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**SEDIMENT TRANSPORT PROCESSES IN RIFFLE-POOL SEQUENCES AND  
THE EFFECTS OF RIVER REGULATION FOR HYDRO-ELECTRIC POWER  
WITHIN THE NORTH TYNE.**

by

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## **Chapter 2.0**

### **Background Details**

#### **2.1 The North Tyne: Background to the Study Area**

The North Tyne is a gravel/cobble-bed river with a catchment area of 1118 km<sup>2</sup>. There are many tributary streams feeding the main channel of which the River Rede, Tarsset, Chirdon, Houxy and Wark Burns are the dominant. The North Tyne catchment is part of the larger Tyne basin, (catchment area 2927 km<sup>2</sup>) which includes the rivers South Tyne, East and West Allens and Derwent.

Maximum recorded flow on the North Tyne at its lowest gauging station at Barrasford (NY920733) was 730 cumecs in 1955. In 1980 the head-waters of the North Tyne were impounded by an earth core dam at Yarrow, and since 1984, the discharge in the North Tyne has been dominated by river regulation for hydro electric power.

#### **2.2 Geology and Physiography**

The geology of the North Tyne can be described as a South Easterly tilted block of folded and heavily faulted Carboniferous sedimentary rock, intruded by igneous dykes and sills, and overlain by a blanket of glacial drift and Holocene alluvium and peat. At the gauging station at Reaverhill (Catchment area 1007 km<sup>2</sup>) the geology for the catchment is comprised of 61% Scremerstone Coal Series, 20% Lower Carboniferous limestone, 10% Fell Sandstone and 10% other rocks, largely associated with the igneous intrusions of the Carboniferous and Tertiary.

The head-waters of the North Tyne drain the South eastern slopes of the Cheviot Dome, locally rising to 500 m O.D. on Carter Fell. The strata dip gradually westwards away from the Cheviot volcanics towards the Rede valley which follows the line of a syncline between the Cheviot and Bewcastle Domes. The exposed geological series in the North Tyne catchment begins with Devonian Old Red Sandstone which is exposed on the Carter Fells above Carter Bar. These are succeeded by the Lower Carboniferous

cementstones, Fell Sandstones and the Scremerstone coal series, which dominate the North Tyne and Rede valleys.

The igneous intrusions in the North Tyne catchment fall into two broad divisions; the Lower Carboniferous Cottonshope lava flows which are locally exposed on the Southern slopes of the upper Rede valley, and the Late Carboniferous and Tertiary intrusions which are dominated by the Whin Sill in the southern part of the North Tyne catchment, and a Dyke Swarm which outcrop above Kielder.

Overlying much of the North Tyne catchment is a thick deposit of glacial drift. The ice flow responsible for the drift deposits came from the southern uplands of Scotland and the Cheviot ice sheet. North of Bellingham the North Tyne valley contains large quantities of blue-grey boulder clay with local Carboniferous rocks within it. The present channel lies within Pleistocene glacial and fluvioglacial deposits and Holocene alluvium. The latter varies from gravel-cobble facies to fine-grained vertically accreted alluvium which comprises much of the present bank material.

Prior to the construction of Kielder Reservoir the North Tyne flowed through a wide alluvial valley floor, bounded by gravel terraces or haughs. Peel (1941) records the presence of two terrace levels throughout the course of the North Tyne until the confluence with the river Rede. The terraces are fluvial in origin, and occupy a height of between 7-8m and 12-14m above the present channel bed (Peel 1941).

Downstream of the current dam site at Yarrow (GR NY710880) the North Tyne flows South East along the line of strike in the direction of younging as far as the confluence with the river Rede. Brierley (1983) describes the channel upstream of the Rede as falling into the river classification categories of Charlton (1975) and Kellerhalls et al (1976) as "not obviously degrading or aggrading, occasionally confined by the valley wall, and topographically independent". The channel is only weakly sinuous (sinuosity = 1.05) but displays a prominent meander at Falstone (GR NY720877). In general the channel is a wandering gravel bed river, characterized by occasional islands, lateral bars, mid channel bars and a well developed riffle-pool sequence. Palaeochannels exist at several locations along the course, with a prominent example on the right bank at Snabdaugh farm (GR NY786849) dated as last active around c.2400 BP (Passmore, pers

comm). The channel is bordered by trees along much of the course upstream of the Tarsset and Chirdon Burns.

Between Bellingham and the Rede confluence Peel (1941;1949) identifies a significant knickpoint which he attributes to rejuvenation of the channel following isostatic readjustment after the glaciations. Valley slope steepens from 0.00174 for the North Tyne upstream of Bellingham to 0.00265 downstream of the knickpoint to the South Tyne confluence. Valley profiles downstream of the Rede confluence exhibit a marked reduction in floodplain width as the channel becomes confined by discrete gorges and rock bluffs of up to 46m height. The channel gradient is controlled by a series of rock bars and rapids. Peel (1941) identifies terrace remnants and palaeochannels within this reach, with terrace levels peaking at 25-30m above the present channel bed. Historically the reach downstream of the Rede confluence has been more laterally stable, with fewer and temporally less active storage of traction load.

The course of the North Tyne abruptly changes course downstream of the Rede confluence to flow due south, plunging through the Countess Wood and Warden gorges, before discharging into the South Tyne some 42 km downstream of the dam site.

### **2.3 Climate and Hydrology**

The climate of the North Tyne catchment is profoundly affected by the western upland region of the Northern Penines. This produces a temperature and precipitation gradient across the North Tyne catchment. The temperature in the region is generally cool in comparison with the rest of England (July max 19.3 C, February min 0.4 C) and increases from the western uplands to the Tyne valley in the southeast.

Precipitation shows the effect of the western uplands, falling from 1275mm pa to 760mm pa at the confluence with South Tyne (Petts et al 1985). Mean annual runoff is 1026 mm pa, accounting for 82% of the mean annual rainfall, which in combination with the steep relief produces rapid runoff response times to rain events (Hall 1964). Archer (1981) detects little evidence of seasonality in precipitation distribution except for a tendency for a winter maximum in the west and a summer maximum in the east.

Rumsby (1991) in a review of the long term temperature and precipitation records for the Tyne basin identified periods of relatively high precipitation associated with 1898-1916, the 1925-1936, the late 1940's and the mid 1960's. A period of low rainfall is associated with the 1970's. Temperature recorded at the Durham observatory reveals cool periods in 1870-1890 and generally since the 1940's.

In association with the periods of above average rainfall, Rumsby (1991) records distinct periods of increased flood frequency within the Tyne basin during 1740-1790, 1860-1899 and 1940-1965. The intervening periods were characterised by low flood frequencies. The largest flood event in the Tyne basin occurred in 1771 with an estimated maximum discharge at Hexham of 3500-4000 cumecs (Archer pers comm) which compares to the largest recorded flood at the Bywell gauging station of 1586 cumecs in 1967.

#### **2.4 Land-use change in the North Tyne**

The North Tyne valley has always been a region of marginality, situated as it is some 50 km from the largest local industrial and commercial centres. This marginality has affected the development of the land, there has been a post-war emphasis on forestry, water resources and lately, tourism (Newson in press).

The historical development of the North Tyne valley began with isolated settlements of Mesolithic and later, with the improving climate, Neolithic farmers. In the North Tyne catchment settlement was probably restricted to isolated valley-side and floor-sites such as that found at Kennel Hall Knowe (Jobey 1978). Clearance of the forest cover began at this time but only became widespread towards the Iron Age and Romano British periods when settlements and cultivation became permanently established (Charlton 1987).

Following the abandonment of sites during the Saxon insurgences, much of the cleared land degenerated back to forest only to be restored to cleared agricultural land in the 12th-13th centuries (Charlton 1987). As a result of the North Tyne's proximity to the contentious Scottish borders, the settlement has always been subject to periods of decline and rise according to the sway in power of the two kingdoms. The fifteenth and sixteenth centuries were periods of relatively high population in the North Tyne, which is evidenced by the large numbers of fortified Pele towers and Bastles found in the

Catchment was permanently cleared for livestock and cereal production.

Contemporary chroniclers describe a picture of rural depopulation in the 17th and 18th centuries which probably resulted from the deterioration in the climate at this time. The Little Ice Age reduced the settlement pattern in the North Tyne valley to much the same as today, with centres at Bellingham, Tarsset, Falstone and Wark. Subsequent increases in population were associated with Coal Mining, Iron ore production and the construction of the Border Counties Railway in 1855. Nevertheless, the North Tyne catchment witnessed nothing like the massive population increases associated with lead and zinc mining in the South Tyne.

The most significant changes in land use have occurred in response to the marginality and low population density of the upper North Tyne. In the 1930's, the Forestry Commission began the development of Kielder Forest. The period of most rapid growth in afforested land occurred between 1946 and 1964, leading to the present day Border Forest/Wark Forest/Kielder Forest amalgamation that dominates the catchment, with some 40% of the total area under forest whilst the catchment of the reservoir is 75% afforested.

The development of Kielder Forest may have had significant affects on the hydrology and sediment productivity of the North Tyne, since the process of afforestation results in an initial increase in drainage density and sediment yields (Newson 1981; Stott 1984). However, as Rumsby (1991) concludes the effects of land use changes are to enhance the signal produced by climatic change. The large flood of 1955 on the North Tyne may well have been enhanced by the drainage associated with forestry.

The next major land use change to dominate the North Tyne valley is associated with the development of Kielder reservoir, which will be detailed in the following chapter.