

Integrating Professional River Study Techniques into School Fieldwork

The enclosed information provides guidance on conducting river-based school fieldwork. Produced in partnership with ERM, a leading global provider of environmental, health, safety, risk and social consulting services, the *Professional Support for Fieldwork* project directly addresses issues surrounding geography fieldwork provision in schools. The project aims to highlight how the skills and knowledge developed through school fieldwork are directly relevant to 'real-world' professional industries, career paths and activities.

... This document provides a series of fieldwork activities for the study of river systems. These activities are demonstrated through an example study area (Tame Valley, Greater Manchester). For each set of activities, this document also provides generic requirements for fieldwork site selection (with an emphasis on site types that can be found within proximity to most schools and at a low cost), the tools and techniques for data collection, pre- and post-fieldwork activities, relevance to GCSE and A Level curricula and critical health & safety considerations.

Integrating Professional River Study Techniques into School Fieldwork

TABLES OF CONTENTS

1. SUMMARY OF EXAM BOARD RIVER STUDIES CURRICULA (2016)	4
1.1. GCSE	4
1.2. A LEVEL	4
2. CASE STUDY PRACTICALITIES (TAME VALLEY)	5
2.1. EXAMPLE STUDY SITES	5
2.2. ACCESSIBILITY	7
2.3. PROXIMITY TO KEY LOCALITIES AND FACILITIES	8
2.4. NOTABLE HEALTH & SAFETY CONSIDERATIONS	8
2.5. OTHER RESOURCES FOR RIVER FIELDWORK PLANNING	9
3. FIELDWORK PROJECT 1: COMPARATIVE STUDY OF RIVER REGIMES	10
3.1. INTRODUCTION	10
3.1.1. LINKS TO CURRICULA	10
3.1.2. 'REAL-WORLD' EXAMPLES	11
3.2. SITE SELECTION	12
3.3. PRE-FIELDWORK ACTIVITIES	13
3.3.1. QUESTIONS & HYPOTHESES	13
3.3.2. METADATA COLLECTION	13
3.3.3. PLAN OF WORK	14
3.3.4. LOGISTICAL PLANNING	15
3.4. MEASURABLE PROCESSES AND FIELD DATA COLLECTION TECHNIQUES	16
3.4.1. FIELD NOTEBOOK	17
3.4.2. RIVER MORPHOLOGY & FLOW REGIME	18
3.4.2.1. River gradient	18
3.4.2.2. River width	20
3.4.2.3. River depth	22
3.4.2.4. Flow velocity	24
3.4.2.5. Cross-sectional area, hydraulic radius, wetted perimeter and discharge	26
3.4.3. WATER TRANSPORT OF SOLIDS	27
3.4.3.1. Bed-load	27
3.4.3.2. Suspended sediments	30
3.4.4. Dissolved matter and water quality	33
3.5. POST-FIELDWORK ACTIVITIES	37
3.5.1. DATA ORGANISATION & INPUT	37
3.5.2. DATA ANALYSIS & VISUALISATION	37
3.5.3. DATA REPORTING & SHARING	37
3.6. RIVER-SPECIFIC DATA ANALYSIS METHODS & CALCULATIONS	38
3.6.1. CROSS-SECTIONAL AREA, DISCHARGE, WETTED PERIMETER AND HYDRAULIC RADIUS	38
3.6.2. PEBBLE DATA (WATER VELOCITY & PEBBLE ROUNDNESS)	39
3.6.3. WATER QUALITY ASSESSMENT	40
4. FIELDWORK PROJECT 2: FLOODING HAZARD VS. RISK	41
4.1. INTRODUCTION	41
4.1.1. LINKS TO CURRICULA	41
4.1.2. 'REAL-WORLD' EXAMPLES	42
4.2. SITE SELECTION	43
4.3. PRE-FIELDWORK ACTIVITIES	44
4.3.1. QUESTIONS & HYPOTHESES	44
4.3.2. PLAN OF WORK	44

Integrating Professional River Study Techniques into School Fieldwork

4.3.3.	METADATA COLLECTION	45
4.3.4.	LOGISTICAL PLANNING	45
4.4.	MEASURABLE PROCESSES AND FIELD DATA COLLECTION TECHNIQUES	46
4.4.1.	FIELD NOTEBOOK	46
4.4.2.	FLOOD RISK CONTRIBUTORS	47
4.5.	POST-FIELDWORK ACTIVITIES	51
3.5.1.	DATA ORGANISATION & INPUT	51
3.5.2.	DATA ANALYSIS & VISUALISATION	51
4.5.3.	DATA REPORTING & SHARING	53

Integrating Professional River Study Techniques into School Fieldwork

1. Summary of exam board river studies curricula (2016)

These resources have been developed with reference to the GCSE and A Level curricula provided by the Department of Education and by the main exam boards (i.e., AQA, Edexcel, OCR, Eduqas).

1.1. GCSE

The study of physical landscapes is a prominent feature of all GCSE geography curricula, with 'River landscapes, landforms and processes' one of three focus areas. Within this focus area, students are required to consider river profiles, fluvial processes (e.g., erosion, transport, deposition), river flow across a channel, fluvial landforms and the physical and human factors related to flood risk.

River studies also touch on other focus areas within the curricula, including interactions with the biosphere and weather-related hazards (i.e., river flooding).

1.2. A Level

For most A Level specifications (i.e., OCR, Edexcel, Eduqas), rivers are primarily considered within the framework of the water and carbon cycles. In this context, river-based investigations should consider rivers through the lens of:

- outputs, inputs, stores, flows/transfers, positive/negative feedbacks, dynamic equilibrium;
- stores and how they change in time and space;
- processes;
- human impacts;
- how the water and carbon cycles support life.

Specific references to rivers are generally focused on characterising river regimes and variations in discharge, catchment hydrology and basin drainage systems, runoff, river transport and the impacts of human actions and changing land use on flood risk.

Only under the AQA exam board are rivers more explicitly included in the curriculum; their inclusion is within the context of flooding, contemporary urban environments, water movement through urban catchments, sustainable urban drainage systems (SUDS) and river restoration projects.

Integrating Professional River Study Techniques into School Fieldwork

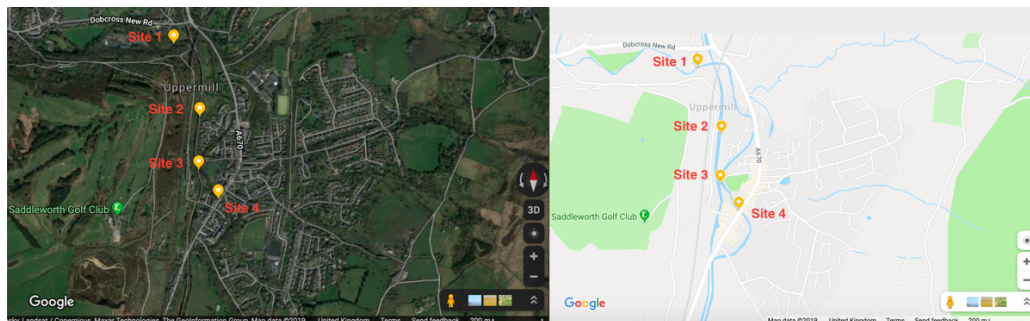
2. Case study practicalities (Tame Valley)

The example study sites are based around Uppermill, a village in the Saddleworth area of Oldham, Greater Manchester (see map below¹). The village is located within the Tame Valley of the South Pennines. It is easily accessed from major transportation (road & rail) routes.



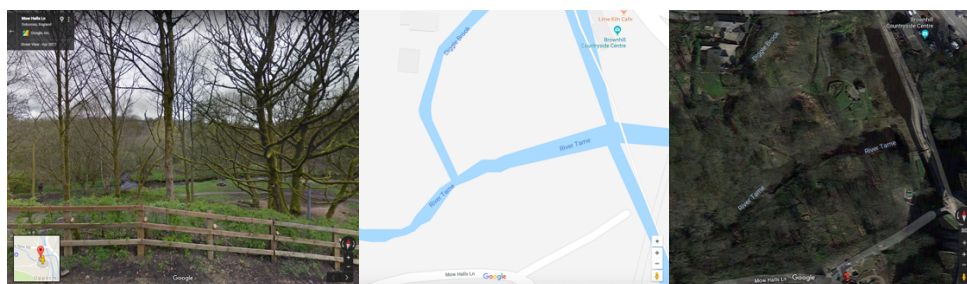
2.1. Example study sites

The study area comprises four separate field sites (see study area map below²):



Site 1: Confluence of the River Tame and Diggle Brook ($53^{\circ}33'11.4''\text{N}$ $2^{\circ}00'33.5''\text{W}$)

Spacious grassy area at the confluence of the River Tame and Diggle Brook (see images below³). A footpath off the Huddersfield Narrow Canal towpath gives direct access to a gentle gravel riverbank and to the flow channel of the River Tame.



¹ Google Maps image

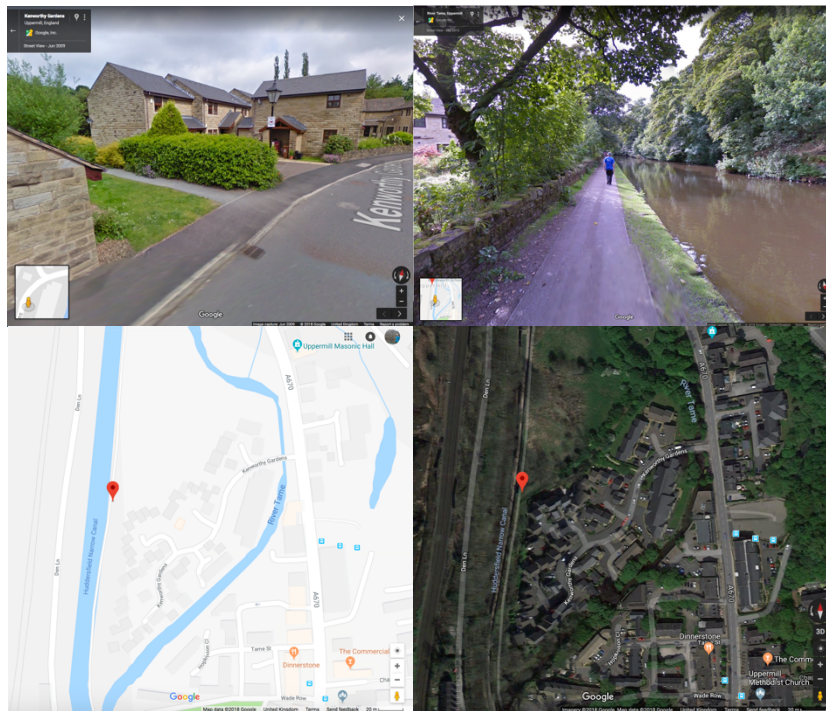
² Annotated Google Maps images

³ Google Maps street view image and maps

Integrating Professional River Study Techniques into School Fieldwork

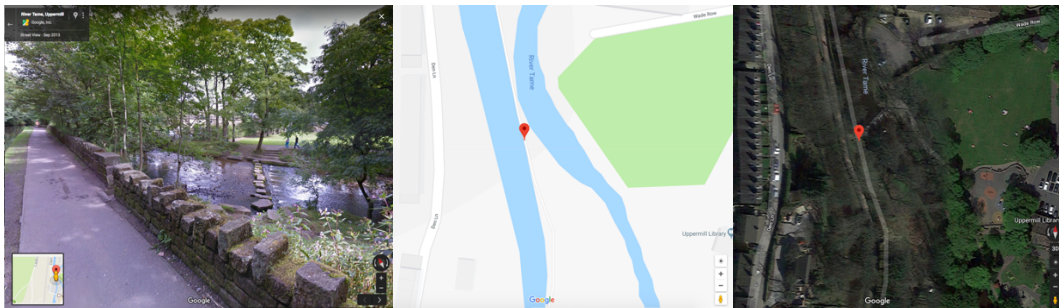
Site 2: Kenworthy Gardens (53°33'01.7"N 2°00'27.7"W)

Modern housing development sandwiched between the Huddersfield Narrow Canal and the River Tame (see images below⁴). The site is surrounded by a flood-protection moat. Direct site access from the canal towpath and from the main road system through the village.



Site 3: Tame stepping-stones (53°32'54.6"N 2°00'28.0"W)

Stepping-stones across the River Tame. The stepping-stones interrupt the natural flow of the river (see images below⁵). Access is from the adjacent Huddersfield Narrow Canal towpath or from a public park on the opposite side of the river. Under normal river conditions, the stepping-stones are safe to cross so long as care is taken; however, an assessment of current river conditions should always be made before visiting the site and when at the site location.



⁴ Google Maps street view images and maps

⁵ Google Maps street view image and maps

Integrating Professional River Study Techniques into School Fieldwork

Site 4: Fika Café (53°32'50.7"N 2°00'23.5"W)

Busy urban road bridge with views from the pavement down to the heavily engineered river course (see images below⁶). Closer access to the river is possible by going down the stairs on the opposite side of the bridge.



Using combinations of these four sites, two river study fieldwork projects have been developed. These projects are designed as standalone units; however, the data from both could be used together to form a larger study of the fluvial role in the study area. Repeat visits to the field area (or any field area) over a number of years and/or seasons would allow a school to develop a comprehensive record of change, which itself could become a valuable teaching tool.

2.2. Accessibility

All field sites are accessible on good quality footpaths (mixture of paved and unpaved walkways) within walking distance (0–15 minutes walking) of the village. Some footpaths are along canal towpaths and along the side of the river course.

River and canal crossings can be made by way of bridges; however, when conditions are deemed safe (i.e., at times of low or normal river flow), one section of the river can also be crossed using stepping-stones. Some of the sites require crossing busy urban roads; however, pedestrian crossings are in place at all crossing points.

⁶ Google Maps street view image and maps

Integrating Professional River Study Techniques into School Fieldwork

2.3. Proximity To key localities and facilities

	Locality/Facility	Distance (as per Google Maps)
Major settlements	Manchester	46 miles / 46 min drive
	Liverpool	55 miles / 1 hour 15 min drive
	Sheffield	35 miles / 1 hour 10 min drive
	Leeds	33 miles / 47 min drive
Major road routes	M62	< 10 miles / 20 min drive
	M1	< 30 miles / 50 min drive
	M60	< 15 miles / 26 min drive
Train station	Greenfield ⁷	1 mile / 5 min drive, 25 min walk
A&E Dept.	Royal Oldham Hospital	6.5 miles / 20 min drive
Food outlets	Selected shops & cafes	Uppermill Village
Picnic facilities	Brownhill Centre ⁸	Uppermill Village
Toilet facilities	Brownhill Centre	Uppermill Village
Field centres	Castleshaw Centre ⁹	3 miles / 10 min drive

2.4. Notable health & safety considerations

Wherever possible, students (particularly at A Level) should be involved in pre-fieldwork planning, including the development of risk assessments.

Guidance for fieldwork safety and planning, including the preparation of risk assessments, has been published by the Field Studies Council and can be found on the RGS-IBG website¹⁰. Here we detail only the main hazards specific to the Uppermill/River Tame case study field area.

Adequate clothing for outdoor fieldwork should be worn or carried, including: long sleeved tops, trousers, wet weather gear, sturdy close-toed shoes and/or wellington boots. Wellington boots are particularly important where students will be entering water bodies to collect samples and take measurements.

When working within rivers, always avoid loose clothing. Always try to walk downstream to avoid overexertion. Move using small steps and always find a steady foothold before moving your other foot. If you are bracing your body to stay upright, the river flow is too fast to be safe.

⁷ Trains to/from Manchester Victoria, Manchester Piccadilly, and Leeds

⁸ <http://www.visitoldham.com/attractions/brownhill-countryside-centre-p84811>

⁹ Provided by Oldham council. Support for residential school visits. https://www.oldham.gov.uk/info/200228/outdoor_education

¹⁰ <https://www.rgs.org/in-the-field/fieldwork-in-schools/fieldwork-safety-and-planning/risk-assessments/>

Integrating Professional River Study Techniques into School Fieldwork

Always consider the impacts of activities on the local environment. To mitigate negative impacts, please keep to established footpaths wherever possible.

Potential Hazard	Control Measures	Level of Residual Risk
Working near waterways and water bodies ¹¹	Water bodies will only be entered for specified sampling and measurement activities. On arrival at a site, assessment should be made of water flow (depth, speed, etc.) in rivers/canals. Only enter rivers where conditions are safe. Otherwise, cross rivers by way of bridges; where it is safe to do so, stepping-stones can be used. If not safe, alternative routes to be identified. All attendees will have fully charged mobile phones.	MEDIUM
Uneven/unstable ground & slippery surfaces	Potential for slips, trips and falls. Keep to flat and level areas where possible; stay a suitable distance from steep riverbanks. Remain aware of ground around you; move with care at all times.	LOW
Biological hazards	Potential for insect bites, particularly in areas close to standing water. Use insect repellent where required. Potential for hazardous plants; avoid overgrown areas; learn to identify potentially hazardous plants. Giant Hogweed is often found along riverbanks and footpaths—contact with sap can cause serious burns. If contact is made with Giant Hogweed, cover affected area and wash with soap and water. Contact a doctor if you feel unwell after contact with Giant Hogweed.	LOW

2.5. Other resources for river fieldwork planning

The RGS-IBG guide to A Level independent investigation¹² covers a range of topics, including guidance on data collection, analysis and presentation techniques; this information could also be used to guide GCSE level investigations. Specific ideas and guidance for river-based fieldwork¹³ and for classroom activities to address relevant theoretical concepts and data skills¹⁴ have been produced by the RGS-IBG and are available online. The Internet provides an excellent source of materials to help with fieldwork planning and execution.

¹¹ The RGS-IBG has produced a series of videos on safety when working around water. These can be accessed at <https://www.rgs.org/in-the-field/fieldwork-in-schools/fieldwork-safety-and-planning/safety-around-water/>

¹² <https://www.rgs.org/schools/teaching-resources/a-student-guide-to-the-a-level-independent-investi/>

¹³ [https://www.rgs.org/schools/teaching-resources/rivers-\(2\)/](https://www.rgs.org/schools/teaching-resources/rivers-(2)/)

¹⁴ <https://www.rgs.org/schools/teaching-resources/gcse-river-landscapes/>

Integrating Professional River Study Techniques into School Fieldwork

3. Fieldwork project 1: comparative study of river regimes

3.1. Introduction

Understanding the role of a river within the larger landscape is critical for many professional practitioners; for example, geotechnical engineers assess river regimes before embarking on engineering projects that may impact upon or alter the flow (e.g., river banks, roads, rail bridges, anti-flood defences); hazard managers assess river regimes for the purposes of flood hazard management; environmental consultants consider the potential for contamination from industrial sites within the catchment.

Given the nature of fluvial processes, upstream intervention can have significant impacts downstream; as such, river surveys require comparative data from sites along the watercourse. This activity asks students to characterise and compare multiple locations along a river in order to show the changing nature of river regimes as a function of position in the landscape.

3.1.1. Links to curricula

At GCSE, this activity directly contributes to the study of physical landscapes in the UK, a core module for all of the exam boards. In each case, river landscapes are given as one of the three study options. Students should consider fluvial landforms and processes, and the roles of geology, climate change, human impact and management in the catchment.

Through a combination of field data collection and both pre- and post-fieldwork classroom study, students can address each of the skills areas specified for GCSE geography by the Department of Education.

- Cartographic skills: use different types of maps (e.g., topographical, aerial, geological) at a range of scales (e.g., national, regional, local) to extract information about a study area (e.g., latitude, longitude, geological setting, topographical setting, local infrastructure, landforms); students should also be able to produce sketch maps and interpret cross-sections and transects.
- Graphical skills: students should be able to use and apply appropriate graphs and charts (e.g., line charts, bar charts, etc.); they should also be able to produce hand-drawn images to present and record information.
- Numerical skills: students should appreciate the concepts of number, area, scale and the relationships between units; they should collect fieldwork data and understand its limitations (e.g., accuracy, sample size, etc.).
- Statistical skills: select and use statistical techniques appropriate to the data type.
- Consider techniques that measure flow (e.g., discharge), scale (e.g., grain size), spatial patterns (e.g., sediment deposition across a river) and temporal change.
- Develop research and fieldwork planning skills, including the development of hypotheses, the planning of appropriate fieldwork procedures and consideration of health & safety.
- Present findings with a text report that should be descriptive, analytical and critical.

At A Level, this activity falls within the study of the water and carbon cycles. Students should consider how rivers relate to water and carbon outputs, inputs, stores, flows and transfers in both time and space.

Integrating Professional River Study Techniques into School Fieldwork

Through fieldwork and both pre- and post-fieldwork classroom study, students can develop many of the skills required by the Department of Education for A Level geography students.

- Understand, collect and use different types of geographical information (e.g., qualitative vs. quantitative, primary vs. secondary).
- Collect and analyse information, and critically assess data sources, methodologies and data outputs/reporting, including the ability to identify data misuse and sources of error.
- The use of quantitative data, for which students should be able to collect, analyse and present geo-referenced data, apply appropriate statistical/data plotting techniques and perform simple calculations (e.g., discharges rates, wetted perimeter).

3.1.2. 'Real-world' examples

Although professional river surveys may use more stringent methodological protocols and expensive, high-tech equipment, the basic river analysis approaches available to GCSE and A Level students are directly comparable to those used by 'real-world' practitioners. Example of 'real-world' river studies include:

- a 1998 United States Geological Survey (USGS) investigation of discharge at government streamflow gauging stations in Massachusetts¹⁵. Basic data (e.g., channel width, channel depth, flow velocity) were taken using 25 to 30 measurements along a cross section of each field site. From these data, discharge and wetted perimeter were calculated;
- a USGS investigation into suspended sediment concentrations, turbidity and particle size fractions in Minnesota rivers from 2007 to 2011¹⁶. Suspended sediments were investigated by filtering water samples and then drying and weighing the material. Turbidity was determined using handheld field turbidimeters.

With the advent of new technologies, the professional study of river regimes is increasingly employing remote analysis techniques, including aerial and satellite remote sensing data, which allow for rapid analysis over large areas. For example:

- in 2016¹⁷, NASA and the USGS used visible light and near-infrared radiation data from a Portable Remote Imaging Spectrometer (PRISM) aboard a Twin Otter Aircraft to investigate water quality in the San Francisco Bay-Delta Estuary, a major source of freshwater for California. Comparison with data from water samples showed that this remote sensing technique could accurately characterise water quality, including turbidity ('cloudiness'), phytoplankton volume, dissolved organic carbon content and suspended sediment volume.

Students should be encouraged to think about possible sources of publicly available remote sensing or modelling data for their field site (e.g., Google Earth, Google Maps, Met Office satellite imagery, earth¹⁸)

¹⁵ <https://pubs.usgs.gov/wri/1998/4094/report.pdf>

¹⁶ <https://pubs.usgs.gov/sir/2013/5205/pdf/sir2013-5205.pdf>

¹⁷ <https://www.nasa.gov/feature/jpl/nasa-demonstrates-airborne-water-quality-sensor>

¹⁸ Interactive global current wind, weather, ocean, and pollution conditions as forecast by supercomputers and updated every 3 hours: <https://earth.nullschool.net/>

Integrating Professional River Study Techniques into School Fieldwork

3.2. Site selection

This activity requires access to a natural watercourse (i.e., a river). While the techniques used and skills developed can be applied at a single site, the activity best meets curricula requirements if students are able to access at least two or three contrasting locations along the same water course, for example:

- river flowing across an area of floodplain;
- river flow through an area of changing topography (e.g., steep river valley, areas where the river loses elevation over a short distance);
- river meander site;
- river flow through an urban area;
- river flow interrupted by a dam or weir;
- confluence of two watercourses;
- locations where river flow is interrupted by other human intervention (e.g., bridge supports, flood defences, stepping-stones, etc.);
- man-made water course (i.e., a canal).

In the example field area (Tame Valley), this activity could be completed with visits to sites 1, 3 and 4:

- Site 1 (Confluence of River Tame and Diggle Brook) represents a free flowing river, uninhibited by human construction or intervention, at a confluence point with another water source;
- Site 3 (River Tame stepping-stones) represents river flow interrupted by small-scale human engineering (the stepping-stones);
- Site 4 (Fika Cafe) represents river flow through an urban area—the river is forced to flow through a channel confined by large-scale man-made structures (bridge, buildings).

A possible extension to this case study could be the addition of a site along the Huddersfield Narrow Canal (see image below¹⁹). This would allow students to compare and contrast flow regimes in natural and man-made environments.



¹⁹ Image by David Dixon (<http://www.geograph.org.uk/photo/2462856>). Image licence: CC-BY-SA 2.0

Integrating Professional River Study Techniques into School Fieldwork

3.3. Pre-fieldwork activities

3.3.1. Questions & hypotheses

Identification of scientific questions & hypotheses: students should develop a series of scientific questions and associated hypotheses to test through fieldwork; for example, these could relate to:

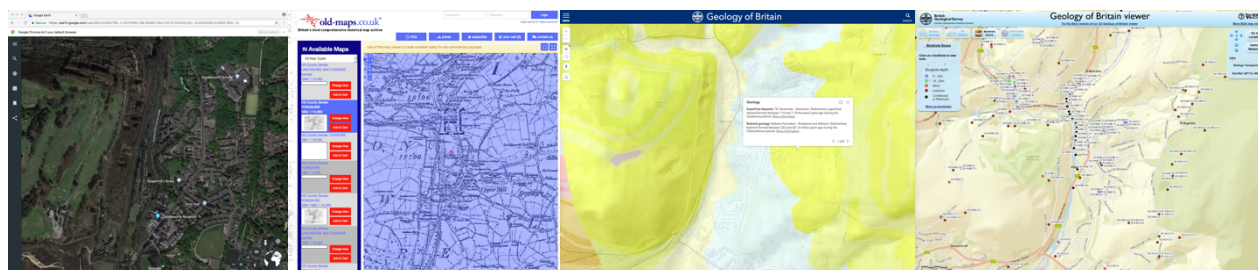
- changes in river morphology associated with locations along a river course;
- changes in river flow rate and bed-load/sediment carrying capacity along a river course;
- impacts of human engineering and infrastructure on fluvial behaviour.

3.3.2. Metadata collection

Field area cartography: before embarking on fieldwork, students should be asked to source relevant maps of the study area, identify each proposed study site on the map and then use the map to extract information on the study site setting. Depending on map type, students should identify the course of the river and its position within the wider fluvial system and landscape (including local and regional topography, identification of catchment area boundaries), identify the geological setting and consider what impacts this might have on the fluvial and hydrological systems, identify proximal natural features/processes formed by or exerting an influence on the fluvial system, identify different types of land use and human infrastructure, and where data are available, how land use has changed over time. Map types may include:

- location on global and UK scale maps;
- current and past Ordnance Survey maps of the study area;
- geological map of the study area²⁰;
- current and past aerial and satellite images of the study area.

In the images below, Site 3 of the example field study area is shown in screenshots from free online resources, including: Google Earth²¹, an 1854 map²², a geological map and a map of boreholes (the data for some of which are publicly available) from the British Geological Survey²³.



²⁰ e.g., using the British Geological Survey (BGS) iGeology App for smart phones. This app provides geological maps and borehole data for the United Kingdom. <http://www.bgs.ac.uk/igeology/>. In addition, the BGS GeoIndex provides multi-layer maps of geological and other relevant information, available online (<http://www.bgs.ac.uk/geoindex/>) or as a download to use with GIS applications

²¹ <https://earth.google.com/web>

²² <https://www.old-maps.co.uk/#/Map/399649/405953/10/101748>

²³ <http://mapapps.bgs.ac.uk/geologyofbritain3d/index.html>

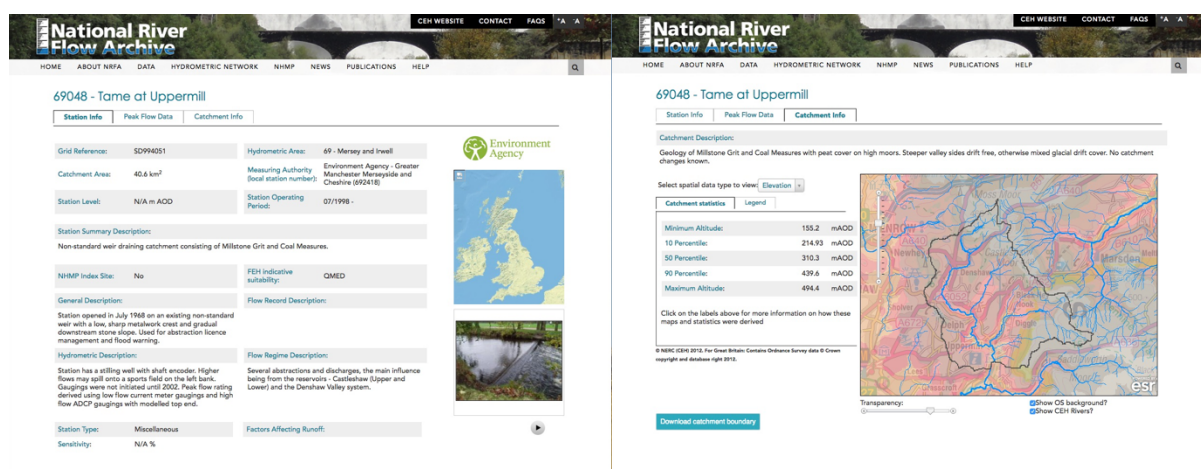
Integrating Professional River Study Techniques into School Fieldwork

**Royal
Geographical
Society**
with IBG

Advancing geography
and geographical learning

Other secondary data sources: students should be encouraged to identify and source other secondary data that provide insights into the field site (e.g., Environment Agency records²⁴, hydrological data²⁵ and flood risk maps²⁶).

The example images below show screenshots of National River Flow Archive webpages for the 'Tame at Uppermill' river gauging station²⁷, located within the example study area. The webpage gives background information on the catchment, including maps of topography, land use, geology and rainfall. It also provides an archive of river flow data.



On completion of fieldwork planning and metadata collection, students should review the study aims and objectives, including scientific questions and hypotheses, and: (i) confirm that the proposed approach will address the scientific questions and (ii) ensure that the hypotheses remain relevant in light of new information from metadata collection.

3.3.3. Plan of work

Site selection: students (particularly at A Level) should be intimately involved in the planning of fieldwork. Where possible, this could include site selection from relevant maps or from pre-fieldwork scouting trips to the proposed field area. Where sites have already been selected (e.g., for the River Tame), students should be asked to consider why those sites have been selected (e.g., accessibility, notable natural or human features of interest).

Students should consider what fluvial processes and landforms could be measured at each site and the most appropriate techniques for measuring those processes should be selected (e.g., by reference to this document or through reference to other fieldwork guides or past fieldwork experience). When selecting and planning fieldwork techniques, students should consider the role of sampling on the quality and relevance of their data²⁸.

²⁴ <https://www.gov.uk/government/organisations/environment-agency>

²⁵ <http://nrfa.ceh.ac.uk/>

²⁶ <https://flood-map-for-planning.service.gov.uk/>

²⁷ <http://nrfa.ceh.ac.uk/data/station/info/69048>

²⁸ <https://www.rgs.org/schools/teaching-resources/sampling-techniques/>

Integrating Professional River Study Techniques into School Fieldwork

3.3.4. *Logistical planning*

Students should be encouraged to develop a realistic plan for fieldwork, including a proposed timetable of site visits that takes into account the number and locations of field sites, the number of people within a group, the time required for data collection at each site and the time available for fieldwork.

Prior to fieldwork, students should be required to procure or construct appropriate equipment to complete the proposed data collection activities.

Students should be asked to consider the health & safety implications of chosen field sites and data collection techniques. Students should be encouraged to create, or contribute to, a risk assessment. Guidelines on fieldwork safety and planning, including guidance on the preparation of risk assessments, have been published by the Field Studies Council and can be found on the RGS-IBG website²⁹.

²⁹ <https://www.rgs.org/in-the-field/fieldwork-in-schools/fieldwork-safety-and-planning/risk-assessments/>

Integrating Professional River Study Techniques into School Fieldwork

3.4. Measurable processes and field data collection techniques

The following pages contain a comprehensive list of fieldwork techniques that are relevant to river flow regime studies. It is unlikely that any given fieldtrip will be able to incorporate all of these techniques, unless the fieldtrip is a multi-day residential or if a divide-and-conquer approach is taken with different groups of students focused on different techniques. In general, students should be encouraged to think carefully about which techniques will best address their scientific questions AND meet the time and budgetary constraints of the fieldwork.

Each of the measurement techniques could be employed during a single site visit. This would provide a snapshot of the river flow regime at a given location for a given time. However, repeat measurements at different times (e.g., before and after rainfall, winter vs. summer) could provide a richer and longer-term dataset for student analysis.

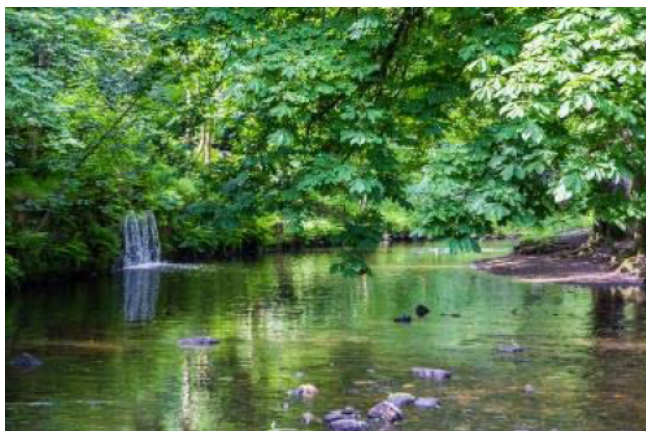
Integrating Professional River Study Techniques into School Fieldwork

3.4.1. Field notebook

On arrival at each field site, students should record observational data on the field site setting in their field notebook. In some professional settings, a field notebook (hand-written or digital) is a legal document that could be used in legal proceedings³⁰. For other professionals, the information recorded in a field notebook could be critical for later stages of data processing. Learning good field notebook skills is a critical part of geography fieldwork training. In this activity, the following should be recorded for each field site:

- date, time, weather conditions and mood of the investigator (these can impact on the quality of data collection);
- name of the field site and location (i.e., GPS waypoint and/or latitude and longitude from a smart phone, handheld GPS or paper map);
- brief description of the site, including surrounding land use and infrastructure, landforms and site condition (vegetation, human impacts). For rivers, observations should include erosional and deposition features, current flow conditions, types of riverbanks, channelisation, etc.;
- site sketch with critical features clearly labelled;
- where data are available, a note of rainfall in the study area in the 1, 12 and 24 hour periods prior to data collection should be made. If no official data are available, general observations of recent weather should be noted;
- data on selected measurements.

Examples of field notebook, sketching and photography good practice have been developed by the University of Liverpool³¹ and the RGS-IBG³². A good site sketch gives a sense of scale and the spatial distribution of features. The images below show an example field sketch and accompanying photograph³³; it can be seen that field sketches do not need to be artistic, they merely need to convey the main features of a site.



³⁰ <https://www.abcls.ca/wp-content/uploads/pdfs/Field-notes-Link-article-Oct-9-2015-Final.pdf>

³¹ <http://www.esta-uk.net/fieldworkskills/tips.htm>

³² <https://www.rgs.org/schools/teaching-resources/sketching-and-photography/>

³³ Images courtesy of ERM

Integrating Professional River Study Techniques into School Fieldwork

3.4.2. River morphology & flow regime

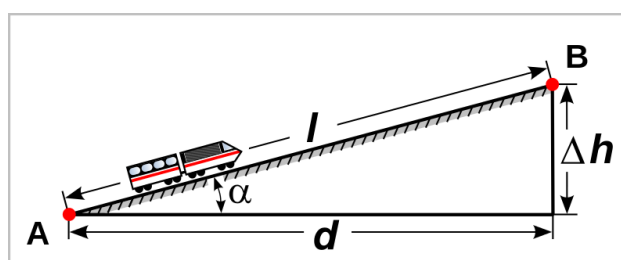
3.4.2.1. River gradient

What is measured?

River gradient is the slope down which a river is flowing. River gradient is a controlling factor in river morphology and flow regime (i.e., steep gradients result in rapid, high energy, turbulent flow; shallow gradients result in gentle, low energy flow).

River gradient is equal to the difference in height between two sites divided by the distance between those sites. See below a diagram of 'gradient'³⁴, where:

$$\text{gradient} = \Delta h / d$$



Gradient is measured by placing two measuring poles at sites a known distance apart, one upstream and one downstream, with the direct line-of-sight between them perpendicular to the flow of water. The angle between matching height horizons on each measuring pole is measured using a clinometer. For best results, students should stand within the riverbed (see images below³⁵).



Detailed guidance on how to measure gradient is available online³⁶.

³⁴ Madcap, from Wikimedia Commons (https://commons.wikimedia.org/wiki/File:Grade_dimension.svg). Image licence: Image in the public domain

³⁵ Measuring gradient Image by Olchfa-Geography (<https://www.flickr.com/photos/olchfageography/828057367/>). Image licence: CC-BY-NC 2.0

³⁶ <http://www.geography-site.co.uk/pages/skills/fieldwork/fluvial/grad.html>

Integrating Professional River Study Techniques into School Fieldwork

Site requirements

Ideally, river gradient is measured along a river channel; however, depending on flow conditions and safe river access points, less accurate measurements could be made along the riverbank.

Equipment and associated costs

Low cost gradient measurements require two surveying poles (metre rulers usually work) and a clinometer (see image below left³⁷). Clinometers can be purchased cheaply, constructed from basic stationery³⁸ or are available at lost cost for use on smartphones³⁹ (see image below right⁴⁰).



Number of data points needed (data resolution)

To ensure good data quality, and where river flow conditions allow it, multiple gradient measurements should be taken at different points across the river width. A good aim would be to collect three to five measurements across the river. An average measurement can then be reported (e.g., mean or median) along with an indicator of data spread (e.g., standard deviation).

Professional measurement techniques

Professional surveying techniques often rely on simple surveying poles and professional clinometers; however, some surveyors use theodolites (see image below⁴¹) and laser equipment to measure distances and gradients. Over wider scales, gradient can also be extracted from LiDAR data, topographical maps, satellite data and digital elevation models (DEMs).



³⁷ Image modified from: Silva Expedition 4 compass-clinometer (https://en.wikipedia.org/wiki/Silva_compass#/media/File:Silva_compass_Expedition_4.jpg). Image licence: CC-BY-SA 3.0

³⁸ <https://www.rgs.org/schools/teaching-resources/make-your-own-clinometer/> and <http://www.geography-site.co.uk/pages/skills/fieldwork/fluvial/grad.html>

³⁹ e.g., <https://itunes.apple.com/gb/app/seelevel-visual-clinometer/id333213338?mt=8>

⁴⁰ Image by Rufiyaa (https://commons.wikimedia.org/wiki/File:Clinometer_on_smartphone.jpg). Image licence: CC-BY-SA 4.0

⁴¹ Image modified from: Kenneth Allen (<http://www.geograph.ie/photo/4190504>). Image licence: CC-BY-SA 2.0

Integrating Professional River Study Techniques into School Fieldwork

3.4.2.2. River width

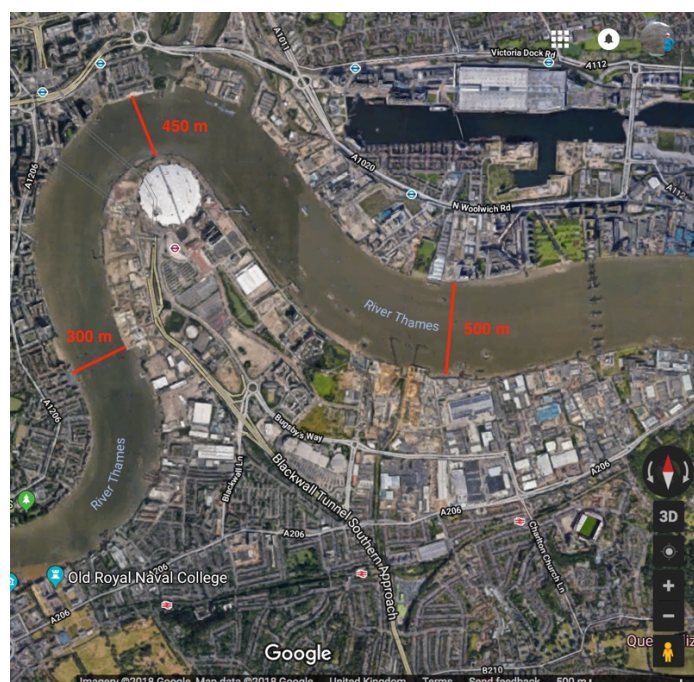
What is measured?

River width is the distance from one side of the river to another. For some studies, this will represent the distance of the river in its current state (e.g., the width of flowing water); however, it is also useful to measure the full width of the river from one bank to another, even if water is not currently flowing over all areas.

Low-cost river width measurements can be made directly using a tape measure, or for wider rivers, using string that is then measured using a tape measure. For the most accurate measurements of current flow, the tape measure or string should be held at ~ 20 cm above the water surface. For measurements of the full river width (including areas of non-current flow), measure from the top of the riverbank (defined as the point at which the river would flood surrounding land if the water level rose above it).

Where a river has multiple channels, the number of discrete channels should be noted and the individual widths of those channels should also be recorded (in addition to the full width measurement).

Where rivers are too wide or cannot be entered or crossed with ease, river width can be measured from satellite imagery (e.g., see below for image of the River Thames in London with annotated measurements⁴²); however, it should always be noted that river widths change with time on a variety of timescales (i.e., daily, seasonally, annually, decadal and longer).



⁴² Annotated Google Maps image

Integrating Professional River Study Techniques into School Fieldwork

Site requirements

River width can be measured at any point where a river can be safely accessed and forded. Rivers large enough to appear in open access satellite imagery (e.g., Google Maps) can be measured from the classroom.

Equipment and associated costs

Low-cost width measurements require string and/or a tape measure. Internet access will be needed for Google Earth (or other satellite based imagery) measurements.

Number of data points needed (data resolution)

Data collection for river width should aim for at least 5–10 measurements. Depending on river access, these measurements would ideally be taken at regular intervals along the riverbank (e.g., every 0.5 or 1 m). From these, an average width (e.g., mean width) can be calculated along with an indicator of data spread (e.g., standard deviation).

Professional measurement techniques

In the field, river widths are often measured using the technique described above; however, they may also be measured using laser range finders or by collecting GPS points on either side of the river. It is also possible to measure river widths using remote sensing images (e.g., Landsat, Google Earth); remote sensing images are particularly useful for looking at temporal changes in river dimensions without incurring the expense of repeat field-based studies. Students could be encouraged to try these methods and compare the results to their directly measured widths.

Integrating Professional River Study Techniques into School Fieldwork

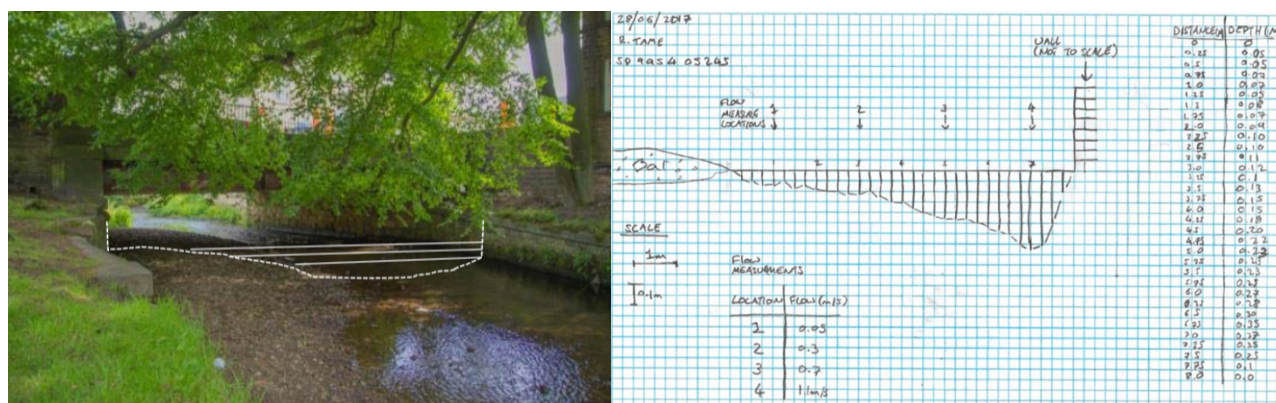
3.4.2.3. River depth

What is measured?

River depth is the vertical distance between the riverbed and the surface of the water. River depth in shallow rivers can be measured using a metre ruler or surveying pole. Data accuracy can be impacted by soft riverbeds (i.e., because the ruler sinks into the bed); always ensure that the ruler is just touching, but not penetrating, the riverbed.

Where a river has multiple channels, it is important to note the positions of gravel bars (i.e., the points at which river depth is 0 m). Note where a depth measurement is taken over a large feature (e.g., a boulder on the riverbed). This data point may need to be discarded.

The images below show a photograph and example field notes for river depth (and flow velocity) measurements at Site 4 (below bridge alongside Fika Cafe) in the case study field area⁴³.



Site requirements

River depth can be measured at any point where a river can be safely accessed and forded.

Equipment and associated costs

Low-cost depth measurements require only a metre ruler or surveying pole.

Number of data points needed (data resolution)

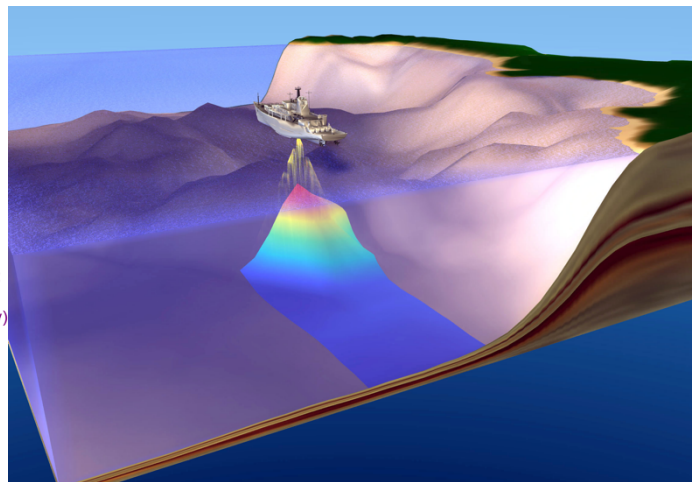
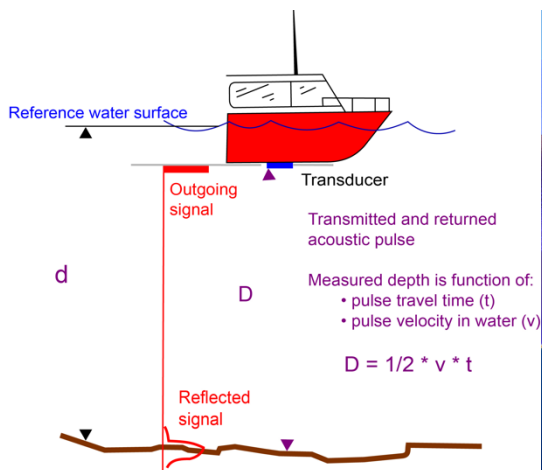
River depth varies across a river; therefore, depth should be measured at regular intervals along a transect perpendicular to flow. The number of data point will depend on the total width of the river; however, a good place to start is taking measurements at 30–50 cm intervals. At each interval, students should consider taking three to five measurements; the average value (e.g., the mean) and an indicator of data spread (e.g., standard deviation) can be calculated. This approach will minimise the impact of changing water level simply due to turbulent river flow.

⁴³ Images courtesy of ERM

Integrating Professional River Study Techniques into School Fieldwork

Professional measurement techniques

Shallow river depths are often measured in the field using the same techniques as outlined above. Deeper and/or very wide rivers are measured using sonar sounding from boats (see images below⁴⁴).



⁴⁴ (left) By Brandon T. Fields (cdated) via the US Army Corps of Engineers - EM 1110-2-1003, Manual of Hydrographic Surveying, based upon Principle_of_SBES.jpg by en:User:Mredmayne. This W3C-unspecified vector image was created with Inkscape (<https://commons.wikimedia.org/w/index.php?curid=23357601>). Image licence: Image in the Public Domain / (right) By http://www.navy.mil/view_image.asp?id=2767. Transferred from en.wikipedia to Commons by Common Good using CommonsHelper (<https://commons.wikimedia.org/w/index.php?curid=4754875>). Image licence: Image in the Public Domain

Integrating Professional River Study Techniques into School Fieldwork

3.4.2.4. Flow velocity

What is measured?

Surface flow velocity is the speed at which river water is moving. The simplest, low-cost, measure of flow velocity can be taken by dropping a floating object (e.g., an orange) into the river at a given point (see image below⁴⁵) and then timing how long that object takes to pass a point a given distance downstream (e.g., 5 or 10 m). The velocity is equal to the distance divided by the time.



It may also be useful to measure velocity at different points across the river. Flow velocity may be faster or slower, depending on channel depth, inner or outer bend of a channel, vegetation growth and/or other obstacles.

When coupled with measurements of river dimensions, river flow can be used to estimate discharge (see section 3.6 *Post-fieldwork Activities*). This information can inform on the availability of water resources (e.g., when budgeting for water extraction to feed small- or large-scale agricultural, industrial or residential uses). It can also be useful when considering potential flood frequency.

Site requirements

Velocity measurements can be taken at any point where two individuals can stand in a river at least 3–5 m apart. Where a river cannot be directly accessed, less accurate measurements could be taken from a bridge (by dropping the object from one side and timing how long it takes to come out the other side).

Equipment and associated costs

Low-cost velocity measurements require a tape measure, a stopwatch and a floating object (this object should be biodegradable in case retrieval is not possible). The floating object must have sufficient weight to not be impacted by waves or wind. It must also be easily visible.

⁴⁵ Image by Gary Peeples, U.S. Fish and Wildlife Service Southeast Region. Image licence: CC BY 2.0 (<https://creativecommons.org/licenses/by/2.0>), via Wikimedia Commons

Integrating Professional River Study Techniques into School Fieldwork

Number of data points needed (data resolution)

At least 5–10 repeat measurements should be taken, allowing an average value (e.g., the mean) along with an indicator of data spread (e.g., standard deviation) to be calculated. Data errors may be introduced if the object is thrown into the water or dropped from height.

Professional measurement techniques

In professional settings, stream flow is commonly measured using permanent flow meter stations (see image below left⁴⁶) or handheld flow meters (see image below right⁴⁷). Handheld meters are placed below the surface (surface waters can be impacted by other factors; for example, wind) and held for a given period of time. Flow meters contain a rotating mechanism and calculate flow velocity by measuring the number of rotations with time as water flows through.



The USGS provides an online teaching resource focused around the measurement of stream flow for US government applications⁴⁸.

⁴⁶ © Copyright Peter Facey (<http://www.geograph.org.uk/photo/804111>). Image licence: CC-BY-SA 2.0

⁴⁷ By Wtshymanski. Image licence: CC-BY-SA 3.0 or GFDL (<http://www.gnu.org/copyleft/fdl.html>), from Wikimedia Commons

⁴⁸ <https://water.usgs.gov/edu/measureflow.html>

Integrating Professional River Study Techniques into School Fieldwork

3.4.2.5. Cross-sectional area, hydraulic radius, wetted perimeter and discharge

Cross-sectional area, hydraulic radius, wetted perimeter and discharge can all be calculated back in the classroom using the data collected above (see post-fieldwork activities below).

Of these, only wetted perimeter⁴⁹ can be directly measured in situ; however, the measurement technique is challenging and requires cumbersome equipment (a heavy chain). Even in professional settings, it is usually calculated from other measurements.

⁴⁹ The wetted perimeter is a measure of the part of the channel that is in contact with the water. It can be measured by laying a heavy chain across the river, perpendicular to flow, allowing the chain to conform to the riverbed—the total length of the wet chain is then measured. However, direct measurements of wetted perimeter can be challenging owing to equipment needs, and problems associated with fast flowing water

Integrating Professional River Study Techniques into School Fieldwork

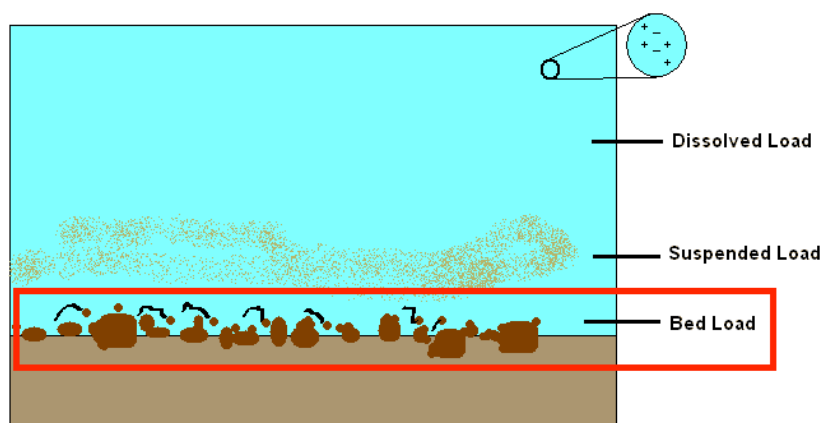
3.4.3. Water transport of solids

A critical aspect of a river's regime is its ability to transport materials downstream. The transportation capacity of a river varies along its course and is a function of the size and nature of the materials being transported. Characterising bed-load materials allows estimates of the energy within the system (i.e., larger pebbles = faster flow velocity = greater energy budget); in particular, bed-load deposits can help to identify flood history along a river. This information is critical for local and national governments when performing flood risk assessments and planning for flood management; it is also important for engineers planning infrastructure works near the river.

3.4.3.1. Bed-load

What is measured?

The bed-load is made of materials (gravel, pebbles, boulders, etc.) that are moved along a riverbed by the force of flowing water (see images below⁵⁰). Bed-load material moves by bouncing and rolling over the riverbed.



The bed-load of a river changes as the flow regime and energy of the water change; this can be along the course of the river (from source to mouth) or across the width of a river at a given point (i.e., the outside of a meander is an erosional environment, the inside corner is a depositional environment). The bed-load can be impacted by human infrastructure, or by any feature that alters the flow of the water.

The analysis of bed-load materials gives insights into past and present river flow conditions. It is also possible to identify the materials making up the bed-load (e.g., parent-rock type) and identify the sources of sediment.

At each study site, bed-load samples should be taken at regular intervals across the river, perpendicular to flow. To collect a sample, point your finger and lower it into the water; pick up the

⁵⁰ (left) Image modified from: PSUEnviroDan. Image licence: Image in the Public Domain, via Wikimedia Commons / (right) Image modified from: © Copyright Eric Jones (<http://www.geograph.ie/photo/3887982>). Image licence: CC-BY-SA 2.0

Integrating Professional River Study Techniques into School Fieldwork

first pebble that it touches. Use callipers (see images below⁵¹) or a ruler to measure and record the longest and shortest axis (or for a more detailed investigation, measure the a, b and c axes⁵²). If investigating the origin of bed-load material, you may also consider describing the pebble, taking a photograph or even collecting it for further analysis back in the classroom.



The size of sandy bed-load can be qualitatively assessed by comparison to a geological grain size chart or by using a series of sieves.

The presence of mid-stream gravel bars (i.e., gravel bars that results in channelised flow; see below for example image from Denali National Park, Alaska⁵³) should be recorded. The length and width dimensions of those gravel bars should be measured. Samples of gravel bar materials should be systematically selected (following the same basic procedure as used for bed-load sampling) and measured (as above).



Further data analysis, including calculation of pebble roundness and estimates of water velocity based on particle size should be completed back in the classroom (see post-fieldwork activities).

⁵¹ (left) Using callipers to measure the a, b and c axes of a pebble by the Field Studies Council (<https://www.geography-fieldwork.org/a-level/coasts/coastal-management/method/>). Image licence: CC_BY / (right) Image modified from: James St. John (<https://www.flickr.com/photos/jsgeology/39200485210>). Image licence: CC-BY 2.0

⁵² <https://www.geography-fieldwork.org/a-level/coasts/coastal-management/method/>

⁵³ Image by Nic McPhee (<https://www.flickr.com/photos/nicmcphee/214496166>). Image licence: CC-BY-SA 2.0

Integrating Professional River Study Techniques into School Fieldwork

Site requirements

Bed-load and gravel bar samples can be collected and measured at any point where a river can be safely accessed and forded.

Equipment and associated costs

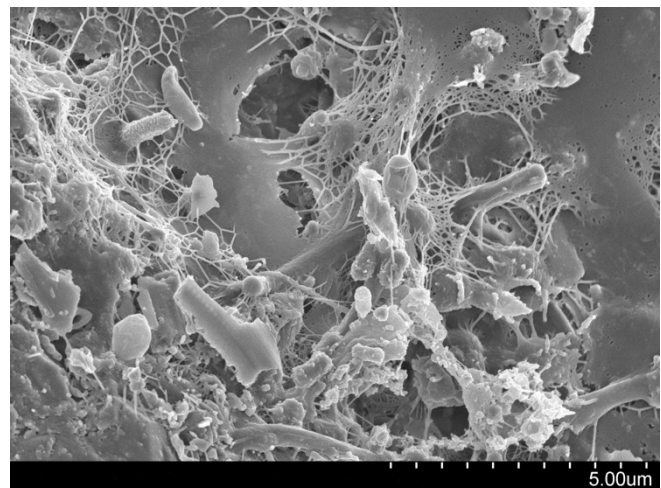
Ideally, pebble dimensions should be measured using callipers, which can be purchased cheaply or at moderate cost; however, a normal ruler can also be used for less accurate data collection.

Number of data points needed (data resolution)

At each sample point across the cross-river transect, at least 10 pebbles should be measured. The interval between sample points should depend on the river width; however, a 0.5–1 m interval would be a good place to start.

Professional measurement techniques

The professional analysis of bed-load materials includes both the simple collection and measurement techniques shown above, but also more intensive examination of pebble composition and morphology using expensive, high-tech laboratory equipment; for example, scanning electron microscopes (SEMs; see image below of an SEM⁵⁴ [left] and of a sand grain imaged by SEM⁵⁵ [right]).



⁵⁴ Image by ZEISS Microscopy (<https://www.flickr.com/photos/zeissmicro/10710025785>). Image licence: CC-BY-SA 2.0

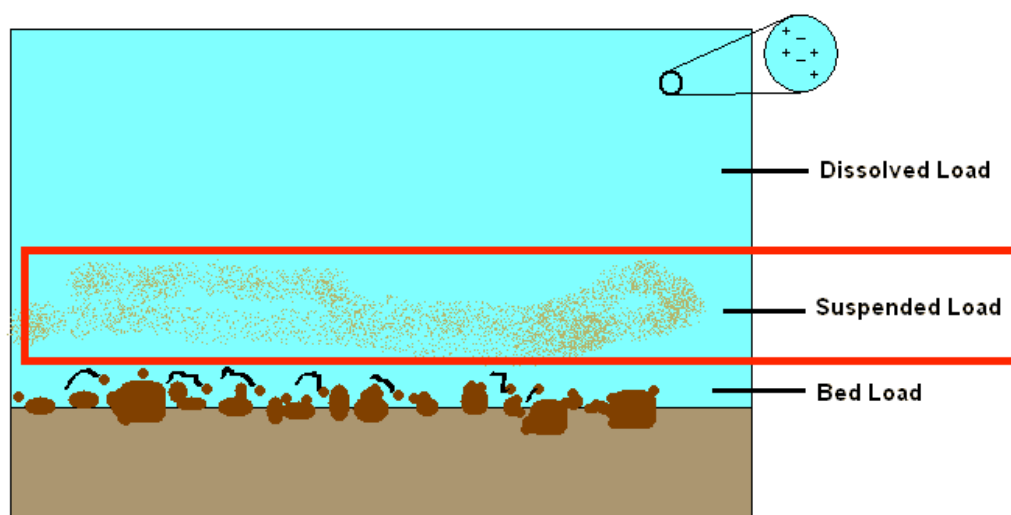
⁵⁵ Image courtesy of the Lewis Lab at Northeastern University (<https://www.flickr.com/photos/adonofrio/albums/72157623620596451>). Image created by Anthony D'Onofrio, William H. Fowle, Eric J. Stewart and Kim Lewis. Image licence: CC-BY 2.0

Integrating Professional River Study Techniques into School Fieldwork

3.4.3.2. Suspended sediments

What is measured?

Suspended sediments are those materials that are suspended within the channel of the flowing water (see image below⁵⁶). The particles are too small to be sampled and measured by hand (unlike bed-load material). The suspended sediment load can be qualitatively and semi-quantitatively described *in situ* or measured quantitatively through sample collection and analysis in the classroom.



For *in situ* analysis, two methods can be used.

- Point the opening of a 2-L bottle upstream and allow it to fill with river water. Set the bottle to stand for a few minutes to allow suspended sediments to settle. Make notes on the sediment layer that forms (e.g., thickness, colour, clarity of water above; see image below⁵⁷).



⁵⁶ (By PSUEnviroDan. Image licence: Image in the Public Domain, from Wikimedia Commons)

⁵⁷ Image courtesy of ERM

Integrating Professional River Study Techniques into School Fieldwork

- Suspended sediment loads between sites can be directly compared using a Secchi disc, a black and white plastic disc attached to a long wire that is lowered into a water body⁵⁸ (see image below⁵⁹). When the black and white disc is no longer visible, stop lowering the disc and pinch the wire at the point where it intersects the water surface. Remove the disc and measure the distance between the pinch point and the disc.



For rapid flowing water, you might want to consider creating a disc with a more robust lowering mechanism (e.g., a rigid plastic rod instead of a thin wire). Secchi disc measurements are semi-quantitative; they vary according to the person taking the measurement, the light levels, current weather conditions, etc. However, for a first order analysis of the data, results can be compared to those of the Secchi-Dip-In project, which has been collecting Secchi disc data from volunteers since 1994⁶⁰.

For more quantitative suspended sediment analysis, water samples should be collected and transported back to the classroom. The water samples should be filtered using filter paper, then the residue on the paper allowed to dry. The dried sediment can then be weighed and recorded.

Site requirements

Water samples can be collected and measured at any point where a river can be safely accessed and forded. Where it is not safe to access the water, samples could be taken from the riverbank, although the suspended sediment load along the banks is likely to differ from that in faster flowing water at the centre of the channel.

Equipment and associated costs

The lowest cost approach is the collection of water in a 2-L bottle (requiring only the 2-L bottle). Secchi discs can be purchased at low cost; however, they can also be homemade using low cost classroom materials⁶¹. A ruler or tape measure will be needed for Secchi disc measurements.

⁵⁸ https://serc.carleton.edu/microbelife/research_methods/enviro_n_sampling/turbidity.html

⁵⁹ Image by J. Albert Bowden II (<https://www.flickr.com/photos/jalbertbowdenii/14878253738>). Image licence: CC-BY 2.0

⁶⁰ <http://www.secchidipin.org/>

⁶¹ <https://www.rgs.org/schools/teaching-resources/suspended-sediment/>

Integrating Professional River Study Techniques into School Fieldwork

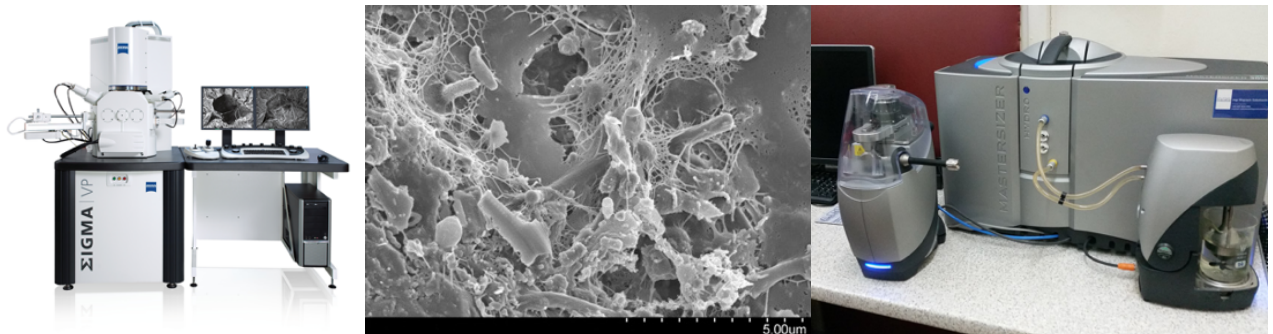
For sample collection and analysis in the classroom, costs will include sample bottles (although these could be cleaned-out plastic water bottles, purchased at low cost), filter paper and weighing scales.

Number of data points needed (data resolution)

At least three to five samples per field site should be collected and analysed. Ideally, these samples should be collected at different points across the river, perpendicular to flow.

Professional measurement techniques

Professional analyses of suspended sediments also make use of the Secchi disc approach; however, the most robust measurements require the collection of water samples for laboratory analysis. As above, samples in the laboratory are filtered, dried (usually using a drying oven) and then weighed on high precision scales. The sediments may then undergo further analysis to investigate their composition and grain morphologies using expensive, high-tech laboratory equipment; for example, scanning electron microscopes (SEMs; see image below left⁶² and centre⁶³) and laser granulometers (see image below right⁶⁴).



The British Society for Geomorphology has published an online guide for the professional sampling of suspended sediments⁶⁵.

⁶² Image by ZEISS Microscopy (<https://www.flickr.com/photos/zeissmicro/10710025785>). Image licence: CC-BY-SA 2.0

⁶³ SEM sand grain image courtesy of the Lewis Lab at Northeastern University (<https://www.flickr.com/photos/adonofrio/albums/72157623620596451>). Image created by Anthony D'Onofrio, William H. Fowle, Eric J. Stewart and Kim Lewis. Image licence: CC-BY 2.0

⁶⁴ Modified image of a Mastersizer 3000 laser granulometer. By Plogeo. Image licence: CC BY-SA 4.0, from Wikimedia Commons

⁶⁵ http://geomorphology.org.uk/sites/default/files/geom_tech_chapters/3.3.6_SuspendedSediment.pdf

Integrating Professional River Study Techniques into School Fieldwork

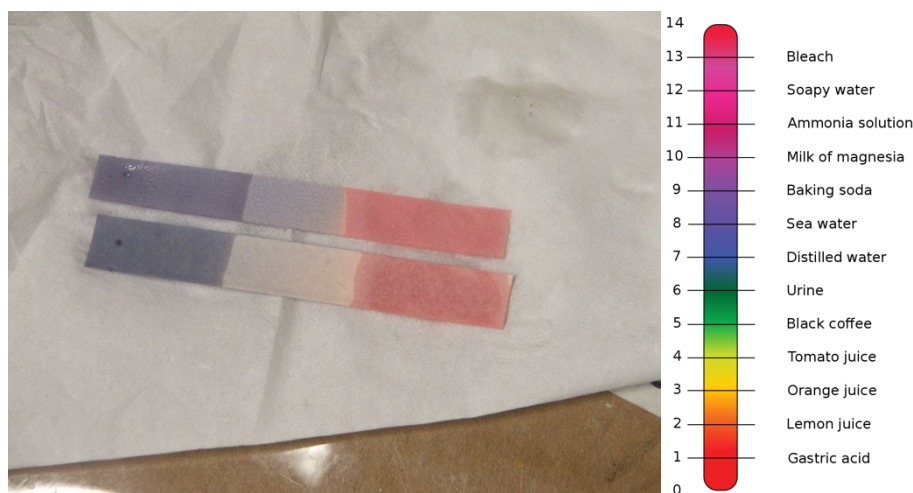
3.4.4. Dissolved matter and water quality

What is measured?

Assessing the water quality of a watercourse is a key component of any river study. In the professional sphere, it is commonly used to identify pollution that may harm humans and other ecosystems; furthermore, systematic investigations of water quality within a catchment are used to identify pollution sources. Water quality monitoring is also important for local and national governments when planning water resource budgets for different applications (e.g., is the water suitable for human consumption, irrigation, industrial applications, etc.).

There are a number of simple water quality measurements techniques.

- Colour and smell: water quality can be qualitatively described by the colour and odour of a water sample; tasting should be avoided.
- Turbidity: turbidity is primarily a function of suspended sediment load and should be measured according to the methods described above.
- Temperature: water temperature can be measure *in situ* using a thermometer; care should be taken to place the temperature below the water surface, as surface water temperature is more likely to be impacted by current weather conditions.
- pH: water pH can be measured using litmus paper (see image below left⁶⁶); when the paper changes colour, the colour should be compared with a litmus colour chart (see image below right⁶⁷) to deduce the pH level of the sample.



Depending on the scope of the study, additional water quality tests could be considered.

- Dissolved oxygen: dissolved oxygen can be measured using either a digital dissolved oxygen meter or through titration (where a reagent is added to a water sample and the colour change can be used to estimate the level of dissolved oxygen)⁶⁸.

⁶⁶ By Chemicalinterest. Image licence: Image in the Public Domain, from Wikimedia Commons

⁶⁷ By Edward Stevens. Image licence: CC BY 3.0, from Wikimedia Commons

⁶⁸ https://serc.carleton.edu/microbelife/research_methods/environ_sampling/oxygen.html

Integrating Professional River Study Techniques into School Fieldwork

- Total dissolved solids and water conductivity: total dissolved solids and water conductivity can be measured using digital meters.
- Dissolved nitrates and phosphates: dissolved nitrates and phosphates can be measured using a digital spectrophotometer.
- Invertebrate population: samples of invertebrate species from the river can be collected using a net (see image below⁶⁹). The net should either be swept back and forth in a figure of eight motion, or should be placed on the riverbed while the area just upstream is lightly disturbed by kicking. The sample should be emptied into a shallow water-filled tray. Invertebrate species can then be identified using a chart⁷⁰. On return to the classroom, data can be analysed in accordance with the Biological Monitoring Working Party score (see section 3.6 *Post-fieldwork Activities*).



- Carbon transport: for A Level students focused on the carbon cycle, the measurement of carbon transport in rivers may be desirable. Measuring the carbon in water requires both field sample collection and extensive classroom/laboratory analysis. While not explored further here, guidelines can be found on the RGS-IBG website⁷¹.

Site requirements

Water samples can be collected and/or variables measured *in situ* at any point where a river can be safely accessed and forded. Where it is not safe to access the water, samples could be taken from the riverbank, although it should be noted that water quality may vary across the width of a river.

Equipment and associated costs

Basic water quality measurements (temperature, pH, colour and smell, turbidity) can be taken using low-cost methods and equipment widely available in schools, including: thermometers, litmus paper, homemade Secchi discs and plastic bottles for sampling. Where the budget allows, a digital

⁶⁹ Image © Copyright John Rostron (<http://www.geograph.org.uk/photo/1430583>). Image licence: CC-BY-SA 2.0

⁷⁰ e.g., <https://www.fba.org.uk/sp68-guide-freshwater-invertebrates> or <http://www.field-studies-council.org/publications/pubs/freshwater-name-trail.aspx>

⁷¹ <https://www.rgs.org/CMSPages/GetFile.aspx?nodeguid=1cbd0e00-ac3d-4c78-92ad-bd4958448579&lang=en-GB>

Integrating Professional River Study Techniques into School Fieldwork

meter for the measurement of temperature and pH can be purchased at relatively low cost (see image below for example of a digital pH meter⁷²).



The analysis of total dissolved solids, dissolved oxygen, conductivity, dissolved nitrate and dissolved phosphate requires the purchase of digital meters and/or Hach kits⁷³ (see image below⁷⁴), both of which can be expensive. In particular, the kits for dissolved nitrogen and phosphates may not work when only low amounts are present.



Invertebrate sampling requires the purchase of sample nets, trays and biota identification guides, all of which will incur moderate cost.

⁷² By Ildar Sagdejev [GFDL (<http://www.gnu.org/copyleft/fdl.html>)]. Image licence: CC BY-SA 4.0, from Wikimedia Commons

⁷³ https://uk.hach.com/?_bt=217882401272&_bk=%2Bhach&_bm=b&_bn=g&clid=EAlaIqobChMI9IHF2p6p2wIVVijTCh1i4wVnEAAYASAAEgJKNPD_BwE

⁷⁴ Science History Institute. Image licence: CC BY-SA 3.0, via Wikimedia Commons

Integrating Professional River Study Techniques into School Fieldwork

Number of data points needed (data resolution)

Where using simple measurement techniques (i.e., litmus paper, thermometer), or where using a digital meter, at least 10 measurements per analysis technique should be collected; from these, an average value (e.g., the mean) can be calculated along with an indicator of data spread (e.g., standard deviation). When using more expensive testing kits, the number of analyses may have to be restricted.

Professional measurement techniques

Professional studies of water quality use a range of low cost techniques (as above), although most manual measurement techniques (e.g., litmus paper) have been replaced by portable digital meters (e.g., those for measuring pH, temperature, conductivity, biological oxygen demand, volatile organic compounds and others). In addition, samples are often sent to laboratories for higher accuracy, higher precision analysis of variables. Increasingly, remote sensing techniques are also being used to estimate water quality.

Other guidelines and ideas for low cost approaches to water quality monitoring are available from the World Bank⁷⁵, the World Health Organisation⁷⁶ and from private companies⁷⁷.

⁷⁵ i.e., turbidity, colour, taste, smell, temperature (<http://blogs.worldbank.org/water/how-test-water-quality-here-are-some-low-cost-low-tech-options>); i.e., chemical element testing <https://blogs.worldbank.org/water/how-test-water-quality-chemical-tests-limited-budgets>

⁷⁶ i.e., temperature, transparency, pH, conductivity, dissolved oxygen, microbiology (http://www.who.int/water_sanitation_health/resourcesquality/wqmchap6.pdf)

⁷⁷ i.e., turbidity, dissolved iron contents, microbial contamination (<http://www.aqsolutions.org/images/2008/01/simple-field-tests-for-water-quality.pdf>)

Integrating Professional River Study Techniques into School Fieldwork

3.5. Post-fieldwork activities

In the professional world, fieldwork often represents only a small part of a project's duration. The post-fieldwork data analysis stage is usually the longest part of any study. Here we outline some of the main steps in the post-fieldwork process, and highlight some of the key post-fieldwork calculations and analyses performed using the data collected from river field sites.

3.5.1. Data organisation & input

On return to the classroom, students should transfer field data from their field notebook onto a computer or tablet. Students should consider the best storage options for their data (e.g., Microsoft Excel, Microsoft Word, ArcGIS, Google Earth). If data were collected by a group, students should consider approaches to data management and data sharing (e.g., Google Drive, Dropbox). It may be appropriate for each group to develop a brief data management plan.

3.5.2. Data analysis & visualisation

Students should consider the most appropriate statistical techniques⁷⁸ and chart types to analyse and present their data. Students should ensure that they consider the accuracy and limitations of their data; this should be clearly stated in their final report.

River-specific data analysis methods and calculations can be found in section 3.6 (below).

Students should be encouraged to consider how GIS tools could help them to visualise and present their data. Guidance on getting started with GIS in the classroom is available online⁷⁹. To support GIS education in schools, ESRI have made ArcGIS Online free for all UK schools. Full details, including help getting started and guidance on using ArcGIS for recording and reporting on fieldwork, are available online⁸⁰.

Based on the results, students should provide an interpretation for their findings. They should return to their original scientific questions and hypotheses and use their results to show how these were met (or not). Students should also be encouraged to think about how their data may have changed under different field conditions (e.g., after a storm event, during different seasons). Students should consider how climate change might impact on their field sites.

3.5.3. Data reporting & sharing

In some professional settings (e.g., academic research), making your data publicly accessible is often a requirement. In others, data are protected by corporate confidentiality; however, they must still be prepared in such a way that findings can be reported back to a client. Students should consider how their data, analyses and interpretations could be shared with teachers, classmates (e.g., written report, class presentation) and a broader audience (e.g., creating a report for the school webpage; organising a school based scientific conference, including students from other classes or even other local schools; sharing data with citizen-science sharing platforms⁸¹).

⁷⁸ <https://www.rgs.org/schools/teaching-resources/fsc-statistical-methods/>

⁷⁹ Getting started with GIS in teaching (<https://www.rgs.org/CMSPages/GetFile.aspx?nodeguid=5ca2377b-d8f4-4aa9-bc97-72fde503bb7e&lang=en-GB>); Using Google Earth for fieldwork (<https://www.rgs.org/schools/teaching-resources/google-earth-as-a-fieldwork-tool/>); Getting started with ArcGIS and ESRI (<https://schools.esriuk.com/teaching-resources/#->)

⁸⁰ <https://schools.esriuk.com/>

⁸¹ e.g., the British Geological Survey mySoil app (<http://www.bgs.ac.uk/mysoil/>); The About GLOBE programme of the United States Government (<https://www.globe.gov/about/overview>)

Integrating Professional River Study Techniques into School Fieldwork

3.6. River-specific data analysis methods & calculations

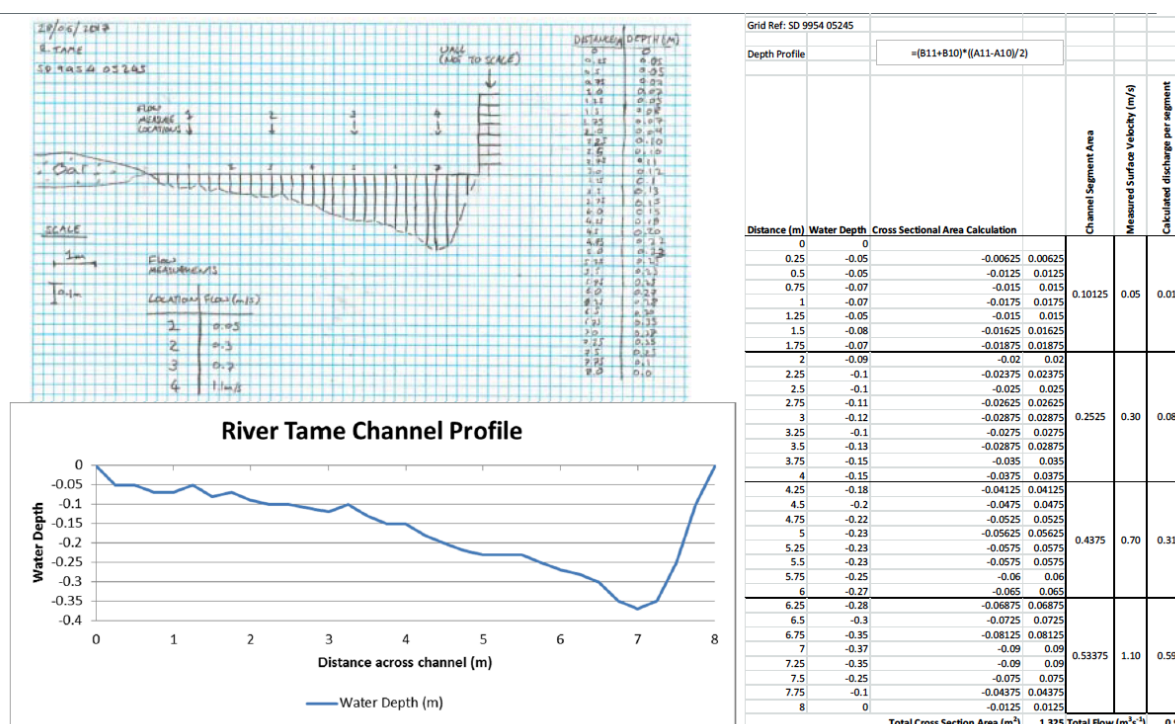
3.6.1. Cross-sectional area, discharge, wetted perimeter and hydraulic radius

Plot water depth measurements (y axis) as a function of distance across the river (x axis). Connect the data points to draw a cross-section of the river. From this cross-section, the shape of the riverbed can now be seen.

Cross-sectional area (m^2) = width (m) x mean depth (m)

Discharge (m^3/s) = cross-sectional area (m^2) x mean velocity (m/s)

The image below shows profile, cross-sectional area and discharge calculations based on data collection at Site 4 (below bridge alongside Fika Cafe) in the case study field area⁸².



For wetted perimeter, contour a piece of string along the profile of the riverbed (or measure each segment with a ruler), to calculate the wetted perimeter.

Hydraulic radius (channel efficiency) measures a river's ability to maintain energy whilst transporting material. Values can be compared across field sites, with higher values indicating greater efficiency.

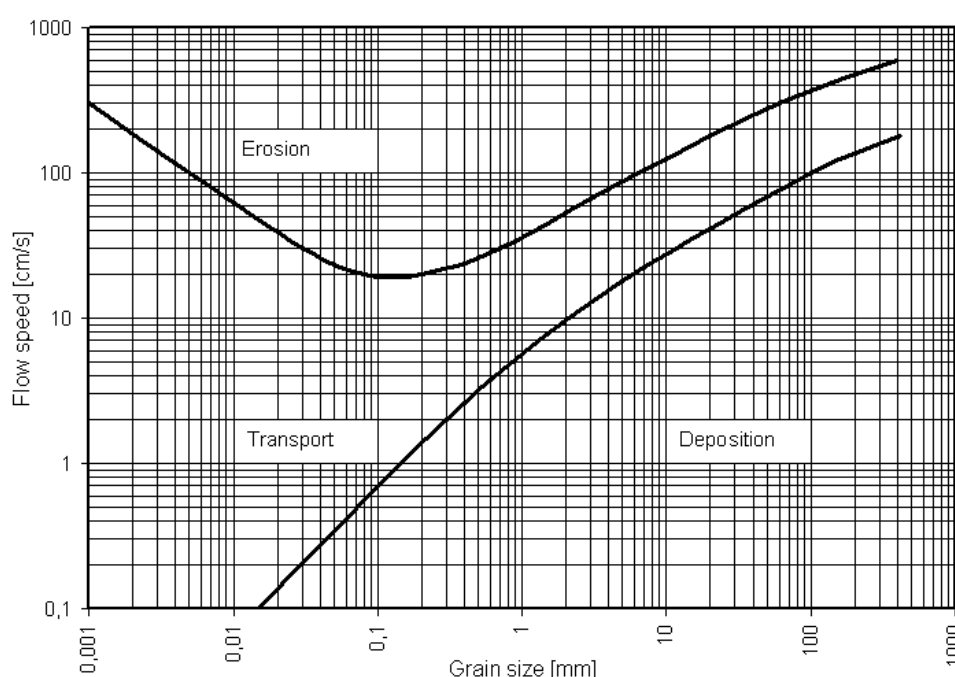
Hydraulic radius (m) = cross-sectional area (m^2) / wetted perimeter (m)

⁸² Images courtesy of ERM

Integrating Professional River Study Techniques into School Fieldwork

3.6.2. Pebble data (water velocity & pebble roundness)

To calculate water velocity from pebble size, take pebble size measurements and plot on a Hjulström-Sundborg diagram (see image below⁸³) to estimate the water velocity. For samples collected in the river, this estimated velocity can be compared to the measured velocity. For sub-aerial samples (those collected on the dry river bank or from gravel bars), this can be used to estimate the velocity of the river when they were deposited.



To assess pebble roundness, use the long and short axis measurements of pebbles to perform particle shape analysis⁸⁴. Students can then use an index to assess pebble roundness. For example, the Cailleux index can be calculated as follows:

$$R = 2r \times 1000 / L$$

where R = Cailleux roundness

r = average radius of curvature (obtained from a chart)

L = average length of pebbles (in sample)

⁸³ Hjulström's diagram, Karrock derivative work: Karrock (<https://commons.wikimedia.org/w/index.php?curid=8258823>). Image licence: CC BY-SA 3.0

⁸⁴ http://serc.carleton.edu/files/NAGTWorkshops/sedimentary/activities/particle_shape.pdf and <https://www.geography-fieldwork.org/a-level/coasts/coastal-management/method/> and <https://www.geography-fieldwork.org/gcse/coasts/coastal-processes/fieldwork/> and https://serc.carleton.edu/files/NAGTWorkshops/sedimentary/activities/particle_shape.pdf

Integrating Professional River Study Techniques into School Fieldwork

3.6.3. Water quality assessment

For a first order analysis, Secchi-based data for suspended sediments/turbidity can be compared to those of the Secchi-Dip-In project, which has been collecting Secchi disc data from volunteers since 1994⁸⁵.

Freshwater invertebrate data can be used to calculate a Biological Monitoring Working Party (BMWP) score⁸⁶ in order to assess water quality.

For other water quality data, students should be encouraged to identify other studies and/or government guidelines and use these to assess the relative water quality of their samples.

Students should also be encouraged to compare their field data with relevant secondary data sources (e.g., flood records and hydrological archives for the field location or its nearest gauging station⁸⁷). The closest monitoring station to the example field area is the 'Tame at Uppermill' river gauging station⁸⁸.

⁸⁵ <http://www.secchidipin.org/>

⁸⁶ https://www.fba.org.uk/sites/default/files/BMWPLIFEtaxa_Modified.pdf or <http://www.cies.staffs.ac.uk/bmwptabl.htm>

⁸⁷ <http://nrfa.ceh.ac.uk/> and <https://flood-map-for-planning.service.gov.uk/>

⁸⁸ <http://nrfa.ceh.ac.uk/data/station/info/69048>

Integrating Professional River Study Techniques into School Fieldwork

4. Fieldwork project 2: flooding hazard vs. risk

4.1. Introduction

The assessment of flood risk and the development of management strategies is an area of increasing concern for local and national governments. Such assessments are necessary to protect existing human life and infrastructure, as a part of the planning process when developing new infrastructure, when budgeting for water resources and to prepare communities for future changes to river regimes due to global climate change and/or human intervention upstream.

This activity asks students to characterise and compare flood risk at different points along the same river, to assess current flood management infrastructure and to suggest possible flood management initiatives. Critically, this activity also asks students to consider the difference between ‘hazard’ and ‘risk’, a distinction critical in many professional settings:

Hazard: a potential source of harm

Risk: likelihood of a hazard causing harm

4.1.1. Links to curricula

At GCSE, this activity directly contributes to the study of natural hazards; in particular, the study of weather related hazards in the UK, a component of all exam boards. Through this activity, students should consider the causes of flooding, the links to weather and climate and the distribution of flood risk. This field activity also links in to the study of physical landscapes in the UK and the study of climate change impacts, both of which are features of all exam boards.

Through a combination of field data collection and both pre- and post-fieldwork classroom study, students can address each of the skills areas specified for GCSE geography by the Department of Education.

- Cartographic skills: use different types of maps (e.g., topographical, aerial, geological) at a range of scales (e.g., national, regional, local) to extract information about a study area (e.g., latitude, longitude, geological setting, topographical setting, local infrastructure, landforms); students should also be able to produce sketch maps.
- Graphical skills: students should be able to use and apply appropriate graphs and charts (e.g., pie charts, pictograms, etc.); they should also be able to produce hand-drawn images to present and record information.
- Numerical skills: students should appreciate the concepts of number, area, scale and the relationships between units; they should collect fieldwork data and understand its limitations (e.g., accuracy, sample size, etc.).
- Statistical skills: select and use statistical techniques appropriate to the data type.
- Consider techniques that measure spatial patterns and temporal change (e.g., land use).
- Use and evaluate data from other (non-cartographical) secondary sources (e.g., media reports, photographs, first-hand accounts).
- Develop research and fieldwork planning skills, including the development of hypotheses, the planning of appropriate fieldwork procedures and consideration of health & safety.
- Present findings using a text report that should be descriptive, analytical and critical.

Integrating Professional River Study Techniques into School Fieldwork

At A Level, this activity falls within the study of the water and carbon cycles. Students should consider how human activities impact on the hydrological cycle (e.g., river and groundwater flooding). This module also relates to the study of hazards (e.g., risks, impacts, management)—this is particularly relevant to modules associated with climate change (OCR), weather & climate (Eduqas) and non-tectonic hazards (AQA and Eduqas).

Through a combination of field data collection and both pre- and post-fieldwork classroom study, students can develop many of the skills required by the Department of Education for A Level geography students.

- Understand, collect and use different types of geographical information (e.g., qualitative vs. quantitative, primary vs. secondary).
- Collect and analyse information, and critically assess data sources, methodologies and data outputs/reporting, including the ability to identify data misuse and sources of error.
- The use of semi-quantitative and qualitative data, for which students should be able to: understand the use of mixed-method approaches (e.g., qualitative land mapping, interviews, analysis of secondary data sources); understand the opportunities and limitations of qualitative data; and appreciate the ethical and socio-political implications of collecting, studying and representing data about humans and their communities.

4.1.2. 'Real-world' examples

Flood risk assessments are performed as standard by government departments and private organisations at all levels. For example:

- 2011 Torbay Flood Risk Assessment⁸⁹;
- 2015 Haringey Flood Risk Assessment⁹⁰;
- Scottish National Flood Risk Assessment⁹¹;
- flood risk assessment documentation used by the USA Federal Emergency Management Agency (FEMA) for training⁹².

Among others, the data used for flood risk assessment within these professional studies included: landscape characterisation (e.g., topography, geology, soils, streamflow data, rainfall data); historical flood data (e.g., from government records, newspaper articles, local knowledge, flood marks on buildings and other infrastructure); data on existing flood defences; identification of areas most susceptible to flooding; inventories of potentially impacted residential properties, key services (e.g., hospitals, schools, transport routes, police), agricultural land, businesses and areas under protection for cultural, historical, environmental or scientific reasons (e.g., World Heritage sites, Sites of Special Scientific Interest).

⁸⁹ <http://www.torbay.gov.uk/media/7736/preliminary-flood-risk-assessment.pdf>

⁹⁰ http://www.haringey.gov.uk/sites/haringeygovuk/files/sfra_document_high_res_red_0.pdf

⁹¹ https://www.sepa.org.uk/media/99914/nfra_method_v2.pdf

⁹² <https://training.fema.gov/hiedu/docs/fmc/chapter%204%20-%20flood%20risk%20assessment.pdf>

Integrating Professional River Study Techniques into School Fieldwork

4.2. Site selection

This activity requires access to land adjoining a natural watercourse (i.e., a river), ideally for at least two or three contrasting locations; for example:

- river flowing across an area of floodplain;
- river flow through an area of changing topography (e.g., steep river valley, areas where the river loses elevation over a short distance);
- river meander site;
- river flow through an urban area;
- river flow interrupted by a dam or weir;
- confluence of two watercourses;
- locations where river flow is interrupted by other human intervention (e.g., bridge supports, flood defences, stepping-stones, etc.).

Ideally, at least two contrasting sites should be chosen; for example, a site with extensive human infrastructure (e.g., an industrial estate, a residential area, a central business district) and a non-urban area.

In the example field area (Tame Valley), this activity could be completed with visits to sites 1, 2 and 4:

- Site 1 (Confluence of River Tame and Diggle Brook) represents a free flowing river, uninhibited by human construction or intervention, at a confluence point with another water source. Flooding at this point would have a relatively low impact on human infrastructure in all but the most severe of cases;
- Site 2 (Kenworthy Gardens) represents a modern residential area bordered by both a river and a canal. The estate has in-built flood protection measures (see the water overflow moat surrounding the estate);
- Site 4 (Fika Cafe) represents river flow through an urban area—the river is forced to flow through a channel confined by large-scale man-made structures (bridge, buildings). This area has flooded in the past. Flood protection measures and marks from previous floods can be seen on local buildings.

Integrating Professional River Study Techniques into School Fieldwork

4.3. Pre-fieldwork activities

4.3.1. Questions & hypotheses

Identification of scientific questions & hypotheses: students should be required to develop a series of scientific questions and associated hypotheses to test through fieldwork; for example, these could relate to:

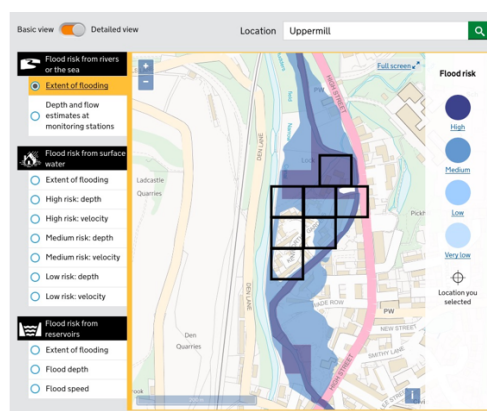
- changes to flood risk according to land use type;
- changes to flood risk according to runoff and infiltration rates.

4.3.2. Plan of work

Site selection: students (particularly at A Level) should be intimately involved in the planning of fieldwork. Where possible, this could include site selection from relevant maps or from pre-fieldwork scouting trips to the proposed field area. Where sites have already been selected (e.g., for the River Tame), students should be asked to consider why those sites have been selected (e.g., accessibility, notable natural or human features of interest).

Students should be asked to design a methodology for assessing the flood risk at each study site. This should include:

- a plan for where data will be collected within each study site. It is recommended that students collect data at multiple points within each study site to allow for a comprehensive review of flood risk. For example, students could split their site into grid segments. While in the field, students will collect data in each of those grids and then combine the results to produce a risk assessment for the site. Ideally, this would be repeated at other sites with different land uses to allow for a comparative study. An example of a gridded flood hazard map (using an Environment Agency⁹³ flood map) for Site 3 (Kenworthy Gardens) of the case study field area is shown below;



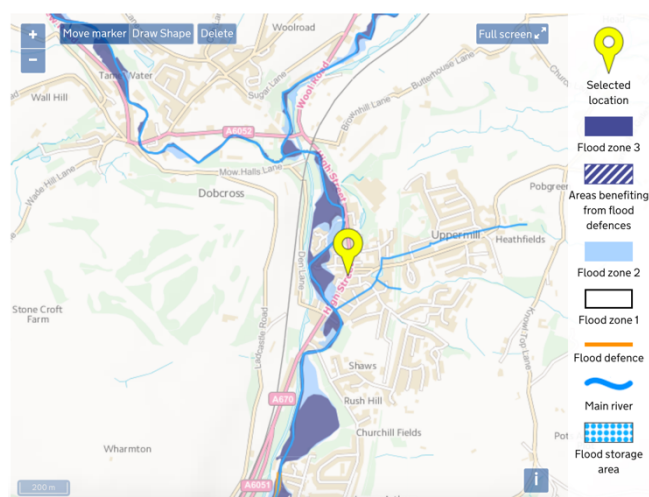
- a plan for methods of data collection (see section 4.4. *Measurable processes and field data collection techniques*).

⁹³ <https://flood-warning-information.service.gov.uk/long-term-flood-risk/map>

Integrating Professional River Study Techniques into School Fieldwork

4.3.3. Metadata collection

For each selected site, students should source flood hazard maps from the Environment Agency⁹⁴ (see below for an example from Uppermill in the example study area). Where data are available (i.e., local newspaper reports, local knowledge, the Historic Flood Map Register⁹⁵, etc.), additional flood hazard maps can also be sourced. For the purposes of this activity, it is important that these are hazard maps (i.e., those that show the potential for a flood without reference to surrounding land use) and not 'risk maps' (i.e., those that use data about the surrounding land use and infrastructure to assess the risk posed by the flood hazard).



4.3.4. Logistical planning

Students should be encouraged to develop a realistic plan for fieldwork, including a proposed timetable of site visits that takes into account the number and locations of field sites, the number of people within a group, the time required for data collection at each site and the time available for fieldwork.

Prior to fieldwork, students should be required to procure or construct appropriate equipment to complete the proposed data collection activities.

Students should be asked to consider the health & safety implications of the chosen field sites and data collection techniques. Students should be encouraged to create, or contribute to, risk assessment development. Guidelines on fieldwork safety and planning, including guidance on the preparation of risk assessments, have been published by the Field Studies Council and can be found on the RGS-IBG website⁹⁶.

⁹⁴ <https://flood-warning-information.service.gov.uk/long-term-flood-risk/map>

⁹⁵ <https://data.gov.uk/dataset/76292bec-7d8b-43e8-9c98-02734fd89c81/historic-flood-map>

⁹⁶ <https://www.rgs.org/in-the-field/fieldwork-in-schools/fieldwork-safety-and-planning/risk-assessments/>

Integrating Professional River Study Techniques into School Fieldwork

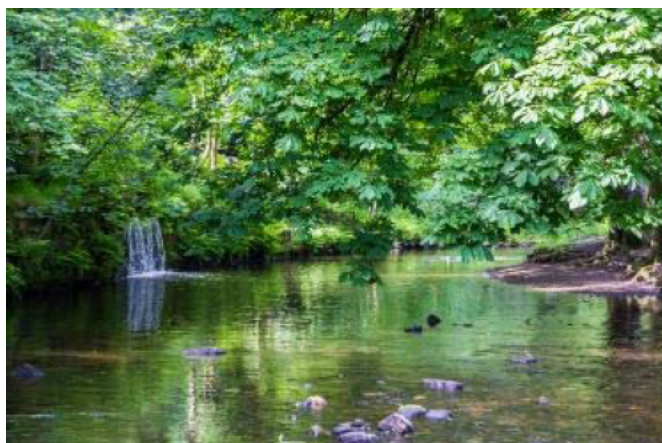
4.4. Measurable processes and field data collection techniques

4.4.1. Field notebook

On arrival at each field site, students should record observational data on the field site setting in their field notebook. In some professional settings, a field notebook (hand-written or digital) is a legal document that could be used in legal proceedings⁹⁷. For other professionals, the information recorded in a field notebook could be critical for later stages of data processing. Learning good field notebook skills is a critical part of geography fieldwork training. In this activity, the following should be recorded for each field site:

- date, time, weather conditions and mood of the investigator (these can impact on the quality of data collection);
- name of the field site and location (i.e., GPS waypoint and/or latitude and longitude from a smart phone, handheld GPS or paper map);
- brief description of the site, including surrounding land use and infrastructure, site condition (vegetation, human impacts);
- site sketch with critical features clearly labelled;
- data on selected measurements.

Examples of field notebook, sketching and photography good practice have been developed by the University of Liverpool⁹⁸ and the RGS-IBG⁹⁹. A good site sketch gives a sense of scale and the spatial distribution of features. The images below show an example field sketch and accompanying photograph¹⁰⁰; it can be seen that field sketches do not need to be artistic, they merely need to convey the main features of a site.



⁹⁷ <https://www.abcls.ca/wp-content/uploads/pdfs/Field-notes-Link-article-Oct-9-2015-Final.pdf>

⁹⁸ <http://www.esta-uk.net/fieldworkskills/tips.htm>

⁹⁹ <https://www.rgs.org/schools/teaching-resources/sketching-and-photography/>

¹⁰⁰ Images courtesy of ERM

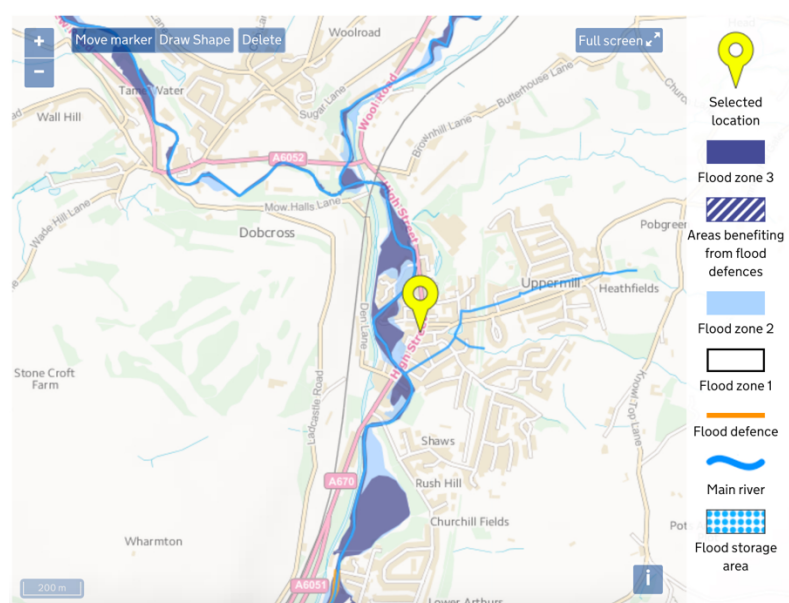
Integrating Professional River Study Techniques into School Fieldwork

4.4.2. Flood risk contributors

What is measured?

In this study, students will collect data on contributors to flood risk. All or some of the following risk contributors could be measured.

- Likelihood of flooding, to be assessed prior to field visit using an Environment Agency flood hazard map¹⁰¹ (see below for an example from Uppermill in the example study area¹⁰²).



- Inventory of property types and infrastructure within each grid square, including,
 - residential
 - community facilities (e.g., hospitals, police, post office, doctors, water treatment plants, etc.)
 - businesses
 - roads (students could consider splitting this category into major road transportation routes [e.g., motorways and A roads] and minor road transportation routes [e.g., B roads])
 - other transport links (e.g., railways)
 - types of green spaces (e.g., gardens, woodland, floodplain, parks, playing fields; note that flooding poses a greater risk to agricultural ground than it does to areas of natural vegetation)
 - sites of scientific, ecological, cultural or historical importance within each grid square (this information may also be sourced before or after fieldwork using the UK government's Magic Map resource¹⁰³)

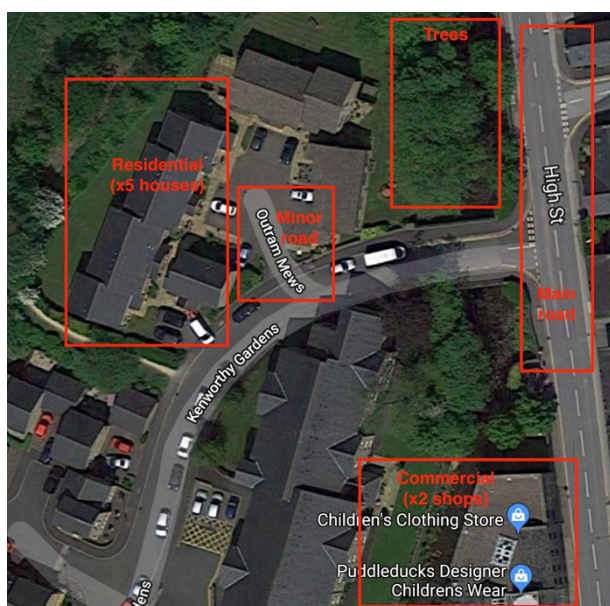
¹⁰¹ <https://flood-warning-information.service.gov.uk/long-term-flood-risk/map>

¹⁰² <https://flood-warning-information.service.gov.uk/long-term-flood-risk/map>

¹⁰³ e.g., Protected areas such as Sites of Special Scientific Interest (SSSIs; <http://www.natureonthemap.naturalengland.org.uk/magicmap.aspx>)

Integrating Professional River Study Techniques into School Fieldwork

This assessment could be performed using a combination of aerial images (see below for an example from Uppermill in the example study area¹⁰⁴) and ground-truthing (i.e., observations and data collected during fieldwork). Data could be reported in terms of area covered by different land-use/property types (in m²) and/or as tallies of numbers of buildings/features within each category.



- Pedestrian and vehicle traffic counts at each locality to assess traffic levels. Students should count for a set period of time (e.g., 5 minutes) and should consider the error introduced by time of day, weather conditions, etc.
- Approximate assessment of the area of impermeable pavement in each grid square. Depending on the size of each grid, this could be qualitatively assessed on a 'high', 'medium' or 'low' scale, could be measured using GPS-based land-use mapping or could be estimated from aerial images (see below for an example from Uppermill in the example study area¹⁰⁵).



¹⁰⁴ Annotated Google Maps image

¹⁰⁵ Annotated Google Maps image

Integrating Professional River Study Techniques into School Fieldwork

Alternatively (or in addition), students could pick a representative spot within each grid square and perform a measurement of infiltration. Infiltration can be assessed qualitatively by observing areas where water drains or forms standing pools or can be measured at low cost by placing a section of drainpipe on the ground surface, filling it with a set amount of water and timing how long it takes for the water to infiltrate the ground (details of this process are available from the RGS-IBG website¹⁰⁶).

- Flood mitigation of management structures or initiatives active in the area (see image below for an example flood prevention barrier in Ireland¹⁰⁷).



In the example study area, Kenworthy Gardens (Site 3) is surrounded by an overflow moat to help protect the site from flooding).

Site requirements

To perform these analyses, students need field sites that are accessible to the public, safe to access and within proximity to a river.

Equipment and associated costs

All data collection techniques are low cost, with the majority requiring only a notebook to record data (e.g., number of houses, number of roads, etc.).

To measure traffic or pedestrian flow rates, a stopwatch will be needed.

To map sites or measure large areas (e.g., to map green space within a grid), students will need access to a tape measure or to a GPS-enabled device to take waypoints.

Infiltration measurements will require a section of drainpipe (or similar), a measured volume of water, a ruler and a stopwatch.

¹⁰⁶ <https://www.rgs.org/schools/teaching-resources/make-your-own-fieldwork-equipment-infiltration/>

¹⁰⁷ © Copyright Albert Bridge (<http://www.geograph.ie/photo/5111498>). Image licence: CC-BY-SA 2.0

Integrating Professional River Study Techniques into School Fieldwork

Number of data points needed (data resolution)

Students must record enough data to be representative of a site. For very small sites or grids within gridded sub-sites, all occurrences of a variable may be included (e.g., all houses counted). Wherever possible, large field sites should be split into smaller more manageable units.

For direct measurement of infiltration, students may consider taking three to five measurements from each site or sub-grid, allowing calculation of average values (e.g., the mean) and associated data spread (e.g., standard deviation).

For measurements of flow (e.g., road traffic), students should count vehicles for at least 5–10 minutes. Ideally, this exercise should be repeated at different times of day.

Professional measurement techniques

Professional flood risk assessments collect similar datasets to those provided above. Often, studies will use remote sensing based data for assessing many variables; however, data may also be ground-truthed by taking selected measurements at selected sites.

Integrating Professional River Study Techniques into School Fieldwork

4.5. Post-fieldwork activities

In the professional world, fieldwork often represents only a small part of a project's duration. The post-fieldwork data analysis stage is usually the longest part of any study. Here we outline some of the main steps in the post-fieldwork process and highlight some of the key post-fieldwork calculations and analyses performed using the data collected from river field sites.

3.5.1. Data organisation & input

On return to the classroom, students should transfer field data from their field notebook onto a computer or tablet. Students should consider the best storage options for their data (e.g., Microsoft Excel, Microsoft Word, ArcGIS, Google Earth). If data were collected by a group, students should consider approaches to data management and data sharing (e.g., Google Drive, Dropbox). It may be appropriate for each group to develop a brief data management plan.

3.5.2. Data analysis & visualisation

For this study, the risk contributor data collected in the field should be input into a multi-parameter risk table designed by the student. An example of such a table is shown below¹⁰⁸.

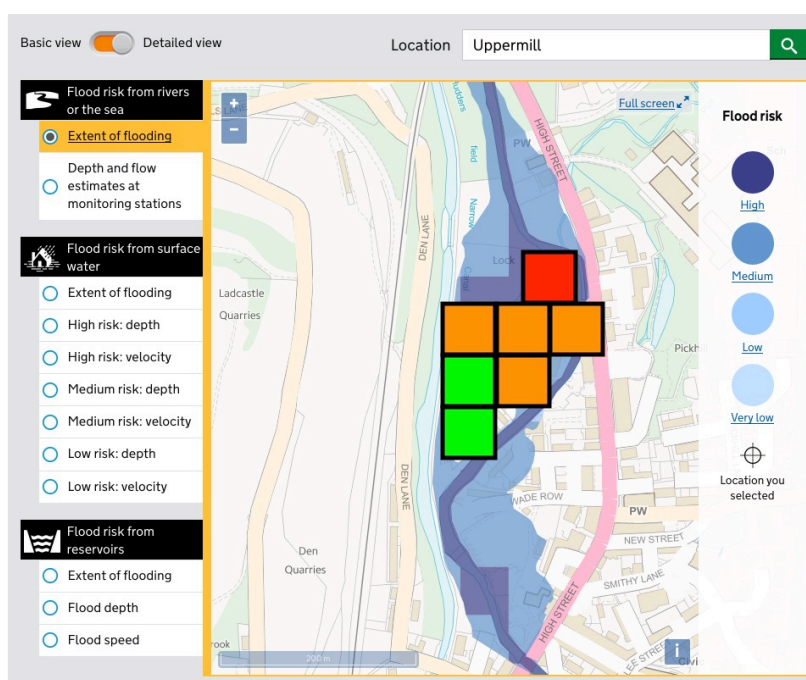
	Very Low	Low	Medium	High	Very High
	Cell Score: 0	Cell Score: 0.5	Cell Score: 2.5	Cell Score: 25	Cell Score: 250
Human Health (A) People	No residential properties located within a flood extent	Continual scale dependant on number of residential properties per 1km ² cell and social flood vulnerability score in cell			Maximum number of residential properties per 1km ² cell
Human Health (B) Community	No community services located within a flood extent	Post offices/GPs/dentists	All waste water treatment works/water pumping facilities/police/fire stations and post offices/GPs/Dentists located in a rural area	All residential homes/education facilities and police/fire stations located in a rural area	All hospitals/ambulance depots and residential homes/education facilities located in a rural area
Economic Activity (A) Businesses	No non-residential properties located within a flood extent	Continual scale dependant on number of non-residential properties per 1km ² cell and weighted annual average damage score in cell			Maximum number of non-residential properties per 1km ² cell
Economic Activity (B) Transport	No roads or rail links located within a flood extent	Minor roads or main roads/rail in less rural areas	B' Roads or minor roads in rural areas or main roads/rail in less rural areas	Motorway/ 'A' Road/Railway or other roads in rural areas	Airports
Economic Activity (C) Agriculture	Natural vegetation, forests, scrub and/or herbaceous vegetation associations and open spaces with little or no vegetation	Pastures, complex cultivation patterns and agro-forestry areas	Arable land, permanent crops and annual crops		
Cultural Heritage	No cultural sites located within a flood extent	Category C Listed Buildings	Category B Listed Buildings, Gardens and Designed Landscapes	UNESCO World Heritage Sites, Scheduled Monuments, Category A Listed Buildings	
Environment	Designated areas containing species/habitats deemed to be of very low ¹ vulnerability (resilience x susceptibility)	Designated areas containing species/habitats deemed to be of low vulnerability (resilience x susceptibility)	Designated areas containing species/habitats deemed to be of medium vulnerability (resilience x susceptibility)	Possible to get a high score but no designated areas resulted in a score higher than medium	

¹⁰⁸ Screen grab from the Scottish Environment Protection Agency National Flood Risk Assessment Methodology (https://www.sepa.org.uk/media/99914/nfra_method_v2.pdf)

Integrating Professional River Study Techniques into School Fieldwork

To create one of these tables, students should devise 3- or 4-point category systems for each measured variable. For example, for residential properties students could divide the area of the grid by the number of residential properties and create thresholds that include: 'no residential properties', 'low residential density', 'medium residential density' and 'high residential density'. For each category, students should assign a point-score (e.g., 'no residential properties/low risk' = 0, 'low residential density/low-moderate risk' = 5, etc.).

Once complete, students should sum the scores for each contributor to yield a total score. Colour codes (e.g., green, yellow, orange, red) can be assigned to score ranges, and on this basis each grid can be colour coded to create a risk map; for example, using an Environment Agency¹⁰⁹ flood map, as shown below.



Based on the results, students should provide an interpretation for their findings. They should return to their original scientific questions and hypotheses and then use their results to show how these were met (or not).

Students should consider whether areas with the highest flood hazard (i.e., likelihood of flooding based on the Environment Agency map), are also the areas with the highest flood risk (i.e., highest likelihood of damage resulting from flooding).

Students should be encouraged to think critically about the methods employed and make suggestions for improvement (e.g., should each of the contributing risk factors hold equal weight within the point system? Are certain variables more critical than others in dictating flood risk? If so, should the point-system be weighted to reflect this?

¹⁰⁹ <https://flood-warning-information.service.gov.uk/long-term-flood-risk/map>

Integrating Professional River Study Techniques into School Fieldwork

Students could be encouraged to develop flood management plans for each location, including if and how each field site should be protected (e.g., hard or soft flood defences) and the relative merits/problems with possible schemes.

4.5.3. *Data reporting & sharing*

In some professional settings (e.g., academic research), making your data publicly accessible is often a requirement. In others, data are protected by corporate confidentiality; however, they must still be prepared in such a way that findings can be reported back to a client.

For this study, students should compile a flood risk assessment report to accompany their flood risk maps.

Students should also consider how their data, analyses and interpretations could be shared with their teacher and classmates (e.g., written report, class presentation). Students could also consider how their data and their analyses could be shared with a broader audience (e.g., creating a report for the school webpage; organising a school based scientific conference, including students from other classes or even other local schools; sharing data with citizen-science sharing platforms¹¹⁰).

¹¹⁰ e.g., the British Geological Survey mySoil app (<http://www.bgs.ac.uk/mysoil/>); The About GLOBE programme of the United States Government (<https://www.globe.gov/about/overview>)