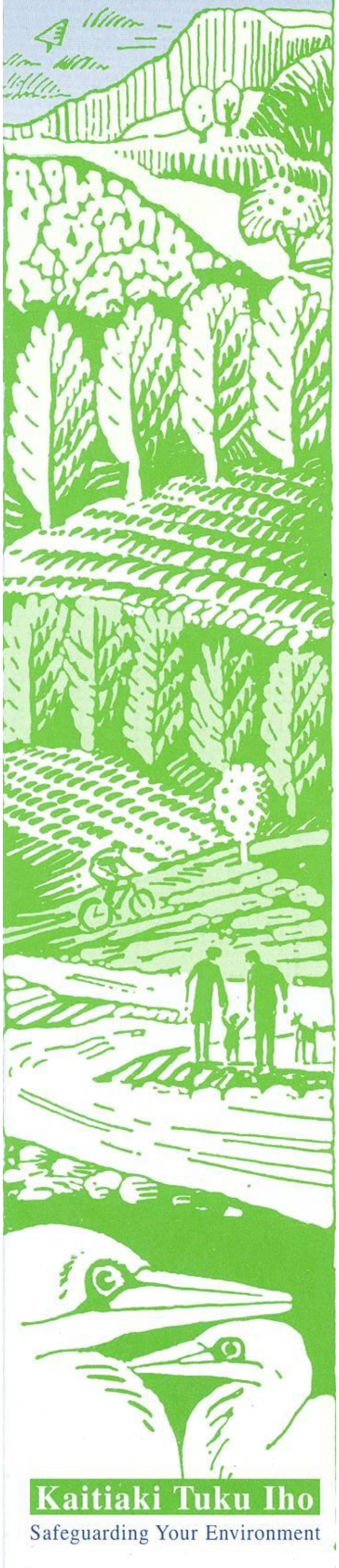
Te Ngaru Stream
Flood Hazard Study

September 2005
AM 05/16
HBRC Plan Number 3794



Hawke's Bay Regional Council
Safeguarding Your Environment

Asset Management Group

Technical Report

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ENGINEERING DESIGN SECTION

Te Ngaru Catchment Flood Hazard Study

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Technical Report

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Te Ngaru Catchment
Flood Hazard Study

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Te Ngaru Catchment
Flood Hazard Study

Te Ngaru Catchment
Flood Hazard Analysis

1 Background and Summary

The Te Ngaru Stream Catchment is located about 20 km north of Napier in the Tangoio area, adjacent to the Pakuratahi Catchment (see Figure 1). The catchment is relatively steep but ends in a flat floodplain at the coast. The floodplain is separated from the ocean by a shingle barrier beach, which is common in Hawke's Bay. The floodplain has been inundated many times from flash flooding due to the extremely volatile nature of the runoff in the catchment.

This report has been prepared in order to provide an up to date analysis of the hydrology and hydraulics of the catchment and floodplain. The impetus for this analysis has been due to a recent plan change proposal that would see part of the floodplain of the Te Ngaru Stream used for residential development.

Based on the results of this analysis, HBRC is opposed to any residential development within the floodplain area of the Te Ngaru Stream. The area is subject to inundation from flash flooding which is an extremely volatile natural hazard. There is a risk to public safety. There is generally very little warning time for flooding in this area. Residential occupation of the floodplain is likely to end in disaster, as it has in many other developments that have taken place on floodplains around New Zealand. The floodplain is an area that is constantly undergoing natural changes due to erosion and siltation. Any permanent structures in this environment will be at risk.

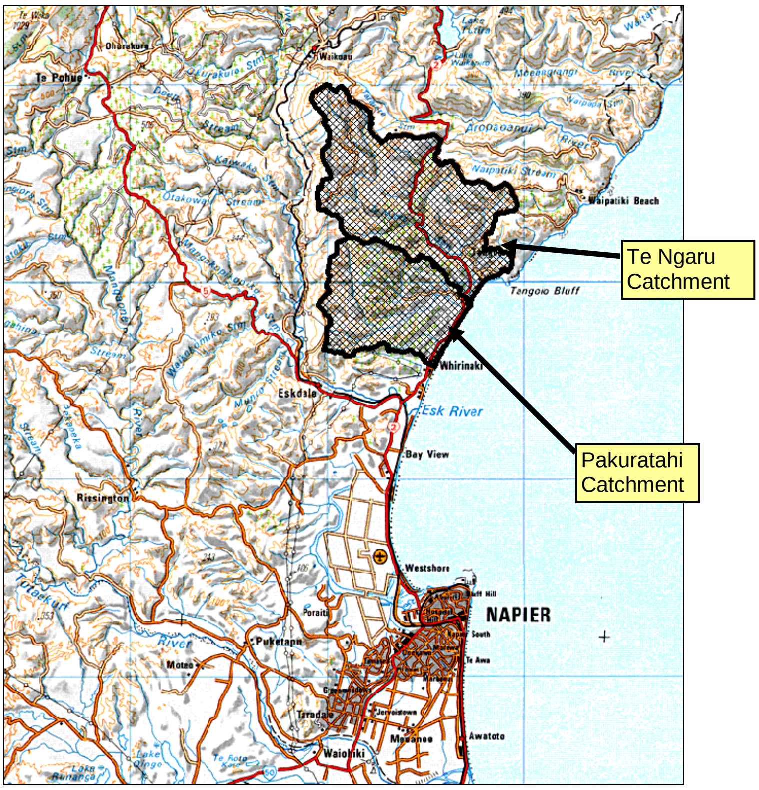

Figure 1: Locality Plan

2 Catchment Characteristics

The Te Ngaru Catchment has an area of approximately 54 km^2. It extends inland about 13 km, with a stream length of about 16 km. The elevation ranges from about 600 m down to sea level. A digital elevation model of the catchment is shown in Figure 2. The catchment is subject to flash floods due to the steep gorges that concentrate the flow and cause very severe flooding in the valley towards the coast. This is typical of the many valleys along the coastal hills of Hawkes Bay. The catchment finishes on the floodplain that has been created by the continual deposition of silt onto the low-lying areas. The past flooding has had devastating effects causing silt deposits, bridges to become impassable and general disruption to the farming that occurs on the valley floor. Flash floods will carry large amounts of silt and debris, making the flood characteristics impossible to predict.

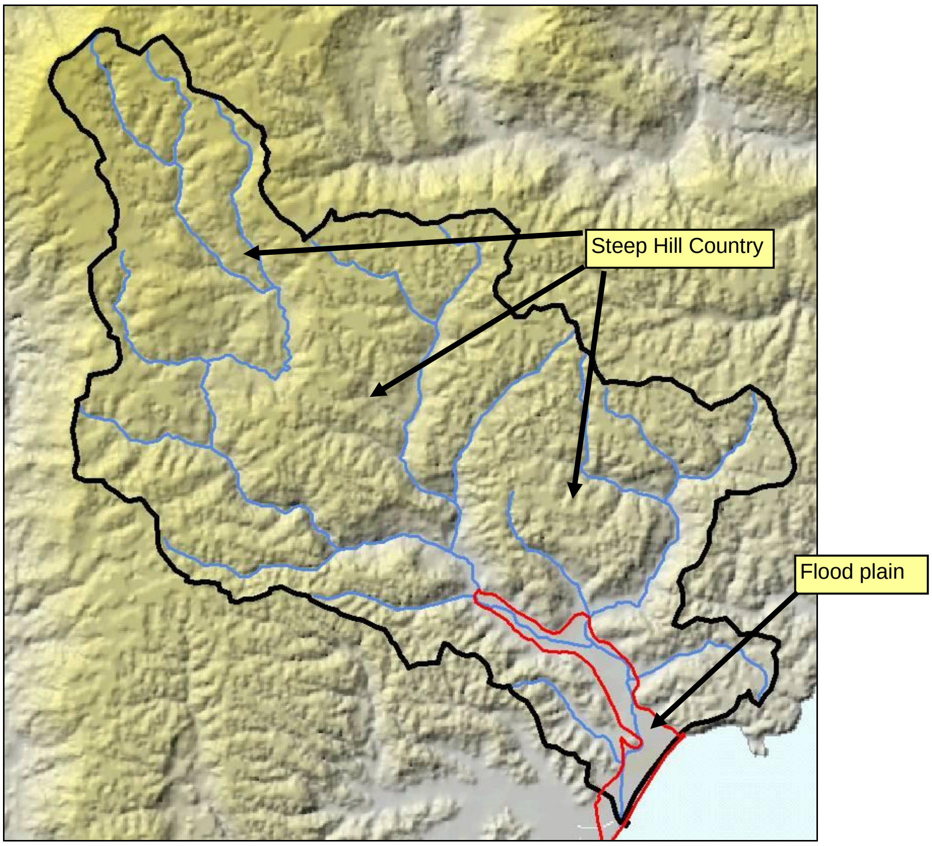

Figure 2: Te Ngaru Catchment Digital Elevation Model

The 1931 earthquake in Hawke's Bay lifted the coastal area of the Te Ngaru catchment by approximately 2 m. There has been no evidence of additional substantial movement since 1931.

3 Te Ngaru Flood Control Scheme

The Te Ngaru Flood Control Scheme was established in 1999 at the request of the residents in the lower floodplain section of the catchment. The objectives of the scheme are to:

1. Reduce the potential for flooding and damage to properties along the section of river maintained.

2. Reduce the probability of closure of Tangoio and Beach Road (within the boundaries of the Scheme) due to flooding.
3. To maintain a riverine environment that provides a diverse habitat for wildlife, a healthy fishery, a pleasing landscape and encourage compatible recreation uses.

The scheme assets that are maintained are the 3 km section of stream from the coast up to Tangoio Settlement Road. The rating area for the scheme is shown in Figure 3

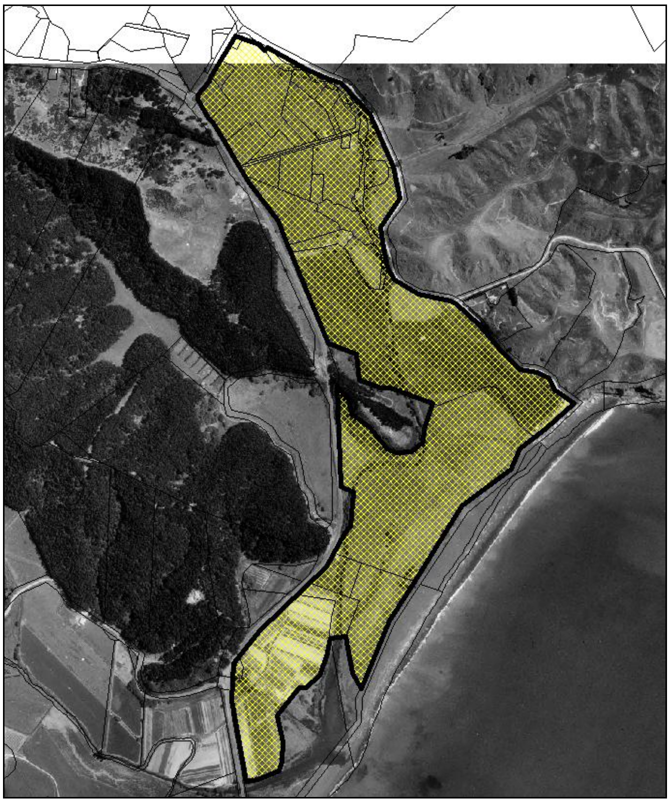

Figure 3: Te Ngaru Flood Control Scheme Rateable Area

The works undertaken to manage the scheme are to remove trees where they are an impediment to the flood flow, as well as to spray willow regrowth on the bed and banks of the stream, and to conduct minor bank stabilisation where required.

The scheme has no specific design standard. The potential for flooding is reduced by ensuring the channel remains clear of unwanted vegetation, which could result in channel blockages.

4 Historical Flooding

The Te Ngaru Catchment has been the subject of regular flood events with records dating back to 1924 that show the severity of the flooding. Details of some of the more serious events are provided below.

4.1 March 11-12, 1924

Approximately 380 mm of rain fell over 24 hours, with about 200 mm of this falling over a 3-hour period. Two houses were washed away at Tangoio.

4.2 April 24, 1938 (Esk Valley Floods)

The rainfall measured at Tutira for this event was 77.5 mm on April 23, 324 mm on April 24, and 209 mm on April 25, giving a total of 610.5 mm over 3 days. The highest intensity was estimated to be about 300 mm over 14 hours. Extensive slips and landslides of the hillsides, and silting of floodplains was a predominant feature of this flood, with some parts of the Esk Valley having over 2 m of silt deposited on the valley floor. It is likely that a similar scale of siltation occurred in the Te Ngaru Catchment. One death by drowning was reported at Tangoio.

4.3 July 31 - Aug 2, 1954

Rainfall records show 152.9 mm on July 22, 1954, followed by 29.7 mm on July 31, 85.3 mm on Aug. 1, and 201.2 on Aug. 2. The three-day rainfall gives 316.2 mm on a wet catchment. No other records were available for this flood.

4.4 March 11 –13, 1955

Rainfall records show 32.3 mm on March 11, 1955, followed by 200.7 on March 12, and 103.4 on March 13, 1955. The three-day rainfall gives 336.4 mm on a relatively dry catchment. No other records were available for this flood.

4.5 July 14, 1956

Rainfall estimates from one rain gauge that may have overflowed were approximately 215 mm on July 13, 38 mm on July 14 and 27 mm on July 15. Another gauge near White Pine Bush measured 241 mm in 15 hours from 6 pm Friday July 12, to 9 am Saturday, July 13.

In the Te Ngaru area, flood water damage occurred in 6 houses and a garage, as well as causing fences to be flattened and depositions of silt on pastures to occur. The estimate of silt deposit was a mean depth of 0.425 m, with 0.9 on the edge of the main channel.

Newspaper reports described the situation as:

The normally sedate Te Ngaru Stream "went on a rampage on Saturday morning about 7 o'clock, spilling millions of gallons of water suddenly into the peaceful Tangoio Valley. The water filled the valley from side to side with a turbulent rushing torrent of water which did immense damage in its short run to the sea."

"A raging torrent about a quarter of a mile across today swept down the Tangoio Valley, invading more than 20 houses and leaving considerable destruction.

The stream swept with it "logs, gates, fences, sheds, and even whole trees."

One local resident commented that it happened so suddenly, they did not have time to take any emergency action, and were forced to wait in their house, having to place items on the kitchen table to keep them dry.

Near one driveway, a letter box about 1.2 m above ground was the only refuge for two chickens for a distance of about 800 m.

The floodwaters were strong enough to remove a large wooden shed without a trace. A resident pointed out where a small house had stood before the flood. "It just disappeared at the height of the torrent and we have been able to find no trace of it since."

Residents forced onto their roof commented that "The whole house shook with the force of the water, and we were afraid we were going to be swept out to sea. Great trunks of trees swept past the house and fortunately none of them made contact."

"Huge trunks of trees battered against the houses in the valley, and families took refuge on house-tops."

Residents believed this flood surpassed that experienced in 1938.

4.6 June 2,3,4 1963

The rainfall estimate at Flatrock Station for this event was 365 mm over 15 hours from 9 am to 6 pm on June 4. The Tareha rainfall station recorded 115.3 mm on June 3, 194.8 mm on June 4, and 28.4 mm on June 5.

Newspaper reports are as follows:

About 40 houses in the area were flooded to the level of their window sills.

Thousands of acres of farmland are under water and stock losses are heavy.

Early this morning (June 3), when the rain gathered in intensity and the threat of flooding became evident, a local resident left his house to drive his vehicle to safety. By the time this task was partly accomplished his house was marooned and he could not return to his family.

There's a sheet of water not quite half a mile wide down there with trees and other debris rushing past.

Early this afternoon water was said to be flowing through Mr. A. Olson's house on the beach.

Mrs. J. Doohan, whose house is on the side of the hill, said she was looking down on a swirling torrent which stretched from side to side of the valley.

On June 5, 1963, a report indicated "The Tangoio Valley is just a sea of mud with the roadway snaking northwards along its western edge.

With the Tangoio Valley declared unsafe, settlers this afternoon decided to evacuate the area permanently. A meeting of Maori settlers with Government officials heard the District Commissioner of Works, Mr. D.U. White, declare the valley unsafe for habitation.

The flats of the valley are completely covered with silt to a depth of up to three feet.

4.7 June 22, 1968

The rainfall estimate for this event was 170 mm overnight at one recorder, and 199.6 mm for 24 hours at another recorder.

Newspaper reports:

Several Tangoio families were taken to safety today as floodwaters swept through the settlement, scene of the ruinous 1963 flood.

Mr. J. Doohan, a farmer in the valley, said the water had churned everything into mud and left a sea of sludge as it receded this morning.

A huge pile of logs and debris has piled up against the bridge over the normally-tiny stream, damaging it and helping to direct the stream's overflow through the settlement.

Where the water flowed over the road at this morning's flood peak is now an impassable pile of silt and rubbish.

4.8 June 14 - 15, 1973

Rainfall records show 65.5 mm on June 14, and 183.5 mm on June 15, 1973. No other records were available for this flood.

4.9 April 16 – 17, 1977

Rainfall records show 85 mm on April 16, and 234.6 mm on April 17, 1977. No other records were available for this flood.

4.10 March 14 - 15, 1985

Rainfall records show 69.4 mm on March 14, and 205.3 mm on March 15, 1985. No other records were available for this flood.

4.11 July 26 – 28, 1985

This was a moderately severe storm with heavy rain and high seas from the southeast. The Esk Valley suffered a reasonably severe amount, with silt deposits of approximately 1 m. The Hawke's Bay Catchment Board flood report shows photos of severe erosion from the Esk Valley up to Te Pohue, and eastward to Tutira. Since the Te Ngaru catchment is within this region, it is likely that similar erosion took place there.

Rainfall records show 357 mm over the 3 days from July 25, 1985 to July 27 1985. The daily (24 hour totals) are 73.7 on July 25, 187.5 on July 26, and 96.0 on July 27.

4.12 March 27, 1987

Rainfall records show this event to have 237.3 mm in March 27, 1987. No other records were available for this flood.

4.13 March 7, 1988 (Cyclone Bola)

This was probably the most severe storm in recent memory for the Hawke's Bay area. Heavy rain and high winds from the southeast persisted from Monday March 7, until the afternoon of Wednesday March 9. The Hawke's Bay Catchment Board storm report comments: *The Te Ngaru Stream sustained a major flood. There was considerable overflows down the valley and this has left major silt deposits. Stream bank damage has also occurred.*

The Te Ngaru Catchment had received about 310 mm of rain for the month of February 1988, resulting in a wet catchment. Over the 6 days from March 5 to 11, 1988, the Te Ngaru received another 805 mm. On March 8, there was 202 mm of rain, followed by another 223 mm on March 9, then followed by 188 mm on March 10. The floodwaters can be seen in Figure 4, while the silt deposits can be seen in Figure 5 and Figure 6.

Figure 4: March 1988 – Cyclone Bola, Te Ngaru Stream Floodplain

Figure 5: March 1988 – After Cyclone Bola, Te Ngaru Stream Floodplain showing silt deposits

Figure 6: March 1988 – After Cyclone Bola, Te Ngaru Stream Floodplain showing silt deposits

This rainfall event was distinctive in that the return period for the 24-hour duration rainfall (about 200 mm) was about a 30-year event. However, this event had three such days of around 200 mm of rain in a row. The statistics used to determine the return periods do not adequately cover this type of occurrence, due to lack of a sufficiently long period of records. The effects of the 200 mm over 24 hours would have been similar to previous events of this magnitude, then the sustained three days of similar rainfall would have caused the effects to carry on for the length of the storm.

4.14 September 1-3, 1988

A moderate rainstorm combined with 3 to 4 m southeast swells occurred. The Hawke's Bay Catchment Board storm report comments: *Te Ngaru Stream: A moderate flood was sustained which caused some inundation of the lower valley. There have been no reports of damage.*

Rainfall records show 24-hour totals of 210.5 mm on Sept. 2, and 20.5 mm on Sept. 3, 1988.

4.15 Jan 27, 1996

Rainfall records show this event to have 218.8 mm on Jan 27, 1996, then 54.4 mm on Jan. 28, 1996, then 61.3 mm on Jan 29. No other records were available for this flood.

5 Historical Air Photos

The following set of air photos is from HBRC archives, showing the change to the lower floodplain over the years. The trees in the 1934 photo show the original flow path that the out of channel flow may have taken during a flood. The subsequent photos show how the area has gradually been developed for farming.

Figure 7: Air photo March 1934 (arrow showing likely flow path through treed area)

Figure 8: Air photo October 1981

Figure 9: Air photo September 1986

Figure 10: Air photo November 1995

Figure 11: Air photo February 2000

6 Hydrologic and Hydrodynamic Computer Model Analysis

A computer model of the Te Ngaru Catchment was created using the Mike-Zero set of analysis tools from the Danish Hydraulic Institute (DHI). A hydrologic model was created using the Mike11-NAM software, while a hydrodynamic model was created using the Mike21-HD software. The hydrologic model uses rainfall and catchment parameters as the inputs, and creates discharge values as the output. The hydrodynamic model uses discharge values from the NAM output, and ground level data (as well as several other parameters) as inputs, then routes the discharge over the ground, which enables velocities and water levels to be calculated.

6.1 Hydrologic Model

The catchment was delineated into 7 separate sub-catchments for the hydrologic model.

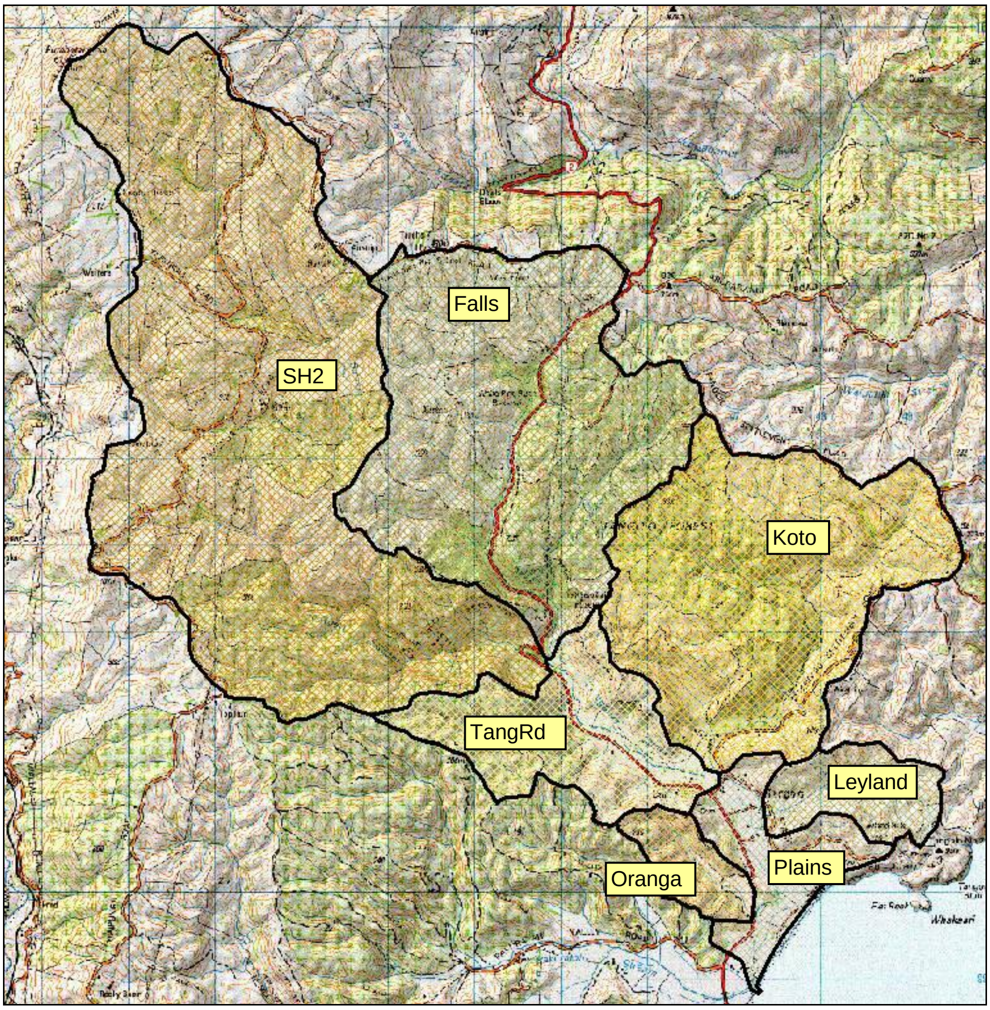

Figure 12: Catchment Delineation for Hydrologic Model (subcatchment name shown)

The model parameters for each subcatchment were assigned based on physical conditions, as well as knowledge from modelling similar catchments in other parts of Hawke's Bay.

6.1.1 Rainfall Analysis

Since 1924, reasonably accurate rainfall records have been kept for the Te Ngaru catchment. The following table summarises the rainfall totals (mm).

Year	Month	Rainfall Totals (mm)				Comments
		Short Duration	1 day	2 day	3 day	
1924	March 11	200 mm in 3 hours	380			
1938	April 24	300 mm in 14 hours	324.0	535.0	610.5	Esk Valley Flood
1954	July 3		201.2	286.5	316.2	Wet catchment
1955	March 11		200.7	304.1	336.4	Dry Catchment
1956	July 14	241 mm in 15 hours	241.0	278.9	318.8	0.4 m silt deposits
1963	June 4	365 mm in 15 hours*	194.8	310.1	338.5	
1968	June 22		199.6	225.5	230.1	
1973	June 14		183.5	249.0	251.5	
1977	April 16		234.6	319.6	323.6	
1985	March 14		205.3	274.7	287.0	
1985	July 26		187.5	283.5	357	
1987	March 27		237.3	256.2	257.5	
1988	March 7		223.0	424.7	612.9	Cyclone Bola
1988	Sept. 2		210.5	231	231	
1996	Jan. 27		218.8	273.3	334.6	
*unofficial record from D. Mckay of Flatrock Station						

Table 1: Rainfall Totals (mm) for Te Ngaru Catchment

A simple average of the occurrence of these types of events gives approximately one such event every 5 years (15 events over 72 years). It is likely that several other events may have occurred that were not recorded, especially in the 1924 to 1954 years.

The rainfall statistics provided by *The Frequency of High Intensity Rainfalls in New Zealand, Technical Publication 19* (TP19) and *High Intensity Rainfall Distribution System* (HIRDS) for the Te Ngaru Catchment are as follows:

	Rainfall Depth (mm)		
Return Period	1 Day	2 Day	3 Day
5 year	200	249	274
50 year	305	380	419
100 year	336	419	460

Table 2: Statistical Rainfall Depths (mm) for Te Ngaru Catchment (from TP 19)

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	Rainfall Depth (mm)		
Return Period	1 Day	2 Day	3 Day
5 year	160	197	223
50 year	279	343	386
100 year	336	413	465

Table 3: Statistical Rainfall Depths (mm) for Te Ngaru Catchment (from HIRDS)

There is a significant difference in some of the results from HIRDS compared to TP19. The reason for the difference is unclear, however, the HIRDS system incorporates the most recent rainfall data, while TP 19 incorporated data up to 1980 only.

Since the methods of analysis for TP19 and HIRDS are centred around the 5-year, 24 hour duration values, their analyses does not incorporate the observed values for the long duration events (such as 612.9 mm over 3 days for Cyclone Bola). This results in a large variability in the return period estimation for this catchment. Since the rainfall of 610 mm over 3 days has occurred twice in the last 50 years, it would seem necessary to ensure the analysis includes provision for this type of event.

6.1.2 Probable Maximum Precipitation

The concept of the probable maximum precipitation (PMP) is used to determine the maximum likely rainfall event that may occur over the catchment. The method adopted to generate the PMP for this study is the generalised PMP method outlined in PMPNZ (1992). The method involves obtaining a representative 24 hour index PMP value, then adjusting this value for elevation and catchment area. This results in a 24 hour catchment PMP in millimetres. This value is then factored to provide PMP estimates for durations other than 24 hours. Each of the factored values is then distributed on an hourly timescale to provide a PMP hyetograph.

The PMP values derived for the Te Ngaru Catchment are as follows:

PMP Rainfall (mm)								
	Rainfall Duration (Hours)							
Time	6	8	12	24	36	48	60	72
0	0	0	0	0	0	0	0	0
1	37.3	33.9	27.8	11.2	8.2	6.3	3.7	1.7
2	37.3	33.9	32.1	12.6	8.6	6.3	3.7	1.7
3	37.3	33.9	36.1	17.0	10.1	7.5	3.7	1.7
4	40.4	33.9	41.6	19.7	12.2	8.3	6.3	2.8
5	40.4	36.7	47.7	20.6	15.2	9.1	6.3	4.4
6	40.4	36.7	52.7	24.4	15.2	12.3	6.3	4.4
7	0.0	36.7	65.4	24.4	15.2	12.3	10.2	4.4
8	0.0	36.7	55.6	29.8	19.4	12.3	10.2	8.1
9	0.0	0.0	45.4	31.2	20.5	12.3	10.2	9.0
10	0.0	0.0	37.4	34.5	20.5	14.6	10.2	9.0
11	0.0	0.0	30.8	39.4	21.9	18.0	10.2	9.0
12	0.0	0.0	21.2	39.4	27.5	18.0	10.2	9.0
13	0.0	0.0	0.0	53.5	27.5	18.0	15.8	9.0
14	0.0	0.0	0.0	53.5	27.5	18.0	15.8	9.0
15	0.0	0.0	0.0	46.5	31.7	22.5	15.8	11.9
16	0.0	0.0	0.0	41.7	34.5	25.5	15.8	13.9
17	0.0	0.0	0.0	40.0	34.5	25.5	15.8	13.9
18	0.0	0.0	0.0	33.2	34.5	25.5	15.8	13.9
19	0.0	0.0	0.0	33.2	46.3	25.5	22.7	13.9
20	0.0	0.0	0.0	25.5	46.3	30.6	22.7	13.9
21	0.0	0.0	0.0	23.5	46.3	31.9	22.7	13.9
22	0.0	0.0	0.0	20.5	41.3	31.9	22.7	16.6
23	0.0	0.0	0.0	15.6	33.8	31.9	22.7	20.7
24	0.0	0.0	0.0	14.7	33.8	31.9	22.7	20.7
25	0.0	0.0	0.0	0.0	33.8	42.2	31.6	20.7
26	0.0	0.0	0.0	0.0	26.8	42.2	31.6	20.7
27	0.0	0.0	0.0	0.0	25.1	42.2	31.6	20.7
28	0.0	0.0	0.0	0.0	25.1	42.2	31.6	20.7
29	0.0	0.0	0.0	0.0	23.6	39.5	31.6	22.9
30	0.0	0.0	0.0	0.0	17.8	28.6	31.6	31.9
31	0.0	0.0	0.0	0.0	17.8	28.6	39.2	31.9
32	0.0	0.0	0.0	0.0	17.8	28.6	39.2	31.9
33	0.0	0.0	0.0	0.0	14.4	28.6	39.2	31.9
34	0.0	0.0	0.0	0.0	12.1	25.1	39.2	31.9
35	0.0	0.0	0.0	0.0	10.9	19.8	39.2	31.9
36	0.0	0.0	0.0	0.0	10.6	19.8	39.2	31.9
37	0.0	0.0	0.0	0.0	0.0	19.8	25.5	37.1
38	0.0	0.0	0.0	0.0	0.0	19.8	25.5	37.1
39	0.0	0.0	0.0	0.0	0.0	16.4	25.5	37.1
40	0.0	0.0	0.0	0.0	0.0	14.2	25.5	37.1
41	0.0	0.0	0.0	0.0	0.0	14.2	25.5	37.1
42	0.0	0.0	0.0	0.0	0.0	14.2	25.5	37.1
43	0.0	0.0	0.0	0.0	0.0	14.2	17.3	37.1
44	0.0	0.0	0.0	0.0	0.0	10.9	17.3	26.1
45	0.0	0.0	0.0	0.0	0.0	10.0	17.3	23.4
46	0.0	0.0	0.0	0.0	0.0	9.2	17.3	23.4
47	0.0	0.0	0.0	0.0	0.0	7.9	17.3	23.4
48	0.0	0.0	0.0	0.0	0.0	7.9	17.3	23.4
49	0.0	0.0	0.0	0.0	0.0	0.0	12.1	23.4
50	0.0	0.0	0.0	0.0	0.0	0.0	12.1	23.4
51	0.0	0.0	0.0	0.0	0.0	0.0	12.1	18.7
52	0.0	0.0	0.0	0.0	0.0	0.0	12.1	15.6
53	0.0	0.0	0.0	0.0	0.0	0.0	12.1	15.6
54	0.0	0.0	0.0	0.0	0.0	0.0	12.1	15.6
55	0.0	0.0	0.0	0.0	0.0	0.0	7.8	15.6
56	0.0	0.0	0.0	0.0	0.0	0.0	7.8	15.6
57	0.0	0.0	0.0	0.0	0.0	0.0	7.8	15.6
58	0.0	0.0	0.0	0.0	0.0	0.0	5.2	13.4
59	0.0	0.0	0.0	0.0	0.0	0.0	5.2	10.2
60	0.0	0.0	0.0	0.0	0.0	0.0	5.2	10.2
61	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.2
62	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.2
63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.2
64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.2
65	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.4
66	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.4
67	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.4
68	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.4
69	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4
70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1
71	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1
72	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1
Total	232.8	282.2	493.9	705.6	867.9	1002.0	1114.8	1220.7

Table 4: PMP Rainfall Depths (mm) for Te Ngaru Catchment

6.1.3 Hydrologic Model Results

The hydrologic model was run with the rainfall from the 1924, 1938 and 1988 storms, the design 50 and 100 year events, as well as the 6, 8, 12, 24, 48 and 72 hour PMP rainfalls. The results from the catchments were aggregated to be input to the hydrodynamic model. The following table provides a summary from the hydrologic model results. The PMP events are assumed to cause the Probable Maximum Flood (PMF).

Event	Peak Discharge (m^3/s)	Rainfall Volume (million m^3)	Runoff Volume (million m^3)
March 1924	512	20.4	10.2
April 1938	169	33.2	16.9
March 1988	239	25.4	16.8
TP19 50 year	380	20.5	14.9
TP19 100 year	427	22.5	16.7
6 hour PMP	510	12.5	8.9
8 hour PMP	456	15.2	11.0
12 hour PMP	753	26.7	20.3
24 hour PMP	628	38.1	29.4
48 hour PMP	510	54.1	42.3
72 hour PMP	448	65.9	52.1

Table 5: Hydrologic Model Results from various storm events

A major assumption in the above table is that the rainfall is assumed to be uniformly spread across the whole catchment at the same time. For most storms this is unrealistic, since rainfall is known to vary considerably within short distances. Despite this assumption, realistic results can still be obtained from the modelling, since the critical locations being examined are in the floodplain area, where the runoff eventually ends up. Any inconsistencies are quite likely to be filtered out by the time the discharge ends up in the floodplain area.

The hydrologic model results show the variability that may result from the variety of storms. The 1938 storm was considered very severe in terms of silt deposits, however it appears to have a lesser peak discharge than other storms. This was one of two 3-day storms that had over 600 mm of rain. This is consistent with research that has shown that 200 mm of rain over 24 hours will cause hillside erosion to take place. The 1938 and 1988 events were two such events that actually had 3 days in a row of 200 mm rain per day.

6.2 2D Hydrodynamic Model

The 2 Dimensional hydrodynamic model was created using the ground elevation data obtained from the HBRC Lidar survey, and a river cross section survey, both completed in July 2003. A 10 m x 10 m grid of the floodplain was created from the data. Where necessary, levels in the 10 x 10 grid were adjusted to match the surveyed cross section levels. A simplification of inputs to the 2D model was made by inputting the entire discharge at one location upstream of the floodplain area. While this results in an overestimation of the water levels near the discharge input location, as the water flows down into the floodplain, the resulting water levels will represent the flow over the floodplain more accurately, as the actual discharge points will be covered.

6.2.1 Limitation of Hydrodynamic Model

The hydrodynamic model created to examine the Te Ngaru Stream does not take into account the movable nature of the bed material in the stream, or depositions of silt on the floodplain. The rainfall events being modelled are, however, likely to be accompanied by severe slipping of the land and therefore large quantities of silt and debris will accompany the floodwater.

Water velocities will reduce as the water flows over the floodplain, resulting in deposition of silt. This in turn will make the river channel unstable, resulting in the potential for course changes, including the river finding a more direct route to the sea.

Since the model does not take the bed movement into account, there is no estimate of flood level that takes into account the changing bed levels. Despite this limitation, the changing level of the floodplain should be taken into account when considering floods that may occur in the future. Depositions of up to 1 m have been observed in recent times, which in turn will cause the water levels to be higher. The floodplain has developed over time from these depositions, and will continue to do so in the future.

6.2.2 Calibration

There is limited measured data which is accurate enough to calibrate the 2D model. The following figures show the water level in the southeast corner of the floodplain where the existing buildings are located. It appears the water level reached approximately RL 14.8 m at this location.

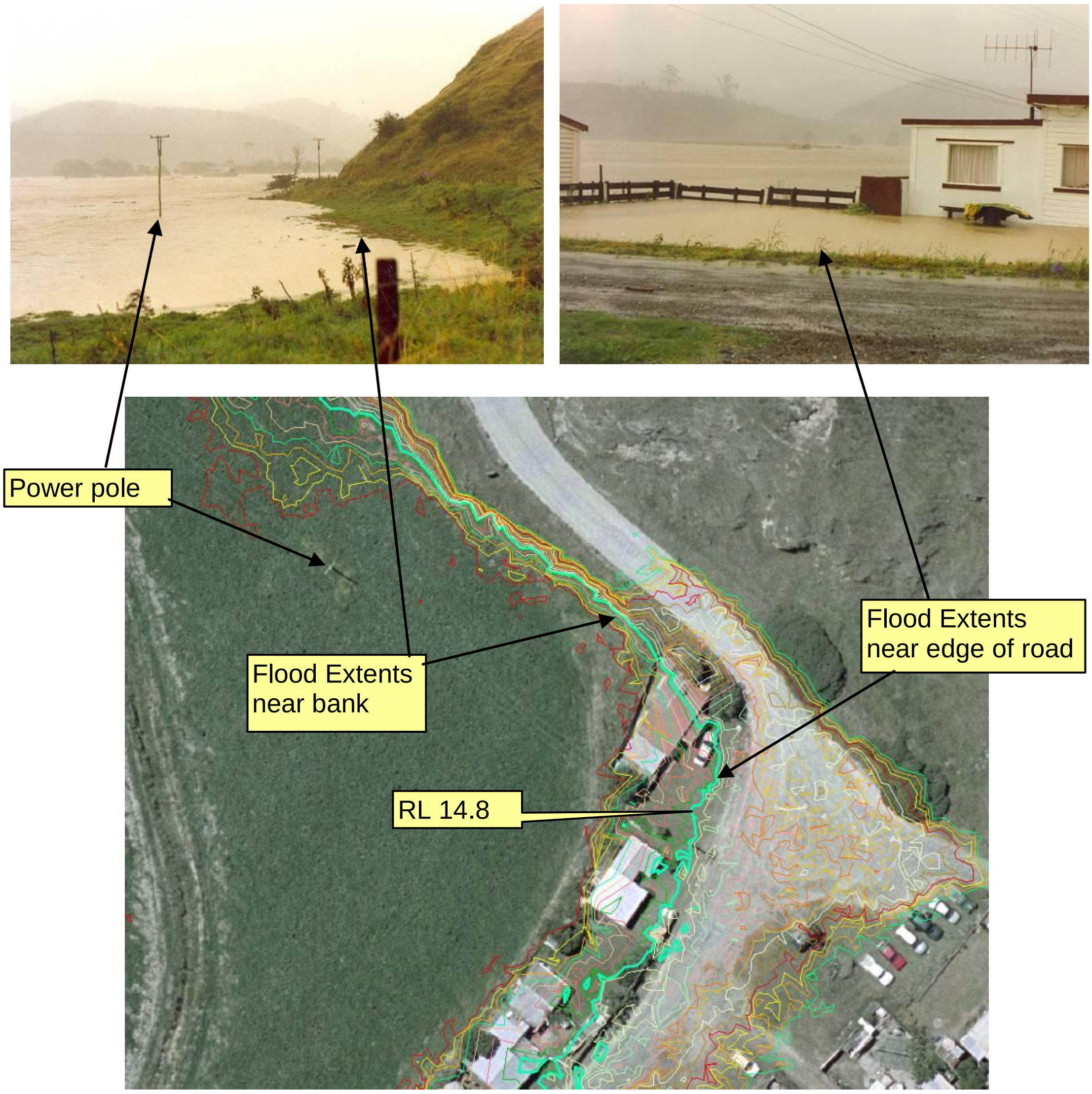

Figure 13: Photos from Cyclone Bola (March 88), Air photo from 2004

The hydrodynamic model was run with the hydrograph generated from the hydrologic model for the March 1988 storm (Cyclone Bola). The results from the model show the maximum water level at same location of above photos to be RL 14.74 m.

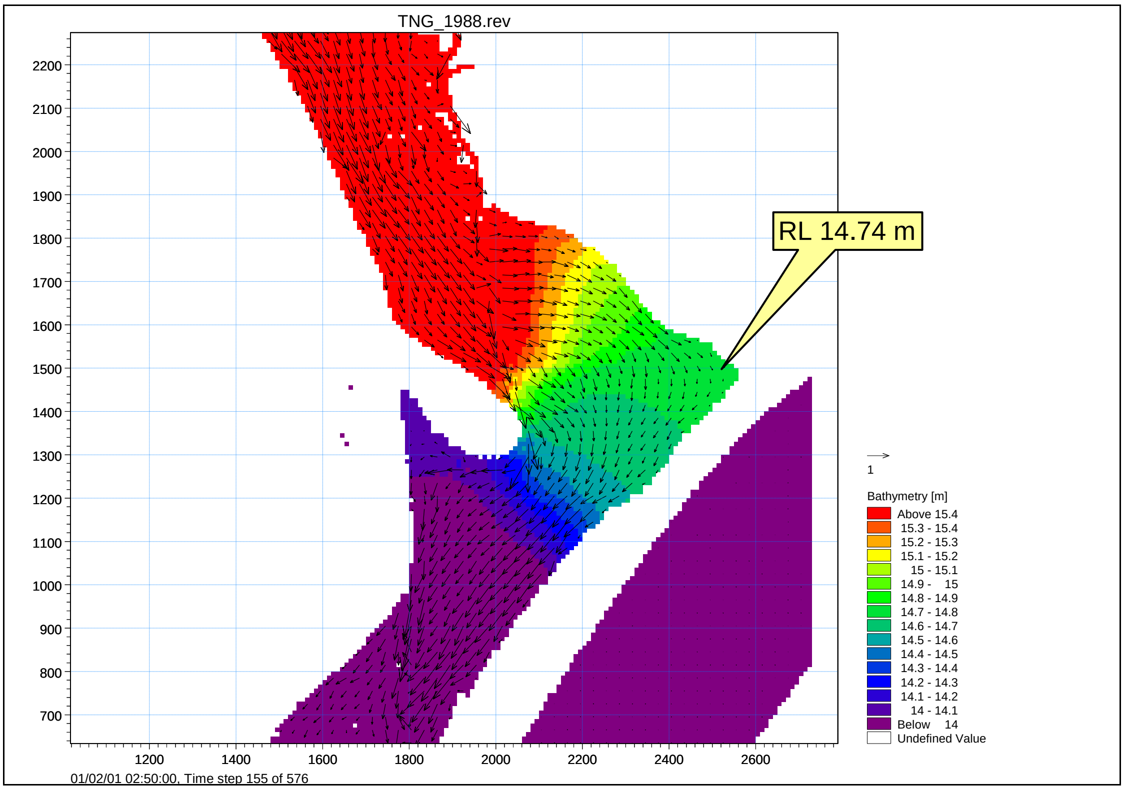

Figure 14: 2D Hydrodynamic Model Results for Bola (March 88) – Water Levels and Velocity Vectors

The above results show that the model is able to predict (within a level of accuracy) the water levels on the floodplain, based on a given rainfall event.

6.2.3 River Mouth

The mouth of the Te Ngaru stream is shared with the Pakuratahi Stream. The combined catchment area is about 87.5 km^2.

Figure 15: Te Ngaru River Mouth

There have been many occurrences of the river mouth blocking from heavy seas depositing shingle across the mouth. This is common for these types of river mouths, with the Esk, Ngaruroro, Tukituki, and several others behaving in similar fashion. The Te Ngaru has a scheme in place to mechanically open the river mouth in the event it is blocked by shingle. Over the period from 2001 to 2005, the Te Ngaru was mechanically opened 40 times. Despite the procedures being in place, there is considerable risk that a blocked river mouth may not be able to be opened prior to a large rainfall event occurring. In the past, the weather patterns that produce the extreme rainfall events also cause large ocean swells, which are the cause of the shingle depositions that close the river mouth.

For the Te Ngaru/Pakuratahi Catchments, the blockage of the river mouth could result in flooding of the Te Ngaru floodplains from heavy rainfall in either catchment. At the present time, the consequence of a blocked mouth is not dire, as there is little infrastructure at risk, however, some preliminary hydrodynamic model results indicate that blockage during a severe event could raise the water level on the floodplain by up to 1 m. This increase in water level is quite variable, and is dependant on the elevation of the blockage, as well as the rate at which the blockage may be eroded from the pressure of the stream water on the beach crest.

6.2.4 2D Hydrodynamic Model Results

A summary of results from the 2D model at the south east corner of the floodplain is provided below. The peak water level for the variety of rainfall events has been provided. The complete set of results from the range of 2D models run are vast and extensive. Each result file contains water levels and discharges for the range of the input time series, for each 10 m x 10 m grid point. Analysis is usually best done by examining the model outputs as dynamic events over the time span of the storm. Since results like this cannot be conveyed easily in report form the following table provides a summary.

Event	Peak Discharge (m^3/s)	Rainfall Volume (million m^3)	Runoff Volume (million m^3)	Peak Water Level (predicted by model)
March 1988	239	25.4	16.8	14.74
TP19 50 year	380	20.5	14.9	15.09
TP19 100 year	427	22.5	16.7	15.21
12 hour PMF	753	26.7	20.3	15.84
24 hour PMF	628	38.1	29.4	15.61
72 hour PMF	448	65.9	52.1	15.28
72 hour PMF with Mouth Closed	448	65.9	52.1	16.33

Table 6: Hydrologic Model Results from various storm events

The above results are based on the ground levels in the floodplain as at July 2003. As the floodplain becomes further silted, these levels will correspondingly increase. The actual rate of siltation is not known, as no long-term measurements have been taken.

The level of the beach crest is approximately RL 16.9 m. The worst case flooding presented above (72 hour PMF with river mouth closed) would likely result in the beach crest being eroded, and a new river mouth forming to the north east of the existing mouth.

6.2.5 Analysis of Flooding Potential

There appears to be three distinct levels of flooding that may occur on the floodplain in this valley. The first being smaller floods with low velocity flow that deposit minor amounts of silt onto one or more locations on the floodplain. These may occur frequently (say every 5 to 10 years). The amount of silt deposit varies quite considerably. For example in the July 1956 flood, it was estimated that between 0.4 m and 1.0 m of silt was deposited in the floodplain of the Te Ngaru Stream. In the April 1938 flood, the Esk Valley had areas of silt deposit of up 3 m, with an average of around 1 m. It has been estimated that 200 mm of rain over 24 hours is enough to trigger a significant amount of slips. The material from these slips eventually gets deposited on the floodplain area. The rainfall statistics show that these types of storms occur approximately every 5 years on average, each with varying amounts of silt deposits.

The second level of flooding that may occur is a medium level that may cause scouring and significant erosion to the river channels and banks, as well as significant silt deposits. The frequency of these may be in the order of once every 50 to 100 years. During this type of flood, it would be anticipated that a significant portion of the beach crest would be eroded, due to the forces of the water acting upon it.

The third and highest level of flooding that may occur is the extreme case of the maximum flood. This will generally cause severe changes to the landscape, and may result in a complete change to the location of the mouth of the Te Ngaru Stream. There is likely to be sufficient scouring potential to cause erosion of the beach crest, which would form a new channel and river mouth, resulting in the water taking a straighter path of least resistance to the ocean.

The following figure shows the direction change that the floodwaters must take at the beach, as well as the potential overflow in the event of an extreme event.

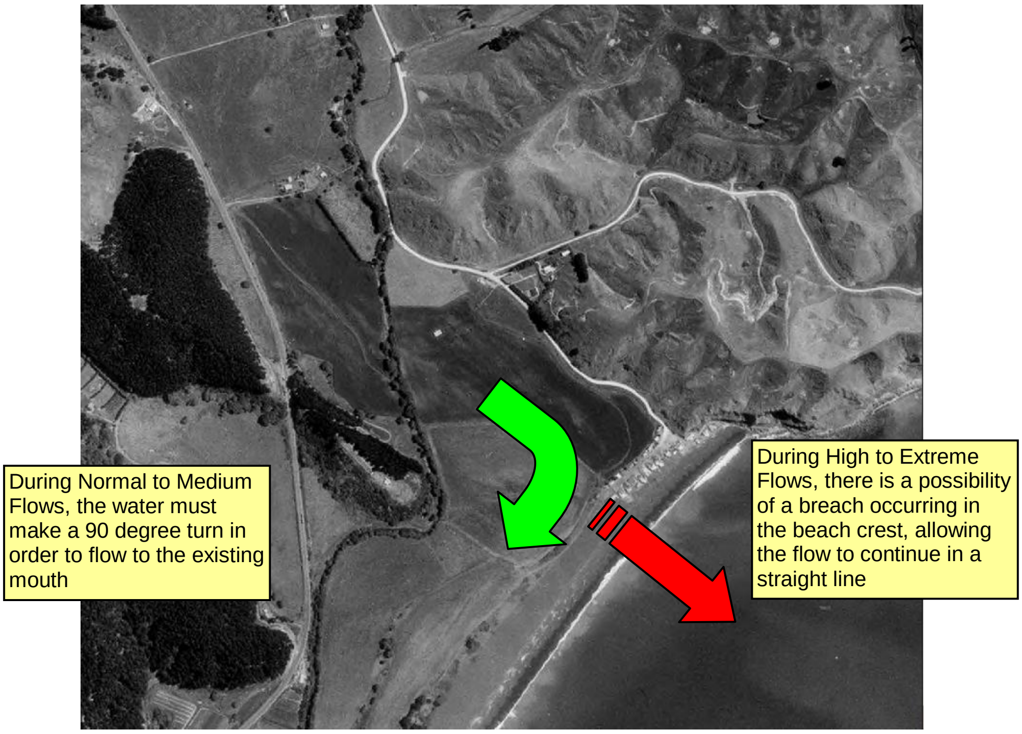

Figure 16: Direction Change on Te Ngaru Floodplain

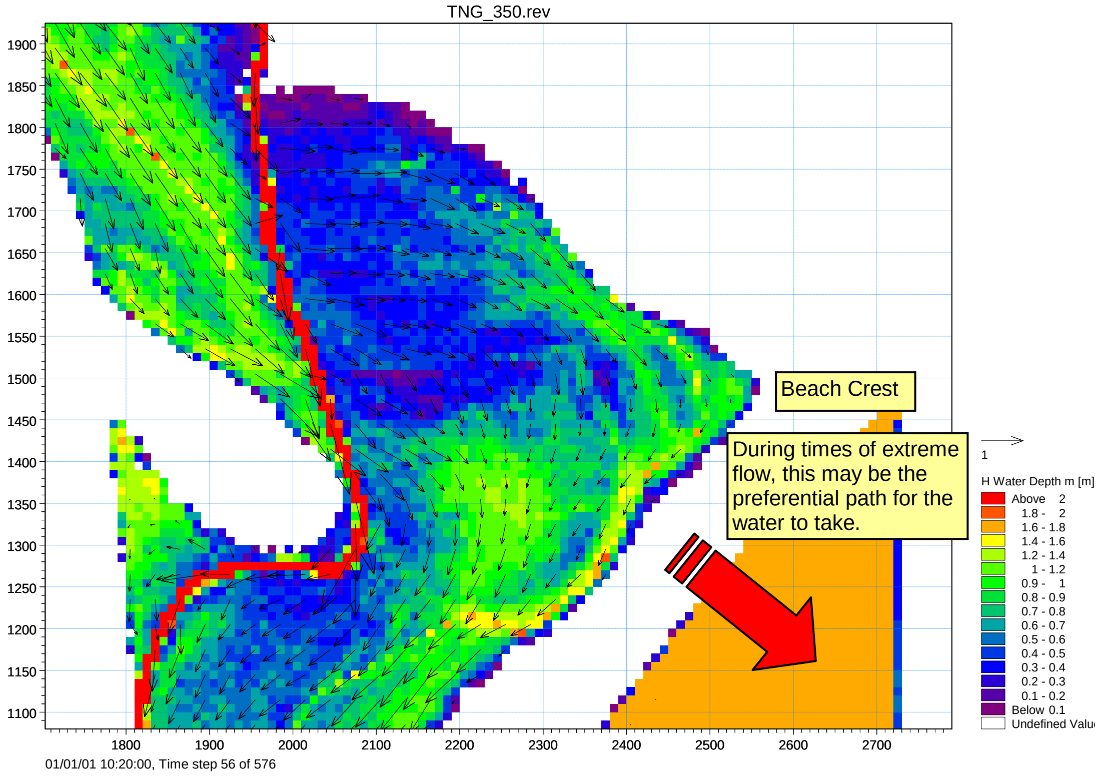

Figure 17: Te Ngaru Floodplain showing velocity vectors

The velocity vectors from the hydrodynamic model show the path the water must take in order to turn the corner before the beach crest. In order to turn this corner, there is a significant amount of energy from the momentum of the water that will be causing the beach crest to erode. At the same time, the change in direction will cause the water to slow in velocity, which in turn causes silt deposition to occur.

These three levels of flooding described above are not distinct from each other, in the sense that there are no specific boundaries that separate a low to medium flood, or a medium to extreme flood. Every event is different in terms of timing and amount of runoff, erosion potential, amount of silt deposited, etc. The three categories merely generalise the floods into the amount of damage that may be expected, with a rough guide to frequency.

7 Flood Hazard Assessment

An assessment of the hazard on the Te Ngaru floodplain was made using the criteria developed from the New South Wales Government Floodplain Management Manual (2001), which uses the depth multiplied by velocity criteria. Figure 18 shows the three levels delineated. Level 1 occurs with shallow water and low velocity, Level 2 occurs with either shallow water and medium velocity, or deeper water and low velocity, while Level 3 occurs with shallow to medium deep water with high velocity, or deep water with low to medium velocity. Values for the 3 levels are calculated for all grid points in the 2D hydrodynamic model.

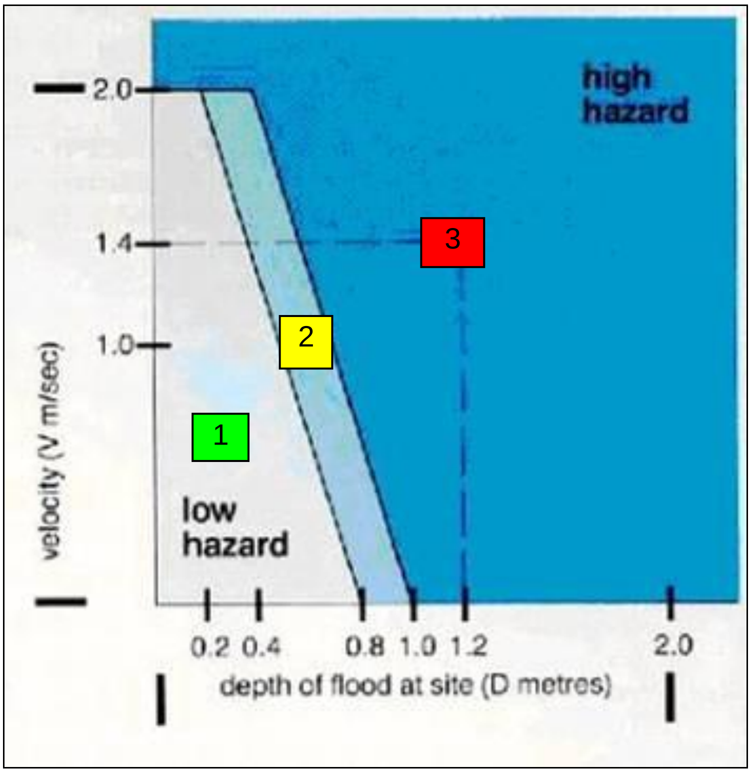

Figure 18: Flood Hazard Assessment Levels

A sample flood hazard map is shown in Figure 19.

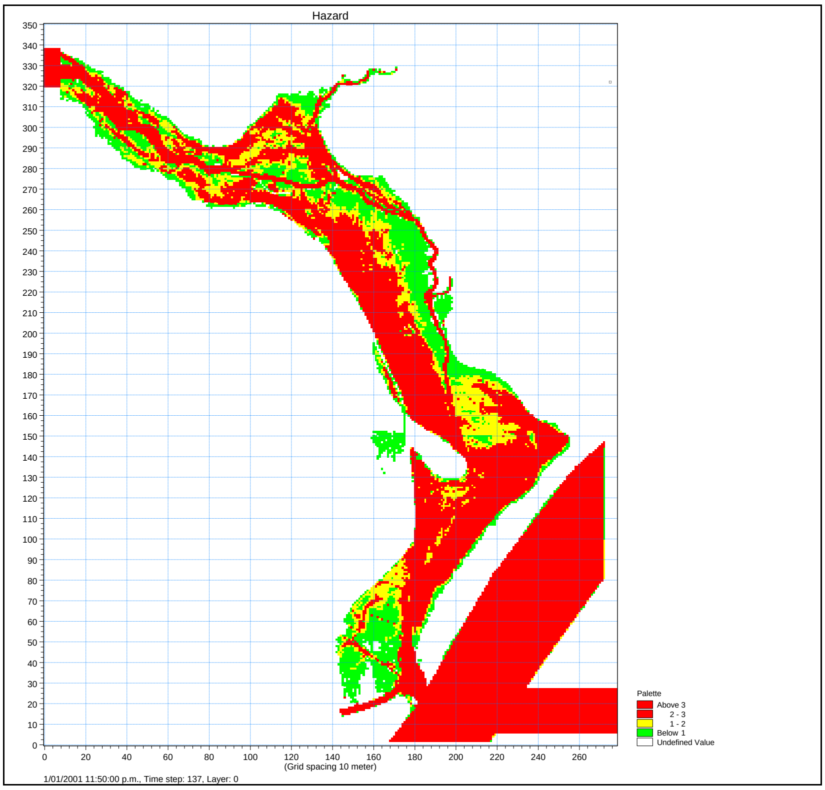

Figure 19: Te Ngaru Floodplain Hazard Output

This flood hazard map was generated based on the 50 year flood levels and velocities. The red shaded area show the extent of the potential hazard level through the entire floodplain.

Based on the potential flood hazard presented above. The following FLOOD HAZARD AREA is proposed for the Te Ngaru Floodplain.

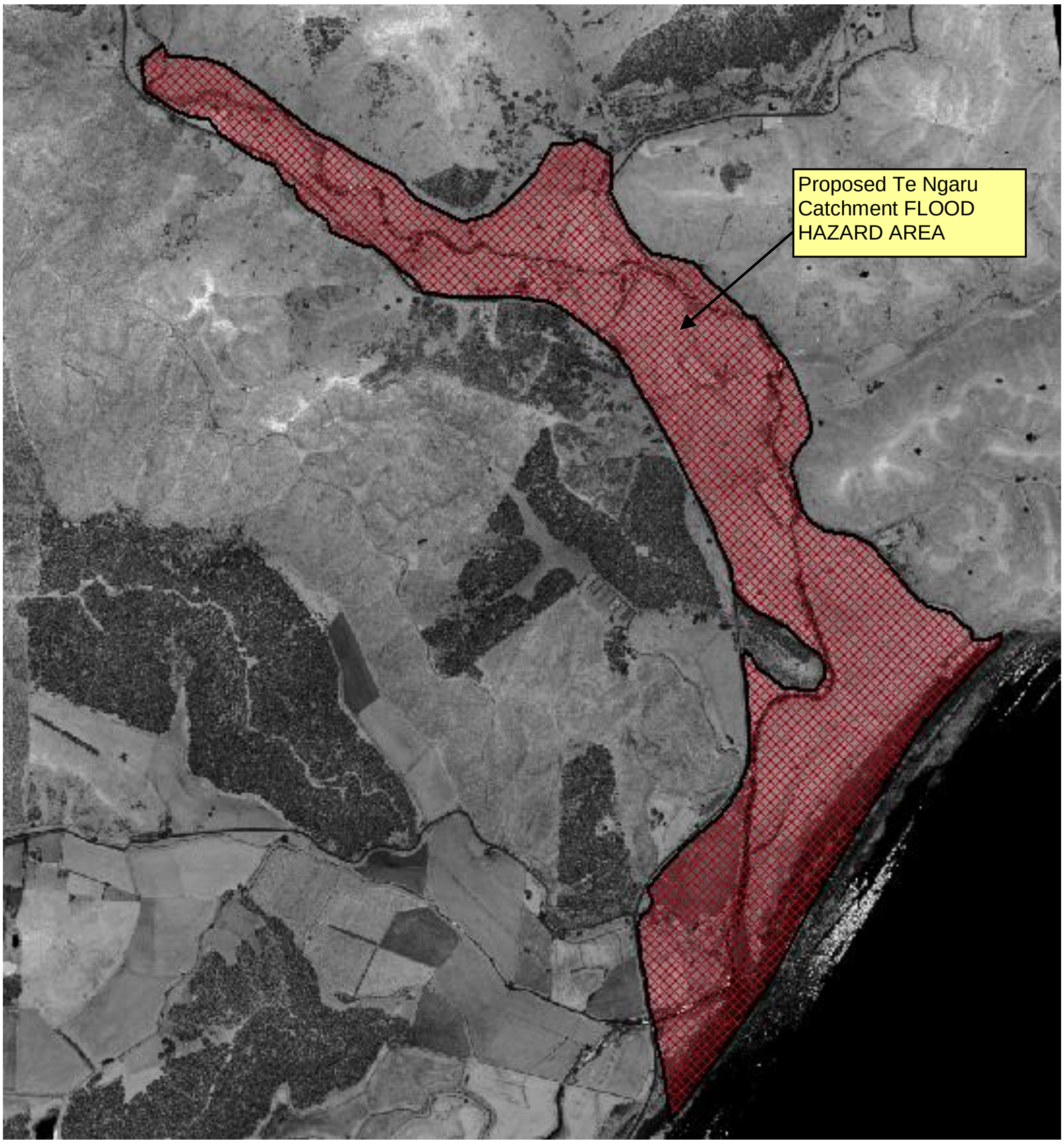

Figure 20: Te Ngaru Catchment Flood Hazard Area

The Te Ngaru Flood Hazard area shown in Figure 20 is based on the 100 year flood discharges. The variety of other discharge calculations shown in this analysis would result in essentially the same flood hazard extents. The difference between the different events is the depth of flooding.

8 Development Potential

The potential to develop the valley floor for residential or similar purposes is very limited due to the extreme flood hazard. This hazard is more than just a ”maybe”; it has happened on many occasions in the past as outlined earlier in this report.

Current climate change predictions are for more extreme weather patterns of the type that cause flooding in this valley.

One might be tempted to consider what mitigation options are available, after all, engineers have been providing solutions to such problems for as long as the problems have existed. The questions to be asked are “Is development in the Te Ngaru a sensible option?” and “Is it essential that the valley be developed?”. The answer in both cases is clearly no.

Mitigation by use of localised raised ground level is fraught with imponderables and will always be a risky option. For example, the level for a building platform should be based on a maximum probable flood, adjusted to allow for the effects of ongoing siltation of the valley floor. Neither of these effects can be confidently determined. Consideration would also need to be given to protection of the platform from scour and undermining as well as the loss of services and access during a flood event.

To date this valley has been largely free of intense settlement, with mainly scattered dwellings in the past, many now gone due to the flooding problems. It is for good reason that development has not proceeded in the valley, it is simply too risky. Ideally the valley should be managed to allow the Te Ngaru “room to move”, any form of control for larger events will be difficult if not impossible.

Our conclusion is that development and settlement in this valley is not wise.

9 Recommendation

Due to the natural flood hazard that has been outlined in this report, we agree that the current rural zone description of the Te Ngaru floodplain in HDC’s District Plan is appropriate. It is recommended that future amendments to the plan include a description of the flood extents from this report.

Even though it may appear feasible to provide an engineering solution, which satisfies the requirements of the Building Act, we strongly discourage development and settlement in the Te Ngaru floodplain. Given the requirement of the Resource Management Act for Regional Councils to: “control …the use of land for the purpose of ... the avoidance and mitigation of natural hazards”, it is recommended that in the case of the Te Ngaru the best and most sensible action is avoidance.

10 Conclusion

The Te Ngaru Stream Catchment spans an area of about 54 km^2, from the coast about 20 km north of Napier, inland for a distance of about 13 km. The catchment is very steep, and is subjected to heavy intense rainfalls that cause flash flooding. The final 4 to 5 km of the catchment are in a narrow valley with opens onto a floodplain that is separated from the ocean by a shingle barrier beach. The high beach crest causes the stream to undergo a 90-degree right angle turn before it empties into Hawke Bay.

The descriptions of all flood events in recent memory involve fast flowing water, combined with lots of debris from trees, buildings and the like. The warning time for such floods is generally less than 2 or 3 hours, and during recent floods there have been several instances of people stranded in houses, having to seek shelter on the roofs to keep out of the flood waters.

Hydrologic and 2D hydrodynamic computer modelling of the catchment has been undertaken as part of this study. The results of this modelling has confirmed that the Te Ngaru Catchment floodplain is a very vulnerable area, that, when subjected to severe rainfall events, responds very rapidly and creates a flood hazard across the entire valley floor. The HBRC recommend that the FLOOD HAZARD AREA be adopted into the HDC district plan in order to prevent development of the floodplain area.