

Washburn Valley Reservoirs

overflow remedial works for 4 Yorkshire reservoirs

by Ian Farmery

Washburn Valley reservoirs, owned by Yorkshire Water, comprise a cascade of four impounding reservoirs situated approximately 12 kilometres to the west of Harrogate in North Yorkshire. The three lower reservoirs, namely Fewston, Swinsty and Lindley Wood were formed between 1875 and 1879 by the construction of earth embankment dams with puddle clay cores. The upper reservoir, Thruscross, was formed between 1962 and 1966 with construction of a mass concrete gravity dam. The upper three reservoirs supply water to Leeds, whereas the lower reservoir, Lindley Wood, provides compensation flows to the River Washburn.



Newly raised Lindley Wood crest & partially buried cottage (courtesy Yorkshire Water).

All four reservoirs are considered to be large raised reservoirs in accordance with the Reservoirs Act 1975. The Statutory Inspecting Engineer's Report published in July 1997, re-designated Fewston, Swinsty and Lindley Wood as Category A dams and it was identified that these three reservoirs had insufficient capacity to prevent overtopping of the dams during the Probable Maximum Flood (PMF). The situation was further exacerbated by introduction of the Flood Estimation Handbook (FEH) as the revised flood assessment techniques contained within the FEH resulted in an increased PMF. In the interests of safety it was recommended that the flood capacity of the reservoirs be upgraded to meet statutory requirements "as soon as practicable". The following table compares previous and new PMF values and existing and proposed flood defence levels for the three reservoirs.

Reservoir	PMF based upon FSR* (cumecs)	PMF based upon FEH (cumecs)	Existing Flood Defence Level (mAOD)	Required Flood Defence Level (mAOD)
Fewston	405	442	156.58	156.58
Swinsty	454	498	140.20	141.28
Lindley Wood	504	536	93.22	96.09

(* FSR= Flood Studies Report)

In October 2000, TEAM, a working agreement between *E C Harris, Arup and MWH* was appointed to carry out a feasibility review, detailed design and project management for the scheme, with a programme to carry out remedial works on the lower two reservoirs. (Swinsty and Lindley Wood) under a single contract (Contract 1), during 2002. Fewston would follow under a separate contract (Contract 2) in 2003. Work at Swinsty and Lindley Wood is now largely complete with work at Fewston about to begin. *Morrison Construction* are the appointed contractors for both contracts. Capital costs for Contract 1 and Contract 2 are £3.4m and £2.2m respectively.

Main components of work are outlined below.

Lindley Wood

Lindley Wood dam is 329 metres long and was a maximum 21.4 metres high with a capacity of 2920 Ml. Remedial works included:

* raising of flood defence levels by approximately 3 metres. Due to the unusually wide dam crest at Lindley Wood this was achieved by construction of a new embankment on top of the existing earth embankment, utilising compacted granular fill with side slopes of 1:2. An HDPE membrane was laid on the upstream face and was terminated within the existing clay core at the bottom and above peak still water level at the top. Design of the crest raising was unusual in that the existing wide crest allowed the construction of

the new embankment downstream of the existing access track. In extreme conditions both the track and existing valve towers will flood, but as this does not pose a threat to reservoir safety, YWS accepted this as a business risk rather than opting for a scheme with higher capital costs that would ensure the track and valve tower did not flood.

* increase of spillway capacity by, demolition of existing foot bridge, construction of a new reinforced concrete headwall structure and provision for out of channel flow by clearance of vegetation, construction of additional bunding where necessary and provision of reinforced grass revetments utilising proprietary precast concrete blocks.

Swinsty

Swinsty dam is 457 metres long and has a maximum of 20 metres high with a capacity of 4655 Ml. Remedial works included:

* raising of flood defence levels by approximately 1.2 metres. This was achieved by the construction of a new 2.25 metre high reinforced concrete wave wall to replace the existing and raising the crest road level by approximately 1.2 metres in granular fill. A sheet pile cut off, embedded at the top in the wall base and at the bottom in the existing puddle clay core ensures a continuous water barrier to above peak still water level.

* increase of spillway capacity by demolition of the existing five arch bridge and replacement with a new single span bridge with the soffit level set above the PMF level. Provision for out of channel flow by construction of additional bunding where necessary and provision of reinforced grass revetments utilising proprietary precast concrete blocks. It should be noted that replacement of the bridge at Swinsty was undertaken as a design and build element by *Morrison Construction*. Main beams for the bridge were prefabricated and delivered to site as single 30 metre long units.

Fewston

Fewston dam is 434 metres long and has a maximum of 21 metres high with a capacity of 3814 Ml. Remedial works will include:

* raising of flood defence levels by approximately 0.9 metres. This will be achieved by the construction of a new reinforced concrete wave wall to replace the existing. The wall will be typically 2.8 to 3.2 metres high. Crest road levels will also be raised by approximately 0.9 metres. A sheet pile cut off, embedded at the top in the wall base and at the bottom in the existing puddle clay core, ensures a continuous water barrier to above peak still water level. The crest road at Fewston is a public highway and, as such, these works are subject to the approval procedures of North Yorkshire County Council and the wave wall has been designed to provide vehicular impact containment to P2 level.

* increase of spillway capacity by demolition of the existing five arch bridge and replacement with a new single span bridge with the soffit level set above PMF level. Provision for out of channel flow by construction of additional bunding where necessary and provision of reinforced grass revetments utilising proprietary erosion control geotextile.

Design issues

Although many of the elements of the three designs were common to each, a number of issues required special consideration.

1, Revetment Protection System

Revetment protection systems were designed on the guidance of CIRIA Report 116-Design of Reinforced Grass Waterways.

Maximum anticipated out of channel flow velocities for the three spillways are as indicated in the table below.

Location	Maximum anticipated out of channel velocity (m/s)
Fewston	6.0
Swinsty	7.1
Lindley Wood	9.7

Flow velocities at **Fewston and Swinsty** resulted in geotextile erosion control matting and interlocking precast concrete blocks respectively to be chosen as the preferred method of protection. At Lindley Wood, peak velocities were anticipated to be in excess of the velocities covered by the guidance of the CIRIA report (8 m/s maximum). However, consultation with one of the authors of the report confirmed that the interlocking precast concrete block system could withstand sustained flows at velocities up to 10 m/s if installed with sufficient attention to detail and therefore this system was adopted.

2. Environmental issues

The Washburn Valley constitutes part of the Nidderdale Area of Outstanding Natural Beauty and as such planning restraints have required that as far as possible the existing landscape be preserved or enhanced. All new structures are required to be fully clad in natural stone work in keeping with the existing surroundings and measures such as ecological surveys, archaeological studies and tree preservation strategies were employed in order to minimise the impact of the works.

3. Lindley Wood Cottage

This disused dwelling was originally intended for demolition as it was considered an obstruction to the dam raising works. However, plans were altered when it was discovered that a colony of bats were living in the roof void. As a protected species a detailed bat survey was undertaken and a mitigation strategy was agreed with the DEFRA. In order to facilitate both the crest raising work and maintenance of the bat habitat, a scheme was devised whereby the existing cottage was partially built in to the raised dam embankment. The existing ground floor was filled with lightweight concrete and the existing first floor became an electrical plant room. Landscaping was designed to maintain flight paths and bat tiles were built into the cottage roof to maintain access for the bats.

4. Water control measures

Due to the necessity to maintain water supplies to Leeds, whilst ensuring that construction could proceed safely, particularly in respect of the spillways, YWS undertook to maintain water levels within the reservoirs at a predetermined level below existing overflow weir levels (corresponding to the level with a 1% chance of exceedance during the critical construction period when work is being undertaken on the dam or the spillway). A procedure for monitoring levels and contingency plans to be followed in the event of water levels rising were formulated by YWS, *TEAM and Morrison Construction*. These contingency plans were called into operation on one occasion during construction at Swinsty and Lindley Wood and were proven to work well.

Work on the scheme is currently on programme and due for completion in January 2004.■

Note: The author of this article, Ian Farmery, is Project Engineer with Arup for the Washburn Valley Reservoirs.