Appendix C
Asset Risk Model Data

Contents

Appendix C Asset Risk Model Data

THAMES COAST FLOOD RISK ASSESSMENT
ASSET RISK MODEL

Tararu **Base Case: 23-Jun-03**

Revision b2
Date 22-Jun-03
Prepared by V Lenting

Key

	Global inputs with distributions
	Global inputs with single values
4	Single value inputs for specific community

DAMAGE COSTS BASED ON DISTRIBUTIONS

		Global inputs (all communities)						Community-specific inputs				Outputs							
								Tararu											
		Damage ratio distributions					Asset value or cost distribution	No. of assets				Damage cost				Total cost (mean)		Flood frequency 0.01 per year	
	TCDC/EW Hazard Zone	Low	Med	High	Very high			Low	Med	High	Very high	Low	Med	High	Very high		%		
	USBR Flood Severity	Very low	Low	Med	High			Very low	Low	Med	High	Very low	Low	Med	High			Annualised cost (risk cost)	
Activity or ass	**Sub-group**																		
Private residences		0.005	0.01	0.05		Per dwelling	$ 89,352		30	9			26,806	40,129		$ 66,934	40.2	$ 669	
Schools		0.005	0.01	0.05		Per location	$ 313,416									$ -		$ -	
Retirement villages		0.005	0.01	0.05		Per accomm. unit	$ 105,019									$ -		$ -	
Camping grour	Tent sites		0.8	1	1	Each	$ 346									$ -		$ -	
	Caravans	0.06	0.10	0.50	1	Each	$ 3,139									$ -		$ -	
	Cabins	0.05	0.10	0.28		Each	$ 4,709									$ -		$ -	
	Direct damage/repair costs	0.15	0.5	1		Lump sum per complex	$ 9,820									$ -		$ -	
	Loss of business	3	5	10		Per day per complex	$ 2,258									$ -		$ -	
Hotels and mo	Accommodation units	0.005	0.01	0.05		Per accomm. unit	$ 50,773		7				3,532			$ 3,532	2.1	$ 35	
	Loss of business	3	5	10		Per day per unit	$ 124		7				4,326			$ 4,326	2.6	$ 43	
Retail/commer	Direct damage/repair costs	0.005	0.01	0.05		Per premises	$ 50,773									$ -		$ -	
	Loss of business	3	5	10		Per day per premises	$ 2,499									$ -		$ -	
Sub-total activities and assets																**$ 74,792**	**45.0**	**$ 748**	
Local agency c	Incident management		0.5	1		Lump sum	$ 12,313			1				12,313		$ 12,313	7.4	$ 123	
	Channel clearing/repair			1		Lump sum	$ 30,610			1				30,610		$ 30,610	18.4	$ 306	
	Bridges			1		Each	$ 3,241			1				3,241		$ 3,241	1.9	$ 32	
	Roads			1		Per km	$ 3,241			0.06				194		$ 194	0.1	$ 2	
	Water supply			1		Lump sum	$ 5,814									$ -		$ -	
	Sewage treatment			1		Lump sum	$ 5,814									$ -		$ -	
Regional agen	Incident management			1		Lump sum	$ 12,313			1				12,313		$ 12,313	7.4	$ 123	
State highway	Bridges			1		Each	$ 29,072			1				29,072		$ 29,072	17.5	$ 291	
	Roads			1		Per km	$ 29,072			0.13				3,779		$ 3,779	2.3	$ 38	
Sub-total infrastructure and agency costs																**$ 91,521**	**55.0**	**$ 915**	
														GRAND TOTAL Mean		**$ 166,314**	100.0	**$ 1,663**	
														95%		**$ 244,300**		**$ 2,443**	

THAMES COAST FLOOD RISK ASSESSMENT
ASSET RISK MODEL INPUTS - ASSET INVENTORY BY FLOOD HAZARD ZONE FOR EACH COMMUNITY

Revision b2
Date 22-Jun-03
Prepared by V Lenting

BASE CASE

		Tararu				Te Puru				Waiomu - Pohue				Tapu				Coromandel			
		No. of assets				No. of assets				No. of assets				No. of assets				No. of assets			
	TCDC/EW Hazard Zone	Low	Med	High	Very high	Low	Med	High	Very high	Low	Med	High	Very high	Low	Med	High	Very high	Low	Med	High	Very high
	USBR Flood Severity	Very low	Low	Med	High	Very low	Low	Med	High	Very low	Low	Med	High	Very low	Low	Med	High	Very low	Low	Med	High
Activity or asset	**Sub-group**																				
Private residences			30	9		44	69	10		16	12	9			17	2			20	25	
Schools						1													1		
Retirement villages																					
Camping grounds	Tent sites								20				5		20		20				
	Caravans					8	121		12		18		53		90						
	Cabins						2								2						
	Direct damage/repair costs							1				1				1					
	Loss of business							1				1				1					
Hotels and motels	Units		7																15		
	Loss of business		7																15		
Retail/commercial	Direct damage/repair costs																		9	1	
	Loss of business																		9	1	
Sub-total activities and assets																					
Local agency costs	Incident management			1				1				1				1				1	
	Channel clearing/repair			1				1				2				1				2	
	Bridges			1												1				5	
	Roads			0.06				0.32				0.46				0.06				0.95	
	Water supply																				
	Sewage treatment																				
Regional agency costs	Incident management			1				1				1				1				1	
State highway	Bridges			1				1				2				1					
	Roads			0.13				0.21				0.1				0.05					

MITIGATION OPTION 2

		Tararu				Te Puru				Waiomu - Pohue				Tapu				Coromandel			
		No. of assets				No. of assets				No. of assets				No. of assets				No. of assets			
	TCDC/EW Hazard Zone	Low	Med	Hi	Very high	Low	Med	Hi	Very high	Low	Med	Hi	Very high	Low	Med	Hi	Very high	Low	Med	Hi	Very high
	USBR Flood Severity	Very low	Low	Med	High	Very low	Low	Med	High	Very low	Low	Med	High	Very low	Low	Med	High	Very low	Low	Med	High
Activity or asset	**Sub-group**																				
Private residences		6	5	1		113	10			28	3	6		10	9				8	8	
Schools						1												1			
Retirement villages																					
Camping grounds	Tent sites							20							2	2					
	Caravan spaces					129	12								9						
	Cabins					2									0.2						
	Direct damage/repair costs						1									0.1					
	Loss of business						1									0.1					
Hotels and motels	Units	7																			
	Loss of business																				
Retail/commercial	Direct damage/repair costs																				
	Loss of business																				
Local agency costs	Incident management			0.5				0.5				0.5				0.5				0.5	
	Channel clearing/repair			1				1				2				1				2	
	Bridges (each)			1												1					
	Roads (km)			0.06				0.16								0.06					
	Water supply																				
	Sewage treatment																				
Regional agency costs	Incident management			0.5				0.5				0.5				0.5				0.5	
State highway	Bridges (each)			1				0.5								1					
	Roads (km)			0.05				0.12								0.05					

MITIGATION OPTION 3

		Tararu				Te Puru				Waiomu - Pohue				Tapu				Coromandel			
		No. of assets				No. of assets				No. of assets				No. of assets				No. of assets			
	TCDC/EW Hazard Zone	Low	Med	Hi	Very high	Low	Med	Hi	Very high	Low	Med	Hi	Very high	Low	Med	Hi	Very high	Low	Med	Hi	Very high
	USBR Flood Severity	Very low	Low	Med	High	Very low	Low	Med	High	Very low	Low	Med	High	Very low	Low	Med	High	Very low	Low	Med	High
Activity or asset	**Sub-group**																				
Private residences				1		1				30	8								6	3	
Schools						1												1			
Retirement villages																					
Camping grounds	Tent sites						20			20					20		20				
	Caravan spaces					12				71				90							
	Cabins													2							
	Direct damage/repair costs					1			0	1	0				1						
	Loss of business					1				1					1						
Hotels and motels	Units																				
	Loss of business																				
Retail/commercial	Direct damage/repair costs																				
	Loss of business																				
Local agency costs	Incident management			0.5				0.5				0.5				0.5				0.5	
	Channel clearing/repair			1				1				2				1				2	
	Bridges (each)			1												1					
	Roads (km)			0.06																	
	Water supply																				
	Sewage treatment																				
Regional agency costs	Incident management			0.5				0.5				0.5				0.5				0.5	
State highway	Bridges (each)															1					
	Roads (km)																				

DAMAGE COSTS AND ASSET VALUES USED IN ASSET RISK MODEL

Revised 26-June-03

			Flood hazard area (TCDC/EW)				
			Low	**Med**	**High**		
			Flood severity zone (USBR)				
			Very low	**Low**	**Medium**	**High**	
Damage ratio (all buildings)[3]		Mean [1]	0.005	0.05	0.05		
(damage cost as fraction of total asset value)		95th percentile [2]	0.01	0.02	0.10		
			Tararu	Te Puru	Waiomu - Pohue	Tapu	Coromandel
Residences[3,7]		Mean [1]	$ 97,000	$ 86,000	$ 92,000	$ 69,000	$ 86,000
(asset value per dwelling)		95th percentile [2]	$ 145,000	$ 153,000	$ 130,000	$ 157,000	$ 155,000
Schools[3]		Mean	$270,000				
(asset value per school)		95th percentile	$510,000				
Retirement villages[3]		Mean	$90,000				
(asset value per dwelling)		95th percentile	$170,000				
Camp grounds	Tent sites[3]	Mean	n/a	$240	$300	$300	
(per complex)	*(each)*	95th percentile	n/a	$400	$500	$500	
	Caravans - damage ratio[3]	Mean	0.06	0.10	0.50	1.00	
		95th percentile	0.10	0.15	0.67	n/a	
	Caravans - asset value[3]	Mean	$3,000				
		95th percentile	$5,000				
	Cabins - damage ratio[3]	Mean	0.05	0.10	0.30		
		95th percentile	0.10	0.20	0.75		
	Cabins - asset value[3]	Mean	$4,500				
		95th percentile	$7,500				
	Direct damage/repair costs[4]	Mean	$1,500	$5,000	$10,000	$10,000	
	(lump sum per complex)	95th percentile	$2,250	$7,500	$15,000	$15,000	
	Loss of business[5]	Mean	$1,500				
	(cost per day per complex)	95th percentile	$5,000				
Loss of business[5]		Mean	3	5	10	10	
(Campgrounds, hotel/motels and business - no. of days)		95th percentile	n/a	n/a	n/a	n/a	
Hotels and Motels	Asset value[3]	Mean	$45,000				
	(value per unit)	95th percentile	$75,000				
	Loss of business[5]	Mean	$120				
	(cost per day per unit)	95th percentile	$150				
Retail/commercial	Asset value[3]	Mean	$45,000				
(per business)	*(value per business)*	95th percentile	$75,000				
	Loss of business[5]	Mean	$1,500				
	(cost per day per business)	95th percentile	$5,000				
Local agency costs	Incident management[6]	Mean	n/a	$5,000	$10,000		
(per community)	*(lump sum per community)*	95th percentile	n/a	$75,000	$20,000		
	Channel clearing/repair[7]	Mean	n/a	n/a	$30,000		
	(per community)	95th percentile	n/a	n/a	$50,000		
	Bridges[7]	Mean	n/a	n/a	$3,000		
	(each)	95th percentile	n/a	n/a	$5,000		
	Roads[7]	Mean	n/a	n/a	$100		
	(per km within each community)	95th percentile	n/a	n/a	$300		
	Water supply[7]	Mean	n/a	n/a	$5,000		
	(each)	95th percentile	n/a	n/a	$10,000		
	Sewage treatment[7]	Mean	n/a	n/a	$5,000		
	(each)	95th percentile	n/a	n/a	$10,000		
Regional agency costs	Incident management[6]	Mean	n/a	n/a	$10,000		
	(lump sum per community)	95th percentile	n/a	n/a	$20,000		
State highway	Bridges[7]	Mean	n/a	n/a	$25,000		
	(each)	95th percentile	n/a	n/a	$50,000		
	Highway[7]	Mean	n/a	n/a	$25,000		
	(per km within each community)	95th percentile	n/a	n/a	$50,000		

Notes:

1. Mean cost is an average cost or "best estimate".

2. 95th percentile means that in 95% of cases the cost will not exceed the estimated amount.

3. Costs are expressed as a damage ratio multiplied by the asset value with the damage ratios developed from historical data on size of insurance claims. The damage ratio varies with the flood severity zone. The asset values for residences are based on average rating values (again expressed as a probability distribution). Asset value for schools and units are based on a percentage of the rating value for residential property. Asset values for caravans and tents is based on an estimated replacement cost of the asset(s). While asset damage is generally independent of season, the exception to this will be camping grounds where the number of caravans will vary with time of year (generally using a similar variation to that used in determining the PAR for lives risk).

4. A cleanup cost is applied according to the flood severity level to reflect the cost of clearing silt, debris etc. from properties, which will generally require external resources (diggers etc.). Cleanup costs are assumed to be minimal for the LOW flood severity zone.

5. Loss of business covers the economic losses faced by a business due to being unable to trade following a flood. Loss of business costs are expressed as a daily rate for the relevant activity multiplied by the estimated number of days of lost business, depending on the flood severity level. For the LOW flood severity zone we have assumed 3 days, the MED zone 5 days and the HIGH zone 10 days. For camping grounds encompassing more than one zone, the no. of days is based on the highest severity zone.

6. Based in costs from the 2002 Weather Bomb. Accounts for the internal agency costs to set up and run situation room and manage the response activities.

7. Based on experience from the 2002 Weather Bomb and other events (if data available) and judgement regarding likely upper limits for the costs (refer

8. n/a indicates that the economic consequence is not significant for that flood severity zone, but it is likely that some economic consequence will be incorporated into the model because the medium severity zone includes a consequence figure.

Estimates of Flood Damage Repairs

April 1981 Event	(reference: unnamed letter/report dated 2 December 1982)			
	12 houses @ $1500 each		$18,000	
	36 houses @ $500 each		$18,000	
	Channel clearing in vicinity of SH25 bridge at Tararu Stream		$3,500	
	TCDC repairs to water and sewage services		$5,000	
	TCDC repairs to Tararu Creek road		$18,000	
17 February 1985 event	(reference: annotated photocopy of unnamed letter/report dated 2 December 1982)			
	1 house with substantial repairs		$20,000	
	15 houses @ $2000 each		$30,000	
	30 houses @ $500 each		$15,000	
	Channel clearing in vicinity of SH25 bridge at Tararu Stream		$15,000	
	TCDC repairs to water and sewage services		$5,000	
	TCDC repairs to Tararu Creek road		$20,000	
19 June 2002 event	(reference: Weather Bomb Final Technical Report, EW Document # 740464)			
	Stream infill clearing at Tararu Stream (part of Waihou Valley Scheme administered by EW)		$63,000	
	Channel repairs for Tararu Stream		$40,000	
	Waiomu Stream (EW assets)		$6,000	
	Tapu Stream	?		
	Te Puru Stream	?		
	Karaka Stream (Coromandel)	?		
	Whangarahi Stream (Coromandel)	?		
	Pohue Stream	?		
	Karaka Stream (Thames) repairs to debris traps and outfall		$23,000	
	Karaka Stream (Thames) channel clearing		$10,000	
	Coromandel Wastewater Treatment System repairs	?		
	Coromandel Water Supply System repairs	?		
	Total TCDC response costs			$1,800,000
	TCDC area house/property damage (242 claims)			$6,000,000
	Insurance claim data from EW summarises 53 claims for Thames Coast area, with average claim ranging from $1,043 to $3,173. Highest single claim for $19,832 (Te Puru). Generally highest claims at other locations ranged from $2,727 to $4,478.			
	Coromandel - 17 claims at average of $1,043		$17,726	
	Tapu - 4 claims at average of $1,197		$4,788	
	Tararu - 5 claims at average of $1,702		$8,509	
	Te Puru - 14 claims at average of $3,173 (highest of $19,832)		$44,426	
	Waiomu - 13 claims at average of $1,415		$18,391	
	EW response costs (emergency and remedial works)			$525,000
	Transit NZ (? Km within TCDC area)			$750,000
	TCDC road repairs (? Km within subject communities)	?		

SUMMARY OF RESULTS - FINANCIAL EXPOSURE PROFILE

TABLE C-1
BASE CASE (current situation under the 1% AEP event)

		Activities	Local costs							Regional costs	State highways	Infrastructure total	Total
			Incident mgmt	Channels	Bridges	Roads	Water	Sewage	Subtotal				
Tararu	Mean	$ 74,880	$ 12,313	$ 30,610	$ 3,241	$ 194	$ -	$ -	$ 46,358	$ 12,313	$ 32,850	$ 91,521	**$ 166,401**
	95%	$ 147,355	$ 19,999	$ 49,960	$ 4,996	$ 300	$ -	$ -	$ 75,255	$ 19,983	$ 56,439	$ 121,015	**$ 244,302**
Te Puru	Mean	$ 245,125	$ 12,313	$ 30,609	$ -	$ 1,037	$ -	$ -	$ 43,958	$ 12,313	$ 35,176	$ 91,448	**$ 336,572**
	95%	$ 388,242	$ 19,994	$ 49,995	$ -	$ 1,600	$ -	$ -	$ 71,588	$ 19,982	$ 60,449	$ 120,487	**$ 481,119**
Waiomu - Pohue	Mean	$ 264,431	$ 12,313	$ 61,219	$ -	$ 1,491	$ -	$ -	$ 75,023	$ 12,313	$ 61,050	$ 148,385	**$ 412,816**
	95%	$ 382,305	$ 19,985	$ 99,960	$ -	$ 2,299	$ -	$ -	$ 122,244	$ 19,980	$ 104,895	$ 205,398	**$ 538,534**
Tapu	Mean	$ 98,317	$ 12,313	$ 30,610	$ 3,241	$ 194	$ -	$ -	$ 46,358	$ 12,312	$ 30,526	$ 89,196	**$ 187,512**
	95%	$ 140,584	$ 19,990	$ 49,997	$ 4,997	$ 300	$ -	$ -	$ 75,284	$ 19,994	$ 52,443	$ 119,276	**$ 236,616**
Coromandel	Mean	$ 294,086	$ 12,313	$ 61,221	$ 16,204	$ 3,079	$ -	$ -	$ 92,817	$ 12,313	$ -	$ 105,130	**$ 399,216**
	95%	$ 497,947	$ 19,984	$ 99,956	$ 24,994	$ 4,746	$ -	$ -	$ 149,680	$ 19,986	$ -	$ 146,164	**$ 605,813**

Overall totals **$ 1,502,518 Mean**
$ 2,106,384 95%

TABLE C-2
MITIGATION WORKS (capital works Option 2 plus warning systems upgrade)

		Activities	Local costs							Regional costs	State highways	Infrastructure total	Total
			Incident mgmt	Channels	Bridges	Roads	Water	Sewage	Subtotal				
Tararu	Mean	$ 13,367	$ 6,156	$ 30,609	$ 3,241	$ 194	$ -	$ -	$ 40,200	$ 6,156	$ 30,525	$ 76,881	**$ 90,249**
	95%	$ 24,880	$ 9,996	$ 49,969	$ 4,996	$ 300	$ -	$ -	$ 65,261	$ 9,992	$ 52,458	$ 105,286	**$ 120,105**
Te Puru	Mean	$ 112,425	$ 6,156	$ 30,610	$ -	$ 519	$ -	$ -	$ 37,285	$ 6,156	$ 17,879	$ 61,320	**$ 173,745**
	95%	$ 189,367	$ 9,997	$ 49,975	$ -	$ 800	$ -	$ -	$ 60,772	$ 9,993	$ 30,728	$ 83,470	**$ 252,719**
Waiomu - Pohue	Mean	$ 41,858	$ 6,156	$ 61,219	$ -	$ -	$ -	$ -	$ 67,375	$ 6,156	$ -	$ 73,532	**$ 115,389**
	95%	$ 87,282	$ 9,999	$ 99,988	$ -	$ -	$ -	$ -	$ 109,987	$ 9,994	$ -	$ 112,445	**$ 174,917**
Tapu	Mean	$ 19,925	$ 6,156	$ 30,609	$ 3,241	$ 194	$ -	$ -	$ 40,200	$ 6,157	$ 30,525	$ 76,882	**$ 96,807**
	95%	$ 35,048	$ 9,997	$ 49,969	$ 5,000	$ 300	$ -	$ -	$ 65,266	$ 9,989	$ 52,457	$ 104,571	**$ 127,962**
Coromandel	Mean	$ 44,653	$ 6,157	$ 61,219	$ -	$ -	$ -	$ -	$ 67,376	$ 6,156	$ -	$ 73,532	**$ 118,185**
	95%	$ 97,939	$ 9,991	$ 99,934	$ -	$ -	$ -	$ -	$ 109,925	$ 9,991	$ -	$ 111,808	**$ 181,690**

Overall totals **$ 594,376 Mean**
$ 857,393 95%

TABLE C-3
MITIGATION WORKS (capital works Option 3 plus warning systems upgrade)

		Activities	Local costs							Regional costs	State highways	Infrastructure total	Total
			Incident mgmt	Channels	Bridges	Roads	Water	Sewage	Subtotal				
Tararu	Mean	$ 4,459	$ 30,610	$ 30,610	$ 3,241	$ 194	$ -	$ -	$ 64,656	$ 6,156.25	$ -	$ 46,358	**$ 50,817**
	95%	$ 10,382	$ 9,989	$ 49,994	$ 5,000	$ 300	$ -	$ -	$ 65,283	$ 9,998	$ -	$ 65,985	**$ 71,081**
Te Puru	Mean	$ 18,054	$ 6,157	$ 30,610	$ -	$ -	$ -	$ -	$ 36,767	$ 6,156	$ -	$ 42,923	**$ 60,977**
	95%	$ 26,639	$ 9,995	$ 49,986	$ -	$ -	$ -	$ -	$ 59,981	$ 9,990	$ 9,990	$ 62,577	**$ 82,050**
Waiomu - Pohue (Option 2)	Mean	$ 41,858	$ 6,156	$ 61,219	$ -	$ -	$ -	$ -	$ 67,375	$ 6,156	$ -	$ 73,532	$ 115,389
	95%	$ 87,282	$ 9,999	$ 99,988	$ -	$ -	$ -	$ -	$ 109,987	$ 9,994	$ -	$ 112,445	$ 174,917
Tapu	Mean	$ 46,041	$ 6,156	$ 30,609	$ 3,241	$ -	$ -	$ -	$ 40,006	$ 6,156	$ 29,071	$ 75,234	**$ 121,275**
	95%	$ 66,796	$ 9,998	$ 49,997	$ 4,998	$ -	$ -	$ -	$ 64,993	$ 9,992	$ 49,967	$ 104,170	**$ 155,384**
Coromandel	Mean	$ 20,351	$ 6,156	$ 61,219	$ -	$ -	$ -	$ -	$ 67,375	$ 6,156	$ -	$ 73,531	**$ 93,882**
	95%	$ 41,640	$ 9,996	$ 99,941	$ -	$ -	$ -	$ -	$ 109,937	$ 9,995	$ -	$ 112,778	**$ 135,506**

Overall totals **$ 442,341 Mean**
$ 618,938 95%

SUMMARY OF RESULTS - RISK QUOTIENTS

TABLE C-4
BASE CASE (current situation under the 1% AEP event)

		Activities	Local costs							Regional costs	State highways	Infrastructure total	Total
			Incident mgmt	Channels	Bridges	Roads	Water	Sewage	Subtotal				
Tararu	Mean	$ 749	$ 123	$ 306	$ 32	$ 2	$ -	$ -	$ 464	$ 123	$ 329	$ 915	**$ 1,664**
	95%	$ 1,474	$ 200	$ 500	$ 50	$ 3	$ -	$ -	$ 753	$ 200	$ 564	$ 1,210	**$ 2,443**
Te Puru	Mean	$ 2,451	$ 123	$ 306	$ -	$ 10	$ -	$ -	$ 440	$ 123	$ 352	$ 914	**$ 3,366**
	95%	$ 3,882	$ 200	$ 500	$ -	$ 16	$ -	$ -	$ 716	$ 200	$ 604	$ 1,205	**$ 4,811**
Waiomu - Pohue	Mean	$ 2,644	$ 123	$ 612	$ -	$ 15	$ -	$ -	$ 750	$ 123	$ 611	$ 1,484	**$ 4,128**
	95%	$ 3,823	$ 200	$ 1,000	$ -	$ 23	$ -	$ -	$ 1,222	$ 200	$ 1,049	$ 2,054	**$ 5,385**
Tapu	Mean	$ 983	$ 123	$ 306	$ 32	$ 2	$ -	$ -	$ 464	$ 123	$ 305	$ 892	**$ 1,875**
	95%	$ 1,406	$ 200	$ 500	$ 50	$ 3	$ -	$ -	$ 753	$ 200	$ 524	$ 1,193	**$ 2,366**
Coromandel	Mean	$ 2,941	$ 123	$ 612	$ 162	$ 31	$ -	$ -	$ 928	$ 123	$ -	$ 1,051	**$ 3,992**
	95%	$ 4,979	$ 200	$ 1,000	$ 250	$ 47	$ -	$ -	$ 1,497	$ 200	$ -	$ 1,462	**$ 6,058**
												Overall totals	**$ 15,025** Mean
													$ 21,064 95%

AEP 0.01

Value of life assumed (mean) $ 4,000,000

	Expenditure	ALR (fatalities per year)	Lives	Total	Assets %	Lives %
Tararu		0.0027	$ 10,800	$ 12,464	13.4	86.6
			$ 10,800	$ 13,243	18.4	81.6
Te Puru		0.01464	$ 58,560	$ 61,926	5.4	94.6
			$ 58,560	$ 63,371	7.6	92.4
Waiomu - Pohue		0.01002	$ 40,080	$ 44,208	9.3	90.7
			$ 40,080	$ 45,465	11.8	88.2
Tapu		0.00725	$ 29,000	$ 30,875	6.1	93.9
			$ 29,000	$ 31,366	7.5	92.5
Coromandel		0.0058	$ 23,200	$ 27,192	14.7	85.3
			$ 23,200	$ 29,258	20.7	79.3
			$ 161,640	**$ 176,665** Mean	**8.5**	**91.5**
			$ 161,640	**$ 182,704** 95%	**11.5**	**88.5**

TABLE C-5
MITIGATION WORKS (capital works Option 2 plus warning systems upgrade)

		Activities	Local costs							Regional costs	State highways	Infrastructure total	Total
			Incident mgmt	Channels	Bridges	Roads	Water	Sewage	Subtotal				
Tararu	Mean	$ 134	$ 62	$ 306	$ 32	$ 2	$ -	$ -	$ 402	$ 62	$ 305	$ 769	$ 902
	95%	$ 249	$ 100	$ 500	$ 50	$ 3	$ -	$ -	$ 653	$ 100	$ 525	$ 1,053	$ 1,201
Te Puru	Mean	$ 1,124	$ 62	$ 306	$ -	$ 5	$ -	$ -	$ 373	$ 62	$ 179	$ 613	$ 1,737
	95%	$ 1,894	$ 100	$ 500	$ -	$ 8	$ -	$ -	$ 608	$ 100	$ 307	$ 835	$ 2,527
Waiomu - Pohue	Mean	$ 419	$ 62	$ 612	$ -	$ -	$ -	$ -	$ 674	$ 62	$ -	$ 735	$ 1,154
	95%	$ 873	$ 100	$ 1,000	$ -	$ -	$ -	$ -	$ 1,100	$ 100	$ -	$ 1,124	$ 1,749
Tapu	Mean	$ 199	$ 62	$ 306	$ 32	$ 2	$ -	$ -	$ 402	$ 62	$ 305	$ 769	$ 968
	95%	$ 350	$ 100	$ 500	$ 50	$ 3	$ -	$ -	$ 653	$ 100	$ 525	$ 1,046	$ 1,280
Coromandel	Mean	$ 447	$ 62	$ 612	$ -	$ -	$ -	$ -	$ 674	$ 62	$ -	$ 735	$ 1,182
	95%	$ 979	$ 100	$ 999	$ -	$ -	$ -	$ -	$ 1,099	$ 100	$ -	$ 1,118	$ 1,817
												Overall totals	**$ 5,944** Mean
													$ 8,574 95%

	Expenditure	ALR (fatalities per year)	Lives	Total	Assets %	Lives %
Tararu	$ 1,033,000	0.00018	$ 720	$ 1,622	55.6	44.4
			$ 720	$ 1,921	62.5	37.5
Te Puru	$ 1,884,000	0.00325	$ 13,000	$ 14,737	11.8	88.2
			$ 13,000	$ 15,527	16.3	83.7
Waiomu - Pohue	$ 1,095,000	0.00061	$ 2,440	$ 3,594	32.1	67.9
			$ 2,440	$ 4,189	41.8	58.2
Tapu	$ 187,000	0.00064	$ 2,560	$ 3,528	27.4	72.6
			$ 2,560	$ 3,840	33.3	66.7
Coromandel	$ 889,000	0.0009	$ 3,600	$ 4,782	24.7	75.3
			$ 3,600	$ 5,417	33.5	66.5
			$ 22,320	**$ 28,264** Mean	**21.0**	**79.0**
			$ 22,320	**$ 30,894** 95%	**27.8**	**72.2**

TABLE C-6
MITIGATION WORKS (warning systems upgrade only)

		Activities	Local costs							Regional costs	State highways	Infrastructure total	Total
			Incident mgmt	Channels	Bridges	Roads	Water	Sewage	Subtotal				
Tararu	Mean	$ 749	$ 123	$ 306	$ 32	$ 2	$ -	$ -	$ 464	$ 123	$ 329	$ 915	$ 1,664
	95%	$ 1,474	$ 200	$ 500	$ 50	$ 3	$ -	$ -	$ 753	$ 200	$ 564	$ 1,210	$ 2,443
Te Puru	Mean	$ 2,451	$ 123	$ 306	$ -	$ 10	$ -	$ -	$ 440	$ 123	$ 352	$ 914	$ 3,366
	95%	$ 3,882	$ 200	$ 500	$ -	$ 16	$ -	$ -	$ 716	$ 200	$ 604	$ 1,205	$ 4,811
Waiomu - Pohue	Mean	$ 2,644	$ 123	$ 612	$ -	$ 15	$ -	$ -	$ 750	$ 123	$ 611	$ 1,484	$ 4,128
	95%	$ 3,823	$ 200	$ 1,000	$ -	$ 23	$ -	$ -	$ 1,222	$ 200	$ 1,049	$ 2,054	$ 5,385
Tapu	Mean	$ 983	$ 123	$ 306	$ 32	$ 2	$ -	$ -	$ 464	$ 123	$ 305	$ 892	$ 1,875
	95%	$ 1,406	$ 200	$ 500	$ 50	$ 3	$ -	$ -	$ 753	$ 200	$ 524	$ 1,193	$ 2,366
Coromandel	Mean	$ 2,941	$ 123	$ 612	$ 162	$ 31	$ -	$ -	$ 928	$ 123	$ -	$ 1,051	$ 3,992
	95%	$ 4,979	$ 200	$ 1,000	$ 250	$ 47	$ -	$ -	$ 1,497	$ 200	$ -	$ 1,462	$ 6,058
												Overall totals	**$ 15,025** Mean
													$ 21,064 95%

	Expenditure	ALR (fatalities per year)	Lives	Total	Assets %	Lives %
Tararu	$ 70,000	0.00145	$ 5,800	$ 7,464	22.3	77.7
			$ 5,800	$ 8,243	29.6	70.4
Te Puru	$ 50,000	0.00756	$ 30,240	$ 33,606	10.0	90.0
			$ 30,240	$ 35,051	13.7	86.3
Waiomu - Pohue	$ 50,000	0.00514	$ 20,560	$ 24,688	16.7	83.3
			$ 20,560	$ 25,945	20.8	79.2
Tapu	$ 50,000	0.00371	$ 14,840	$ 16,715	11.2	88.8
			$ 14,840	$ 17,206	13.8	86.2
Coromandel	$ 25,000	0.00305	$ 12,200	$ 16,192	24.7	75.3
			$ 12,200	$ 18,258	33.2	66.8
			$ 83,640	**$ 98,665** Mean	**15.2**	**84.8**
			$ 83,640	**$ 104,704** 95%	**20.1**	**79.9**

TABLE C-7
MITIGATION WORKS (capital works Option 3 plus warning systems upgrade)

		Activities	Local costs							Regional costs	State highways	Infrastructure total	Total
			Incident mgmt	Channels	Bridges	Roads	Water	Sewage	Subtotal				
Tararu	Mean	$ 45	$ 306	$ 306	$ 32	$ 2	$ -	$ -	$ 647	$ 62	$ -	$ 464	$ 508
	95%	$ 104	$ 100	$ 500	$ 50	$ 3	$ -	$ -	$ 653	$ 100	$ -	$ 660	$ 711
Te Puru	Mean	$ 181	$ 62	$ 306	$ -	$ -	$ -	$ -	$ 368	$ 62	$ -	$ 429	$ 610
	95%	$ 266	$ 100	$ 500	$ -	$ -	$ -	$ -	$ 600	$ 100	$ 100	$ 626	$ 820
Waiomu - Pohue (Option 2)	Mean	$ 419	$ 62	$ 612	$ -	$ -	$ -	$ -	$ 674	$ 62	$ -	$ 735	$ 1,154
	95%	$ 873	$ 100	$ 1,000	$ -	$ -	$ -	$ -	$ 1,100	$ 100	$ -	$ 1,124	$ 1,749
Tapu	Mean	$ 460	$ 62	$ 306	$ 32	$ -	$ -	$ -	$ 400	$ 62	$ 291	$ 752	$ 1,213
	95%	$ 668	$ 100	$ 500	$ 50	$ -	$ -	$ -	$ 650	$ 100	$ 500	$ 1,042	$ 1,554
Coromandel	Mean	$ 204	$ 62	$ 612	$ -	$ -	$ -	$ -	$ 674	$ 62	$ -	$ 735	$ 939
	95%	$ 416	$ 100	$ 999	$ -	$ -	$ -	$ -	$ 1,099	$ 100	$ -	$ 1,128	$ 1,355
												Overall totals	**$ 4,423 Mean**
													$ 6,189 95%

		ALR (fatalities per year)
Tararu	$ 2,484,000	0.00002
Te Puru	$ 3,200,000	0.00078
Waiomu - Pohue		
Tapu	$ 379,000	0.00228
Coromandel	$ 2,468,000	0.0004

Lives	Total	Assets %	Lives %
$ 80	$ 588	86.4	13.6
$ 80	$ 791	89.9	10.1
$ 3,120	$ 3,730	16.3	83.7
$ 3,120	$ 3,940	20.8	79.2
$ -	$ 1,154	100.0	0.0
$ -	$ 1,749	100.0	0.0
$ 9,120	$ 10,333	11.7	88.3
$ 9,120	$ 10,674	14.6	85.4
$ 1,600	$ 2,539	37.0	63.0
$ 1,600	$ 2,955	45.9	54.1
$ 13,920	**$ 18,343 Mean**	**24.1**	**75.9**
$ 13,920	**$ 20,109 95%**	**30.8**	**69.2**

Appendix D
Details of Risk Treatment Works

Contents

Appendix D Details of Risk Treatment Works

Appendix D
Details of Risk Treatment Works

D1.1 Details of Possible Risk Treatment Measures

Details of the types of risk treatment measures considered for each community and their estimated costs are given in Table D-1, overleaf. The details of the risk treatment measures are based on information supplied by Environment Waikato. The engineering measures and their potential impacts in reducing flood consequences should be regarded as preliminary only and would be subject to further concept and detailed design development.

D1.2 Level of Warning

The probabilities representing the likelihood of there being adequate, little or no warning of the flooding used in the post-works risk model are:

Level of warning	Day	Night
Adequate warning	0.8	0.6
Little warning	0.15	0.3
No warning	0.05	0.1

These compare with the probabilities listed in Section 4.1.1 of the main report.

D1.3 Benefit Cost Ratio

Using Waiomu - Pohue as an example, the benefit cost ratio has been estimated as follows: The figures represent annual "risk costs".

	Activities	Infrastructure	Lives	Total
Before risk reduction (base case)				
Mean	$2,644	$1,484	$40,080	$44,210
After risk reduction (Option 2 plus warning system upgrade)				
Mean	$420	$735	$2,440	$3,595
			Difference	$40,615

Assuming:

- a discount rate of 10%;
- a 25 year discounting period;
- capital cost of the works is $290,000;
- neglecting any ongoing maintenance/repair costs at this stage.

The benefit cost ratio for this case is approximately 0.4, which indicates that the costs of the works outweigh the economic benefits. Benefit cost ratios for the various mitigation works for each community are summarised Tables D-2 and D-3.

TABLE D-1: PROPOSED MITIGATION OPTIONS

All data except for shaded cells provided by Environment Waikato (EW).

Option 2 costs in coloured cells, which have been used to calculate BCRs, are based on revised figures provided by EW on 10 July 2003 (capital and maintenance cost summaries attached). *Catchment works have not been included*.

Original "rough order cost estimates" showing breakdown of proposed works, have not been revised.

Tararu Community and the Tararu Stream

1. Catchment Description

   Area = 15.6 km^2

   Time of Concentration = 60 minutes

2. Hydrology and Hydraulics

Description	AEP (%)	Peak Flow (m^3/s)
2 year flood event	50	88
10 year flood event	10	124
20 year flood event	5	146
50 year flood event	2	182
100 year flood event	1	218
Existing channel capacity	-	100

3. Flood Scenario Description

4. Description and Assessment of Mitigation Options

Option 1: Development Restrictions	
Description	- Do not allow any development within the high hazard zone. - Restrict floor levels within the medium and low hazard zones for areas already developed. - Do not allow any new development of currently undeveloped land within the medium and low hazard zones.
Level of Service	5 year event
Advantages	✓ Does not exacerbate the risk in the short – term and reduces risk in the long – term (i.e. once development and floor level restrictions begin to take effect). ✓ Relatively capital low cost.
Disadvantages	× Will only be effective in the long-term and does not address the communities short-term concerns. × Flood hazard continues to impact community.

Rough Order Cost Estimate	The costs associated with this option have not been estimated, however will include: - District planning and enforcement costs. - Existing channel maintenance costs following flood events to remove debris and bed material (currently funded by the Waihou Valley Scheme and managed by Environment Waikato).
	These measures will not have any immediate significant effect in terms of reducing potential flood consequences. Over the longer term (say, 5 years plus) there will be some benefit. Therefore, at this stage the effects have not been assessed in the risk model. This is the case for each community under Option 1.

Option 2: Partial Floodway Development Proposal	
Description	Upstream of the SH25 bridge: - Acquire easement on property along the true left bank and construct either a concrete floodwall. - Terminate the downstream end of the concrete floodwall with an earth embankment across the reserve adjacent to the southern SH25 bridge approach. - Retain development restrictions on unprotected properties to protect floodway from development (refer to option 1). At the SH25 bridge: - Acquire property on corner of SH25 and Tararu Creek Road and provide a formised overland flow path north along SH25. - Provide erosion protection for the section of SH25 proposed to form the overland flow path. - Construct stoplogs to protect properties from the proposed overland flow path (e.g. Sunset Motel). Downstream of the SH25 bridge: - Construct timber floodwalls using existing available property.
Level of Service	100 year event (partial)
Advantages	✓ 100 year protection for a majority of the Tararu community. ✓ Avoids immediate need for the costly replacement of the SH25 bridge. ✓ Provides a floodplain on the right bank to act as a buffer for the predicted variability of flows and channel profile. ✓ Provides a formalised overland flow path (as opposed to the existing scenario of uncontrolled overland flow around the SH25 bridge). ✓ Retains existing access to the Tararu Stream along the right bank for maintenance (e.g. removal of debris, bed material and other blockages).

Rough Order Cost Estimate **(not updated)**	$215,000 (floodwalls and stopbanking) $300,000 (property purchase – upstream of SH25 bridge) $100,000 (property purchase – at SH25 bridge) $50,000 (erosion control along overflow path) + 15% for design/supervision/management + 10% for contingencies + 20% for resource consents $964,000 (total capital cost) $11,000 (annual maintenance and depreciation cost)
Optional Works	Construct timber floodwall along true right bank upstream of SH25 bridge → Add $78,000 to capital cost Construct overland flow path using concrete channel and culverts → Add $602,000 to capital cost

Reduction in consequences for risk model. **(final costs shown)**	**Improved warning systems** - $70,000 Increases probability of occupants having adequate warning and being able to escape from floodwater. **Engineering works and property purchase** - $963,000 + $43,000 annual maintenance and depreciation: • All properties in HIGH zone (except one upstream of floodwall) become MEDIUM zone since works design for 50 year ARI, which will reduce flood velocity and water depth from the 100 year ARI event. Flooding under 100 year event not eliminated but considerably reduced. • All properties in MEDIUM zone become LOW zone, except for six on true right of river above SH25 bridge. • Damage to roads and bridges reduced to minimal amount (local and state highway). • Channel deposition still occurs so cost to clean out debris remains. • Agency management costs reduced but not eliminated entirely.

Option 3: Full Floodway Development Proposal	
Description	Upstream of the SH25 bridge: - Implement recommendations included under option 2. At the SH25 Bridge: - Implement recommendations included under option 2. - Upgrade the SH25 bridge to pass the 100 year flow (TNZ expense). - Retain the formalised overland flow path described under option 2 as a 'safety valve'. Downstream of the SH25 bridge: - Implement recommendations included under option 2.. - Widen the existing floodway created by the timber floodwalls to allow the 100 year flow the pass (option 2 does not require the full 100 year flow to pass through this lower section because the capacity of the bridge is only equivalent to the 20 year flow.
Advantages	✓ Addresses the short term community concerns by mitigating the flood hazard with engineering works (e.g. floodwalls). ✓ Addresses the longer term concerns regarding the effect of the SH25 bridge of flood flows by ensuring that the capacity is increased when replacement occurs. ✓ Ensures that the capacity of the Tararu Stream downstream of the SH25 bridge is also upgraded when the bridge is upgraded. ✓ Retains a water level buffer in the form of the unprotected true right bank upstream of the SH25 bridge and the overland flow path at the SH25 bridge.
Rough Order Cost Estimate	$1,000,000 (replacement of SH25 bridge – TNZ expense) $215,000 (floodwalls and stopbanking) $300,000 (property purchase – upstream of SH25 bridge) $100,000 (property purchase – at SH25 bridge) $50,000 (erosion control along overflow path) + 15% for design/supervision/management + 10% for contingencies + 20% for resource consents $2,414,000 (total capital cost)
Reduction in consequences for risk model	**Improved warning systems** - $70,000 Increases probability of occupants having adequate warning **Engineering works and property purchase** - $2,414,000 • All properties protected (except one upstream of floodwall in High zone) • Damage to SH25 and bridge prevented. Local road and bridge not protected.

Te Puru Community and the Te Puru Stream

1. Catchment Description

   Area = 22.9 km^2

   Time of Concentration = 75 minutes

2. Hydrology and Hydraulics

Description	AEP (%)	Peak Flow (m^3/s)
2 year flood event	50	151
10 year flood event	10	168
20 year flood event	5	197
50 year flood event	2	245
100 year flood event	1	300
Existing channel capacity	-	150

3. Flood Scenario Description

4. Description and Assessment of Mitigation Options

Option 1: Development Restrictions	
Description	- Do not allow any development within the high hazard zone. - Restrict floor levels within the medium and low hazard zones for areas already developed. - Do not allow any new development of currently undeveloped land within the medium and low hazard zones.
Level of Service	5 year event
Advantages	✓ Does not exacerbate the risk in the short – term and reduces risk in the long – term (i.e. once development and floor level restrictions begin to take effect). ✓ Relatively capital low cost.
Disadvantages	× Will only be effective in the long-term and does not address the communities short-term concerns. × Flood hazard continues to impact community.
Rough Order Cost Estimate	The costs associated with this option have not been estimated, however will include: - District planning and enforcement costs. - Existing channel maintenance costs following flood events to remove debris and bed material.

Option 2: Partial Floodway Development Proposal	
Description	Upstream of the SH25 bridge: - Undertake channel improvement works (including rip-rap protection on the outside of bends). - Acquire properties adjacent to Te Puru Creek Road and raise Te Puru Creek Road to contain the 50 year event. - Provide a spillway for flows that exceed the 50 year event along existing overland flow path (i.e. path of old channel). - Retain development restrictions on unprotected properties to protect floodway from development (refer to option 1). At the SH25 bridge: - Acquire property on the true right bank and form an overland flow path to pass 60 – 70 m^3/s (i.e. the difference between the 50 year event and the SH25 bridge capacity). Downstream of the SH25 bridge: - Undertake channel improvement works (including rip-rap protection on the outside of bends). - Construct earthbanks to improve the capacity of the main channel to contain the 50 year flow. - Provide a spillway downstream of campground for events that exceed the 50 year event along the existing overland flow path.
Level of Service	50 year event
Advantages	✓ Improves the performance of the Te Puru Stream channel a reasonable standard for flood protection works (e.g. the Piako River Scheme is designed for the 50 year flood event). ✓ Reduces the probability of the current overland flow paths operating and hence reduces the risk to properties within them.
Rough Order Cost Estimate **(not updated)**	$143,000 (floodwalls) $600,000 (property purchase – upstream of SH25 bridge) $300,000 (property purchase – at SH25 bridge) $240,000 (channel improvements including rip-rap) + 15% for design/supervision/management + 10% for contingencies + 20% for resource consents $1,860,000 (total capital cost) $22,000 (annual maintenance and depreciation cost)
Optional Works	Construct timber floodwall to protect property on true right bank adjacent to SH25 bridge → Add $44,000 Construct overland flow path using concrete culvert under SH25. → Add $363,000 to capital cost

Reduction in consequences for risk model. **(final costs shown)**	**Improved warning systems** - $50,000 Increases probability of occupants having adequate warning and being able to escape floodwater. **Engineering works and property purchase** - $1,834,000 + $33,000 annual maintenance and depreciation: • All properties in HIGH zone become MEDIUM zone. Flood velocity and flow depths reduced but not eliminated in 100 year ARI event. • All properties in MEDIUM zone become LOW zone. • Campsite – caravans in VERY HIGH zone become MEDIUM, tent sites in VERY HIGH zone become HIGH zone. • Damage to roads and bridges reduced by 50% (local and state highway). • Channel deposition still occurs so cost to clean out debris remains. • Agency management costs reduced but not eliminated entirely.

Option 3: Full Floodway Development Proposal	
Description	Upstream of the SH25 bridge: - Implement recommendations included under option 2 but raise level of service to contain the 100 year flow. At the SH25 bridge: - Implement recommendations included under option 2. - Upgrade the SH25 bridge to pass the 100 year flow (TNZ expense). Downstream of the SH25 bridge: - Implement recommendations included under option 2 but raise level of service to contain the 100 year flow.
Advantages	✓ Addresses the short term community concerns by mitigating the flood hazard with engineering works (e.g. floodwalls). ✓ Addresses the longer term concerns regarding the effect of the SH25 bridge of flood flows by ensuring that the capacity is increased when replacement occurs.
Rough Order Cost Estimate	$1,500,000 (replace the SH25 bridge – TNZ expense) $122,000 (floodwalls) $600,000 (property purchase – upstream of SH25 bridge) $240,000 (erosion control) + 15% for design/supervision/management + 10% for contingencies + 20% for resource consents $3,150,000 (total capital cost)
Reduction in consequences for risk model	**Improved warning systems** - $50,000 Increases probability of occupants having adequate warning **Engineering works and property purchase** - $3,150,000 • All properties protected except those in low zone on Low zone (north side of river, downstream of SH25 bridge). • Campsite – caravans in Very High zone become Low, tent sites in Very High zone become Med. • Damage to roads and bridges (local and state highway) prevented.

Waiomu / Pohue Communities and the Waiomu / Pohue Stream

1. Catchment Description

   Area (Waiomu) = 22.9 km^2
   Area (Pohue) = 3.5 km^2

   Time of Concentration (Waiomu) = 75 minutes
   Time of Concentration (Pohue) = 30 minutes

2. Hydrology and Hydraulics (Waiomu)

Description	AEP (%)	Peak Flow - Waiomu (m^3/s)	Peak Flow - Pohue (m^3/s)
2 year flood event	50	59	23
10 year flood event	10	83	34
20 year flood event	5	97	39
50 year flood event	2	124	50
100 year flood event	1	148	67
Existing channel capacity	-	80	

3. Flood Scenario Description

4. Description and Assessment of Mitigation Options

Option 1: Restricted Development	
Description	- Do not allow any development within the high hazard zone. - Restrict floor levels within the medium and low hazard zones for areas already developed. - Do not allow any new development of currently undeveloped land within the medium and low hazard zones.
Level of Service	10 year event
Advantages	✓ Does not exacerbate the risk in the short – term and reduces risk in the long – term (i.e. once development and floor level restrictions begin to take effect). ✓ Relatively capital low cost.
Disadvantages	× Will only be effective in the long-term and does not address the communities short-term concerns. × Flood hazard continues to impact community.
Rough Order Cost Estimate	The costs associated with this option have not been estimated, however will include: - District planning and enforcement costs. - Existing channel maintenance costs following flood events to remove debris and bed material.

Option 2: Full Floodway Development Proposal	
Description	Waiomu Stream: - Replace Waiomu Creek Road ford (including low bund). - Undertake channel improvement works (including rip-rap protection on the outside of bends). - Acquire the portion campground property that borders the Waiomu Stream and construct an earthbank. - Retain development restrictions on unprotected properties to protect floodway from development (refer to option 1). Pohue Stream: - Undertake channel improvement works (including rip-rap protection to stabilise the channel). - Raise 'at risk' houses identified by weather bomb damage reports (private expense). - Upgrade the Pohue Road culvert (TCDC expense).
Level of Service	100 year event (Waiomu) 10 year event (Pohue)
Advantages	✓ Improves the performance of the Waiomu Stream channel to a standard that is similar to the 'weather bomb'. ✓ Significantly reduces the number of properties effected by the flood hazard. ✓ Addresses the flood hazard affecting the Pohue community in the most cost-effective manner.
Rough Order Cost Estimate (Waiomu) **(not updated)**	$150,000 (channel improvement works – including rip-rap) $15,000 (improvement to ford) $42,000 (stopbanking) $200,000 (property purchase – portion of camp ground) + 15% for design/supervision/management + 10% for contingencies + 20% for resource consents $456,000 (total capital cost) $14,000 (annual maintenance and depreciation cost)
Rough Order Cost Estimate (Pohue) **(not updated)**	$103,000 (channel improvement works – including rip-rap) $120,000 (culvert replacement – TCDC expense) $60,000 (raise 3 'at risk' homes – private expense) + 15% for design/supervision/management + 10% for contingencies + 20% for resource consents $363,000 (total capital cost) $8,000 (annual maintenance and depreciation cost)

Reduction in consequences for risk model. **(final costs shown)**	**Improved warning systems** - $50,000 Increases probability of occupants having adequate warning and being able to escape floodwater. **Engineering works and property purchase** - $1,045,000 + $26,000 annual maintenance and depreciation: • All properties (including camping ground) in Waiomu except one, become LOW zone. • Three properties in Pohue in HIGH zone become MED zone. • Damage to roads and bridges prevented (local and state highway). • Channel deposition still occurs so cost to clean out debris remains. • Agency management costs reduced but not eliminated entirely.

Tapu Community and the Tapu River

1. Catchment Description

   Area (Waiomu) = 26.7 km^2

   Time of Concentration (Waiomu) = 90 minutes

2. Hydrology and Hydraulics

Description	AEP (%)	Peak Flow (m^3/s)
2 year flood event	50	110
10 year flood event	10	159
20 year flood event	5	186
50 year flood event	2	235
100 year flood event	1	283
Existing channel capacity	-	135

3. Flood Scenario Description

4. Description and Assessment of Mitigation Options

Option 1: Restricted Development	
Description	- Do not allow any development within the high hazard zone. - Restrict floor levels within the medium and low hazard zones for areas already developed. - Do not allow any new development of currently undeveloped land within the medium and low hazard zones.
Level of Service	5 year event
Advantages	✓ Does not exacerbate the risk in the short – term and reduces risk in the long – term (i.e. once development and floor level restrictions begin to take effect). ✓ Relatively capital low cost.
Disadvantages	× Will only be effective in the long-term and does not address the communities short-term concerns. × Flood hazard continues to impact community.
Rough Order Cost Estimate	The costs associated with this option have not been estimated, however will include: - District planning and enforcement costs. - Existing channel maintenance costs following flood events to remove debris and bed material.

Option 2: Partial Floodway Development Proposal	
Description	- Retain development restrictions on unprotected properties to protect floodway from development (refer to option 1). - Raise 'at risk' houses identified by weather bomb damage reports (private expense). - Re-designate TCDC land currently occupied by Tapu Camp Ground as a floodway. - Designate land on the true right bank downstream of the SH25 bridge as part of the floodway and therefore not appropriate for future development.
Level of Service	5 year event
Advantages	✓ Addresses the flood hazard affecting the Tapu community in the most cost-effective manner.
Rough Order Cost Estimate **(not updated)**	$200,000 (raise 10 'at risk' homes - private expense) + 15% for design/supervision/management + 10% for contingencies + 20% for resource consents $250,000 (total capital cost)
Reduction in consequences for risk model. **(final costs shown)**	**Improved warning systems** - $50,000 Increases probability of occupants having adequate warning and being able to escape floodwater. **Engineering works and property purchase** - $137,000 + $15,000 annual maintenance and depreciation: • All properties in Tapu become LOW zone. • Camping ground closed. • Damage to roads and bridges (local and state highway) – no change. • Channel deposition still occurs so cost to clean out debris remains. • Agency management costs reduced but not eliminated entirely.

Option 3: Full Floodway Development Proposal	
Description	- Construct stopbank stopbank from the southern abutment of the SH25 bridge along the land between the Tapu River and the Tapu Coroglen Road. Include timber walls where necessary. - Acquire property between the Tapu River and the Tapu Coroglen Road to facilitate works. - Provide floodgated drainage outlet on the true left bank adjacent to the SH25 bridge. - Retain development restrictions on undeveloped properties to protect floodway from development (refer to option 2).
Advantages	✓ Addresses the short term community concerns by mitigating the flood hazard with engineering works. ✓ Ensures that the undeveloped land on the true right bank downstream of the SH25 bridge remains undeveloped.
Rough Order Cost Estimate	$126,000 (stopbanking and floodwall) $15,000 (internal drainage work) $100,000 (property purchase) + 15% for design/supervision/management + 10% for contingencies + 20% for resource consents $329,000 (total capital cost) $7,000 (annual maintenance and depreciation cost)
Reduction in consequences for risk model	**Improved warning systems** - $50,000 Increases probability of occupants having adequate warning **Engineering works and property purchase** - $329,000 capex + $7,000 maintenance and depreciation • All residential properties protected. • Camping ground Med zone becomes Low zone – no change to High zone. • Damage to roads prevented (local and state highway) – bridges no change.

Coromandel Town Community and the Whangarahi Stream

1. Catchment Description

   Area = 17.5 km^2

   Time of Concentration = 45 minutes

2. Hydrology and Hydraulics

Description	AEP (%)	Peak Flow (m^3/s)
2 year flood event	50	99
10 year flood event	10	140
20 year flood event	5	162
50 year flood event	2	203
100 year flood event	1	248
Existing channel capacity	-	

3. Flood Scenario Description

4. Description and Assessment of Mitigation Options

Option 1: Restricted Development	
Description	- Do not allow any development within the high hazard zone. - Restrict floor levels within the medium and low hazard zones for areas already developed. - Do not allow any new development of currently undeveloped land within the medium and low hazard zones.
Level of Service	< 10 year event
Advantages	✓ Does not exacerbate the risk in the short – term and reduces risk in the long – term (i.e. once development and floor level restrictions begin to take effect). ✓ Relatively capital low cost.
Disadvantages	× Will only be effective in the long-term and does not address the communities short-term concerns. × Flood hazard continues to impact community.
Rough Order Cost Estimate	The costs associated with this option have not been estimated, however will include: - District planning and enforcement costs. - Existing channel maintenance costs following flood events to remove debris and bed material.

Option 2: Partial Floodway Development Proposal	
Description	General Works for the Whangarahi and Karaka Channels: - Undertake channel works within the Whangarahi Stream and the Karaka Stream to remove bed material and debris. - Provide rip-rap protection for sections of the Whangarahi Stream and the Karaka Stream that are susceptible to erosion (e.g. on the outside of bends). - Fence upper Karaka Stream to arrest bank erosion. In the Vicinity of the Wharf Road Bridge: - Construct floodwalls upstream of the Wharf Road bridge (using concrete walls adjacent to the bridge and timber walls where land is restricted). - Provide floodgated drainage adjacent to the Wharf Road bridge. In the Vicinity of the Karaka Stream Bridge: - Construct overland flow path around Karaka Stream bridge. For the Flood Hazard Zones within the Coromandel Township: - Retain development restrictions on unprotected properties to protect floodway from development (refer to option 1).
Level of Service	100 year event (partial)
Advantages	✓ Restores the Whangarahi Stream and the Karaka Stream to a condition similar to pre-weather bomb. ✓ Protects property close to the main channels from erosion. ✓ Restores the upper Karaka Stream (a source of gravel that deposits in the channel within the Coromandel Township). ✓ Protects the Coromandel Township CBD (high financial benefit).
Rough Order Cost Estimate **(not updated)**	$120,000 (channel improvement works – including rip-rap) $30,000 (fencing and planting upper Karaka Stream) $255,000 (floodwalls to protect CBD including drainage outlet) $135,000 (erosion control around floodwalls) $45,000 (Karaka Stream bridge area) + 15% for design/supervision/management + 10% for contingencies + 20% for resource consents $848,000 (total capital cost) $39,000 (annual maintenance and depreciation cost)

Reduction in consequences for risk model. **(final costs shown)**	**Improved warning systems** - $25,000 Increases probability of occupants having adequate warning and being able to escape floodwater. **Engineering works and property purchase** - $864,000 + $36,000 annual maintenance and depreciation: • 17 residences in HIGH zone and 12 in MEDIUM zone become LOW zone (protection works for CBD upstream of bridge). • Hotels/motels and businesses all become LOW zone. • Damage to roads and bridges (local and state highway) now prevented. • Channel deposition still occurs so cost to clean out debris remains. • Agency management costs reduced but not eliminated entirely.

Option 3: Full Floodway Development Proposal	
Description	General Works for the Whangarahi and Karaka Channels: - Implement recommendations included under option 2. In the Vicinity of the Wharf Road Bridge: - Implement recommendations included under option 2. In the Vicinity of the Karaka Stream Bridge: - Upgrade the Karaka Stream bridge to pass the 100 year flow (TCDC expense). - Upgrade the floodway in the vicinity of the Karaka Stream bridge to pass the 100 year event. In the Vicinity of the 'Albert Street Meander': - Purchase properties within the 'Albert Street meander' (other options for this area, such as floodwalls and overland flow paths, are either not economic or are not technically feasible). Over the Remaining Length of the Whangarahi Stream and the Karaka Stream: - Implement recommendations included under option 2.
Advantages	✓ Restores the Whangarahi Stream and the Karaka Stream to a condition similar to pre-weather bomb. ✓ Protects property close to the main channels from erosion. ✓ Restores the upper Karaka Stream (a source of gravel that deposits in the channel within the Coromandel Township). ✓ Protects the Coromandel Township CBD (high financial benefit). ✓ Removes a significant risk from the Albert Street meander in the most cost effective manner.
Rough Order Cost Estimate	$120,000 (channel improvement works – including rip-rap) $30,000 (fencing and planting upper Karaka Stream) $255,000 (floodwalls to protect CBD including drainage outlet) $135,000 (erosion control around floodwalls) $795,000 (upgrade Karaka Stream bridge – TCDC expense) $350,000 (property purchase – Albert Street meander) + 15% for design/supervision/management + 10% for contingencies + 20% for resource consents $2,443,000 (total capital cost)

Reduction in consequences for risk model	**Improved warning systems** - $25,000 Increases probability of occupants having adequate warning **Engineering works and property purchase** - $2,443,000. • 17 residences in High zone and 12 in Med zone protected (protection works for CBD upstream of bridge). • 4 high + 1 med property removed (purchase of Albert Street meander). • 1 High zone and 1 medium zone property protected (Karaka Stream bridge and flood path). • Hotels/motels and businesses all protected. • Damage to roads and bridges (local and state highway) now prevented.

CAPITAL COST SUMMARIES - OPTION 2
(Data from EW 10-Jul-03)

		Coromandel	**Pohue**	**Tapu**	**Tararu**	**Te Puru**	**Waiomu**
Category A	Category B	3. Full Protection - Wharf St	2. Intermediate Option	2. Intermediate Option	2. Intermediate Option (a)	2. Intermediate Option (a)	4. Full Protection Option
Group1	Channel Improvement	$ 274,000	$ 120,000	$ 60,000	$ -	$ 240,000	$ 155,000
	Flood Bank	$ 258,000	$ -	$ 22,500	$ 197,600	$ 134,800	$ 68,000
	Floodgate	$ 5,000	$ -	$ 10,000	$ -	$ -	$ -
	Overland Flow Channel	$ 45,000	$ 25,000	$ -	$ 85,000	$ 50,000	$ -
Group1 Total		$ 582,000	$ 145,000	$ 92,500	$ 282,600	$ 424,800	$ 223,000
Planning and Property	Planning Controls	$ -	$ -	$ -	$ -	$ -	$ -
	Property Purchase	$ -	$ 62,205	$ -	$ 494,260	$ 1,093,950	$ 391,300
Planning and Property Total		$ -	$ 62,205	$ -	$ 494,260	$ 1,093,950	$ 391,300
Engineering @ 15% of Works Total		$ 87,300	$ 21,750	$ 13,875	$ 42,390	$ 63,720	$ 33,450
Resource Consents @ 20% of Works Total		$ 116,400	$ 29,000	$ 18,500	$ 56,520	$ 84,960	$ 44,600
Sub Total		$ 785,700	$ 257,955	$ 124,875	$ 875,770	$ 1,667,430	$ 692,350
Contingency @ 10% of Sub Total		$ 78,570	$ 25,796	$ 12,488	$ 87,577	$ 166,743	$ 69,235
TOTAL		**$ 864,270**	**$ 283,751**	**$ 137,363**	**$ 963,347**	**$ 1,834,173**	**$ 761,585**

MAINTENANCE SUMMARIES - OPTION 2
(from EW 10-Jul-03)

		Coromandel	Pohue	Tapu	Tararu	Te Puru	Waiomu
Category A	Category B	3. Full Protection - Wharf St	2. Intermediate Option	2. Intermediate Option	2. Intermediate Option (a)	2. Intermediate Option (a)	4. Full Protection Option
Flood Protection	Channel Improvement	$ 9,580	$ 3,900	$ 1,800	$ -	$ 7,200	$ 5,000
	Channel Maintenance	$ 13,500	$ 4,500	$ 10,800	$ 30,800	$ 16,500	$ 6,500
	Channel Monitoring	$ 2,250	$ 1,500	$ 1,440	$ 1,440	$ 1,560	$ 1,500
	Flood Bank	$ 9,140	$ -	$ 675	$ 7,888	$ 5,444	$ 2,040
	Floodgate	$ 150	$ -	$ 200	$ -	$ -	$ -
	Overland Flow Channel	$ 1,800	$ 1,000	$ -	$ 3,000	$ 2,000	$ -
Grand Total		$ 36,420	$ 10,900	$ 14,915	$ 43,128	$ 32,704	$ 15,040

TABLE D-2
Benefit Cost Ratios Option 2 and Warning Systems Upgrade Only

			Capital works (Option 2) and warning systems					Warning systems upgrade only				
	EXAMPLE		Tararu	Te Puru	Waiomu-P	Tapu	Coromandel	Tararu	Te Puru	Waiomu-P	Tapu	Coromandel
	Mitigation option											
Annual Maint	$ -											
Total financial risk quotient	$ 38,100		$ 12,464	$ 61,926	$ 44,208	$ 30,875	$ 27,192	$ 12,464	$ 61,926	$ 44,208	$ 30,875	$ 27,192
Capital cost yr1	$ 290,000		$ 1,033,000	$ 1,884,000	$ 1,095,000	$ 187,000	$ 889,000	$ 70,000	$ 50,000	$ 50,000	$ 50,000	$ 25,000
Capital cost yr2	$ -											
Capital cost yr15	$ -											
Annual Maint before	$ -											
Annual Maint New Asset a	$ -		$ 43,000	$ 33,000	$ 26,000	$ 15,000	$ 36,000					
Annual Maint Cleanup afte	$ -											
Post works risk quotient	$ 5,230		$ 1,622	$ 14,737	$ 3,594	$ 3,528	$ 4,782	$ 7,464	$ 33,606	$ 24,688	$ 16,715	$ 16,192
Discount Factors												
Discount rate	10%		10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Cap Yr1	0.9091	1	0.9091	0.9091	0.9091	0.9091	0.9091	0.9091	0.9091	0.9091	0.9091	0.9091
Cap Yr2	0.8264	2	0.8264	0.8264	0.8264	0.8264	0.8264	0.8264	0.8264	0.8264	0.8264	0.8264
Cap Yr15	0.2394	15	0.2394	0.2394	0.2394	0.2394	0.2394	0.2394	0.2394	0.2394	0.2394	0.2394
USSPWF Yr1	0.954	1	0.9538	0.9538	0.9538	0.9538	0.9538	0.9538	0.9538	0.9538	0.9538	0.9538
USSPWF Yr2	1.821	2	1.8209	1.8209	1.8209	1.8209	1.8209	1.8209	1.8209	1.8209	1.8209	1.8209
USSPWF Yr25	9.524	25	9.5237	9.5237	9.5237	9.5237	9.5237	9.5237	9.5237	9.5237	9.5237	9.5237
PRESENT VALUE												
PV Do Min Maint	$ -		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
PV Option Maint	$ -		$ 368,504	$ 282,805	$ 222,816	$ 128,548	$ 308,515	$ -	$ -	$ -	$ -	$ -
PV Capital Cost	$ 263,639		$ 939,091	$ 1,712,727	$ 995,455	$ 170,000	$ 808,182	$ 63,636	$ 45,455	$ 45,455	$ 45,455	$ 22,727
PV Do Min	$ 362,864		$ 118,703	$ 589,761	$ 421,025	$ 294,045	$ 258,970	$ 118,703	$ 589,761	$ 421,025	$ 294,045	$ 258,970
PV Option	$ 81,169		$ 25,793	$ 185,364	$ 72,966	$ 59,685	$ 66,916	$ 75,854	$ 347,063	$ 253,741	$ 172,696	$ 164,701
PV Benefits	$ 281,696		$ 92,910	$ 404,397	$ 348,059	$ 234,360	$ 192,053	$ 42,849	$ 242,698	$ 167,284	$ 121,349	$ 94,268
PV Costs	$ 263,639		$ 1,307,595	$ 1,995,533	$ 1,218,271	$ 298,548	$ 1,116,697	$ 63,636	$ 45,455	$ 45,455	$ 45,455	$ 22,727
Benefit Cost Ratio=	**1.07**		**0.07**	**0.20**	**0.29**	**0.79**	**0.17**	**0.67**	**5.34**	**3.68**	**2.67**	**4.15**

TABLE D-3
Benefit Cost Ratios Option 3

Capital works (Option 3) and warning systems

	EXAMPLE		Tararu	Te Puru	Waiomu-P	Tapu	Coromandel
	Mitigation option						
Annual Maint	$ -						
Total financial risk quotient	$ 38,100		$ 12,464	$ 61,926		$ 30,875	$ 27,192
Capital cost yr1	$ 290,000		$ 2,484,000	$ 3,200,000		$ 379,000	$ 2,468,000
Capital cost yr2	$ -						
Capital cost yr15	$ -						
Annual Maint before	$ -						
Annual Maint New Asset a	$ -					$ 7,000	
Annual Maint Cleanup afte	$ -						
Post works risk quotient	$ 5,230		$ 588	$ 3,730		$ 10,333	$ 2,539
Discount Factors							
Discount rate	10%		10%	10%	10%	10%	10%
Cap Yr1	0.9091	1	0.9091	0.9091	0.9091	0.9091	0.9091
Cap Yr2	0.8264	2	0.8264	0.8264	0.8264	0.8264	0.8264
Cap Yr15	0.2394	15	0.2394	0.2394	0.2394	0.2394	0.2394
USSPWF Yr1	0.954	1	0.9538	0.9538	0.9538	0.9538	0.9538
USSPWF Yr2	1.821	2	1.8209	1.8209	1.8209	1.8209	1.8209
USSPWF Yr25	9.524	25	9.5237	9.5237	9.5237	9.5237	9.5237
PRESENT VALUE							
PV Do Min Maint	$ -		$ -	$ -	$ -	$ -	$ -
PV Option Maint	$ -		$ -	$ -	$ -	$ 59,989	$ -
PV Capital Cost	$ 263,639		$ 2,258,182	$ 2,909,091	$ -	$ 344,545	$ 2,243,636
PV Do Min	$ 362,864		$ 118,703	$ 589,761	$ -	$ 294,045	$ 258,970
PV Option	$ 81,169		$ 16,929	$ 91,030	$ -	$ 118,000	$ 47,694
PV Benefits	$ 281,696		$ 101,774	$ 498,731	$ -	$ 176,045	$ 211,276
PV Costs	$ 263,639		$ 2,258,182	$ 2,909,091	$ -	$ 404,534	$ 2,243,636
Benefit Cost Ratio=	**1.07**		**0.045**	**0.17**		**0.44**	**0.09**