

Consequential Flood Assessment

Whirinaki

Prepared for Hawke's Bay Regional Council

Prepared by Beca Limited

22 August 2025



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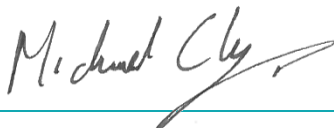


Appendix A – Flood hazard change tables – Buildings

Appendix A – Flood hazard change tables – Areas

Revision History

Revision N°	Prepared By	Description	Date
1	Michael Law	Draft for client review	10 March 2025
2	Michael Law	Final draft for client review	24 March 2025
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Document Acceptance

Action	Name	Signed	Date
Prepared by	Michael Law		22 August 2025
Reviewed by	Elliot Tuck		22 August 2025
Approved by	Elliot Tuck		22 August 2025
on behalf of	Beca Limited		

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Executive Summary

Background

Following Cyclone Gabrielle in February 2023, Hawkes Bay Regional Council (HBRC) commenced a series of projects to mitigate future flooding in certain areas within the region. These projects include a proposal for a stopbank along the eastern side of Whirinaki Drain, primarily to protect commercial and residential properties in the lower Esk Valley, about 12 km north of Napier. The area to be protected includes the Pan Pac timber and wood pulp mill, a power station, electricity substation and residential areas.

NIWA reported a peak flow during Cyclone Gabrielle of 2,175 m³/s for the Esk River at Waipunga Bridge (Site No. 22802), about 7 km upstream of SH2, based on PDP modelling. Based on the pre-cyclone flood records from 1963 onwards, NIWA calculated that a flow of 2,175 m³/s would have an average recurrence interval (ARI) of 180-220 years, depending on whether the cyclone is included in the record (Table 2, NIWA 2024). However, ongoing work for HBRC suggests the ARI could be 300-500 years, though this is to be confirmed.

After Cyclone Gabrielle, HBRC and the NZ Government’s Cyclone Recovery Taskforce assessed future severe weather risk across the region, establishing three main ‘land categories’ which have been used to determine the future severe weather risk for specific areas impacted by the cyclone. Land east of Whirinaki Drain was classed as Category 2C, where “Local government repairs and enhances flood protection schemes to adequately manage the risk of future flooding events in the face of climate change effects.”

The proposed stopbank alignment is shown as the red and yellow lines on **Error! Reference source not found.** The stopbank will tie into higher ground where Whirinaki Stream emerges from the hills behind Pan Pac and close at the coast.

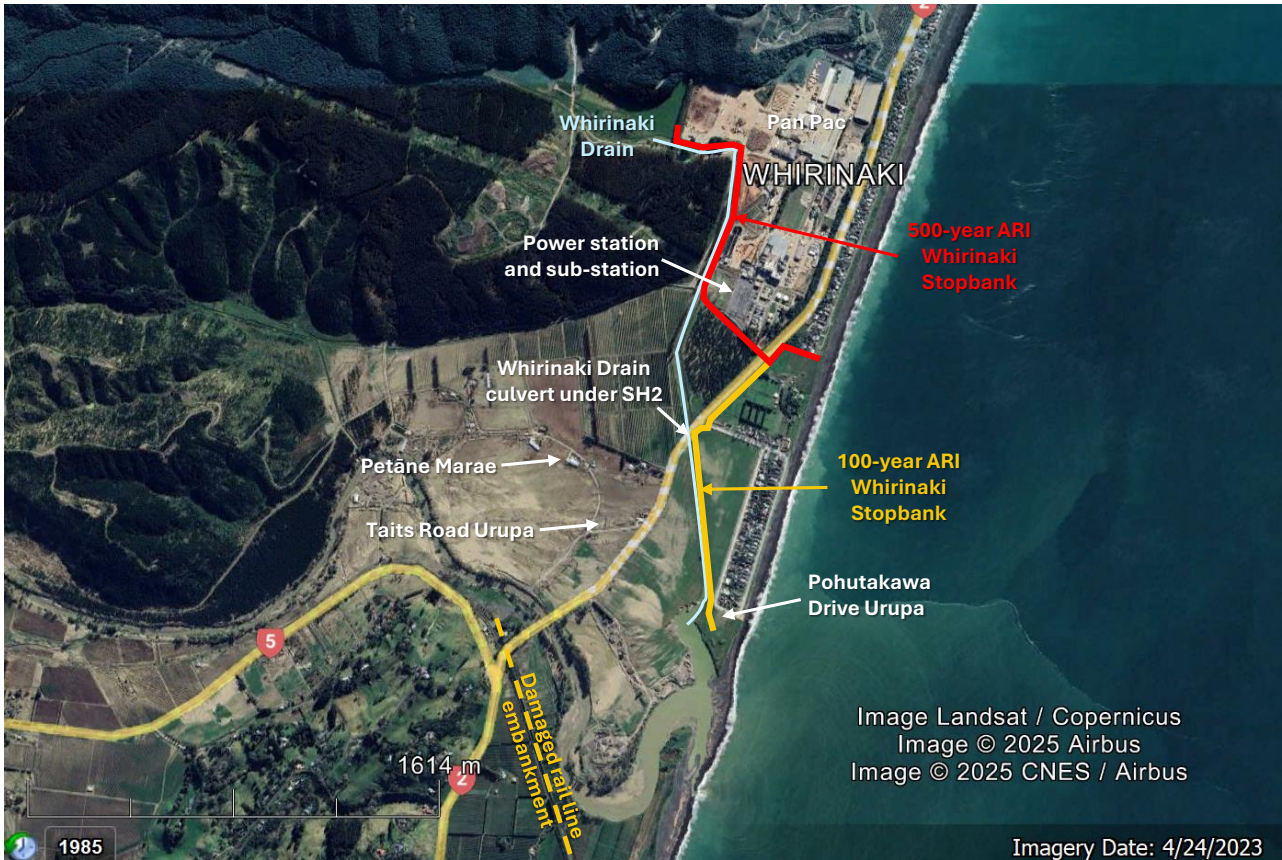


Figure 0-1 Key locations (Figure 3 PDP Effects Report)

The stopbank will provide a mixed level of service, with the upper section around Pan Pac and the substation providing protection from flooding by the Esk River for events up to and including the in the 500-year ARI event, while the lower section provides protection in the 100-year ARI event to residential areas of North Shore Road and Pohutukawa Drive. The design level for the proposed stopbank includes allowance for climate change and freeboard.

Pattle Delamore Partners (PDP) modelled the flood alleviation options and effects, reporting the areas and buildings positively and adversely affected by the stopbank in the 50-year 100-year and 500-year ARI flood events, with and without the effects of climate change, and under Cyclone Gabrielle conditions.

Conclusions and recommendations

Subject to external review of the Esk Valley Design Model, the modelling and reporting undertaken by PDP is robust. PDP have cooperated in providing information to inform this report and previous versions.

PDP's modelling shows that the proposed Whirinaki stopbank prevents flooding of about 1km² of Category 2C land (and 250 buildings) east of Whirinaki Drain in the design 100-year and 500-year ARI floods. The area protected by the 500-year ARI 'level of service' stopbank would have likely been protected by the proposed stopbank if it had been in situ during Cyclone Gabrielle. The proposed 100-year ARI 'level of service' stopbank would have resulted in less flooding in the area around North Shore Road during Cyclone Gabrielle. The area protected by the 500-year AR stopbank includes the Pan Pac timber and wood pulp mill, Contact Energy power station, Transpower substation, and residential areas in Whirinaki along SH2 and Whirinaki Road. The area protected by the 100-year ARI stopbank includes Pohutukawa Drive Urupa, and residential areas along North Shore Road and Pohutukawa Drive. As such, the proposed works provide a significant level of protection to critical infrastructure and residential areas.

However, flood risk and hazard increase slightly in the Taits Road area between Whirinaki Drain and the Esk River. The area is identified as Category 3 land that HBRC has identified as where "Future severe weather event risk cannot be sufficiently mitigated." However, this Category 3 land does also include vulnerable land uses, such as the marae, urupa and some residential properties including 1023 SH2 (**Error! Reference source not found.**)

The model result indicate Flood Hazard category H1 (generally safe for people, vehicles and buildings) applies to the Taits Road area in the 50-year ARI flood with, or without, the stopbank and with only a few small areas are affected in the 100-year ARI flood. Therefore, the effect of the stopbank of increasing flood depths in the Taits Road area is that flood hazard generally only increases in extreme floods (greater than the 100-year ARI event). The Category 2C area protected by the proposed stopbank is primarily high-value industrial/commercial and residential land. In contrast, most of the Category 3 land on the river side of the stopbank is rural land used for pasture and horticulture, and so would be considered more tolerant to flooding. The scope of this report has been to weigh up the benefits of protecting the Category 2C land against the adverse effects on other areas. These consequences have been evaluated by considering the effects against five criteria:

- **Magnitude of Effect:** Changes in flood depths, water velocities, and flood hazard category.
- **Event Scale:** Differences in flood effects in different design/historic events.
- **Property Sensitivity:** Consider how the change in flood effects will affect properties; removing flood risk, still flood prone but increased/decreased risk, introducing flood risk
- **Land use:** Evaluate the vulnerability/resilience of the affected land to flooding.
- **Scale of the proposal:** Considering the scale of proposed works against the accrued benefits.

Based on the flood consequences evaluation, the proposed Waiohiki stopbank passes the five criteria in that the benefits outweigh the adverse impacts on a community wide scale. This would indicate that **the consequences of the proposed stopbank are acceptable.**

1 Introduction

1.1 Scope

Following Cyclone Gabrielle in February 2023, Hawkes Bay Regional Council (HBRC) commenced a series of projects to mitigate future flooding in certain areas within the region. These projects included stopbanks to protect vulnerable communities. One such project is at Whirinaki where the Esk River meets the coast, about 12 km north of Napier.

HBRC appointed Pattle Delamore Partners (PDP) to undertake the flood modelling and design of the stopbank, which has changed during the project. Subsequently, HBRC appointed Beca to:

- Review and provide comment on PDP’s report Assessment of Effects on Flooding for Proposed Whirinaki Stopbank. (PDP Effects Report).
- Report on the consequences of the proposed works on the local community. This includes the areas and numbers of buildings where the risk of flooding will change due to the works, with the information drawn from the PDP report.

This report is the second of those; the ‘Consequences Report’.

1.2 Key locations

The existing Whirinaki stopbank runs along the eastern side of Whirinaki Stream/Drain. After it emerges from the hills behind the Pan Pac timber and wood pulp mill, the drain turns south toward the tidal floodplain of the River Esk in an engineered channel until it discharges into the River Esk channel about 100 m from the coast. The existing low stopbank only extends as far downstream as SH2. At SH2 the drain is culverted under the highway. The proposed stopbank will extend to the coast (red and yellow lines on Figure 1-2).

Figure 1-1 shows how the outlet of the Whirinaki Drain into the Esk River changed as a result of Cyclone Gabrielle. The Pre-cyclone (2020) LiDAR shows a clearly defined channel for the drain, whereas the post-cyclone (2023) LiDAR shows a 70 m wide tidal inlet, with a much-changed alignment of the Esk River to the south. While it’s not the purpose of this report to consider the geomorphology of the outlet, it has been a consideration in choosing the alignment of the proposed stopbank, which will extend to tie into the higher ground by the coast.

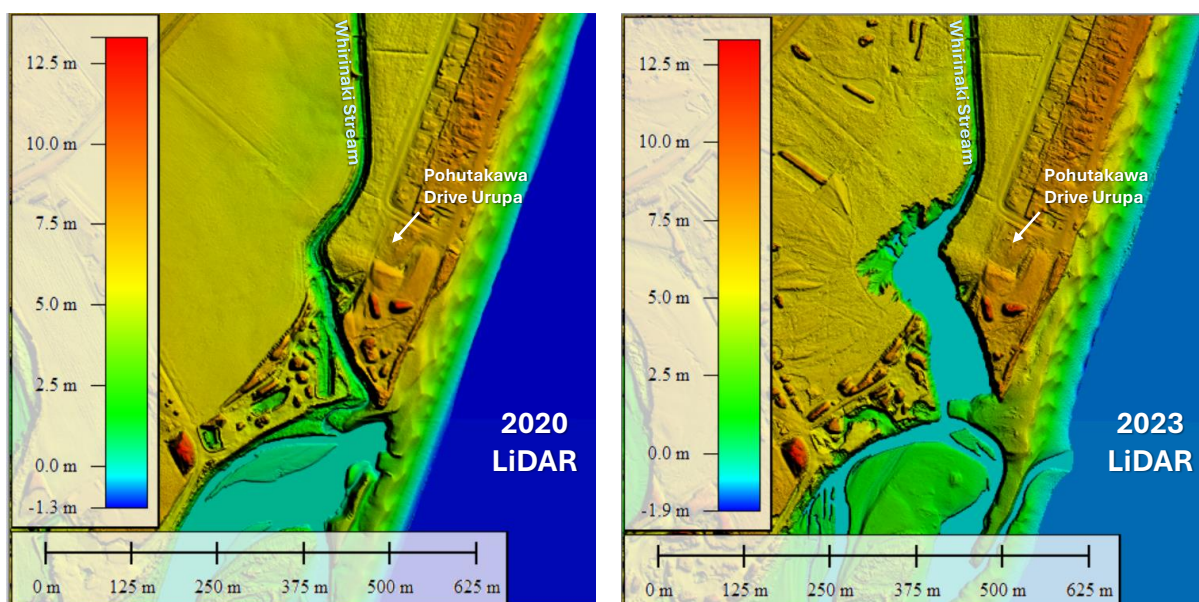


Figure 1-1 Post-cyclone change to the Whirinaki Drain mouth

The proposed stopbank will provide a mixed level of service, with the upper section around Pan Pac and the substation providing protection from flooding by the Esk River for events up to and including the in the 500-year ARI event, while the lower section provides protection in the 100-year ARI event to residential areas of North Shore Road and Pohutukawa Drive. Figure 1-2 shows the areas that will be protected by the proposed stopbank are:

- **Pan Pac Forest Products LTD timber and wood pulp mill**, which lies immediately adjacent to the drain and stopbank alignment as it emerges from the hills and borders the drain for about 500 m. The proposed stopbank ties into the top end of the Pan Pac site to minimise the opportunity for water to inundate the site.
- The **Contact Energy Whirinaki Gas Turbine Power Station** and adjacent **Transpower sub-station**, which lie between the stopbank and SH2 and immediately downstream of Pan Pac.
- **SH2** and residential properties in Whirinaki, particularly along the lower-lying areas of **North Shore Road** and **Pohutukawa Drive**. Note that SH2 is generally 1-2 m higher than the Pan Pac, Contact Energy and Transpower sites. The beach side properties along North Shore Road and Whirinaki Road are generally 1-2 m higher than SH2 and not subject to flooding from Whirinaki Drain or the Esk River.

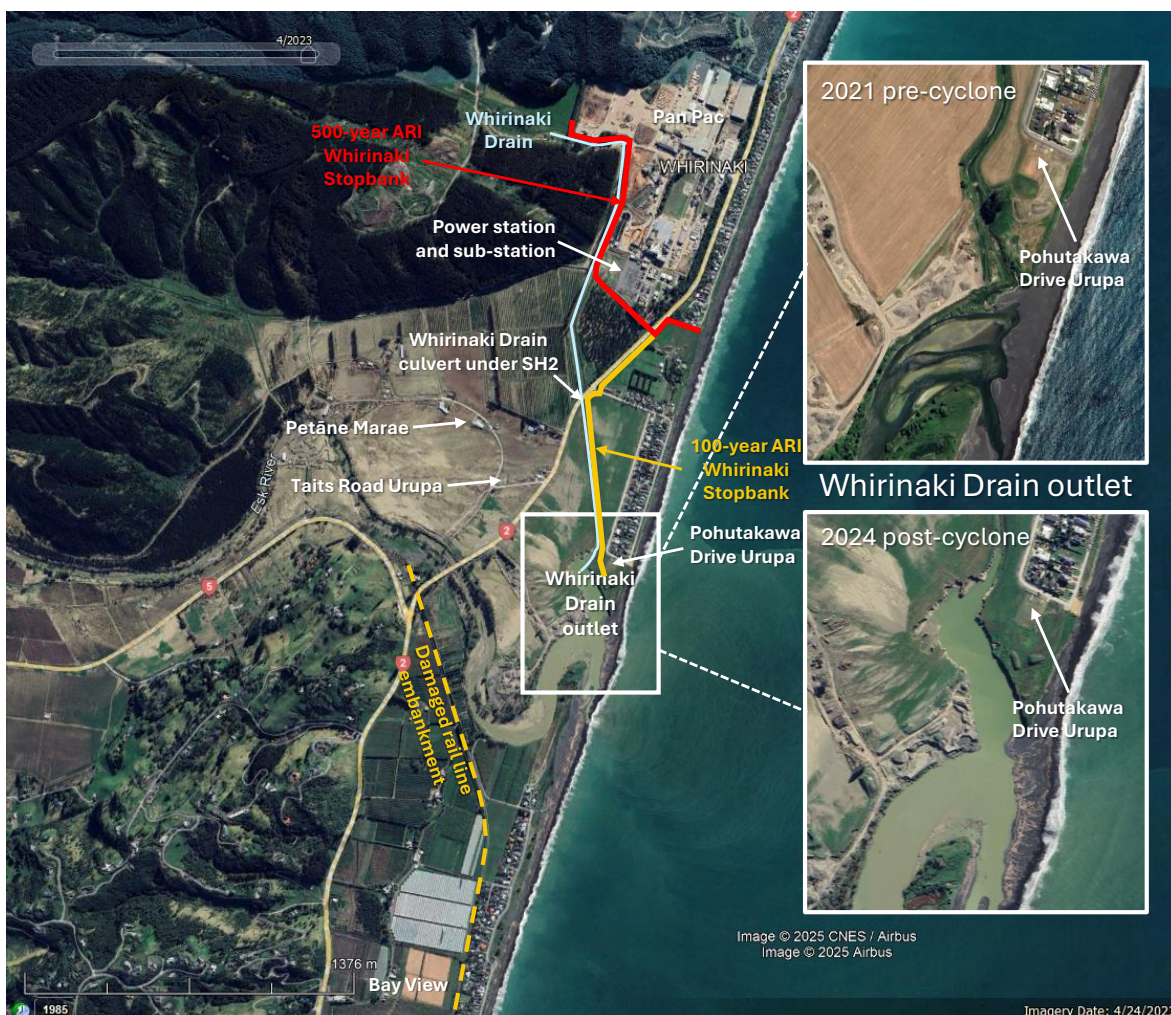


Figure 1-2 Post-cyclone aerial photo and key locations

On the south (true right) side of the Esk River is the Bay View area and KiwiRail’s Palmerston North – Gisborne Line (PNGL), which SH2 crosses over on Bridge 218. Between SH82 and Bay View the rail line is on an embankment about 2 m above the surround area. The embankment acted as an informal stopbank but was breached during Cyclone Gabrielle. There is uncertainty whether the embankment will be reinstated.

1.3 Cyclone Gabrielle

The extent and damage inflicted on the Esk Valley and wider Hawkes Bay region is well documented, and it's not the purpose of this report to restate or expand on the details of the event. However, it is pertinent to consider the local severity of the event, which occurred in mid-February 2023.

Following the cyclone, HBRC appointed NIWA to undertake extreme flood flow analysis of the event. This allowed HBRC and other parties to understand the severity of the river floods with reference to previous storms and design flood events. The results were presented in a letter report (NIWA, 2024) dated 23 February 2024.

NIWA reported a peak flow of 2,175 m³/s at Waipunga Bridge (Site No. 22802), about 7 km upstream of SH2, based on PDP modelling. Based on the pre-cyclone flood records from 1963 onwards, NIWA calculated that a flow of 2,175 m³/s would have an average recurrence interval (ARI) of 180-220 years, depending on whether the cyclone is included in the record (Table 2, NIWA 2024). However, ongoing work for HBRC suggests the ARI could be 300-500 years, though this ARI is to be confirmed.

NIWA also summarised the effects succinctly as follows...

“In many locations there was considerable sediment and debris in the flood water and in some locations (notably the Esk Valley) considerable amounts of this sediment were deposited during the flood. Debris build-up, especially around bridges, may have caused damming which may have backed up water upstream. If these dams burst, they also may have caused surges down the river. Stopbanks were overtopped and breached.” (Page 12, NIWA 2024)

The extent of flooding at Whirinaki is possibly best indicated by the extent of post-cyclone sediment shown by the light brown areas on Figure 1-3, which cover the entire Pan Pac site, substation and power station sites, as well as land to the south of SH82 on the Whirinaki side of Whirinaki Stream. The Esk River side of the drain, the deposition of sediment is extensive including around the orchards alongside Whirinaki Drain, Petāne Marae and Taits Road Urupa, and other properties, including 10231032 SH2.

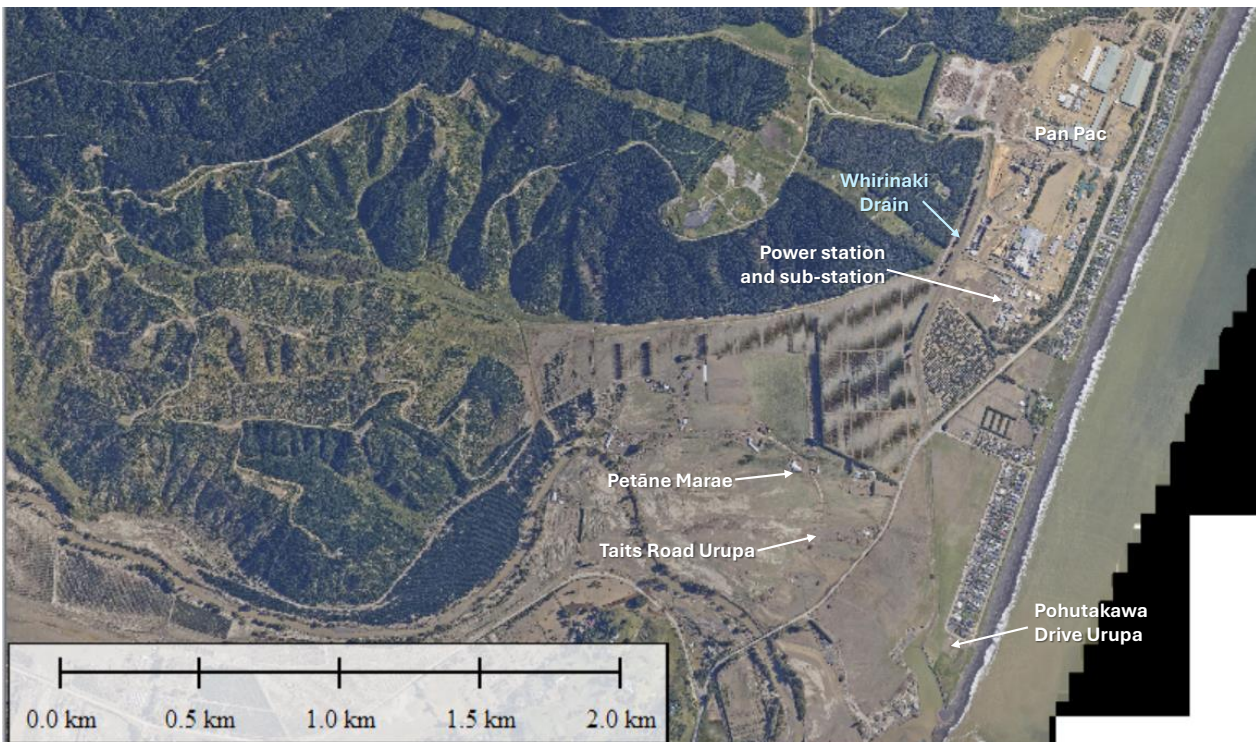


Figure 1-3 Post-cyclone sediment at Whirinaki

1.4 Land categorisation

As a result of Cyclone Gabrielle, HBRC and the NZ Government’s Cyclone Recovery Taskforce assessed future severe weather risk across the region. They established three main ‘land categories’ which have been used to determine the future severe weather risk for specific areas impacted by the cyclone. Areas in Land Category 1 can be repair to its previous state to manage future risk, whereas future risk cannot be sufficiently mitigated in Land Category 3 areas. Land Category 2 (divided into four sub-categories) areas fall between the two with interventions needed to mitigate future risk. Figure 1-4 shows the land categorisation of the Esk Valley. Land in the main river valley is all classed as Land Category 3, while the land north of Whirinaki Drain is Land Category 2C. Table 1-1 provides definitions of the two categories. The proposed Whirinaki stopbank is designed to protect that 2C land and mitigate future risk from severe weather events.

Table 1-1 HBRC Land Categorisation Categories¹

Category	Definitions	Examples
2C	Community level interventions are effective in managing future severe weather risk event.	Local government repairs and enhances flood protection schemes to adequately manage the risk of future flooding events in the face of climate change effects.
3	Future severe weather event risk cannot be sufficiently mitigated. In some cases, some current land uses may remain acceptable, while for others there is intolerable risk of injury or death.	In the face of enhanced climate risks the property may face unacceptable risk of future flooding. Other property could be subject to unstable land that poses an ongoing risk.

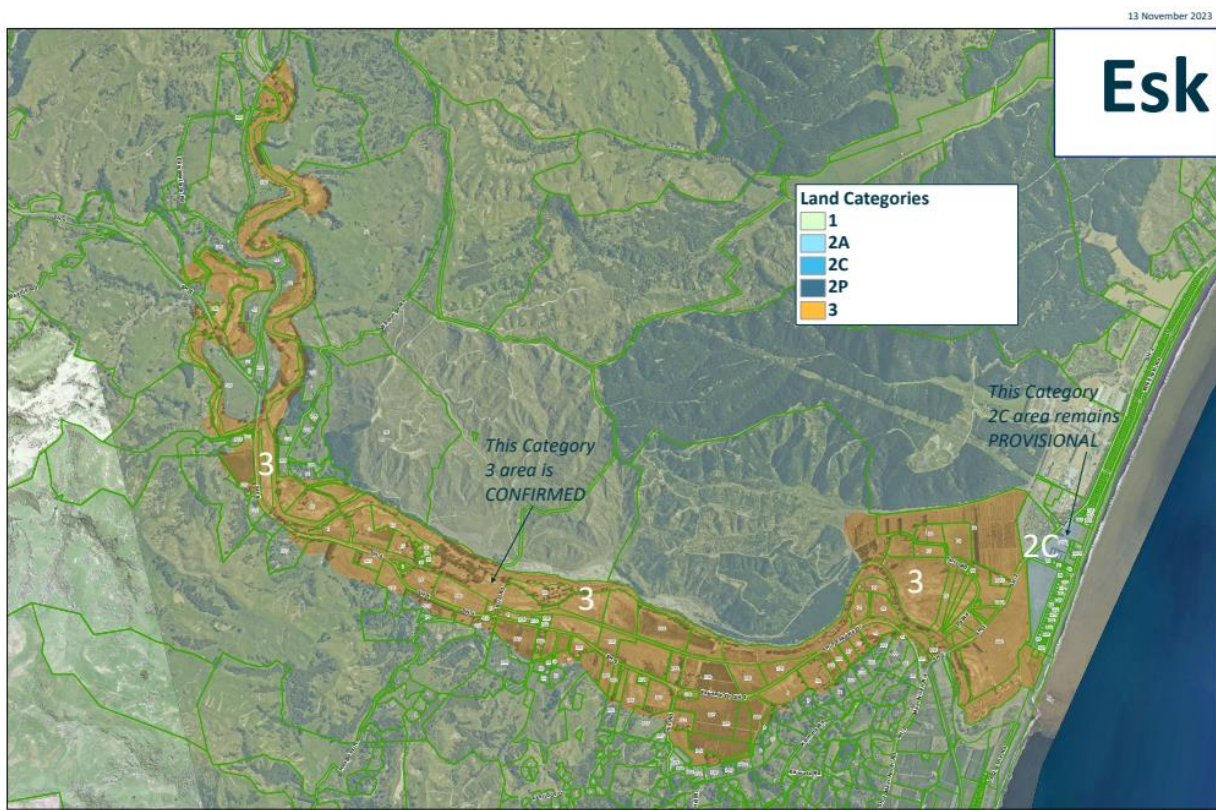


Figure 1-4 Esk Valley Land Categorisation Map (HBRC 2023)

¹ <https://www.hastingsdc.govt.nz/land-categorisation-hb/information/>

1.5 Information received

As noted above, HBRC appointed Pattle Delamore Partners (PDP) to undertake the flood modelling and design of the stop bank. PDP provided copies of the following reports:

- **Esk Valley: Design Model Build Report** (PDP Model Report). Provided for reference to inform this consequences report. The PDP Model Report describes the modelling undertaken to inform the design height of the proposed Whirinaki stopbank and assess the effects of flooding pre- and post-construction. The modelling described in the report builds on PDP’s earlier 2023 modelling of the Esk catchment for HBRC. The modelling was undertaken using Tuflow software package, which is widely used for flood modelling in New Zealand and overseas. Two versions of the report have been viewed and used in the preparation of this consequences report:
 - 5 February 2025. ‘Final’ version of the report prepared for the stopbank alignment with a uniform 500-year ARI level of service and referred for the March 2025 version of this flood consequences report.
 - 26 June 2025. Described in the report’s Quality Control Sheet as “Design Report for Mixed Level of Service”. The February version of the report updated to accommodate the change in the stopbank alignment and level of service.
- **Assessment of Effects on Flooding for Proposed Whirinaki Stopbank** report (PDP Effects Report). This report takes the results of the modelling covered in the PDP Model Report and describes how flooding depths, velocities and extents will change because of the proposed Whirinaki stopbank and the reinstatement (or otherwise) of the PNGL rail embankment at Bay View. Three versions of the report have been viewed and used in the preparation of this consequences report:
 - 18 December 2024. Client review version. Draft report provided to HBRC for comment and review.
 - 26 February 2025. Peer review version: Report updated in response to peer review comments from Beca Ltd. This version included more detail on the consequences of the stopbank at key locations.
 - 26 June 2025². Described in the report’s Quality Control Sheet as “Effects Report For New Alignment”. The February version of the report updated to accommodate the change in the stopbank alignment and level of service. Result maps and tables updated.

1.6 Site visit

Mike Law (Beca), the author of this report, visited the site on 29 January 2025 with Luke Cahalin (HBRC). They walked the stopbank alignment from the back of the Pan Pac site to SH2, as well as the Pohutukawa Drive Urupa site and stopbank alignment around the outlet into the Esk River. Mike also visited Taits Road, noting the Urupa site, Petāne Marae and other properties along the road. Mike got a wider view of the Esk Valley and floodplain driving up SH5 noting residual evidence of Cyclone Gabrielle two years after the event and visiting Waipunga Road Bridge, the location of the HBRC flow recorder.

2 Proposed Whirinaki Stopbank

As noted above, the proposed stopbank has changed from a uniform 500-year ARI level of service to a revised alignment and a mixed level of service. The updated alignment is shown on Figure 1-2 and Figure 2-1. The proposed levels of service and freeboard allowances (including allowance for climate change using RCP 8.5 to 2044) are shown in Table 2-1, and now includes five sections.

² Note that the report issue date is shown as June 2026, whereas it should be June 2025.

SH2 and North Shore Road cross the stopbank alignment, and so modifications will be made to both roads where they cross the new stopbank.



Figure 2-1 Proposed stopbank sections (Figure 17 PDP Model Report, 26 June 2025)

Table 2-1 Stopbank levels of service and freeboard requirements (from Table 7 PDP Model Report, 26 June 2025)

Stopbank section		Level of Service	Freeboard requirement
	Haulage Road	500-year ARI	500 mm
	Haulage Road to SH2		700 mm
	SH2 to Gravel Beach		900mm
	SH2 to North Shore Road	100-year ARI	700 mm
	North Shore Road to Whirinaki Drain Mouth		

Figure 2-2~~Error! Reference source not found.~~ and Figure 2-3 are taken from the PDP Model Report and shows modelled flood levels for the 100-year ARI and 500-year ARI design floods, and Cyclone Gabrielle (CGB), as well as the design stopbank height. The brown 'Design Terrain' levels on the plot are the bed levels of the Whirinaki Stream channel, except at SH2 and the River Mouth.

The proposed design height of the 500-year ARI section of stopbank upstream of SH2 rises from about 8.6 mRL³ at the Gravel Beach to about 9.0 mRL at the Pan Pac Haul Road, compared to existing ground levels of 4-6 mRL. Upstream of the Haul Road the stopbank height increases in two steps to 9.8 mRL and then 11.6 mRL

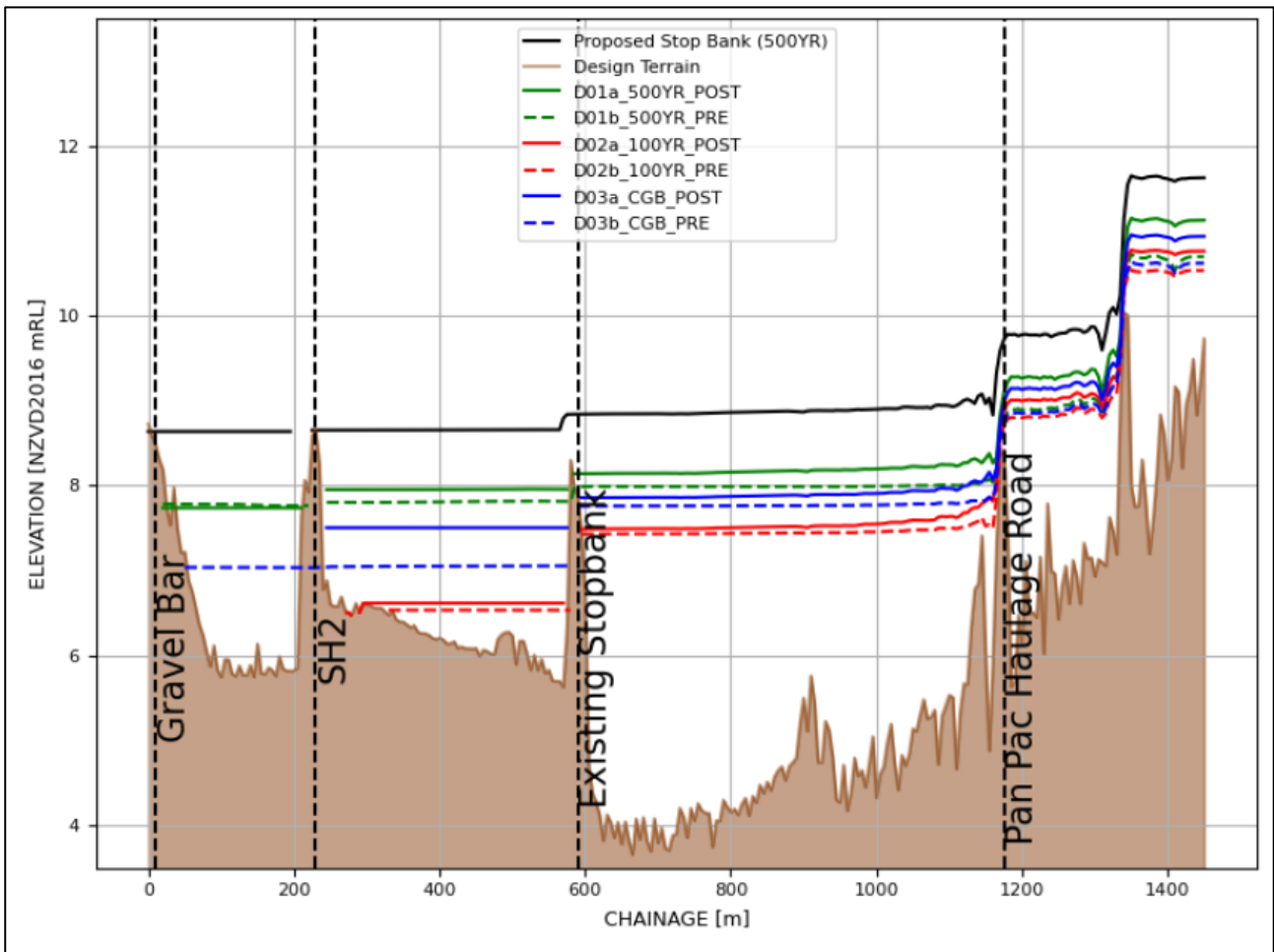


Figure 2-2 Modelled flood levels and proposed stopbank level – 500-year ARI level of service section – Haulage Road to Gravel Beach (Figure 23 PDP Model Report, 26 June 2025)

³ All elevations to NZVD2016

Between the start of the 100-year ARI level of service section of the stopbank (opposite the entrance to the substation) and North Shore Road, the realigned stopbank runs along the seaward side of SH2 at an elevation of about 7.6 mRL. The proposed stopbank level then drops gradually down to 6.1 mRL at the Whirinaki Drain Mouth.

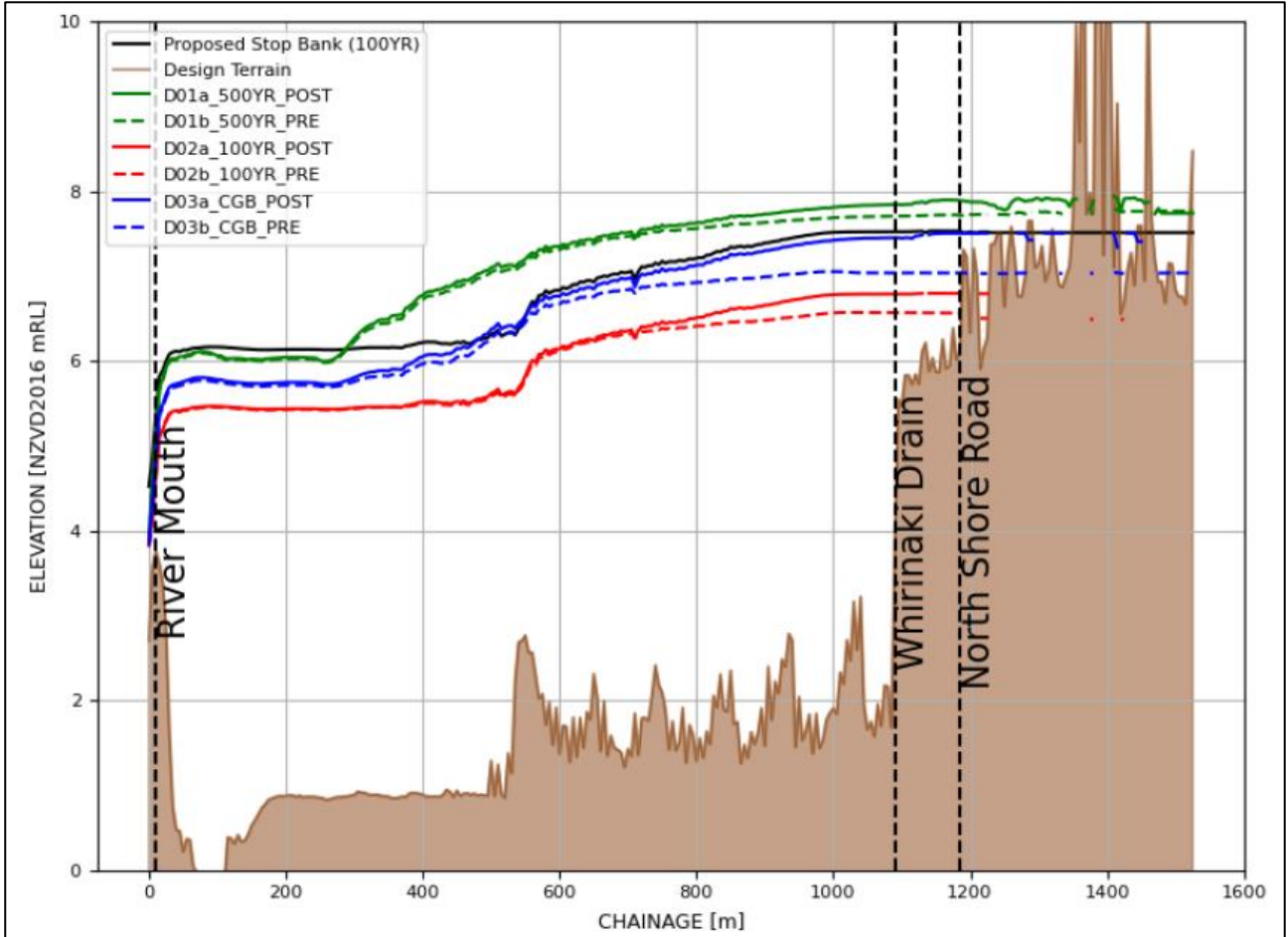


Figure 2-3 Modelled flood levels and proposed stopbank level – 100-year ARI level of service section – SH2 to Whirinaki Drain Mouth (Figure 22 PDP Model Report, 26 June 2025)

3 Consequential Flood Risk

3.1 Flood hazard classification

It is a consequence of stopbanks that while they will protect some areas, floodwater is diverted or ponded elsewhere. This can increase the risk of flooding to properties and infrastructure in those areas on the ‘upstream’ side of the stopbank.

The PDP Effects Report outlines the overall areas and numbers of buildings that will be positively or adversely affected by proposed stopbank. “The “*flood hazard classification specified by the Australian Rainfall and Runoff Guidelines have been adopted for this assessment ... which was adopted from Smith et al., (2014). These flood hazard curves are often employed in New Zealand and are the hazard curves recommended by the Greater Wellington Regional Council Flood Hazard Modelling Standard (GWRC, 2021).*” (PDP Effects Report). The flood classification curves are shown in Figure 3-1.

The flood hazard classification is based on a combination of the flood depth and water velocity at the site of interest, with the different hazard classes defined on the potential danger/damage to people, vehicles and property. It can be quite ‘broad brush’ with large variations in flood depth or velocity falling within the hazard class. To provide more nuance to the results, the PDP Effects Report includes separate plots of pre- and post-stopbank flood depth and water velocity at six sites within the Lower Esk and Whirinaki area (Figure 3-2). All six reporting sites are on the Esk River and Whirinaki Drain side of the proposed stopbank.

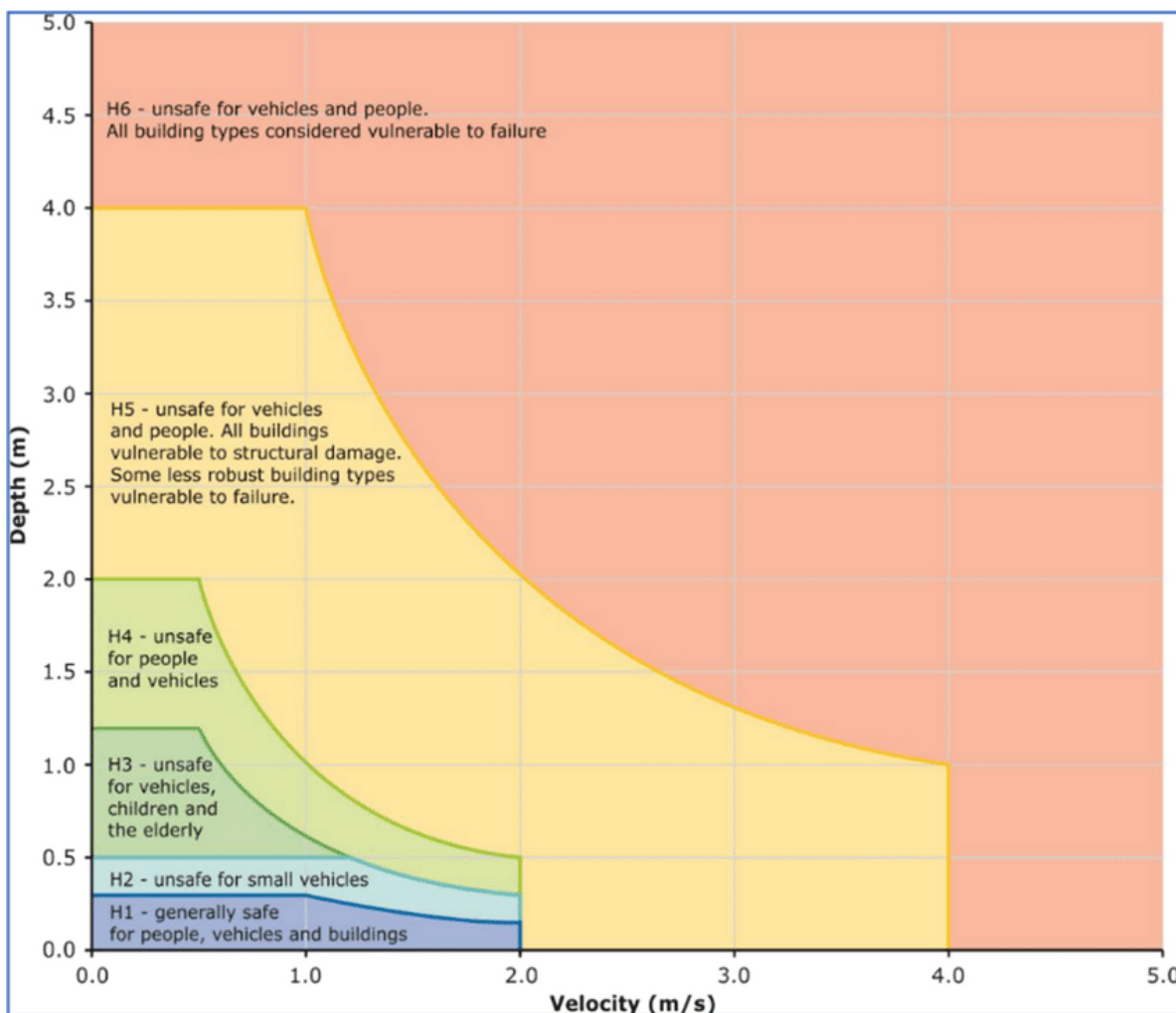


Figure 3-1 Flood hazard curves (Smith et al 2014)



Figure 3-2 Flood hazard reporting locations

3.2 Area-wide effects

Without the stopbank, over half of the area behind (east of) the stopbank is in flood hazard classes H2 to H4 in the 500-year ARI, including climate change, flood. This indicates that the area is generally unsafe for people and vehicles. This area includes the Pan Pac site, Transpower substation, Contact Energy power station and the residential areas of North Shore Road, Pohutakawa Drive and Whirinaki Road. These are all places where many people live and work. With a proposed stopbank height (equal to the climate change adjusted 500-year ARI flood level around the industrial areas and 100-year ARI flood levels protecting North Shore Road plus freeboard, these areas behind the stopbank are flood-free during their design level of service events.

3.2.1 Flood depths

However, PDP’s modelling and reporting, confirms that some areas on the Esk River side of the stopbank will experience higher flood depths, velocities and hazard classes because of the proposed stopbank. Figure 5 of the PDP Effects Report indicates that the stopbank will have no discernible effect on peak flood depths in the Esk River at Tait’s Road or SH2, nor at Thurley Place or the Whirinaki Drain at the Coast (locations 1,2, 5 and 6 on Figure 3-2) for the 50, 100, and 500-year ARI events. Flood hazard increases are mostly in the Taits Road area.

However, peak flood depths increase along Whirinaki Drain upstream of SH2 (locations 3 and 4 on Figure 3-2) as shown in Figure 3-3, with the largest increase of about 200 mm occurring during the 500-year ARI event. The earlier iteration of the stopbank design with a uniform 500-year level of service included a new culvert for Whirinaki Drain under SH2. The currently proposed stopbank alignment does not require the SH2 culvert to be replaced, which removes apparent benefits in smaller events due to a SH2 culvert upgrade.

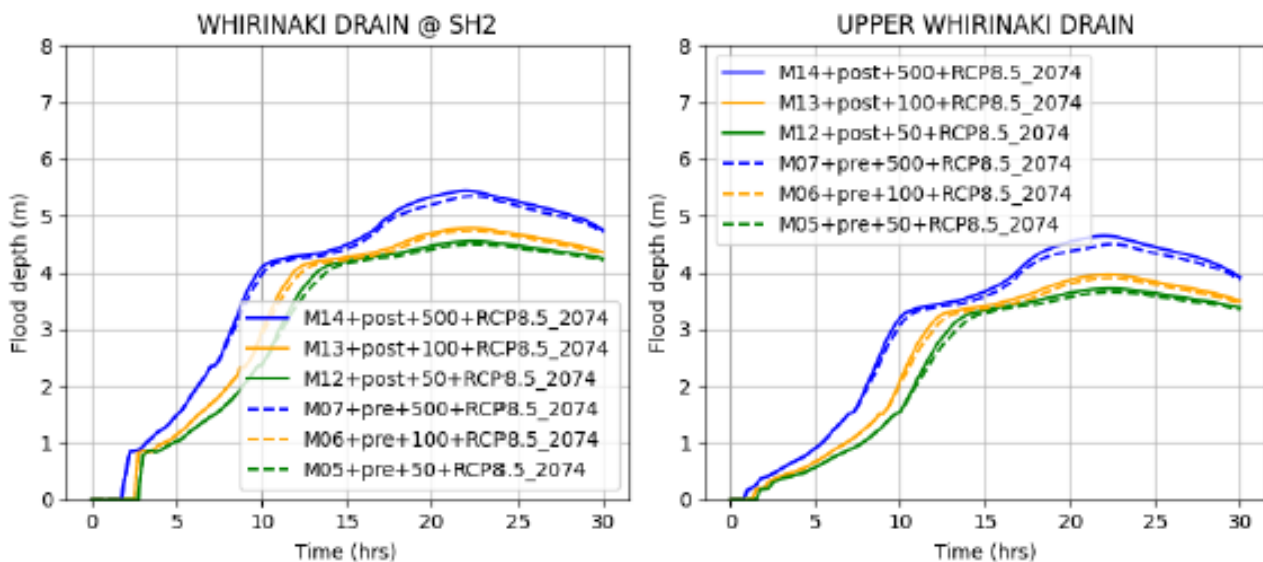


Figure 3-3 Whirinaki Drain flood depths (snip from Figure 5 PDP Effects Report)

While PDP’s modelling indicated that the proposed stopbank would have a negligible effect on flood levels at Thurley Place in Bay View (Location 6 on Figure 3-2), they also modelled the effect of reinstating the damaged rail line embankment at Bay View east of SH2. This work was reported in a PDP **Whirinaki Resilience Works - Rail Line Impacts** memo to HBRC dated 19 December 2024 (PDP Rail Impacts Memo). This showed that reinstating the embankment would make little difference to flood levels in the 100-year ARI flood event but that about 40 m³/s less water would cross the rail line in the 500-year ARI event if the rail embankment were reinstated, with a small reduction in flood levels on the west (landward) side of the embankment.

3.2.2 Flood velocities

As with flood depths, there is no discernible change in water velocities in the Esk River at Tait’s Road or SH2, nor at Thurley Place in Bay View. Velocities in Whirinaki Drain at, and upstream of, SH2 increase. However, water velocities are less than 1 m/s and so unlikely to cause significant erosion. Modelled water velocities are higher where Whirinaki Drain discharges at the coast, being just over 2 m/s for all events, but the stopbank and culvert upgrades don’t make a material difference to maximum velocities. The only noticeable difference is that velocities rise slightly quicker.

3.2.3 Changes in flood hazard

Across the modelled Esk Valley area, PDP calculated the numbers of buildings and hectares in each flood hazard category with, and without, the proposed stopbank in place. These assessments were conducted for seven flood events; the 50-year, 100-year, and 500-year design events with, and without, climate change and for Cyclone Gabrielle conditions. For greater definition different building types and land uses have been separated out from each other in the analyses.

PDP reported the numbers of buildings and hectares that have moved from one hazard category to another, so that it can be seen if there is a minor change in flood hazard or a major shift. Table 3-1 provides an example of the tabulated results for the 500-year ARI flood with climate change. This shows that while there is no change in flood hazard category for 1253 buildings (sum of 'grey cells' 952+80+71+127+17+6), 87 (33+10+32+9+3) buildings move to flood hazard category H0, meaning that they are flood free. However, six buildings move from H0 to H1, while four move from H1 to H2, two from H2 to H3, one from H3 to H4, and one from H4 to H5. So, 87 buildings are at less risk of flooding, while 14 are at increased risk, a net benefit of 73 residential buildings.

Table 3-1 Changes in flood hazard (no. of buildings) – Residential buildings in 500-year flood with climate change

500yCC RCP8.5 2074									
Change in building count in each hazard category		Totals	Post hazard category						
			H0	H1	H2	H3	H4	H5	H6
			1039	86	75	129	18	7	0
Old hazard category	H0	958	952	6					
	H1	117	33	80	4				
	H2	83	10		71	2			
	H3	160	32			127	1		
	H4	27	9				17	1	
	H5	9	3					6	
	H6	0							

The Table 3-2 to Table 3-7 in Sections 3.2.3.1 and 3.2.3.2 provide summaries of the net change in flood risk for each building type and land use for each of the seven flood events modelled.

The full results tables are presented in Appendix A (Buildings) and Appendix B (Areas).

3.2.3.1 Buildings

a. Rural and Open-Space Buildings

There are nearly 1,000 'Rural and Open-Space' buildings in the modelled area. The flood hazard category of the majority of these is unchanged in all events. For the 50-year and 100-year ARI floods, a handful of buildings change flood hazard category, with approximately the same number at less risk as at more risk. However, the detailed tables in Appendix A shows that most of those buildings at less risk have been moved from flood hazards H1-H5 to category H0 (no risk of flooding), whereas the buildings with increased flood risk have moved one flood hazard category (e.g. H3 to H4).

Table 3-2 Changes in flood hazard (no. of buildings) – Rural and Open-Space buildings

Flood hazard change summary (number of buildings)							
	50-year ARI		100-year ARI		500-year ARI		Cyclone Gabrielle
	noCC	withCC	noCC	withCC	noCC	withCC	
Improving	2	2	2	6	6	2	14
No Change	960	959	959	951	949	952	945
Worse		1	1	5	7	8	3
Net change	2	1	1	1	-1	-6	11

b. Commercial Buildings

All 77 commercial buildings in the model area move to flood hazard category H0 (no risk of flooding) for all modelled events with the stopbank in place.

Table 3-3 Changes in flood hazard (no. of buildings) – Commercial buildings

Flood hazard change summary (number of buildings)							
	50-year ARI		100-year ARI		500-year ARI		Cyclone Gabrielle
	noCC	withCC	noCC	withCC	noCC	withCC	
Improving	56	60	60	65	68	76	67
No Change	21	17	17	12	9	1	10
Worse	0	0	0	0	0	0	0
Net change	56	60	60	65	68	76	67

c. Residential

As with the Rural & Open Space buildings, most of the buildings that are listed as at less risk of flooding have moved to flood hazard category H0 (no risk of flooding), whereas those adversely affected have moved one flood hazard category (e.g. H2 to H3).

Table 3-4 Changes in flood hazard (no. of buildings) – Residential buildings

Flood hazard change summary (number of buildings)							
	50-year ARI		100-year ARI		500-year ARI		Cyclone Gabrielle
	noCC	withCC	noCC	withCC	noCC	withCC	
Improving	0	11	11	23	49	87	43
No Change	1353	1339	1341	1327	1303	1253	1303
Worse	1	4	2	4	2	14	8
Net change	-1	7	9	19	47	73	35

3.2.3.2 Areas (hectares)

a. LC3

There is over 133 km² of LC3 land in the Esk Valley. The detailed tables in Appendix B show that there is no change in flood hazard category for the vast majority of the LC3 areas. Depending on the flood event, Table 3-5 shows that 2 to 17 ha of LC3 land will have a reduced flood hazard and up to 10 ha would have an increased flood hazard. The maximum net change in flood hazard ranges from a 9 ha reduction to a 3 ha increase in flood hazard

Table 3-5 Changes in flood hazard (ha) - LC3 land

Flood hazard change summary (ha)							
	50-year ARI		100-year ARI		500-year ARI		Cyclone Gabrielle
	noCC	withCC	noCC	withCC	noCC	withCC	
Improving	2	11	11	17	10	4	19
No Change	13327	13317	13317	13309	13315	13324	13305
Worse	5	6	6	8	8	6	10
Net change	-3	5	5	9	2	-2	9

b. Rural and Open

Across the events modelled, up to 23 ha moves to a higher flood hazard category due to the proposed stopbank, however there will be a net lowering of flood hazard. Depending on the event, 35 ha to 55 ha moves to a lower flood hazard category, the majority of which moves to category H0 (no risk of flooding).

Table 3-6 Changes in flood hazard (ha) – Rural and Open land

Flood hazard change summary (ha)							
	50-year ARI		100-year ARI		500-year ARI		Cyclone Gabrielle
	noCC	withCC	noCC	withCC	noCC	withCC	
Improving	35	48	49	52	47	42	55
No Change	6941	6926	6925	6908	6916	6927	6904
Worse	5	7	7	21	18	12	23
Net change	30	41	41	31	29	30	32

c. Residential and Commercial

Across the events modelled, up to 4 ha moves to a higher flood hazard category due to the proposed stopbank. Depending on the event, 36 ha to 59 ha moves to a lower flood hazard category (mostly to H0).

Table 3-7 Changes in flood hazard (ha) – Residential and Commercial land

Flood hazard change summary (ha)							
	50-year ARI		100-year ARI		500-year ARI		Cyclone Gabrielle
	noCC	withCC	noCC	withCC	noCC	withCC	
Improving	35	40	40	46	53	59	51
No Change	2912	2907	2907	2900	2892	2885	2895
Worse	1	2	2	2	3	4	3
Net change	34	38	38	44	50	55	48

3.2.4 Summary

Over the Whirinaki and Bay View area, the PDP Effects Report documents about 7 km² of land being at risk of flooding in the 50-year ARI flood and over 13 km² at risk in the 500-year ARI flood. The effect of the proposed Whirinaki stopbank is to reduce the affected areas by 10%-11% in all events, principally the areas behind the stopbank.

For buildings, protection of the Land Categorisation 2C land behind the stopbank results in 76 commercial buildings being removed from flood hazard classes H1-H6. Mostly, these are the buildings associated with Pan Pac, the substation, and the power station.

There are 87 fewer residential buildings at risk of flooding in the Pohutukawa Drive, North Shore Road, and Whirinaki Road areas. However, 91 residential buildings (which includes garages and out-buildings, as well as houses) are still at risk in the 100-year ARI (with climate change) flood and 315 in the 500-year ARI (with climate change) flood. Most of these will be in the Bay View area.

There has been a small net reduction of rural buildings at risk of flooding. However, there are a handful of exceptions (notably around Taits Road) where the flood hazard will increase because of the proposed stopbank. These are in the Land Categorisation 3 area between the Esk River and the proposed stopbank, and the effects are considered in the sections below.

3.3 Locations of interest

The 26 February 2025 and 26 June 2025 versions of the PDP Effects Report included more information on the changes to flood risk at individual properties and locations of interest than the previous version of the report had done. It is not the purpose of this report to restate verbatim the information in the PDP Effects Report. Rather the effects are summarised, and the results considered in balancing the consequences of the proposed stopbank on the areas benefiting from it or adversely affected by it. For reference, the key locations are shown on Figure 3-4, which is a reproduction of Figure 3 in the PDP Effects Report.

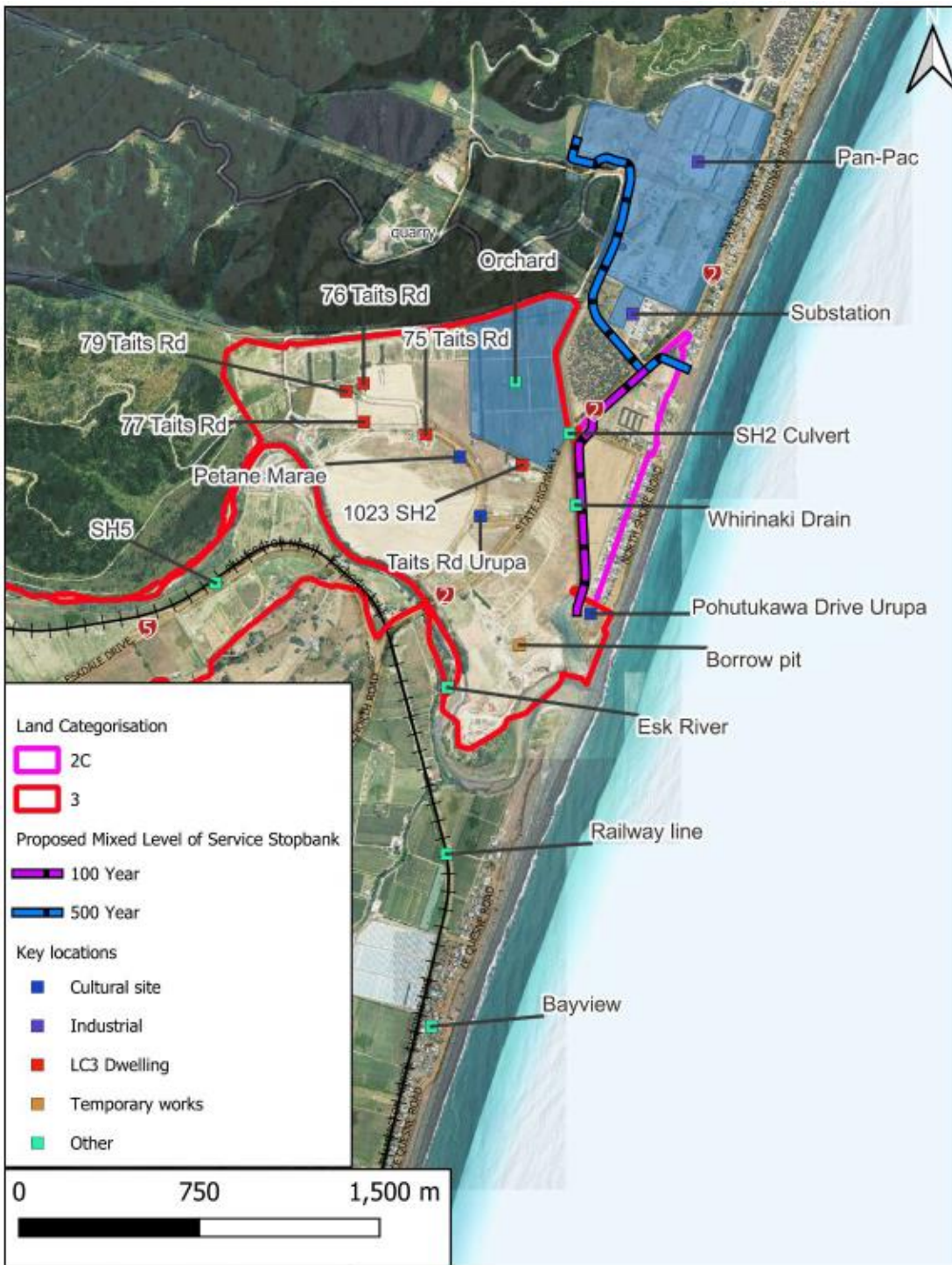


Figure 3-4 Key locations (Figure 3 PDP Effects Report)

3.3.1 Taits Road

The Taits Road area lies between the Esk River and the proposed stopbank. It is the area most adversely affected by the proposals as the loss of floodplain storage currently available on the Category 2C land is removed and so that water is contained around Taits Road, resulting in increased flood depths. Figure 3-4 shows the locations Petāne Marae and Taits Road Urupa, as well as four properties (75, 76, 77 and 79 Taits Road), 1023 SH2, and 30ha orchard.

3.3.1.1 Cultural Sites

The Petāne Marae and Taits Road Urupa are both dry or considered safe (flood hazard category H1) in floods smaller than the 100-year ARI event but experience a small (<50 mm) increase in flood depths in the 500-year ARI flood. There is no change to the maximum flood hazard category (H2 for the urupa and H3 for the marae), but the length of time in these flood hazard categories does increase slightly.

3.3.1.2 75-79 Taits Road

As with the marae and urupa, Nos. 76, 77 and 79 are currently either dry or subject to shallow flooding (flood hazard category H1) in events up to the 100-year ARI flood. In the 500-year flood, Nos. 76 and 79 are in flood hazard category H2 without the proposed stopbank, while No.77 remains in H1. No. 75 is in flood hazard category H2 in the 100-year ARI flood and flood hazard category H3 in the 500-year ARI flood. With the proposed stopbank in place, the maximum increase in peak flood depths is 22 mm, with no change in flood hazard category.

3.3.1.3 Horticultural Land:

Flood depths on parts of the 30ha orchard adjacent to Whirinaki Drain are modelled to increase by 50-100 mm. The flood hazard category is H4 (unsafe for people and vehicles) for the 100-year event with climate change, with flood depths in excess of 500 mm for large part of the orchard even without the stopbank. People and vehicles would not be expected to be on the orchard site during a flood event. Debris and silt would be the biggest effects on orchard operation post-flood.

3.3.1.4 1023 SH2

The property at 1023 SH2 lies on the North side of SH2. The entrance to the property is at the low point (6.2 mRL) in SH2 between the Esk River and Whirinaki Drain. This forms a secondary flow path draining water that can't be conveyed by the Whirinaki Drain. The property's buildings are on the edge of this flow path. With the stopbank in place, flood depths will increase by 22-86 mm (depending on the event), with no change to the flood hazard category; H2 in the 100-year event with climate change event and H3 in the 500-year event with climate change event. The duration of time in the maximum flood hazard category for each event increases slightly.

3.3.1.5 Category 3 land east of SH2

The proposed stopbank will make negligible difference to flood depths and velocities on the downstream (coastal) side of SH2, where tidal levels dominate.

3.3.2 Category 2C land behind the stopbank

3.3.2.1 Cultural site

The Pohutukawa Drive Urupa site is not currently at risk of flooding from the 100-year flood, or smaller. However, it is subject to flooding in the 500-year ARI event (flood hazard category H1; 'generally safe for people, vehicles and buildings') and there will be no change with the proposed stopbank.

3.3.2.2 Pan Pac, Transpower substation and Contact Energy power station

Though generally not shown as at risk of flooding in the 50-year ARI flood without the proposed stopbank, some parts of these commercial/industrial sites are currently shown as being in flood hazard category H5 (Unsafe for vehicles and people, and building at risk of structural damage or failure) in the 500-year ARI with climate change event. With the stopbank in place, these areas will be flood-free in the 500-year ARI with climate change event.

3.3.2.3 Residential areas

The effects of the proposed stopbank on residential depends on whether they are protected to the 100-year of 500-year ARI level of service.

Properties along SH2 opposite the substation and Pan Pac and Whirinaki Road are protected to the same degree as the commercial /industrial sites, in that they are not at risk from the 500-year ARI flood, but were inundated by Cyclone Gabrielle and some areas would be in flood hazard category H5 in a 500-year ARI flood with climate change. With the stopbank in place, these areas will be flood-free in the 500-year ARI with climate change event.

Currently, properties along North Shore Road and the lower part of Pohutukawa Drive are in (or adjacent to) areas of flood hazard category H3 and H4 in the 100-year ARI flood event with climate change. With the stopbank, they are flood-free in this event. These areas will be protected by the 100-year ARI level of service stopbank, which also reduces the severity of flooding in larger flood events; generally reducing the flood hazard by one category.

3.3.3 Bay View

Flood depths at Thurley Place at Bay View show no change as a result of the proposed Whirinaki stopbank. However, separate modelling by PDP (Appendix E of PDP Effects Report) indicated that the rail embankment east (downstream) of SH2 acted as an informal stopbank, reducing the risk of flooding to parts Bay View. It is not within the scope of this report to consider the consequences of reinstating the rail embankment to pre-cyclone condition.

3.3.4 Lifelines

There are three main transport corridors that could be potentially affected by the proposed stopbank; SH2 that crosses the stopbank alignment, as well as SH5 and the Kiwirail's Palmerston North – Gisborne Line (PNGL). The proposed stopbank results in no changes in flood hazard category for SH5 or the PNGL rail line. There are changes in flood hazard for SH2 on the Taits Road side of the stopbank, with an increase from H5 to H6 (all buildings vulnerable to failure) for a short length of road just west of the Whirinaki Drain culvert. On the eastern side of the proposed stopbank SH2 will be flood-free in the 500-year ARI event.

3.4 Indicators

Towards the end of Section 5 of the PDP Effects Report, the author of that report notes that “There is no formal guidance available nationally or locally which can be applied as a framework for assessing effects on flooding and flood hazard.” (pp 6&7, PDP Effect Report), and so propose a framework of five criteria against which to evaluate the effects of proposed works. The five criteria are listed and described below in Table 3-8, which also includes a summary of the effects/consequences of the proposed Whirinaki stopbank against each of the criteria, and an evaluation as to whether it passes the criteria.

Table 3-8 Flood consequences evaluation

Criteria	Effect and consequences of the Whirinaki Stopbank	Evaluation
<p>Magnitude of Effect: Changes to the flood depth/level and changes to the flood hazard classification.</p>	<p>Land and buildings in the 2C area behind the stopbank would be protected from flooding in events up to the 100-year and 500-year ARI flood levels of service, whereas some of those areas would experience flood depths of more than 1 m without the stopbank. However, a limited number of buildings on the river side of the stopbank would experience flood depths increasing by less than 50 mm.</p>	<p>Pass</p>
<p>Event Scale: An effect for a smaller, more frequent, event is considered worse than the same effect for a larger, less frequent event.</p>	<p>The model result indicate Flood Hazard category H1 (generally safe for people, vehicles and buildings) applies to the Taits Road area in the 50-year ARI flood with, or without, the stopbank and with only a few small areas are affected in the 100-year ARI flood. Therefore, the effect of the stopbank of increasing flood depths in the Taits Road area is that flood hazard generally only increases in extreme floods (greater than the 100-year ARI event).</p>	<p>Pass</p>
<p>Property Sensitivity: Properties with existing flood vulnerabilities have a lower tolerance for additional flooding compared to those with low or no flood hazards.</p>	<p>The properties in the Taits Road area that will experience small increases in peak flood depth and duration of flooding in the extreme events will not see their risk of flooding increase materially during smaller events, if at all.</p>	<p>Unclear</p>
<p>Land use: The land use of the affected property is also a consideration. Rural land used for grazing/cropping/horticulture is considered to have a greater tolerance to flood effects when compared to residential dwellings.</p>	<p>The Category 2C area protected by the proposed stopbank is primarily high-value industrial/commercial (Pan Pac, the substation and power station) and residential land. In contrast, most of the Category 3 land on the river side of the stopbank is rural land used for pasture and horticulture and so would be considered more tolerant to flooding. However, the Category 3 land does also include vulnerable land uses, such as the marae, urupa and some residential properties, including 10231032 SH2.</p>	<p>Pass</p>
<p>Scale of the proposal: While less critical than the factors above, the size of the proposal generating the effect should be considered. A significant proposal which will protect regionally significant infrastructure and 100's of residential properties, generating an effect is more acceptable than a smaller proposal (for example a stopbank protecting ten houses) generating the same effect.</p>	<p>The proposed Whirinaki stopbank will protect a large area (about 1km²) and about 250 commercial, residential and rural buildings removed from flooding. However, this will be at the expense of small increases in flood risk in extreme events (>100-year ARI) to rural land and isolated properties on the river side of the stopbank.</p>	<p>Pass</p>

4 Conclusions and recommendations

Subject to external review of the Esk Valley Design Model, the modelling and reporting undertaken by PDP is robust. PDP have cooperated in providing information to inform this report and previous versions.

The modelling shows that the proposed Whirinaki stopbank prevents flooding of Category 2C land east of Whirinaki Drain in the design 100-year and 500-year ARI floods. The area protected by the 500-year ARI 'level of service' stopbank would have likely been protected by the proposed stopbank if it had been in situ during Cyclone Gabrielle. The proposed 100-year ARI 'level of service' stopbank would have resulted in less flooding in the area around North shore road during Cyclone Gabrielle. The area protected by the 500-year AR stopbank includes the Pan Pac timber and wood pulp mill, Contact Energy power station, Transpower substation, and residential areas in Whirinaki along SH2 and Whirinaki Road. The area protected by the 100-year ARI stopbank includes Pohutukawa Drive Urupa, and residential areas along North Shore Road and Pohutukawa Drive. As such, the proposed works provide a significant level of protection to critical infrastructure and residential areas.

However, flood risk and hazard increases slightly in the Taits Road area between Whirinaki Drain and the Esk River. The area is identified as Category 3 land that HBRC has identified as where "Future severe weather event risk cannot be sufficiently mitigated."⁴

The scope of this report has been to weigh up the benefits of protecting the Category 2C land against the adverse effects on the Category 3 areas. Based on the flood consequences evaluation shown in Table 3-8, the proposed Whirinaki stopbank passes four of the five criteria with an unclear result for the remaining criteria. This would indicate that **the consequences of the proposed stopbank are acceptable.**

5 References

- ***Esk Valley: Design Model Build Report.*** PDP report for HBRC (PDP Model Report).
 - February 2025
 - June 2025 Design Report for Mixed Level of Service (Rev 1)
- ***Assessment of Effects on Flooding for Proposed Whirinaki Stopbank.*** PDP report for HBRC (PDP Effects Report).
 - December 2024 Draft
 - February 2025 Final
 - June 2025 Update for new stopbank alignment (Rev A)
- ***Extreme Value Analysis of Flood Flows,*** NIWA letter report. 23 February 2024
<https://www.hbrc.govt.nz/assets/Document-Library/Reports/External-Reports/NIWA-letterreport-230224.pdf> (NIWA 2024)
- ***Esk Valley Land Categorisation Map Hawkes Bay Regional Council.*** 13 November 2023.
<https://www.hastingsdc.govt.nz/assets/Document-Library/Cyclone-Land-Categorisation-Hastings-and-Napier/Esk-13-Nov-2023.pdf> (HBRC 2023)
- ***Flood Hazard Modelling Standard.*** Greater Wellington Regional Council. (GWRC 2021).
- ***Flood Hazard (WRL Technical Report 2014/07).*** University of New South Wales. Smith, G. P., Davey, E. K., & Cox, R. J. (Smith et al 2014).
- ***Whirinaki Resilience Works - Rail Line Impacts.*** Memo from PDP to HBRC. 19 December 2024 (PDP Rail Impacts Memo)

⁴ <https://www.hastingsdc.govt.nz/land-categorisation-hb/information/>

A

Appendix A – Flood hazard change tables – Buildings

Effect of Whirinaki Stopbank on flood hazard

Rural

Buildings

Change in building count in each hazard category		Totals	50y Post hazard category						
			H0	H1	H2	H3	H4	H5	H6
			806	44	27	44	17	11	0
Old hazard category	H0	804	804						
	H1	44		44					
	H2	27			27				
	H3	46	2			44			
	H4	17					17		
	H5	11						11	
	H6	0							

Change in building count in each hazard category		Totals	100y Post hazard category						
			H0	H1	H2	H3	H4	H5	H6
			770	39	25	61	33	21	0
Old hazard category	H0	768	768						
	H1	40		39	1				
	H2	24			24				
	H3	61				61			
	H4	35	2				33		
	H5	21						21	
	H6	0							

Change in building count in each hazard category		Totals	500y Post hazard category						
			H0	H1	H2	H3	H4	H5	H6
			535	65	74	147	60	62	6
Old hazard category	H0	534	533	1					
	H1	67		64	3				
	H2	71			68	3			
	H3	146			3	143			
	H4	61				1	60		
	H5	64	2					62	
	H6	6							6

Change in building count in each hazard category		Totals	Cyclone Gabrielle Post hazard category						
			H0	H1	H2	H3	H4	H5	H6
			563	86	71	116	56	54	3
Old hazard category	H0	549	549						
	H1	92	5	86	1				
	H2	76	5		70	1			
	H3	117	2			115			
	H4	56					56		
	H5	56	2					54	
	H6	3							3

Change in building count in each hazard category		Totals	50yCC RCP8.5 2074 Post hazard category						
			H0	H1	H2	H3	H4	H5	H6
			776	35	25	60	32	21	0
Old hazard category	H0	775	774	1					
	H1	34		34					
	H2	25			25				
	H3	60				60			
	H4	34	2				32		
	H5	21						21	
	H6	0							

Change in building count in each hazard category		Totals	100yCC RCP8.5 2074 Post hazard category						
			H0	H1	H2	H3	H4	H5	H6
			679	60	42	89	40	38	1
Old hazard category	H0	677	673	4					
	H1	60	3	56	1				
	H2	41			41				
	H3	90	1			89			
	H4	42	2				40		
	H5	38						38	
	H6	1							1

Change in building count in each hazard category		Totals	500yCC RCP8.5 2074 Post hazard category						
			H0	H1	H2	H3	H4	H5	H6
			500	49	48	163	93	86	10
Old hazard category	H0	501	498	3					
	H1	47		46	1				
	H2	48			47	1			
	H3	165				162	3		
	H4	90					90		
	H5	88	2					86	
	H6	10							10

	Flood hazard change summary (number of buildings)						
	50-year ARI		100-year ARI		500-year ARI		Cyclone Gabrielle
	noCC	withCC	noCC	withCC	noCC	withCC	
Improving	2	2	2	6	6	2	14
No Change	947	946	946	938	936	939	933
Worse	0	1	1	5	7	8	2
Net change	2	1	1	1	-1	-6	12

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Effect of Whirinaki Stopbank on flood hazard

Open Space

Buildings

Change in building count in each hazard category		50y						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		11	1	0	0	1	0	0
Old hazard category	H0	11						
	H1	1	1					
	H2	0						
	H3	0						
	H4	1				1		
	H5	0						
	H6	0						

Change in building count in each hazard category		100y						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		11	1	0	0	0	1	0
Old hazard category	H0	11						
	H1	1	1					
	H2	0						
	H3	0						
	H4	0						
	H5	1					1	
	H6	0						

Change in building count in each hazard category		500y						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		2	0	2	8	0	1	0
Old hazard category	H0	2						
	H1	0						
	H2	2		2				
	H3	8			8			
	H4	0						
	H5	1					1	
	H6	0						

Change in building count in each hazard category		Cyclone Gabrielle						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		2	1	1	8	0	1	0
Old hazard category	H0	2						
	H1	1	1					
	H2	2		1	1			
	H3	7			7			
	H4	0						
	H5	1					1	
	H6	0						

Change in building count in each hazard category		50yCC RCP8.5 2074						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		11	1	0	0	0	1	0
Old hazard category	H0	11						
	H1	1	1					
	H2	0						
	H3	0						
	H4	0						
	H5	1					1	
	H6	0						

Change in building count in each hazard category		100yCC RCP8.5 2074						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		11	0	1	0	0	1	0
Old hazard category	H0	11						
	H1	0						
	H2	1		1				
	H3	0						
	H4	0						
	H5	1					1	
	H6	0						

Change in building count in each hazard category		500yCC RCP8.5 2074						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		2	0	0	10	0	0	1
Old hazard category	H0	2						
	H1	0						
	H2	0						
	H3	10			10			
	H4	0						
	H5	0						
	H6	1						1

	Flood hazard change summary (number of buildings)						
	50-year ARI		100-year ARI		500-year ARI		Cyclone Gabrielle
	noCC	withCC	noCC	withCC	noCC	withCC	
Improving	0	0	0	0	0	0	0
No Change	13	13	13	13	13	13	12
Worse	0	0	0	0	0	0	1
Net change	0	0	0	0	0	0	-1

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Effect of Whirinaki Stopbank on flood hazard

Commercial

Buildings

Change in building count in each hazard category		50y							
		Post hazard category							
		Totals	H0	H1	H2	H3	H4	H5	H6
			77	0	0	0	0	0	0
Old hazard category	H0	21	21						
	H1	28	28						
	H2	24	24						
	H3	4	4						
	H4	0							
	H5	0							
	H6	0							

Change in building count in each hazard category		100y							
		Post hazard category							
		Totals	H0	H1	H2	H3	H4	H5	H6
			77	0	0	0	0	0	0
Old hazard category	H0	17	17						
	H1	26	26						
	H2	24	24						
	H3	10	10						
	H4	0							
	H5	0							
	H6	0							

Change in building count in each hazard category		500y							
		Post hazard category							
		Totals	H0	H1	H2	H3	H4	H5	H6
			77	0	0	0	0	0	0
Old hazard category	H0	9	9						
	H1	1	1						
	H2	3	3						
	H3	27	27						
	H4	36	36						
	H5	1	1						
	H6	0							

Change in building count in each hazard category		Cyclone Gabrielle							
		Post hazard category							
		Totals	H0	H1	H2	H3	H4	H5	H6
			77	0	0	0	0	0	0
Old hazard category	H0	10	10						
	H1	2	2						
	H2	3	3						
	H3	54	54						
	H4	7	7						
	H5	1	1						
	H6	0							

Change in building count in each hazard category		50yCC RCP8.5 2074							
		Post hazard category							
		Totals	H0	H1	H2	H3	H4	H5	H6
			77	0	0	0	0	0	0
Old hazard category	H0	17	17						
	H1	26	26						
	H2	27	27						
	H3	7	7						
	H4	0							
	H5	0							
	H6	0							

Change in building count in each hazard category		100yCC RCP8.5 2074							
		Post hazard category							
		Totals	H0	H1	H2	H3	H4	H5	H6
			77	0	0	0	0	0	0
Old hazard category	H0	12	12						
	H1	10	10						
	H2	19	19						
	H3	36	36						
	H4	0							
	H5	0							
	H6	0							

Change in building count in each hazard category		500yCC RCP8.5 2074							
		Post hazard category							
		Totals	H0	H1	H2	H3	H4	H5	H6
			77	0	0	0	0	0	0
Old hazard category	H0	1	1						
	H1	1	1						
	H2	2	2						
	H3	9	9						
	H4	30	30						
	H5	34	34						
	H6	0							

Flood hazard change summary (number of buildings)							
	50-year ARI		100-year ARI		500-year ARI		Cyclone Gabrielle
	noCC	withCC	noCC	withCC	noCC	withCC	
Improving	56	60	60	65	68	76	67
No Change	21	17	17	12	9	1	10
Worse	0	0	0	0	0	0	0
Net change	56	60	60	65	68	76	67

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Effect of Whirinaki Stopbank on flood hazard

Residential

Buildings

Change in building count in each hazard category		50y						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		1330	9	10	5	0	0	0
Old hazard category	H0	1330						
	H1	10	9	1				
	H2	9		9				
	H3	5			5			
	H4	0						
	H5	0						
	H6	0						

Change in building count in each hazard category		100y						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		1296	23	10	25	0	0	0
Old hazard category	H0	1286	1					
	H1	28	6	22				
	H2	15	4	10	1			
	H3	25	1		24			
	H4	0						
	H5	0						
	H6	0						

Change in building count in each hazard category		500y						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		1098	96	72	81	7	0	0
Old hazard category	H0	1066	1					
	H1	106	15	90	1			
	H2	76	7	4	65			
	H3	91	8	1	6	76		
	H4	15	3			5	7	
	H5	0						
	H6	0						

Change in building count in each hazard category		Cyclone Gabrielle						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		1142	95	67	47	3	0	0
Old hazard category	H0	1108	1101	7				
	H1	103	16	86	1			
	H2	75	9		66			
	H3	63	16			47		
	H4	5		2			3	
	H5	0						
	H6	0						

Change in building count in each hazard category		50yCC RCP8.5 2074						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		1302	19	11	22	0	0	0
Old hazard category	H0	1293	1291	2				
	H1	25	7	17	1			
	H2	15	4		10	1		
	H3	21				21		
	H4	0						
	H5	0						
	H6	0						

Change in building count in each hazard category		100yCC RCP8.5 2074						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		1263	36	20	33	2	0	0
Old hazard category	H0	1242	1240	2				
	H1	44	9	34	1			
	H2	22	2		19	1		
	H3	44	12			32		
	H4	2					2	
	H5	0						
	H6	0						

Change in building count in each hazard category		500yCC RCP8.5 2074						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		1039	86	75	129	18	7	0
Old hazard category	H0	958	952	6				
	H1	117	33	80	4			
	H2	83	10		71	2		
	H3	160	32			127	1	
	H4	27	9				17	1
	H5	9	3					6
	H6	0						

Flood hazard change summary (number of buildings)							
	50-year ARI		100-year ARI		500-year ARI		Cyclone Gabrielle
	noCC	withCC	noCC	withCC	noCC	withCC	
Improving	0	11	11	23	49	87	43
No Change	1353	1339	1341	1327	1303	1253	1303
Worse	1	4	2	4	2	14	8
Net change	-1	7	9	19	47	73	35

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B

Appendix A – Flood hazard change tables – Areas

Effect of Whirinaki Stopbank on flood hazard

Land Category 3

Areas (ha)

Change in area (ha) in each hazard category		Totals	50y Post hazard category						
			H0	H1	H2	H3	H4	H5	H6
Old hazard category	H0	12925.7	12924.6	1.1					
	H1	99.0	1.8	95.5	1.7			0.0	
	H2	50.2	0.2	0.0	48.5	1.4	0.0	0.0	
	H3	84.0			0.0	83.8	0.1		
	H4	52.1				0.0	52.1	0.0	
	H5	79.7					0.0	79.7	0.0
	H6	43.2						0.0	43.2
Totals			12926.6	96.6	50.2	85.2	52.3	79.7	43.2

Change in area (ha) in each hazard category		Totals	100y Post hazard category						
			H0	H1	H2	H3	H4	H5	H6
Old hazard category	H0	12851.0	12850.6	0.3					
	H1	84.1	5.3	77.1	1.7			0.0	
	H2	59.3	3.0	0.0	53.8	2.4	0.1		
	H3	91.2	2.8		0.0	87.5	0.8		
	H4	71.7	0.0	0.0	0.0	0.0	71.3	0.4	
	H5	125.5					0.0	125.4	0.1
	H6	51.1							51.1
Totals			12861.8	77.4	55.5	90.0	72.2	125.8	51.3

Change in area (ha) in each hazard category		Totals	500y Post hazard category						
			H0	H1	H2	H3	H4	H5	H6
Old hazard category	H0	12791.9	12791.7	0.2					
	H1	18.5	0.4	17.5	0.5	0.0		0.0	
	H2	29.8	0.1	0.6	27.6	1.4	0.1	0.0	
	H3	69.5	0.3	0.2	0.9	64.9	3.1	0.1	
	H4	84.6	0.3	0.2	0.0	3.2	78.4	2.4	
	H5	239.0		0.4	0.1	0.1	3.5	234.7	0.3
	H6	100.7						0.0	100.7
Totals			12792.7	19.1	29.1	69.7	85.0	237.2	101.0

Change in area (ha) in each hazard category		Totals	Cyclone Gabrielle Post hazard category						
			H0	H1	H2	H3	H4	H5	H6
Old hazard category	H0	12796.3	12796.1	0.1	0.0				
	H1	30.2	1.7	27.8	0.7	0.0	0.0	0.0	
	H2	37.6	1.2	0.1	34.1	2.0	0.2	0.0	
	H3	83.2	7.8	0.7	0.0	71.3	3.0	0.4	
	H4	79.8	1.9	2.7	1.2	0.5	70.5	3.0	
	H5	220.3	0.2	0.5	0.3	0.2	0.1	218.5	0.4
	H6	86.6							86.6
Totals			12808.8	31.9	36.3	74.1	74.0	221.9	86.9

Change in area (ha) in each hazard category		Totals	50yCC RCP8.5 2074 Post hazard category						
			H0	H1	H2	H3	H4	H5	H6
Old hazard category	H0	12856.1	12855.7	0.3					
	H1	87.2	5.8	79.6	1.8			0.0	
	H2	59.6	2.6	0.0	54.3	2.6	0.1	0.0	
	H3	90.0	2.4	0.0	0.0	86.8	0.8		
	H4	70.2				0.0	69.9	0.3	
	H5	120.8					0.0	120.7	0.1
	H6	50.0							50.0
Totals			12866.6	80.0	56.1	89.4	70.7	121.0	50.1

Change in area (ha) in each hazard category		Totals	100yCC RCP8.5 2074 Post hazard category						
			H0	H1	H2	H3	H4	H5	H6
Old hazard category	H0	12812.7	12812.6	0.1	0.0				
	H1	54.1	2.3	50.8	1.0	0.0		0.0	
	H2	47.7	2.3	0.0	43.6	1.6	0.0	0.0	
	H3	99.8	10.4	0.0	0.0	86.0	3.3	0.1	
	H4	73.9	1.6		0.0	0.0	70.7	1.5	
	H5	179.0	0.0		0.0		0.0	178.7	0.3
	H6	66.7						0.0	66.7
Totals			12829.2	50.9	44.7	87.7	74.1	180.3	67.0

Change in area (ha) in each hazard category		Totals	500yCC RCP8.5 2074 Post hazard category						
			H0	H1	H2	H3	H4	H5	H6
Old hazard category	H0	12787.7	12787.6	0.1					
	H1	4.9	0.0	4.7	0.3	0.0			
	H2	10.5	0.1	0.0	9.7	0.6	0.1	0.0	
	H3	36.6	0.2		0.0	34.3	2.1		
	H4	71.8	0.3	0.0	0.1	0.3	68.8	2.3	
	H5	282.6	0.3		0.1	0.2	2.0	279.6	0.4
	H6	139.8						0.0	139.8
Totals			12788.5	4.8	10.2	35.5	72.9	281.9	140.2

	Flood hazard change summary (ha)						
	50-year ARI		100-year ARI		500-year ARI		Cyclone Gabrielle
	noCC	withCC	noCC	withCC	noCC	withCC	
Improving	2	11	11	17	10	4	19
No Change	13327	13317	13317	13309	13315	13324	13305
Worse	5	6	6	8	8	6	10
Net change	-3	5	5	9	2	-2	9

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Effect of Whirinaki Stopbank on flood hazard

Residential & Commercial

Areas (ha)

Change in area (ha) in each hazard category		50y						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		2942.7	1.7	0.8	1.8	0.7	1.0	0.0
Old hazard category	H0	2907.4	2907.2	0.2	0.0	0.0		
	H1	23.8	22.1	1.5	0.3		0.0	
	H2	8.8	7.9	0.0	0.5	0.3	0.0	0.0
	H3	7.2	5.5	0.0	0.0	1.5	0.3	
	H4	0.6	0.0			0.0	0.4	0.1
	H5	0.8	0.0				0.0	0.8
	H6	0.0						0.0

Change in area (ha) in each hazard category		50yCC RCP8.5 2074						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		2940.6	1.8	1.3	2.8	0.9	1.2	0.0
Old hazard category	H0	2901.5	2901.1	0.4	0.0	0.0		
	H1	21.2	19.4	1.5	0.4	0.0	0.0	
	H2	12.1	10.8	0.0	0.9	0.3	0.1	0.0
	H3	12.3	9.4	0.0	0.0	2.4	0.4	0.0
	H4	0.8	0.0			0.0	0.4	0.3
	H5	1.0	0.0				0.0	0.9
	H6	0.0						0.0

Change in area (ha) in each hazard category		100y						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		2940.4	2.0	1.3	2.9	1.0	1.3	0.0
Old hazard category	H0	2900.7	2900.3	0.4	0.0	0.0		
	H1	20.4	18.4	1.6	0.4	0.0	0.0	
	H2	12.9	11.6	0.0	0.9	0.4	0.0	0.0
	H3	12.9	9.9	0.0	0.0	2.5	0.4	0.0
	H4	0.8	0.0			0.0	0.5	0.3
	H5	1.0	0.0				0.0	0.9
	H6	0.0						0.0

Change in area (ha) in each hazard category		100yCC RCP8.5 2074						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		2938.0	2.8	1.6	3.7	1.2	1.6	0.0
Old hazard category	H0	2892.2	2891.7	0.5	0.0	0.0		
	H1	12.5	9.7	2.3	0.4	0.1	0.0	0.0
	H2	11.2	9.7		1.1	0.3	0.0	0.0
	H3	29.4	25.7	0.0	0.0	3.2	0.5	0.0
	H4	2.2	1.1			0.0	0.6	0.4
	H5	1.2	0.1				0.0	1.1
	H6	0.0						0.0

Change in area (ha) in each hazard category		500y						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		2925.4	7.6	5.5	6.4	1.8	2.0	0.1
Old hazard category	H0	2873.7	2872.9	0.7	0.1	0.0	0.0	
	H1	11.9	4.5	6.7	0.4	0.3	0.0	0.0
	H2	8.0	2.5	0.2	4.7	0.4	0.0	0.0
	H3	24.7	18.5	0.0	0.3	5.4	0.5	0.1
	H4	28.0	25.9		0.0	0.3	1.2	0.7
	H5	2.4	1.0				0.0	1.3
	H6	0.1						0.1

Change in area (ha) in each hazard category		500yCC RCP8.5 2074						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		2921.2	7.0	5.3	9.8	2.5	2.7	0.3
Old hazard category	H0	2863.2	2862.1	0.7	0.3	0.0	0.0	
	H1	11.0	4.0	6.3	0.3	0.4	0.0	0.0
	H2	7.7	2.4		4.7	0.6	0.0	0.0
	H3	16.5	6.9			8.8	0.8	0.1
	H4	26.3	23.9			0.0	1.6	0.8
	H5	23.9	21.9				0.0	1.8
	H6	0.1						0.1

Change in area (ha) in each hazard category		Cyclone Gabrielle						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		2928.4	7.5	5.0	4.4	1.4	1.9	0.1
Old hazard category	H0	2878.5	2877.6	0.8	0.0	0.0	0.0	
	H1	12.7	5.5	6.6	0.5	0.2	0.0	0.0
	H2	8.5	3.5		4.5	0.4	0.0	0.0
	H3	36.8	32.3	0.1		3.8	0.5	0.1
	H4	10.9	9.2	0.1	0.0	0.0	0.9	0.6
	H5	1.4	0.2				0.0	1.2
	H6	0.0						0.0

Flood hazard change summary (ha)							
	50-year ARI		100-year ARI		500-year ARI		Cyclone Gabrielle
	noCC	withCC	noCC	withCC	noCC	withCC	
Improving	36	40	40	46	53	59	51
No Change	2912	2907	2907	2907	2892	2885	2895
Worse	1	2	2	2	3	4	3
Net change	34	38	38	44	50	55	48

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Effect of Whirinaki Stopbank on flood hazard

Rural and Open Space

Areas (ha)

Change in area (ha) in each hazard category		50y						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		6474.4	112.7	64.7	108.4	61.8	99.9	59.0
Old hazard category	H0	6440.5	6439.3	1.2				
	H1	120.3	7.0	111.5	1.8		0.0	
	H2	66.9	2.4	0.0	62.9	1.5	0.1	0.0
	H3	132.8	25.7		0.0	106.9	0.2	
	H4	61.7	0.1			0.0	61.5	0.1
	H5	99.9				0.0	0.0	99.8
	H6	59.0						0.0

Change in area (ha) in each hazard category		100y						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		6395.5	95.1	67.6	116.6	87.5	149.8	68.9
Old hazard category	H0	6348.5	6346.9	1.5	0.0	0.0		
	H1	105.4	10.0	93.6	1.8		0.0	
	H2	73.6	5.2	0.0	65.7	2.5	0.1	0.0
	H3	127.3	12.2	0.0	0.0	114.1	0.9	0.0
	H4	108.1	21.1	0.0	0.0	0.0	86.5	0.5
	H5	149.5				0.0	0.0	149.4
	H6	68.8						0.0

Change in area (ha) in each hazard category		500y						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		5983.8	123.9	120.1	215.7	133.8	281.2	122.6
Old hazard category	H0	5946.9	5945.6	1.3	0.0			
	H1	124.2	0.7	121.4	2.0	0.1		0.0
	H2	122.1	0.6	0.4	117.4	3.6	0.1	0.0
	H3	220.6	3.2	0.2	0.6	208.8	7.6	0.1
	H4	136.9	8.4	0.2	0.0	3.0	122.5	2.7
	H5	308.1	25.2	0.4	0.1	0.1	3.5	278.4
	H6	122.3						0.0

Change in area (ha) in each hazard category		Cyclone Gabrielle						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		6025.6	156.5	121.2	197.6	112.9	259.3	108.0
Old hazard category	H0	5979.8	5977.3	2.4	0.1	0.0		
	H1	156.7	2.1	150.2	3.5	0.8	0.0	0.0
	H2	123.2	1.5	0.2	116.1	5.2	0.3	0.0
	H3	210.2	11.8	0.6	0.0	190.8	6.5	0.4
	H4	125.6	12.2	2.5	1.2	0.5	106.0	3.1
	H5	278.2	20.7	0.5	0.3	0.2	0.2	255.7
	H6	107.4						0.0

Change in area (ha) in each hazard category		50yCC RCP8.5 2074						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		6404.6	94.5	68.4	116.0	85.5	144.5	67.6
Old hazard category	H0	6356.9	6356.4	0.5	0.0			
	H1	106.6	10.7	94.0	1.9		0.0	
	H2	74.1	4.9	0.0	66.5	2.6	0.1	0.0
	H3	126.4	12.2	0.0	0.0	113.3	0.9	0.0
	H4	105.3	20.4			0.0	84.6	0.4
	H5	144.3				0.0	0.0	144.2
	H6	67.5						0.0

Change in area (ha) in each hazard category		100yCC RCP8.5 2074						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		6229.3	124.8	77.9	156.6	96.5	209.6	86.3
Old hazard category	H0	6183.2	6177.7	5.0	0.5	0.0		
	H1	128.0	3.4	119.8	3.4	1.4		0.0
	H2	82.6	3.3	0.0	74.0	5.2	0.0	0.0
	H3	170.7	17.1	0.0	0.0	149.9	3.5	0.1
	H4	122.2	27.7			0.0	92.9	1.6
	H5	208.4	0.0			0.0	0.0	207.9
	H6	86.0						0.0

Change in area (ha) in each hazard category		500yCC RCP8.5 2074						
		Post hazard category						
		H0	H1	H2	H3	H4	H5	H6
Totals		5942.2	84.5	85.0	220.1	141.5	343.7	164.0
Old hazard category	H0	5903.8	5903.3	0.5				0.0
	H1	85.9	0.5	83.9	1.5	0.0		0.0
	H2	86.1	0.4	0.0	83.3	2.4	0.1	0.0
	H3	221.8	1.3	0.0	0.0	217.1	3.4	0.0
	H4	144.0	3.9	0.0	0.1	0.4	135.9	3.7
	H5	375.9	32.9	0.0	0.1	0.2	2.1	340.0
	H6	163.6						0.0

	Flood hazard change summary (ha)						
	50-year ARI		100-year ARI		500-year ARI		Cyclone Gabrielle
	noCC	withCC	noCC	withCC	noCC	withCC	
Improving	35	48	49	52	47	42	55
No Change	6941	6926	6925	6908	6916	6927	6904
Worse	5	7	7	21	18	12	23
Net change	30	42	41	31	29	30	32

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