

Flood Risk Categorisation, Ex-Tropical Cyclone Gabrielle Impacted Areas: Pakowhai Addendum

✦ Prepared for

Hawkes Bay Regional Council

✦ September 2023



PATTLE DELAMORE PARTNERS LTD
Level 2, 134 Oxford Terrace
Christchurch Central, Christchurch 8011
PO Box 389, Christchurch 8140, New Zealand

Office +64 3 345 7100
Website <http://www.pdp.co.nz>
Auckland Tauranga Hamilton Wellington
Christchurch Invercargill



solutions for your environment

Quality Control Sheet

TITLE Flood Risk Categorisation, Ex-Tropical Cyclone Gabrielle Impacted Areas:
Pakowhai Addendum

CLIENT Hawkes Bay Regional Council

VERSION Final

ISSUE DATE 28 September 2023

JOB REFERENCE HB01032500

SOURCE FILE(S) HB01032500R002.docx

DOCUMENT CONTRIBUTORS

Prepared by

SIGNATURE



Ramon Strong

Reviewed by

SIGNATURE



Martina Groves

Approved by



Ramon Strong

Limitations:

This report has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Hawkes Bay Regional Council. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the report. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

This report has been prepared by PDP on the specific instructions of HBRC for the limited purposes described in the report. PDP accepts no liability if the report is used for a different purpose or if it is used or relied on by any other person. Any such use or reliance will be solely at their own risk.

© 2023 Pattle Delamore Partners Limited

Executive Summary

Over the course of 13 and 14 February 2023 parts of the Hawkes Bay Region were, along with the other parts of Te Ika-a-Māui/ the North Island (including neighbouring Tairāwhiti), impacted by ex-Tropical Cyclone Gabrielle (ETC Gabrielle).

In some places ETC Gabrielle caused catastrophic damage and resulted (in the Hawkes Bay region) in the loss of 8 lives; the economic impact has yet to be fully determined but will be substantial and will be felt well beyond 2023. Following the event central Government, through the office of the Cyclone Recovery Minister, asked councils in those impacted areas to “build a picture of high-risk areas following Cyclone Gabrielle”¹, including categorisation in accordance with specified criteria. The primary consideration with this task is the location of the residential properties that were most impacted – where risk to life is intolerably high and where the ability to mitigate practically/ cost-effectively appears to be limited.

Risk to life with future events on a scale comparable to ETC Gabrielle can be articulated in general terms but is difficult to codify with little national guidance. Factors such as flood depth and velocity are common risk assessment considerations but the picture for Hawkes Bay is much more complex than that – other factors such as the rate of rise of the floodwaters, and entrained silt and debris loads are also important.

Pakowhai has a number of unique characteristics that arguably make the hazard the most complex when compared to the other Category 3 areas identified in Hawkes Bay, areas that are largely defined by valley floors. It is reported separately because of those unique characteristics and the scale/ complexity of the hazard.

Multiple stopbank breaches occurred along the true (facing downstream) right Tutaekuri and left Ngaruroro stopbanks during ETC Gabrielle; those stopbanks join just over 2km from the coast and accordingly those breach discharges rapidly inundated the Pakowhai area, in some instances to relatively significant depths. The pattern and timing of the flows into the Pakowhai area added to the hazard – the oscillating nature of the flood and the often complex flow patterns.

Defining the northern and southern extents of the high hazard area is relatively straight-forward – the existing stopbanks. Defining the western extent is much more complex – the gradual rise of the land contour to the west. The initial categorisation work focussed on a land contour of RL 3 that generally lies east of Gilligan Road, encompassing those houses that were for the most part completely submerged by floodwater. Consideration of an expanded Category 3

¹ 1 May 2023 Beehive press release.

area for Pakowhai that better reflects the extent of the hazard was under consideration but the timelines set by central Government meant that this work was not able to be completed for the release of the initial version of the maps.

This confirmed report is based on the submissions and discussions with those impacted on a revised Category 3 boundary for Pakowhai based on a RL 5 contour. Those amendments in summary pull the north-western boundary back to Allen Road, snap the boundary largely to land parcels immediately east of Pakowhai Road, transitioning across Pakowhai Road between Brookfield and Hodgson Road (reflecting the lower elevation and cluster of red sticker properties toward the southern end of Pakowhai Road), and pulling the boundary back slightly east along Hodgson Road.

It is important to note the accelerated process associated with determining the Category 3 areas in particular. In any other context determining such hazard areas would take a number of years - the development of comprehensive numerical hydraulic models and a detailed, granular assessment of the event impacts. Those timelines are not compatible with the understandable need those impacted have for certainty - to meet that need the mapping is an amalgam of applied value judgements based on contextual factors and some of the broad considerations outlined in the report, informed by a range of different datasets.

Category 3 signifies not only the scale of the hazard/ risk to life but also the limited ability to mitigate that hazard for Pakowhai. In many ways that is self-evident – the sheer scale of the ETC Gabrielle impacts and the inescapable characteristics of the Pakowhai area; floodplain situated between two large rivers with densely populated areas to the north and south. There are major and arguably insurmountable challenges in seeking to optimally configure flood defences that robustly and cost-effectively address the hazard to Pakowhai without compromising the protection system as a whole or creating unacceptably high residual risks, all in the context of a changing climate (in particular the intensity of future ex-tropical cyclones and rising sea levels).

Table of Contents

SECTION	PAGE
Executive Summary	i
1.0 Introduction	1
2.0 Flood Impact Summary	2
3.0 Defining Unsafe in a Flood Hazard Context	4
4.0 Categorisation Framework Applied	6
5.0 Revised Pakowhai Hazard Categorisation	7
6.0 Mitigation Approaches	10

Table of Figures

Figure 1 Pakowhai inundation mechanism, ETC Gabrielle	3
Figure 2 Confirmed Land Categorisation Map for Pakowhai	9

Table of Tables

Table 2 Summary of Suggested Mitigation Approaches for Pakowhai	11
---	----

Appendices

Appendix A: HBRC Land Categorisation Methodology	
--	--

1.0 Introduction

PDP have been engaged by Hawkes Bay Regional Council (HBRC) to review, collate and summarise flood hazard categorisation/ mapping undertaken following the Ex-Tropical Cyclone Gabrielle weather event (ETC Gabrielle) that occurred in February 2023. ETC Gabrielle impacted Hawkes Bay to varying degrees, with the rainfall largely concentrated in the northern and central parts of the Region, resulting in catastrophic damage to a number of communities, including Pakowhai.

Those impacts have been categorised in accordance with the definitions contained Appendix A - this report solely focusses on the Pakowhai Category 3 area. That separation is based in part on compatible hazard types – the difference between the broad flood plain between major rivers that is Pakowhai and the other largely valley floor contexts – and the scale/ complexities of matters pertaining to Pakowhai.

Located between the lower reaches of the Tutaekuri and Ngaruroro Rivers, Pakowhai is a rural community dominated (due to its fertile alluvial soils) by horticulture and pastoral farming. It is essentially flat floodplain with flood defences (stopbanks) between it and the adjoining rivers. Residential dwellings are mainly clustered along Gilligan and Pakowhai Roads, connected to areas further north and south by both State Highway 2 to the west and Brookfields Bridge over the Tutaekuri River and Pakowhai Bridge over the Ngaruroro River.

Its location by any measure suggests a degree of exposure to flooding. A commonly cited reference publication in regard to historic recorded floods is Flood in New Zealand 1920 – 1953 (With notes on some earlier floods) published in 1957 by The Soil Conservation and Rivers Control Council, a now defunct central Government entity. It covers the country by region from north to south, noting in the Hawkes Bay chapter numerous large historic floods dating back to 1867 including the 1938 floods, the most significant historic event behind ETC Gabrielle.

Pakowhai is frequently mentioned in that publication from the earliest recorded event (1867 where Pakowhai is noted as being “nearly all submerged”). The December 1893 flood followed and while not specifically mentioned the nature of the other impacts described suggest that Pakowhai was significantly impacted; ten lives were lost in that event. The next significant event detailed occurred in June 1917 – the description suggests that it was larger than the 1897 event. The March 1924 event description notes that “the river [Ngaruroro] flooded large tracts of land around Pakowhai and Clive”. This event in particular appears to share many of the ETC Gabrielle event characteristics. Pakowhai is also mentioned with the 1932 (April and September), 1935, 1938 (January and February – almost certainly significantly impacted in the April event but not noted), 1949- and 1951 event descriptions.

Accordingly, the general area has been the subject of much technical work commissioned/ undertaken by both HBRC and its Catchment Board predecessor. River alignments in this part of the region are relatively recent and somewhat modified, a combination of both 1931 earthquake effects (the uplift north of Napier pushing the alignment of the Tutaekuri south from the Ahuriri estuary to join with the Ngaruroro) and subsequent man-made modifications around thirty years later to the alignment of the lower reach of the Ngaruroro. A joint mouth was a particularly important component of the Heretaunga Plains Flood Protection Scheme – the combined power of the two rivers in negating the significant/ dynamic coastal influences that can block/ offset river mouths along the Hawkes Bay coastline.

A flood hazard study was completed in 1999 with the accompanying report examining a number of scenarios that look at the potentially floodable areas resulting from breach scenarios. This report however does not aggregate the risk and focused on assessing the floodable area, potential flood damage and population affected. Pakowhai and Gilligan Rd were assessed at that time as having relatively low levels of potential flood damage and relatively low potential population affected.

The initial June 2023 report noted, amongst other things, that the Category 2 and Category 3 boundaries “will evolve further with both more technical work and community engagement”, noting that “the boundary between Categories 2 and 3 in the Pakowhai area in particular will be the subject of further refinement”. It is important to note the exact wording from central Government in regard to Category 2A - “Interventions may be required / possible but insufficient information to provide initial categorisation (these [properties categorised as 2A] may subsequently move between “2” categories or to categories 1 / 3”.

As noted earlier 8 people lost their lives in the Hawkes Bay region as a result of the ETC Gabrielle weather event. The subsequent technical work summarised in this and the earlier June report does not presuppose or speculate on the circumstances of their death which will presumably be the subject of a future formal coronial enquiry. Clearly such a formal enquiry would be beneficial to informing this technical work (given the focus on risk to life) but such enquiries may be years away; like many other aspects circumstance and the need for certainty has dictated the order of events.

2.0 Flood Impact Summary

Flood impacts for the Pakowhai area were a combination of four sources, each of which occurred at different stages of the event. That’s illustrated with Figure 1 below (blue areas approximate inundation extents, green lines stopbanks, red segments stopbank breaches and orange segments damaged/ partly compromised sections of stopbank), summarised as follows:

- ∴ Tutaekuri inundation via Waiohiki (Redclyffe Bridge blockage of the Tutaekuri River);

- ∴ Tutaekuri inundation via Moteo/ Swamp Road;
- ∴ Ngaruroro inundation via stopbank breaches;
- ∴ Tutaekuri inundation via stopbank breaches.

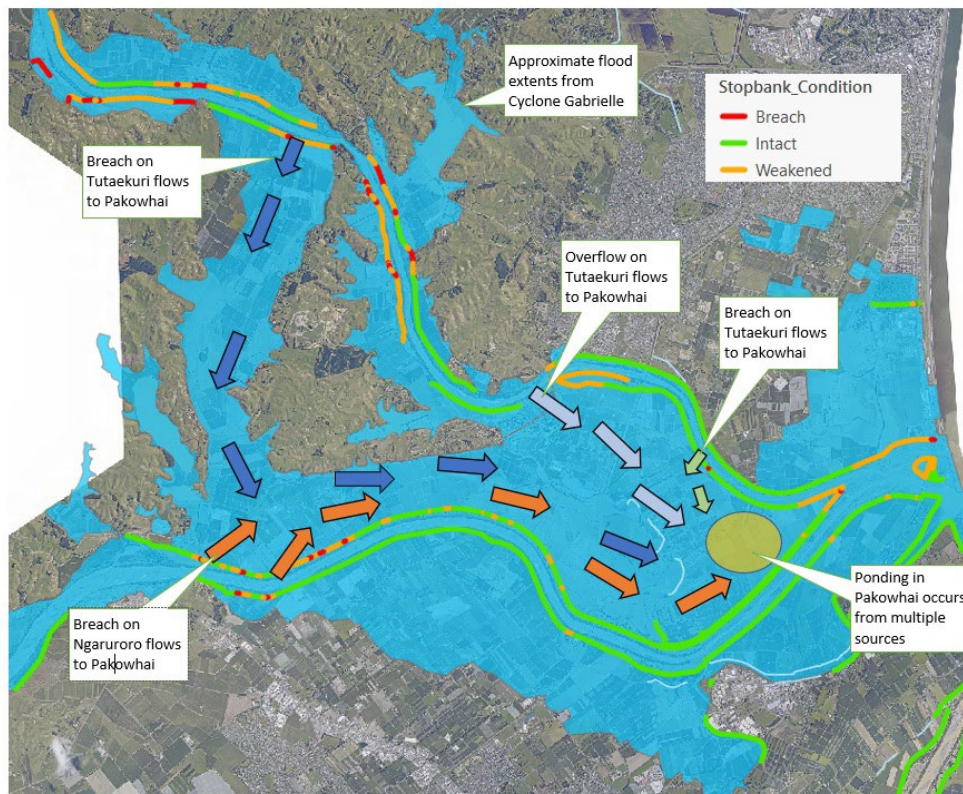


Figure 1 Pakowhai inundation mechanism, ETC Gabrielle

Inundation via Waiohiki was likely to be the first stage of flooding – an Allen Road resident described initial shallow inundation early in the event holding steady for some time. Inundation via Waiohiki is assumed to be attributable to debris building up against (and ultimately destroying) the Redclyffe Bridge, flood flow backing up behind the blockage and then exiting the river through Waiohiki and running into the Pakowhai area.

The breaches of the Ngaruroro stopbank are likely to have been induced by the upper catchment peak meeting a veritable torrent of water from the Ohiwa Stream, overwhelming the Ngaruroro stopbanks immediately downstream (thought to be the factor behind the high concentration of stopbank breaches around/ immediately downstream of Fernhill). That breach water combined with the spill from the Tutaekuri via Swamp Road, running into Pakowhai from the west/ southwest.

Much of the inundation is likely to derive from the Ngaruroro stopbank breaches but it is important to note the extensive overtopping (the orange sections shown in Figure 1). All of these breaches have been attributed to prolonged

overtopping – as the floodwater overtops the stopbank it causes scour, cutting through the grass cover. Once scour of the embankment core beneath commences breach will (and did) occur relatively rapidly.

The Tutaekuri right and Ngaruroro left stopbanks join around 2km from the coast, defining the eastern extent of the Pakowhai area. The initial overtopping from the Tutaekuri via Waiohiki began filling the area as the floodwater has no exit. This rate of filling appears to have been relatively slow at first - the multiple stopbank breaches of the Ngaruroro stopbank would have dramatically increased that rate of filling (estimated at it's peak to be close to 1,000 m³/s). The junction of the Tutaekuri and Ngaruroro stopbanks eventually breached releasing the water impounded in the Pakowhai area but (at their eastern end these stopbanks are close to 6m high) by then the damage had already been done.

3.0 Defining Unsafe in a Flood Hazard Context

Risk to life is clearly the primary consideration in categorising hazard type based on ETC Gabrielle impact and that approach is adopted for this assessment. That's defined as a function of:

- ✧ The maximum depth and rate of rise of floodwater;
- ✧ How swift or otherwise the floodwater was;
- ✧ How quickly a river rises and overtops its banks (how much warning those living close to a river might have that a flood is imminent) and how accessible safe egress is for those potentially impacted;
- ✧ The volume of silt and debris entrained in the floodwater;
- ✧ Particular geographic features that exacerbate the hazard e.g. valley confinement;
- ✧ How apparent the hazard is to those potentially impacted. That encompasses understanding/ awareness of the hazard (which will inevitably decline with time following ETC Gabrielle) but also whether the connect between the flood source and where people live is clear (whether their level of exposure is obvious or not);
- ✧ The complexity of the flood hazard. Inundation of the Pakowhai area was particularly complex - fluctuating flood levels during the early stages of the event and accounts of objects moved by the floodwater in a counter-intuitive direction due to the prevailing currents.

Some of the ETC Gabrielle impacts will be unique/ specific to that event. Others follow a pattern from past events and accordingly have a high likelihood of being repeated (in the absence of any interventions) with future extreme events, an important consideration with any risk assessment. While the breach pattern and timing might differ between events the impacts (inundation of Pakowhai) are highly likely to be the same.

Factors that also influence but that are potentially subject to change over time and not able to be predicted with any certainty at the present include the future configuration/ standard of flood defences and bridge crossings (the exacerbating effect that many bridges had on flooding with the ETC Gabrielle event). Clearly it would be desirable for any new bridges to be built to a standard sufficient to allow unimpeded passage of a ETC Gabrielle type event and for that to be done in a manner that complements the Region's flood defences.

The areas identified solely relate to flood hazard and do not include other forms of natural hazard such as land instability, seismic-related hazards (liquefaction/lateral spread) or coastal hazards (inundation and/ or erosion). The mapping does not account for climate change effects – sea level rise and the change in flood frequency relationship for the region's rivers over time – nor future earthquake-related impacts.

A range of data sources have been used to define the Category 2 and Category 3 areas, a key one being the rapid assessment categorisation of impacted properties (dwellings that were either red or yellow stickered - prohibited and restricted access respectively reflecting the levels of impact). The mapping is also informed by:

- ∴ Approximate flood extents for the Tutaekuri and Ngaruroro derived from satellite imagery (taken approximately five days after the event);
- ∴ Stopbank breach information;
- ∴ Contour information derived from LiDAR data collected in November 2020;
- ∴ Aerial photography taken following the event;
- ∴ Information received from the public (information in varying forms has been received by HBRC from more than 70 people).

The assessments are not informed by any specific flood modelling and are based solely on ETC Gabrielle observed/ recorded impacts. While there are some limitations with that approach (impacts specific to that event – the particular temporal and spatial characteristics of ETC Gabrielle) those limitations are substantially outweighed by the advantages of basing the assessment on an actual extreme event (the inherent limitations associated with solely theoretical/ model-based assessments).

The ETC Gabrielle event will almost certainly lead to a comprehensive review of approaches to flood protection and protection standards for impacted communities, work that will inevitably be involved, complex and time-consuming. The demand for certainty in a timely fashion from those impacted is understandably high, posing a very difficult challenge in determining whether the issues so graphically highlighted with Gabrielle are resolvable or not well in advance of that more detailed technical work, requiring further value judgement.

Lastly it is important to note the particular flood risk exposure that the Pakowhai area has. Flood risk, as with any risk, is the product of probability and consequence. The stopbanks protecting Pakowhai are assigned are 1% AEP containment standard (notwithstanding any subsequent changes attributable to the inclusion of the ETC Gabrielle event in the dataset). That is, they are able to contain events up to and equal to a 100 year Return Period event - events larger than that will overtop the stopbanks.

As noted previously, Pakowhai has exposure to two inundation sources – the Tutaekuri and Ngaruroro rivers. Although the catchments of these rivers adjoin they also have different characteristics and accordingly respond differently to particular weather events, meaning that the actual level of exposure for Pakowhai is greater than a 1%AEP. That is, a weather event could, for example, generate a 150 year Return Period flood in one river and an 80 year Return Period flood in the other. Accordingly flood risk from each is correlated, but not fully dependent, and therefore the risk is at least partly additive, making Pakowhai's risk profile fundamentally different to other locations.

4.0 Categorisation Framework Applied

Categorisation follows the criteria outlined in Appendix A.

What constitutes an acceptable level of residual risk in a flood context is inherently very complex and subjective, a function of those risk to life factors identified earlier and the nature of any flood defences. With the latter specifically the reliability/ robustness of any flood defences, their gross protection standard and their ability to cater for events that exceed that design standard.

Value judgements are inevitably applied based on generally accepted 'norms' that relate to both flood protection standards and residual risk in a national context – what constitutes an acceptable level of flood risk in a broad sense. That's generally accepted as a 100 year Return Period/ 1% Annual Exceedance Probability protection standard but that's equally a far from complete definition of what's acceptable/ tolerable in regard to residual risk.

There are, for a multitude of reasons (affordability being one – Wairoa being a prime example in northern Hawkes Bay where the town has a high level of exposure to flooding and no flood defences), many exceptions to that and a wide spectrum of protection standards exist around the country, one of many reasons why flood protection resists 'codification' at a national level.

Judgements around what constitutes an acceptable level of risk/ residual risk (where flood defences exist) in a flood hazard context is further complicated by the fact that what constitutes a 1% AEP event is constantly changing as river flow records continue to lengthen with time, without accounting for either climate change effects or natural processes that cause protection standards to vary over time. Protection standards for Hawkes Bay's major river systems will alter with

ETC Gabrielle added to the flow record – by how much is the subject of a separate piece of technical work currently underway.

5.0 Revised Pakowhai Hazard Categorisation

Pakowhai is a unique feature of the Heretaunga Flood Protection Scheme and one that poses significant risk to life in a flood event that exceeds the capacity of the protection system. Assigning a Category 3 status to the area is clearly appropriate – inevitably the discussion/ debate rests on where the line is most appropriately drawn to define the western extent.

The preliminary mapping contained in the June 2023 report was based on a 3m (reduced level with mean sea level as the datum) contour line, where the flood level was generally well over roof height, with the revised mapping based on an RL of 5m. The analysis of the ETC Gabrielle event shows little water surface slope within Pakowhai, not unexpected given the ‘bath tub’ characteristics of the area, making ground contour a good proxy for hazard (notwithstanding fluctuations in house floor levels). That’s borne out by the interrogation of the rapid assessment database as part of defining the hazard area – recorded inundation depths but most importantly the photographs taken.

Note that assigning a 2C status to the area west of the Category 3 area allows full consideration of the mitigation options available for that area.

As part of the land categorisation process all impacted communities were offered the opportunity to request a change and corroborate their request by sharing their comments, videos and photos. Hastings District Council and Hawkes Bay Regional Council provided a number of avenues for those affected to have their say. This has included face to face engagements, online surveys, emails and phone conversations.

- ✦ Staff were invited to and participated in community led meetings on 10 March, 29 March and 7 June.
- ✦ 7 June site visit to Pakowhai and meeting with an Allen Road resident.
- ✦ HDC led community engagement meeting on 22 June and 15 August.
- ✦ Four drop-in sessions led by HDC held 21 Jun, 28 Jun, 5 Jul, 12 Jul.
- ✦ Facebook live for Pakowhai residents on 9 August
- ✦ Considered/ reviewed over 109 Land Categorisation change requests including supplied information (comments, viewing associated video footage and photo evidence).

Assessing what is tolerable in a flood inundation context is a complex area. Factors (in no particular order) include the level of understanding (in general and specific to an event), likely demographics relating to the population at risk, availability of safe egress, maximum depth, velocity, rate of rise and the volume of entrained debris. The time of the event is particularly important (night vs day) – during summer an event is more likely to coincide with daylight hours.

Clearly the stopbank comprises a significant portion of the outer perimeter of the area and those delineations have not changed from the June 2023 version of the Pakowhai Category 3 area. The revised mapping (the 5m contour as the basis for that mapping) had the Category 3 extending north of Allen Road and snapping to a section of State Highway 2 in the vicinity of the Links Road roundabout. The confirmed boundary for the north-western corner is brought back to Allen Road and does not extend west of Pakowhai Road, based on both site discussions with a group of Allen Road residents and revisiting the rapid assessment database.

The adjustments are relatively small for much of the western boundary, snapping to property boundaries immediately east of Pakowhai Road and crossing Brookfield Road mid-way between Gilligan and Pakowhai Road. The southern end of Pakowhai Road is lower-lying the section further north and that combined with the cluster of red stickered properties at that end (homes damaged by the ETC Gabrielle event) sees the boundary (as it did with the revised RL 5m mapping) crossing Pakowhai Road about 1km away from the Ngaruroro stopbank. The boundary across Hodgson Road has been moved a small distance east, in part based on discussions with affected residents.

As a final note, easily the most challenging part of the mapping has been how much weighting to assign to the views of property owners affected. As expected with a population, perceptions relating to hazard as well as the age, mobility and degree of initiative varies between individuals and households, and some are understandably very connected to their property – their tūrangawaewae. Inevitably properties are bought and sold – those who reside in the future may have a quite different outlook and degree of independence – the mapping represents a balance between a purely technical assessment and the many conversations with those impacted.

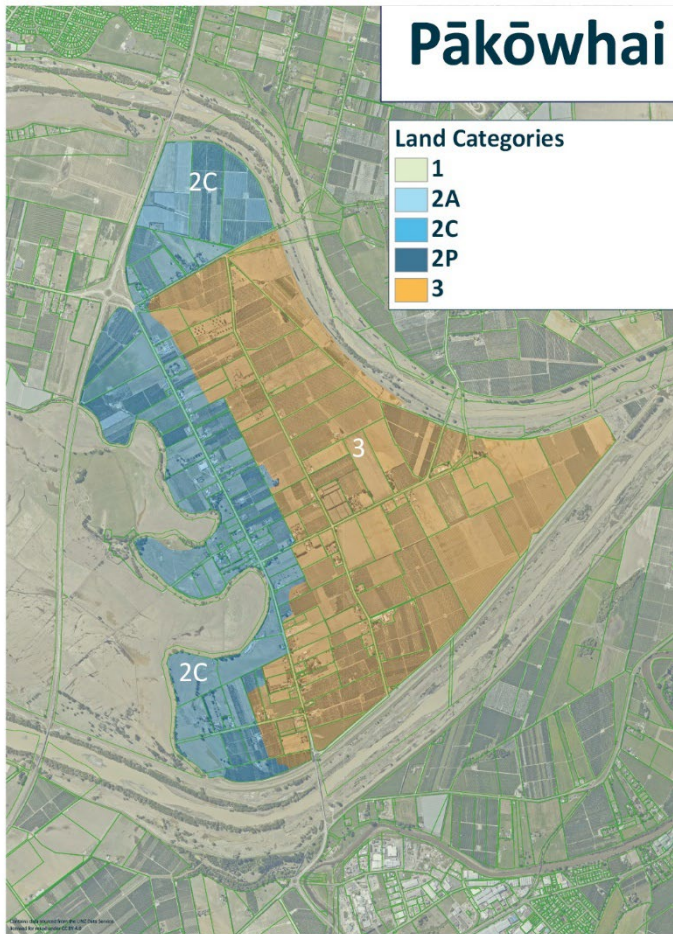


Figure 2 Confirmed Land Categorisation Map for Pakowhai

6.0 Mitigation Approaches

A number of suggestions as to possible mitigation approaches have been made during the community engagement process. Discussions associated with the 7 June site visit included drain maintenance but there was general understanding among those present that maintenance standards associated with Pakowhai's network of drains would have no impact on the events that unfolded in February.

Suggestion has been made regarding the benefit that some form of flood water storage could be located on Chesterhope Station (the unoccupied southwestern part of the Pakowhai area). The area would require very high embankments along the eastern edge to achieve any meaningful storage volume requiring high engineering design/ construction standards to address the associated risks/ dam safety considerations (it would be a high PIC – Potential Impact Classification – dam). This is likely to have a very significant price tag associated with it.

Options have also been proposed for low-level stopbanking on Chesterhope Station to take overflows from the Tutaekuri and Ngaruroro Rivers. Initial investigation into such options indicated that at times when significant flows are occurring from either river, the outlet from the Tutaekuri-Waimate overflow will also be impeded due to high river levels, causing backflow into the Chesterhope area and consequently high floodwater levels in the storage area. This will reduce the effectiveness of the storage area, and if only low level inner stopbanks exist, these will quickly become overwhelmed if the inflow is significant. This option does have some benefit in dealing with low to moderate overflow, and this level of intervention needs to be investigated more thoroughly as part of the scheme review.

The concept of an overflow channel alongside the Ngaruroro left stopbank through Chesterhope Station and further downstream to the Tutaekuri confluence has also been suggested. Connecting the main breach locations at/ immediately east of Fernhill to the Ngaruroro/ Tutaekuri confluence would require almost 14km of new stopbanking and the acquisition of almost 700 hectares of land, roughly the same area as the Category 3 area proposed in this report.

Another suggestion involves some form of modification of the junction of the Tutaekuri and Ngaruroro stopbanks. That includes having reduced height or a gap in the stopbanks to allow floodwater to exit or some sort of gate structure that allows water to exist but not enter Pakowhai.

Clearly the risks with reduced height or no stopbanking at the confluence are inundation back into Pakowhai with smaller, more frequent flood events, in particular in combination with high tide/ storm surge. While they may limit the depth of flooding seen with ETC Gabrielle many of the impacts on Pakowhai are likely to be similar in scale (the sea level recorder at Napier Port recorded 6m wave heights during ETC Gabrielle shortly before it was destroyed).

Gates of sufficient dimension to allow the full protection standard to be retained and floodwater to be released from the Pakowhai area would be a significant, Moutoa gate type structure. It would have a cost likely in excess of \$30M factoring in required height/ capacity, ground conditions and coastal environment and would have a benefit that would only be marginal.

A variant proposed is to extend both the Tutaekuri right and Ngaruroro left stopbank to the coast providing an exit for floodwater impounded in the Pakowhai area. This has numerous challenges – foundation conditions, the presence of the road and rail bridges, the height of the sea during ETC and would not be a practical or cost-effective remedy.

Table 1 Summary of Suggested Mitigation Approaches for Pakowhai			
Option Description	Benefits	Limitations	Status
Improve Drain Maintenance.	Drainage improvements during low level rainfall events.	Does not improve flood conditions since drains only carry a fraction of the flood flows. Likewise, the drainage pumpstation is sized for land drainage purposes. To size the PS for flood water is cost prohibitive.	A new Pakowhai Drainage Pumpstation will be constructed.
Large Flood water storage on Chesterhope Station.	Inundates open pasture instead of horticulture and housing.	Initial and ongoing cost is high, risk of additional failure of storage system. Storage system would be classified as high PIC dam. Extensive regulatory requirements.	Initial modelling indicated not a viable mitigation approach.
Low to Moderate Flood water storage on Chesterhope Station	Directs low volume overflows away from vulnerable areas	Only deals with moderate river overflows, which are not likely to cause severe impacts	Can be investigated as part of scheme review.
Overflow channel left bank Ngaruroro form Fernhill to Pakowhai.	Controls overflow on left bank to confined linear area.	Approximately 14 km of stopbank required, cost and land required is extensive. Similar area of land flooded as Category 3 lower Pakowhai.	Initial modelling indicated not a viable mitigation approach.

Table 1 Summary of Suggested Mitigation Approaches for Pakowhai			
Option Description	Benefits	Limitations	Status
Modify outflow from Pakowhai by reducing height or create gap in stopbank at confluence of Tutaekuri/Ngaruroro.	Allows water to flow out of Pakowhai at a lower level, thus preventing flooding above the outlet level in the event of a major breach.	Risk of flooding from rivers back into Pakowhai is more probable, since stopbank height needs to be consistent to be effective. Low level gap would be counterproductive and possibly allow storm surge into Pakowhai.	Discounted as doesn't address core risk.
Construct Control Gate for outflow from Pakowhai at confluence of Tutaekuri/Ngaruroro.	Allows full protection standard to be retained and gates operated to release water from Pakowhai at appropriate times and rates.	Doesn't prevent inundation of Pakowhai. A gate would only allow managed discharge once Pakowhai was flooded. Gates are ineffective if river level is higher than water level in Pakowhai. Cost of gates is excessively high.	Discounted as doesn't address core risk.
Separate Ngaruroro and Tutaekuri Rivers and create new opening for Pakowhai.	Creates independent outlets reducing the risk that high river levels will impede outlet flow from Pakowhai.	Past river management decisions (i.e. 1930's to 1960's) considered a single Tutaekuri/ Ngaruroro mouth an essential component of flood mitigation as separate mouths would be more prone to closure due to wave action and gravel movement. Maintaining 3 mouths (i.e. Ngaruroro, Pakowhai, Tutaekuri) would be very unlikely to be successful, since there would be no constant flow from Pakowhai to maintain an open mouth. An additional opening through the area with the rail and road crossings would also require modifications to those bridges. There is no conceivable space for an additional Pakowhai outlet.	Discounted on cost, consenting risk and acquisition of additional land.

Appendix A: HBRC Land Categorisation Methodology

Hawke's Bay Regional Council



Hawke's Bay Regional Council's Land Categorisation Process and Framework following Cyclone Gabrielle






September 2023

Prepared by:	Hawkes Bay Regional Council
Date:	11 September 2023
Version	V1 FINAL

The purpose of this report is to outline how the Hawke’s Bay Regional Council (HBRC) applied the Government’s Future of Severely Affected Land Risk Categorisation Framework.

BACKGROUND OF LAND CATEGORISATION

1. On 1 May 2023, the Government released its initial risk categories and associated definitions to guide local authorities’ decision making in respect of the risk categorisation of affected properties. These categories and definitions do not have a specific statutory basis.
2. The Government’s three risk categories were to be applied to flood and landslide affected properties in areas impacted by Cyclone Gabrielle and January floods across the North Island. The Government’s three categories were:
 - a. Low Risk – Repair to previous state is all that is required to manage future severe weather event risk. This means that once any flood protection near the property is repaired, the home can be rebuilt at the same site.
 - b. Managed Risk – Community or property-level interventions will manage future severe weather event risk. This could include the raising of nearby stop banks, improving drainage or raising the property.
 - c. High Risk – Areas in the high risk category are not safe to live in because of the unacceptable risk of future flooding and loss of life. Homes in these areas should not be rebuilt on their current sites.
3. The descriptions of the categories are as follows:

Category	1 	2P 	2C 	2A 	3 
Description	Repair to previous state is all that is required to manage future severe weather risk event.	Property level interventions are needed to manage future severe weather event risk, possibly in tandem with community level interventions	Community level interventions are needed for managing future severe weather risk events.	Significant further assessment is required to assess a property, as well as engagement with property owner.	Future severe weather event risk cannot be sufficiently mitigated. Some land uses may remain acceptable, while intolerable risk of inquiry or death for residential land use.
Actions	Flood damage to repair, but no need for community interventions.	Property specific measures are necessary, for example improved drainage, raising houses. Benefits accrue to property owners.	Local government could repair and enhance flood protection schemes to adequately manage the risk of future flooding events. Cost is shared by the community.	Interventions may be required or possible, but insufficient information to answer all questions. These may subsequently move between “2” categories or to categories 1 or 3.	In the face of enhanced climate risk to the property there is unacceptable risk of future flooding. This will involve combined local and central government assistance.

4. The Government has been clear that categorisation of properties (and the articulation of the technical metrics that are used to determine whether risk is “intolerable”) is the responsibility of local government.
5. Staff have developed a process and technical framework to assess risk to affected residential properties in the Hawke’s Bay region, which were primarily impacted by flooding during the Cyclone Gabrielle event. This is generally limited to impacts at a community scale rather than impacts to discrete / individual residential properties. Where the future risk to residential properties from flooding is intolerably high and where that risk cannot be sufficiently mitigated, those properties will be identified as “Category 3”.
6. Individual vulnerability to flood hazard is highly variable and context dependent, being a function of factors that reflect the specific characteristics of the areas, properties, and people exposed to flood hazard. The outcome of a risk assessment considers risks that are tolerable or acceptable, and takes into account the community’s social, cultural, environmental and economic situation. This makes the quantitative estimation of risk to life from flooding at a property level complex. Whether risks can be mitigated through viable and cost-effective property or community level interventions is a further complex consideration.
7. It is important to note that in the Hawke’s Bay region the affected areas for the purpose of categorisation relate solely to flood hazards arising from Cyclone Gabrielle, and do not include other forms of natural hazard

such as land instability, seismic related hazards (liquefaction/lateral spread) or coastal hazards (inundation and/or erosion). This is because flooding was the only known cause of community scale impacts in the Hawke’s Bay region, following Cyclone Gabrielle.

8. Additionally, the process and technical framework does not account for climate change effects such as sea level rise and the change in flood frequency relationship for the region’s rivers over time, nor future earthquake-related impacts.

NEGOTIATED FUNDING OUTCOMES

9. An integrated package of funding has been negotiated by Hawke’s Bay Councils and the Government to support recovery from Cyclone Gabrielle. HBRC sought Government funding specifically for contributions to repair, restore and construct flood protection measures.
10. On 2 August 2023, HBRC accepted the Government’s offer of \$203.5 million towards flood mitigation and approved an additional \$44.15 million of debt to fund its cost-share portion. The combined funding is based on community interventions to move properties out of Category 2 to Category 1, thus limiting the number of properties that might otherwise become Category 3. The funding package also includes other region-wide projects such as repairs and upgrades to telemetry.
11. The proposed distribution of funding for impacted communities is as follows:

Funding for flood mitigation measures*		
Wairoa (100% Crown Funded)	Potential flood mitigation measures for areas in the vicinity of Wairoa and Frasertown (2A).	\$ 70,000,000
Hastings and Central Hawkes Bay (Costs shared between Crown and HBRC)	Potential flood mitigation measures for areas in the vicinity of: <ul style="list-style-type: none"> ○ Havelock North (2C) ○ Omahu (2A) ○ Pakowhai (2C) ○ Porangahau (2A) ○ Tongoio (2A) ○ Waiohiki (2C) ○ Whirinaki (2A) 	\$109,650,000
General Works		
	Provision for additional work to rapid repair sites following technical review	\$30,000,000
	Telemetry network repairs and upgrade	\$5,000,000
	Drainage pump station repairs/upgrades required	\$30,000,000
	Scheme reviews - to reconfigure & build resilience	\$3,000,000
	Total	\$247,650,000

*These figures represent the best estimate of potential protection works required for areas in Category 2 to move to Category 1. It is noted that, following full technical assessment (particularly in relation to Category 2A), flood mitigation may not be feasible in all Category 2 areas. In such cases, affected properties will be recategorised to Category 3.

12. The availability of funding for flood mitigation works has informed the land categorisation process, in particular the application of Category 2. However, should initial investigation and design work highlight that specific proposed flood mitigations cannot be delivered, these properties will likely be recategorised to Category 3. It is envisaged that should this occur, HBRC will enter into negotiations with the Crown with a view that unused funding from the Crown for flood mitigation measures will be reallocated to the relevant territorial authority for the purpose of Category 3 buy-outs.
13. At the time of negotiations with the Government, the costings for flood mitigation measures were based on high level estimates of possible solutions to mitigate flood risk in identified areas.

DEVELOPMENT OF TECHNICAL RISK ASSESSMENT

14. Following the direction from Government, HBRC commenced work to develop a categorisation approach that satisfied the principles the Government had articulated. This approach was required for the Hawke's Bay Region to be eligible for the Government's funding contribution. HBRC's land categorisation methodology is detailed in the next section below.
15. Developing the methodology in a principled and equitable manner, whilst limiting Council's financial and legal exposure has been complex. This was compounded by the need to move at pace to meet the timeframes set by Government, including those relating to negotiations for funding contributions, and to limit as much as possible the negative social impacts on communities brought on by flood damage and the uncertainty of the land categorisation framework.
16. The over-arching consideration when determining categorisation has been whether there is an intolerable risk to life from flooding. This is a technical question that has been considered by technical experts alone. While the categorisation process is underway, work will continue to ensure the methodology and technical frameworks are appropriate and that the categorisation process is evidence-based and robust.
17. From the outset, HBRC amended the Government's risk categories and definitions to make them applicable to the Hawke's Bay context following Cyclone Gabrielle. The assessment of "managing future severe weather risks" was refined to "mitigating future flood risk from design events".
18. An additional Category 2C* was defined which enabled HBRC to move a number of communities to Category 1 at pace to avoid the prolonged uncertainty of sitting in Category 2. For Category 2C*, future flood risk is capable of being sufficiently mitigated because of existing flood infrastructure in the area that could be repaired and restored by "HBRC Rapid Repair" teams.
19. It is critical to note that being in Category 1 does not mean there is no risk to life, or that there was no impact from Cyclone Gabrielle. For the purpose of this process, Category 1 has been applied to properties where there is no intolerable risk to life.

Technical assessment

20. The considerations required for a risk to life assessment were detailed by Pattle Delamore Partners in their report from June 2023. Pattle Delamore Partners stated that risk to life for future events on the scale of Cyclone Gabrielle can be articulated in general terms but was difficult to codify. There is little national guidance in this space with the NZS9401 Managing Flood Risk – A Process Standard being the primary guiding document.
21. Assessments will involve consideration of:
 1. Damage assessment: an assessment of flood levels and damage sustained during the Cyclone Gabrielle event.
 2. Assessment of Flood Danger and Flood Damage Risk as a combination of:
 - a. Event likelihood (in terms of the probability of an event of a given magnitude being equalled or exceeded within a year – the Annual Exceedance Probability, or AEP);
 - b. Hazard (the level of risk to life by flooding);
 - c. Exposure (what is exposed to flood hazard in a given place); and
 - d. Vulnerability (propensity to suffer adverse effects of flooding, based on individual characteristics and external factors).
 3. These factors are complex, interrelated and are taken into account to inform categorisations.
22. All decision making throughout the land categorisation process has been informed by the available expert advice and applied standard industry concepts and processes as detailed in the Pattle Delamore reports. In all of the above we considered evidence from the event and from site visits in addition to other information

submitted by affected residents. The risk to life assessment used in Hawke’s Bay is detailed further in the methodology below.

Quality assurance

23. HBRC commissioned Pattle Delamore Partners to independently review and assure its provisional mapping. Site visits to all Category 3 locations were completed in order to validate the provisional mapping.
24. The Cyclone Gabrielle Recovery Taskforce Secretariat engaged Tonkin & Taylor Ltd to provide a high-level assurance review of the process followed by HBRC and Pattle Delamore Partners. Tonkin & Taylor considered that the preliminary risk categorisation process used was technically valid and appropriate given the constraints of the available information and the need for timely decision making and community engagement.
25. Tonkin & Taylor specifically noted that the process used to identify Category 2 and 3 areas relied heavily on expert judgement applied by HBRC and Pattle Delamore Partners. The process was informed by observations of the flood damage that occurred during the event with some input from territorial authorities. They considered this was a suitable approach for the initial assessment, and for very high-risk situations where Category 3 is clearly appropriate. It was acknowledged that more detailed technical assessment would be required to confirm the feasibility and levels of service for community and property-level interventions and to resolve cases on the borders between Category 2 and 3.
26. While the categorisation process is underway, the detailed technical assessment will continue to be worked through for each categorised area by teams of technical experts. Areas are recategorised as soon as possible following completion of technical assessments.
27. Pattle Delamore Partners will provide a final peer review of decision making and a quality assurance report with recommendations to the HBRC Chief Executive to inform completion of the technical risk assessment.

LAND CATEGORISATION METHODOLOGY

1. Identification of Impacted Areas

METHODOLOGY	PATHWAY
In determining areas that will be subject to the land categorisation process, a technical expert will consider the following question:	No – Area not included in provisional categorisation process.
1. Is the area impacted by flooding caused by Cyclone Gabrielle at a community scale?	Yes – Area included in provisional categorisation process.

2. Provisional Categorisation

METHODOLOGY	PATHWAY
In determining provisional categorisation, a technical expert will consider the following questions:	Category 1 - Repair to previous state is all that is required to mitigate risk to life from flooding.
1. Is there an intolerable risk to life from flooding?	Note: Category 1 does not mean there is no risk, or that there was no impact from Cyclone Gabrielle, but that there is no intolerable risk to life.
The risk to life assessment, as detailed by Pattle Delamore Partners, considers the following factors: <ul style="list-style-type: none"> - The maximum depth and rate of rise of floodwater; - How swift or otherwise the flood water was; - How quickly a river rises and overtops its banks and/or flood management system (how much warning those living close to a river might have that a flood is imminent) 	Category 2C* - Repairs to existing flood scheme assets are effective in

<ul style="list-style-type: none"> - How accessible safe egress is for residents of affected areas; - The volume of silt and debris entrained in the floodwater; - Particular geographic features that exacerbate the hazard eg valley confinement; - How apparent the hazard is to those potentially impacted. That encompasses understanding / awareness of the hazard (which will inevitably decline with time following Cyclone Gabrielle) but also whether the connect between the flood source and where people live is clear (whether their level of exposure is obvious or not); - The complexity of the flood hazard. <p>2. Are mitigations available to sufficiently reduce the risk to life from flooding so the area or property can be reinhabited. This includes through:</p> <ol style="list-style-type: none"> a) Repairs to flood scheme assets? b) Community level interventions? c) Property level interventions? <p>3. Is significant further assessment required to determine the risk to life?</p>	<p>mitigating future flood risk from design events.</p> <hr/> <p>Category 2C – Additional community level interventions are effective in mitigating future flood risk from design events.</p> <hr/> <p>Category 2P - Property level interventions are needed to mitigate future flood risk, including in tandem with community level interventions.</p> <hr/> <p>Category 2A - Significant further assessment required before category determined.</p> <hr/> <p>Category 3 - Future flood risk cannot be sufficiently mitigated.</p>
--	--

3. Refinement of Categorisation Mapping

METHODOLOGY	PATHWAY
<p>Provisional mapping will be refined to address alignment of the provisional mapping boundaries for properties around the border of categorised areas.</p> <p>The further detailed assessment will take into consideration the following factors:</p> <ul style="list-style-type: none"> - Topographical features; - Known level of damage; - Property boundaries; and - How accessible safe egress is for potentially impacted residents. <p>Refinement to the boundary of categorised areas will occur where the further detailed assessment reveals issues with the alignment of the provisional mapping boundaries.</p>	<p>Refinement of categorised boundaries.</p>

4. Recategorisation of Category 2s

METHODOLOGY	PATHWAY
<p>Category 2C*</p> <p>Future flood risk can be mitigated by reinstating existing flood infrastructure to pre-Cyclone Gabrielle standards and levels of service utilising similar construction techniques and design to the original. The reinstatement of flood infrastructure must reduce risk to life to a tolerable level.</p> <p>Category 2C* areas will be recategorised to Category 1 following these steps:</p> <ol style="list-style-type: none"> 1. Asset has been reinstated to the original standard prior to Cyclone Gabrielle of 1% AEP. 2. Materials selection has been overseen by dedicated geotechnical engineers. 3. Compaction testing has been undertaken by nuclear densometer given real time results with compaction results required to be met prior to proceeding with the next layer of construction. 4. Quality assurance commenced by independent experts. <p>Note: An AEP (annual exceedance probability) of 1% for a given flood level means there is a 1% chance of having a flood exceed that level in any one year.</p>	<p>Release to Category 1.</p>

<p>Category 2C</p> <p>Additional community level interventions will be implemented to mitigate future flood risk from design events. These will be considered where there are no adequate existing flood protections.</p> <p>The intervention must contribute to reducing risk to life to a tolerable level for a community and will take into consideration the following factors:</p> <ul style="list-style-type: none"> - Land use; - Practicality and feasibility; - Favourable cost / benefit analysis; - Overall cost; - Funding availability; and - Consenting risks. <p>Subject to confirmation of this pathway, Category 2C's will be released to Category 1 when the following conditions are met:</p> <ul style="list-style-type: none"> - A sound concept that has a consenting pathway; and - A legal interest in favour of HBRC in the relevant land; and - Available funding. 	<p>Intention is to release to Category 1 but if viable solution is not found then area may be moved to Category 3.</p>
<p>Category 2P</p> <p>Additional property level interventions will be implemented in order to mitigate future flood risk.</p> <p>The intervention must contribute to reducing risk to life to a tolerable level for a residential property owner and will take into consideration the following factors:</p> <ul style="list-style-type: none"> - Practicality and feasibility; - Safe egress; - Favourable cost / benefit analysis; - Overall cost; - Funding availability; and - Consenting issues. <p>Subject to confirmation of this pathway, Category 2P's will be reclassified to Category 1 when appropriate property level interventions have been completed to the satisfaction of the building consent authority or other relevant authority.</p>	<p>Intention is to release to Category 1 but if viable solution is not found then area may be moved to Category 3.</p>
<p>Category 2A</p> <p>Significant further assessment is required before categorisation can be determined.</p> <p>The process for further assessment will involve:</p> <ol style="list-style-type: none"> 1. The appointment of independent experts to conduct a review of potential community and/or property level interventions that can mitigate risk; 2. Engagement with the community, facilitated by HBRC and the relevant territorial authority, on potential solutions; and 3. Consideration of community feedback by technical experts; and 4. Experts will then make recommendations to HBRC on future mitigation works, and final categorisation of properties. <p>Based on the outcome of the further assessments, HBRC will determine whether reclassification to Category 2C or 2P, with a view to moving to Category 1 is appropriate. If not, then Category 3 will be applied as an intolerable risk to life cannot be mitigated.</p>	<p>Significant further assessment required before category determined.</p>

5. Reassessment Process

METHODOLOGY	PATHWAY
<p>All requests for reassessment from landowners and territorial authorities will be considered while the categorisation is provisional, and where relevant new information is provided.</p> <p>Any reassessment will be undertaken by a technical expert, and may involve the following steps and considerations:</p> <ol style="list-style-type: none"> 1. Review the desktop assessment to determine if there are any errors, or other justification for reconsidering the categorisation. 2. Decide whether further information is required for an additional technical review. 3. Consult with additional experts where further detailed assessment is required. 4. Arrange a site visit where required. 5. Factors that may be considered at the point of reassessment are: <ol style="list-style-type: none"> a. Topographical features; b. Observed level of damage; c. Property boundaries; and d. How accessible safe egress is for potentially impacted residents. 6. Reassessment recommendation internally peer viewed by HBRC, with a recommendation provided to HBRC Chief Executive for decision. 7. The HBRC Chief Executive may seek further technical advice or information as required before making a final decision. 	<p>Re-categorisation where appropriate.</p>

6. Completion of Risk Assessment

METHODOLOGY	PATHWAY
<p>The land categorisation process will be completed following:</p> <ol style="list-style-type: none"> 1. Notification to affected landowners of the intent to close the land categorisation process; 2. A public meeting will occur for each Category 3 community; 3. A period of two weeks will be provided for final feedback; 4. Feedback will be considered and assessed by technical experts, including any requests for reassessment; 5. Pattle Delmore Partners will provide a final peer review and quality assurance report with recommendations to the HBRC Chief Executive. 	<p>HBRC will release completed land categorisation maps to the Government and territorial authorities to inform future processes.</p>
<p>HBRC Chief Executive will direct the release of the land categorisations to the Government and territorial authorities. HBRC will only consider further changes to land categorisations after this point in the event that new compelling information is presented that was not previously available to the technical experts.</p>	
<p>HBRC will publicly release:</p> <ul style="list-style-type: none"> - Pattle Delmore Partners provisional categorisation report; - Pattle Delmore Partners supplementary land categorisation report; - Tonkin + Taylor land categorisation process assurance report; - Land categorisation methodology; and - Land categorisation process mapping. 	