Endrick Water, Stirling

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Highlights

Small-scale, active meanders, which have not been subject to extensive engineering, are well displayed in the lower reaches of the Endrick Water. Lateral migration of this river over hundreds of years has generated a series of cutoff channels which are now steadily becoming infilled by sediment.

Introduction

The British Lowlands often display rivers with small-scale active meanders that are no longer evolving naturally because of engineering schemes, which have sought to confine channel migration. Sites at which this has not occurred, thereby allowing the river and its adjacent floodplain to develop unhindered, are comparatively rare in the lowlands. One such site is the Endrick Water, draining the Campsie Fells and flowing into Loch Lomond. This river, in its lowest reaches, provides an excellent example of an active, small-scale irregular to tortuous type of meander development (Kellerhals *et al.,* 1976) unimpeded by large-scale river engineering. It also illustrates modes of channel migration across a floodplain over the past 220 years. Past study of fluvial processes at this site has concentrated on the macro-scale study of channel planform adjustment, including the formation of an oxbow channel (Brazier and Werritty, 1992) and the micro-scale monitoring of facies change, especially the structure and origin of the channel sediments (Bluck, 1971).

Description

The site comprises the Endrick Water downstream of Drymen Bridge and that part of its floodplain which lies below the 15 m contour. This section of the floodplain is subject to frequent overbank flooding, particularly during the winter months, partly as a result of the base-level control exercised by Loch Lomond, into which the Endrick Water flows.

A history of channel change has been compiled by Brazier and Werritty (1992) from historical maps (estate plans from the 18th century, the Six Inch Ordnance Survey County Series for 1861 and 1896 and National Grid Metric 1 : 10 000 Edition for 1966) and aerial photographs. These sources reveal progressive channel change over 200 years, confined to a meander belt no wider than the amplitude of the present-day meandering system. Within this active area of the floodplain, the following distinct types of channel behaviour have been identified over a period of 200 years in four reaches (Figure 2.17) between Drymen Bridge and the outflow into Loch Lomond:

1. progressive migration associated with increased channel sinuosity, the series of meander loops becoming more tortuous;
2. channel cutoff, abandonment and infilling;
3. progressive meander migration with no change in channel curvature and shape;
4. little change, the channel being essentially locked into a position within the floodplain which pre-dates the earliest map of 1770.

The floodplain adjacent to each of these reaches records the recent history of channel migration, with meander scrolls (the product of point bar formation and channel migration) being especially well developed immediately below Drymen Bridge. Map analysis reveals that this complex assemblage of ridges and hollows was created by channel migration in a north-westerly direction over the past 200 years. Further downstream, the surface expression of the meander scrolls diminishes, reflecting the lower rates of channel migration and the increasing age of the adjacent floodplain. Nevertheless, there are still a number of oxbow lakes, notably that on Low Mains near the outflow into Loch Lomond.

This particular site demonstrates channel change over a timespan probably far exceeding 200 years.

The most dramatic event in the recent development of the channel has been the creation of a meander cutoff within the highly tortuous channel 1 km downstream of Drymen Bridge (Figure 2.18). Evidence from the accretion topography of the meander scrolls demonstrates a steady northwest migration of the channel coupled with an expansion of the outer bend (Bluck, 1971). This resulted in the convergence of two bends to create a 'neck', which was cut through on 18 October 1983 (Figure 2.18). As a result of channel steepening, the reach immediately downstream of the cutoff has undergone extensive erosion and widening, creating a riffle and concave bench (for details of the processes involved, see Nanson and Page, 1983). The sedimentary environment of the former channel has now become semi-lacustrine. It is not yet a true 'oxbow' lake because the upstream end is still open across a shallow bar to low-stage flows from the main channel. By contrast, the downstream end of the cutoff is infilled by a plug of sands, silts and organic material. Only during high flood stages does this abandoned channel act as a flowing system.

Sediment cores from the downstream plug reveal two distinct sedimentary facies which are locally interbedded (Brazier and Werritty, 1992):

1. *Fluvial sediments* (coarse-grained sand and gravel) derived from material transported by saltation or rolling along the bed, and deposited as the flow competence is reduced in shallow water. Bedforms associated with these sediments include ripples, dunes, and horizontal and vertical cross-strata.
2. *Lacustrine sediments* (silts and clays) derived from fine-grained suspended material subject to differential settling in the ponded water within the abandoned channel. Leaf litter is often interbedded within these fine-grained sediments. Sedimentary structures include fining upward sequences and flat-bedded sedimentary and organic units.

Alluvial deposition adjacent to the active channel is dominated by point bars (Bluck, 1971), although locally concave benches (Nanson and Page, 1983) also form. The point bars are typically compound in form, comprising a relatively stable 'bar platform' (composed of gravel) upon which more transient and finer-grained 'supra-platform' sandy deposits are accreted. Typically the sediment size decreases from a coarse, gravelly bar head to a sandy bar tail. With lateral migration of the channel, point bar units are successively attached to each other, giving rise to a break of slope termed an 'inner accretionary bank' (Bluck, 1971). The best example of a concave bench is to be found upstream of the very tight bend immediately downstream from the 1983 cutoff channel (Brazier and Werritty, 1992; (Figure 2.18)).

Interpretation

The significance of the site can be demonstrated at two contrasting scales. At the macro-scale, the Endrick Water displays a fine example of a progressive change in the morphology of a meandering channel as it approaches a local base level. Channel sinuosity and channel activity both decline as the Loch Lomond outflow is approached. At Drymen Bridge, channel palaeo-forms in the floodplain are particularly well developed, and the progressive lateral migration of the river can be clearly documented from historical maps and aerial photographs. There is also an instructive sequence of abandoned channels (several of which form excellent oxbow lakes) of varying ages, which attest both to the former location of the main channel and rates of sedimentation which arise from overbank floods, notably in the winter.

At a micro-scale, Bluck (1971) has focused on the transportation and size-sorting of gravel and finer sediment, in relation to pool, riffle and point bar sequences along the Endrick Water. The scale of the features studied is smaller than in many other case studies on meandering rivers and their associated rates and styles of sedimentation (e.g. Jackson, 1976), but the scale is appropriate for many UK rivers reported elsewhere in this volume (e.g. the River Dane in Cheshire). In addition to many exam ples of classic point bars, the site also affords a few examples of the less well-known concave bench, few of which have, as yet, been recorded in Britain.

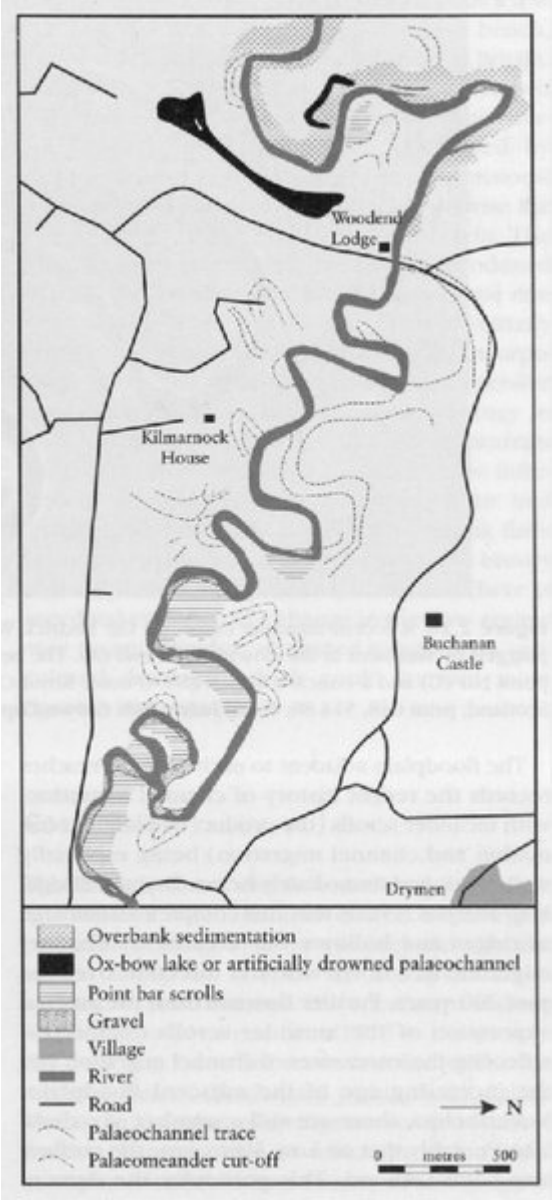
Future research at this site could be developed in a number of directions. Bluck's (1971) pioneering research could be further developed by subsurface investigations of the three-dimensional geometry of the alluvial units which comprise the sedimentary architecture of the floodplain. The existence of a recent, and well-dated abandoned channel, affords an opportunity to study the rate and manner whereby a cutoff channel initially becomes an oxbow lake and is ultimately incorporated into the floodplain. The progressive downstream change in channel morphology in response to the local

base level would also warrant more detailed investigation alongside more information on the gravel-sand transition in bed material. Winter floods supplying overbank fines are an important, but neglected part of the history of floodplain development at this site. There is anecdotal evidence of a change in the flow regime over recent decades, attributed to upstream agricultural drainage, which could warrant more rigorous investigation.

Conclusion

The Endrick Water affords a noteworthy example of a lowland meandering river which undergoes progressive change in its morphology and a decline in its ability to rework its floodplain as it approaches Loch Lomond. Historical maps and aerial photographs extend from 1770 to the present day, enabling a detailed reconstruction of the former positions of the channel within its floodplain. There are a number of well-preserved remnants of former channels, two of which provide classic examples of oxbow lakes, thereby affording opportunities for investigating alluviation at this site over the past 200 years. In the upper reaches, the channel is still actively reworking its floodplain by the formation of point bars and other alluvial landforms such as concave benches. The recent, and well-documented, cutoff of a meander loop in 1983 provides an excellent opportunity for direct investigation of sedimentation processes within an abandoned channel. This site exhibits channel and floodplain features typical of an active meandering river but increasingly rarely conserved; it is also the site of internationally important work on sedimentary structures.

References



(Figure 2.17) Endrick Water: a geomorphological map of point bars, overbank sedimentation, point bar scrolls, oxbow lakes and palaeochannels. (Based on 1988 aerial photographs.)

(Figure 2.18) A recent meander cutoff on the Endrick Water (October 1983). The abandoned channel has been plugged by sediment at the downstream end (A). The neck of the former floodplain (B) is now a riffle between a point bar (C) and a concave bench (D). (Photo: Royal Commission on the Ancient and Historical Monuments of Scotland; print 048, 514 88; flown June 1988: Crown Copyright.)