Environment Waikato Technical Report 2005/32

Flooding of Mangatoetoe Stream Waihi : July 2005

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1 Background

The catchment of the Mangatoetoe Stream experienced heavy rainfall during the period 16-17 July 2005. This rainfall caused high flows in the Mangatoetoe Stream through Waihi township and resulted in overtopping of the culvert at the junction of Consols St and Baber St. and flooding of one dwelling at 20 Baber St.

This report provides assessment of the magnitude of the recent flood event, the fifty year flood levels and recommends the appropriate minimum floor levels of buildings within this reach of the stream. It also defines the responsibilities of Environment Waikato for maintaining the Mangatoetoe stream under the Waihou Valley Scheme.

2 Objectives

The objectives of this report are:

- to estimate the magnitude of the event downstream of the Consols St – Baber St culvert in terms of both peak flow and Avera-ge Recurrence Interval (ARI).
- to assess the 50 year ARI flood level for 20 Baber St.
- to assess the effect of the stream condition on water levels.

3 Rainfall

Rainfall for the July 2005 storm event was recorded by automatic recorder at the Waihi Water Treatment Plant (WTP) located on the eastern edge of the Mangatoetoe Catchment at grid reference NZMS 260 T13 620 212. There is another telemetered gauge at the sewer plant on the south side of the Ohinemuri River, but it failed in the event. For the purpose of this analysis the WTP Gauge has been used.

Rainfall totals for a range of different durations during the event have been calculated by Hauraki District Council from the raw record. These have then been compared with the HIRDS rainfalls for the same duration to determine the Average Recurrence Interval (ARI) of the July 2005 storm for each duration. These are shown in Table 1.

Table 1 Rainfall depth - duration – frequency data: Waihi WTP raingauge 16 and 17 July 2005

Duration	Depth (mm)	Average recurrence interval (years)
5 min	8.4	
10 min	15.8	15
20 min	28.2	30
30 min	40.4	50
60 min	59.2	48
6 hr	135.4	30
24 hr	179.2	~5

Based on Table 1, it would appear that the July 2005 storm maximum 1 hour rainfalls had a return period of around 50 years. Recent experience with use of HIRDS rainfall frequency data in the Coromandel and Waihi areas has however led to concerns that

HIRDS may underestimate rainfalls for a given recurrence interval and duration, particularly for shorter duration events. As a check 50 year ARI rainfalls have been estimated for each of four local rain gauges in the area. These are set out in Table 2 below.

Table 2: Estimated 50 year ARI 1 hour rainfalls for local gauges

	Queens Head	Golden Cross	Schriders	Wairongomai
No. of years record	15	14	9	17
50 year ARI rainfall	51	45	67	71

These estimates are based on limited lengths of record and are therefore subject to some uncertainty. The Queens Head rainfalls are lower than those generated by HIRDS, and this gauge is at a similar elevation to Waihi. The Schriders and Wairongomai gauges predict a higher 1 hour rainfall than HIRDS, but these gauges are at a higher elevation than Waihi. Based on the above information it seems that the HIRDS data for Waihi Rainfalls is reasonable.

On the information available it would appear that the July 2005 rainfall event for the Mangatoetoe catchment was approximately a 50 year ARI event.

4 Stream flows

No direct measurements were made of peak flows in the Mangatoetoe Stream during the flood event. Some peak water level data was obtained following the event, and several stream cross sections were surveyed downstream of the Consols St culvert.

The head drop across the Consol St culvert as measured was 1.02 metres. The culvert consists of twin 1.8 metre diameter concrete pipes with headwalls. The discharge through the culvert has been estimated from culvert hydraulics with an entrance loss coefficient of 0.5. This gave a flow figure of 18 m^3/s. Additionally, the amount of water spilling across the road has been calculated from the estimated width and depth of flow (60 metres and 150 mm respectively, as determined by Hauraki District Council). This calculation gave a spill flow of 6 m^3/s, and thus the total estimated flow is 24 m^3/s.

Additionally, flows have been estimated using water levels measured upstream and downstream of the Quarry Rd bridge. This bridge had a differential head across it of 0.45 metres, and using culvert hydraulics again, flows have been estimated at 36 m3/s.

The large discrepancy between the two estimates reflects the fact that estimating the peak flows in this way involves uncertainties. The true flows through the culvert and bridge will be very dependent on entrance conditions, and will be overestimated if there is any debris blockage. For the bridge there are also greater uncertainties in estimating a representative value of Mannings n. For the Consol St culvert, there are also uncertainties in estimating the road overflow based on an average depth and width of flow.

5 Catchment characteristics and design flows

The TM61 method and Rational method have been used to calculate expected flows for different return periods. In addition, flood frequency analyses have been performed on records from three local river recorder sites, and the results scaled by catchment area raised to the power of 0.8 to obtain estimates for the Mangatoetoe catchment at Consol St. The catchment characteristics, frequency data, and design discharges estimated by the different methods are summarised in table 2 and table 3 as follows:

Table 3 Catchment characteristics

Parameter	Value
Catchment Area	4.31 km^2
Urban percentage	23%
Channel Length	4.11 km
Direct Length	3.60 km
Elevation Difference	352 m
Average Channel Slope	0.023 m/m
Time of Concentration	1 hour
TM61 Infiltration Factor W_{ic}	1.1
TM61 Slope Factor W_s	42
TM61 Discharge Coefficient C	885
Rational Method C Value	0.45

The catchment of the Mangatoetoe Stream is rolling country with an average gradient of 2.3%. It can be considered flashy in the sense that the time of concentration is relatively short, so it will be responsive to high intensity short duration storms.

The results of the frequency analysis undertaken for flow recorder sites in the vicinity of Waihi is shown in Table 4.

Table 4: Results of regional frequency analysis

	Ohinemuri at Karangahake	Ohinemuri at Queens Head	Waitekauri at Swing Bridge
Catchment Area	287.5	134.6	13.1
No of Years Record	49	21	16
$Q_2/A^{0.8}$	4.37	3.29	5.10
$Q_{10}/A^{0.8}$	7.71	5.81	9.57
$Q_{20}/A^{0.8}$	8.98	6.78	11.36
$Q_{50}/A^{0.8}$	10.63	8.02	13.53
$Q_{100}/A^{0.8}$	11.87	8.96	15.20

For the purpose of estimating design flows for the Mangatoetoe Stream, the Waitekauri figures have been used. This is because of the proximity of the two catchments to each other and because of the general similarity in catchment size.

Table 5 Design rainfalls and flows (1 hour duration)

Average recurrence interval	Rainfall (ex HIRDS)	Design discharges		
		TM61	Rational Method	Regional Frequency Analysis
2 yr storm	28.7 mm	11.4	15.4	16.4
10 yr storm	41.3 mm	16.4	22.3	30.8
20 yr storm	48.4 mm	19.3	26.1	36.5
50 yr storm	60.5 mm	24.1	32.6	43.5
100 yr storm	72.6 mm	28.9	39.1	48.9

It should also be noted that Opus Consultants have undertaken assessments of peak flood discharges for the Mangatoetoe Stream at a number of culvert locations, as part of a proposed Waihi Catchment Management Plan. Their estimates for the 10 year and 100 year discharges for the Consols St culvert are 41 m^3/s and 66 m^3/s respectively. These calculations are based on a larger estimate of catchment area (488 ha) than that used in this study. The Opus equivalent flood discharge estimates for a fifty year flood is 59 m^3/s which is more than twice the estimates obtained for the TM61. Opus has used a modified form of the Rational method to obtain their flow figures. It seems based on all the other information available that the Opus estimates are overly conservative.

For the purpose of this investigation the regional frequency analysis results are adopted as the design discharges for the Mangatoetoe Stream catchment at Consols St. It is our view that these represent the best estimates as they are based on information from a nearby flow recorder and the approach is conservative because they are the highest values from the three methods used.

6 Assessment of the recurrence interval of the July 2005 flood event

As set out in Section 4, it is estimated that the peak flow in the Mangatoetoe Stream at Consols St for the July 2005 event was between 24 m^3/s and 36 m^3/s. Additionally, from Section 3, HIRDS data would suggest that the recorded maximum 1 hour duration rainfall (the time of concentration of the catchment) for the storm had approximately a 50 year recurrence interval. There are other factors however which will determine whether 50 year rainfalls will produce a 50 year flood event, i.e. antecedent soil moisture conditions.

Based on the regional frequency analysis estimates of flood flows, it seems that the July 2005 event had a recurrence interval of up to 20 years.

7 Waihou Valley Scheme

The Waihou Valley Scheme comprises of a range of works and services including stopbanks, floodgates, pump stations, soil conservation and river works. The levels of protection and services provided were defined in the scheme reports and reflected in the scheme rating classification. The Waihi settlement is classified U4 for rating purposes, which is the lowest level of service within an urban area. The benefits received under this classification are defined as erosion control and general improvement of community access under flood conditions. These were achieved initially through the scheme capital works on the Mangatoetoe Stream. The capital works of the scheme provided for channel works to be undertaken through Waihi over a distance of approximately 2,000 metres. The works included clearing the channel of willows and other obstructions and control of re-growth. There was also provision for erosion control works where necessary. The works were to consist of light to medium willow work anchored and weighted with stone filled gabions.

The Waihou Valley Scheme Asset management Plan provides for channel maintenance to be undertaken on a 10 year cycle, which is a relatively low level of activity, but is consistent with the Scheme Classification and the low level of rating across the Waihi Urban area. Clearly these works were intended to provide limited benefits across the whole urban area. They were not designed to provide any more specific benefits to landowners directly adjacent to the stream.

It is also noted that there is no specific scheme standard set for the channel improvement work, in terms of flood levels for any particular event. Such standards were only set within flood protected areas, where flood protection assets were constructed.

8 Hydraulic modelling

Hydraulic modelling has been undertaken between Quarry Road and Consols St. to compare modelled flood levels for the July 2005 event with observed flood levels and to then allow an investigation of the causes of the flooding in July. The question arises as to what flow should be used to model this event, as the estimated flow ranges from 24 to 36 m^3/s. For the purpose of this study, the average of the two estimates has been used, i.e. 30 m^3/s. The network used for hydraulic modelling is shown in figure

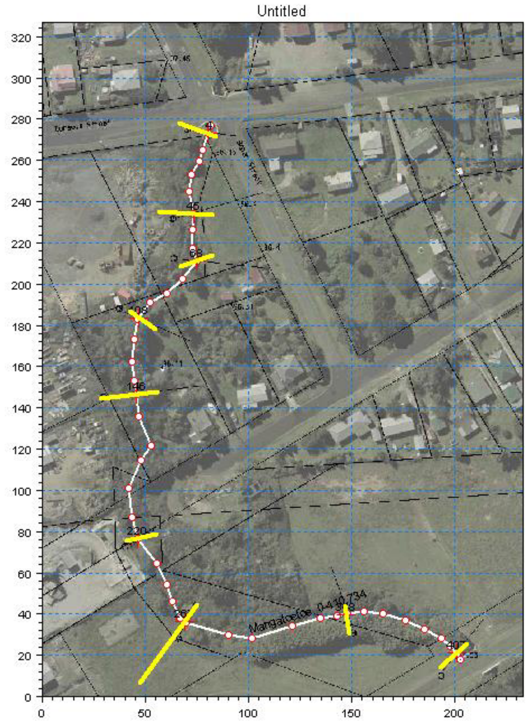

Figure 1: Hydraulic model network

The Waihou Valley Scheme does not set any standard for this stream, and therefore there are no design parameters or flood levels for particular flows which the stream is to be maintained to. The modelling has been undertaken purely to investigate the hydraulic characteristics of the channel during the July 2005 flood.

Cross sections of the stream were surveyed by Hauraki District Council between 2 August and 31 August, and these have been used as the basis for the hydraulic model. During this period the stream has been cleaned of vegetation and some trimming of restricted sections has also been undertaken, therefore the sections may not absolutely represent the channel as it was during the July 2005 flood.

Modelling has been undertaken for two scenarios, firstly for the relatively clean and unobstructed channel as it exists now and secondly for a worst case scenario of heavily vegetated/obstructed channel. The berm roughness has been set to the same value for both scenarios to reflect the fact that the berms will be relatively rough due to vegetation, gardens fences, trees and buildings in the floodplain. Mannings n roughness coefficients for each scenario are as per Table 6

Table 6 Roughness coefficients used for modelling

Scenario	Mannings n	
	Channel	Berms
Clean channel	0.05	0.10
Heavily obstructed	0.10	0.10

The modelled water levels and observed water levels are shown in Figure 2 below. It is apparent that the observed flood levels are similar to the water levels modelled for the heavily obstructed case. While heavy vegetation may have contributed to this degree of obstruction, It is more than likely that there was also some form of physical blockage in the channel, which could have either been pre-existing or due to debris brought down during the event becoming caught up. The stream is relatively steep and the catchment consists of farmland and urban property. The stream can therefore be expected to carry substantial amounts of debris during a flood and there is a real risk of trees falling in to the channel during an event and trapping smaller debris.

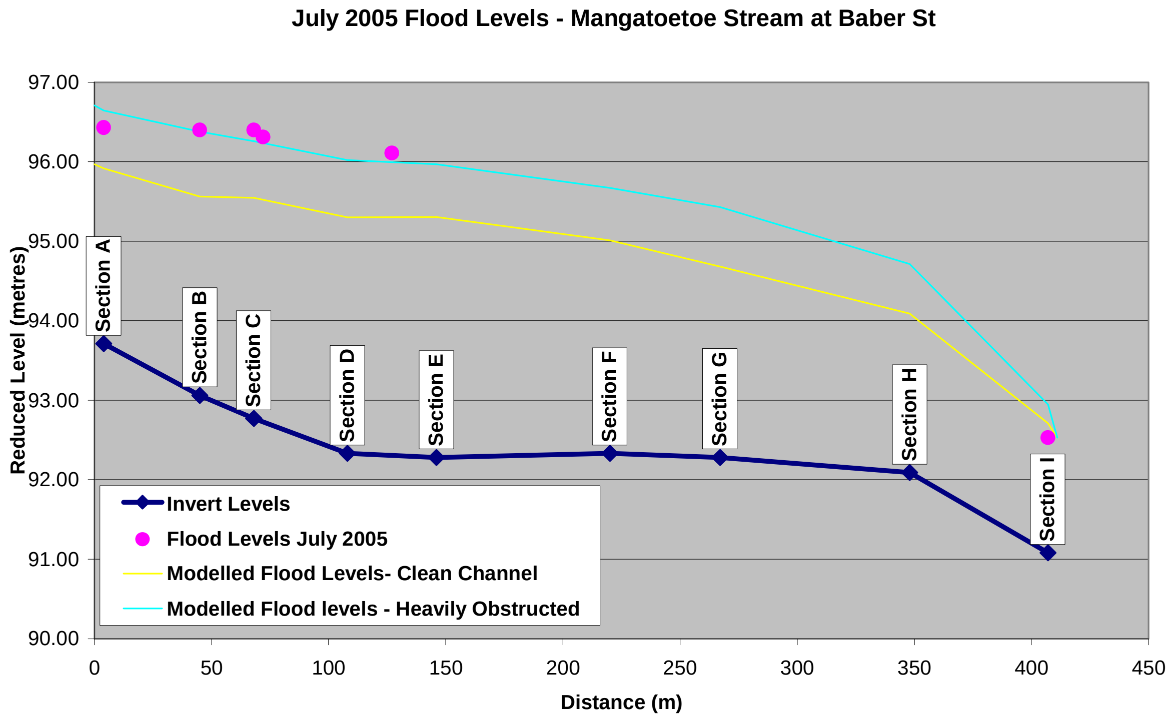

Figure 2 Observed and modelled water levels for the Mangatoetoe Stream

Inspection of the channel following the flood event by Environment Waikato staff revealed a significant debris blockage in the channel in the vicinity of Station Road. The blockage consisted of a trailer, coils of alkathene pipe, a fallen tree and other debris (See Figure 3). Reports indicate that it is likely that this debris accumulated during the flood, and it may well have contributed substantially to the elevated flood levels observed.

Figure 3 Debris in the Mangatoetoe Stream following the July 2005 Flood

Inspection of the channel following the clean up did not reveal any unusually narrow or restricted sections of channel. Because the clean up involved trimming back several restricted sections of channel, it is possible that these areas contributed to the degree of obstruction in the channel that was apparent

9 Assessment of fifty year flood levels

The Building Act requires that houses be constructed with floor levels at a sufficient level to prevent ingress of floodwaters in a 50 year event.

The July 2005 flood event had an estimated recurrence of 5-20 years. Estimation of a 50 year flood discharge is subject to uncertainty for reasons explained previously. The lowest estimate obtained is 24 m^3/s from the TM61 method, and the highest discharge obtained is 59 m^3/s (Opus Consultants estimate). The Opus consultants estimate seems unduly conservative when compared with the other methods. It is expected that the most reliable estimate will be that obtained from the regional flood frequency analysis, and this figure (43.5 m^3/s has been adopted for the purpose of assessing 50 year flood levels).

In addition to the uncertainties in flows, estimation of flood levels involves other considerations:

Channel roughness:
The Waihou Valley Scheme Asset Management Plan makes provision for a 10 yearly cycle of erosion protection and willow clearing in unprotected rivers and streams. This is a limited level of work consistent with the low level of rating associated with these areas. Therefore the worst case scenario for channel roughness (i.e. at the end of a 10 year cycle) would be the heavily vegetated state.

Debris and obstructions

The nature of the catchment, and experience with the July 2005 event indicates that the stream can be expected to bring down flood debris and that obstructions in the channel are a distinct possibility. This should be considered as a characteristic of this stream and hence allowed for in assessing floor levels.

Because of the uncertainties involved in the underlying data, a conservative scenario has been considered for assessing the peak 50 year flood levels:

This involves a conservative estimate based on a peak flow of 43.5 m3/s with a heavily vegetated and partially blocked channel (Mannings n = 0.1).

Modelled 50 year flood levels are shown in Figure 4. The estimated fifty year flood level for 20 Baber St is 96.86 metres compared to a recorded level for the July 2005 event of 96.40 metres.

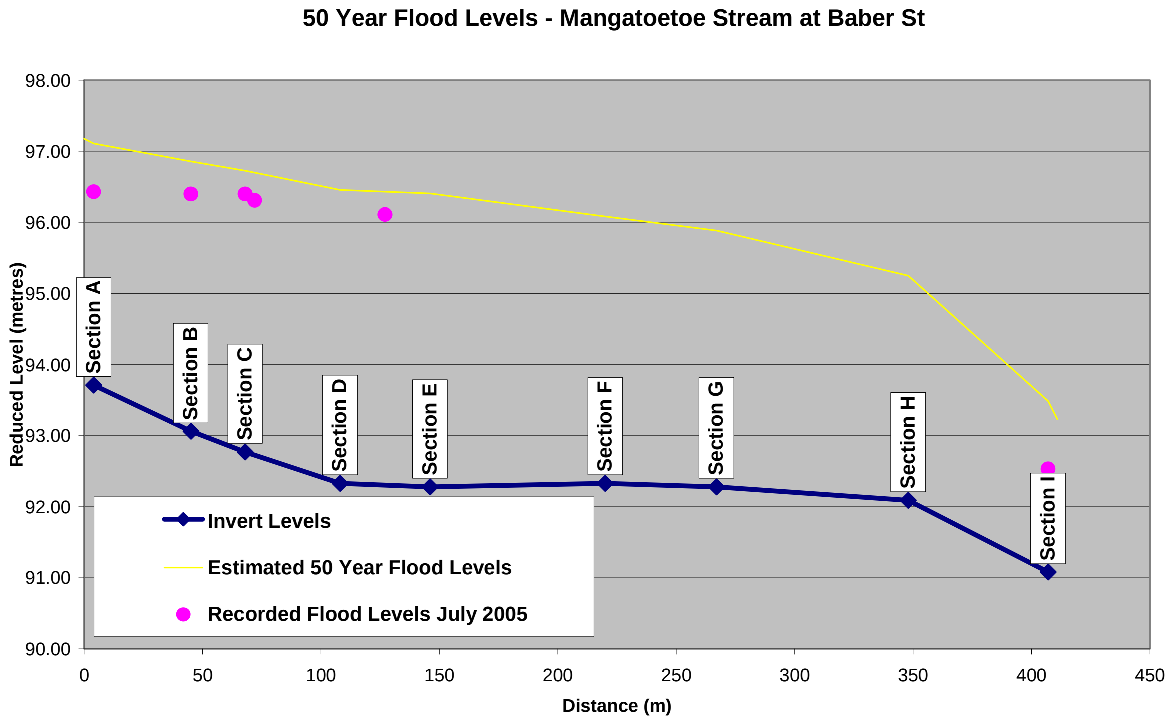

Figure 4 Modelled 50 year flood levels

10 Conclusions

1. The July 2005 flood event for the Mangatoetoe Stream had an estimated average recurrence interval of up to 20 years.

2. The flood levels recorded along Bader St were probably elevated due to debris blockage and/or constriction of the channel. A significant obstruction was observed by Environment Waikato staff immediately following the flood in the vicinity of Station Rd. This is likely to have been a significant contributing factor to the elevated flood levels which were experienced along Baber St during the event. The evidence suggests that this constriction resulted from debris swept in to the stream during the flood, including a trailer, a fallen tree, and other debris.

3. The Waihou Valley Scheme provided for this stream to be cleared of excessive vegetation and for periodic maintenance of this work. No measurable standard was however identified in the Scheme for this work. The Scheme Asset Management Plan provides for limited maintenance of this stream with cleaning

on a 10 yearly cycle. This limited level of maintenance is consistent with the scheme classification and the level of scheme rates for this area.

4. The scenario considered in assessing 50 year flood levels for the stream involves using the regional frequency analysis estimates of flood discharges in conjunction with a high roughness coefficient consistent with a heavily vegetated channel with some obstructions.

5. Design floor levels along Baber St for the purpose of the Building Act should be determined from the fifty year flood levels plotted in figure 4 plus an appropriate freeboard (500 mm is suggested). On this basis floor levels at 20 Baber St should be set above RL 97.36.