Land & River Limited

- RIVERS
- DRAINAGE
- RESOURCE MANAGEMENT

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A. Strange - Roding River Bridge
Flood levels

INTRODUCTION

Andrew Strange wishes to build a bridge across the Roding River to provide vehicle access to a proposed subdivision. Nelson Consulting Engineers have requested design flood levels at the bridge site as part of the bridge design process. This report provides the appropriate flood levels.

BACKGROUND

Methodology follows that laid out in LTNZ's bridge manual (originally Transit 2004). Flood levels were calculated by deriving a design flow and then routing it down the reach of the Roding River adjacent to the proposed bridge using the US Army Corps of Engineers' HEC RAS hydraulic modelling software. River cross sections were generated from LiDAR survey data and three ground surveyed cross sections at the bridge site.

Calculated flood levels were then compared to observations of flood levels at the site.

DESIGN FLOWS

Design flows with return periods of 25, 50 100 & 500 years were required. These were calculated (see Appendix I) using the regional flood method (RFM) (McKerchar & Pearson, 1989) giving:

T (years)	Q_T (m^3s^{-1})
25	540
50	620
100	700
200	780
500	890

Table 1: Design flows

As a check, the Q_{100}s (as calculated by TDC based on statistical analysis of the flow records) for four nearby sites with flow records were scaled using the RFM scaling factor of $Area^{0.8}$ to provide comparative estimates of Q_{100} at this site.

Recorder site	Catchment area (km^2)	Site Q_{100} (m^3s^{-1})	Scaled Q_{100} for bridge site (m^3s^{-1})
Roding at Caretakers	41.5	316	749
Wairoa at Irvines	465	1451	500
Maitai South	17.8	99	462
Lee at Waterfall Ck	65.3	333	550

Table 2: Comparative estimates of Q_{100}

The Q_{100} calculated using the RFM lies within the range of the Q_{100}s calculated from adjacent catchments. It is noted that the Q_{100} calculated from a Roding at Caretakers (a subcatchment of the bridge site) give the closest agreement with the RFM calculation. The RFM calculation was accepted as relevant for the bridge site.

CALCULATED FLOOD LEVELS

River cross sections

All topographic detail and survey data used was as supplied by NCE Ltd.

Three cross sections (bridge centerline, 20 upstream of bridge centreline and 20 m downstream of bridge centreline) were ground surveyed.

Upstream and downstream of the bridge site, cross sections above water line were derived from a LiDAR survey based contour map (2 m contour interval). The bed level sections of the cross sections was derived by linear interpolation along the centre line of the river between contour lines. The bed level was reduced by 400 mm below the LiDAR level to account for the depth of water over the bed.

Manning's 'n'

Manning's 'n's for the cross sections were derived using "Guide for Selection Manning's Roughness Coefficients for Natural Channels and Flood Plains" - USGS paper 2339 and checked against "HECRAS Hydraulic Reference Manual - V 4.1 2010" (Appendix II) and benchmark sites in "Roughness Characteristics of New Zealand Rivers".

"Guide for Selection Manning's Roughness Coefficients for Natural Channels and Flood Plains"

For the river bed:

$n = (n_b + n_1 + n_2 + n_3 + n_4) * m$

where:

$n_b = 0.035$ straight uniform channel with bed material approximately 100mm diameter median size

$n_1 = 0.005$ slightly irregular bed

$n_2 = 0$ gradual changes in cross section

$n_3 = 0$ no obstructions

$n_4 = 0$ no vegetation

$m = 1$ straight reach

gives $n = 0.040$

For river banks:

as for river bad except $n_4 = 0.10$ for dense bushy willow

gives $n = 0.14$

<u>HECRAS Hydraulic Reference Manual</u>

for river bed
$n = 0.030$ clean, straight, no riffles or pools

for river bank
$n = 0.15$ dense willows, straight

<u>Roughness Characteristics of New Zealand Rivers</u>

for composite channel/bank

n = 0.0.029 *c.f.* Pomahaka at Burkes Ford with R = 1.68m (R in this reach under flood conditions will be at least 5 m)

n = 0.032 *c.f.* Mangaheia at Willowbank with R = 1.44

Manning's 'n' of 0.030 was adopted for the bed subsection of the cross sections and 0.140 was adopted for the banks.

Contraction/expansion loss coefficients

A contraction loss coefficient for the bridge site of 0.5 and 0.3 elsewhere was adopted and expansion loss coefficients of 0.3 and 0.1 similarly (after "Flow Transitions in Bridge Backwater Analysis" HEC 1995).

Flood level calculation scenarios

For each of the required return periods, flood levels were calculated at a position 4 m upstream of the proposed bridge centre line both for the existing river with no bridge and for the river with the proposed bridge in place (abutments as in NCE Ltd drawing number 15527.0.03, dated 6/5/15, sheet 3).

Flood return period (years)	Flood level (m)	
	Existing river	Bridge in place
25	90.68	90.72
50	91.03	91.10
100	91.34	91.44
200	91.61	91.73
500	91.95	92.12

Table 3: Calculated flood levels

OBSERVED FLOOD LEVELS

Salient observations include:

- Andrew Strange (client) had been living in the valley since 1981. The April 2013 flood was the biggest in the Roding River but the 1986 flood (the outstanding flood on record for the Roding at Caretakers recorder site) was bigger in the Hackett but not in the Roding. The April 20143 flood came to road level at the bridge site.
- Martin Fisher (owns the property across the road from the bridge site) was away for the April 2013 flood but lost a section of fence fronting the road. Flood debris in his fence at a point 1/2 way between the bridge site and the culvert under the road infront of his place suggests the flood was up to the top wire of th fence at that location. He could not recall if there was any evidence of flooding of the road at the bridge site.
- Paul & Marina Bennett (own the next property upstream of Martin Fisher) report that during the April 2013 flood, the road at the bridge site was under water and the water was sufficiently deep as to make it undrivable. They were at home at the time of the flood but as the flood peaked at 2,00am (approximately) they did not see the flood but observed the debris on the fences the next day, Also, as their front gate was washed away and they found it on the roadside downstream of

Fisher's, they concluded that the water was deep enough along that stretch of road to move their gate. They pegged the height of the flood on their place.

The provision of flood levels in this report does not imply that there would be no damage by flooding, only that the probability of damage is limited to the proscribed levels.

This report has been prepared for the benefit of Nelson Consulting Engineers Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without Land & River Ltd's prior review and agreement.

REFERENCES

McKerchar, A.I.; Pearson, C.P., 1989: "Flood Frequency in New Zealand". Publication No. 20 of the Hydrology Centre, DSIR, Christchurch.

Hydraulic Engineering Centre 1995. RD-42, Flow Transitions in Bridge Backwater Analysis, U.S. Army Corps of Engineers Davis CA., 1995.

APPENDIX I

Regional Flood Method Calculation

Catchment area at bridge site = 122 km^2 (planimetered from 1:50,000 topo map),

$\bar{Q}/A^{0.8}$ = 5.0 (from fig 3.5) and q_{100} = 3.0 (from fig 4.9)

gives $\bar{Q}$ = 233 m^3s^{-1}

and from equations 4.11, 5.3 and 5.4 and table 5.1:

T (years)	y_T	x_T	$Q_T/\bar{Q}$	Q_T (m^3s^{-1})
25	3.199	0.3484	2.30	540
50			2.65	620
100			3.00	700
200			3.35	780
500	6.214	-0.4012	3.80	890

APPENDIX II

HECRAS Hydraulic Reference Manual - V 4.1 2010 Manning's 'n' Table

Table 3-1 Manning's 'n' Values

Type of Channel and Description	**Minimum**	**Normal**	**Maximum**
A. *Natural Streams*			
1. **Main Channels**			
a. Clean, straight, full, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. Same as "d" but more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy. deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stands of timber and brush	0.070	0.100	0.150
2. **Flood Plains**			
a. Pasture no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
2. Same as above, but heavy sprouts	0.050	0.060	0.080
3. Heavy stand of timber, few down trees, little undergrowth, flow below branches	0.080	0.100	0.120
4. Same as above, but with flow into branches	0.100	0.120	0.160
5. Dense willows, summer, straight	0.110	0.150	0.200
3. **Mountain Streams, no vegetation in channel, banks usually steep, with trees and brush on banks submerged**			
a. Bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
b. Bottom: cobbles with large boulders	0.040	0.050	0.070