

Investigating River Catchments

Hydrology, soils and water quality

Summary

This resource package is designed to allow students to independently investigate river catchments with a focus on hydrology, water quality and soils. The data package combines spreadsheet-based gauging and water quality monitoring data with an online web-GIS mapping package of catchment characteristics.

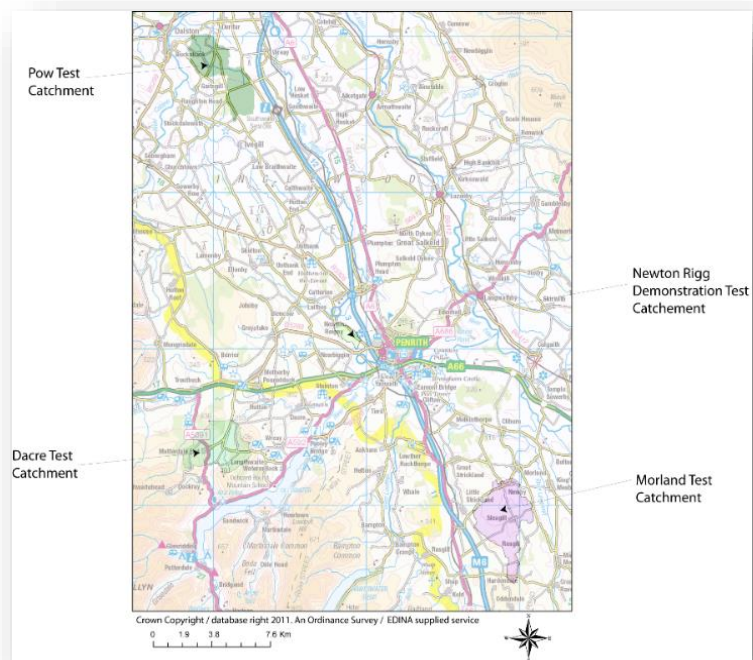
The resources and suggested investigations are designed to support lesson topics such as: river regimes, hydrographs, storm/flood hydrographs, soil erosion and organic water pollution. Students are encouraged to relate the in-stream measured flows and water quality with the wider physical and human characteristics of the catchment.

Eden Demonstration Test Catchment Project

This resource package has been developed with support and data provided by the River Eden Demonstration Test Catchment Project (Eden DTC), a research project funded by Defra. The aim of the project is to assess if it is possible to cost effectively mitigate diffuse pollution from agriculture whilst maintaining agricultural productivity.

The project is focused on three sub-catchments within the River Eden catchment, selected to represent a range of land uses, physical characteristics and weather.

The focus areas are in the **Dacre** (Thackthwaite), **Morland** (Newby) and **Pow** catchments. Each catchment has an area of approximately 10km². The project is monitoring the stream water quality and looking at how the catchment responds to storm events. This work includes measuring many properties of the water including the amount of nitrogen, phosphorus, sediment contained and the total amount of water leaving the catchment.



The Eden DTC team is led by Lancaster University, and the consortium includes Durham and Newcastle Universities, Eden Rivers Trust, the Centre for Ecology and Hydrology (CEH), British Geological Survey (BGS) and Newton Rigg College. Find out more about the project at www.edendtc.org.uk

Key resources

The following data and resources can be used independently or in combination to support catchment investigations and case studies. *Note: Information on how to access the resources lies within the detailed descriptions of them below.*

- Hydrological and water quality data 01/10/2012- 30/09/2013,
- Online ArcGIS package with data about the Eden catchment,
- Catchment information sheets describing the hydrology, pollution pathways and water quality of the sub-catchments for the 2011/2012 Hydrological Year,
- Photos from the Eden DTC Flickr Account,
- Soil Water continuum video.

1. Hydrological and water quality data

Provided in spreadsheet format for three sub-catchments of the River Eden (Morland - Newby Beck, Dacre – Thackthwaite Beck and Pow Beck).

Please request this data from our Learning Coordinator at learning@edenrt.org

Data includes rainfall, stream discharge, sediment, phosphate and nitrate concentrations recorded at 30 minute intervals (Pow and Morland Beck) or hourly intervals (Dacre Beck). Please note there are some small gaps in the water quality data due to equipment malfunctions. Gaps in rainfall data have been filled to generate a complete dataset. Water quality data is only provided for the Morland Beck and Pow Beck. (Please credit data © Eden Demonstration Test Catchment).

	A	B	C	D	E	F	G	H	I	J	K	L	M
	Date/time	Rainfall (mm)	Flow (m3/s)	Suspended sediment (mg/l)	Total P (mg/l)	Total reactive P (mg/l)	Nitrate (mg/l)						
2	01/10/2012 00:30	0.00	0.31647315	12.4	0.122	0.056	7.38						
3	01/10/2012 01:00	0.00	0.31647315	11.8	0.120	0.055	7.43						
4	01/10/2012 01:30	0.00	0.32463446	11.1	0.115	0.053	7.45						
5	01/10/2012 02:00	0.00	0.31378412	10.8	0.114	0.053	7.48						
6	01/10/2012 02:30	0.00	0.31647315	10.3	0.097	0.053	7.50						
7	01/10/2012 03:00	0.00	0.30581078	10.0	0.107	0.053	7.52						
8	01/10/2012 03:30	0.00	0.30057293	9.7	0.103	0.050	7.54						
9	01/10/2012 04:00	0.00	0.29539688	9.1	0.100	0.050	7.57						
10	01/10/2012 04:30	0.08	0.30318411	9.0	0.100	0.053	7.60						
11	01/10/2012 05:00	0.00	0.29539688	8.7	0.097	0.047	7.66						
12	01/10/2012 05:30	0.00	0.29283193	8.4	0.095	0.048	7.65						
13	01/10/2012 06:00	0.09	0.29283193	8.4	0.095	0.050	7.64						
14	01/10/2012 06:30	0.00	0.29283193	8.2	0.092	0.047	7.67						
15	01/10/2012 07:00	0.04	0.29539688	7.7	0.092	0.047	7.70						
16	01/10/2012 07:30	0.11	0.28023636	7.5	0.092	0.048	7.71						
17	01/10/2012 08:00	0.00	0.27286083	7.6	0.089	0.047	7.74						
18	01/10/2012 08:30	0.15	0.28023636	7.0	0.086	0.045	7.71						
19	01/10/2012 09:00	0.05	0.26801887	6.9	0.087	0.045	7.73						
20	01/10/2012 09:30	0.00	0.27530429	6.6	0.087	0.053	7.74						
21	01/10/2012 10:00	0.00	0.27530429	6.5	0.086	0.053	7.77						

2. Online ArcGIS Package

Provides data on catchment characteristics for the River Eden which can be accessed online at: <http://arcg.is/2tov14B>. The following datasets are included:

1. **Live river levels:** gauging stations are mapped with a link to view live river level data for the past 5 days,
2. **Weather station data:** the location of weather stations which record rainfall rates and daily rainfall accumulation totals are mapped with a link to the Met Office Weather Observation Web-site where you can view, graph and download the data,
3. **The Eden Demonstration Test Catchment monitoring stations** are mapped with a link to the DTC website where you can view live data. The catchment boundaries for the three EdenDTC catchments (Morland Beck, Pow Beck and Dacre Beck) are also included,

Please note: alternative names for the sub-catchments which may be used on the DTC live data website. Morland Beck is sometimes referred to as Newby. Dacre Beck is sometimes referred to as Thackthwaite.

4. **Average Annual Rainfall (mm) (Met Office):** is the 1961 to 1990 average annual rainfall per 5km square. This is a basic dataset that allows you to get a feel for how much rainfall the catchment expects to receive over a year and highlights areas where rainfall is higher,
5. **Land Cover (EU Corine)** provides basic land cover information in 34 classes for the whole of Europe. This dataset gives a feel for both natural and manmade land cover types in the catchment,
6. **Risk of Flooding from Rivers and Sea (Environment Agency):** This layer identifies where flooding from rivers and the sea may occur and the level of risk at each location e.g. % risk of flooding in any given year. *Note: This is a very detailed dataset and you can therefore only see it on the map when zoomed in to the level of individual towns,*
7. **Soil Erodibility (EU soils):** identifies soils that are vulnerable to erosion if high risk land management activities are practiced. The darker the colour, the higher the risk of soil erosion for any given land management,
8. **Soil Type (Soilscapes – Cranfield University):** Soilscapes is a simplified soils dataset covering England and Wales. Click on each soil type for a link to more information about that soil type including information about water protection issues.
9. **Bedrock Geology (British Geological Survey):** This layer is the 1:625k bedrock geology map from the British Geological Survey symbolised into broad categories of rock type. You can click on the data to find out more information such as the geological time period within which the rock was formed,
10. **Terrain (OS Terrain 50):** This layer has been produced from Ordnance Survey's 50m resolution terrain data. It has been presented to show slope in degrees. You can also turn on other sub-layers within the dataset such as elevation, hill shaded relief and aspect,
Note: There is no pop-up information with this dataset, but you can view the legend.
11. **Add Additional Data:** You can also add additional datasets to the map from The Rivers Trust's Catchment Mapping Portal using the **Add Data** tool. This could include information on river ecological health such as WFD (Water Framework Directive) status, information on flood risk such as the risk of surface water flooding, and information on river habitat such as the level of riparian (riverside) shading from trees.

There are some key functions to help you explore the online map package:

You can print a PDF of your map to use in reports.

Click on the Basemaps button to change the basemap e.g. to aerial imagery or OS data.

Use the Annotate tool to draw on and add text to your map to highlight key features.

Click directly on layers within the map to bring up more information about that location in a pop-up.

Use the Add Data tool to add additional data to your map from The Rivers Trust's Catchment Data Mapping Portal e.g. WFD River Status, Risk of Surface Water Flooding, River Habitat Assessment Data etc.
You can also use this tool to add field data that you might have collected via a csv file created in Excel.

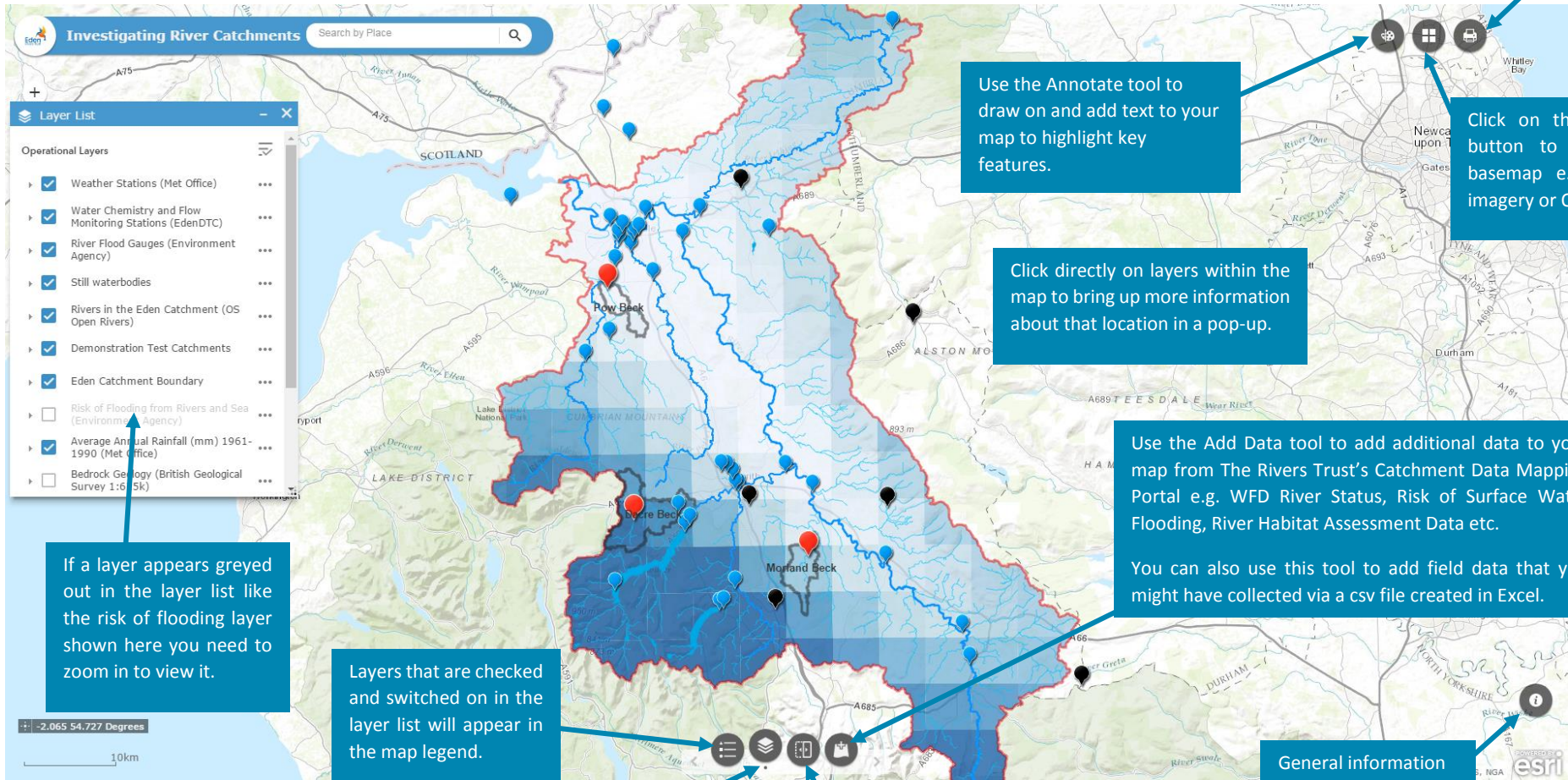
If a layer appears greyed out in the layer list like the risk of flooding layer shown here you need to zoom in to view it.

Layers that are checked and switched on in the layer list will appear in the map legend.

Click on the Layers button to bring up a list of datasets included in the map. You can switch the layers on and off by checking the box next to them.

Use the Swipe tool to select a key data layer to swipe on and off across the map.

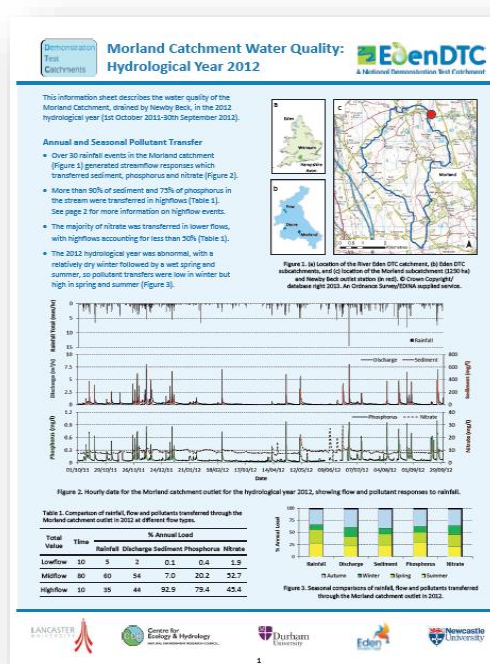
General information about the map.



You can also use this tool to add your own data collected during a field visit directly into the online mapping package. You can do this by saving an Excel spreadsheet of field results as a .csv file and directly upload it to the online map using the Add Data from the File option. Students could then print off their own catchment maps including their collected data to include in a catchment investigation report.

3. Example catchment information sheets

Prepared by the EdenDTC project describing the hydrology, pollution pathways and water quality of the [Morland Beck](#), [Dacre Beck](#) and [Pow Beck](#) sub-catchments for the 2011/2012 Hydrological Year.



4. Photos from the Eden DTC Flickr account

Illustrating pollution pathways, sediment sources, stream flow variations, land use and farming practices can be found and downloaded from the Eden DTC Flickr account

https://www.flickr.com/groups/eden_dtc/

Students can use these in reports and presentations. (Please credit © EdenDTC if you use any images).

5. Soil-water Continuum Video

A six minute video about the soil-water continuum produced by Prof. Phil Haygarth at Lancaster University. The video gives an excellent introduction to agricultural diffuse pollution, pollution sources and pathways, and the role of soils. <https://youtu.be/YJpnpt8X-go>

Suggested exercises and investigations

Below are a range of initial suggested topics, exercises and lessons which could be supported using the data resources provided.

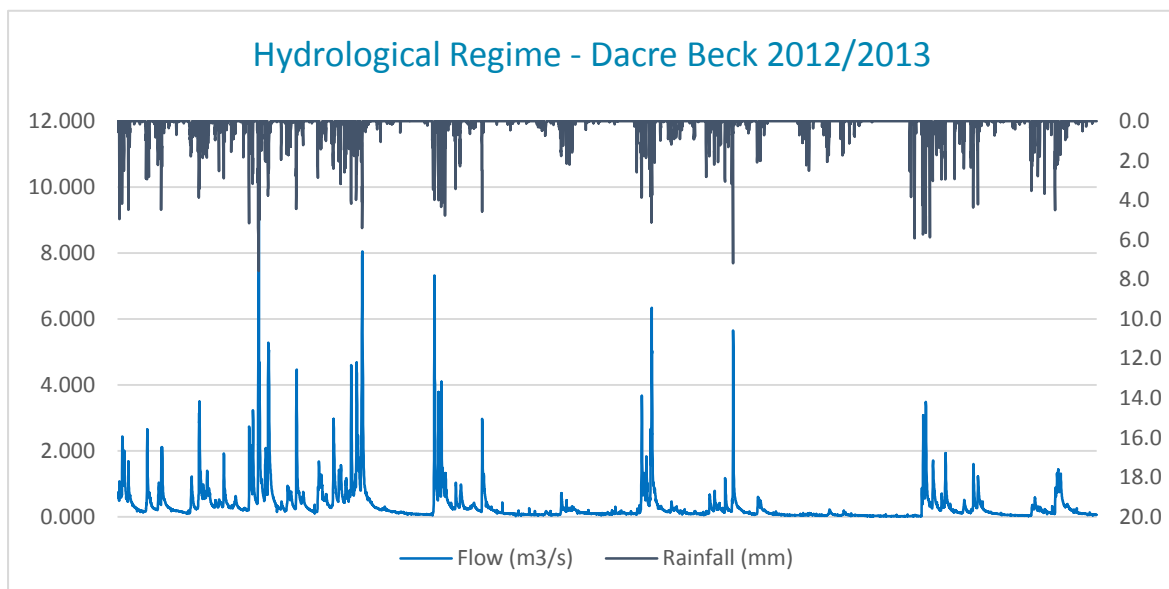
1. Catchment investigation:

Students use the data provided to develop their own case study report investigating the hydrology and water quality for one of the sub-catchments. Within their reports, students could include graphed and tabular outputs from analysis of the Excel-based in-stream hydrological and water quality data, maps of catchment characteristics taken from the online map package, and photos to illustrate hydrological processes and issues from the EdenDTC Flickr account.

The investigation could be broken down into the sections below.

a) River regimes and hydrographs:

Use the spreadsheet-based data provided to draw and describe the yearly hydrological regime for one of the sub-catchments.

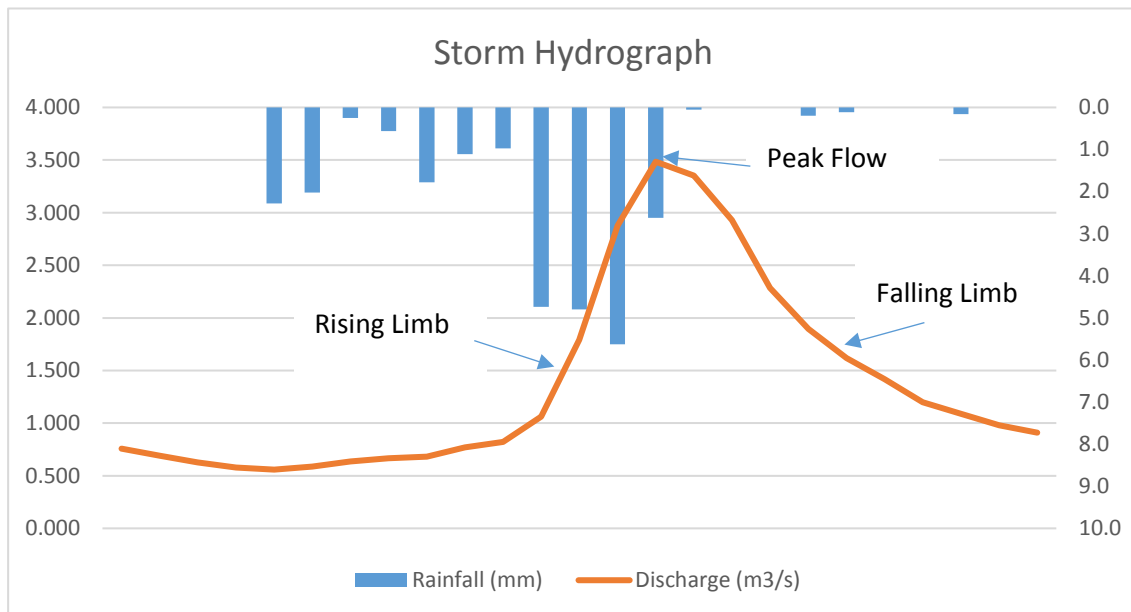


Q1. How many rainfall events were there during the 2012/2013 hydrological year?

Q2. How do rainfall events and river flows vary throughout the year?

Q3. Can you identify a period of high flows and a period of low flows?

Select one storm event and draw the storm hydrograph (not necessarily the largest!) Describe the storm hydrograph and label key terms (e.g. rising limb, falling limb, peak flow).



Q1. What is the time-lag between peak rainfall and peak discharge for your event?

Q2. What were the antecedent conditions before your storm event occurred? How might this have affected the storm hydrology?

Q3. Ask students to compare the characteristics of the different storms they have selected.

b) Hydrological investigation:

Compare the hydrology of the three sub-catchments. Use the spreadsheet-based data to calculate and analyse a range of hydrological variables, producing both graphed and tabular outputs. This could include looking at:

- Total annual rainfall,
- Total monthly or seasonal rainfall variations throughout the year,
- Number of rainfall events in the year and their distribution over time,
- Average daily discharge,
- Compare the correlation between rainfall and discharge for each of the three catchments,
- Calculate the Q95 low flow (the flow which is exceeded 95% of the time) and the Q1 high flow (flow which exceeded only 1% of the time),
- Gather information from the web links on live river levels and rainfall and undertake a correlation analysis e.g. Spearman Rank.

c) Unknown catchment investigation:

Students could be given the hydrological data without catchment names. By analysing the various hydrological variables above and then looking at the online map package, students could be asked to work out which set of data goes with which EdenDTC catchment and explain why they think this is the case e.g. by looking at total rainfall, topography, geology etc.

2. Soils & sediment

Investigate the risk of soil erosion and fine sediment pollution within the Morland Beck and/or Pow Beck sub-catchment. Watch the video by Lancaster University as an introduction to the topic. The following resources would support the investigation:

- Use the online map package to identify and discuss catchment risk factors such as soil type, land cover, hillslope and soil erosion potential,
- Use the EdenDTC spreadsheet data to investigate fine sediment transport regimes within the river,
- Use the EdenDTC Flickr account to illustrate sediment sources, pathways and impacts within the catchment.

As part of the investigation students could be asked the following questions (as examples):

Q1. Draw a graph of the catchment's sediment regime (including river flow and rainfall) and describe. Calculate the annual fine sediment load for the catchment. When is most sediment transported through the river system (at high, medium or low flow and at what time of year)?

What might this tell you about pollution sources, pathways and risks within the catchment?

Q2. Using the online mapping package, where do you think the riskiest places for soil erosion and transport are in the catchment?

Print out and annotate some maps to highlight the risk factors and locations. Look at the EdenDTC Flickr account and identify some sediment sources and pathways which illustrate the risk factors you have identified above.

Q3. What issues does excess sediment cause for the river system?

Q4. What could be done to reduce the risk of sediment loss from the catchment?

3. Nutrient pathways & pollution:

Investigate the annual and seasonal nutrient transfer within the Morland Beck or Pow Beck sub-catchment. Have a look at the Eden DTC info and data sheet for the 2011/2012 hydrological year and produce your own version for the 2012/2013 hydrological year using the spreadsheet-based in-stream monitoring data provided.

Q1. What does the data tell you about pollution pathways in the catchment?

Q2. When is most pollution transferred through the catchment?

Q3. Are pollution transfer characteristics the same for phosphate and nitrate? If not, why might they vary?

Q4. What sources of nutrients might there be in the catchment? (Use the online map package to look at risk factors such as land cover)

Q5. How might nutrient pollution affect the ecology of the river?

Q6. What could be done to reduce pollution transfer in the catchment?

This topic could be linked with the [Improving the River Petteril](#) Story Map which provides a case study and more information on catchment-based actions to reduce pollution, and includes more detailed datasets e.g. phosphate source apportionment model outputs, pollution incidents, Groundwater Safeguard Zones, and sewage discharges.

Field visit opportunity

In collaboration with Eden Rivers Trust, organise a field visit during which students collect their own data to support a catchment investigation. They could then compare their data to that collected by the EdenDTC Project over the 2012/2013 Hydrological Year (e.g. stream flow, water quality, soil infiltration) and analyse it in the context of other layers in the online map.

Using the **Add Data** tool students can add their own data collected in the field to the online mapping package. You can do this by saving an Excel spreadsheet of field results as a .csv file and directly upload it to the online map using Add Data from the File option. Students could then print off their own catchment maps that include their collected data to use in a catchment investigation report.

If your school is registered with the ESRI UK Schools Programme, it may be possible for Eden Rivers Trust to work with you to set up a mobile data collection app to be used on a smart phone or tablet during the field visit.

Additional resources

Access additional data from the Demonstration Test Catchment project via the DTC Data Archive. Use the links below to find further monitoring data for the three sub-catchments.

Morland – Newby Beck: <http://www.environmentdata.org/archive/dtceden:247>

Pow Beck: <http://www.environmentdata.org/archive/dtceden:177>

Dacre – Thackthwaite Beck: <http://www.environmentdata.org/archive/dtceden:208>

You can download more free ArcGIS resources to use in the classroom from the Eden Rivers Trust website,

www.edenriverstrust.org.uk/arcgis-resources-secondary-schools



This series of ArcGIS resources for Secondary Schools have been developed by Eden Rivers Trust in conjunction with The Rivers Trust with support from the Heritage Lottery Fund. Thank you to all of the teachers who helped with the development of these resources.