Geomorphological Site Investigation Report

Report Details

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Date: 17/02/06

Site Visit Details
Project / Job Reference: Woundell Beck Irish Bridge
Date: 16/0206 Time: am
Location: Ennerdale water River: Woundell Beck NGR: NY 13245 13771
Work Undertaken for: Chris Addy Section: FRB Area: North Personnel on site:- Agency: Chris Addy

Extent of Investigation
Site Only:
Full Catchment:
Partial Catchment:- Y Distance U/S of site: 100 m
Distance D/S of site: 200 m

Nature of Investigation
Investigate eroding Irish Bridge crossing.

Findings
Woundell Beck is a tributary of the Liza, and joins the Liza 2 kilometres upstream of Ennerdale Water. Woundell Beck drains the high Lakeland fells of Cawfell and Haycock, and descends steeply from the fell tops in a confined hillside ravine down into the Liza valley. It has high energy and is a boulder-bed, step-pool stream in its upper sections. At the site of interest, the crossing, the gradient lessens as the alluvial and post-glacial material of the wider main Liza valley floodplain is encountered. As such the river in this reach is an active deposition/transport reach, where the sediments conveyed from the upper reaches start to deposit out. Without the constraints of valley sides, the watercourse in this location will have changed direction considerably over time – it is in such locations that alluvial fans are commonly observed.

At the crossing, an Irish bridge has been installed. This consists of four 400 mm diameter concrete pipes overlain by rip-rap, faced with cemented blockstone and capped with concrete (see photos 1 and 2). Further over to the right bank is an additional bypass culvert, consisting of a 1m diameter plastic pipe. There is an erosion and blockage issue associated with the pipes, which requires the Forestry Commission to clear gravel from the upstream side of the crossing, and reinstate the material of the track at numerous intervals over an average year. There is a significant scour pool downstream of the crossing, presumably a result of the flow overtopping the structure once the pipes are blocked. The bridge design would apparently have been to allow sediment and low flows to pass through the culvert pipes and for higher flows to spill over the bridge top. This is not happening for the following reasons :

1) The pipe culvert diameters (both individually and in total) are of insufficient capacity to convey the bed sediment load of the channel. This is a particularly active stream conveying significant sediment size and load. An estimated D_{50} for the bed sediment load (upstream of the bridge – and not influenced by the backwater effect of the bridge which will trap smaller sediment too) is around 250 mm, with an extreme range of boulder size up to 500 mm (see photo 3). This sort of sediment size will not be passed through the pipes. Additionally, the presence of a small branch or stick will easily block the pipes also (as was observed during the site visit).
2) The river is very dynamic at this point and is transporting/depositing/redistributing a significant sediment load within this reach. The rivers dynamic nature means that attempts to control and constrain its planform are likely to be more susceptible to failure. This should be borne in mind even if a viable solution can be found – under an extreme event, it may fail.
3) The angle of the pipes to the river does not aid conveyance. The crossing is actually skewed to the river (rather than perpendicular), which makes the crossing longer, requires more backfill material, and encourage energy pressures on to the right bank (where the skew of the crossing concentrates the energy). The pipes were skewed to discourage (apparently) the river erosion on the right bank downstream, but as a result they discourage conveyance through the pipes. The large pipe to the right looks largely redundant as it appears that sediment regularly blocks would block the entry.
4) The backfill between the top of the culvert level and the concrete bridge deck of around 200 mm is quite significant – it means that overtopping flows have further to fall to the bed on the downstream side, which will enhance the downstream scour (considerable at this location). It also causes more of an obstruction to flow conveyance, resulting in more lateral erosion and sediment accumulation (and further exacerbates lateral erosion).
5) The upstream base level of the pipe culverts look to be slightly higher than the natural bed level. This may have been deliberate to prevent blockage but may lead to increased upstream deposition. It is not as important as an issue as the pipe capacity.
6) The concrete deck does not extend far enough on the right hand side, which allows the uncohesive alluvial material of the track to be washed easily away by overtopping flows.

A workable solution would have to have the following criteria :
a) Allow natural bed load sediment conveyance (including high flow sediment conveyance).
b) Present a minimum cross sectional profile to flow.
c) Minimum disturbance to the natural gradient of the section.
d) Encourage fish migration.

This is most likely achieved by one of three means :
1) Keeping an Irish bridge design but have sufficient capacity to allow sediment conveyance, and have a minimum x-sectional area.
2) Keep the crossing high enough away from the bed to allow flow and sediment conveyance.
3) Go for a low, ford crossing.

Each option will be considered in detail.
The first option would be to use a design approach similar to what was attempted, but would attempt to overcome the capacity issue. This could be achieved by realigning the crossing so that it crossed perpendicular to the river (rather than skewed), and to utilise culvert box sections that have a high aspect ration (i.e. high x-sectional area per supporting material area). These have been successfully installed downstream on the Liza (see photo 4). This crossing is a definite success, judged from: the lack of sediment build up on the left bank (there is some build up but this relates more to the bend than the structure); the conveyance of natural sediments through the structure, as evident from the distribution of bed sediment up and downstream, and the lack of lateral scour or flow diversion, due to the blockstone bank protection, and due to it having a minimal cross section profile; there was also absence of a scour pool downstream, partly due to it having a low deck level and minimum cross section profile, and downstream bed scour protection. It should be noted that the sediment D_{50} at this location is large cobbles (100 mm), and not the large boulders seen on Woundell Brook – which is the reason why the culvert deck can be lower. On Woundell beck, the height of the bottom of the deck above 'natural' bed level would have to be at least 450 mm. The concrete deck of such a solution would have to go further laterally up the right hand bank to avoid the existing track washout problem.

The second option is to get the bridge deck high above the bed to allow sediment and flow conveyance (see photo 5). This would require building up of the approach heights of the road and would require stone pier foundations. The bridge span on photo 5 is 10 m – ideally this would be slightly wider on the Woundell as the natural channel is around 12 metres wide.

For both options, moving the crossing point is a possibility. Upstream of the site by 60 m the right bank shelves up to form a terrace, and the river is more constrained on the right bank, but not the left. An Irish bridge at this site may result in flow being forced to the left and bypass the structure. There are paleo channel and relic flood deposits in this area. This might suite a bridge option though as the right bank would not require raising. It is not known whether a bridge would fit in with the 'Wild Ennerdale' vision.

Detailed design would be required for each option, and other constraints would b have to be accounted for (i.e. wild vision, vehicle passage etc)

If vehicle and foot crossing was not required to the same degree, a ford consisting of concrete blocks (or preferably natural boulders), could also be considered. There is a good example further up on the Liza at NY 19166 12283).

Recommendations
The current solution does not provide sufficient sediment transmission and will require continued maintenance. It is recommended that alternative solutions be investigated, accounting for all the requirements of the crossing, and with the 'Wild Ennerdale' vision. A variety of options may be feasible in this location.

Photos

Photo 1) Irish bridge, downstream looking upstream from NY13257 13778

Photo 2) Irish Bridge, Photo from NY13233 13762, downstream.

Photo 3) alternative upstream crossing site, photo form NY 13142 13698, downstream.

Photo 4) Irish bridge on Liza. Photo from NY 13078 14237, upstream.

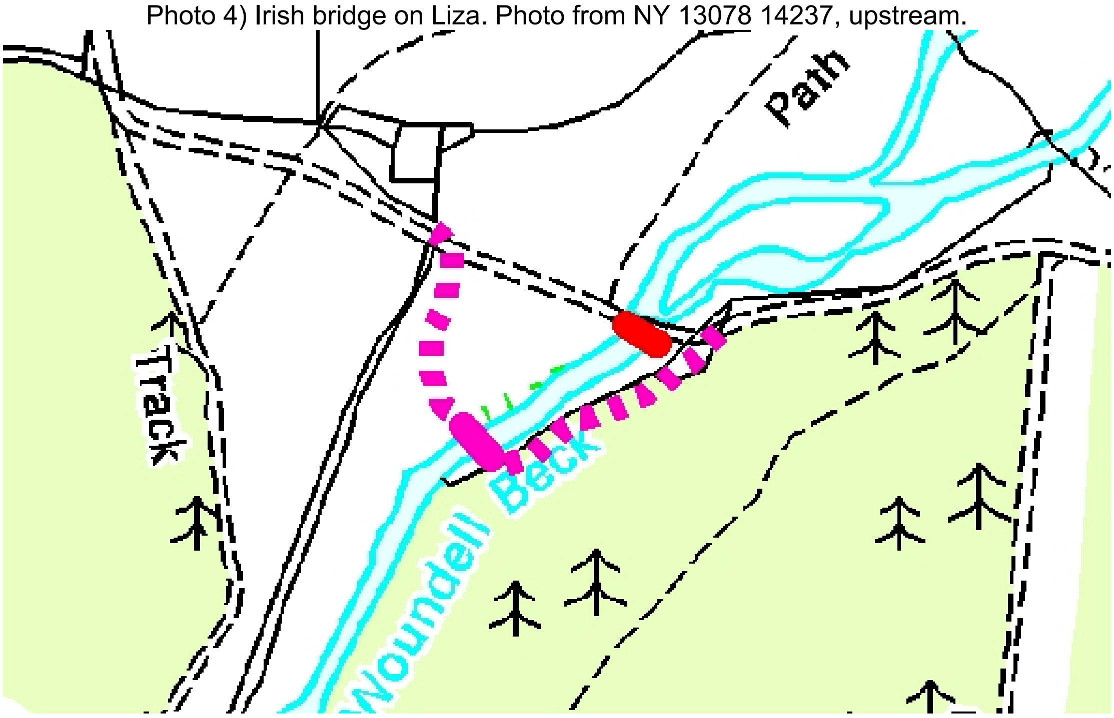

Figure 1) Suggested 'perpendicular' crossing point in red, and upstream alternative in pink.

Photo 5) View of river channel and floodplain morphology, showing a transport reach with scattered deposition. Photo from NY 56831 03334, upstream.

References

Thorne, C.R., Hey, R.D., and Newson, M.D. (Eds.), 1997. Applied fluvial geomorphology for river engineering and management, Wiley, 376 pp.
Sear D.A., Newson M.D. and Thorne C.R. 2003. Guidebook of Applied Fluvial Geomorphology. Environment Agency R&D technical Report FD1914. WRc, Swindon.
Environment Agency, 1999. Waterway bank protection: a guide to erosion assessment and management. R & D, W5-635.