

Flood Risk Categorisation, Ex-Tropical Cyclone Gabrielle Impacted Areas

• Prepared for

Hawkes Bay Regional Council

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Executive Summary

Over the course of 13 and 14 February 2023 parts of the Hawkes Bay Region (the 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.

A key consideration with this event are the location of the residential properties that were most impacted – those where the risk to life in future events is likely to be equally high.

Risk to life with future events on the scale of ETC Gabrielle can be articulated in general terms but is difficult to codify. There is little national guidance in this space – the Ministry for the Environment (MfE) did undertake some work in the mid 2000's, culminating in the release of NZS9401 in 2008 (Managing Flood Risk – A Process Standard). The nature of that document and it's relatively sparse use since it's release are testament to the challenges in codifying flood hazard.

The fundamental consideration for this assessment is the risk to life and that in turn is a function of a range of factors well-illustrated by ETC Gabrielle. They include flood depth and rate of rise, and silt and debris loads, reflected in the ability inhabitants have to quickly and easily access safe egress. Clearly the greater the peril the greater the need for clear, fast and safe egress.

This is a complex area and ideally needs to be underpinned by a substantive body of technical work over a period of years. However circumstance has very much driven process – the understandable need those impacted have to be able to get on with their lives. To meet that need the maps contained in this report are, necessarily, an amalgam of applied value judgements based on the set of contextual factors outlined in the report and informed by a range of different datasets and are provisional. Engagement with those affected is an essential component of this process – ensuring the maps accurately capture what took place during ETC Gabrielle but also to better understand those impacts at an individual property level.

The datasets that inform the mapping were largely captured immediately after the event - the rapid assessment work ('sticking') of those habitable properties impacted, stopbank breach locations and aerial photos that graphically illustrate the impacts of the event. Other inputs include the remote-sensing work undertaken by the University of Canterbury both to derive flood extents and to estimate silt depths in the Esk Valley. It also includes a general evaluation of the context/ terrain of each area, both in a desktop context and with sites visits/ discussion with residents.

Some areas clearly lend themselves, by any reasonable definition, to being a high risk for habitation; scale/ extent of impacts, the shape of the whenua, the ease with which an individual or a household could become isolated and whether history suggests a pattern (acknowledging the scale of ETC Gabrielle). In the case of the Esk Valley the hazard is also clearly compounded by uplift associated with the 1931 earthquake.

Much of the initial data collation and mapping has been undertaken by Hawkes Bay Regional Council (HBRC) staff, the local knowledge and expertise in some cases extending back many decades. PDP have assisted with the refinement and verification/ critiquing of those areas and their categorisation as defined by central government. Some uncertainty remains for many Category 2 areas – the further technical work required to determine whether a collective or individual mitigation approach best suits each circumstance. Those decisions will inevitably come back to funding – addressing the hazard highlighted by ETC Gabrielle will in many cases require significant investment.

There are likely to be extreme difficulties associated with determining how large (by way of an assigned return period or recurrence interval) ETC Gabrielle was at a catchment/ sub-catchment level. Flood frequency relationships are based on statistical analysis of recorded datasets but the loss of recorders during ETC Gabrielle and the difficulties associated with capturing ‘horizontal’ rain makes such assessments challenging.

Most problematically recorded datasets are short relative to the timescales accorded to extreme weather events – extrapolation is required and that will in some cases be significant with a correspondingly large margin of uncertainty. The time elapsed since the devastating 1938 floods perhaps provides as good a guide as any to the likely frequency of such events.

The north and east of Te Ika-a-Māui is clearly vulnerable to ex-Tropical Cyclones and climate change effects would appear to be manifest with ETC Gabrielle. For example, extreme sea surface temperatures persisted in the Tasman Sea during the most recent El Nino Southern Oscillation phase (the recent La Nina event), presumably allowing ETC Gabrielle to sustain more intensity than might otherwise have been the case.

The assessment work concludes that the risks to the inhabitants of the Aropaoanui, Tangoio and Esk valley floors, Rissington and the lower Pakowhai area is simply too great with no feasible form of mitigation. That includes the addition of a cluster of houses along Dartmoor Road beside the Tutaekuri River approximately 3km west of Puketapu, a particular pinch point in the valley with a concentrated hazard and seemingly with little chance of being able to mitigate, in extreme events, that hazard.

Outside of those extreme risk to life areas, there are some obvious priorities for investment - Wairoa with the extent of impact and well-documented level of exposure would seem to be a high priority. It would also seem timely to re-evaluate the performance/ configuration/ protection standards afforded by both the Heretaunga and Upper Tukituki Schemes. With the latter just under 300 properties were impacted in Waipawa – consideration in the wake of ETC Gabrielle as to whether current protection standards meet the communities’ needs.

This assessment has a focus related to the more extreme end of flood risk in Hawkes Bay graphically illustrated with ETC Gabrielle. It’s focussed just on that hazard and isn’t a complete picture of flood hazard or hazards in general in Hawkes Bay. There are a number of areas particularly adjacent to the Tutaekuri River where houses are not currently present and where further development will clearly add to the hazard – the importance of using available land use planning tools, now more than ever, to avoid adding to that risk in the future.

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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. That resulted in flooding of parts of Wairoa and catastrophic damage to the Esk Valley - the University of Canterbury estimates that more than 2.7M tonnes of sediment was deposited in just the lower 5km of the valley - and adjoining catchments. Further south the event resulted in multiple breaches to flood defences along the lower reaches of the Tutaekuri and Ngaruroro Rivers along with impacts to the Central Hawkes Bay communities of Waipawa and Porongahau.

Return period estimates at an individual catchment level for those rivers impacted are still being made but are likely to prove problematic in many cases, complicating any assessment of risk for those areas impacted. That is, the statistical basis for determining the frequency/ expected interval with which the impacts associated with ETC Gabrielle could be expected to be repeated or exceeded at an individual catchment level in the future.

The ETC Gabrielle event is particularly relevant as a basis for a risk assessment - the intensity of the event but importantly it's relatively long duration. A long duration event produces a fully saturated catchment condition increasing the scale/extent of landslips and making riverbank vegetation more vulnerable, adding to both silt and debris loads and placing the impacts at the upper end of the scale. Long duration events also inevitably place more pressure on protection systems - a well designed and constructed stopbank (the available information indicates this is largely the case for Hawkes Bay) can generally withstand shallow, short duration overtopping but not for extended periods.

This report summarises work completed to date on mapping particular/ discrete areas impacted as a result of the ETC Gabrielle weather event. The mapping is preliminary and will evolve further with both more technical work and community engagement. That evolution will relate both to the outline of the areas and the status of the Category 2 areas. The boundary between Categories 2 and 3 in the Pakowhai area in particular will be the subject of further refinement.

What (if any) form future flood hazard mitigation work takes for the Category 2A areas is clearly very difficult to predict at this point in time – whether feasible mitigation options exist, how much they might cost and to some degree the risk appetite the community has (which will have a wide variation at an individual level).

The format adopted for this report (the order in which each of the impacted areas is addressed largely follows a north to south approach, clustered based on Territorial Authority (city and district council) boundary).

The assessment does only relate to flood hazard, only one aspect of a wide array of natural hazards that applies to Aotearoa/ New Zealand. Specifically it does not consider coastal hazards (erosion, inundation) or land instability. The assessment focus is on the issues highlighted by ETC Gabrielle that impact communities rather than at an individual property level.

Note that the definition of a residential property is the occupied areas of primary consented residence generally defined as a house. It doesn't extend to outbuildings or sheds, uninhabited areas like garages, unconsented structures and does not include the footprint of the land – the house on the land is the basis of the analysis.

2.0 Flood Impact Summary

This summary is mainly taken from discussions with HBRC staff but is also informed by site visits and discussions with some residents.

The main impacts for the Wairoa District were to the town of Wairoa and those impacts were in turn mainly confined to the northern part of the town (i.e. North Clyde, the area north of the river). Approximately 500 properties were impacted when the flow in the Wairoa River overtopped its banks, the most concentrated impact in terms of houses flooded. The flood risk relates to the sinuous lower reach of the river as it nears the coast (where the town is located) – the awa looks to 'cut off' a loop in the river just to the northwest of the town when in flood, running through North Clyde as it finds its way back to the river. Without by any means providing a full flood history for the town it has been flood on a number of occasions during the 20th century although Gabrielle appears to be the largest in living memory.

A few properties on the lower-lying margins of Frasertown north of Wairoa (located at the confluence of the Wairoa and Waiau Rivers – the Waiau being a major tributary draining the western part of the catchment) were also flooded during ETC Gabrielle with flooded properties also recorded on Awamate Road and Tiniroto Road Ruakituri. Note that no red stickering took place in Wairoa (no properties were deemed structurally unsafe).

Hastings District undoubtedly bore the brunt of ETC Gabrielle impacts in Hawkes Bay. Those impacts were concentrated on the Tangoio and Esk valleys north of Napier, Rissington and lower Dartmoor, Puketapu, Omarunui and Waiohiki to the west and Pakowhai to the south, with the headwaters of the most affected catchments all not surprisingly largely adjoining (where the rainfall associated with ETC Gabrielle was at its most intense).

Esk Valley impacts were particularly extreme, depositing metres of silt in places and entraining significant volumes of flood debris (trees that slipped into the river and its tributaries and/ or were ripped from river banks). The devastation that wrought to the valley had been well-documented elsewhere and is not repeated in this report. Shaw Road was arguably at the epicentre of those Esk Valley impacts – a visit to Shaw Road noted the marker placed beside the road recording the 1938 flood height, with the flood height of ETC Gabrielle significantly higher.



Figure 1 – 1938 Flood Marker beside Shaw Road, Lower Esk Valley

The impacts to Rissington were in a similar vein, albeit on a slightly smaller, more localised scale than the Esk Valley. Rissington is located beside the Mangaone River, a major tributary of the Tutaekuri River, with a handful of houses severely impacted. A local resident described the flood ‘waves’ that accompanied the event, a domino like effect attributed to a series of debris dams forming (including but not limited to bridge crossings) and breaking,

progressively moving down the river, with the formation of the dam immediately downstream of Rissington literally burying houses almost instantaneously in silt.

The floodwater, silt and debris from the Mangaone entered a presumably already well-in-flood Tutaekuri around 8.5km west of Puketapu. The substantive impacts associated with the Tutaekuri began with the valley floor west of Puketapu –with a notable feature of the floods the concentrating effect that the ridge just west of Moteo had in concentrating/directing flood flow south of the main river channel back north across the river toward Dartmoor Road, to devastating effect. Floodwater exited the Tutaekuri just east of that ridge at Moteo (upstream of Puketapu Bridge on the Tutaekuri, flowing south overland toward the Ngaruroro just north of Omahu.

Tutaekuri impacts continued downstream along the berms/ valley floor before valley confinement ceases at Waiohiki. The bridge at Waiohiki formed yet another dam, leading to some early overtopping into the Waiohiki and then downstream to the Pakowhai area. The prolonged blockage of the bridge resulted in substantial volume of water flowing into, and ponding in the lower Pakowhai area.

Most stopbank breaches were attributed to prolonged overtopping – the inevitable scour and consequent breach – leading to a depth/ extent/ rate of inundation of the Pakowhai area almost without parallel in an Aotearoa/ New Zealand context. The junction of the Tutaekuri and Ngaruroro stopbanks eventually breached releasing the water impounded in the Pakowhai area but by then the damage had already been done.

With the Ngaruroro River, breaching was also extensive, resulting in inundation of the Twyford area and contributing the majority of the water which inundated Pakowhai.

Further south the event exceeded the capacity of the Mangarau detention dam leading to localised flooding of a small part of Havelock North.

It is worth noting the effects on Taradale during ETC Gabrielle – the shallow overtopping of the true left Tutaekuri stopbank that occurred. These banks had recently been fortified and partly raised by HBRC but it is difficult to estimate without more detailed examination how critical that work was to the protection of Taradale during that event.

It seems likely given the scale of the event (peak flows associated with ETC Gabrielle appearing to exceed the stopbanked capacity of the Tutaekuri by a considerable margin) that without the extensive breaching of the stopbanks upstream of Waiohiki (i.e. Moteo, Puketapu and Omarunui), the stopbanks protecting Taradale would have come under much more intense pressure. A significant breach did occur to the true left stopbank on the Waitangi Washout portion of the Tutaekuri River at Awatoto, leading to inundation of the Awatoto/Brookfields and area, with floodwaters seeping into Te Awa, Maraenui and Pirimai.

For the Central Hawkes Bay district ETC Gabrielle presented a still severe but less extreme threat to its communities. Portions of stopbanks protecting Waipawa overtopped and failed during the event, resulting in extensive flooding for the eastern part of the town. Toward the southern margins of the region Porangahau marks the other more concentrated community impact, flooding a number of properties in the town.

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 impacts and that approach is adopted for this assessment. 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 it's 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 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 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. For Hawkes Bay with the ETC Gabrielle event 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 are unique/ specific to that event and likely to have a lower degree of repeatability when an event of a similar size impacts the region (as it will) at some point in the future, an important consideration with any risk assessment. Stopbank breach pattern (plan view) is an example – the breach pattern in a future extreme flood event is likely to look different from that experienced with ETC Gabrielle, for a range of reasons. In other instances a similar event is likely to lead to a similar outcome.

Accordingly the net impact to a place like Pakowhai (where as the scheme is currently configured stopbank breach discharges accumulate) will be similar for future extreme weather events but the impacts at an individual property level further west attributable to discrete breaches will likely look different. That is, houses damaged as a result of the impacts of a discrete stopbank breach during ETC Gabrielle are not necessarily at more risk than other dwellings in close proximity to stopbanks that were not in the path of a stopbank breach during that event.

Equally some areas (eg the lower reach of the Esk, Wairoa) are influenced to some degree by river mouth conditions and those conditions are likely to differ from event to event and not be easily predicted as to likely state at the start/ during the event.

Other factors that influence and that are potentially subject to change over time but not able to be predicted with any certainty at the current point in time include the future configuration/ standard of flood defences and bridge crossings (the exacerbating effect that many bridges had on the flooding). 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 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.

Hazard areas have been defined by HBRC that look to capture the more extreme impacts of ETC Gabrielle. A range of data sources have been used to define those 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.

Understandably HBRC are not able to be definitive that this data captures every issue that arose during ETC Gabrielle – the focus with the mapping is more on impacts at a community scale rather than discrete/ individual property impacts – and in that regard they are not definitive flood maps. In most cases floodwater will have receded quickly with the mapping based on either the residual ponded floodwater and/ or silt left behind identifiable from the available imagery (flood events are inevitably accompanied by dense cloud cover and it can be many days before weather conditions permit a clear view of the ground). By their very definition rapid assessments can contain data gaps although none were identified in the course of this assessment work.

The assessments are not informed by any specific flood modelling although HBRC advise that the Heretaunga Scheme performance during ETC Gabrielle is consistent with that described in the 1999 Flood Hazard Study. Ground truthing for this initial report could best be described as representative and inevitably community engagement will aid refinement.

In a few cases with the desktop assessment it proved difficult to differentiate between purely flood-related impacts and those related to land instability or coastal inundation (some overlap occurred during ETC Gabrielle). Inevitably those hazard types in particular areas do begin to merge in an event like ETC Gabrielle but ultimately those matter were not material to the mapping.

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 (the substantive changes in land elevation and flood hazard that accompanied the 1931 earthquake).

It is important to note that the mechanisms that accompanied the worst impacts of ETC Gabrielle for Hawkes Bay are not unique to this event. The 1957 publication *Floods in New Zealand 1920 to 1953* includes a detailed account of flooding in Hawkes Bay as far back as 1867, including the 1938 floods.

Two flood occurred in 1938 – one in February and one in April. The February event focussed more on Tairāwhiti and resulted in the deaths of 21 people at Kopuawhara near Mahia Peninsula (the Kopuawhara disaster) – described as a flash flood (a 5m high “wall of water”). The April event impacted Hawkes Bay, causing catastrophic damage to the Esk Valley in particular.

4.0 Categorisation Framework Applied to ETC Gabrielle

Categorisation follows criteria prescribed as follows:

Table 1 Categorisation Definitions as defined by Central Government		
	Description	Examples
1	Repair to previous state is all that is required to manage future flood risk	<i>Minor flood damage to repair but no need for significant redesign/retrofitting. Private insurance is sufficient but uninsured may face hardship</i>
2C	Community level interventions are effective in managing future flood risk	<i>Local government repairs and enhanced flood protection schemes to adequately manage the risk of future flooding events in the face of climate change effects.</i>
2P	Property level interventions are needed to manage future flood risk, including in tandem with community level interventions	<i>Property specific measures such as improved drainage and raising houses is necessary. Benefits accrue to property owners but some may face affordability issues.</i>
2A	Potential to fall within 2C / 2P but significant further assessment required	<i>Interventions may be required / possible but insufficient information to provide initial categorisation (these may subsequently move between "2" categories or to 1 / 3).</i>
3	Future flood risk cannot be sufficiently mitigated. In some cases some current land uses may remain acceptable, while for others there is an unacceptable risk of injury or death.	<i>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.</i>

What constitutes an acceptable level of residual risk in a flood context is inherently very complex, a function of those risk to life factors identified earlier and the nature of any flood defences. Specifically the reliability/ robustness of any flood defences, their gross protection standard and their ability to cater for events that exceed that design standard. Particular types of flood defence (detention or flood dams such as those behind Havelock North) have a finite containment volume, making them vulnerable to long-duration events.

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 (ie what's safe and what's not). That's generally accepted as a 100 year Return Period/ 1% Annual Exceedance Probability protection standard but that's equally (for the reasons identified above) far from a complete definition of safe.

There are for a multitude of reasons (affordability being one – Wairoa being a prime example in northern Hawkes Bay where the town has 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 a 1% AEP 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 degrade 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.

The areas subject to assessment and their respective categorisation referencing Table 1 are summarised below in Section 5. The focus with the mapping is understandably on those areas viewed as matching the descriptions associated with categories 2 or 3 - the balance of the flood-affected area that does not lie within these categories are either category 1 or not specifically assessed/ considered, based on the information supplied to/ obtained and collated by HBRC.

5.0 Hazard Categorisation and Mitigation Options

This section of the report provides context to the categorisations made at a community level based on the impacts associated with ETC Gabrielle.

It is worth noting that while no ‘league tables’ exist for protection standards/ levels of exposure for urban areas across the country (a function of the great difficulty that exists in comparing ‘apples with apples’) Hawkes Bay (with the exception of Wairoa) compares well to other regions in that regard. That may well be out of necessity given the added level of exposure the Region has to ex-tropical cyclones.

As noted earlier ETC Gabrielle will lead to flood frequency relationships being updated and that in turn may change the protection standards assigned to different parts of Heretaunga and Upper Tukituki Schemes. The extreme nature of the flood event in the Tutaekuri River (where defences were overwhelmed by a considerable margin) may see a correspondingly large reduction – National Institute of Water and Atmospheric Research (NIWA) staff are currently undertaking that analysis. HBRC are committed to a 100 year protection standard and accordingly once stopbank repairs are effected areas identified as 2C will be dropped back to Category 1.

In summary the risk assessments made in this report that involve existing protection systems that were overwhelmed are made in advance of the revised flood frequency analysis – they assume an unchanged protection standard.

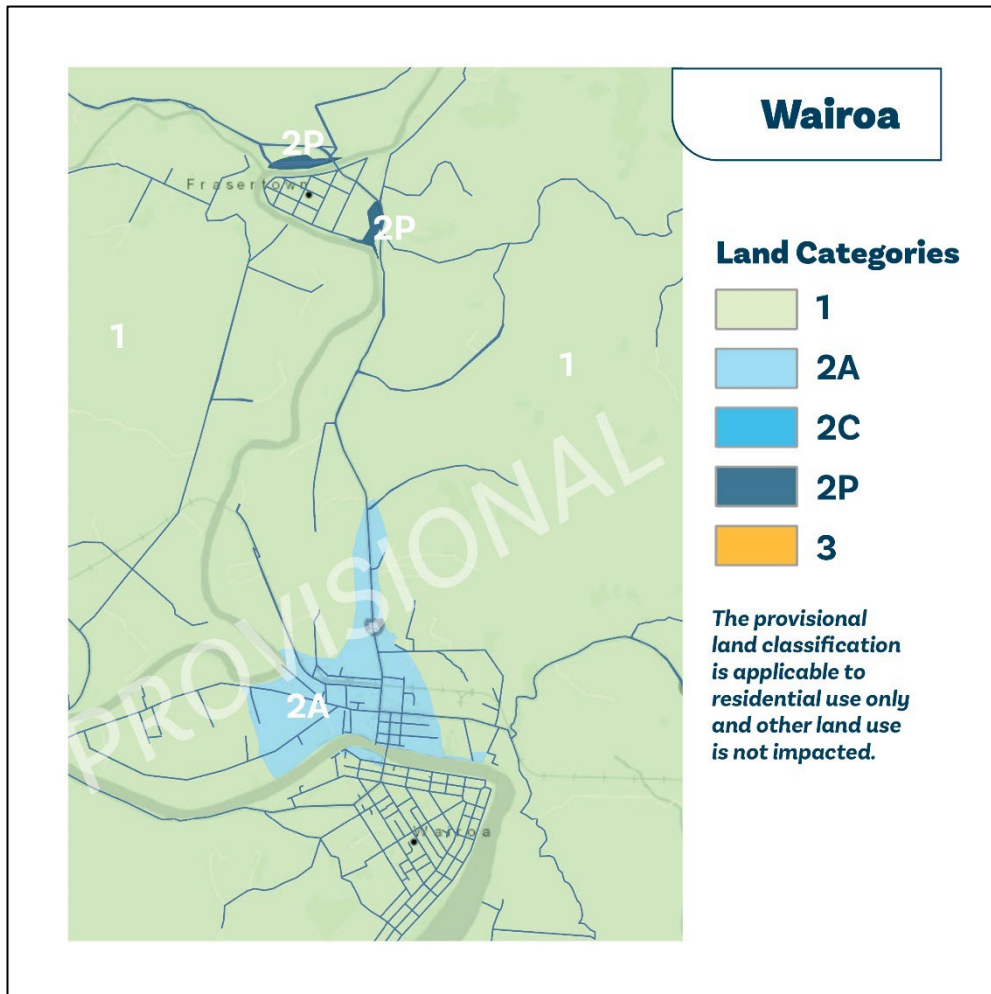
There are a number of rapid assessment ‘clusters’ that don’t appear in the maps below. Those include a part of Taradale (attributable to shallow overtopping of the Tutaekuri left stopbank during the event – any stopbank damage will be repaired reinstating protection for the town) and Haumoana (thought to be mainly attributable to storm surge that accompanied the ETC Gabrielle event). A small second (in addition to the Mangarau Stream issues specifically noted in the following maps) cluster was recorded in Havelock North, attributed to local stormwater network issues outside of the scope of this report.

5.1 Wairoa District

The focus for the Wairoa District was on the towns of Wairoa and Frasertown, with the primary inundation source the Wairoa River. The risk to life is assessed as low but that is not to say that flooding hasn’t/ does not cause considerable financial impact and hardship to the town. Wairoa has a relatively high level of exposure to flooding when considered in a national context and is clearly a priority focus.

Although not the subject of exhaustive review with the preparation of this report HBRC and it’s predecessor Catchment Board have considered flood protection options for Wairoa in the past, focussing on the formation of secondary flow paths and/ or stopbanking to protect the town. Wairoa is assigned a 2A status to permit a full range of mitigation approaches to be explored.

The map also captures localised inundation on the margins of Frasertown, which is generally consider to have a lower level of exposure to flooding (more elevated) than Wairoa. For those handful of properties a collective approach to flood mitigation is likely to be more expensive than an individual approach (2P). The remainder of the ‘stickered’ properties in the Wairoa District are considered to be Category 1.



5.2 Hastings District

Hastings District was most impacted by ETC Gabrielle – Esk Valley, Rissington, Pakowhai – and contains all of the Category 3 areas identified in the Region. HBRC’s Heretaunga Scheme is at the core of flood protection for the district and region, and much of the affected property categorisation rests to varying degrees on whether (and at what cost) some of the issues illustrated by ETC Gabrielle can be addressed.

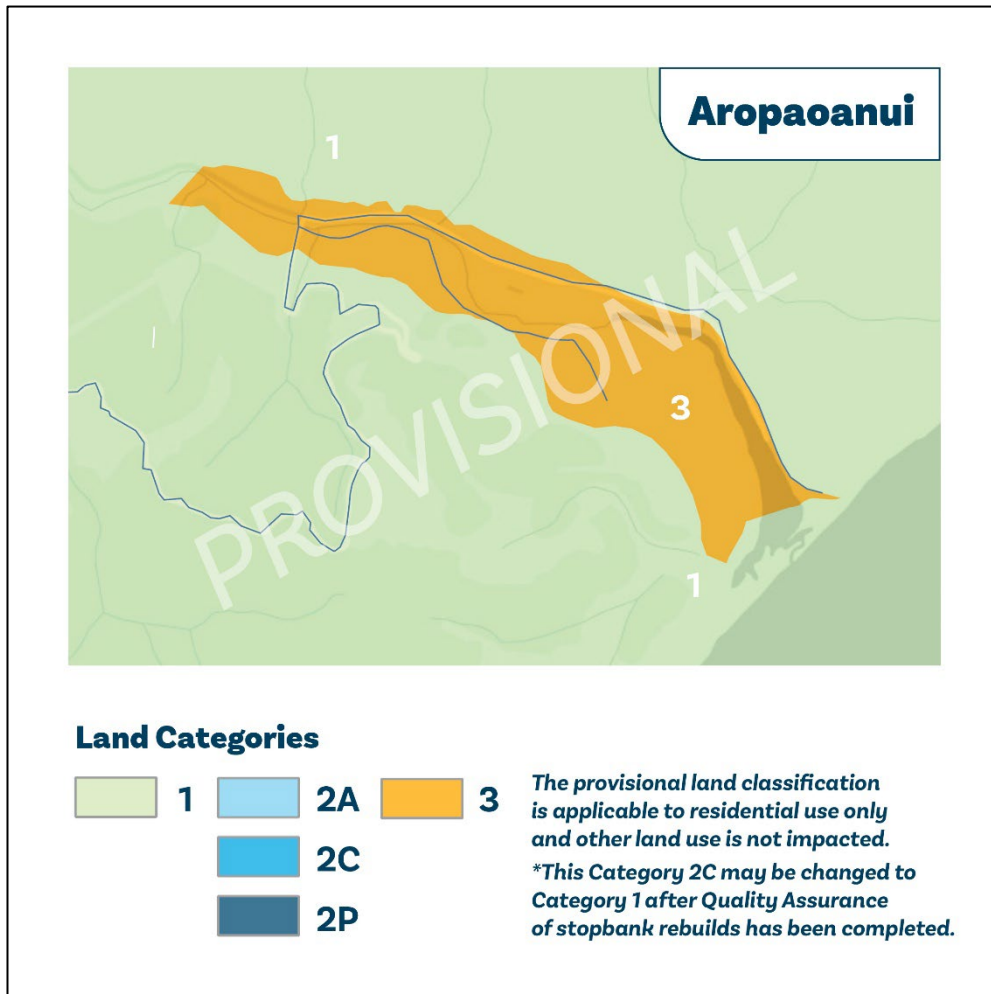
Most of the category 3 areas (all except Pakowhai) are characterised by confined valley floors with high silt and debris loads unsuited to any feasible form of mitigation (without significant expense and high residual risk). The flood mechanism described by a Rissington resident (debris dams working their way down the Mangaone) is of particular cause for concern and something that historic records (Floods in NZ 1920 – 1957) suggest is more common than generally perceived (an extreme flood inevitably presents as a flash flood).

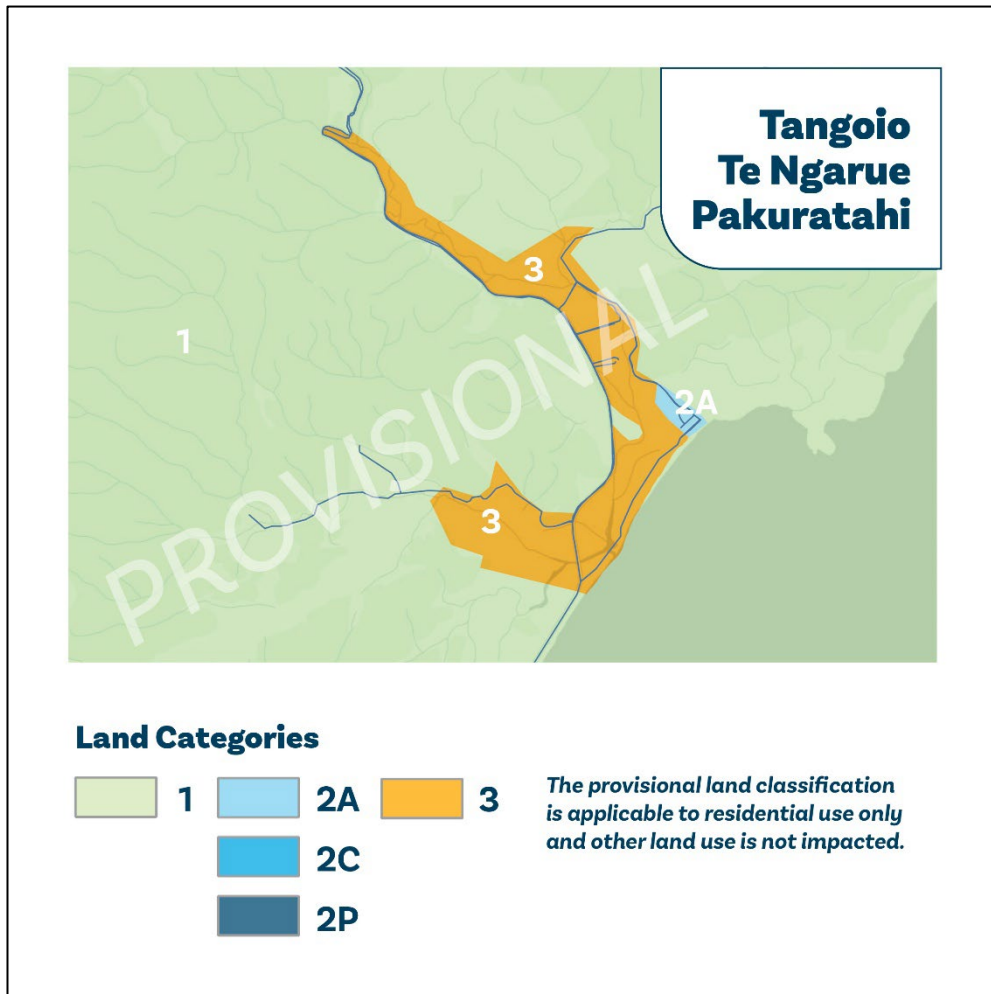
It should be noted that the impacts along the lower reaches of the Tutaekuri and Ngaruroro Rivers do not appear to relate the quality of the stopbanking. Work undertaken in the wake of the event looking at stopbank failures concludes that the stopbank network was well constructed and maintained – it was inevitable given the scale and duration of the ETC Gabrielle event that stopbank breaches would occur.

5.2.1 Aropaoanui and Tangoio

The Aropaoanui and Tangoio valleys are located north-east of the Esk Valley and sit around 9.5km apart - they are very similar in nature and sparsely populated. Both were severely impacted with ETC Gabrielle and the risk, particularly for the few houses that sit closer to the valley centres, is sufficiently high that they've been assigned Category 3 status.

The exception is the recent development at Tangoio Beach – some effort was applied with this development to set floor levels high but those levels were not high enough to avoid flooding with ETC Gabrielle. Safe egress exists as does some scope for measures to protect those properties from future flooding and accordingly the area has been assigned 2A status.



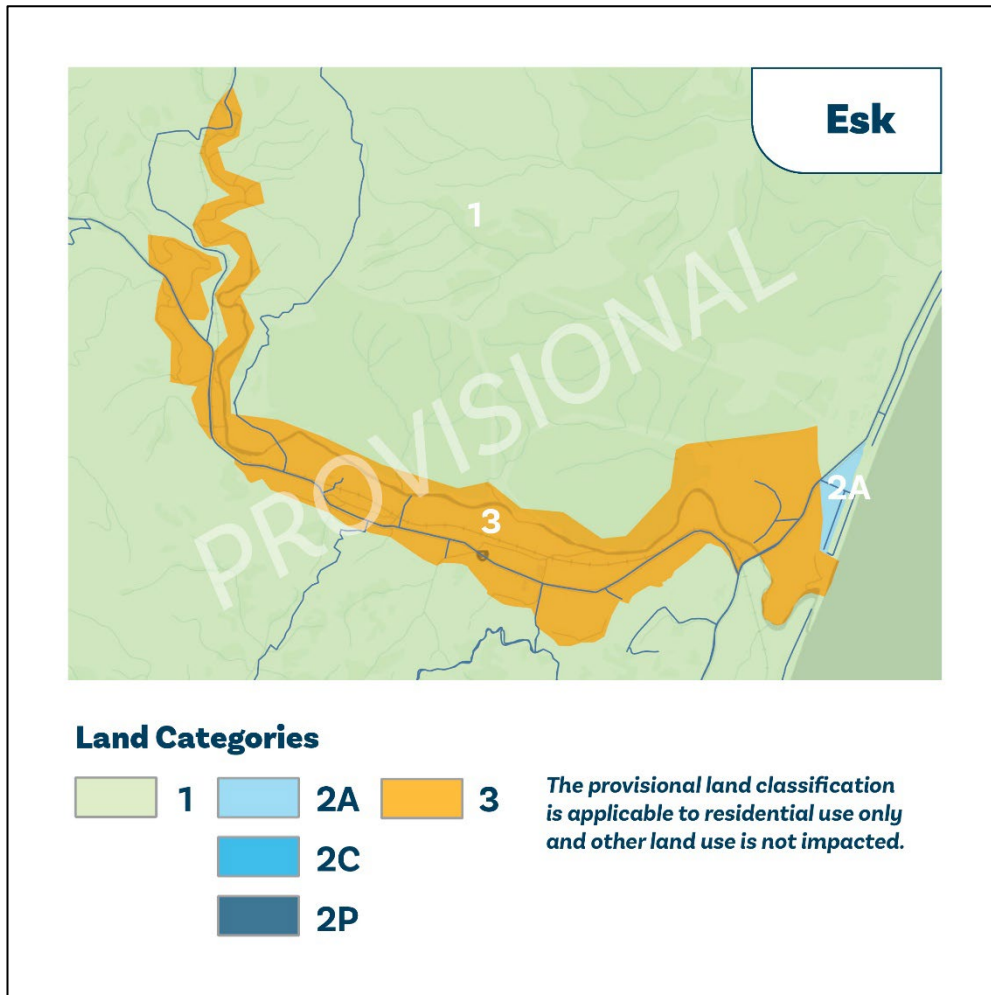


5.2.2 Esk Valley

The floor of the Esk Valley was severely impacted with ETC Gabrielle. As noted earlier there is precedent albeit on a slightly lesser scale (although silt deposition makes it difficult to compare flood magnitudes with any particular precision) with the 1938 floods. The much-publicised impacts of ETC Gabrielle (including houses being shifted several hundred metres down valley) make the Esk Valley floor a clear Category 3 candidate.

The project team did discuss whether the margins of the valley and in particular houses located at the base of the adjoining hills (in some cases flooded/floodable but seemingly with safe egress) should be assigned Category 2 rather than Category 3 status. It is noted that (albeit as a very long-term trend) with successive floods silt deposition will be concentrated more in the centre of the valley, possibly making the margins more hazardous over time (again acknowledging the very long timescales).

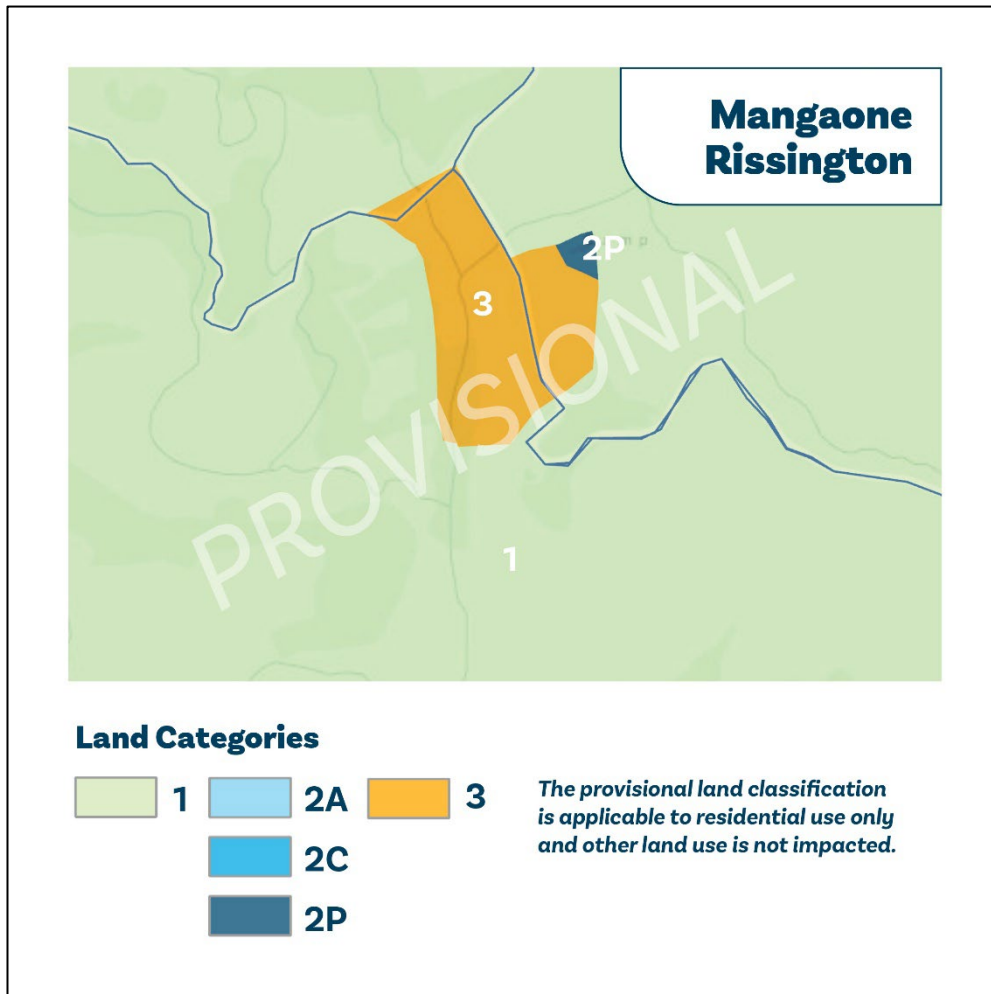
The exception to Category 3 is Pohutukawa Drive – scope for mitigation to reduce the risk to an acceptable level potentially in parallel with the wider Whirinaki Resilience project (2A).



5.2.3 Mangaone @ Rissington

Rissington is located beside the lower reaches of the Mangaone River – the Mangaone catchment borders the Esk and accordingly was severely impacted by ETC Gabrielle. All of the factors identified in Section 3 apply to Rissington – it is a hazard on an extreme scale and a clear risk to life exists for those not well-elevated, reflected in the high proportion of red stickers.

Site visit and discussion with a resident confirmed some of the desk-top conclusions related to Omatua Lodge – located somewhat in the lee of a ridge with relatively modest inundation/ impacts with ETC Gabrielle and scope for easy/ safe egress in the event of the flood (the hillside behind the lodge). For that reason the Lodge is separated from the rest of Rissington as Category 2P.

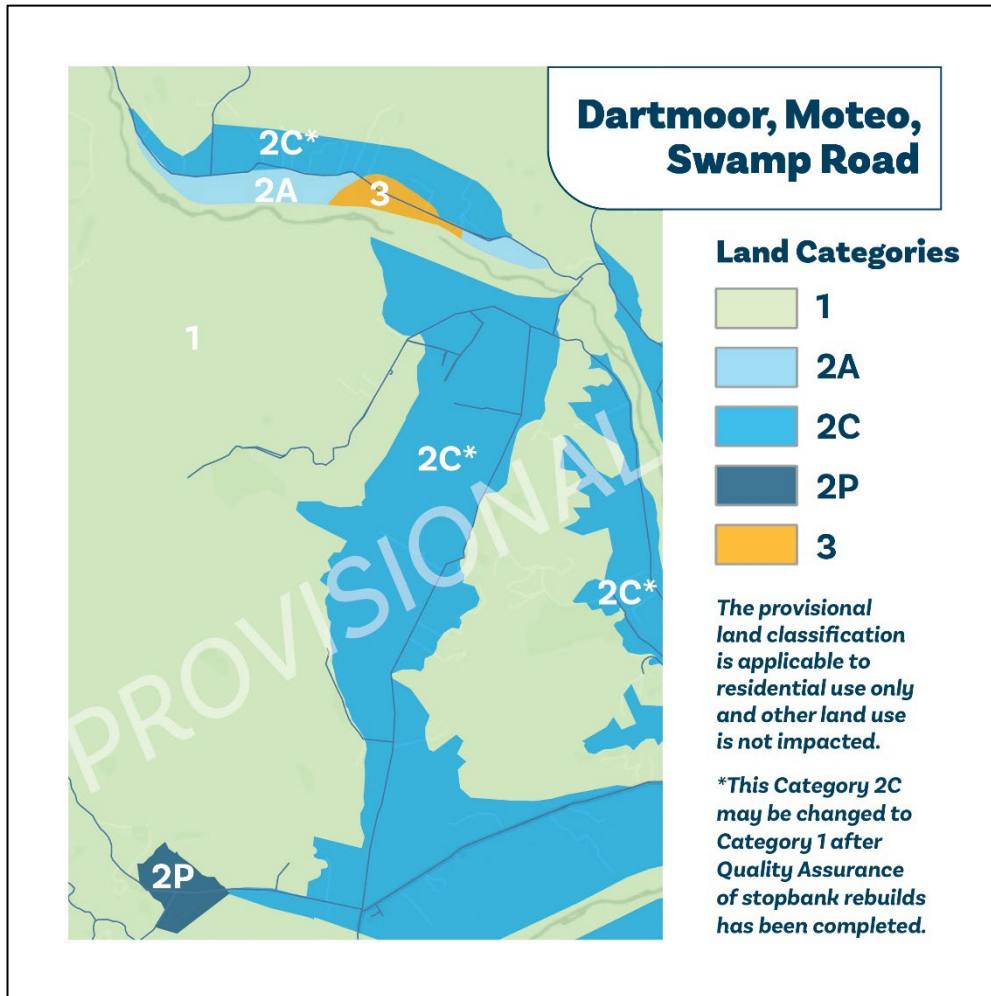


5.2.4 Dartmoor, Moteo and Swamp Road

This area begins to touch on existing flood protection infrastructure and accordingly introduces the 2C category – either reinstating the existing protection system damaged during the event and/ or increasing protection standards sufficiently addresses the flood risk.

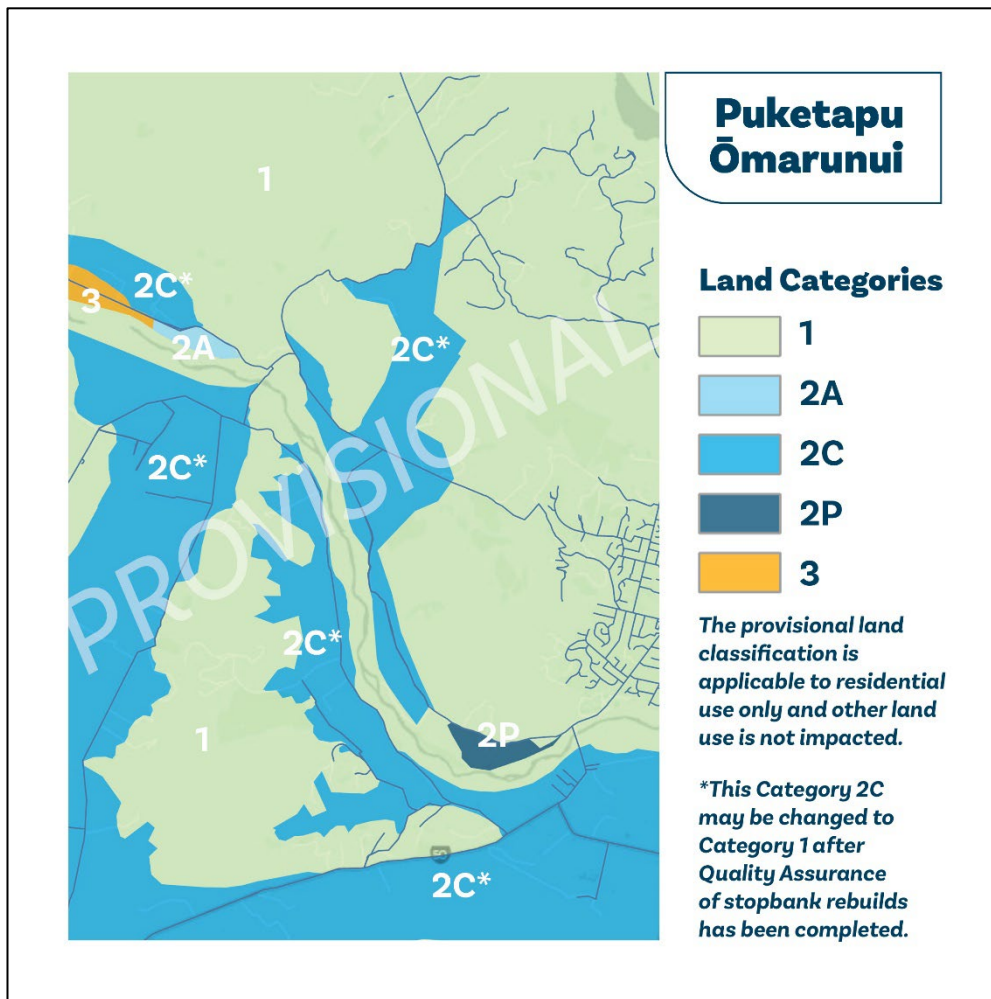
The most notable part of this area is the Category 3 assignment to the part of the valley floor approximately 2.5km west of Puketapu – as described earlier this area sustained particularly concentrated impacts during ETC Gabrielle, a function of the event and the ridge near Moteo that projects toward the river concentrating/ directing flood flows. The impacts evident on the aerial photo are matched on the ground with certainty of being repeated in the future due to the topography and scepticism that it can be mitigated against.

Swamp Road to the south clearly follows a corridor between the Tutaekuri and Ngaruroro Rivers that the river has occupied in flood in the past, adding to the complexity of the floodwater interactions and impacts to the Pakowhai area downstream.



5.2.5 Puketapu, Omarunui

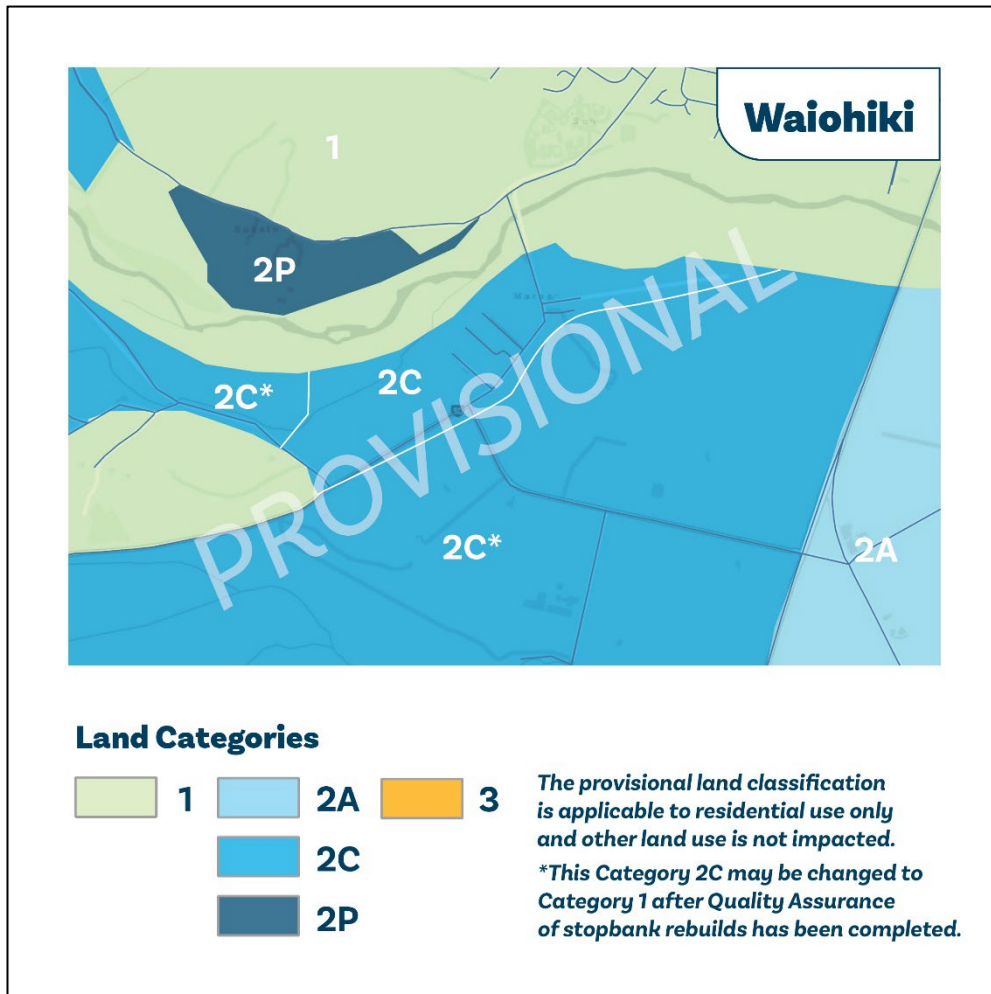
These impacts relate to the Tutaekuri River where existing flood defences were overwhelmed with ETC Gabrielle. Parts of the true (facing downstream) right berm at Omarunui have some similarities with the Dartmoor Category 3 area but on balance fall short of constituting an unacceptable risk to life. The valley floor defines the extents of the Category 2 areas.



5.2.6 Waohiki

Waiohiki marks the start of the true right stopbanking protecting Pakowhai - the more elevated parts are not protected but the lower-lying parts are. As was common with the ETC Gabrielle event the bridge collected debris and aided some of the floodwater breakout at this point. It's categorised as 2C, transitioning to Category 1 once flood defences are repaired.

The small 2P area on the north side of the river is not protected by existing flood defences.



5.2.7 Pakowhai

Pakowhai lies between the Ngaruroro and Tutaekuri stopbanks and its eastern end is defined by the convergence of those stopbanks. Those structures are close to 6m high - with no floodwater release mechanism discharge from the numerous stopbank breaches along the true left of the Ngaruroro and true right of the Tutaekuri (estimated to total at its peak close to 1,000 m³/s) led to rapid filling of the area. Eventual breaching of the stopbank at the junction released the ponded floodwater.

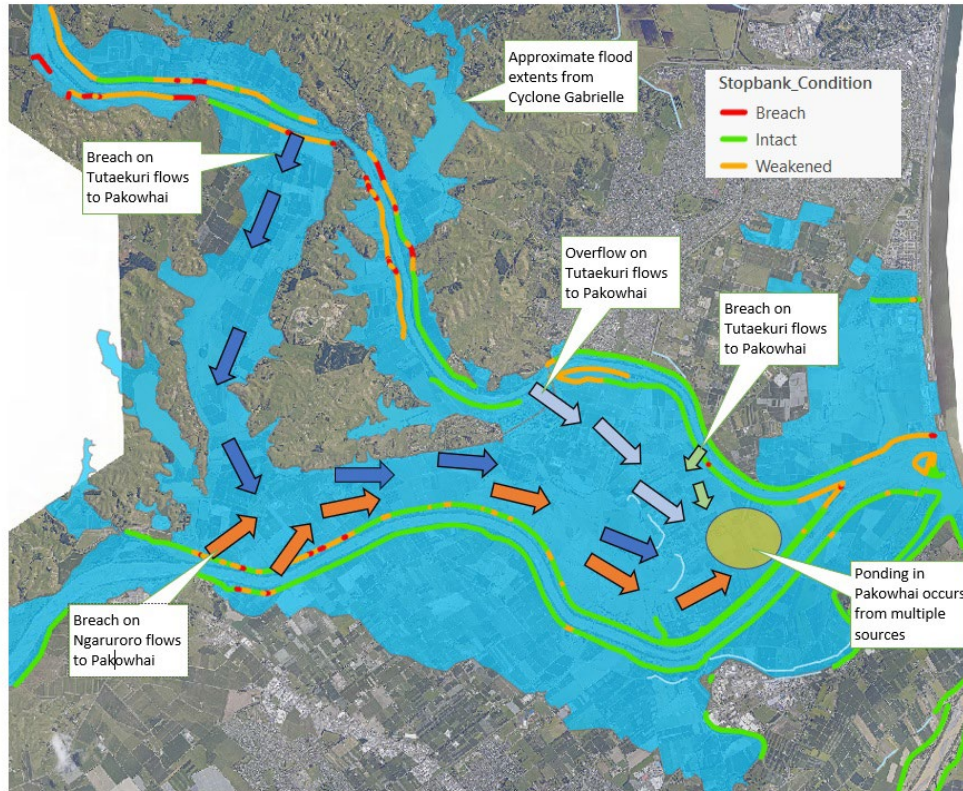
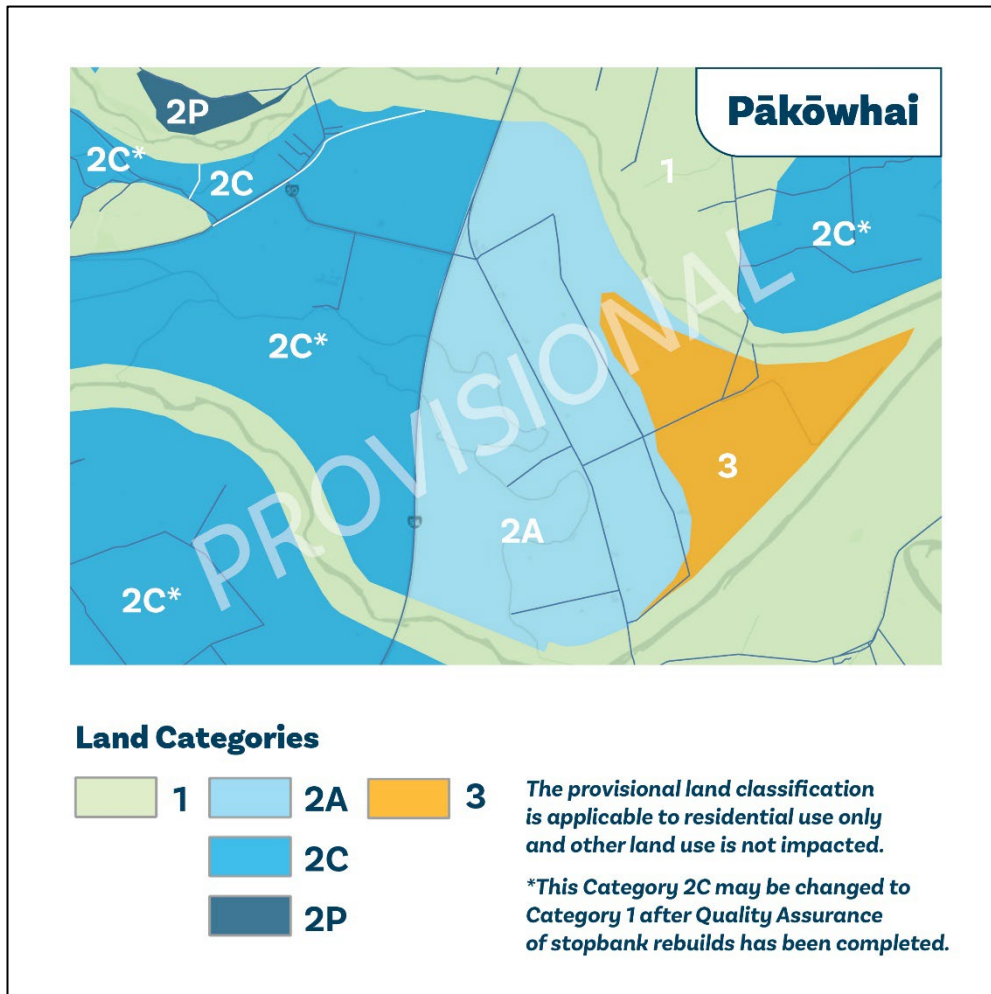


Figure 2 – Flow pattern into the Pakowhai area. Green lines are stopbanks, red segments stopbank breaches and orange segments damaged/ partly compromised sections of stopbank.

As noted earlier Pakowhai is a unique feature of the Heretaunga 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.

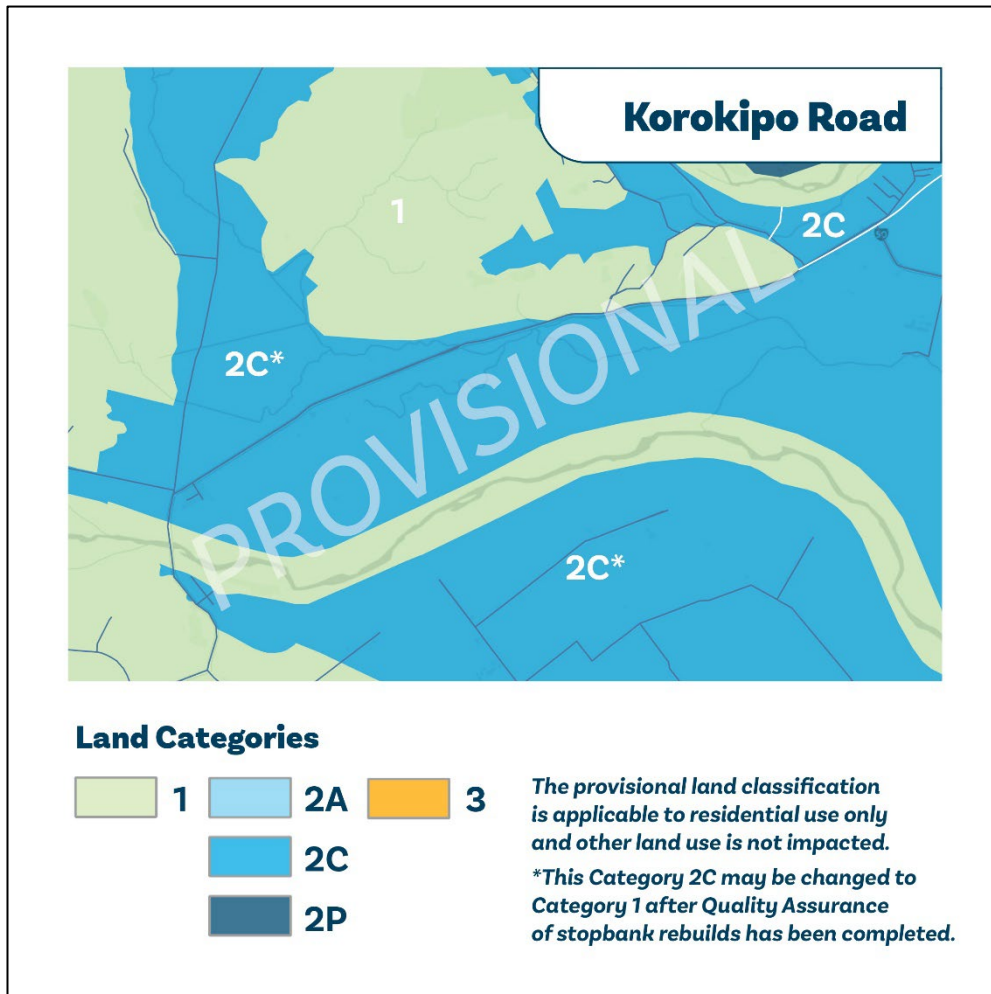
Less clear is determining where the boundary between Category 3 and the category to the west should lie. Preliminary mapping is based on a 3m (mean sea level datum) contour line, where the flood level was generally well over roof height. With that as a benchmark adopting a 4m contour line (Category 3 boundary more or less in line with Gilligan Road/ Gilbertson Road) puts inundation in rough terms below roof peaks and a 5m contour (takes the boundary close to Pakowhai Road) places flood levels more or less at the tops of windows/ close to roof eaves.

Assigning a 2A status to the area west of the Category 3 area allows full consideration of the mitigation options available - that work may also enable a better, more precise definition between the two areas.



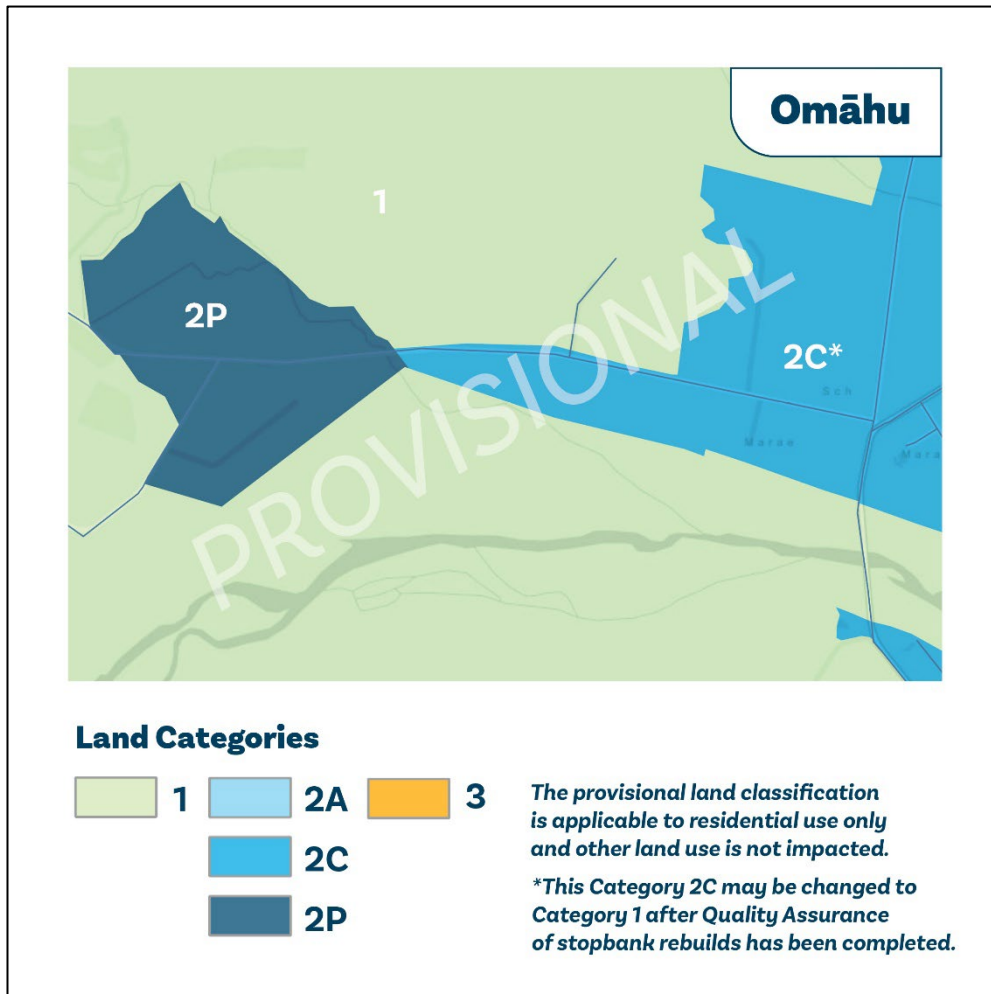
5.2.8 Korokipo Road

In the ETC Gabrielle event the Korokipo Road area became a corridor for flow that had exited the Tutaekuri River via Swamp Road (the blue arrows that run from north to south in Figure 2) and from the adjoining Ngaruroro true left stopbank breaches, running overland into the Pakowhai area. It contained a number of yellow stickered and a few red stickered properties. This has been assigned 2C status – the risk is determined as acceptable once the stopbank breaches (including those related to the Tutaekuri) are repaired ie the area is likely to transition to a Category 1 status.



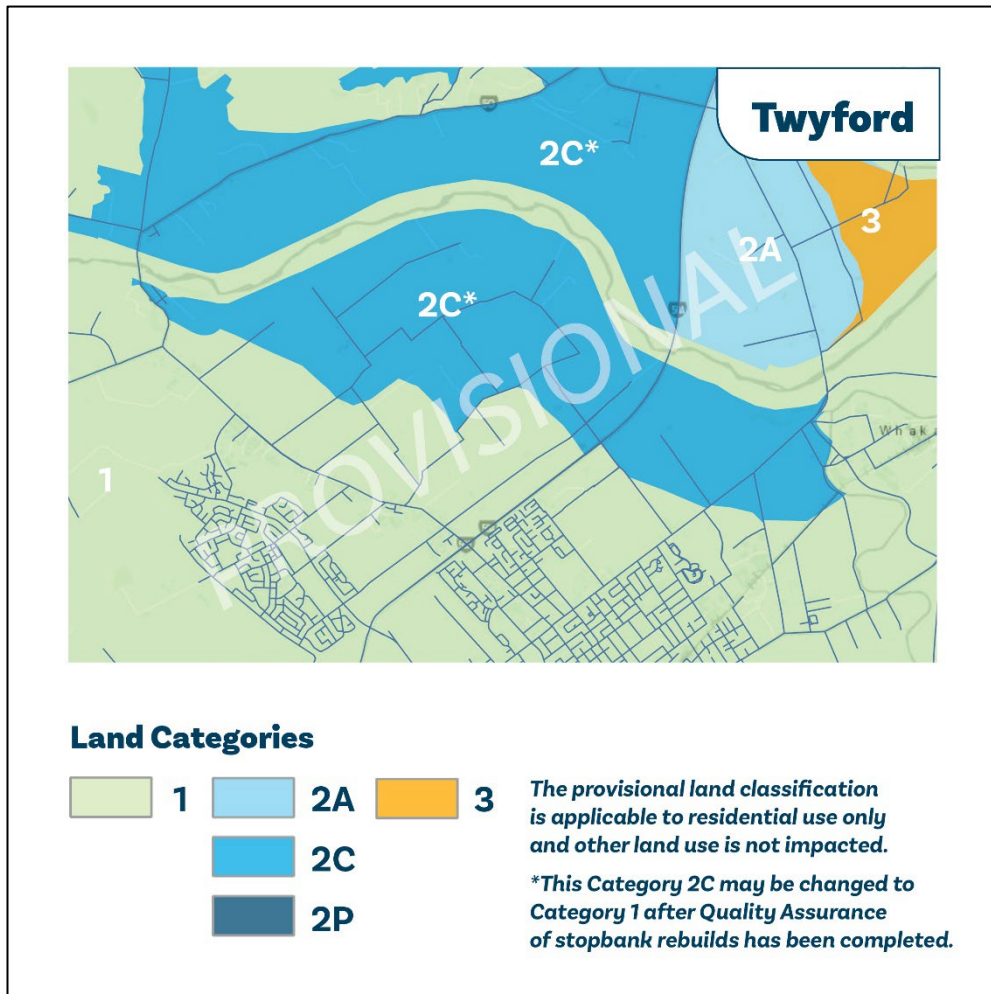
5.2.9 Omahu

Omahu is an area that sits at the top end of the Ngaruroro true left stopbank, with some houses at the western end sitting outside the protection system. Those protected areas are assigned a 2C status with a likely transition to Category 1 once stopbank repairs are completed, while the unprotected western extents are assigned a 2P status (property specific mitigation approach).



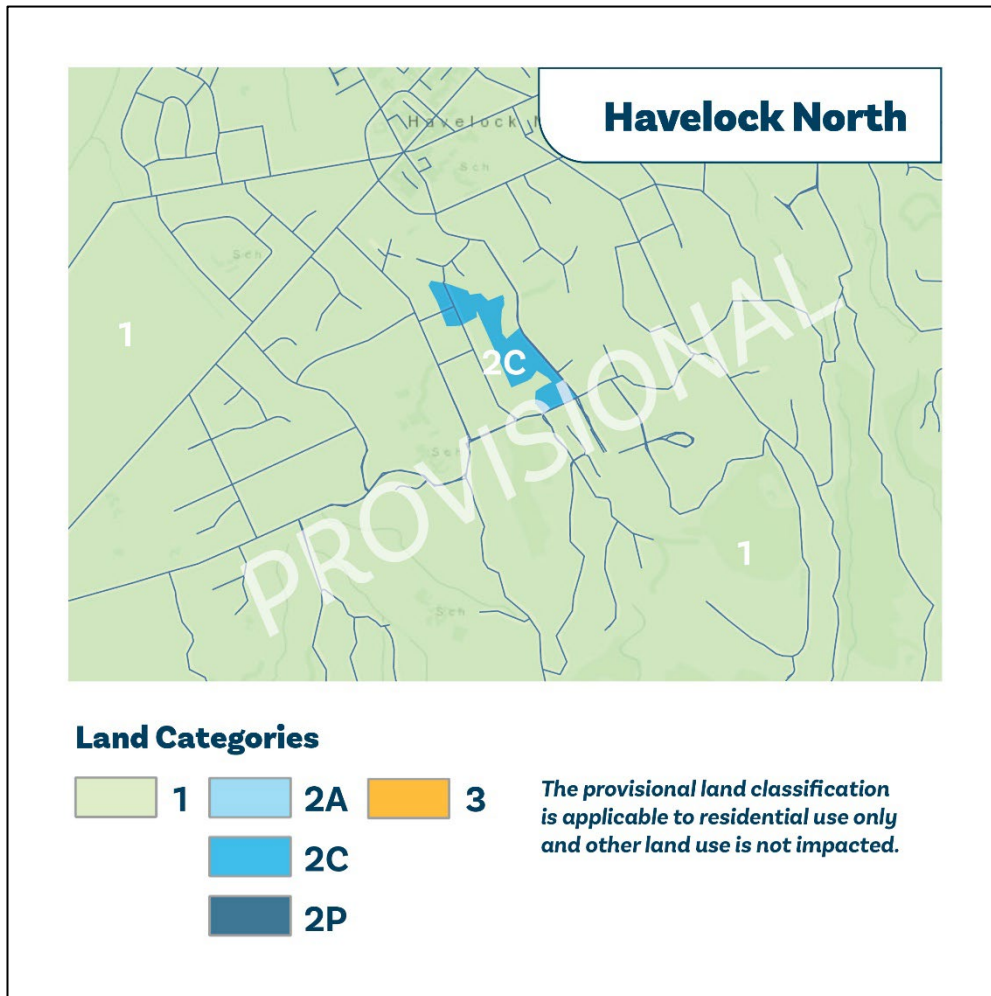
5.2.10 Twyford

Inundation immediately south of the Ngaruroro occurred during ETC Gabrielle, attributable to the stopbank breaches that occurred just east of Fernhill. This area has been assigned a 2C status – once stopbank breaches are repaired it's intended to transition the area back to Category 1.



5.2.11 Mangarau Stream, Havelock North

Flood protection for Havelock North takes the form of a number of flood detention dams that impound and then release floodwater once the flood recedes. The intensity and importantly duration of ETC Gabrielle caused the Mangarau dam to fill and then spill, resulting in localised flooding to a part of Havelock North. This area is assigned a 2C status, which assumes an engineered solution and/ or modification to the existing protection system can address the issues that ETC Gabrielle has highlighted.



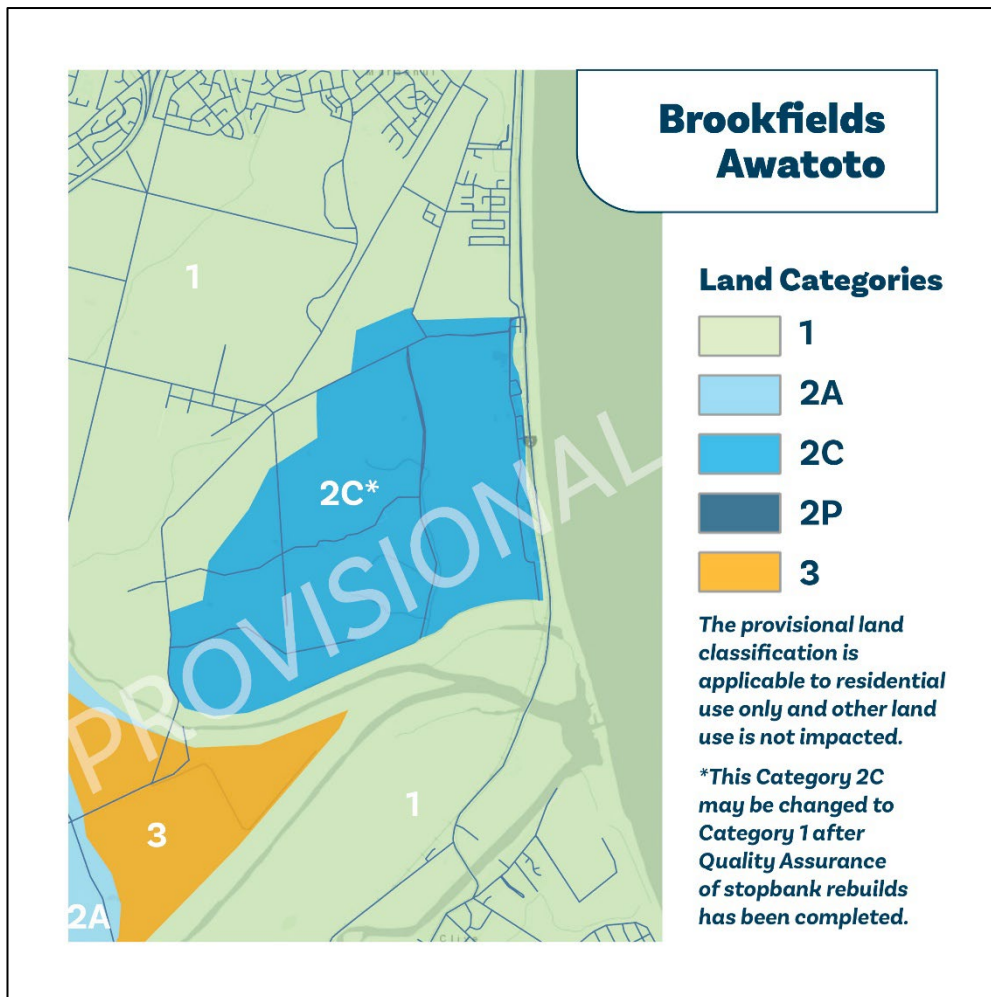
5.3 Napier City

5.3.1 Esk Valley

Refer to Section 5.2.2.

5.3.2 Brookfields/ Awatoto

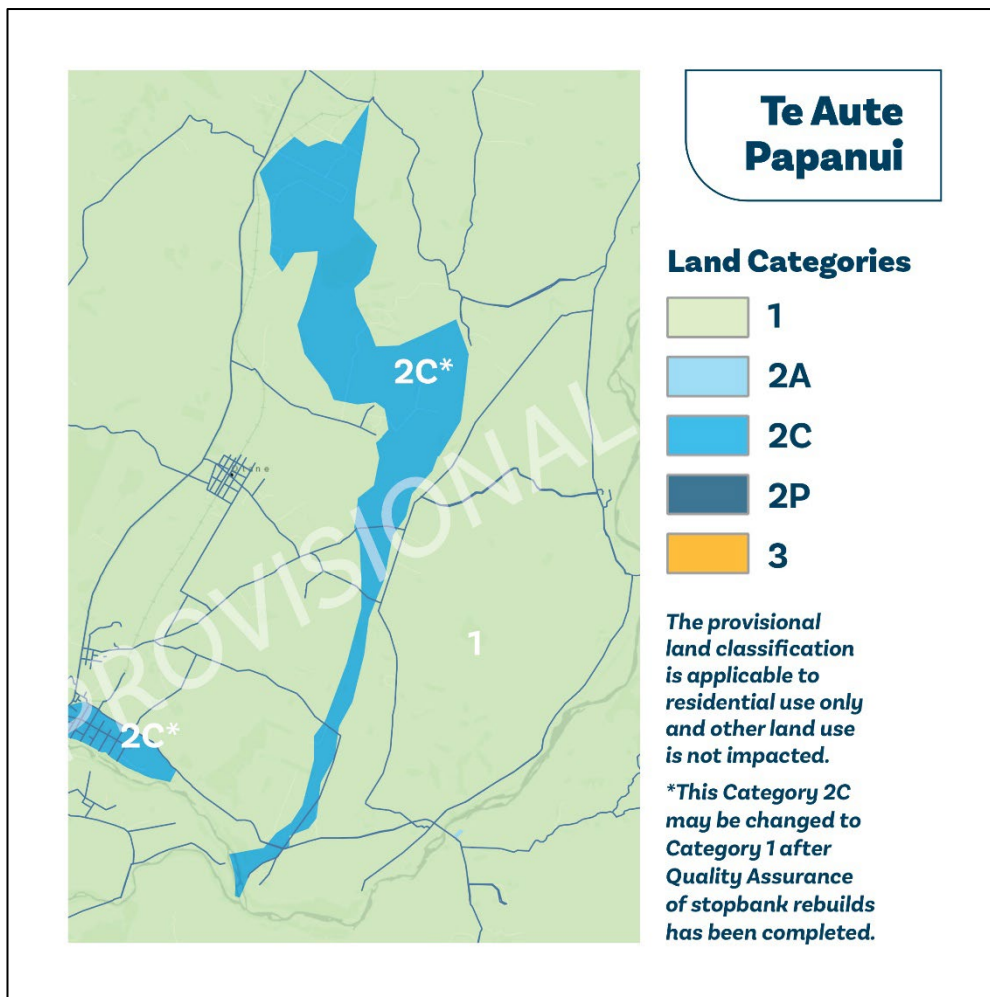
The source of inundation for this area was primarily the Tutaekuri River with overtopping of the true left stopbank. This is seen as a fairly straight-forward remedy – rectifying any stopbank damage to reinstate protection to this area, then updating it’s categorisation to 1.



5.4 Central Hakes Bay District

5.4.1 Te Aute Papanui

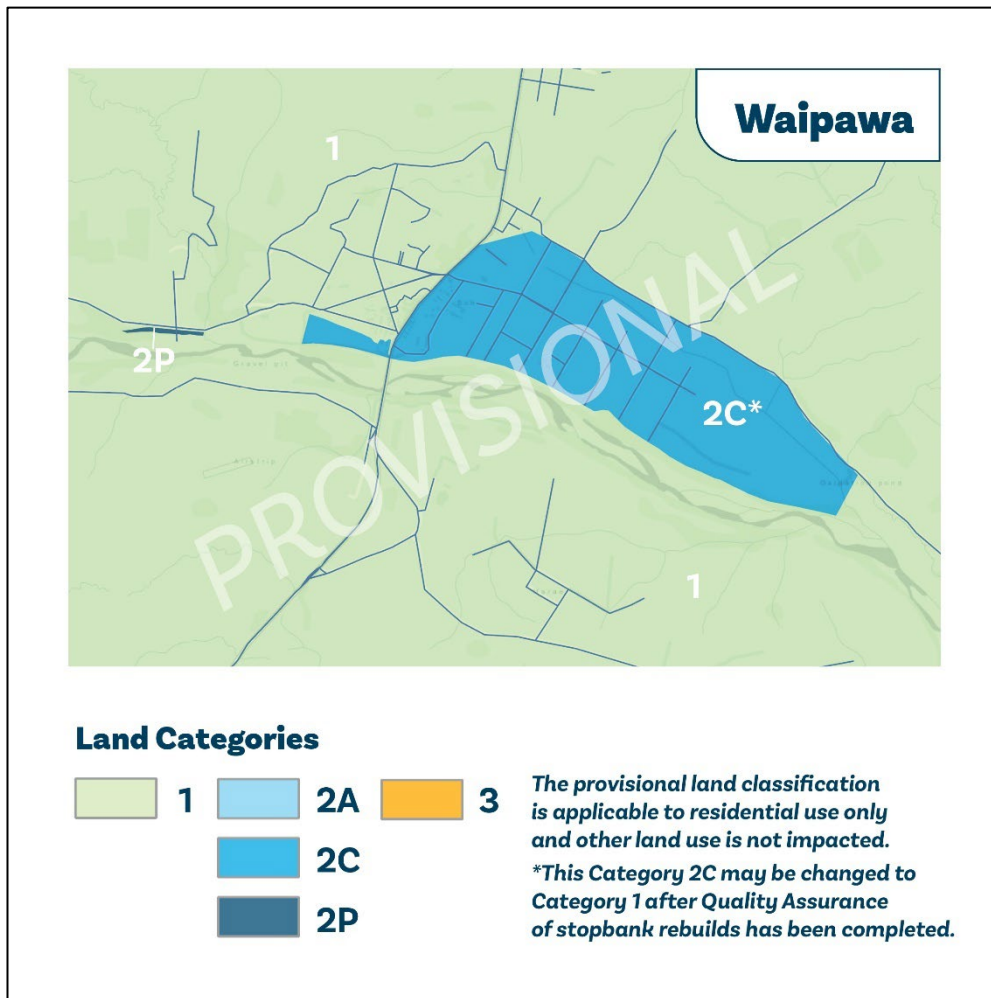
During the ETC Gabrielle event the Waipawa River reached a height such that it overtopped defences and occupied the old river corridor that meets the current river corridor around 5km downstream of Waipawa. This resulted in extensive flooding projecting many kilometres north inundating substantial tracts of farmland and flooding two residential properties. This area is assigned a 2C status to be shifted to Category 1 once protection systems (stopbanks) adjoining the Waipawa River are reinstated.



5.4.2 Waipawa

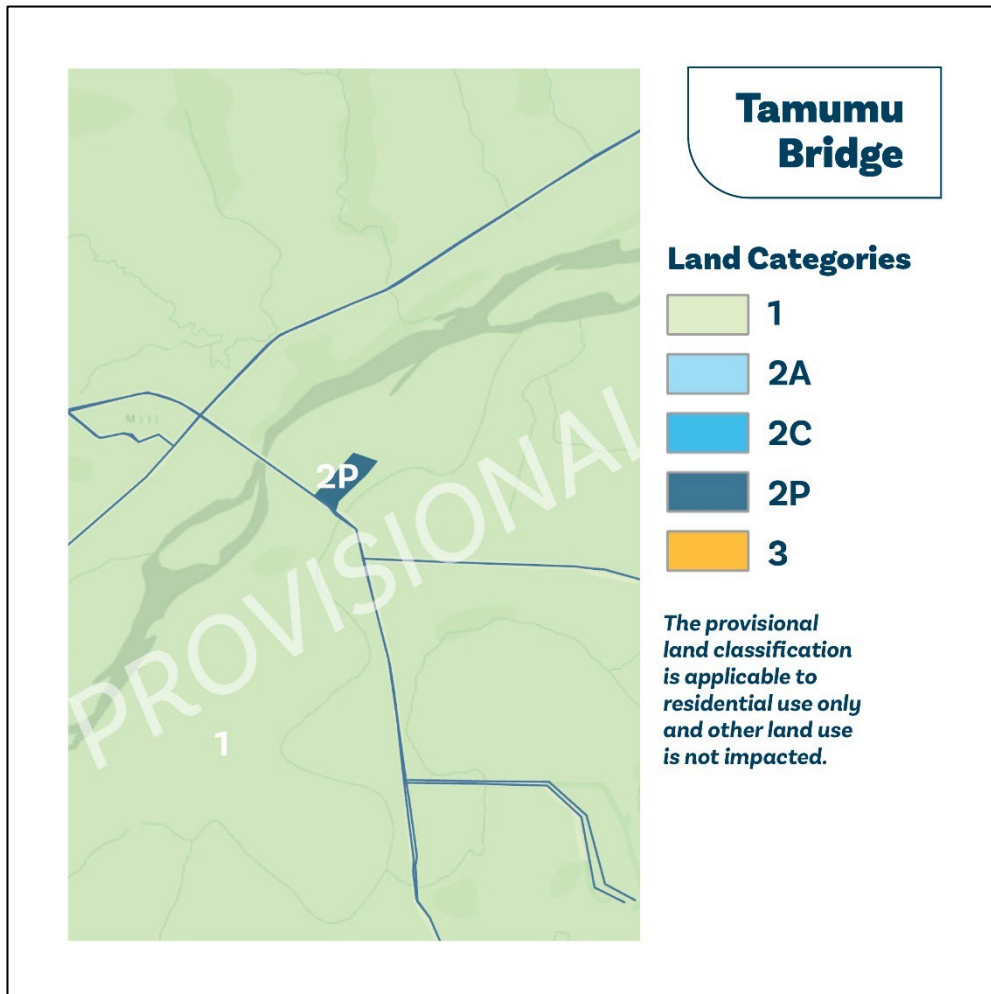
Stopbanking adjacent to Waipawa breached during the ETC Gabrielle event, flooding around 280 homes in the eastern part of the town. A small area of residential property on the western edge of the town beside the Waipawa River outside of the flood defences was also flooded.

The small area west of the town is assigned a 2P status with the eastern part of the town assigned a category 2C status to be changed to Category 1 once stopbank repairs have been completed and the protection system for the town reinstated.



5.4.3 Tamumu Bridge (Pourerere Road)

Tamumu Road inundation consisted of habitable property located immediately southwest of the bridge being flooded. No existing protection systems are in place and given the nature of the impacted property a categorisation of 2P is appropriate.



5.4.4 Porangahau

The town of Porangahau in southern Hawkes Bay was significantly impacted during ETC Gabrielle. The town is located on the north bank of the river a short distance from the coast with the flood peak in the Porangahau River coinciding with high tide, exacerbating flooding. The town has no flood defences and around 35 houses, a marae and urupa (both on the south side of the river) were flooded.

It has been assigned a 2A categorisation – further investigation is required to determine whether a protection scheme for the town is viable or if property-level/specific interventions are the best mitigation approach.

