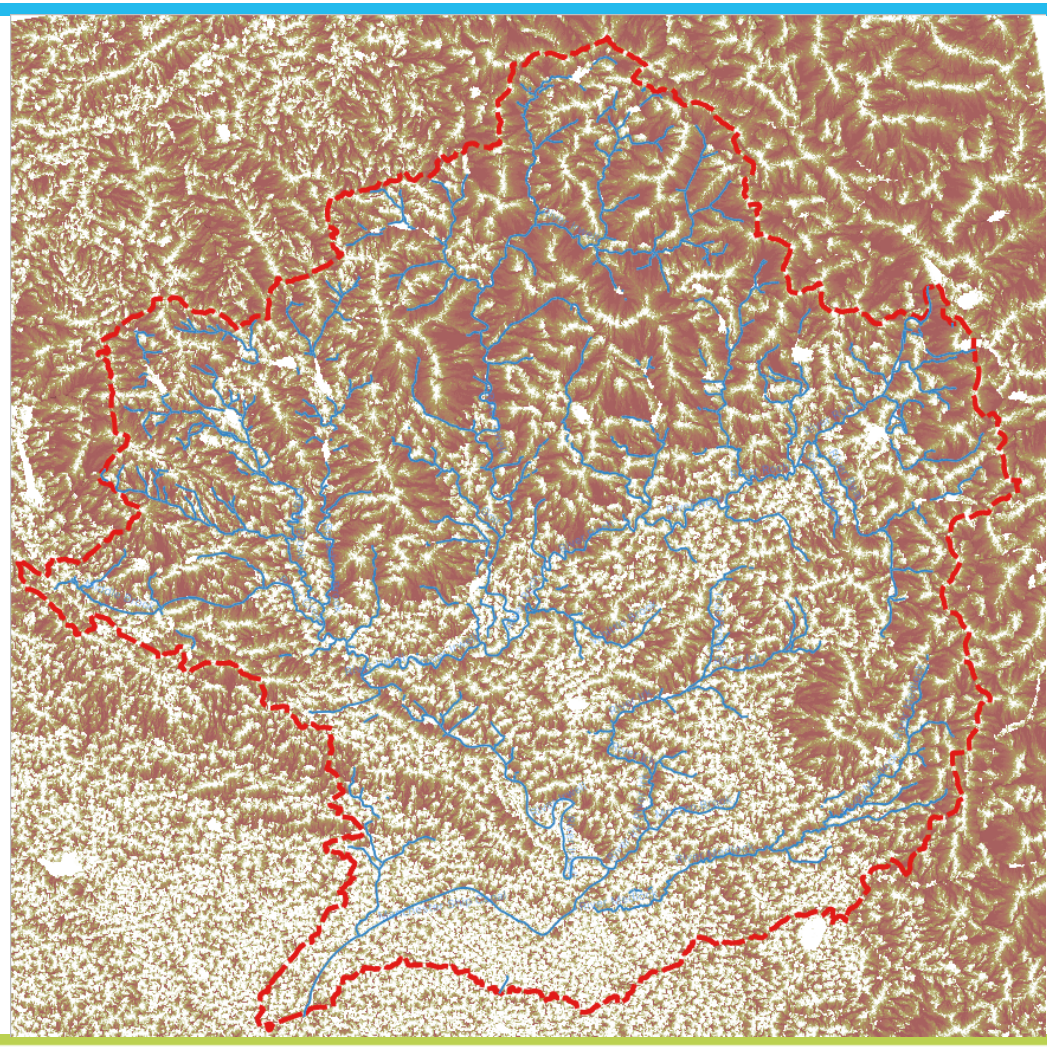
Workshop exercise: Hydrologic modelling

- The output flow accumulation layer will look fairly plain initially. That's because as the flows coalesce, the pixels consecutively add in value, whilst QGIS displays rasters with a linear gradient by default.
- Apply the **eu_dem_v11_Irwell500m_flow_accumulation.qml** style file to the output flow accumulation layer
- In this style file, the darker the shade, the more flow has accumulated.



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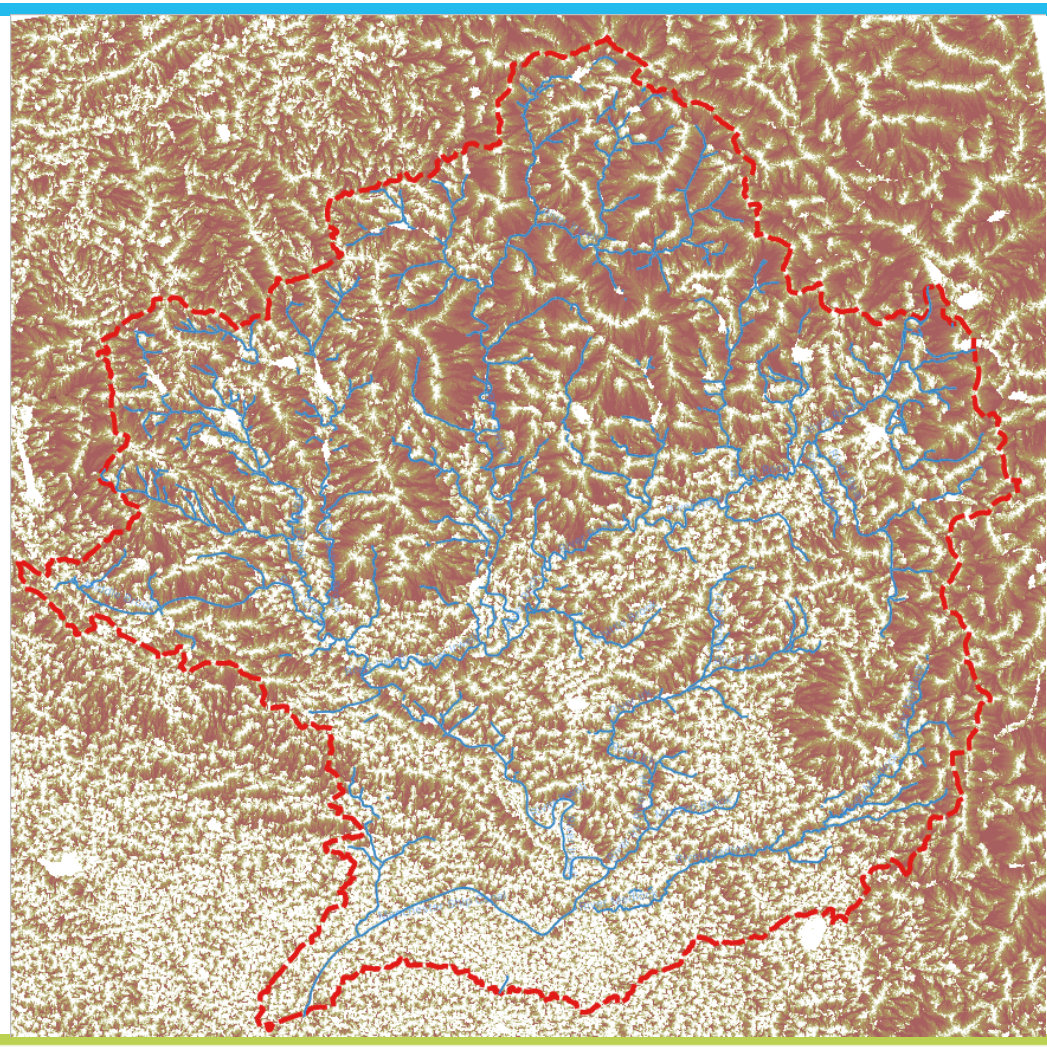
Hydrologic modelling discussion

- From our flow accumulation results, we can look for larger contiguous areas of heavy (darker shaded) flow
- This identifies areas where water flows over the land and into which section of river
- As such, intervention measures placed in these areas will likely mitigate downstream river problems
- However, this is just using topography without consideration for whether natural features already provide some measure of mitigation



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Hybrid solutions

Short overview of Viridian Logic methodologies

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Hybrid solutions

- With NDVI and flow accumulation datasets, it is now possible to produce a metric that captures both areas of flow, and areas where vegetative cover can be improved, and determine effective nature-based interventions that mitigate problems downstream
- NDVI varies between -1 and 1, whilst flow accumulation starts from zero and has no upper bound, so a combined metric is not straightforward
- Both methods covered today do not consider other factors, such as rainfall or soil texture, whilst calculating flow.
- As with NDVI and basic flow accumulation, it is not clear how to marry contrasting measurements, such as soil depth with rainfall volume

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Hybrid solutions – Viridian Logic

- Viridian Logic methodology is based around variations of RUSLE (Revised Universal Soil Loss Equation) which weights the flow accumulation calculation with multiple contributory and resistive factors in determining flow volumes
- Viridian Logic works from the solution end (as per NDVI), with the idea that knowing “what to plant where?” is a more immediately actionable item than ”how bad is the problem?”
- Landscape factors are ranked and weighted and processed, which then re-ranks the landscape by flow accumulation to determine how well the landscape mitigates overland flow problems
- Simultaneously, factor combinations relating to different habitat types are fit to determine what and where habitats deliver the greatest catchment improvement

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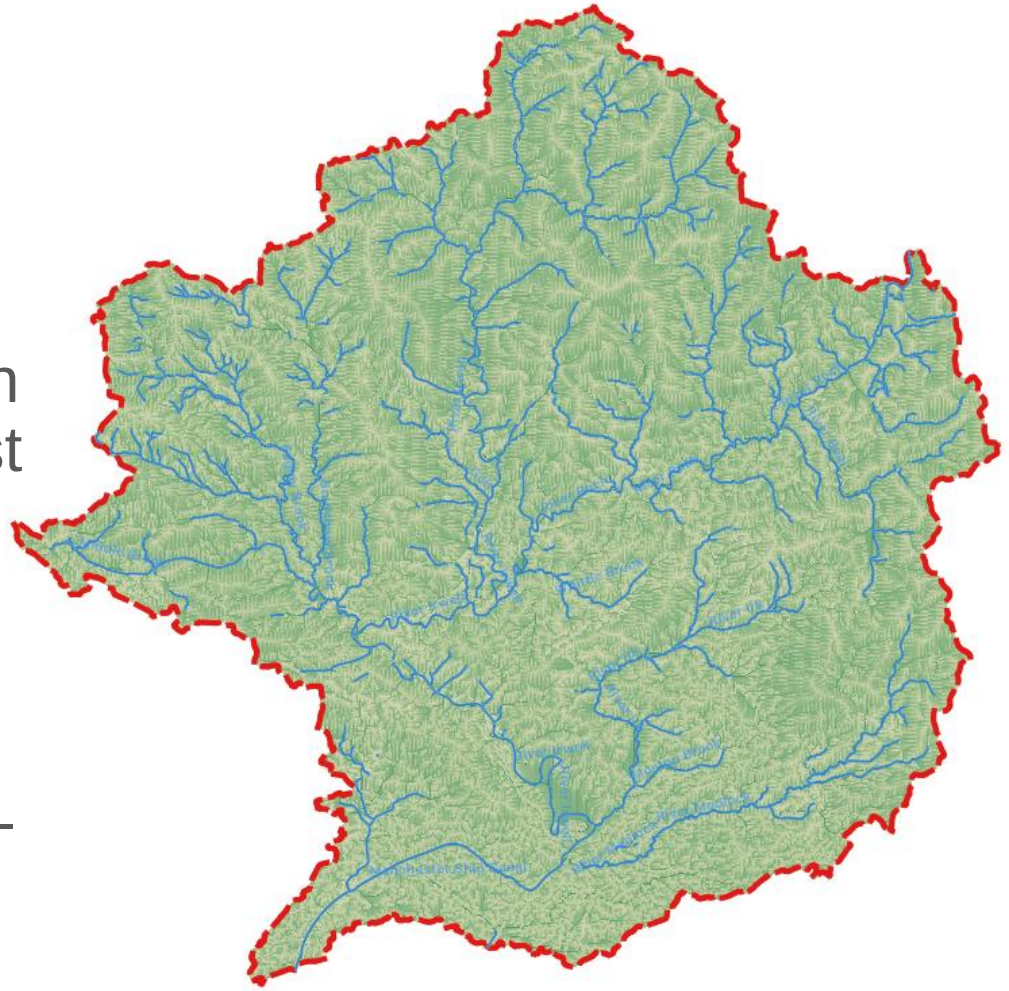
Workshop exercise: Hybrid solutions

- Load **flood_upslope_source_ViridianLogic.tif** from the **ViridianLogic** folder
- Do use the Layers panel to switch between this data and the earlier flow accumulation output.
- Note how, on large scales, this layer can be seen to reflect the basic flow accumulation layer, whilst smaller scale details reveal deviations from the basic methodology.
- This is an *intermediary* product of Viridian's processing pipeline shown here to demonstrate flow accumulation's power in determining nature-based solutions for water



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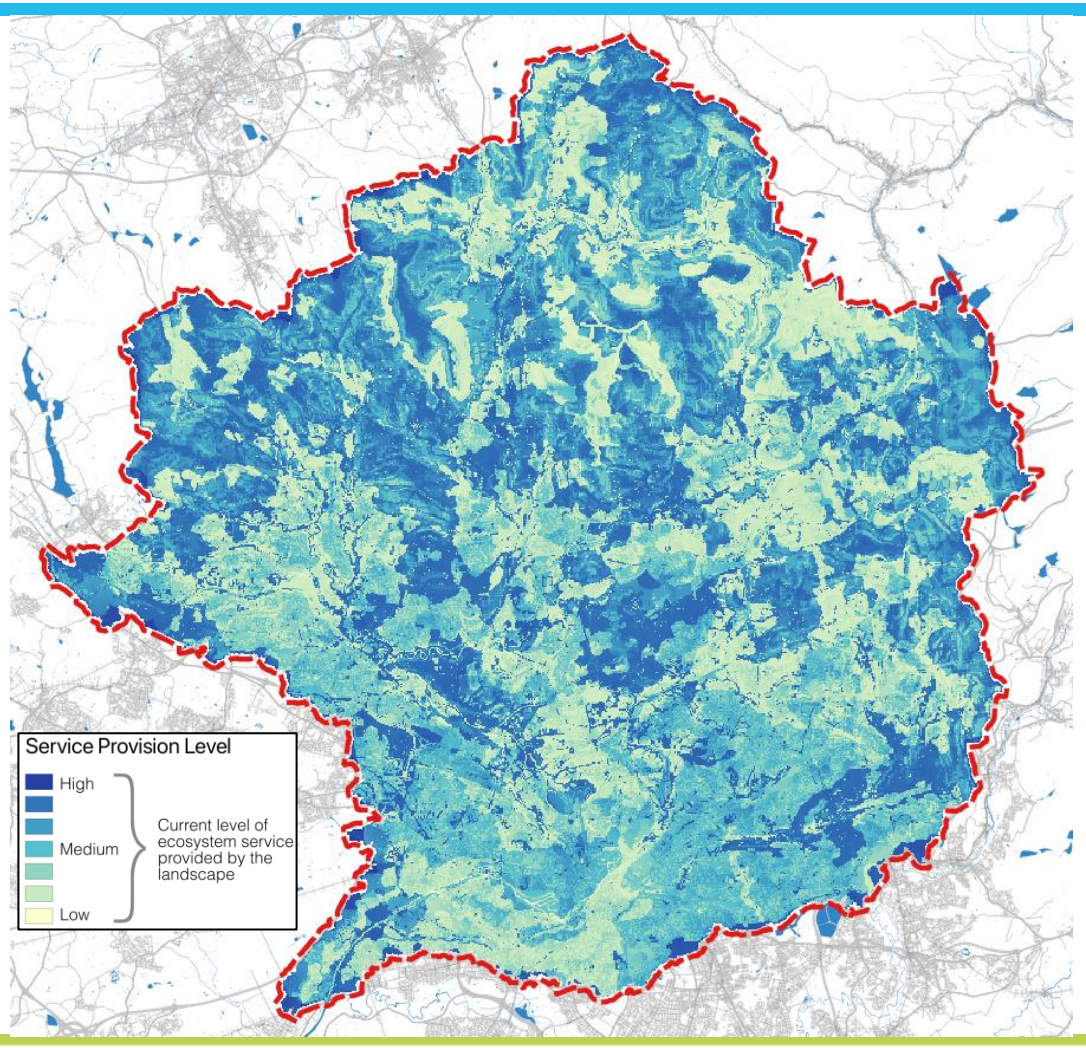
Workshop exercise: Hybrid solutions

- Now load **flood_mitigation_provision_ViridianLogic.tif** from the **ViridianLogic** folder
- This provision layer describes how well the landscape is working at mitigating the amount of flow it receives *relative* to other parts of the landscape
- As such, there is no definitive problem being defined by the data – it simply reflects on where land use can be improved with respect to riparian flooding relative to the rest of the catchment



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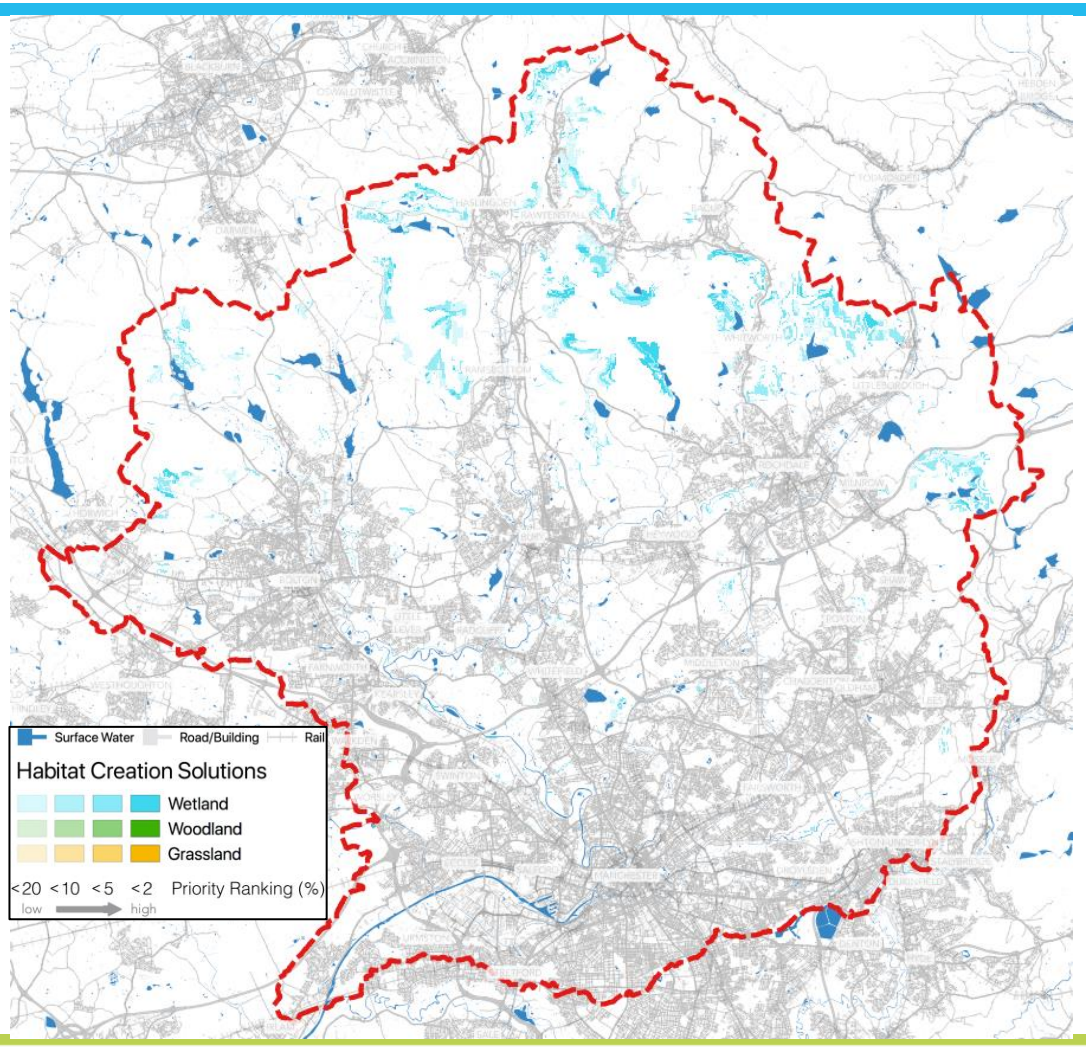
Workshop exercise: Hybrid solutions

- Now load **flood_mitigation_10.00pct_solution_ViridianLogic.tif** from the **ViridianLogic** folder
- This solution layer describes what should be done where to mitigate flooding in the downstream areas of the catchment
- A note here is “Wetland” solutions are collective for just installing wetland, but solutions that raise the water capacity of the land e.g., rewetting peatland, bunds, swales…
- The image shown here displays multiple levels of solution, rather than just at the 10% level



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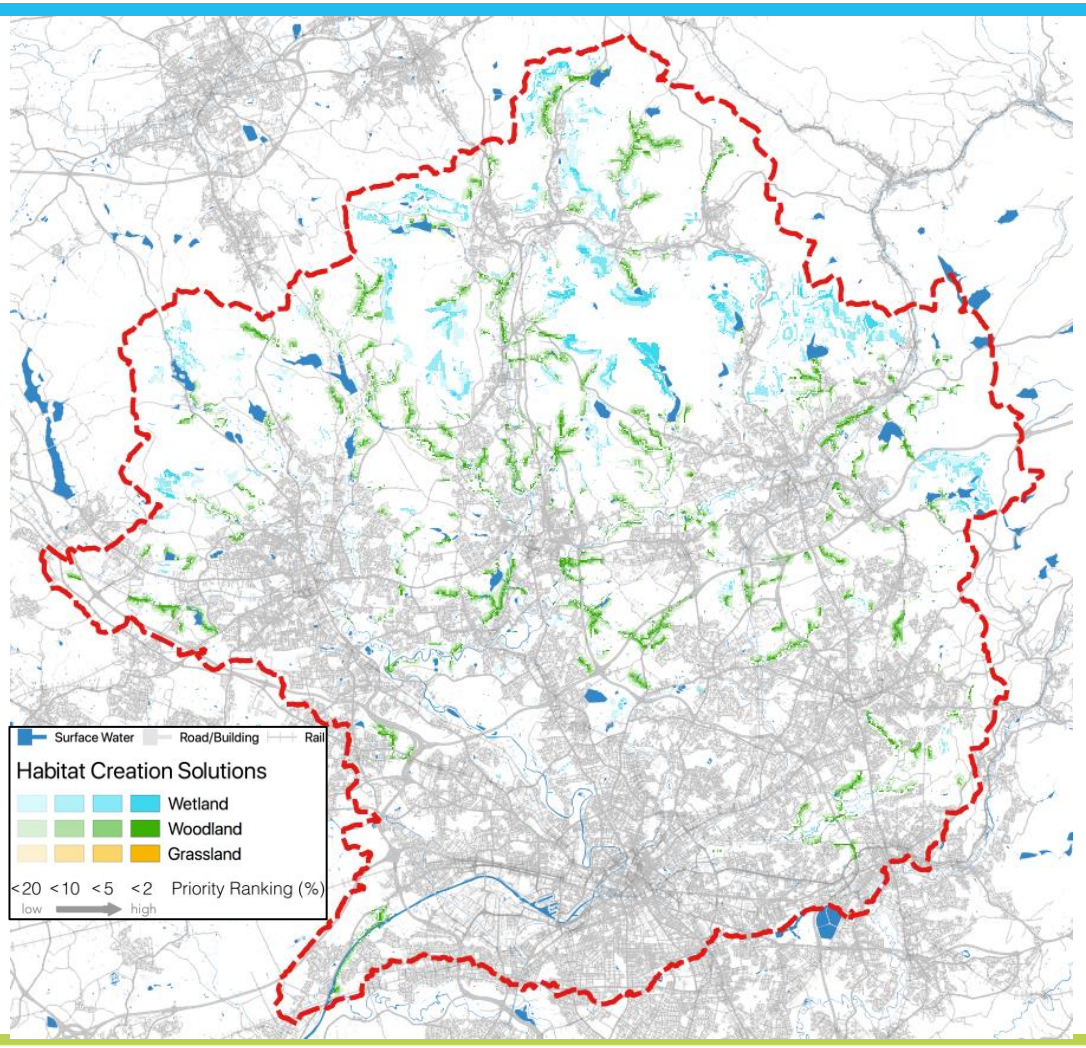
- With a ranking methodology, it is possible to combine different riparian solutions efficiently
- Here, the wetland prioritized for flood reduction has been combined with the woodland planting prioritized for phosphate reduction
- The data Viridian Logic provides to clients are the 100% solutions and thresholds raster
- Load **flood_mitigation_100.00pct_solution_ViridianLogic.tif** and **flood_mitigation_percent_thresholds_ViridianLogic.tif** into QGIS



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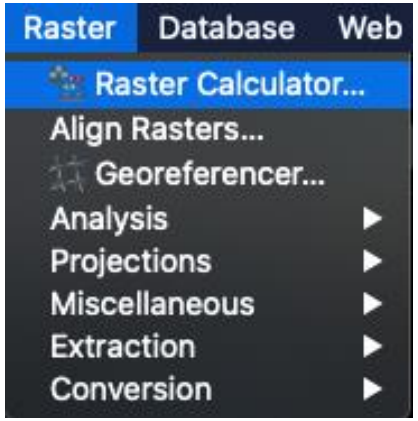
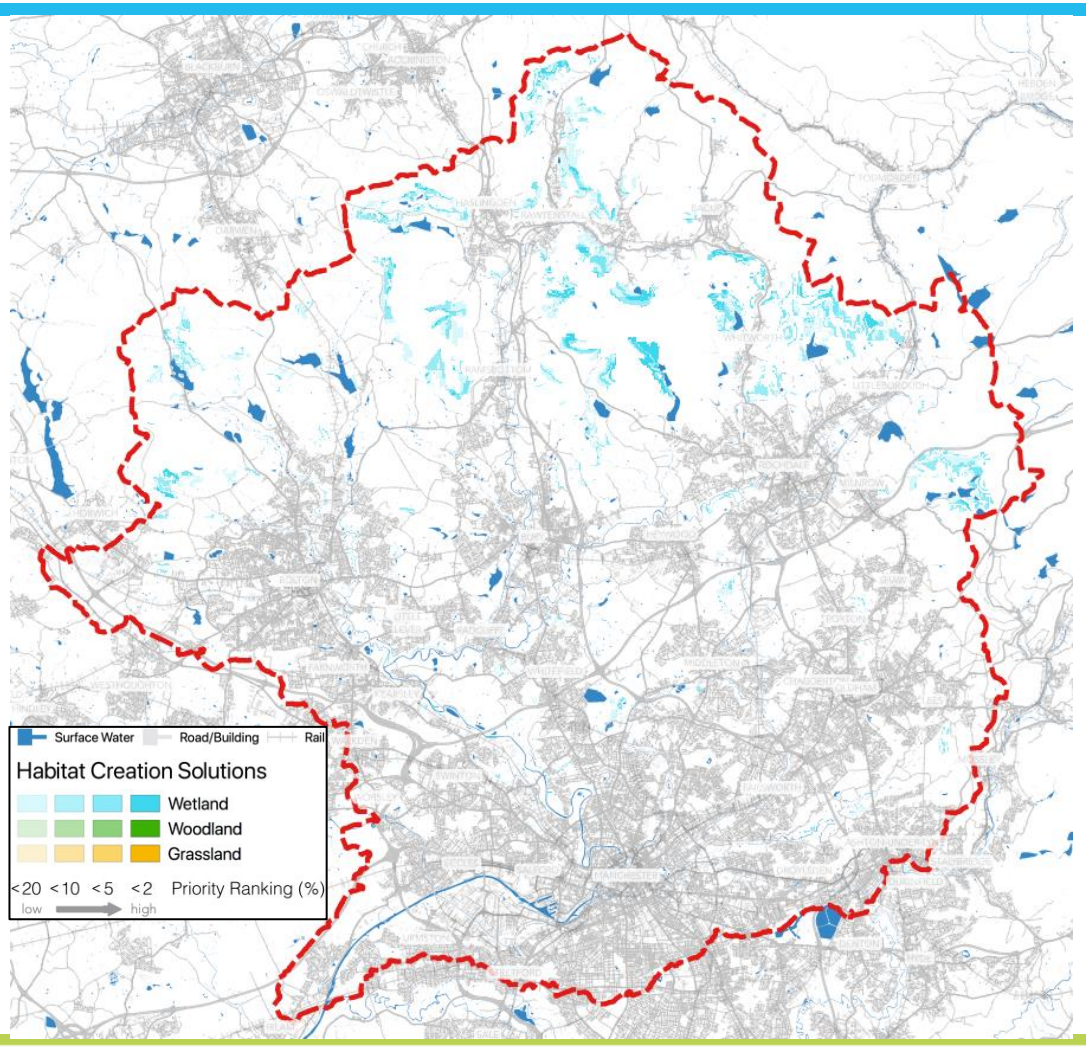
Workshop exercise: Hybrid solutions

- First, apply the **flood_mitigation_10.00pct_solution…qml** style file to the **…100.00pct_solution…tif**
- To generate a 20% solution raster, or indeed the layers needed to recreate the map on this slide, we need **Raster Calculator** again





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Workshop exercise: Hybrid solutions

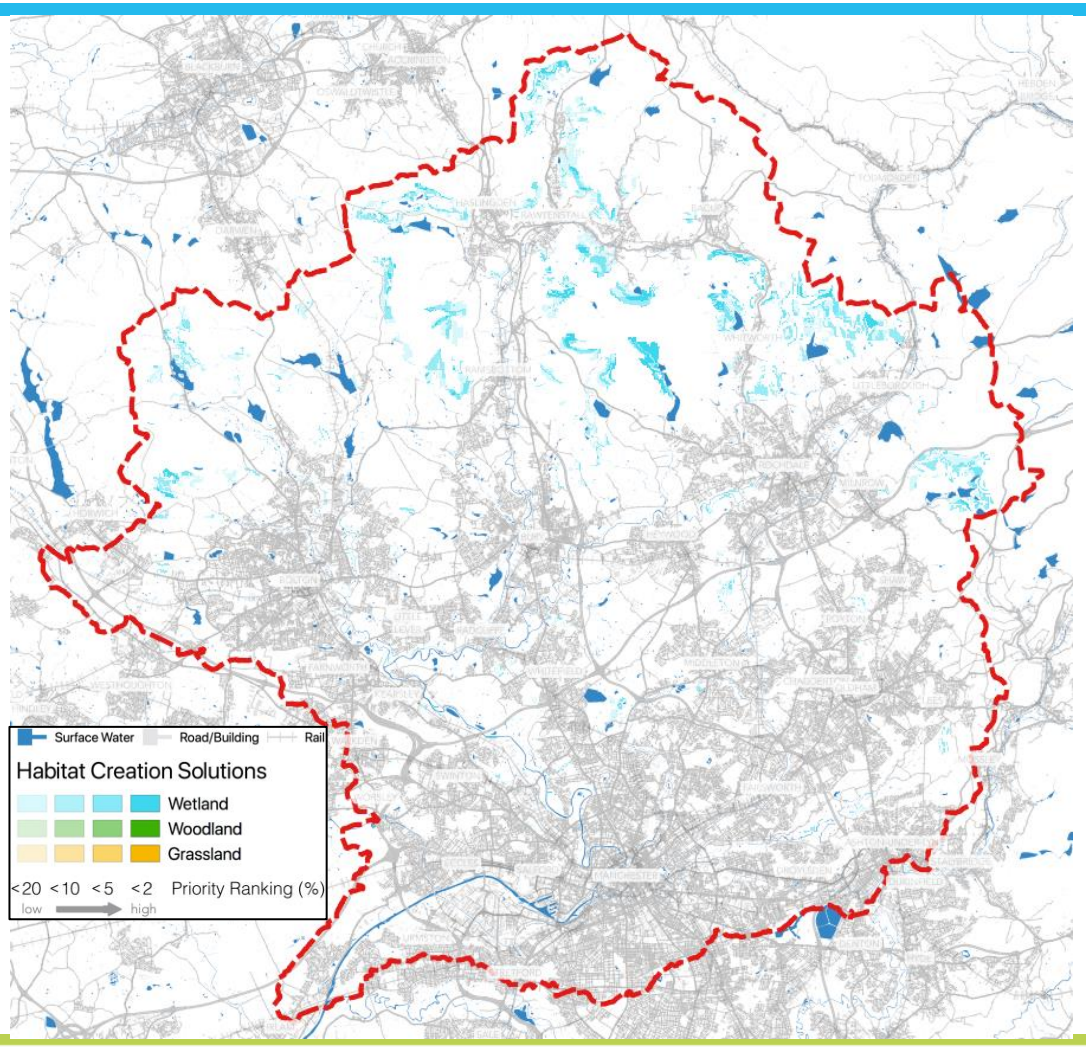
- The formula needed to generate a 20% solution raster is

```
( 0. < "flood_mitigation_percent_thresholds_ViridianLogic@1" )  * ( 0.2 >
"flood_mitigation_percent_thresholds_ViridianLogic@1") *
"flood_mitigation_100.00pct_solution_ViridianLogic@1"
```

where the logic is

- SELECT (percentages above 0, i.e., exclude null data)
- AND (percentages below 0.2, i.e. the top 20%)
- FROM (100% solutions raster, i.e., the "what to do" raster)

In this way, if the highest priority areas cannot be enhanced with nature, the next best priority areas can be selected.



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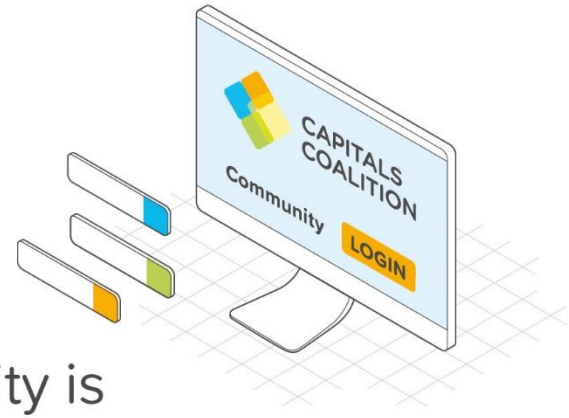
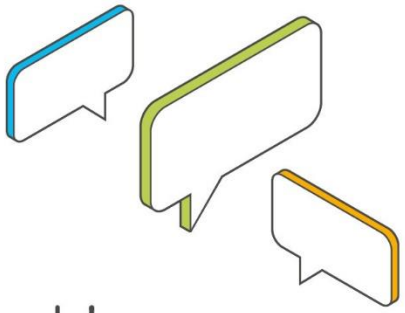


The Capitals Community is
the networking space for the
We Value Nature 10-Day Challenge.

Sign up and join the We Value Nature
group to take part in the conversations:

https://community.capitalscoalition.org



We want your feedback!

Please share your thoughts on
this session and the overall
10-Day Challenge event at:

https://wevaluenature.eu/Feedback

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