Paper 1 Physical Core

UNIT 1 Hydrology and fluvial geomorphology

Recommended Prior Knowledge Students require little prior knowledge for this unit. They may have some foundation from earlier studies, such as IGCSE. However it is recommended that the key concept of the hydrological cycle is introduced in the first or second lesson.

Context Although this is a discrete unit, close links exist with all the units that follow, as water is a vital resource without which none of the other physical units could operate. Processes introduced here, such as evaporation and condensation, are fundamental to the whole of physical geography and to some human geography topics.

Outline The unit covers the functioning of the hydrological, fluvial and human aspects of drainage basins.

Recent recommended text Hordern B; Rivers and Coasts; 2006 Philip Allan Updates

Content	Objectives	Terminology	Teaching Strategies (TS) and Activities (A)	Resources
	• Understanding of hydrology • Knowledge of the global hydrological cycle • Understand the distinction between open and closed systems	**Hydrology** **Hydrological cycle** **System** **Open system** **Closed system** **Components: flows/stores/ inputs/outputs**	• **TS** To introduce the idea of a system by analogy. • Open systems e.g. car, computer, domestic water supply. • Closed systems e.g. central heating, air conditioning. • The global hydrological cycle - why a closed system? • **A** Flow diagram Fig. 1 Boxes for stores, arrows for flows. Could be completely blank or partially filled in. Same diagram on OHP or board to be filled in by teacher as discussion with class proceeds and they complete their diagrams. Written definition of global hydrological cycle comprising three ideas 1. Closed 2. Water 3. Scale. May or may not contain volumes of water involved. Useful to suggest climatic variation in volumes of water.	Waugh p.45 Hart OCR text pp.1-2 fig.1.4 Ross et al. p.221 fig. 7.1 Bowen and Pallister p.6 Fig.1 Guinness and Nagle p.1 Fig.1 Prosser, Raw and Bishop p.41 Fig. 1 The Global Hydrological Cycle See Prosser, p.41 Waugh, p.58 fig. 3.1 excellent flow diagram.

1.1 The drainage basin system (a) The hydrological cycle (b) Components of the drainage basin system	• An open system • Appreciate that it is a spatial unit • <u>Know its components - flows stores, inputs, outputs</u> • <u>Understand the links between the components</u> • <u>Each component of the system should be developed</u> • Remember that the channel is an important store and flow within the basin system • Appreciate operation of some of the components e.g. overland flow especially in relation to climatic variations	**Watershed** **Catchment area** **Precipitation** **Interception** **Throughfall** **Stemflow** **Runoff/overland flow** **Discharge** **Infiltration** **Throughflow** **Percolation** **Baseflow** **Groundwater** **Recharge** **Water tables** **Springs** **Evaporation** **Evapotranspiration** **Gauging station** **Saturated overland flow** **Hortonian or infiltration excess flow**	• **TS** Teacher uses an OHP or board to build up the drainage basin diagram with class. • **A** Compile a cross-sectional diagram or flow diagram of a drainage basin. Fig 2 The pictorial version may be easier to appreciate than the flow diagram. Outline of surface, soil, rock, water table could be given or done from scratch. Sun, vegetation, urban areas, water bodies and river channel added. Different colours used for flows, stores inputs and outputs to distinguish them. Students could be introduced to flow diagram as consolidation. • **A** The component groups of flows, stores, inputs and outputs could be coloured. • **A** Written definitions of the processes. • **A** A written account of the drainage basin system. • The concept of discharge needs to be introduced at an early stage. • **TS** and **A** Details of all the processes at work within the system and factors that influence those processes and the inter-relationships between the processes, e.g. soil moisture affects infiltration capacity, etc. **TS** Relationship between infiltration capacity and rainfall intensity is significant in producing different reasons for overland flow. If infiltration capacity is greater than rainfall intensity then the stores will fill before overland flow occurs. This situation is typical of humid climates, e.g. UK. This type of overland flow is known as saturated overland flow. If rainfall intensity exceeds infiltration capacity then Hortonian (or infiltration excess flow) flow occurs. The water cannot enter the ground so it runs straight off the surface. This occurs in arid and semi-arid environments where the rain is intense or in areas of impermeable surfaces.	**June 2007 and Nov 2006** have useful diagrams to use as teaching aids. Hordern p.1 flow diagram. Fig 2 Flow diagram of the drainage basin system Hart pp.5-7 Good pictorial diagram fig. 1.13 p.7 Ross et al. pp.222-224, good cross sectional diagram p.224 Bowen and Pallister pp.7-10 Guinness and Nagle p.2 Good definitions of components of interception. Prosser et al. p.44 , a useful diagram fig. 2.8 Hordern p.3 changes in flows during a storm, is useful as a teaching aid. Nagle p.61 Good cross section and definitions Ross et al p.224 useful practice questions p.19 Hart passing reference but no detail **June 2007 Q. 1** Questions on flows and stores are popular in both **Sections A and B** of 9696/01

1.2 Rainfall - discharge relationships within drainage basins	• Understand how a drainage basin responds to a given input of rainfall • Ability to draw a hydrograph (labelled well) • Understand the storm (flood) hydrograph		**TS and A** Begin with a theoretical diagram of the storm hydrograph. Label fully including the axes. Give some data and a graph can be constructed. **A** This could be reinforced by a "living graph" exercise – give students a basic outline of a hydrograph with a series of explanatory captions which need to be inserted/attached around the diagram. This can be very effective way of promoting discussion of the relative influence of different processes as well as a possible revision exercise. This could then be developed to look at the effects of different factors.	
	The factors that influence the hydrograph of a river	**Storm hydrograph** **Lag time** **Rising limb** **Falling limb** **Peak** **Baseflow separation line** **Flashy hydrograph** **Attenuated peak**	A range of different hydrographs could then be shown as a springboard to discussion about the factors which influence the nature of hydrographs.	Hordern pp. 5-9 Good introduction to the factors that influence hydrographs.
	• Understanding of factors • Knowledge of a range of factors • Understanding the inter-relationships between the factors • Knowledge and understanding of land use changes and their effects on inputs, outputs stores, flows in the drainage basin and hydrographs	**Land use** **Rainfall duration and intensity** **Drainage density** **Porosity** **Permeability** **Aquifer** **Wilting point** **Field capacity**	**Drainage basin characteristics**: size, shape, drainage density, soil moisture, rock type, slope, vegetation, land use. It is worth emphasising that shape is a factor when area is the same. Attenuated response in elongated basins whereas flashy in round ones. Case studies could be effective in illustrating these general principles. **Suggested Extension Study**: Detailed drainage basin morphometry in terms of bifurcation ratios, etc. (This is not essential as it is not specified in the syllabus.)	Prosser p.48 Ross et al p.229 Fig. 3 Bowen and Pallister p. 14 Waugh p.61 Nagle pp. 62-3 Fig.3. Storm hydrograph

	Appreciate annual hydrographs/river regimes		**TS** Introduce the idea of **permeability**: ability to transmit water and **porosity**: volume of pore space. The two are linked via the connectivity of the pore space. If the pores are interconnected then the rock/soil may be porous and permeable e.g. sandstone. If the pores are tightly packed water holding is possible but transmission is very slow e.g. clay. Optional - Introduce idea of a pervious rock which is one which is permeable via joints and bedding planes. • Clays are porous but not permeable, • sandstones are porous and permeable, • chalk is not as porous as clay and is permeable, • limestone is pervious, but not porous. Analogies can be used like sponges - real and synthetic and sieves. Links to water tables, aeration zone and saturation zone. Study a range of annual hydrographs/river regimes to appreciate the impact of climatic variations on discharge, e.g. comparison of Mediterranean, arid, cool temperate, alpine hydrographs can be instructive. The important aspect here is how these factors and combination of factors influence the nature of the response of the river. Therefore they should be studied together with a selection of hydrographs. Develop ideas of how changes in these factors cause different responses and changes to the volumes and nature of the flows. Human activities are a significant factor in	Prosser p. 49 has a good detailed table of factors Ross, p.230, example p.231 Hart p.24 has a summary table Waugh p.62 Waugh pp.65-6 Ross pp.236-7 Nagle pp.83-86 Waugh p.63 Hart p.14 Prosser p.46

			influencing hydrographs. It may be useful to include human activities in this section as well in terms of river basin management (**1.4**). Equally, human activities could be considered in that section only, e.g. land use changes such as deforestation, afforestation, pasture to arable farming or vice versa, dam and reservoir building, urbanisation - concrete surfaces are impermeable hence their inability to transmit water therefore increased surface runoff. Make sure students can develop a full explanation, rather than assuming that it can be assumed that concrete is impermeable. Water abstraction and water quality should be consideration either as part of a relevant case study or in general terms. Depending on the river basin chosen, political factors may be relevant where the river crosses international boundaries.	Nagle pp. 64-5 has very good detailed diagrammatic visual material on urban hydrology. Also good on deforestation p.69 and dams p.68. Waugh p.100 Prosser p.51 Ross pp.232-3 Hart p.28 Waugh pp.69-70 Waugh p.72 For data on UK drainage basins, try the National Water Archive at www.nwl.ac.uk/ih/nrfa/river_flow_data Also hydrology web on http://etd.pnl.gov.2080/hydroweb.html For rivers and dams, try www.im.org/basics/ard
1.3 River channel processes and landforms The channel as a system			**TS** In discussion with the group, the basic ideas and concepts can be introduced. • Revise the concept of a system - inputs outputs, flows, discharge. Idea of moving water because of gradient, therefore energy to carry out work.	Ross et al. pp.241-3 This is a good source with practical exercises on hydraulic radius and channel efficiency Nagle pp.79-81

	Dynamic equilibrium • Knowledge and understanding of channel variables • Relationships between the variables	**Gradient of channel bed** **Load - capacity and competence** **Discharge** **Velocity** **Channel efficiency** **Channel roughness** **Capacity** **Competence**	• Ask what the work would be in a channel. • Introduce idea of dynamic equilibrium with respect to a river channel, i.e. adjustment of channel bed to transport its load. • Suggest that there would be a changing dynamic downstream as a result of a number of aspects of the channel which vary, i.e. variables. • What are they and how may they change downstream? • Discharge. Define and use as a springboard for discussion of cross sectional area which links directly to hydraulic radius via wetted perimeter. Look at two or three comparative diagrams of cross sectional area. Introduce idea of how variable discharge can influence channel efficiency by changing the level of water in the channel. (This idea will be picked up again in relation to landforms like braided channels). • The other variables can be discussed once this has been understood, to form the foundations of the succeeding sections on process and form • Channel roughness • Gradient • Velocity • Competence • Capacity • Friction/flow characteristics **A** To reinforce all these ideas fieldwork or use of a sand tank would be ideal. However if this is not	Hordern part 3 pp.21-30 Nagle p.103

		Flows - laminar, turbulent, helicoidal	possible then discussion of measurement in the field in theory can aid understanding, e.g. difficulty of measuring discharge in low / high flow conditions. Use of orange peel and cork versus flow meters in terms of accuracy and practicality.	
	Fluvial processes Knowledge and Understanding of processes of erosion transportation and deposition • Direction of erosion	**Abrasion/corrasion** **Corrosion/solution** **Hydraulic action as erosion and transportation** **Traction** **Suspension** **Saltation** **Entrainment** **Critical erosion and deposition velocity** **Bed load** **Solute load**	At the outset emphasise that these processes are influenced by the dynamics of the channel, interrelate and produce landforms which will be the next section of the work. Result from the energy possessed by the river. For processes of erosion, most authorities consider that abrasion and corrasion result from the action of the transported load. The load is the tool for erosion. Closest analogy 'like sandpaper'. Assists in undercutting and bank caving. More especially linked to turbulent flow and potholes in river bed. Hydraulic action sheer power of water. Cavitation is the implosion of gas bubbles in turbulent flow causing shock waves and weakening the banks of the channel in particular. Both processes lead to bank caving. Vertical, headward and lateral erosion should be covered, either here, or in connection with landform development. Processes of transportation can be done easily by means of one diagram, which shows traction/bed load, saltation, suspension and solution.	Erosion Nagle p.87 Prosser p.54 Ross p.240. Good exercises pp.242-244 Bowen and Pallister p.19 Waugh pp.72-3 Contains a good case study of the Afon Glaslyn, Wales, UK. There is a video to go with it. Bowen and Pallister p.20 Nagle pp.88-91 Bowen and Pallister p.21 Prosser p.55 Ross p.240 Fig. 5 Hjulstrom curve Waugh p.72 Bowen and Pallister p.21 Ross p.241
	• Hjulstrom curve - link between process and load		**TS Hjulstrom curve** Fig. 5 Begin with a diagram of the graph. Emphasise what it demonstrates via the axes of the graph. Explanation can be done by	Nagle p.95, good whole page spread

	The nature of channels Link between process and form • Straight • Meandering • Braided	**Floodplain** **Braided channel** **Eyot** **Meander** **Pool** **Riffle** **Flows - laminar, turbulent, helicoidal**	annotating the graph, highlighting critical erosion and deposition velocities in relation to fraction of the load. Reasons why clay needs such a high velocity when they are such small particles. Distinguish between entrainment and settling location of these curves on the graph. Entrainment (ability of the river to transport material) is the velocity line between erosion and transportation and the settling velocity marks the division between transportation and deposition **TS** Use survey maps of Zimbabwe (Victoria Falls) (**June 2004**) and Port Antonio (**Nov 2007**) and **June 2006 Q. 1** as teaching tools. Very useful. For meandering channels and floodplain characteristics. Discussion can focus on the contrasts and reasons for the contrasts. Conditions under which each occur, e.g. braided channels found in areas of variable discharge and large loads, whereas gradient variation causes meandering channels	**June 2006 Q. 1 Fig. 1** is an aerial view of a flood plain. Prosser p.62 Nagle p.93 very good on meandering channels Ross p.248 ‘The Great Meander Debate’ contains useful graph correlating bankfull discharge and channel slope and plots meandering and braided channels. This has been used as stimulus material in examination questions. Geofile 529 Sept 2006 River channels fieldwork Waugh pp.75-80 Bowen and Pallister pp.23-31 Ross pp.245-252 Prosser pp.58-65 Good floodplain diagrams Ross p.257 and Prosser p.64

	Landforms Classification according to processes of formation • Erosional forms - waterfalls, gorges • Meander characteristics • Depositional - point bars, floodplains, levées, alluvial fans, deltas	**River cliff** **Slip-off slope** **Point bar** **Waterfall** **Plunge pool** **Rapids** **Gorge** **Bluff** **Floodplain** **Levée** **Cut-off/ox-bow lake** **Alluvial fan** **Delta**	Description, explanation and an example or examples of these landforms is needed. Annotated diagrams can be a useful way of condensing the material. The floodplain with its assemblage of features can be considered as a section of work. This could be a way of creating the link between the geomorphology and the human impact on the physical environment, i.e. the final section of work in this unit.	Geofile 563 Jan 2008 Deltas Hordern part 4 pp.30-45
1.4 The human impact	Floods • Knowledge of causes of river flooding. (The unit is about fluvial processes so examination questions refer to river flooding as opposed to flooding by the sea.) • Understanding of effects. Floods as a hazard • Prediction • Prevention • Amelioration • Management	**Bankfull discharge** **Overbankfull discharge** **Recurrence interval**	Flood risk, prediction in terms of measurement like recurrence intervals. (Prediction is often given insufficient attention and it may be examined in its own right). Factors such as global warming and climate change could be covered as factors influencing	Nagle pp.100-1 Causes of floods Guinness and Nagle p.18 Bowen and Pallister p.32 Ross p.259 Flood prediction Hart pp.29-30 www.pbs.org/wgbh/nova/flood/deluge.html Prosser pp.68-73 Good on soft engineering p.71 Management - Guinness and

		Hard engineering **Soft engineering** **Management strategies - wing dykes, levées, etc.**	prediction and management. Inadvertent changes versus management strategies, which are part of possible amelioration, could be considered. **TS** A case study would be the obvious way. River basin management and river channel management. There are many well-documented examples other than the Mississippi. The use of local examples is encouraged. **Hard and soft engineering** techniques. General principles of physical geography could be the starting point for instance, increasing channel capacity, decreasing discharge and then how the engineering schemes can achieve these objectives rather than just a catalogue of measures. Perhaps the catalogue can be the starting point and students are asked what the objective is and then a classification can be drawn up. Emphasise the impact of the human activities upon the physical environment rather than the human activities as ends in themselves, i.e. hydrograph changes, modifications to channel and impact on discharges which then result in floods. The case study could include consideration of human use of, and impact on, flood plains. **Note** Make sure there is an emphasis in the presentation on channel flow, i.e. volume and velocity. Candidates are expected to be able to distinguish between flooding and channel flow and appreciate what flooding is, i.e. over bankfull discharge.	Nagle AS concepts Several case studies. pp.18-34 Also found in AL Concepts and cases pp.249-292 Mississippi and Yangtze. (Internet sites will provide up-to-date material on the Three Gorges Dam scheme) Ross distinguishes between channel and basin management pp.253-268. Hordern Part 5 pp.46-56 Bowen and Pallister Case Studies in LEDCs and MEDCs Severn, UK and Bangladesh 1998 4 further case studies Waugh Mississippi very detailed pp.87-90 Yangtze pp.91-7 Hart pp.31-2 Good on protection measures. **Nov 2006 Q. 6(c)** Flood plain development – risk assessment. **June 2006 Q. 6(c)**