Design width of active channel and floodway & Bank erosion protection

Marlborough District Council (Brin Williman). *This document includes an edited excerpt from a major review of its river control strategies in 1994.*

Wairau (Tuamarina to Waihopai Confluence)

Channel characteristics (typical)

Type	:	Semi braided gravel bed river
Length	:	22 km
Floodway Width	:	800 m (reduced from 1000m in 1958)
Fairway Width	:	400 m (reduced from 600m in 1958)
Slope	:	0.3% (1 in 300), but steepens from 1 in 700 at Tuamarina to 1 in 250 at Waihopai Confluence.
Design Flood	:	5500m³/sec Design Freeboard 0.8m.

(i) A coordinated approach to river control strategy for the Wairau floodplain began in 1921. In the braided section of the Wairau river above Tuamarina but downstream of the Waihopai confluence bank protection works was by strong points of wire mesh and stone crates with heavy willow boughs built as and where river attack occurred on the south bank, and often very close to the stopbanks themselves. The 600m width of the braided channel allowed the main channel braid to develop at very oblique angles with strong cross river flows and heavy direct attack on the banks. Considerable expenditure was required on these stone netting and willow tree based groyne structures.

(ii) The Wairau Valley Scheme in 1960 reviewed this approach. River works on this reach of the Wairau river were intended to train this braided river into a single thread channel. The advantages of training a braided river into a single thread channel were at the time advanced by the Ministry of Works as outlined in a paper by Nevins (1969). One of the anticipated advantages was the formation of a concentrated main channel which would then deepen by scouring its bed. This could be expected to reduce bed levels, confine the 2000m³/sec mean annual flood into this main channel, and lower flood levels.

(iii) Another advantage of this single thread channel was the expected stable meander pattern that was achieved. Rock bank protection work would then only be required on the outside of the defined bends. The length of bank requiring such heavy bank protection would only be approx. 1/3 the total length of stopbanks.

(iv) In the Wairau Valley Scheme report Davidson (1959) stated :

"It is recognised that considerable difficulties will be experienced in training this channel to (single thread) regime conditions. However, the advantage in lower flood levels, sediment discharge capacity, easier lateral protection and greater safety generally, are so considerable as to warrant considerable expenditure and effort to obtain conditions as closely approaching the ideal as possible."

(v) Laceys empirical equations (based on steady flowing Indian sand bed rivers) were used to set this intended single thread channel width at 220 metres, the radius of curvature of the meander as 900 metres, the meander wavelength as 2000 metres and the meander amplitude as 700 metres.

Curved rock line training banks on the outside of intended bends were used to create this predetermined channel alignment. Construction started in 1966.

(vi) By 1974 shortcomings of the design were noted and realignment of training banks was carried out so as to achieve a longer meander wavelength and longer radius curvature. This was a major exercise. In some areas a new training bank was constructed directly on the opposite side of the river, in other areas significant removal of already placed rock was required and to be replaced on a preferred flatter curve alignment.

(vii) The degree to which these training banks could be relocated was limited by existing physical features such as bridges, hillsides, stopbanks and other river control works. The finally constructed rock training banks in place today have an overall meander pattern that differs from site to site with regard to meander length, amplitude and radius.

(viii) By 1994 such an incised "single thread" channel had only been achieved to a very limited degree at low and average flows. There is no clear cut 220m wide incised channel. At 220m width the flow is typically 150m³/sec. This is a little bit greater than the 120m³/sec that typically occurred previously, but much less than 2000m³/sec "dominant discharge" contemplated as possibly occurring. At flood flows of 2000m³/sec the river is stopbank to stopbank, typically 800m wide.

(ix) The river training works were not able to hold the river down to a width of 220 metres. In large flood events the river washed away the training works. It was only areas where the width was relaxed to a width of some 400 metres that less erosion occurred. The vegetation free active channel width was also pushed up towards 400 metres.

(x) In the steeper reaches (1 in 250) of the river towards the Waihopai confluence a 500 metre width was found more appropriate, in the flatter reach (1 in 500) above Tuamarina a 320 metre width could be held.

(xi) A fairway width of typically 400 metres is therefore now recommended as the design fairway width for this reach of the Wairau. This is significantly more than the 220m "Lacey" width, but significantly less than the 600m original braided active channel width.

(xii) There is no evidence that the river width has any influence on sedmiment transport.

(xiii) For 16km of the reach from Tuamarina to lower Conders groyne the meander form and length has been partially successful. The main river braid has usually flowed along and been directed by these outside of bend training banks. Oblique angle cross river flows have been significantly reduced as the reduced width of the active channel inhibits their development.

(xiv) The further required works in this reach therefore consist of maintaining the existing curved rock training banks. Tree based works to strengthen the

majority of the fairway edge where there are no rock training banks; though in the case of major flood damage these tree works will have to be strengthened by rock.

(xv) For the 6km reach from Conders groyne to the Waihopai confluence the meander form and length has been much less successful. This is not surprising as the slope has steepened to 1 in 250. The equation of Leopold and Wolman (1960) indicate that the Wairau should be naturally braided at slopes steeper than 1:2000, and that it becomes progressively more difficult to force a braided river into a single thread pattern at steeper slopes. At a slope of 1:250 it has become very difficult. A meander pattern on the intended alignment has not developed.

(xvi) Since the 1990 flood the river has been threatening to erode a new alignment and outflank the rock lined bank at lower Conders that protects the entry to the old Opawa channel. This is a vital area to protect and substantial further works are required. For this 6km reach the single thread meander training approach is not providing reliable protection for the very important potential breakout path towards Renwick, the Upper Opawa and eventually Blenheim.

(xvii) The required river control works consist of some form of continuous protection for the south bank of the river fairway is required. There are two main alternatives for providing continuous protection.

- A continuous rock lined guide or training bank, parallel with the river, and backed up with a band of willow trees. Apart from the lower Conders training bank there is also a 1.5km training bank further upstream. These therefore cover much of the south bank of the river. There is still a 2.5 kilometre gap between these two training banks and there is also a further 1 km in the upper Conders are without a rocked bank.

- Rock headed groynes at right angles to the river, use considerably less rock and are therefore cheaper. Such groynes have been used extensively on the similar Waimakariri. Again, three planting in between the groynes is useful back up and will inhibit turbulent eddying flows between the groynes. One rock headed groyne was built in 1972 at the Waihopai Confluence, and another in the reach between the two training banks following the 1990 flood.

- The preferred option is a blend of these two approaches. The lower Conders training bank would be extended upstream; 2 more rock headed groynes will be required upstream of this; and a further two more in the Upper Conders reach.Tree planting by a blend of willow protection planting and commercial pine (or other varieties) would be planted as back up to these works. This tree planting should occupy all the area between the channel fairway and the new realigned stopbank. Apart from stopbank protection these tree plantings will reduce the size of any flood breakout should it occur.

(xviii) On the **north bank** some form of continuous bank protection is virtually already provided by two stopbank height rock lined training banks. In between these rock banks is hillside. The only concern is therefore preventing the most upstream training bank opposite Waihopai from being outflanked at its upstream end. The June 1993 flood eroded into this area, and the river is threatening to do just that.

The logical option is therefore return banking suitably rock protected to prevent outflanking the top end of this "Wilsons" bank.