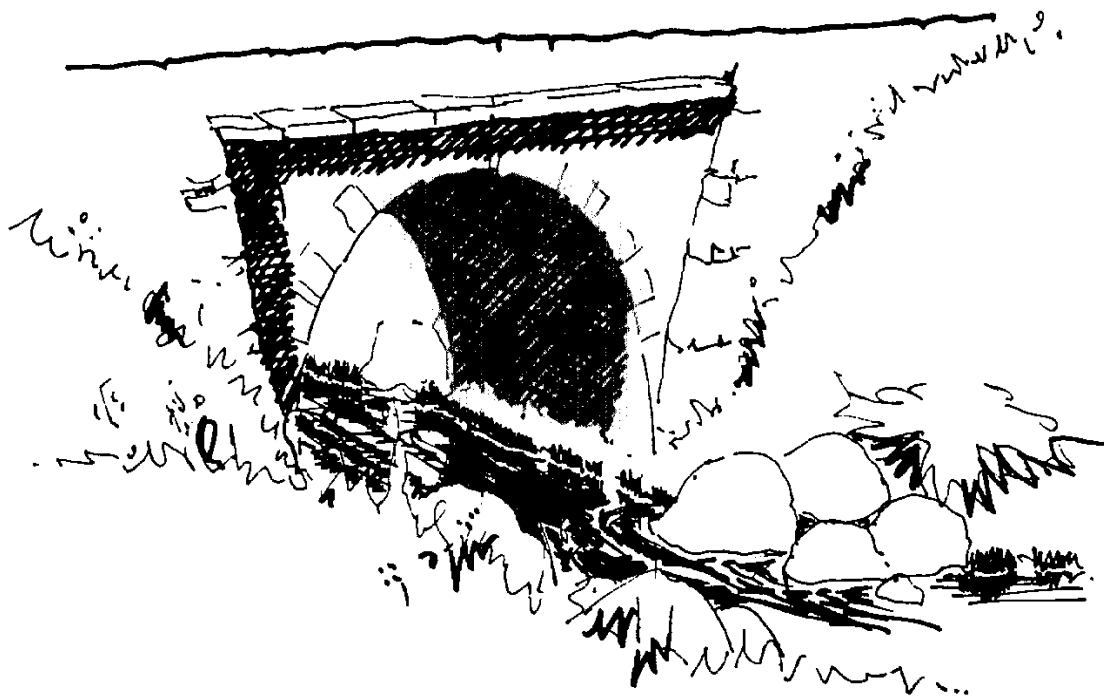


River Processes and Landforms: A Case study of Rivers on the North side of Mont Lozere



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RIVER PROCESSES AND LAND FORMS

A CASE STUDY OF THE USCLADE AND SOURDE RIVERS

TEACHERS' NOTES

- Channel processes and landforms come under close scrutiny in this unit, as does river morphology. River morphology can usually be considered in three dimensions; long profile, cross-sectional shape and plan form. This unit concentrates on the changes which the Rivers exhibit on their journey down the northern flank of Mont Lozere to the junction with the Lot at Le Bleyard.
- The work for this unit is carried out starting from the Le Bleyard Ski Station. Students walk almost the entire length of the rivers (approx. 8km) along footpaths and some road sections. Five sites are normally visited, although more may be possible if required. Liaise with your group leader before you set out on the number of sites and the locations that you wish to study. After heavy rain or snow melt it may not be possible to measure some of the lower sites, although these can still be visited.
- This study gives many opportunities for students to produce coursework based upon the data collected. A list of possible project titles is included with this unit.
- The unit is designed to both take measurements of river channel variables and investigate landforms. It is of course possible to look at either of these in greater detail if desired.
- Many groups spend a good deal of time in the evening drawing out cross-sectional areas. We have available a commercially available software package (Amflow) that processes the student's data quickly and efficiently, producing a cross-sectional diagrams, calculating discharge, drawing long profiles etc. If you would like to use the software, please ask your group leader.
- Some groups may choose to study variations in water quality. Because of the organic nature of the farming in the valley, there is very little nitrate pollution. Although an old lead mine is passed, lead pollution of freshwater is difficult to measure with students. The most successful way of testing for changes in water quality is to look for biological indicator species. However the 'clean' nature of the river means that little variation is apparent between sites. For a more detailed investigation the **Freshwater Pollution unit** based upon the River Lot should be considered.
- On the walk down the valley, the geology will change from Schist to Limestone. This should be noted and the effects of this upon landforms and river measurements noted.

REFERENCE TEXTS

Knighton D (1984) "*Fluvial Forms and Processes*"

Lenon & Cleves (1994) "*Fieldwork Techniques and Projects in Geography*" Collins

Miller (2000) "*Fieldwork Ideas in Action*" Hodder & Stoughton

INTRODUCTION

GENERAL INFORMATION

The Massif Central, a roughly triangular upland area covering one-sixth of France, contains a landscape of enormous variety characterised by a number of distinctive landforms. Water is an important and dynamic component of this landscape system. The striking gorges of the limestone Causses reflect the erosive power of the Massif's principal rivers. Today these waters have become a major recreational attraction and have brought an important source of revenue into the region.

Elsewhere, water plays a vital role in agricultural activity and many rural valley communities rely upon the flow of rivers for their continued prosperity. The dynamic nature of the river system has a direct impact on humans. Heavy rain in October 1987, September 1994 and December 2003 brought severe flooding to many areas. Conversely the droughts of 1989, 1990 and 2003 have reduced river flow and this, together with increased deposition, has made it almost impossible for some of the canoeing and rafting businesses to operate profitably.

People also have an impact on rivers: pollution is becoming a major problem as more farmers turn to chemicals to increase yields and as domestic waste tips build up outside the major settlements. River channels have been straightened and banks protected in urban areas and in the rural sector channelisation has been used to re-direct flow onto agricultural land.

The physical geography of the Massif Central means that the region forms a vast watershed from which rivers flow to the Mediterranean, and the Atlantic coasts. These rivers are not important for navigation but their valleys provide route-ways for road and rail transport away from the mountain mass to other parts of France. The water input into these river systems comes principally from the Atlantic depressions.

The Massif is well watered. Lozère has more than 2700 km of water courses and 230 000 hectares of forest land – it constitutes “Water Tower” and green lungs of Languedoc-Rousillon to which it belongs. Precipitation is high with more than 1,200 mm per annum being recorded in the highest areas. The whole of the Massif has more than 75 days of frost each year and large areas of ground are snow covered for more than two months of the year, rising to six months in the high mountains. The prevailing soil and geological conditions favour rapid run-off and overland flow tends to be the dominant process during periods of heavy rain (See Figure 1). This is accentuated where deforestation has occurred on a large scale. There are many natural and artificial water stores that may help to regulate river-flow, such as *Lac Villefort* at Villefort and the *Reservoir de Cambous* between Florac and Alès. These are used for the supply of water to surrounding towns and for recreational purposes.

River management is an important aspect of water control and conservation in the Massif. Much of the management in the Cévennes is entrusted to the National Park who are primarily responsible for maintaining the landscape. Elsewhere Regional River Authorities have implemented various river management schemes. Good management can only be achieved by gaining a full understanding of the physical processes acting within river channels - the processes at work today, the erosional history, and the physical controls of the environment (See Figure 2).

Although total yearly precipitation is high in the region, it is distribution that is the problem. An examination of rainfall figure from the Eagles Nest in 2003 reveals that even in a year of drought there is less variation in amounts between months, than might be expected. However, in summer the rain is often in the form of short, heavy downpours that do little to refill reservoirs. This can be seen by comparing the actual days of precipitation (3 or 4 in summer compared to 15 in winter). Thus, during the long, dry summer, water supply may be barely sufficient to meet demand. With an ever-increasing number of tourists in the region, the problem is becoming more acute. The Departement of Lozère has become sufficiently concerned to fund research by the University of Alès into the hydrology of the region. It is hoped that a more efficient way of managing the available water will be found.

Precipitation Details for The Eagles Nest 2003

Month	Rainfall (mm)	Snow (cm)	Days of Rain	Days of Snow
January	28	17.3	3	12
February	20	39	3	12
March	23.5	0.3	6	2
April	76	2.8	10	4
May	77	0	8	0
June	31	0	3	0
July	52	0	4	0
August	61	0	4	0
September	75	0	7	0
October	121	12.8	17	4
November	371	0.4	12	1
December	190	25.2	8	6
	1125.5	97.8	68	41

SPECIFIC INFORMATION

The Usclade and Sourde valleys lie along the northern slopes of Mont Lozère. These are the two main rivers in area, although a number of smaller tributaries exist. The confluence of these rivers occurs below the settlement of Malavielle and the rivers continue flowing northwards until meeting the River Lot at the settlement of Le Bleyard. The rivers initially are characteristic of an upland stream, draining off a schist rock. The soils are generally acidic and very thin on the slopes, but in places are deeper in the valley bottoms where periodic flooding has provided some input of alluvium. Both valleys are steep sided so land use is restricted to forestry, with some grazing on flatter areas. Both rivers are important to the valley communities. Water is supplied from these to the Ski Station complex, Malavielle and le Mazel. In places 'Beals' may be observed. These are channels that supplied water from the river to fields, but most have been now abandoned. Also noticeable in Malavielle is the old mill that used the river as a form of power, to grind grain. Both rivers flow continuously and much of this flow can be attributed to a slow release from stores held high up on Mont Lozère. These are peat bogs that play an important role in the basin hydrological cycle.

FIGURE 1: THE DRAINAGE BASIN SYSTEM

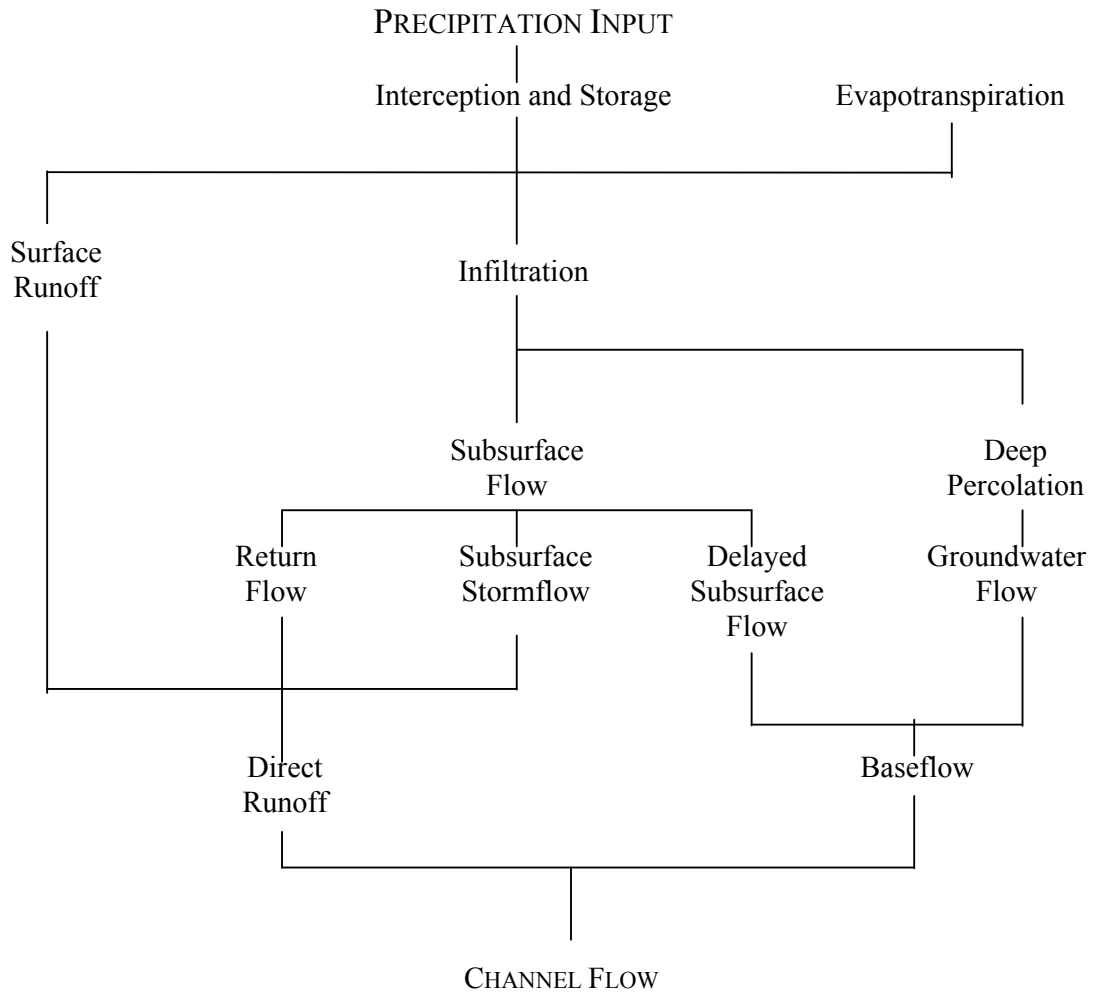
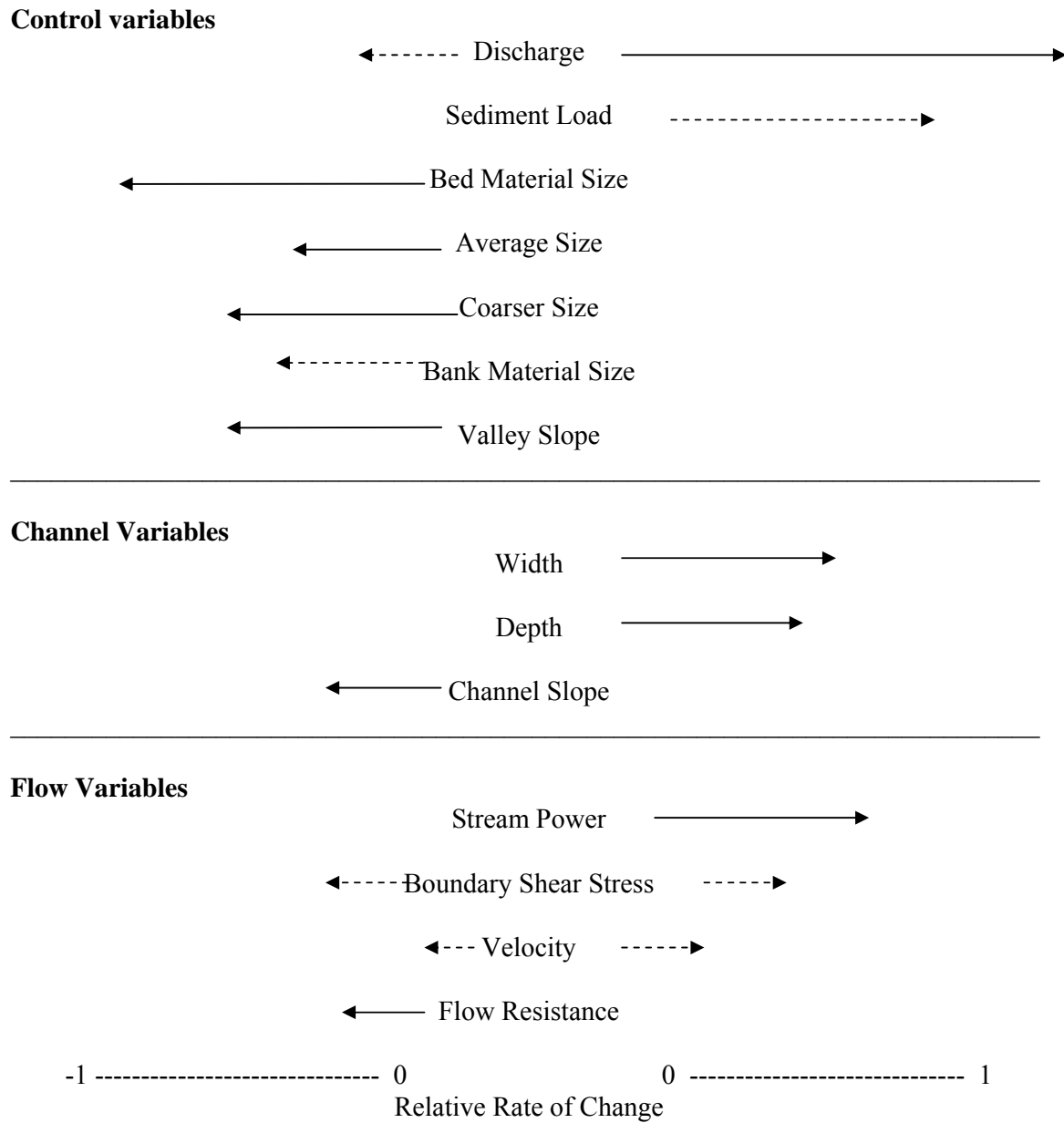
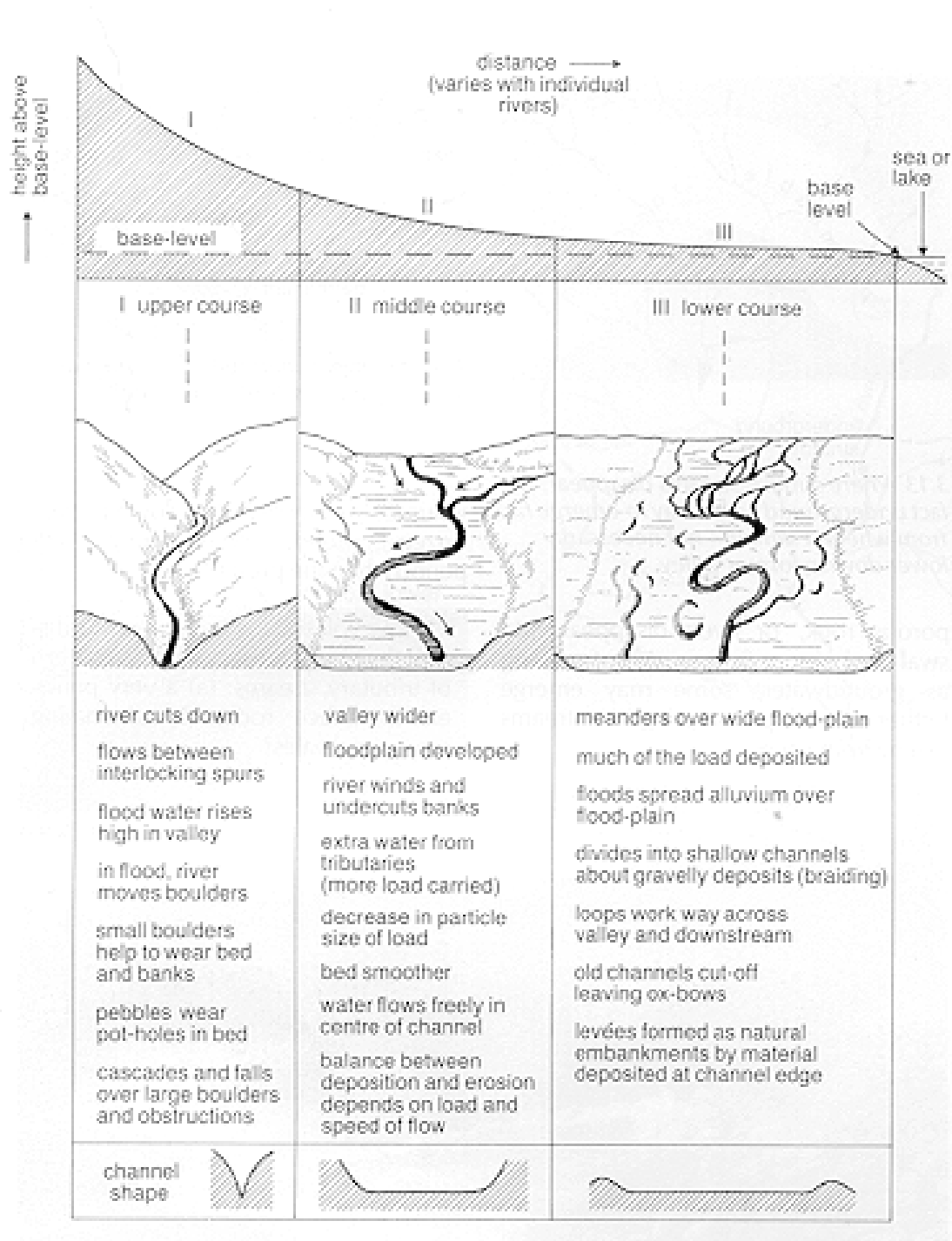


FIGURE 2: SCHEMATIC DIAGRAM OF THE RELATIVE RATES OF DOWNSTREAM CHANGE IN CHANNEL FORM



Note: Dashed lines signify greater uncertainty in behaviour

FIGURE 3 TYPICAL CHANGES IN A RIVER CHANNEL ALONG ITS LONG PROFILE



AIMS

1. To investigate downstream changes within the river channel and to account for the changes which take place.
2. To investigate the different landforms produced by a river along its course and to explain the formation of these.
3. To examine the changes in valley cross profile that occur along the course of a river.
4. Examine the effects of Human activity upon rivers on Mont Lozere.

HYPOTHESES

1. The cross-sectional area increases downstream.
2. Bed-load size decreases downstream.
3. Bed material will become more rounded downstream.
4. Mean velocity and discharge increase downstream.
5. Channel gradient will decrease downstream.
6. Valley cross profiles will become wider and sides less steep downstream.

DATA COLLECTION SITES

Most groups look at between 3 to 5 sites at a variety of locations over an 8km stretch. Please liaise with your group leader over the number and location of the sites that you wish to study. If a large number of sites are to be visited then considerable planning is necessary. This may involve the splitting of groups to visit different sites or the allocation of tasks.

Under high flow conditions it may be impossible to sample at some of the more downstream sites.

EQUIPMENT

- Ranging Poles
- Tape Measure
- Metre Rules
- Callipers
- Flow Metres or floats
- Clinometers
- Conductivity meter
- Power's scale of roundness
- pH indicator solution

METHOD AND ORGANISATION OF STUDY

TASK ONE – CHANNEL CROSS SECTION

(Hypotheses 1, 2, 3, 4, and 5)

Channel form is more a measurement of bank-full discharge than any other factor. Discharges lower than bank-full are likely to have a smaller proportion of excess energy to mould the channel, and although flood discharges may cause damage and channel change, their effects will be neutralised by the next bank-full state (once every 1-3 years).

- i) Most natural channels are irregular. Where is the 'bank-full' cross section to be measured from?
- ii) Climatic conditions have changed dramatically over the last 10,000 years. Is the present river responsible for the channel erosion?

Equipment

Metre rule, tape measure, callipers, power's scale, flowmeter or float, clinometer.

METHOD

1. Present flow Cross-section

- Measure water surface width and divide into 10 equal intervals – i.e. divide the width by 10. This will mean that you take 11 depth readings. Your first measurement should be taken directly against one bank and your last measurement should be taken against the other bank.
- At each of the 11 sites measure stream depth.
- Calculate the mean depth.
- Cross-sectional area is calculated by multiplying the width by the mean depth.

2. Bank-full Cross-section

- Measure the width of the channel to its bank-full level.
- Measure the distance from the tape to the water surface. This value is added onto the present flow depth reading (normally once the mean has been calculated). The tape must be held taut and horizontally at bank-full level.
- Cross-sectional area is calculated by multiplying the width by the mean depth.

3. Bedload

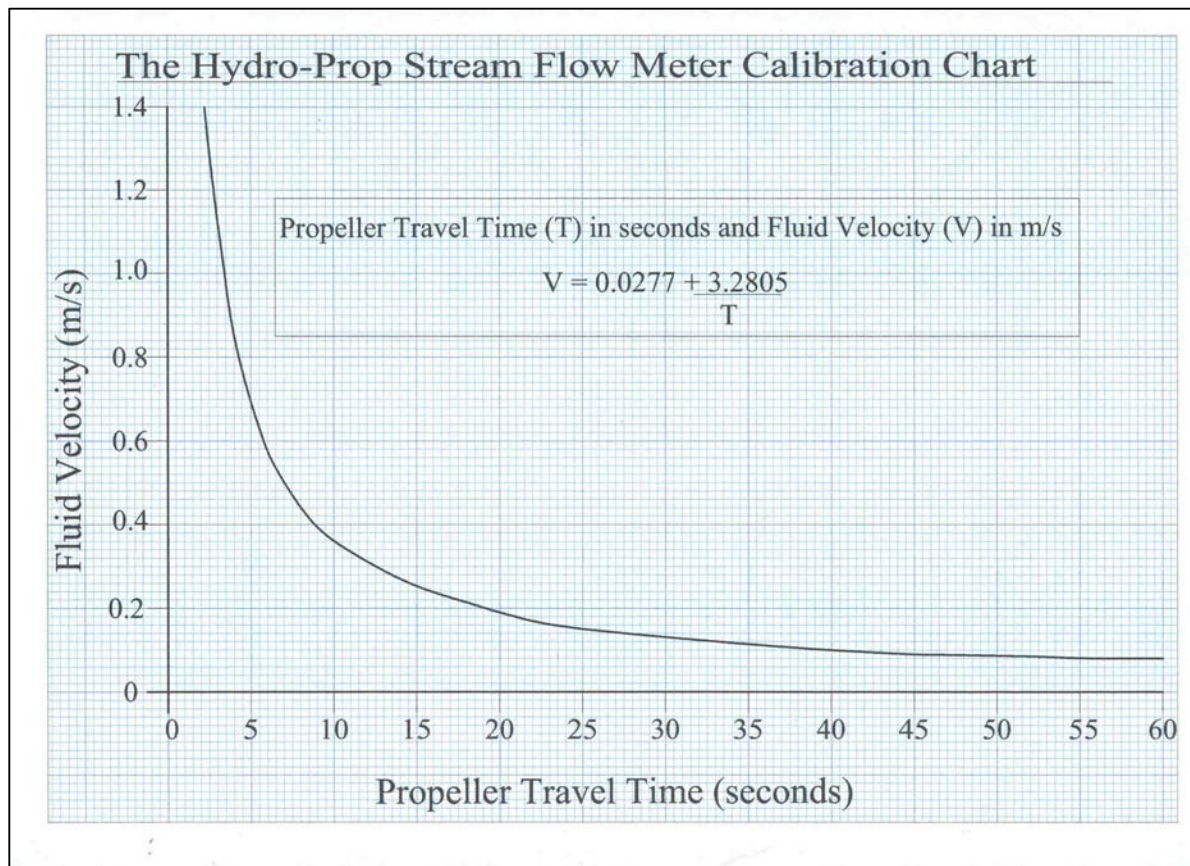
- At 10 equally spaced points across the stream (ideally the same points that you took your depth readings from) measure the width ('b axis') of the FIRST PEBBLE that your finger touches. The width is used as this is considered to be the most representative axis of most clasts in relation to their size.
- Calculate the average size of sediment for the station.
- The shape (roundness) of the clast is compared to a Power's roundness scale.

4. **Gradient**

- Place the ranging poles at either end of a measured stretch of stream.
- Using the clinometer, measure and record the gradient of the stream.

5. **Velocity Using a Flow Metre/Impellor assembly**

- Measure the width of the stream and divide into 4 equal intervals (this will provide 3 measuring points – $\frac{1}{4}$, $\frac{1}{2}$, & $\frac{3}{4}$ across the channel).
- At each of these 3 points measure the velocity –set the impellor at $\frac{1}{2}$ of the water depth and ensure that it is pointing upstream. Make sure that you stand downstream of the impellor when taking readings!
- Record the time taken for the impellor to move from start position to finish position.
- Calculate the velocity using the formula or chart.
- Calculate the mean velocity for the station.



5. **Velocity using a float**

- Measure out a length of the river.
- Place the float upstream of the first point and release.
- As the float passes the first point, start recording the time. Stop when it passes the second point. (DON'T FORGET TO COLLECT THE FLOAT)
- Repeat the exercise at least three times, recording the time.
- Calculate the average time taken
- Calculate the velocity by using the formula **Distance/Time Taken**

- Multiply this figure by **0.8** to give an average for the water column.

ANALYSIS

Using the Computer Software

- Use the Amflow programme to input the width and depth data. The programme will draw up the cross-sections of the river sites. It will also automatically calculate wetted perimeter and hydraulic radius. By inputting the mean velocity, discharge (cumecs) will also be calculated. By adding information about the site altitude, distance along the river and gradient a long profile will be drawn up. Ask your group leader if you require assistance.

Cross Sectional Area (Hypothesis 1)

By Hand:

- Draw a cross-section of the stream at each survey point. A cross-section is drawn using the width and depth measurements.
- Work out a horizontal and vertical scale for the measurements. The depth axis is normally drawn to a larger scale (known as vertical exaggeration) as this makes the cross section clearer. However take care to avoid producing an over exaggerated section
- Draw a horizontal line to represent the water surface
- Below the line representing the water surface, mark the 10 depth measurements across the stream.
- Join up the points representing the depth of the stream.
- Try to use the same scale for all the cross sections as this will make it easier to compare the differences downstream.
- Ensure the cross-section is fully labelled.
- This exercise can be repeated for the bank full readings.
- Describe any changes in cross-sectional shape and area downstream. Is there any pattern? Try to give reasons for any trends shown. Does one or more of the sites not fit the pattern? Use your site descriptions to explain why this might be so.

Bedload Size and Shape (Hypothesis 2 and 3)

- Tabulate the results that you obtained for each site. Calculate a mean bedload size for each site.
- Calculate a mean sediment shape. Note that this should be taken to the nearest 'whole figure' to reflect that the 'Powers scale' is an index.
- Refer to your site cross-sections and try to explain the changes in bedload across the stream channel.
- Draw a scatter graph (or dispersion diagram) to show changes in bedload size downstream. Do you notice a trend? Why might this be so?

Mean Velocity and Discharge (Hypothesis 4)

Velocity:

- Tabulate your velocity readings and calculate a mean velocity for each site.
- Describe any patterns in changes in velocity across the stream channel. Can you account for these patterns?
- Draw a scatter graph to show how average velocity varies downstream? Does this show the result that you expected? If not, why might this be so?

Discharge:

- The discharge is the cross-sectional area (m^2) multiplied by the average velocity (m/s) and is measured in cubic metres per second (cumecs m^3/s). If you have used the Centre's software then discharge will be calculated automatically. If not, first calculate the discharge as described above.
- Plot a scatter graph to show how discharge varies downstream. Does it show the pattern you expected. If not, why might this be so?
- Discharge is very closely linked with **hydraulic radius**. This is the cross-sectional area (m^2) divided by the wetted perimeter (m). The hydraulic radius for each site is given on your computer print out for each site, or can be calculated by hand. It is an efficiency ratio. The higher the number, the greater the efficiency of the stream channel. What might the relationship be between discharge and hydraulic radius?

Channel Gradient (Hypotheses 5)

- Compare the gradient readings at each of the sites. How do these change downstream?
- Most theories relating to the long profile of a stream suggest that gradient should decrease. Has this happened in your survey? It is actually very difficult to get an accurate reading of gradient in rivers. Why do you think this is?
- Should steep rivers flow more quickly? Is there any relationship between gradient and velocity?

pH and Conductivity

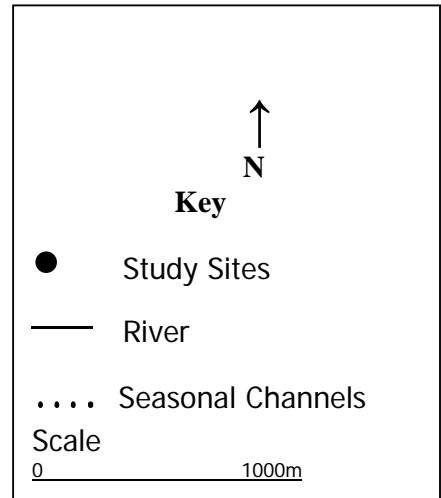
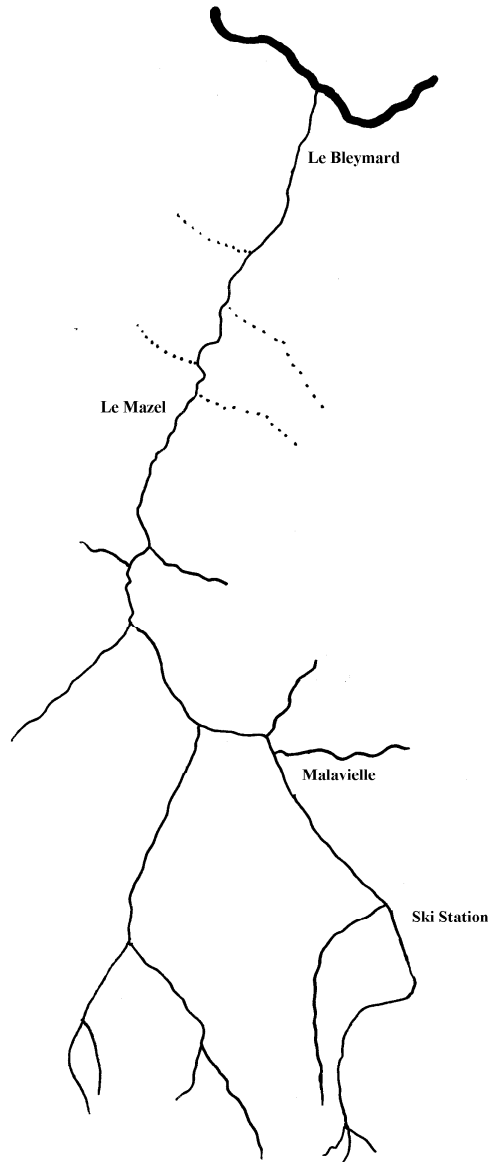
- pH and the conductivity will give an idea about what materials are dissolved in the river. What do your results show? Has the change in geology, from Schist to Limestone had any effect? Could human activity have any effect upon these factors?

POINTS FOR DISCUSSION

Comment on trends and anomalies of graphs and calculations. Particular points to consider might be:

- Problems encountered by the group in carrying out the planned investigations.
- Limitations of the study – length of river, number of samples, methods of sampling etc.
- Ways of improving the accuracy of the study. Which methods are the liable to contain the most errors and can they be improved upon?
- What else may affect the results, for example how do humans impact on the river?
- How would different weather conditions change the results?
- What changes have taken place in pH and dissolved materials? How do these relate to other factors?
- Are the Usclade and Sourde typical rivers? Can it be related to river models?
- Is Le Bleymard at risk from flooding? Why or Why not? Is there any evidence of attempts by people to control or respond to flood risk?

MAP 1: SITE OF STUDY STATIONS



Downstream Rivers Recording Sheet

	Station		Station		Station	
	Present Flow	Bank-full	Present Flow	Bank-full	Present Flow	Bank-full
Width (w)						
Depth (m)		Measure from tape to water surface 		Measure from tape to water surface 		Measure from tape to water surface
		Add to present flow mean depth		Add to present flow mean depth		Add to present flow mean depth
Mean Depth (m)						
Sediment Size (cm) And Shape	Size	Shape	Size	Shape	Size	Shape
Mean Size & Shape						
VELOCITY Distance						
Time Taken						
Mean Time						
Velocity (m/s)						

RIVER INVESTIGATION RESULTS SHEET

It is recommended that this sheet be filled in with pencil so that any errors can be easily changed.

	Station		Station		Station	
	Present flow	Bank full	Present flow	Bank full	Present flow	Bank full
W (w)	m	m	m	m	m	m
Depth (d)	m	m	m	m	m	m
Area (A) (w x d)	m ²	m ²	m ²	m ²	m ²	m ²
Wetted Perimeter (P)		m	m	m	m	m
Hydraulic Radius(A/P)						
	Present flow only		Present flow only		Present flow only	
Velocity (v)		m/s		m/s		m/s
Discharge (Q)		m ³ /s		m ³ /s		m ³ /s
Conductivity		ppm		ppm		ppm
pH						
Gradient (S)						
Sediment Shape						
Sediment Size		cm		cm		cm

RIVER LANDFORMS RECORDING SHEET

Site Number

Distance from Source

Altitude

What River Landforms can you identify in this area?

Draw and label a cross section of the river valley, looking downstream

How are humans affecting the river channel and valley?

ANALYSIS

Compare the cross sections of the valleys and landforms that have been noted at each site. The valley cross sections should be redrawn in neat on graph paper. By reference to the 1:25000 map it should be possible to label the height and width of the valleys. Mark on any land uses identified.

Draw up a table of landforms identified at each site.

- What changes have occurred in the valley shape along the course of the river?
- What landforms are present near the source?
- What landforms are present lower down?
- Does the transition seem to be gradual or sudden?
- Why is this?
- In what areas does the river appear to be eroding vertically (downwards)?
- In what areas does the river appear to be eroding laterally (sideways)?
- Are there any depositional features on these rivers?
- How do these rivers compare to the model of changes along a river long profile?
- Why are there more dry valleys lower down the river than further up?
- How do you think these have been formed?
- Are the changes you have identified because the river has moved along its course or because the geology has changed?
- Have human activity had any effect upon the river landforms or its valley shape?

POSSIBLE PROJECT TITLES

The following are some possible ideas for projects which students can undertake for coursework using data collected in this unit.

- The Usclade and Sourde rivers exhibit the classical model of development forwarded by W.M. Davis.
- How do river channel variables change downstream.
- To examine the relationships between width and depth, and velocity and discharge along a river channel.
- Do streams of different orders exhibit different characteristics?
- Mountain rivers become more efficient downstream.
- Velocity is related more to channel efficiency than to gradient.
- Sediment size and shape are related to velocity.
- Sediment size and shape will change downstream.
- Does velocity change with water depth?
- A comparison of a river channel at bank-full and normal flow conditions.
- Dissolved load and pH are related to geology and land-use.
- Stream channel size and discharge is directly related to the size of basin area drained.
- A comparison of the landforms found on the rivers on the south side of Mont Lozere with a model of river development.

The following titles require more data to be collected either on these rivers or elsewhere.

- Do streams of the same order exhibit similar characteristics?
- Comparison of rivers on the north and south sides of Mont Lozere.
- Comparison of an upland stream with a lowland stream.
- Comparison of a stream on schist with one on granite.
- The mine at Le Mazel is causing pollution on the River Sourde.
- Flooding is a hazard in Le Bleygard.