GNS #3:

RIVER CAPTURE AND OUTLIERS: SUCCESSFUL AND INCIPIENT.

This article highlights the evolving nature of the Cotswold landscape by examining examples of features which point to the continuing development of the river system and the Cotswold scarp. The processes of landscape evolution are ongoing and continue to the present day. These processes are rapid in the context of geological time, but in the context of human history they are (with some exceptions, e.g. landslides, tsunamis) very slow – rather like observing a frozen frame in a War and Peace – length movie. So, whilst it is possible to identify the beginnings of river capture, or scarp erosion and outlier formation, it is very unlikely that anyone alive today will actually see these events come to pass. It is instructive to consider them, however, because they provide an insight into the processes that must have acted to form the landscape we see today. There is a famous geological saying "*The present is the key the past*", but it also works in reverse, so "*The past is the key to the present (and future)*".*[1]

Whereas the first two papers in this series were founded upon a combination of my own ideas with concepts and research derived from the technical literature, this paper comprises rather more of the former and rather less of the latter, so it does come with an element of 'health warning'.

The concept and mechanisms of river capture and outlier formation are well established in the literature with examples from all over the world:-

- *River capture* is the process whereby the headwaters of one river are 'captured' by another river which intercepts its course, and thus diverts the headwaters of the first river down the course of the second river, leaving the downstream part of the first river beheaded and much reduced.

- An *outlier* is defined as an area of younger rock (usually forming a hill) completely surrounded by older rocks. They form when sufficient erosion occurs to sever the original continuity of the younger rock from a larger mass of the same younger rocks nearby.

---

[1] This is why so much current research is focussing on the Greenland and Antarctic ice caps, and the data they provide on the variations in climate and atmospheric composition during the Quaternary, because this will give us an indication of what effect rising CO2 and CH4 levels in the atmosphere will cause by way of global warming and sea level rise.

Starting with outliers: the outliers of the northern Cotswolds are well developed (Fig. 1), and they form distinctive hills detached from the main escarpment and rising from the adjacent vale (Fig. 2).

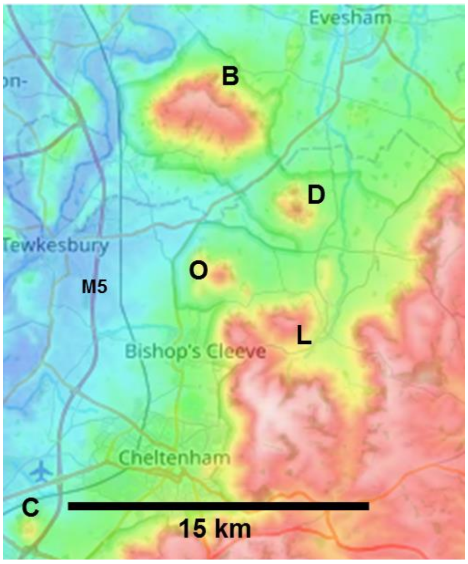

Fig. 1: Digital elevation map showing the location of outliers of the northern Cotswolds. (Reds = high ground; blues = low land).
C = Churchdown Hill; L = Langley Hill; O = Oxenton Hill; B = Bredon Hill; D = Dumbleton Hill.

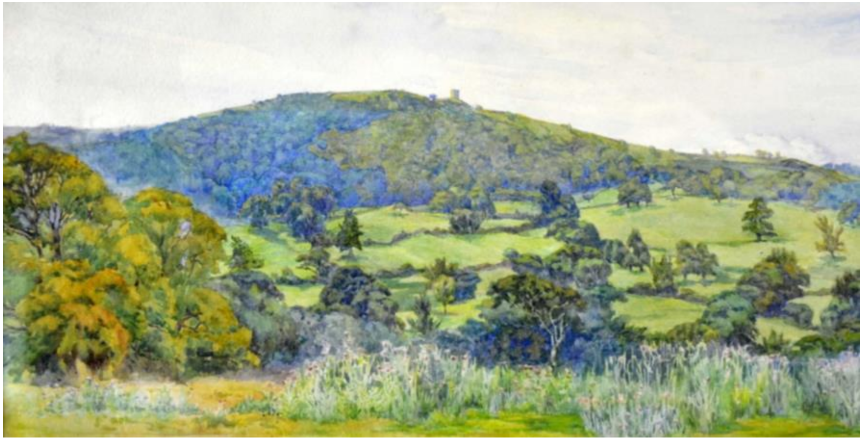

Fig. 2: View to Bredon Hill, by Frank Harper (watercolour)
www.mutualart.com/Artwork/Bredon-Hill/957CD30D72C49147

The outliers are capped by Middle Jurassic Oolitic Limestone and surrounded by the older Lower Jurassic Liassic shales and Triassic mudstones which floor the vales (Fig. 3). The outlier hilltops provide expansive views over the vales, and consequently are often the site of prehistoric hill forts, but now are sparsely settled.

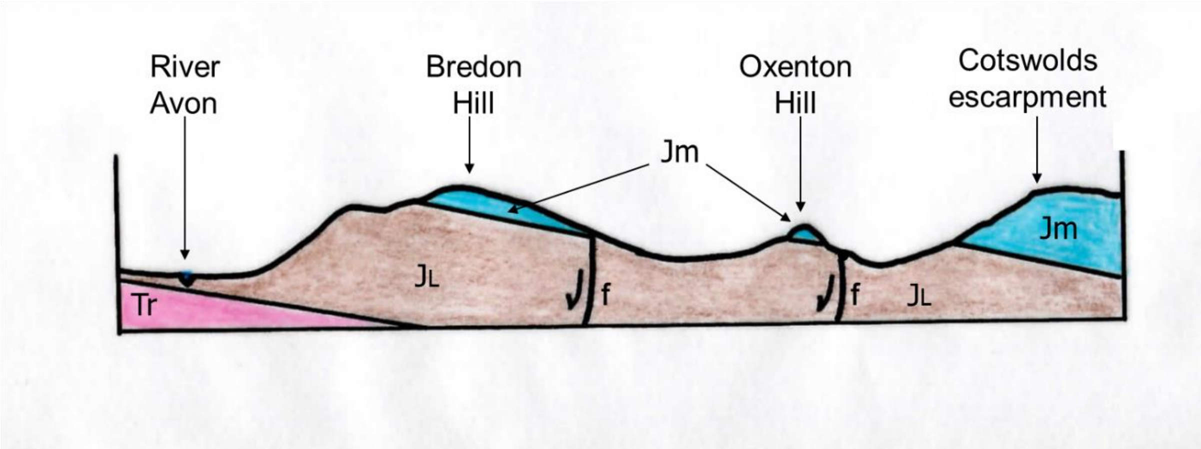

Fig. 3: Sketch section from the Cotswolds escarpment NW-wards to the R. Avon, showing the outliers of Bredon and Oxenton Hills, capped with Middle Jurassic limestone (blue), and surrounded by Lower Jurassic shales and mudstones (brown). The section is broken by 2 faults (**f**) which downthrow to the NW (as indicated by the single-headed arrows) and successively lower the limestone / shale contact from south to north.
Redrawn from https://deeptime.voyage/bredon_site3/

The outliers also provide an indication of former positions of the limestone escarpment. Farrant et al (2014) estimate that the Cotswolds scarp has retreated ~0.6 km in the last 350 ka (i.e. 350,000 years), and ~5 km since the Jurassic rocks were first exposed from below the sub-Cretaceous unconformity some 2-3 million years ago.

This process of outlier formation continues to the present day, largely due to the high energy nature of the streams which flow down the scarp. These incipient outliers, which are still in the process of formation, are exemplified by Nottingham Hill (Fig. 4) which lies just north of Cleeve Hill, across the B4632, and which has been almost separated from the

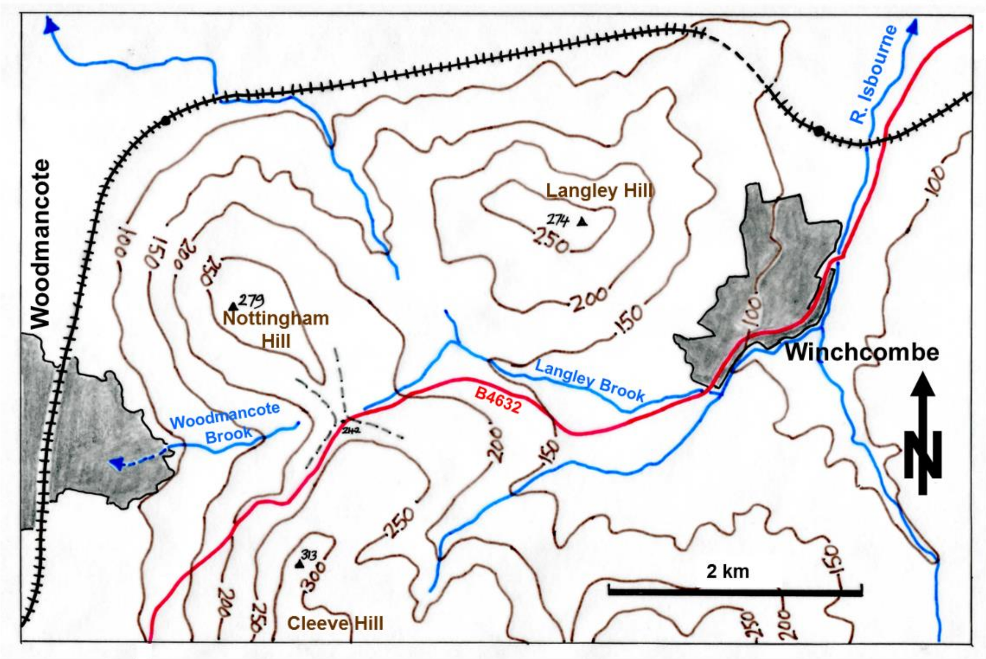

Fig. 4: Nottingham Hill – almost an outlier. Woodmancote Brook and Langley Brook have not quite succeeded in separating it from the main Cleeve Hill outcrop.

main escarpment by the headward erosion of Langley Brook from the east and Woodmancote Brook from the west. However, it is unlikely that the processes of erosion will be permitted to fully separate Nottingham Hill from the main mass of Cleeve Hill because this would impact the integrity of the B4632 roadway, and the housing adjacent to it.

Further south along the Cotswolds escarpment are more outliers (e.g. Robinswood Hill and Churchdown Hill on the edge of Gloucester), and incipient outliers (e.g. Haresfield Beacon, almost completely separated from the main escarpment by the Painswick valley, and Stinchcombe Hill, west of Dursley, which is just joined to the main outcrop by the narrow ridge of the Whiteway (A4135)).

Now turning to river capture:

Over the last 2.6 million years (Quaternary period), multiple glaciations in England have had profound effects on the landscape, through the damming, diversion, creation, and destruction of major river systems. This has already been discussed in the first paper of this series (Jeans, 2020a), in which it was shown that the present-day drainage system of the Cotswolds is basically the beheaded remnant of the old, pre-Anglian river system. However, in some areas, more recent, post-Anglian, erosion has caused adjustment to the inherited drainage system.
An example of this younger river capture lies in the Sapperton area (Figs.

5, 6), whilst an example of incipient capture and beheading lies in the region of Sandywell Park, near Andoversford (Figs. 8, 9).

The Sapperton example is proposed as a two-phase evolution of the river system. Initially, a major pre-Anglian river flowed from Mid Wales to the Cotswold Water Park – Lechlade area and beyond, following a course suggested by the present-day Upper Wye – River Leadon – Holy Brook – River Thames (Fig. 4).

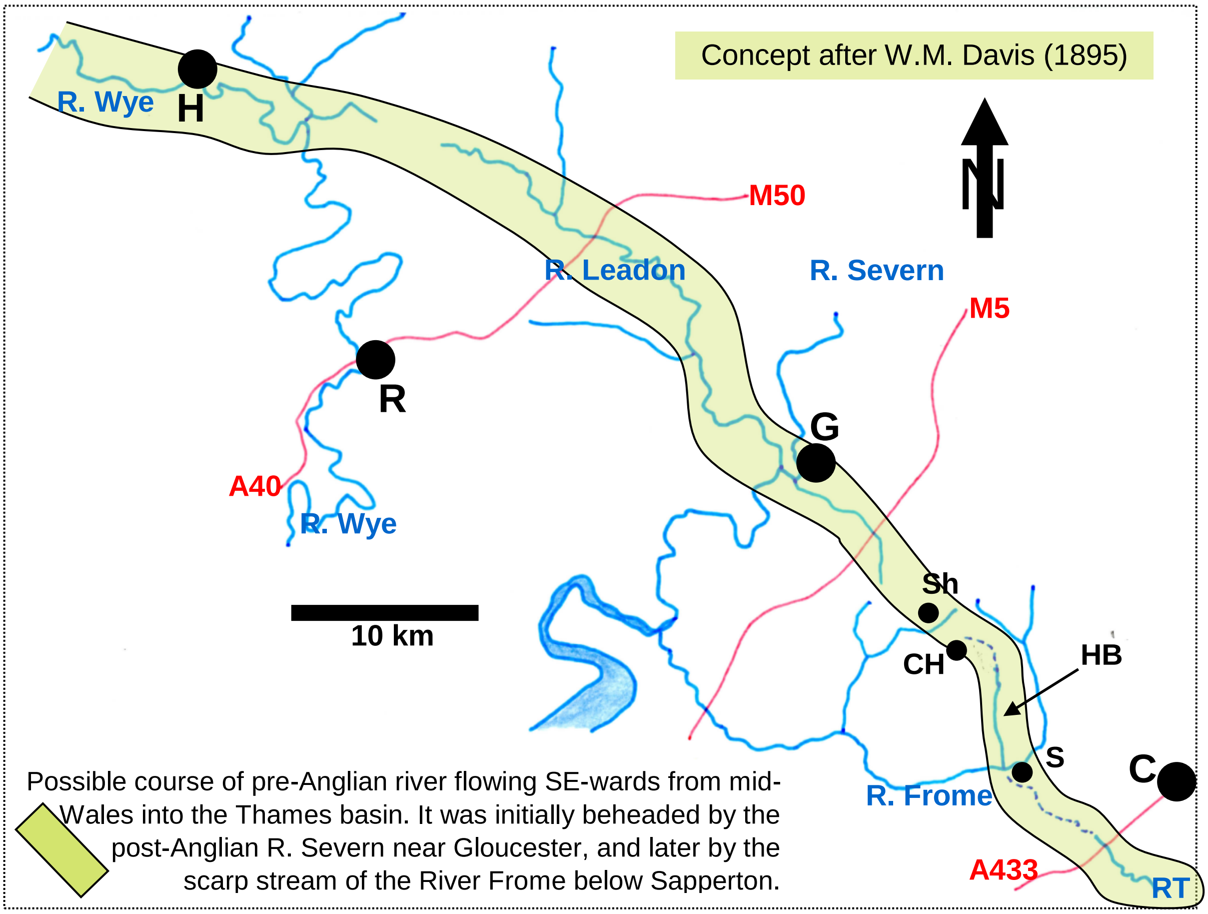

Fig. 5: Sketch map of the Gloucestershire – Herefordshire area, showing the present drainage pattern, and the possible course of a pre-Anglian river which could have flowed from Mid-Wales into the Thames Basin, and in doing so could have carved the initial course of Holy Brook and the Sapperton – Thames Head dry valley. H = Hereford; R = Ross on Wye; G = Gloucester; C = Cirencester; S = Sapperton; CH = Cave Hill; Sh = Sheepscombe; HB = Holy Brook; RT = River Thames

This river was beheaded by the River Severn in the vicinity of Gloucester after the Anglian Glaciation (~400 ka BP) which left a truncated ancestral Thames rising somewhere upstream (NW) of Sheepscombe and flowing via the ancestral Holy Brook past Sapperton and down into the Upper Thames basin. A second beheading event occurred (possibly after the last glaciation (15-20 ka BP)) as the high energy scarp stream of the

River Frome cut its deep valley back eastwards and captured the headwaters of Holy Brook (Fig. 6).

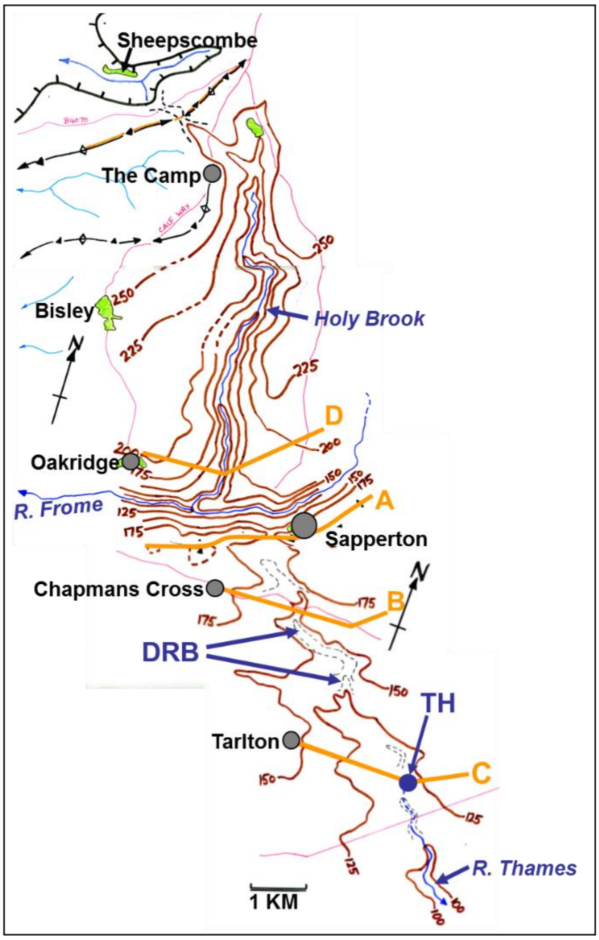

Fig. 6: Sketch map of the Sheepscombe – Thames Head (TH) area, showing the course of Holy Brook, and the Dry River Bed (DRB) of the palaeo-Thames above its source at Thames Head. A, B, C, and D are the locations of cross-sections shown in Fig. 7.

What is left of this twice-truncated river now rises at Thameshead, upstream of which is a pronounced dry valley which climbs gently NW-wards towards a low saddle just SW of Sapperton. Comparison of the cross-sectional profiles of the dry Thames valley (A, B, C, Fig. 7) with the cross profile of Holy Brook (D, Fig. 7) shows just how effective the deeply eroding River Frome and its tributaries have been since this second capture event. A possible pre-capture shape of the Holy Brook valley can be postulated (dotted line in Fig. 7) which would have linked up with the ancestral Thames valley running down to Thameshead and beyond.

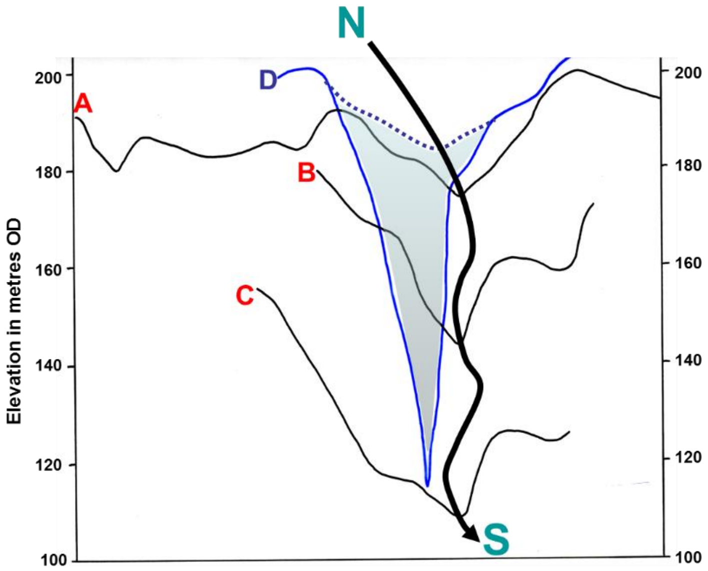

Fig. 7: A,B,C, = series of cross sections over the dry Thames valley from Sapperton (A) to Thames Head (C). Profile D runs across the Holy Brook valley. For location of profiles, see Fig. 6. The blue dotted line represents the possible shape of the palaeo-Thames valley in the area North of the present-day Frome valley. The heavy black arrow represents the North-South course that the palaeo-Thames could have followed before it was beheaded by the River Frome. The blue shaded area represents the amount of rock which has been eroded by the Holy Brook after the Frome beheaded the palaeo-Thames, i.e. Holy Brook has cut down rapidly to keep pace with the deeply-eroding River Frome.

It is believed by many authors that rivers became much larger and more powerful during the transition from cold glacial periods to warmer periods because of:-

1. Much greater discharge due to more intense spring snow melts
2. Much higher run-off because of the lack of vegetation, and
3. A lack of soak-away into the limestone because the ground was frozen (permafrost).

This could explain the dramatic incision by the River Frome and the deepness and steepness of its valley and those of its tributaries.

From a historic example of river capture to an incipient example, at Sandywell Park, which forms the watershed between the River Chelt to the west and the River Coln to the east (Fig. 8). As shown by the W-E cross-section along the A40 (Fig. 9), the Chelt has the deep, steep valley characteristic of scarp streams, whereas the land to the east of Sandywell Park slopes down gently to the valley of the Coln. If the River Chelt was able to continue actively downcutting, it would eventually erode its way back through Sandywell Park and then to capture the headwaters of firstly, Whittington Brook, and secondly, the Coln just below Syreford, a distance of less than 2km. This would leave a truncated Coln to rise somewhere in the Shipton – Foxcote area.

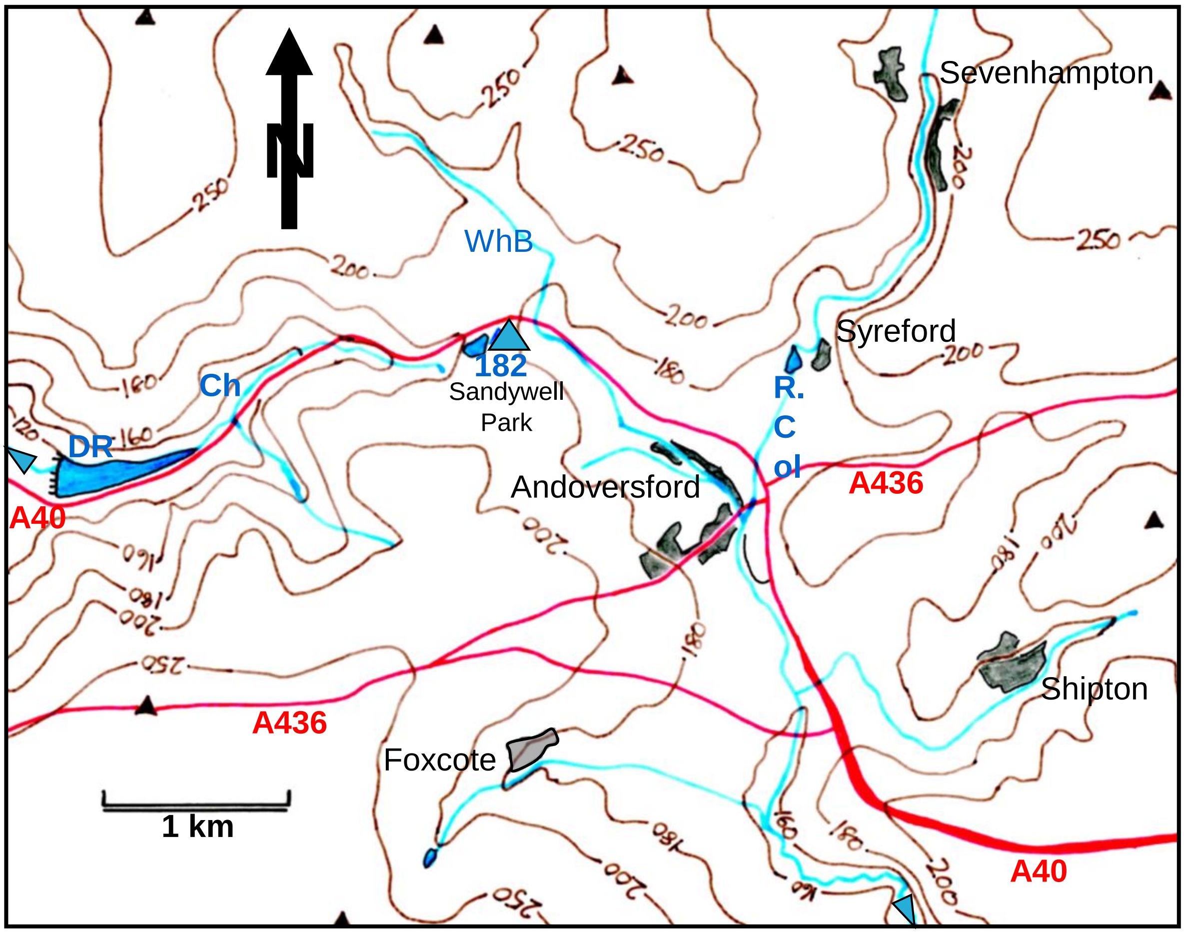

Fig. 8: Sketch map of the R. Chelt / R. Coln watershed, showing the area between Dowdeswell and Andoversford. The steeper, more active R. Chelt could cut back eastwards and capture the headwaters of both Whittington Brook and the R. Coln. DR = Dowdeswell reservoir; WhB = Whittington Brook; Ch = River Chelt.

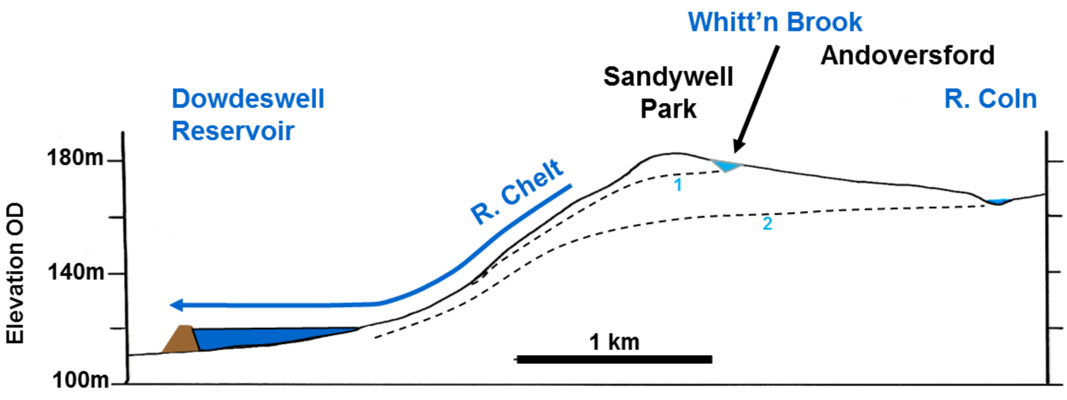

Fig. 9: W-E sketch cross-section along the A40 road from Dowdeswell to the R. Coln at Andoversford showing how close the headwaters of the R. Chelt are to

the R. Coln in elevation, and the potential for future river capture, i.e of Whittington Brook (1), and the R. Coln (2).

The operative word in the previous paragraph is 'If': the valley of the Chelt has been constrained and culverted firstly by the railway and then by the improvements to the A40, such that its ability to freely erode its bed is now minimised, and so the incipient capture described above is unlikely ever to occur (unless Cheltenham runs low on water).

Pete Jeans (Ph.D. (Geol))

Email: pete.jeans2@gmail.com

www.pj-exploration.co.uk

Acknowledgements: I would like to thank Robin Lauckner, Tom Prudence, and Bob Thompson for their comments, which greatly improved the clarity of this paper.

References:

Davis, W.M. (1895) The development of certain English rivers. Geogr. Jl. **V**, 127-146

Farrant, A.R. and 4 others (2014) Speleothem U-series constraints on scarp-related retreat rates and landscape evolution. Jl. Geol. Soc. **172**, 63-76.

Jeans, P.J.F. (2020a) The Thames story and its ancient Plateau Gravels. GNS News, Sept. 2020.

(2020b) Wind Gaps, and the contrast between Scarp and Dip Streams. GNS News, Dec. 2020.