APPENDIX 6: STOPBANK ALIGNMENT OPTIONS ASSESSMENT

REPORT

Tonkin+Taylor

Te Karaka Flood Management Optioneering

Final Option Recommendation

Prepared for
Gisborne District Council

Prepared by
Tonkin & Taylor Ltd

Date
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Executive summary

Tonkin & Taylor Ltd (T+T) was engaged by Gisborne District Council (GDC) to support the development and evaluation of flood mitigation options for Te Karaka, a community at risk from flooding by the Waipaoa River. The purpose of this report is to provide a detailed account of the process undertaken to identify a preferred flood mitigation option for implementation by GDC. It outlines the methodology used to refine potential solutions, drawing on hydraulic modelling results, a geomorphic assessment of the Waipaoa River, input from community engagement, and property-specific considerations.

The optioneering process undertaken to identify a preferred flood mitigation option for Te Karaka involved a structured, multi-stage approach. It began with the development of an initial longlist of nine potential options, which was subsequently refined to a final longlist of six. From this, four options were selected for the shortlist and subjected to further investigation and refinement. This process was guided by a Multi-Criteria Analysis (MCA) framework, which provided a consistent and transparent basis for evaluation. The MCA criteria used were aligned with those applied in other catchments across Tairāwhiti as part of GDC's broader climate resilience programme, ensuring continuity and comparability in decision-making.

Once the shortlisted options were confirmed, additional investigations were undertaken to further refine and enhance understanding of each alternative. This process included a high-level geomorphic assessment, which subsequently informed updated flood modelling by DHI NZ Ltd. Following this, the modelling results were analysed to assess any risks associated with the geomorphic effects of the different stopbank options. The main outcomes of the geomorphic assessment were:

- Understanding the existing geomorphology of the Waipaoa River and catchment.
- Understanding the geomorphic history of the Waipaoa River and catchment.
- An understanding of what the river "wants to do".
- Guidance on how shortlist options could support the natural processes of the river system.
- An understanding of how the geomorphology of the river and catchment affects flooding.
- Providing expert opinion on the geomorphic effects of proposed berm lowering and channel widening.

A key finding from the geomorphic assessment that guided the optioneering process was the trend of channel aggradation in the Waipaoa River at Te Karaka, which is expected to continue and further reduce the river's capacity to convey floodwaters in the future. Relocating the stopbank to a more retreated position is likely to promote additional aggradation, as reduced flow velocities may no longer be sufficient to keep sediment entrained. However, this approach may allow the natural process to occur more gradually than if the stopbank were placed closer to the channel. Modelling indicates that velocities could decrease by up to 1.1 m/s in the Waipaoa channel. Providing more room for the river can reduce flow velocities, attenuate peak flows, and lower pressure from increased sediment further downstream by allowing water to spread out and slow down.

The workshop to determine a preferred option from the shortlist was held on the 26 June 2025 to apply the consistent MCA approach to score different options. All MCA criteria were scored except for those in the Community/Stakeholders category, which was reserved for input from the community and mana whenua, as agreed in a meeting with community representatives on 11 June 2025. The MCA assessed four shortlisted options (Options 1–4) using updated information, including flood modelling, landowner feedback, geomorphology assessment, and NZTA engagement to date. Previous scores from the longlist MCA were revisited and revised accordingly. Cost estimates were excluded from the scoring but have been prepared and will be considered by Council alongside this report.

The actions from the 11 June workshop was for Options 3 and 4 to be consulted on with the community on the GDC website to receive public comment and feedback. The information outlining the two preferred options went live on the 20 June, with a submission deadline of 9am on the 28 July.

At the 24 July Te Karaka community meeting, Council Officers presented a modified version of Option 3 as the 'draft preferred option' based on the GDC website comments and feedback to date. Following the consideration of feedback from community engagement, the results of the MCA preferred option workshop, and website comments and feedback received up to the 28 of July GDC officers confirmed that the modified version of Option 3 was the preferred option. Option 3 is to be recommended to Council as the preferred option for several reasons:

- It achieved the highest score in a multi-criteria analysis (MCA) across a range of technical factors, excluding community criteria which were assessed separately.
- It offers better alignment with natural processes and provides more space for the river to move compared with Options 1 and 2.
- It reduces pressure on Kanakanaia Bridge by enabling floodwaters to bypass the area and offers protection to the oxidation pond, which Option 4 does not.
- It was the preferred option from the public based on the GDC website pre-consultation undertaken up to 9am on the 28 July.

A more detailed rationale for the MCA scoring can be found in Section 8.1. In addition to its technical merits, Option 3 received strong support during hui with the community and Māhaki representatives. Furthermore, online submissions also showed a clear preference for Option 3.

Given the geomorphic trends in the Waipaoa River system, coupled with uncertainties surrounding the effectiveness of proposed land use changes, policy developments, and the impacts of climate change, maintaining effective flood mitigation for Te Karaka presents significant long-term challenges. With ongoing aggradation expected in the river, any retreated stopbank is likely to offer only a medium-term solution, likely in the order of decades, without further works being required. However, without further data or modelling, it is difficult to define what "medium-term" means in this context, or to estimate the rate at which the stopbank's level of service may decline as this will be episodic in response to large floods. This uncertainty underscores the need for improved catchment-wide management and greater use of nature-based solutions or land use change to help mitigate sediment influxes that are driving aggradation in the river.

Glossary

Term	Definition/Description
Active channel	The width of the stream channel that is wider than the low-flow channel, sits within the bank-full channel and carries frequent flow events (i.e. seasonal rainfall).
Aggradation	The process of general bed raising by deposition of sediment.
AEP (Annual Exceedance Probability)	A measure of the likelihood of a flood occurring in any given year. For example, a 1% AEP flood has a 1 in 100 chance of occurring each year.
Backwater effect / backwatering	A localised rise in water surface elevation which may occur upstream of constriction in river width or where a river meets a larger body of water. This alters the water surface gradient in the river to an almost flat profile. This reduces the velocity and energy of stream flow.
Bankfull	The fullest flow of the river contained entirely within the channel between its banks without spilling onto the floodplain.
Bed	The bed of a river is referred to as the base of the channel, including the thalweg, and excluding the banks.
Berm	A flat strip of land, often between the river and a stopbank, which can be lowered to improve flood flow and provide material for construction.
Deposition	The laying down of sediment that is carried by water.
Erosion	When material is removed from the bed or bank of a river. Several types of erosion exist including on banks and adjacent slopes: block failure, gullying, rilling, mass wasting, slumps, slips, flaking, slaking; and in channels: bed scour
Floodplain	Typically, a flat area of land beside a river, above the bankfull level, which has been formed through the repeated deposition of sediment by the river itself.
Fluvial geomorphology	How rivers shape the world, the interaction between sediment, water and vegetation.
Freeboard	An extra height added to the top of a stopbank above the predicted flood level to account for uncertainties and safety.
Level of Service (LOS)	The standard of protection provided by flood infrastructure, often defined by the size of flood it can withstand.
LiDAR	Light Detection and Ranging. A method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth's surface.
Multi-Criteria Analysis (MCA)	A decision-making tool that compares different options based on various factors like cost, environmental impact, and community benefit.
River behaviour	Adjustments to river morphology induced by a range of erosional and depositional mechanisms, producing characteristic assemblages of landforms at the reach scale.
Scour	A type of erosion, where sediment is removed from a surface by swift flowing water, lowering the riverbed locally (e.g. at a confluence).
Sediment	A solid material that is moved and deposited in a new location. Sediment can consist of rocks and minerals (minerogenic sediment), as well as the remains of plants and animals (organic sediment).
Sediment transport	The way that sediment is moved through a river system. This usually refers to when (as in what sized flows) sediment is eroded or moved by water. Bed sediment is moved intermittently along the bed during high flow events of sufficient energy to move the material; suspended sediment is moved in suspension within the water column.

Term	Definition/Description
Superelevation	The rise in water level on the outside of a river bend due to the speed and direction of flow.

1 Scope and purpose of report

Tonkin and Taylor Ltd (T+T) has been engaged by Gisborne District Council (GDC)[1] for the purposes of supporting project management, analysis, optioneering design, and evaluation of potential solutions to mitigate the flood risk to Te Karaka, a township situated in Tairāwhiti. The purpose of this report is to present the preferred option recommendation for mitigating the flood risk to the Te Karaka community. The report also documents the process followed to reach this recommendation.

At the point T+T became involved, an initial longlist had already been developed by GDC (working with flood modellers DHI) which had been presented to the community. Very early on after Cyclone Gabreille, the option of wholesale retreat of the township from the floodplain was suggested. This option was very strongly rejected by the community in favour of a flood scheme (stopbank) upgrade.

T+T's scope was to support the high-level design and refinement of the identified options, providing technical input and analysis to inform the decision-making process. This included close collaboration with DHI on further flood modelling to assess the performance of each option. T+T also facilitated a structured longlist–shortlist–preferred option process, during which GDC officers considered the technical information alongside other key drivers and stakeholder input. The final selection of the preferred option was made by GDC officers, reflecting their assessment of the full range of considerations. Additionally, T+T:

- Carried out a high-level assessment of the fluvial geomorphology in this river reach, including implications for options (Appendix D).
- Produced maps of the options, incorporating flood modelling results provided by DHI (Appendix E).
- Prepared a summary table of flood level impacts at different properties, which for privacy reasons has been provided separately and is not discussed in this report.
- Provided separate outputs to support GDC in its stakeholder and community engagement.
- Preparing high-level cost estimates and construction programme (provided separately to this report).

T+T has not reported on the technical aspects of the flood modelling by DHI; nor has T+T peer reviewed this work. It is understood that the modelling work (model build, calibration and options modelling) will be described by DHI in a separate report following modelling of the preferred option and that the calibrated model itself has been peer reviewed by others.

[1] Letter of Engagement: Te Karaka Flood Management Optioneering, Tonkin and Taylor Ltd. Signed 17 February 2025, T+T Ref: 1092556.0020.

2 Background

Te Karaka is a small settlement located approximately 25 km inland from Gisborne, with a population of approximately 525. The Waipaoa River forms a loop around the Te Karaka township. The river originates from the eastern slopes of the Raukūmara Range, with a catchment area of approximately 216,000 ha (Figure 2.1).

In the early 1980's the former Waikohu County Council requested the (former) East Cape Catchment Board to investigate a new stopbank, to improve the level of protection then existing in Te Karaka. In the summer of 1987/88 construction began on a new stopbank designed to protect Te Karaka from a flood of 4,000 cubic metres per second (m^3/s). When Cyclone Bola struck in March 1988 the work was almost complete except for one section near the end of Morris Road. Flood waters swept into Te Karaka through the uncompleted section and flooded part of the township. Following the flood, the uncompleted sections of stopbank were completed, and adjacent banks raised up to Cyclone Bola flood levels.

Due to rapid aggradation of the Waipaoa River post Bola, a review of the level of flood protection to Te Karaka was completed in 1997. By 2002, an upgrade of the scheme was completed which raised the stopbank between 300 mm and 1000 mm to a design capacity of 4,500 m^3/s.

Prior to Cyclone Gabrielle in 2023, Te Karaka relied on 4.5 km of stopbanks along the Waipaoa River for flood risk reduction. In March 2021, an asset performance assessment was completed for the Te Karaka Stopbanks. The modelling showed no overtopping of any stopbank during the 50-year design event, with all cross sections having 570mm freeboard. Modelling for the 100-year event indicated overtopping downstream of the Rangitira Bridge at the 90-deg bend at multiple locations. For current work, GDC has adopted a design flow based on Cyclone Bola + 25% (equal to 5,625 m^3/s) which aligns with the current upgrade of the Waipaoa River Flood Control Scheme downstream of Te Karaka (construction started in 2019, expected to be fully completed in 2027). Modelling of the existing stopbanks under this design flow shows that the entire township would be inundated due to stopbank overtopping. For comparison, Cyclone Gabrielle peak flows were estimated by NIWA at around 4,000 – 4,500 m^3/s (information provided by GDC) and the previous design standard was 4,500 m^3/s. The discrepancy here that resulted in the flooding of Te Karaka is most likely related to Waipaoa riverbed and berm aggradation trends over the previous two decades, noted that peak flows during a flood can be very difficult to estimate.

The aftermath of Cyclone Gabrielle required extensive cleanup efforts, with significant government investment and community support. Many homes and buildings were uninhabitable due to flood damage, resulting in displaced families. Cyclone Gabrielle is the costliest cyclone on record in the Southern Hemisphere, with total damages estimated at NZD$14.5 billion[2]. According to information provided by GDC, 47 homes were flooded during Cyclone Gabrielle, the majority of which have now been raised. The low-lying geography of Te Karaka increases the flood risk, making even moderate floods a threat to homes, infrastructure, and livelihoods.

The government has approved a budget of $13.2 million to reduce flood risk for Te Karaka. This funding is part of a $71.1 million broader government investment into flood resilience that includes infrastructure improvements, investigations and reassessments of flood mitigation systems across Tairāwhiti. GDC had previously engaged DHI to model various flood mitigation options using the

[2] Public Health Communication Centre Aotearoa, *Cyclone Gabrielle by the numbers – A review at six months* (Wilson, Broadbent & Kerr, 2023).

MIKE Flood software, and T+T has utilised this information, along with insights from a site visit on 12 February 2025 and its own flood mitigation expertise, in supporting the optioneering process.

GDC is working closely with a community working group to ensure that residents and key stakeholders are kept informed and can contribute. This working group has provided input on GDC's initial longlist and the shortlist stopbank alignment options for Te Karaka.

Figure 2.1: Location plan of Te Karaka and an aerial image of the township

2.1 Overall optioneering process

The optioneering process for arriving at a preferred option recommendation followed a longlist – shortlist – preferred option approach. A summary of this process follows:

- **Initial longlist**: An initial longlist of options was developed by GDC considering a wide range of alternatives for flood mitigation at Te Karaka. These options were modelled by DHI to produce flood maps and to broadly understand potential upstream and downstream impacts.
- **Final longlist**: T+T assessed the initial longlist and the work done to date (including the flood modelling) and recommended a longlist for GDC to take forward. A report recommending the longlist, including broad consideration of the options against the agreed assessment criteria, is included in Appendix A.
- **Longlist to shortlist decision**: a structured but high-level multi-criteria analysis (MCA) assessment was carried out on the longlist options. The longlist options were qualitatively reviewed and scored based on specific categories (refer to Section 2.3) and a shortlist was agreed with GDC officers.
- **Shortlist option development**: the shortlist options were developed in more detail, including higher level design and technical assessments. This included additional hydraulic modelling, geomorphic assessments, and consultation by GDC with directly affected landowners. The option alignments were refined to better follow the topography and other key constraints.

- **Preferred option recommendation**: an initial preferred option was arrived at by GDC officers, supported by T+T, from amongst the shortlist options using a further MCA assessment (Appendix C). In parallel, GDC consulted with the community and stakeholders to find out their preferences. These phases are described in the following sections.

2.2 Timeline of options development

The timeline in Figure 2.2 gives a high-level overview of the optioneering process. This is described in more detail from Section 3 onwards.

Figure 2.2: Indicative timeline for options development

2.3 Multi-criteria analysis (MCA)

MCA is a structured decision-making tool that supports the evaluation of multiple alternatives against a consistent set of criteria, which is particularly useful when balancing complex trade-offs such as environmental impacts and social benefits. In this process, the same set of nine evaluation criteria (Appendix C) initially used across other catchments in Tairāwhiti as part of broader climate resilience work served as a guiding framework.

3 Longlist options

As directed by GDC, all options were to have a level of service of a 5,625 m^3/s flood, corresponding to Cyclone Bola + 25% peak flows, with 600 mm of stopbank freeboard[3]. This is the design standard for the entire 65km of the Waipaoa River Flood Control scheme located downstream and is incorporated in the funding agreement that GDC has with the Crown for these works.

The 25% increase to allow for climate change is based on a hydrological study in the Ngaruroro Catchment in Hawkes Bay, which found corresponding increase of 25% in peak flows for a 2.1 ˚C temperature rise[4]. As time goes on, the effective level of service in terms of AEP will reduce due to climate change and river/berm aggradation. The Cyclone Bola flows have been assessed by GDC as being approximately a present day 1% AEP event.

Refer to Section 6 for further information on the options design approach, including Section 6.3 for stopbank geometry.

3.1 Initial longlist

With DHI responsible for carrying out the hydraulic modelling for this project, the longlist of options was developed from an initial, extensive set of options created by GDC and DHI. The initial longlist (from GDC) is included in the T+T longlist memo in Appendix A. This is referred to as the 'initial longlist' in this report and contains 9 different options. One of these options involved berm lowering, however, GDC decided that this would be an integral component for any of the stopbank options and was incorporated into each of the final longlist options.

Given the severity and extreme nature of the stopbank overtopping event for Te Karaka township, the 'do nothing' option was never a consideration. The community has strongly advocated for a flood scheme upgrade from very early on in the process.

3.2 Final longlist

A final longlist was developed by GDC and T+T from the initial longlist, alongside the additional proposed option of using the State Highway as a spillway. This final longlist was qualitatively assessed with reference to the MCA criteria (Appendix C), and was intentionally selected to encompass the full range of possibilities—from upgrading the existing stopbanks in their current locations maximising room for the river by retreating the stopbanks as far as practicable. The final longlist is presented in Table 3.1.

[3] Freeboard is an allowance above the modelled water level, to account for phenomena that are not represented in the modelled results.
[4] Waipoua Stopbank Improvements 2015 – 2030: Technical Memorandum (GDC, June 2024, ref: A1640108)

Table 3.1: Longlist options for Te Karaka

Longlist Option #	
1	Upgrade existing stopbanks following same alignment.
2	Retreat northern stopbank 160 m.
3	Retreat northern stopbank 160 m plus State Highway Spillway.
4	Retreat northern stopbank by 300 – 315 m, with retreated eastern stopbank (~50 m).
5	Retreat northern stopbank by 300 – 315 m, with even further retreated eastern stopbank than longlist Option 4 to edge of wastewater treatment pond.
6	Furthest stopbank retreat to maximise room for the river.

Each of these options and associated criteria summary are described in Appendix A. The six longlist options differ in the extent to which they reduce flood risk to the Te Karaka community and their setback from the river. For all options—except Option 3—the state highway must be raised to connect both ends of the stopbanks to the high ground to the south. The need for a high-level feasibility of this was assessed based on available LiDAR and was verified during a site visit on 12 February 2025.

4 Shortlist options

The longlist options were considered in more detail at an MCA workshop, to arrive at a shortlist of options to be further developed and assessed.

4.1 Longlist to shortlist MCA workshop

To select the options for the short list a workshop was held on 7 April. GDC staff present were Tim Barry, Joss Ruifrok, and Dean Foote. Mark Hooker and James Flanagan from T+T were present and facilitated the workshop (via MS Teams). The key components of the workshop were:

- Review and confirmation of the assessment categories and criteria.
- Review of the longlist stopbank alignments, with a focus on identifying the differences between the various options.
- Initial impressions of the options, based on participants' existing knowledge.
- Scoring of the options against the agreed criteria. The MCA criteria used at longlist to shortlist stage are displayed in Appendix C.

4.2 Shortlist recommendations

Following the longlist to shortlist MCA workshop, the following options were carried forward to the shortlist; Option 1 (Figure 4.1), Option 3 (Figure 4.2), Option 5 (Figure 4.3), and Option 6 (Figure 4.4). This was on the basis that Option 1 and Option 6 represented the two extremes of enclosed area (of flood risk reduction), Option 5 was the highest scoring of the remaining options and Option 3 represented a different concept with potential additional benefits that GDC wished to explore further. Option 1 was also considered because it best represented the existing situation. The options were renumbered as "shortlist option 1" to "shortlist option 4" at this point.

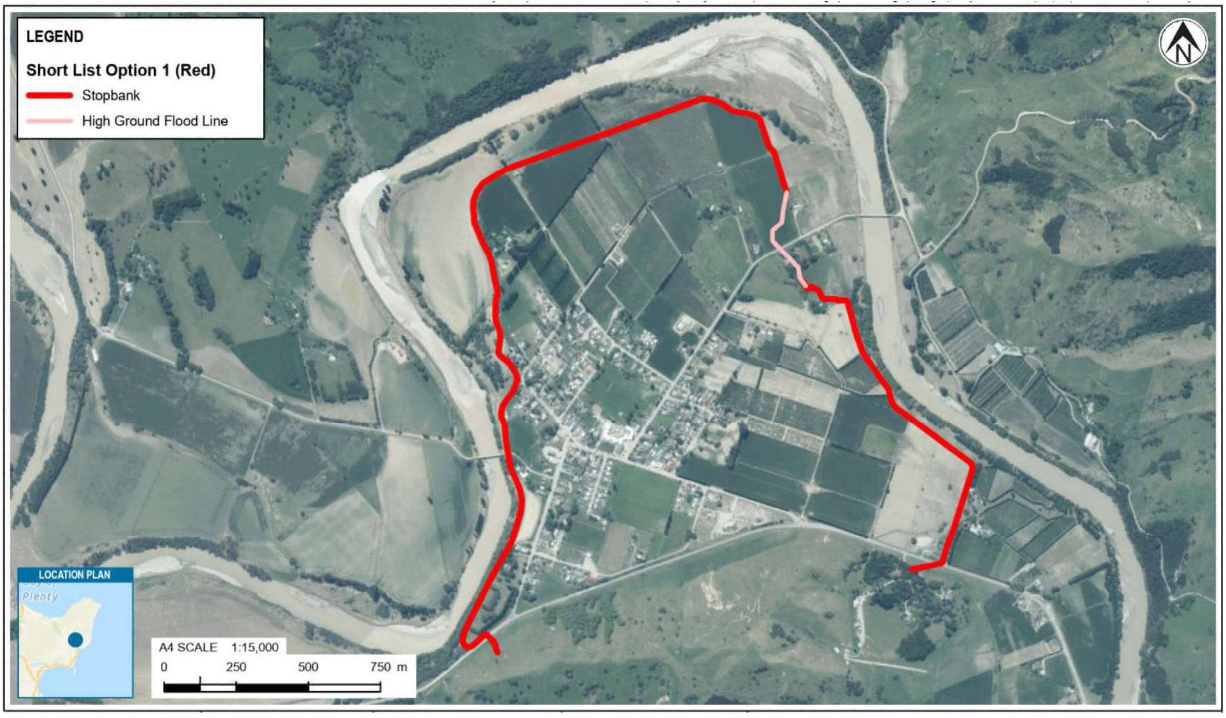

Figure 4.1: Shortlist stopbank alignment for shortlist option 1 (longlist option 1)

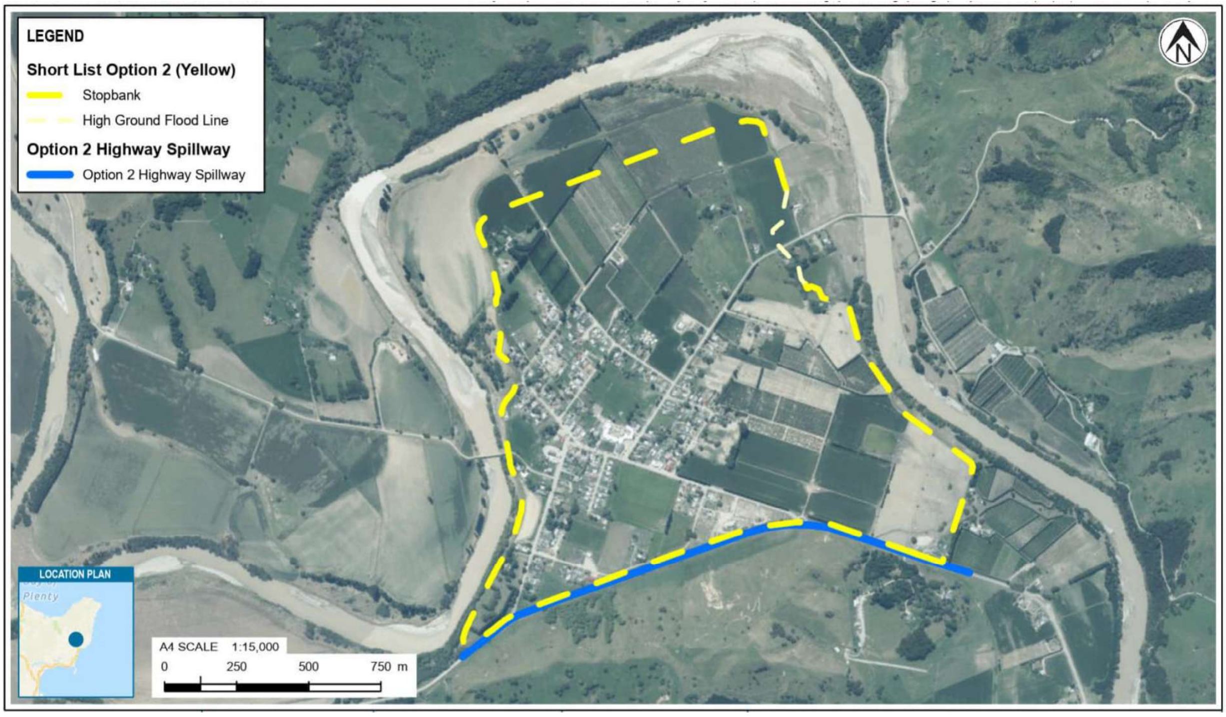

Figure 4.2: Shortlist stopbank alignment for shortlist option 2 (longlist option 3)

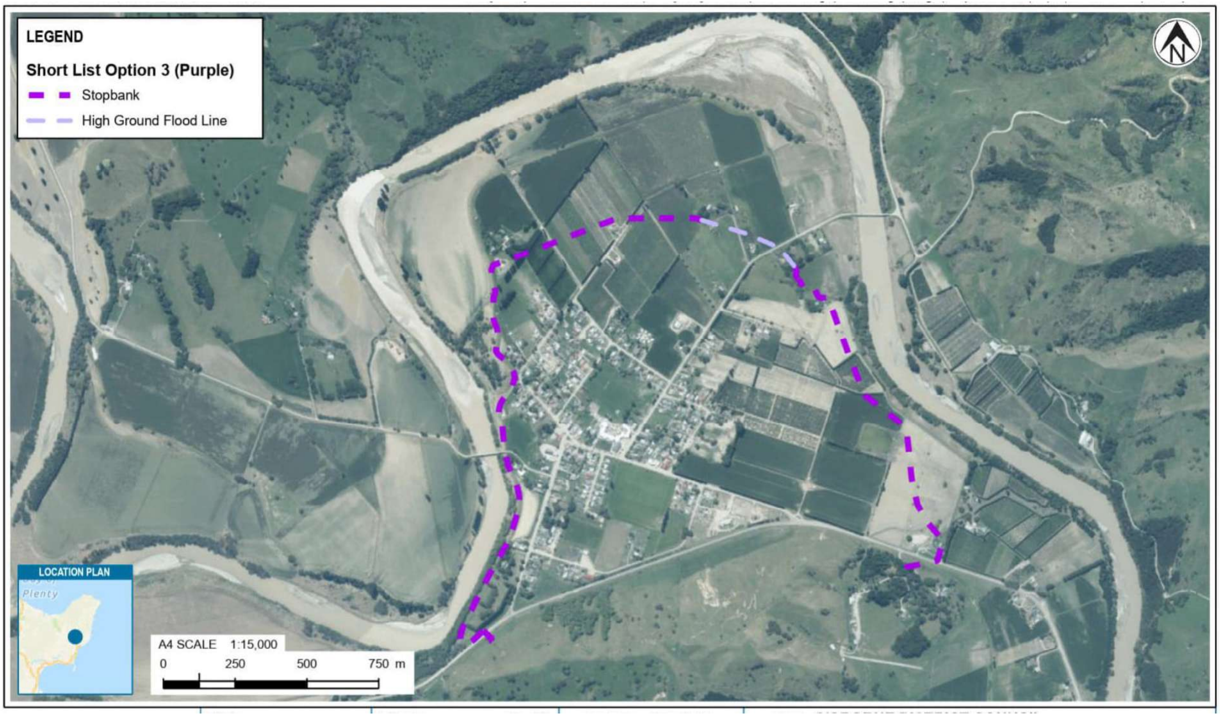

Figure 4.3: Shortlist stopbank alignment for shortlist option 3 (longlist option 5)

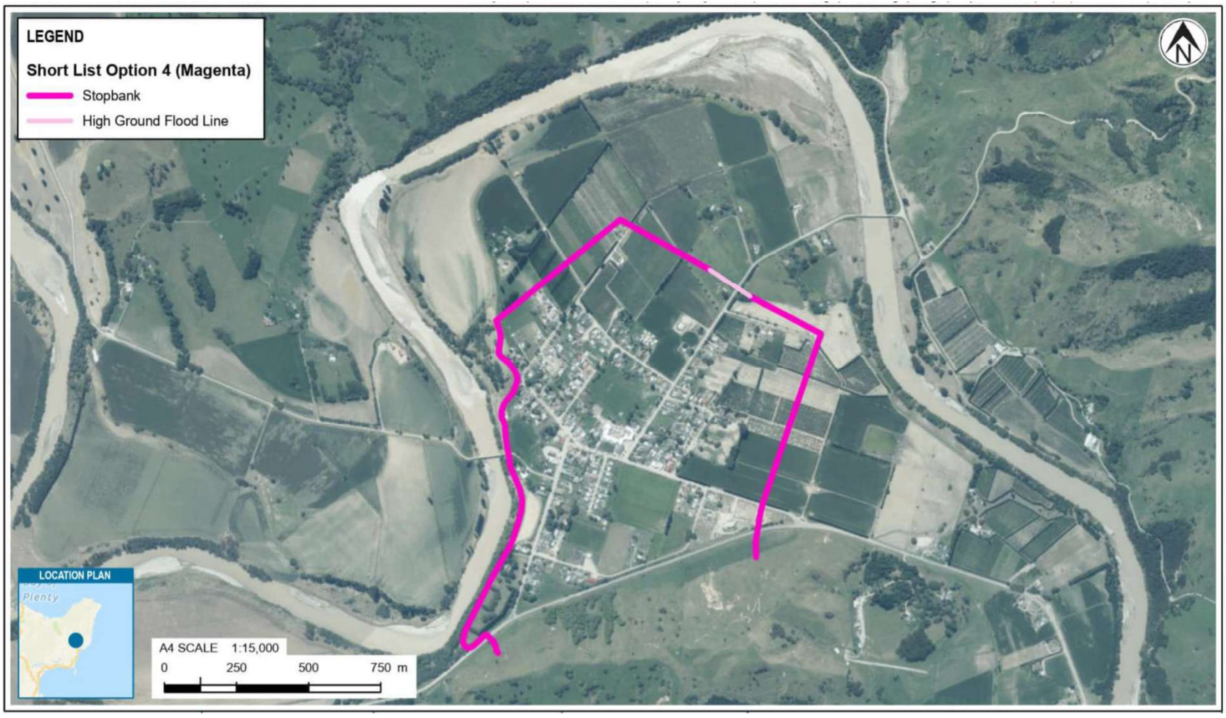

Figure 4.4: Shortlist stopbank alignment for shortlist option 4 (longlist option 6)

5 Refinement of the shortlist options

Once the shortlisted options were confirmed, additional investigations were undertaken to further refine and enhance understanding of each alternative. This process included a high-level geomorphic assessment, which subsequently informed a series of updated flood modelling runs performed by DHI. Following this, flood modelling results were analysed to assess any risks associated with the geomorphic effects of the different stopbank options.

5.1 Geomorphic context

T+T produced a geomorphic assessment for the Waipaoa River, included as an appendix to this report (Appendix D). This technical assessment was carried out to support the development of shortlisted options and guide the selection of a preferred option. By analysing the river's character and behaviour, the assessment provided critical insights into potential geomorphic risks and the system's capacity to tolerate various interventions. A summary of the key findings is provided below.

The geomorphic assessment was undertaken to enhance understanding of the catchment history, river character and behaviour, as well as its response to recent high-magnitude events. The assessment involved analysing surveyed cross sections to evaluate spatial and temporal changes in channel form and applying Geomorphic Change Detection (GCD) software to quantify geomorphic change associated with Cyclone Gabrielle. This provided valuable insights into sediment dynamics, erosion and deposition patterns (see Figure 5.1), and the river's capacity for adjustment. Based on these findings, it was recommended that each shortlisted option be modelled by DHI twice: first using the existing bed levels, and then with the bed level of the active channel increased by 1 m to represent a plausible future aggradation scenario.

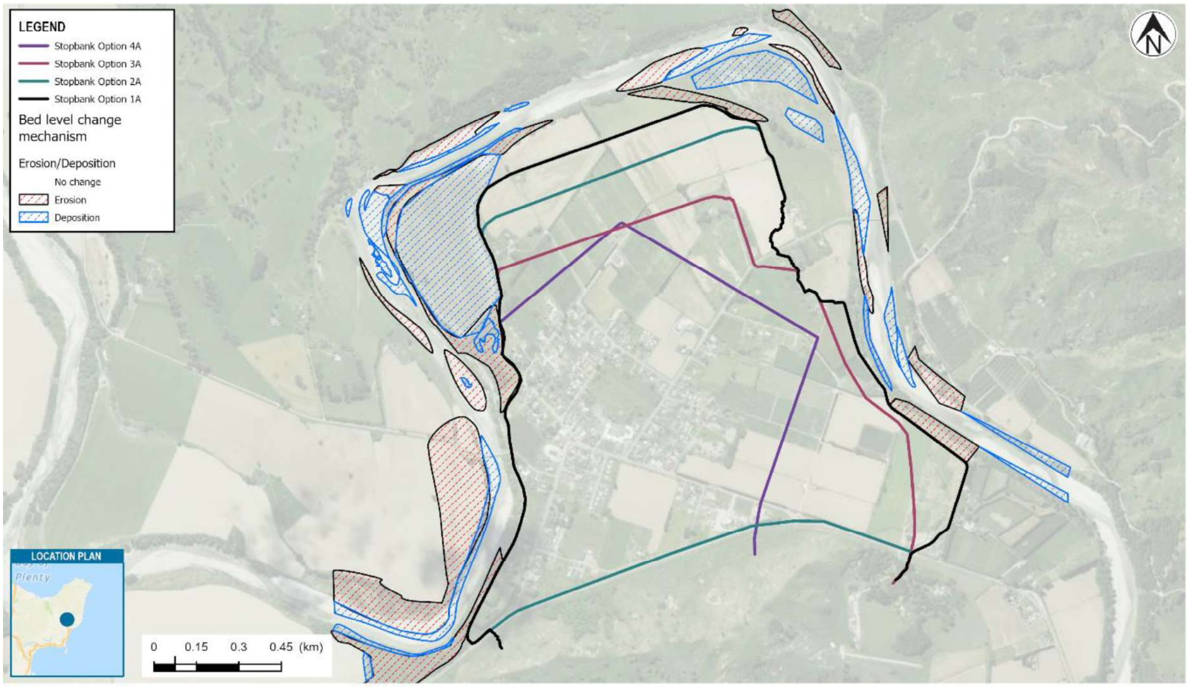

Figure 5.1: Indicative areas with trends of either erosion (red) or deposition (blue) in the Waipaoa River surrounding Te Karaka, following analysis of GCD results between 2018-2023.

5.2 Shortlist hydraulic modelling results

The shortlist options were modelled by DHI to assess the impacts of each option relative to the flood scenario with the existing stopbank height and alignment. Hydraulic modelling was executed using the technique of "glass-walling". This approach simplifies the representation of physical barriers such as stopbanks, as thin vertical lines with a height higher than any feasible water level in the river. This enables the determination of the required stopbank height by evaluating the water level against the barrier, incorporating an appropriate freeboard (in this case, 0.6 m). While this only approximates actual stopbanks, this approach is widely used for rapid modelling of options and is considered appropriate for options development, when alignments are being trialled.

A total of eight scenarios were modelled from the shortlist. For each scenario, berm lowering of 1.5 m was applied across the previous modelling extents for the section of the Waipaoa River between cross sections 33 and 38. As described in Section 5.1, above, each option was also modelled with 1 m of riverbed aggradation. The 2D hydraulic model used to evaluate the effects of raising and relocating the stopbanks also resolved superelevation of the flood water surface on the outside of bends and backwater effects from the increase or release of constraints to the flow.

The results of these models were compared to the base scenario (existing stopbanks) to generate flood difference maps, appended to this report in Appendix E. These show the change in modelled flood level relative to this baseline scenario. Note that in the baseline scenario, the township of Te Karaka is completely inundated by floodwaters in the design event, which is reflective of the significant flooding observed following Cyclone Gabrielle. The modelling outputs—including flood extents, depths, and differences—were used to inform the determination of appropriate stopbank heights and supplement material provided for community engagement. A summary of the main results relative to the modelled baseline scenario are as follows;

- An increase in modelled flood levels upstream of Kanakanaia Road Bridge in all scenarios, due to the flood flows through Te Karaka being redirected.
- Upstream modelled flood levels decrease the further back the stopbank alignment is placed away from the river channel, that is, Option 1 has the highest stopbank raising requirements and therefore the greatest upstream water levels and Option 4 the least.
- A decrease (complete reduction) in modelled flood levels within the Te Karaka township, within the area enclosed by the proposed stopbanks.
- An increase in bed level results in an increase in modelled flood levels across the entire reach.
- A slight increase in modelled flood levels for approximately 2 km downstream of Kanakanaia Road Bridge in all scenarios, with no changes further downstream.

5.3 Geomorphic interpretation of model results

The results of the hydraulic modelling for the two extreme stopbank alignments with aggraded bed level (Option 1A and Option 4A) were analysed to assess the geomorphic risks and tolerances for the project. These results were used to evaluate how different options may influence sediment movement, erosion and deposition, particularly through changes in flow velocity and shear stress—key drivers of geomorphic change. This analysis helped to identify areas where geomorphic effects may be intensified or mitigated depending on the stopbank configuration. These risks are summarised as follows;

- Option 1 presents the greatest potential erosion risk to the stopbanks, depending on construction methods and the velocities associated with sediment mobilisation, due to constraining flows and raising stopbanks by the greatest amount.
- Increased deposition is likely on the inside bend north of Te Karaka, with the extent of deposition influenced by how far the stopbank is set back from the active channel.
- Shifting the stopbank alignment further south results in greater reductions in velocity and shear stress in the active channel north of Te Karaka. This change is expected to promote sediment deposition in that area, which may gradually reduce the flood conveyance capacity of the Waipaoa River near Te Karaka over time. However, aggradation is already occurring in this part of the Waipaoa River, and retreating the stopbank further may allow this to occur without reducing the flood capacity as quickly as a stopbank close to the channel. Encouraging deposition to occur on floodplain areas will help to manage aggradation more sustainably and reduce aggradation pressure further downstream.
- Areas currently experiencing deposition may face exacerbated sediment build-up, particularly where in-channel velocities are reduced compared to present-day conditions.
- While the risk of river avulsion or the formation of new channels is low—due to the cohesive nature of the Waipaoa's banks at this location—it remains a possibility during extreme flood events, given the persistently high velocities in the active channel.
- Some localised scour may occur in areas no longer protected by the new stopbank alignments. Although, these zones generally show a tendency toward deposition.
- Immediately following a storm event, aggradation rates may spike due to increased sediment supply, increasing the risk of further deposition in flow expansion zones or erosion within the channel if a second event occurs in close succession.
- Ongoing channel aggradation is expected to continue in this reach, further limiting the river's capacity to convey floodwaters. While providing more space for flood flows may encourage sediment deposition in wider flow areas, this geomorphic response must be anticipated and planned for. In the future, maintaining effective flood risk reduction for Te Karaka will be increasingly challenging given the evolving geomorphic trajectory of the Waipaoa system.

5.4 Road raising

Feedback on the proposed road raising for all options, and input to the cost estimates, was sought from Waka Kotahi/NZTA.

Comment on the options and costs has not been received at the time of issue for this report.

6 Stopbank design approach

The shortlist options were based on high-level optioneering-stage designs. Stopbanks were represented by polylines in a Geographic Information System (GIS) overlaid on aerial imagery. The modelling approach used in estimating stopbank dimensions was high-level, although appropriate to this stage of design and cost estimation, where multiple options were still under consideration.

Stopbank heights were assessed by determining the nearest modelled water level from the DHI hydraulic model and applying the agreed freeboard of 600 mm. The ground level from a Digital Elevation Model (DEM), from which the existing stopbanks had been removed, was subtracted from the stopbank top level to estimate the height. This height was used in combination with the agreed stopbank geometry (Section6.3) to estimate the stopbank footprint and earthworks volume. Stopbanks have not been modelled in civil design software, although T+T recommends that this be done during more detailed design of the preferred option.

The following characteristics were adopted for the optioneering-level designs. These are subject to confirmation/refinement in the next stage of design but provided an appropriately conservative approach in the absence of more detailed modelling and design.

The estimation of stopbank volumes and footprints was used to inform the high-level cost estimates by T+T and the property strategy/costs report by The Property Group, both of which were provided to GDC separately from this report.

6.1 Berm lowering

Berm lowering involves stripping topsoil and excavating shallow sediment layers to a maximum depth of 2 m using an excavator across the river berm. Material will be loaded into trucks and transported to the stopbank construction site to be re-used in new stopbanks. It is assumed that this material will be suitable for incorporating into the new stopbanks (with mixing if necessary), however, this will be verified in detailed design. For cost estimation purposes, temporary works include approximately 800 m of access track and a loading area to support haulage and site access.

6.2 Stopbank material

The stopbank will be constructed using a homogeneous mixture of clays, silts, and sands from the river berms and potentially the reuse of the existing stopbank material. Again, it is assumed that this material will be suitable for bulk fill, however, this will be verified in detailed design. T+T understands that in May 2025, WSP labs collected three 2 m deep hand augers across the high berm on northern side of the existing alignment. The samples all showed that the material (cohesive clayey-silt) was suitable for stopbank construction fill.

6.3 Stopbank geometry

A standard GDC stopbank geometry was adopted for the shortlist concepts and cost estimation. This geometry is consistent with other recent stopbank projects on the Waipaoa River and is part of the funding agreement with the Crown for these works. Its key features (as shown in Figure 6.1) are:

- A 4 m crest width).
- 2 horizontal to 1 vertical batter slopes.
- Freeboard of 600 mm (as discussed in Section 3).
- Construction from silts and clays with no inclusion of gravels.
- No additional foundation treatment is to be applied, settlement from increased bearing is expected over time.

Note that as well as providing for access, the 4 m top crest also allows for a minor 'top up' of up to 500 mm to be easily added with widening of the stopbank footprint, if required in the future. A minor 50 mm crown is also added to the top crest to promote stormwater runoff and to mitigate ponding and saturation issues.

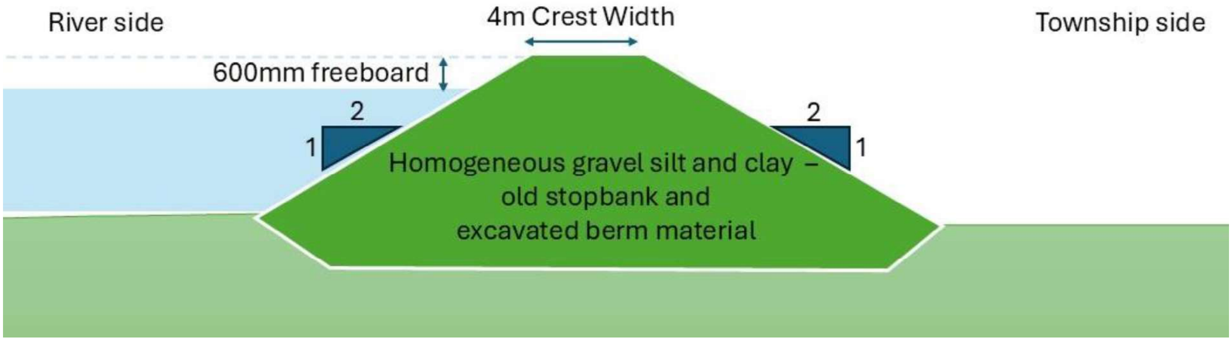

Figure 6.1: Typical detail of the new stopbank construction (not to scale)

7 Engagement summary

The following dates summarise the key engagement events undertaken throughout the project, including hui with mana whenua, the steering group, and wider community.

- **13 April 2024 – Community hui.** Presented the partially calibrated flood model outputs to the community for validation. Attendees were invited to provide feedback during the hui.
- **July 2024 – Steering Group Formation.** A Te Karaka community-led Steering Group of approximately 20 members was established, with representation from Lavenham and Branson Roads, along Matawai Road (from the Lavenham Road junction through Te Karaka Township and up to Mangamaia Road, Whatatutu).
- **7 August 2024 – Steering Group Hui #1.** The inaugural meeting of the Steering Group was held. Group tikanga and purpose were established. The calibrated Cyclone Gabrielle flood model was presented and discussed. Two modelling scenarios were introduced. Members were invited to consider and bring additional scenarios to the next hui for discussion.
- **13 August 2024 – Community Hui.** A brief update on the formation and progress of the Steering Group was shared with the broader Te Karaka community as part of a wider recovery-focused hui.
- **31 August 2024 – Steering Group Hui #2.** A representative from DHI (modelling specialist) attended this session. The Steering Group presented to Council their firsthand experiences of Te Karaka and surrounding area flooding. The results of three modelled scenarios were presented. The group discussed the current extent of the model and identified further scenarios for analysis.
- **27 March 2025 – Community Hui.** The concept of retreating the stopbank alignment was introduced early. At least seven longlist alignment options were discussed.
- **30 April 2025 – Community Hui.** Four shortlist alignment options were presented for community consideration and feedback.
- **29 June 2025 – Community Hui.** Two final alignment options were presented and discussed. The online Council webpage and submission portal was also promoted.
- **24 July 2025 – Community Workshop.** Community drop-in hui – an adjusted alignment based on the community feedback received at that point in time was presented for discussion. Attendees were encouraged to complete the online feedback in advance of the close date.
- **28 July 2025 – Online Feedback Closed.** The online Council webpage and submission form for community feedback closed at 9am.
  - **21 August 2025 –** Gisborne District Council Meeting. Submission and discussion of the Te Karaka Report by Council officers.

7.1 Key engagement events since Cyclone Gabrielle

Community engagement by GDC officers has been ongoing and multi-staged. Following an initial hui with the community on 13 April 2024, the Te Karaka community met in July 2024 to form a steering group of around 20 community members, with representation from Lavenham and Branson Roads, along Matawai Road from the Lavenham junction through to Te Karaka township then up to Mangamaia Road Whatatutu. Further hui took place on 7 and 31 August 2024 (with the Steering Group) and on 13 August 2024 (with the wider community). At these meetings, the community shared its experiences of flooding in Te Karaka. Group tikanga, purpose, optioneering approach and the modelling extent and scenarios were also discussed. There was then a gap of seven months while GDC worked up initial options, which were then modelled by DHI, in order to bring these back to the community.

Initial optioneering discussions commenced during a hui on 27 March 2025, where at least seven of the 'initial longlist' options were presented. The possibility of retreating the stopbank was raised at this time. This first hui was followed by a second hui on 30 April 2025, during which the four shortlisted options were shared with the community.

At a meeting with community representatives at GDC's offices on 11 June, two key themes emerged:

1. Mana whenua (Te Aitanga a Māhaki) representatives felt that GDC and T+T should not be assessing criteria relating to Te Ao Māori (such as Te Mana o te Wai, or other cultural values) and rather, these should be commented on by the community.
2. Those present strongly supported either Option 3 or Option 4 (the two most retreated options) and requested that these be the only two options taken forwards for in-depth consultation with the wider community.

The final two alignment options (Option 3 and Option 4) were presented at a community hui on 29 June 2025. At this hui, there was a strong desire for a retreated stopbank alignment and a preference for Option 3, due to it protecting more land, more houses and the oxidation pond.

In addition to in-person engagement, an online Council webpage and submission form were made available before and after the final hui to facilitate broader community input. Direct engagement with potentially affected property owners has continued since the initial longlist stage through phone calls, emails, meetings, and informal discussions. These discussions have primarily been around the areas of potential impact, which include changes in alignment, backwater effects, downstream influences, and properties located on the true left of the river near the scheme, including elevated areas near Kanakanaia Bridge.

7.2 Mana whenua engagement outcomes

The project has been delivered in partnership with Te Aitanga a Māhaki and included extensive consultation with tangata whenua. Key engagement milestones include hui with local iwi and the formation of a community steering group. The co-design approach, and the incorporation of feedback into the development and refinement of stopbank alignment options, supports active Māori participation in governance processes.

Rangatiratanga was demonstrated through early and ongoing engagement with Te Aitanga a Māhaki as a project partner, as well as with Māori landowners affected by the proposed stopbank retreat. GDC has expressed that it does not wish to purchase land in order to build or upgrade stopbanks, unless this is the preference of landowners. This aligns with the principles of Te Ture Whenua Māori Act and upholds mana whenua authority.

The community steering group structure enabled community-led input into the hydraulic modelling and optioneering, ensuring tangata whenua had meaningful influence over the direction of the project.

The project promotes equity by addressing systemic flood risks that affect a community disproportionately impacted by Cyclone Gabrielle, with a predominantly Māori population. The strategy to retreat the stopbank and restore natural river processes enhances community resilience, improves public safety and wellbeing, and aligns with the principles of Te Mana o te Wai, which prioritises the health and wellbeing of water bodies and the communities connected to them.

Te Aitanga a Māhaki have been active partners in Te Karaka Flood Resilience Improvement Project since its inception. Engagement has extended beyond consultation, to a co-development model, including participation in steering groups, hui, and optioneering discussions. This collaboration reflects a genuine commitment to honour mana whenua status and integrate their aspirations into flood resilience planning.

7.3 GDC online feedback

Responses from the online feedback submission form on GDC's website is summarised as follows:

- 97% of respondents supported Council taking action to improve flood resilience for Te Karaka.
- 74% of respondents support the 'make room for the river' approach of retreating the stopbank alignment.
- 53% supported Option 3, 28% preferred 'Other' and only 5% supported the more retreated Option 4.

8 Shortlist MCA and preferred option decision

The same MCA approach was used to guide the selection of a preferred flood mitigation option from the shortlist, following a process recommended by T+T and adopted by GDC. The intended process involved:

1 A workshop with GDC staff and mana whenua representatives to collaboratively score each option.
2 Summing scores across evenly weighted criteria to determine overall performance.
3 Applying alternative weighting scenarios as sensitivity analysis to reflect diverse values.
4 Using the results to inform GDC's preferred option selection.

During the initial MCA workshop (11 June 2025), as described in Section 7.1, participants requested that GDC not score criteria relating to Te Ao Māori and expressed a preference for taking Options 3 and 4 to the community for consultation. It was agreed that GDC would separately score the remaining criteria, as well as considering cost, to ensure completeness of the process for arriving at a preferred option.

As a result, a revised scoring workshop was held on 26 June 2025 with GDC (Joss Ruifrok, Dean Foote) and T+T (James Flanagan, Nicole Cameron, Mark Hooker). All categories were scored except for the Community/Stakeholders category, which was reserved for community and mana whenua input, as agreed on 11 June 2025. Thus, any discussion of these additional criteria is not included in this report.

The MCA assessed four shortlisted options (Options 1–4) using updated information, including flood modelling, landowner feedback, geomorphology assessment, and NZTA engagement to date. Previous scores from the longlist MCA were revisited and revised accordingly. Cost estimates were excluded from the scoring. The scoring criteria for the revised scoring workshop is shown in Table 8.1.

Table 8.1: Shortlist to preferred option MCA workshop criteria and guidance

Category	Criteria	Suggested guidance
Delivery	Feasibility	How easy is the option to build/implement?
	Consentability	How easy would it be to gain consent to complete the works for the option?
Long term	Sustainability	Is the option sustainable for the community? Including consideration of renewal/maintenance needs, residual risk, aggradation trends etc.
Environment	Environmental	How does the option affect the environment (ecology and landscape)?
	Natural Processes	How does the option impact natural river processes, including erosion, aggradation and other geomorphic pressures in the catchment?
Flood benefits	Flood risk reduction to residential properties	How does the flood hazard associated with the option impact residential properties and people?
	Flood risk reduction to other assets	How does the flood hazard associated with the option impact other assets (critical infrastructure and productive land)?

The scores from the workshop are presented in Table 8.2 below.

Table 8.2: Summary of finalised MCA scores from the shortlist to preferred option workshop

Category	Criteria	Option 1	Option 2	Option 3	Option 4
Delivery	Feasibility	2	1	1	1
	Consentability	2	-3	-2	-3
Long Term	Sustainability	-3	-1	1	2
Environment	Environmental	0	0	0	0
	Natural Processes	-1	1	2	3
Flood Benefits	Flood risk reduction to Residential Properties	2	2	2	2
	Flood risk reduction to Other Assets	-1	-1	1	-3
TOTAL SCORE		0.1	0.1	0.7	0.3

A radar plot (Figure 8.1) was produced to visually compare how each of the four shortlisted options performed across the full set of MCA criteria. In this plot, options positioned closer to the centre indicate lower (more negative) scores, while those extending toward the outer edges reflect stronger (more positive) performance. The plot clearly illustrates that Option 3 scored more positively across the criteria than the other options, because it occupies more space overall.

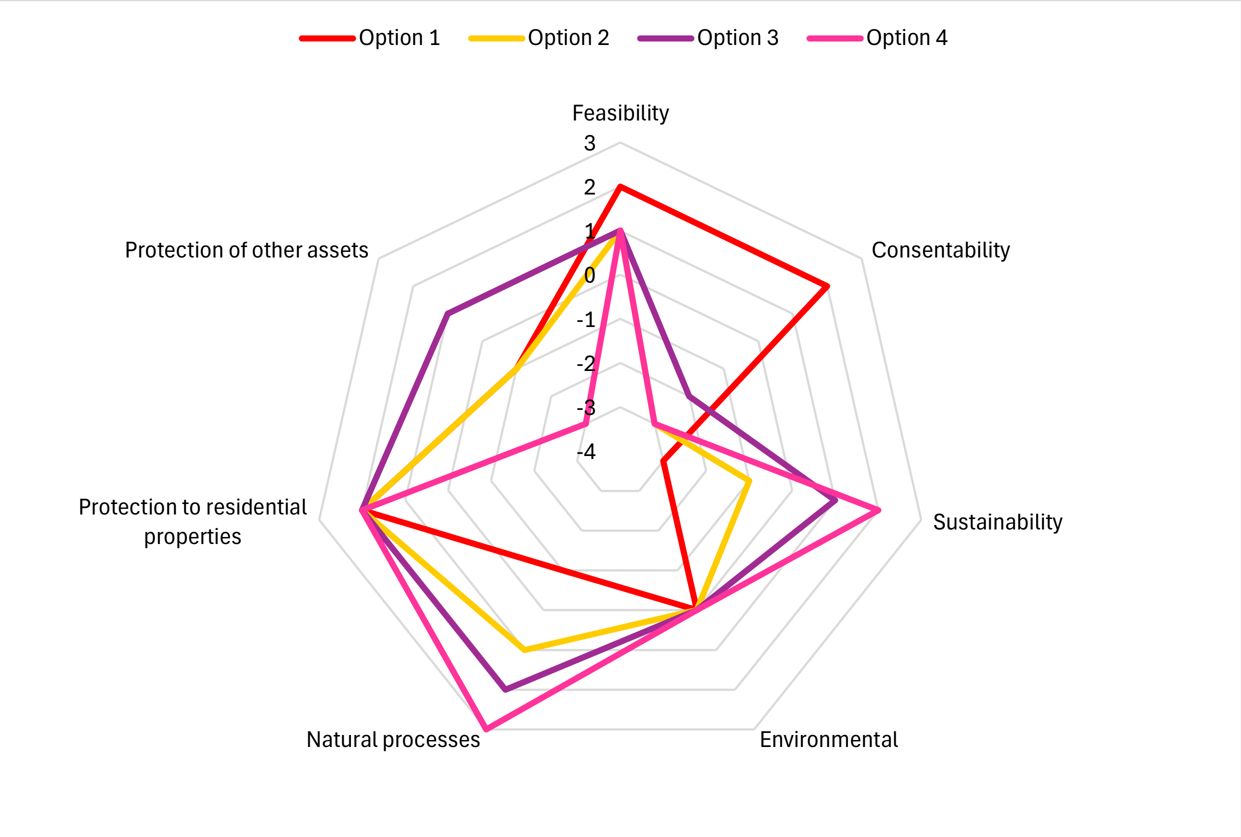

Figure 8.1: Radar plot of MCA scores from shortlist to preferred option workshop. The line colours in the plot match the option alignment maps in Section 4.2

8.1 Scoring rationale and option scoring summaries

All four options were assessed using a consistent set of criteria (Table 8.1). While all options were considered technically feasible and offered flood risk reduction to residential properties, none were considered straightforward or fully sustainable in the long term. Cost was excluded from the MCA scoring at this stage. Key comments included:

- **Delivery**: There is need for Māori land considerations across all options, with greater complexity for new alignments (increasing complexity from Option 1 to Option 4). All options are viable, with Option 1 being the easiest to implement due to its existing alignment.
- **Environment**: Options 3 and 4 align better with natural processes but even they are best viewed as medium-term solutions, due to aggradation trends reducing channel capacity over time.
- **Natural Processes**: Retreated stopbanks may increase aggradation across the floodplain at Te Karaka but reduce it downstream.
- **Residential Impact**: All options scored positively, as most properties are protected despite some trade-offs in increased/decreased flood levels or properties being outside the protected areas. All four shortlisted options significantly reduce the risk to life from flooding, by protecting the township from flooding to a much higher level than at present (while noting residual risk remains, see below). There was little difference assessed between the four shortlisted options in terms of risk to life.
- **Long-term sustainability**: All four options have similar residual risk implications in terms of creating an “island” of flood-free land with a high consequence of flooding, should a stopbank overtop (from an above-design event) or fail. Initially, Option 1 was considered to be fatally flawed due to the degree of stopbank raising required and the perception of perched floodwaters posing a considerable residual risk if a stopbank breach or overtopping occurred. However, during the workshop this was revised to "heavily risky" after noting that existing downstream stopbanks in the Waipaoa scheme are very high and similarly perched. Option 4 is the least risky in this sense, as it has the lowest stopbank heights. Long-term aggradation trends mean that stopbanks close to the river are likely to lose their capacity faster than those further retreated; this, and the stopbank height factor noted above are reflected in the scoring of this criterion.

The following sections outline the detailed scoring rationale from the 26 June MCA workshop.

8.1.1 Option 1

- **Consentability**: Easiest to consent and deliver. Minimal direct stakeholder impact beyond the increased stopbank footprint. This is reflected in the ‘+2’ score, when compared to the other options (negative).
- **Environmental/Natural Processes**:
  - Environmental: Neutral – significant impacts on water quality/ecological habitat etc. only occur during extreme floods and are similar for all options.
  - Natural Processes: Scored ‘-1’ due to inhibiting geomorphic processes. This option does not accommodate riverbed level changes or provide additional room for the river.
- **Protection of Residential Properties**: Comparable to other options; protects a great number of properties but worsens conditions upstream (to the greatest degree of all options). There are 194 buildings including businesses within the proposed scheme (GDC 2025). All options scored a ‘+2’ for this criterion due to the small number of impacted properties (either exposed to flooding by the option or experiencing a higher flood water level) in comparison with the number for whom the risk is substantially reduced.

- **Protection of Other Assets**: Scored '-1' - No improvement; backwater effects to the roading network (highway, bridges, local roads) remain.
- **Feasibility**: Scored '+2' – easiest to implement as the alignment is the same as existing.

8.1.2 Option 2

- **Consentability**: Lower compared to Options 1 and 3 due to the highway spillway, which is unlikely to be able to convey significant water volumes but nonetheless has a significant impact on the highway (generally this was considered a less effective alternative to Option 3).
- **Environmental/Natural Processes**:
  - Environmental: Neutral - significant impacts on water quality/ecological habitat etc. only occur during extreme floods and are similar for all options.
  - Natural Processes: Scored '+1' – provides more room for the river so is better than no change (0). However, doesn't allow for natural processes as much as Options 3 and 4.
- **Protection of Residential Properties**: Similar to other options; some areas benefit while others are newly exposed.
- **Protection of Other Assets**: Scored '-1' - worsens access to community during flood event.
- **Feasibility**: Scored '+1' – more complex to implement than Option 1, so slightly less feasible, although the stopbank alignment is mostly the same as existing.

8.1.3 Option 3

- **Consentability:** Scored '-2' – more retreat than Option 2 but without the difficulty of the State Highway spillway, so this was scored similarly. Still significant land and stakeholder impacts.
- **Environmental/Natural Processes:**
  - Environmental: Neutral - significant impacts on water quality/ecological habitat etc. only occur during extreme floods and are similar for all options.
  - Natural Processes: Scored '+2' – better alignment with natural river processes and provides more room for the river when compared to Options 1 and 2.
- **Protection of Residential Properties:** Similar to other options; most areas benefit while others are newly exposed.
- **Protection of Other Assets:** Scored '+1' - Improves conditions around Kanakanaia Bridge by allowing water to bypass, as well as protecting the oxidation pond (unlike Option 4)
- **Feasibility:** Scored '+1' – more land acquisition and engineering required compared to Option 1 but still technically viable.

8.1.4 Option 4

- **Consentability**: Lower compared to Option 1 and 3 – significant opposition from landowners and increased area that is not inside the stopbank.
- **Environmental/Natural Processes**:
  - Environmental: Neutral - significant impacts on water quality/ecological habitat etc. only occur during extreme floods and are similar for all options.
  - Natural Processes: Scored 3 – maximises space for river processes and accounts for bed level changes within the river.

- **Protection of Residential Properties**: Similar to other options; some areas benefit while others are newly exposed.
- **Protection of Other Assets**: Scored '-3' due to need to relocate oxidation pond.
- **Feasibility**: More land acquisition and engineering required compared to Option 1 but still technically viable.

8.2 Scoring sensitivity

A sensitivity analysis was undertaken as part of the 26 June MCA workshop to assess the robustness of the scoring outcomes under varying weighting scenarios. A range of alternative weightings were applied to the MCA criteria to evaluate how changes in the relative importance of criteria affected the overall alignment rankings. This process provided insight into the influence of individual criteria on the final scores and helped ensure that the preferred alignment options remained consistent across a range of plausible weighting assumptions. It was found that Option 3 scored consistently high in relation to the other options, across a range of reasonable sensitivity weightings (typically a 200% or 300% weighting on a particular criterion or pair of criteria).

9 Preferred option

On 24 June 2025 a community meeting was held at Te Karaka School for Council staff to present the proposed stopbank alignment based on all feedback and comments received to date. The alignment presented was a modified version of 'Option 3'. There was general agreement on the option presented to the approximately 40 attendees.

Following the closing of online submissions on the two shortlisted options on 28 July 2025 (along with the other engagement undertaken by GDC and described in Section 7), GDC officers confirmed that Option 3 (refer to Figure 9.1 for the proposed alignment) was the preferred option for both them (from a technical perspective) and the community. Option 3 will be recommended to Councillors on the 21 August Full Council meeting for adoption as its preferred option, on the basis that:

1. Option 3 clearly scored the highest in an MCA of a number of "technical" factors (not including the 'community' criteria, which were to be assessed separately by the community/mana whenua). The MCA highlighted Option 3's key advantages, including its ability to provide more room for the river and support natural processes, while also protecting critical infrastructure by reducing pressure on Kanakanaia Bridge and lower backwater effects relative to less-retreated alignments, and maintaining protection for the oxidation pond.
2. Feedback at hui with the community and with Te Aitanga a Māhaki representatives was in favour of Option 3.
3. Online submissions favoured Option 3.

Cost has also been assessed but has not been part of the assessment above and the recommendation on the preferred option. Cost estimates will be presented to Council alongside this report and recommendation.

Minor changes were made to Option 3 during the shortlist development and community engagement processes. These consisted of:

- Aligning the route more closely with property boundaries.
- Avoiding the need to traverse Māori Reservation Land.
- Incorporating feedback from a property owner to refine the alignment.
- Protecting an additional house through a small route modification.
- Better tying the stopbank into adjacent high ground.

These changes are shown on Figure 9.1 below. These changes will form part of the preferred option and be taken to the next stage of design, should this option be adopted by Council.

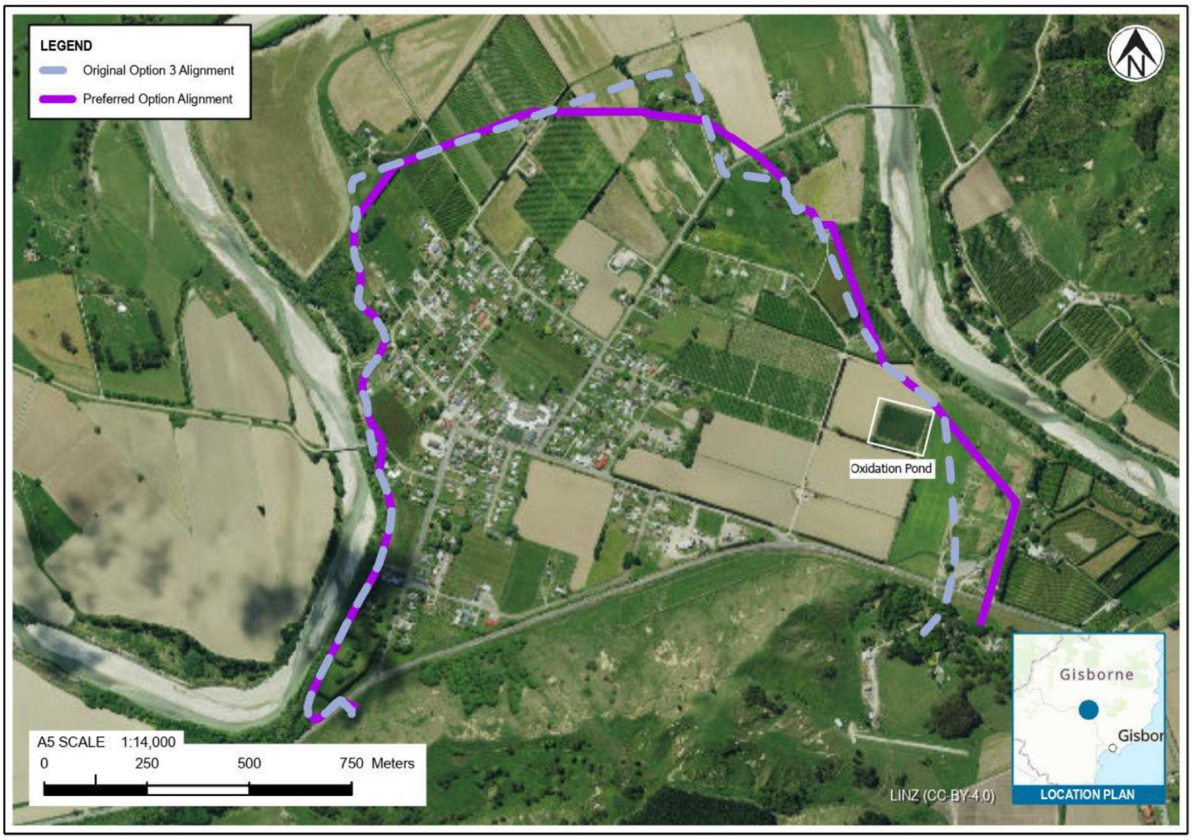

Figure 9.1: Changes to the alignment of Option 3 during the optioneering process.

Part of the stopbank alignment traverses high ground, resulting in a part of the alignment where no stopbank may be required; this is indicated on the maps in Appendix E. If existing high ground is to be relied on for flood protection, GDC may need to consider legal instruments to protect this ground from any future lowering.

Given the ongoing aggradation trend in the Waipaoa River, coupled with uncertainties surrounding the effectiveness of proposed land use changes, policy developments, and the impacts of climate change, the construction of a new stopbank may be best viewed as a medium-term (i.e. several decades) flood risk reduction measure for Te Karaka, rather than a long-term (century-scale) solution. However, the new, retreated alignment provides a better response to the flood risk than a stopbank close to the river, because:

- The retreated alignment allows more room for flood flows. This lowers flood velocities and spreads floodwaters out, which may also help by restoring some floodplain storage/attenuation.
- The retreated alignment has lower stopbank heights, resulting in a lower residual consequence of failure (threat to life risks) when/if stopbanks are overtopped, or perhaps allowing more potential for future raising, if necessary, as there is more room available on both sides.

The additional time that is 'bought' by the stopbank upgrade allows for a further conversation about the ongoing flood risk and planning for how it should be mitigated, as well as catchment management improvements and policy changes around how we manage unsustainable hill country to counter future erosion and aggradation trends. Emergency management planning will have to reflect the possibility of the area inside the stopbank being flooded in the case of a stopbank failure or overdesign event, and the lack of access to the community during a large flood.

It is also important to note that Gisborne District Council (GDC) has established a Transition Advisory Group (TAG) tasked with developing guidelines to support the shift from existing unsustainable land use practices within the catchment to the implementation of permanent vegetative cover across all land uses. While this initiative falls outside the direct scope of this project, it remains a critical consideration within the broader context of the Waipaoa catchment and the Tairāwhiti region's long-term strategy.

9.1 High-level programme

The following "working programme" in Figure 9.1 has been provided by GDC, with input from T+T.

Table 9.1: High-level programme outline

Date	Action/Milestone	Comments
Now/late 2025	Concept design	Rough order costs.
Late 2025	Securing funding for Te Karaka Flood Resilience Improvements	Reallocation of funds between resilience projects under the approved flood resilience programme. Securing funds.
Late 2025/early 2026	Consent level design	Updated alignment and modelling, stopbank design and bridge risk analysis.
Early/mid-2026	Property negotiations	Engage with owners, negotiations, instruct valuations, reach agreements for general land. Ongoing engagement with owners/trustees of Māori land.
Early/mid-2026	Lodgement of resource consent	Timing to be concurrent with property negotiations.
Mid-late 2026	Detailed design	Construction drawings, geotechnical assessments, technical specifications, engineers estimate.
Late 2026	Tendering and procurement	Tendering and contract award.
Late 2026/early 2027	Start construction / delivery	Completion of physical works. Risk that this may take two construction seasons.

10 Applicability

This report has been prepared for the exclusive use of our client Gisborne District Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

We understand and agree that our client will submit this report as part of an application for resource consent and that Gisborne District Council as the consenting authority will use this report for the purpose of assessing that application.

Tonkin & Taylor Ltd
Environmental and Engineering Consultants

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
....	....
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Reviewed by: James Flanaghan (Senior Water Resources Engineer) and Mark Hooker (Principal Water Engineer)

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