Consequences of avulsion of the George River and potential management options

PRELIMINARY REPORT

February 2024

Alluvium recognises and acknowledges the unique relationship and deep connection to Country shared by Aboriginal and Torres Strait Islander people, as First Peoples and Traditional Owners of Australia. We pay our respects to their Cultures, Country and Elders past and present.

Artwork by Melissa Barton. This piece was commissioned by Alluvium and tells our story of caring for Country, through different forms of waterbodies, from creeklines to coastlines. The artwork depicts people linked by journey lines, sharing stories, understanding and learning to care for Country and the waterways within.

This report has been prepared by Alluvium Consulting Australia Pty Ltd for [CLIENT NAME] under the contract titled '[INSERT CONTRACT NAME]'.

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Cover image: Sand accumulations in the lower George River

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1 Introduction

1.1 Project scope

The lower George River Trust and Break O'Day Council received funding to investigate the socioeconomic impacts of an avulsion of the lower George River. The first stage of this work (Water Technology 2022) identified the likely locations that the George River may breakout from the current alignment. That first stage is being used as an input to the second and main stage (this project); appraising the possible consequences of an avulsion and compiling management options to minimize those consequences.

Alluvium Consulting has been engaged by the Break O'Day Council to undertake an assessment of the socioeconomic impacts of river channel break-out scenarios for the lower George River floodplain and neighbouring St Helens. This report outlines the likely scenarios for the new course of the lower George River and the potential impacts of a new river alignment on the wider community in the Break O'Day Council region. A suite of potential management options to mitigate the consequences that would arise from a river avulsion is presented.

1.2 Project area

The lower George River is located immediately downstream of a steep gorge and flows across a large delta complex (the George River floodplain) before draining into the Georges Bay. Evidence of previous avulsions that have occurred over the last several thousand years can be found in the form of abandoned river channels across the floodplain. This project also considers the indirect impacts avulsion across the George River floodplain would have on the wider region.

2 What is an Avulsion and why it occurring on the George River?

Avulsion is the process of abandonment of a waterway channel in favour of a new, more hydraulically efficient channel. The term avulsion refers to both the progressive processes of channel abandonment and new channel formation (which may occur over several decades or even a century), and the final, potentially very rapid, switching of a waterway course from the old to the new channel (i.e. the avulsion 'event' that connects the two channels).

The new course may be a channel scoured from the floodplain during a series of floods or may be an existing channel on the floodplain that is re-occupied. In the George River floodplain, a combination of new channel scouring and re-occupation of former (and much older) channels of the George River will determine the alignment of a new course of the George River following avulsion.

The George River avulsion is occurring because the capacity of the lower George River to transport sediment and convey larger flows is decreasing over time. As the capacity of the George River decreases, the river becomes increasingly likely to change its course in favour of an alternative course that is straighter, steeper and more efficient.

The decrease in capacity (also termed hydraulic efficiency) is driven by the steady decrease in channel slope as sediment deposited at the mouth of the George River extends into Georges Bay, lengthening the river (this process is summarised in Figure 1). The natural accumulation of sediment in the lower George River, and the steady rise in bed level, has been accelerated by increased sediment inputs to the reach, derived from historic mining in the upper catchment. That historic mining generated a large pulse of sand sized sediment (often termed a sand slug) that is currently migrating into the lower George River (Water Technology, 2018).

As sediment accumulates in the bed of the George River, high flows are displaced from the river and spill across the floodplain more regularly. Flow spilling from the George River deposits sand, forming an alluvial ridge along the banks of the George River that perches the bed of the George River above the surrounding floodplain. This mismatch in elevation across the valley, shown in Figure 2, makes an avulsion of the George River inevitable.

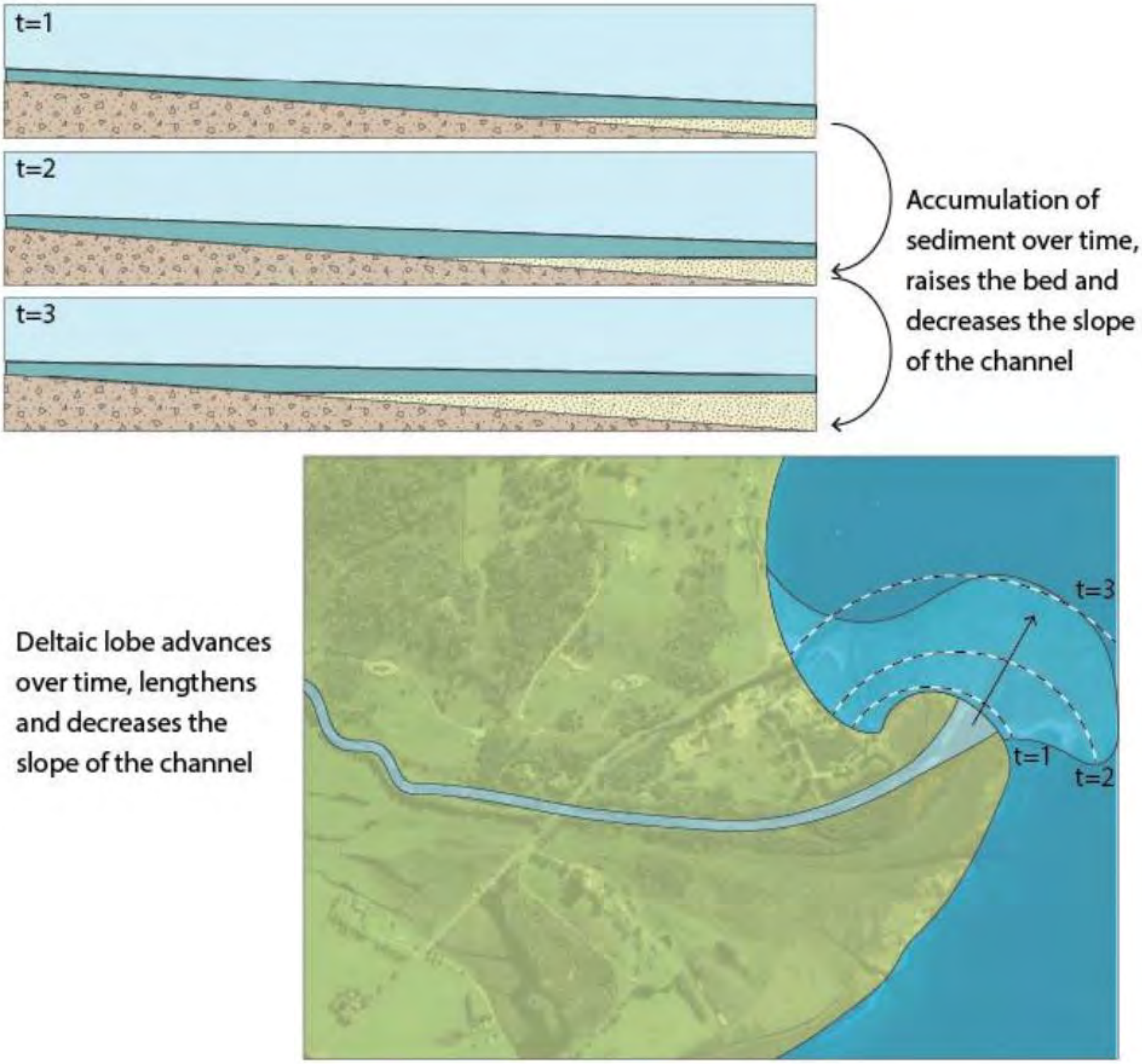

Figure 1. *The progression of a deltaic lobe at the mouth of the Goerge River and its impact on channel slope. Figure from Water Technology, 2022.*

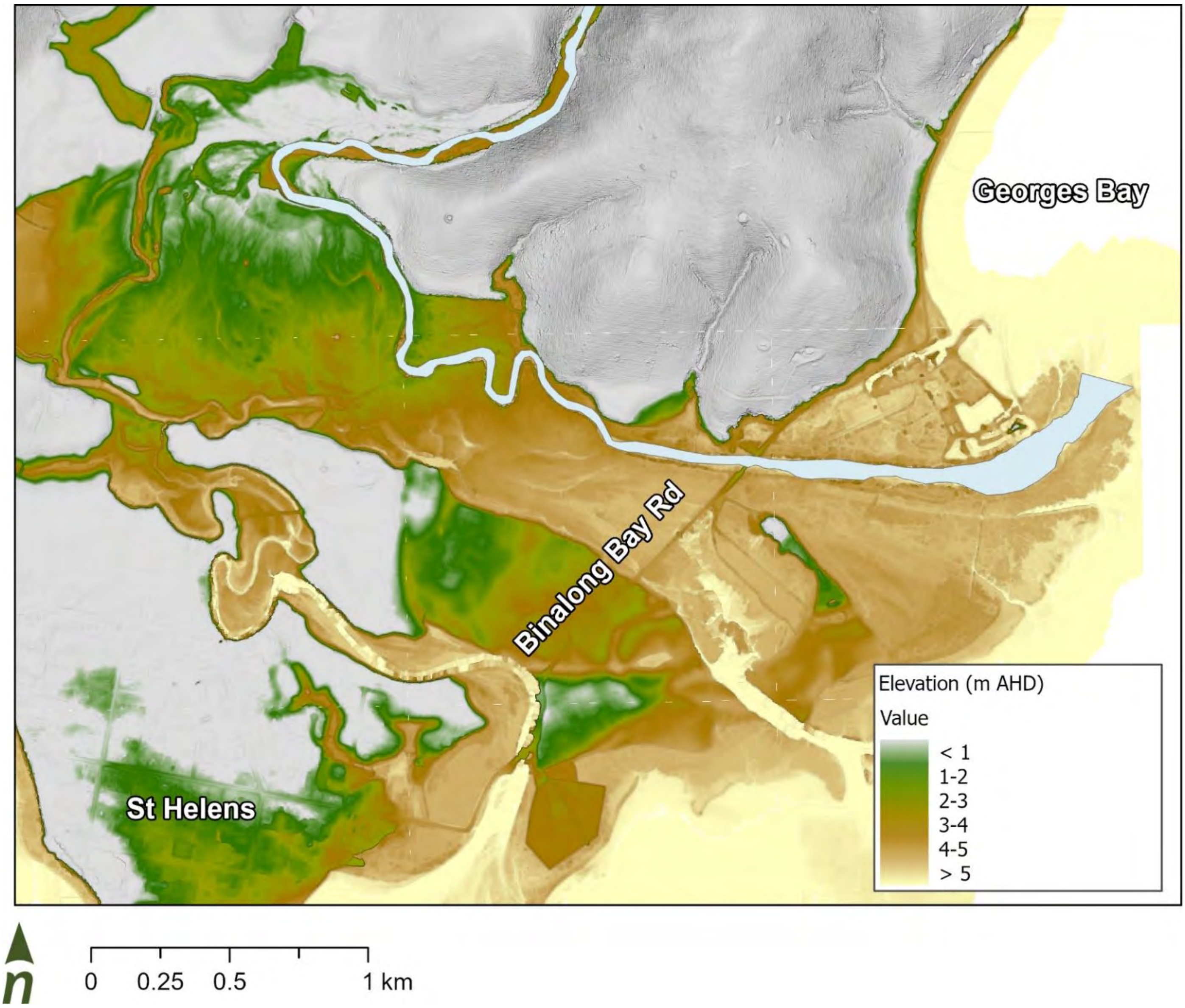

Figure 2. *A elevation map of the George River floodplain.*

The relationship between avulsion and floods

Floods drive both the gradual decrease in capacity of the George River and provide the flows that scour the floodplain and enlarge older, existing channels. Floods also act as the final 'trigger' for completion of the avulsion cycle when the George River fully connects with the new channel. However, the risk posed by flood inundation (flooding) is fundamentally different to the risk posed by an avulsion, triggered by a flood event.

Flood hazards include inundation, damage to assets by fast moving waters or flood debris and blocking of road access by flood water.

The primary hazard arising from an avulsion is the complete loss of land to erosion. Erosion caused by an avulsion may also deliver large volumes of sediment to Georges Bay, which has the potential to impact oyster farming operations.

While flood inundation and avulsions are closely related to flood events, they are different and as a result different approaches are required to manage the risks they pose to assets and waterway condition.

3 Where will the avulsion occur?

An assessment conducted by Water Technology (2022) identified four potential alignments of the George River following avulsion. Each of the new river alignments identified, termed avulsion scenarios, consists of a breakout point on the George River and a new channel that will be scoured on the floodplain. The newly scoured channels feed into one of several former channels on the floodplain and then follow the alignment of those old channels to Georges Bay. Each of the four scenarios is briefly summarised below.

Scenario 1

In the first scenario, the current alignment of the lower George River is maintained, and no avulsion occurs. This scenario is used as a base case with which the consequences of other avulsion scenarios can be compared. This scenario is considered unlikely to occur over the long-term, as a change in river course becomes more likely with time. Under this scenario, bed aggradation will continue in the lower reaches of the George River, which will force flow out of the channel and lead to sediment deposition and scouring of the floodplain.

Scenario 2

Under this avulsion scenario, the lower George River breaks out approximately 700 m upstream of Binalong Bay Road. A new channel of approximately 300 m in length is formed between the breakout point and a prior river channel. Downstream of the breakout point, the lower George River will flow through the new channel and into the prior channel. This scenario is considered the most likely scenario and is expected to occur within a 30-year timeframe.

Scenario 3

Under this avulsion scenario, the lower George River breaks out approximately 2 km upstream of Binalong Bay Road. A new channel of approximately 400-500 m length forms across the floodplain to link the breakout point with a prior channel. The lower George River will flow from the breakout point, through the new river channel, and down a prior river channel to reach Georges Bay. Two prior channels have the potential to be reoccupied; one of these prior channels hugs the perimeter of St Helens proper, while the second channel flows primarily through agricultural lands at in the middle of the floodplain. Floodplain scouring and new channel development is expected to occur over a 10-year timeframe.

Scenario 4

Under this avulsion scenario, the lower George River breaks out in the vicinity of Binalong Bay Road and occupies a prior channel that runs adjacent to Binalong Bay Road to Georges Bay. This scenario is considered the least likely and is not expected to cause the complete abandonment of the current channel.

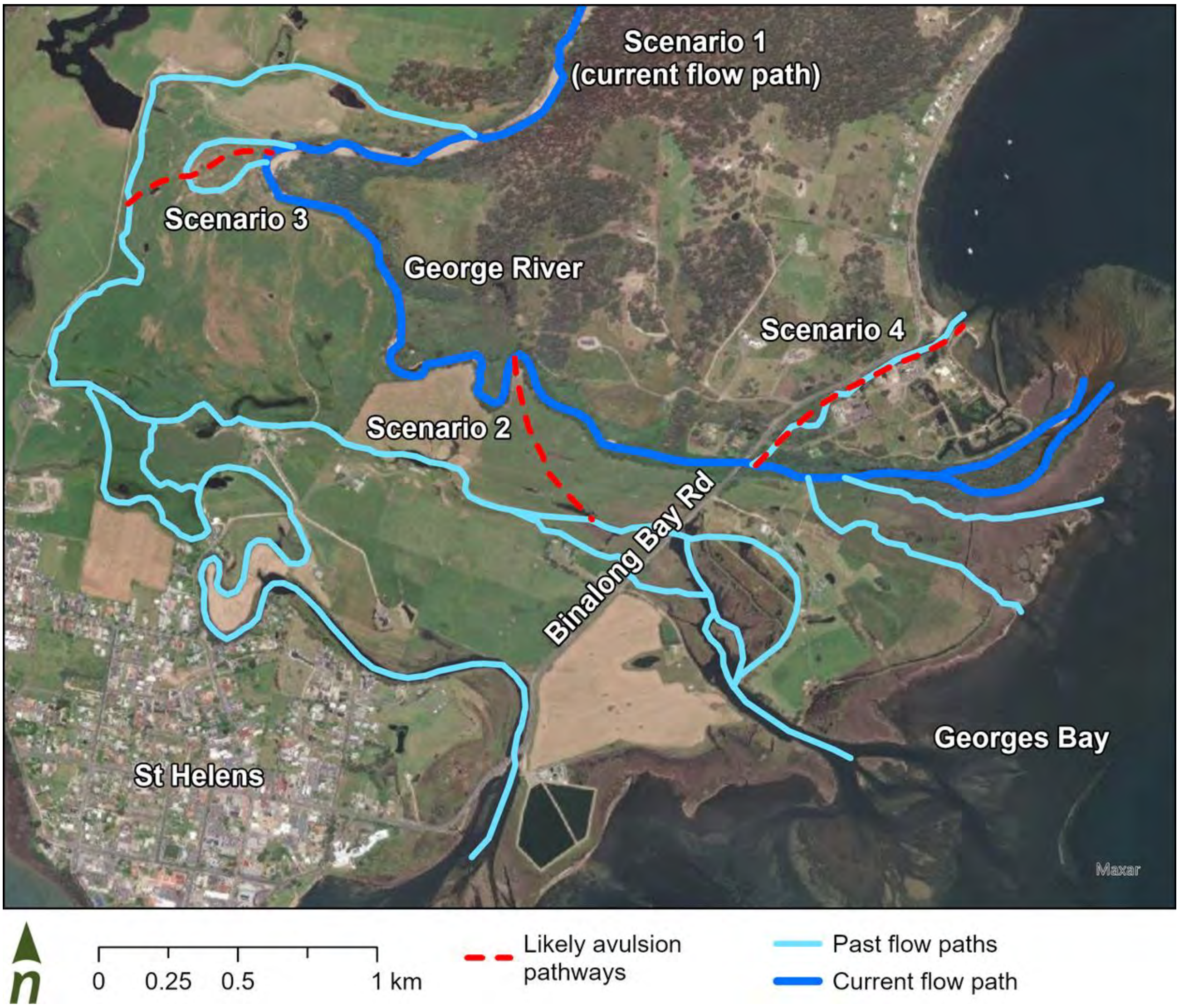

Figure 3. *Overview of the four avulsion scenarios. Red dashed lines are liekly alignments of newly scoured channel on the floodplain and light blue lines are channels that may be re-occupied by the George River following avulsion.*

4 When will the avulsion occur?

It is not possible to predict with high certainty when the George River avulsion will occur but without intervention, the likelihood of avulsion increases over time. Avulsion of the George River may occur over several decades, as the George River is progressively abandoned in favour of one of the alternative flow paths shown in Figure 3, or very rapidly during a single flood (or a series of floods that occur in quick succession). How quickly the George River avulsion develops will depend on:

- **The magnitude and frequency of flood events.** Floods drive the avulsion process, so larger and/or frequent floods will accelerate the avulsion process.
- **Sediment supplied to the lower George River.** Sediment accumulating in the bed of the George River is elevating the channel above the surrounding floodplain. The greater the supply of sediment, the faster the existing channel will fill and the more likely an avulsion.
- **Colonisation of the channel banks by willows**. Willows trap sediment and promote channel contraction.
- **Channel blockages in the lower George River.** Channel blockages force floodwater to spill from the parent channel and concentrate in developing daughter channels. Blockages may arise due to large wood jams in the channel, beds of willow on the channel bed, pulses of sediment causing rapid

streambed aggradation, or bank collapse that dams the channel. (Typically associated with spontaneous channel avulsions).

- The removal of floodplain vegetation. Floodplain vegetation decreases the velocity of floodwaters and limits floodplain scour. Removing floodplain vegetation promotes scour and channel development.
- Management interventions in the lower George River. If, how, when and where management interventions are implemented in the George River or the surrounding floodplain will change the rate of sediment accumulation in the George River or the potential for scouring of floodplain channels.

Climate change projections for the east coast of Tasmania include increased rainfall intensity, run-off, and sea level rise. These changes will exacerbate flood hazard on the lower George River floodplain and will act to accelerate the avulsion process. Therefore, while it is possible that a large flood in the near future could trigger the avulsion, the avulsion is more likely to develop over the coming decades.

For all scenarios, it is important to note that the likelihood of an avulsion event occurring is determined by the frequency, intensity, and timing of future flooding events. Therefore, predicting the timing and evolution of an avulsion is difficult and has large uncertainties.

5 What are the likely consequences of avulsion?

Avulsion of the George River will have near-term and medium-term consequences for assets and livelihoods on the George River floodplain, on communities that rely on Binalong Bay Road for direct access to St Helens and the east coast and on industries in Georges Bay (e.g. oyster farming, recreation, and tourism). This section summarises the consequences of avulsion of the George River for these stakeholders, for each of the four scenarios outlined in section 3. This consequences assessment will be used in conjunction with the likelihood assessment (already completed) to describe the risk that each avulsion scenario poses to the George River floodplain and nearby communities.

The description of consequences has been written as 'storylines', which describe the consequences of each scenario, who is impacted by those consequences and how these consequences will emerge and evolve over time. A more detailed breakdown of consequences according to each industry, area, or stakeholder affected is provided in Table 1.

The main consequence of an avulsion is an expansion of a newly formed floodplain channel and the abandonment of the existing course of the George River. As the avulsion unfolds the new floodplain channel, and the old course of the Goerge River that is reoccupied, will become deeper and wider, to accommodate the water and sediment delivered to this 'new' channel. The alignment of the new channel and its deepening and widening are the largest determinates of consequences for infrastructure, livelihoods and the environment.

Which of the multiple consequences described in this section materialise and at what time depend on:

- Which of the four avulsion scenarios occurs (or some fifth scenario).
- The rate at which the avulsion process unfolds. If the avulsion process proceeds more slowly than the most likely alignment of the new channel can be identified with more certainty, allowing more targeted management responses.

Scenario 1

Under Scenario 1, or the business-as-usual scenario in which no avulsion occurs, the changes in the George River that are driving avulsion will continue. Sediment will continue to accumulate on the channel bed and willows on the channel banks are likely to spread inwards, colonising islands in the channel. Sand splays, which are large lobe-like deposits of sand that emanate from breakout points on the right bank of the George River will continue to grow, and new splays will emerge over time. It is likely that flooding from high flows in the George River will become more frequent over time. The increase in flow spilling from the channel is driven by an increase in the magnitude and frequency of rainfall due to climate change, and the continued reduction of channel capacity in the George River due to sand accumulation.

The impacts of a continuation of the status-quo will predominantly be felt by landholders on the George River floodplain and users of Binalong Bay Road.

Flooding from the George River already impacts Binalong Bay Road, making the road either hazardous or temporarily impassable due to inundation. Under scenario 1, these flood impacts will become more frequent and possibly more severe over time.

Residential properties that currently experience flooding from the George River during high flows can continue to expect to be inundated by future floods, which may lead to damages. Livestock on agricultural lands will be displaced by the floodwaters. Sand splays, which are large lobes of sand that deposited on the floodplain can be expected across paddocks adjacent to the George River.

Over time, the impacts described above will become more pronounced. In addition to changes in rainfall patterns, climate change will also cause sea level to rise, which will exacerbate the avulsion-related impacts just described. As mean sea level rises, salt water will begin to encroach past Binalong Bay Road and onto the lower George floodplain. At first this encroachment may occur during large storm surge events (i.e. rarely) but over time unusually high tides and eventually the more frequent, twice-daily high tides will be high enough to drive saltwater onto the floodplain. We expect that this will cause the floodplain to become more saline over time, and for the salt marshes between Binalong Bay Road and Georges Bay to extent inland. The change in the ability of the floodplain to support agriculture and residential land use may decrease as this process unfolds and those stresses will be superimposed on the impacts caused by the status-quo avulsion scenario.

It is important to note that Scenario 1 becomes increasingly unlikely with each flood, and that the impacts associated with one or more of scenarios 2-4 are likely to be more relevant.

Figure 4. *Aewrial view of the salt marsh at the edge of Georges Bay which is separated from the George River floodplain by Binalong Bay Road. Yellow arrows indicate scour channel shown in Figure 5.*

Scenario 2

Many of the impacts associated with scenario 2 are already occurring as the avulsion process continues to shape the George River floodplain.

Flow will increasingly spill from the breakout in the right bank of the George River (shown in Figure 3), depositing sand splay on the floodplain. Flood by flood, the sand splays will grow larger over time, extending outwards across the floodplain. Smaller scour channels often form within those sand splays, as flood flows mobilise the sandy sediment sand sculpt the floodplain. An example of this sand deposition occurring at the same time as channel are (re) scouring can be seen on the meander bend at the upstream extent of the floodplain (and addressed in scenario 3). As the breakout develops over time it will become wider and deeper, meaning that George River will spill onto the floodplain more frequently. The sand splays bury grasses on the floodplain, making them inaccessible to stock until new grass establishes. Other breakouts on the right bank may also begin to form and will be most recognisable immediately after a flood event.

Floodwaters generally move southward and downstream across the floodplain, accumulating in low lying areas to the south. Those floodwaters are leading to the slow and steady expansion of the low-lying channels marked by white arrows in Figure 5. These channels will become deeper and grow in an upstream direction, moving as small head cuts that migrate towards the breakout point (yellow arrow in Figure 5). Users of the floodplain will notice these channels getting larger after each flood. If a large flood occurs then the channel may grow very quickly in a single event, ‘appearing’ as sculpted channels once floodwaters recede.

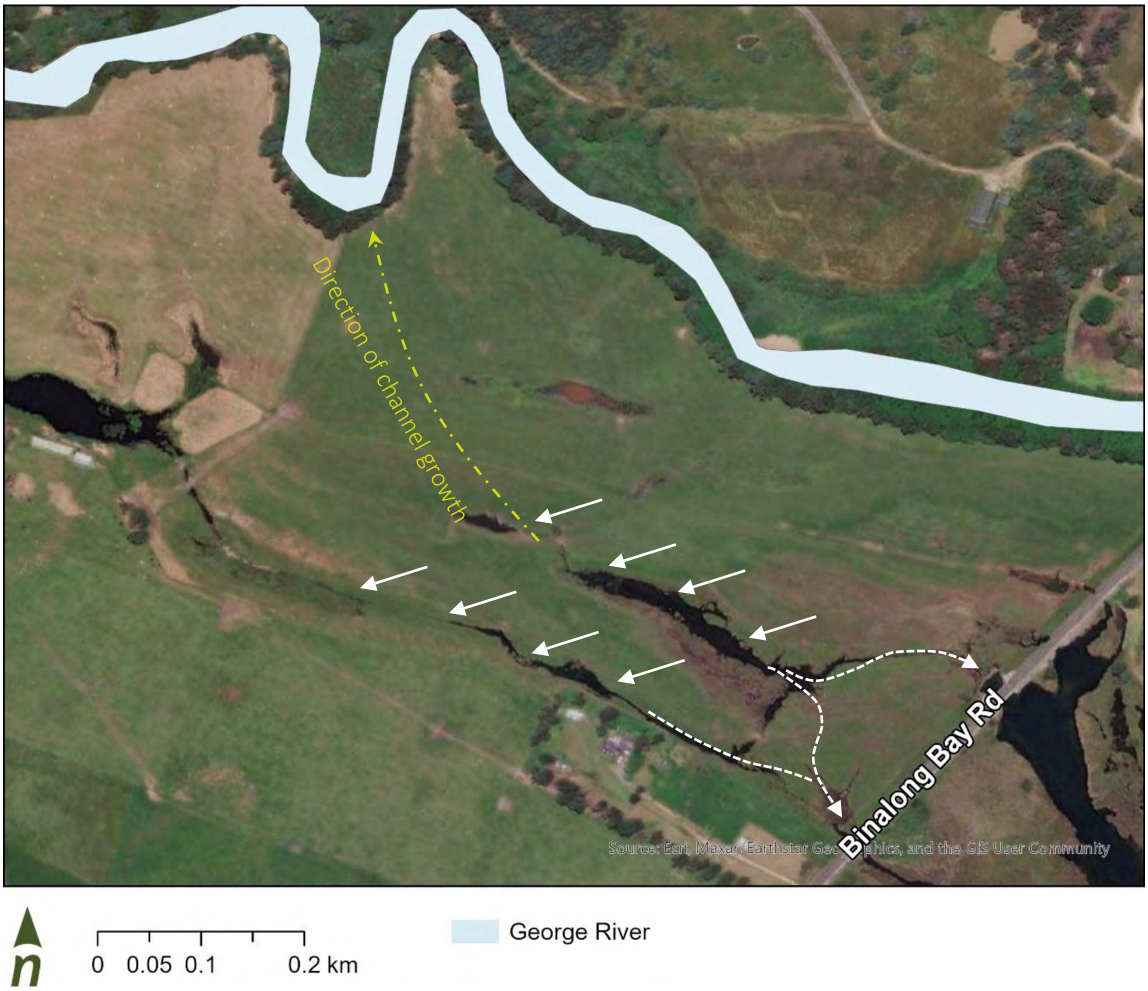

Figure 5. *Scour channels that are developing on the George River floodplain. White arrows show developing scour channels, Yellow dashed arrow shows the likely direction and alignment of scour channel growth.*

In the later stages of the avulsion, the floodplain channels marked by white arrows in Figure 5 likely are much larger and will have also become wider. The land within and around these channels will be muddier and less productive. At the same time that the floodplain channels in Figure 5 are being scoured, the pressure on existing culverts beneath Binalong Bay Road, where these channels terminate, will increase. The eventual completion of the avulsion cycle means that these channels from a continuous channel between the George River and the tidal channel beneath Binalong Bay Road, severing this section of the floodplain in two. That new alignment will likely follow one of the white dashed lines in Figure 5. It is at this 'completion' phase that the impacts on Binalong Bay Road will be most noticeable.

Binalong Bay Road can be expected to flood or be undermined at the point where it crosses over the reoccupied channel. This would lead to residential properties and small businesses along Binalong Bay Road becoming inaccessible until Binalong Bay Road (or a temporary solution such as Reids Road) can be established.

The George River will find a new outlet into Georges Bay as a result of the avulsion. Aquaculture stocks may be impacted by changes in nutrient and sediment distribution in the Georges Bay as result of the new outlet. Additionally, decreased water quality can be expected as increased fine sediment discharge is expected immediately after the avulsion, which may impact recreation in the bay (e.g., swimming, fishing).

Scenario 3

Like scenario 2, under scenario 3 the current course of the George River will be abandoned. Slowly at first and then, potentially very quickly. The breakout point lies at the upper extent of the floodplain, where flow emerging from the George overtops the right bank at a large meander bend (Figure 3). That meander bend has a history of erosion and migration and has been reinforces with rock armouring to prevent outward migration – note that the rock armour does not prevent flow from spilling over the top of the structure but does prevent lowering of the bank from the above, which prevents breakout points from forming.

Were avulsion to occur via this scenario, landholders on the George River floodplain would likely notice:

- Potential damage to the rock armouring of the bank, including evidence that flows are outflanking the structure and scouring the bank immediately upstream or downstream end.
- Increased sand deposition on the floodplain at the time as scour channels form and to grow, extending towards the George River.
- Increasing flows in the abandoned channel (left side of Figure 6), causing the channel to become deeper and wider, and for parts of that channel that are currently disconnected, to re-connect.

Under Scenario 3, there are two paths the new river channel may take depending on the abandoned channel that becomes reoccupied during the avulsion:

A. The George River reoccupies an abandoned channel that flows along the perimeter of downtown St Helens.
B. The George River reoccupies an abandoned channel that flows through agricultural lands in the centre of the floodplain.

The two possible alignments are shown in Figure 7.

If the avulsion follows Scenario 3A with the channel flowing adjacent to St Helens proper, residential properties may experience flooding and/or loss of land from widening of the abandoned channel. This erosion would occur at first during flood events, as more and more water is diverted southward along this flow path. There are a number of water mains emplaced through or adjacent to this abandoned channel that would likely be damaged and would require repair following the avulsion. Potable water access would be limited in some areas while these water mains were repaired. As the avulsion process accelerated and eventually completed, this new course would become the George River- a significant change in flood hazard and the lived experience for those residents who currently live adjacent a swampy, abandoned channel. Note that there is a high level of uncertainty as to how these impacts may evolve and at what rate over time.

Figure 6. *The breakout point under scenario 3. White dashed lines show approximate direction water and sediment will move and green dashed lines show the two dominant directions floodwaters may travel, which determines whether alignment 3A or 3B is realised (see Figure 7).*

Alternatively, the new channel alignment may follow Scenario 3B, when the channel instead flowing eastwards rather than south and traversing the middle section of the floodplain (to eventually meet the existing channels that would also be re-occupied under scenario 2, (shown in Figure 5). Like scenario 2, agricultural land may be temporarily or permanently inundated from widening of the abandoned channel as it becomes the George River. This new course, which is effectively a translating of the lower George River from the Northern side of the floodplain to the southern side of the floodplain, would sever a large area, leaving a strip of agricultural land between the new channel and the abandoned channel.

Under either scenario, it is possible that Binalong Bay Road may be flooded or undermined by widening of the reoccupied channel (as described in Scenario 2). Access may be lost to residential properties and local businesses along Binalong Bay Road during flooding or while repairs are made to the road. Non-local traffic can be redirected to Reids Road.

A new discharge point into Georges Bay will be established. The location of the discharge point will depend on which abandoned channel the George River reoccupies during the avulsion. The new discharge point is expected to disrupt aquacultural industries by redistributing nutrients throughout the bay. Additionally, decreased water quality can be expected in the bay following the avulsion from increased amounts of sediment discharge.

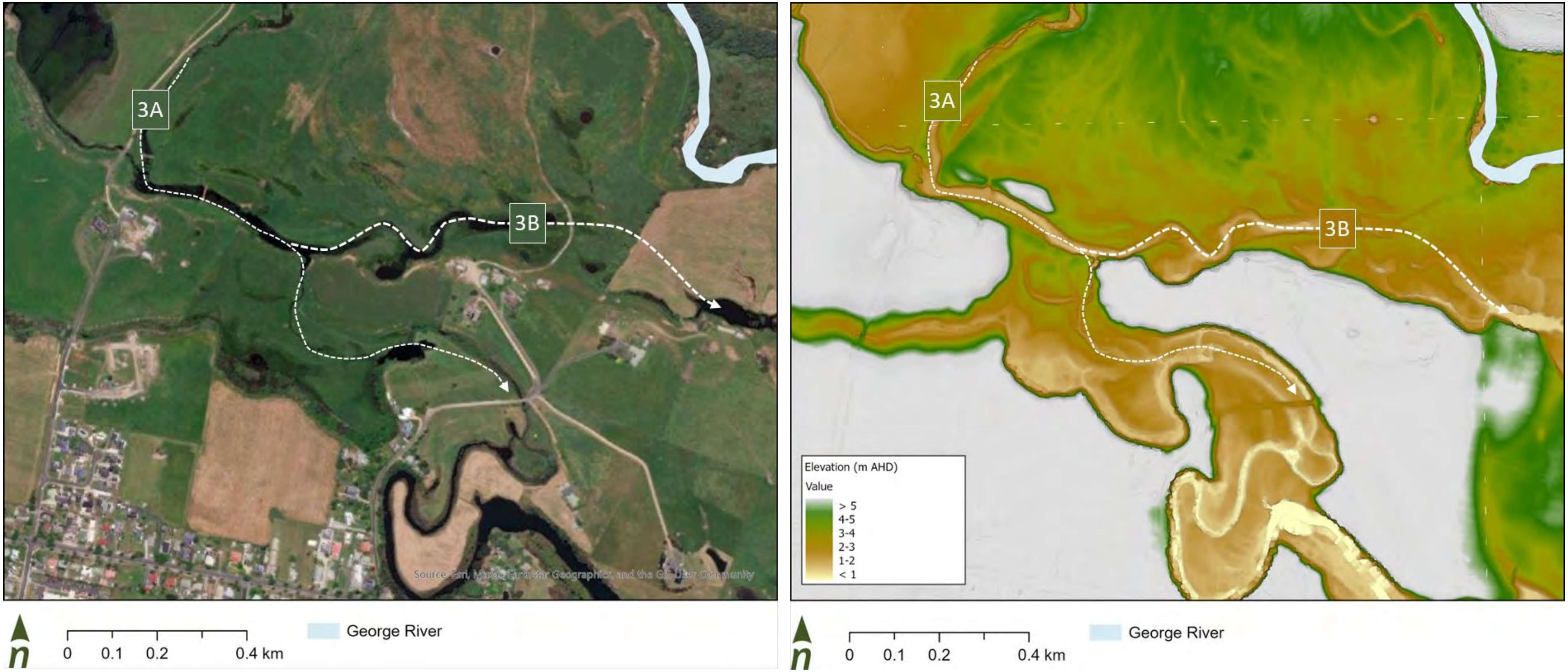

Figure 7. *The alignments of two abandoned channel that may be re-occupied by the George River under scenarios 3A and 3B. The George River is likely to re-occupy one (but not both) of these channels under scenario 3.*

Scenario 4
The current course of the George River is not expected to be fully abandoned under Scenario 4. Rather, an older and relatively short, abandoned channel at the downstream extent of the floodplain is expected to be reoccupied (Figure 3). Unlike scenarios 2 and 3, scenario 4 sees the George River break out from the left bank, carve a short section of new channel and then spill into an existing tidal channel that flows in a straight line into Georges Bay (Figure 8). The location of this breakout near the downstream extent of the floodplain means the impacts on the George River floodplain will be much less sever – no land on the floodplain will be served by channel formation and St Helens township will not be affected directly.

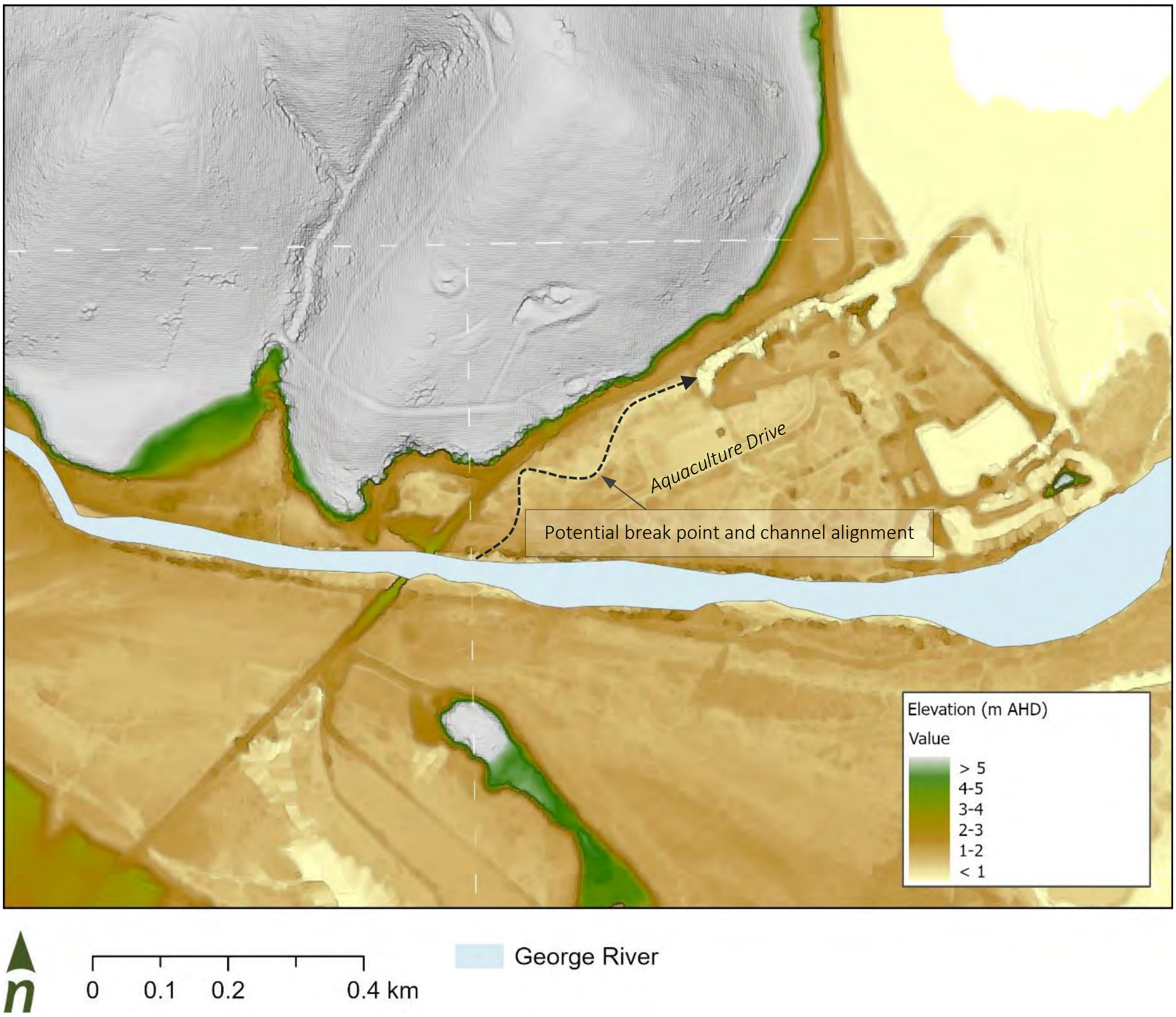

Figure 8. *The potential alignment of a newly scoured channel under scenario 4 (grey dashed line), adjacent Aquaculture Drive.*

However, the impacts of scenario 4 on the business located along Aquaculture Drive and for the section of Binalong Bay Road between the Georges Bay and the hillside to the north of the floodplain will be significant. Initially, businesses along Aquaculture Drive would experience increased flooding, potentially damage to the road and the loss of vegetation and some scour along the alignment of the abandoned channel (grey dashed lines in Figure 8). As the avulsion process nears completion, potentially accelerating, the extent of flooding and scour along the new alignment would threaten the use of this area for industry. Depending on the alignment of the newly scoured channel, erosion may threaten Binalong Bay Road, requiring rock armouring or similar protection to ensure the road is not undermined. Finally, some increase in width of the tidal channel may occur, but the fact that this channel is tidal and that there is much smaller elevation drop between the current George River and bay in this area means that stream powers (and erosion potential) in this channel will be lower than the new channels eroded in scenarios 2 and 3.

Table 1. Summary of near term and long-term consequences of a George River avulsion for scenarios 1-4 for relevant industries, areas and stakeholders.

Timeframe of likely consequences	Industry, area, or stakeholder affected	Avulsion scenario			
		Scenario 1	Scenario 2	Scenario 3	Scenario 4
Near term (decades)	River channel and floodplain	• Continuing and more frequent flooding of the lower George River during high flows • Sediment deposition on the floodplain	• Abandonment of the old river channel • Scouring of floodplain to form new channel • Widening and reoccupation of old river channel • A new discharge point into Georges Bay is established	• Abandonment of the old river channel • Scouring of floodplain to form new channel • Widening and reoccupation of old river channel • A new discharge point into Georges Bay is established	• Widening and reoccupation of an old river channel • A new discharge point into Georges Bay is established
	Residential	• Residential properties flooded	• Residential properties are flooded or become inaccessible • Homes require repair from flood damage	• Residential properties are flooded or become inaccessible • Homes require repair from flood damage	
	Agricultural	• Livestock have to be relocated during flooding	• Livestock have to be relocated during flooding	• Livestock have to be relocated during flooding	
	Aquacultural		• Stocks are impacted by changes to nutrient flows in Georges Bay • Aquaculture industries lose business due to effects of new discharge point in Georges Bay	• Stocks are impacted by changes to nutrient flows in Georges Bay • Aquaculture industries lose business due to effects of new discharge point in Georges Bay	• Stocks are impacted by changes to nutrient flows in Georges Bay • Aquaculture industries lose business due to effects of new discharge point in Georges Bay
	Local businesses and tourism		• Local businesses are flooded or become inaccessible • Local businesses lose revenue due to inaccessibility	• Local businesses are flooded or become inaccessible • Local businesses lose revenue due to inaccessibility	

Timeframe of likely consequences	Industry, area, or stakeholder affected	Avulsion scenario			
		Scenario 1	Scenario 2	Scenario 3	Scenario 4
			• Tourism decreases as people avoid the area or use alternative routes	• Tourism decreases as people avoid the area or use alternative routes	
	Binalong Bay Road	• Binalong Bay Road is unpassable during floods	• Binalong Bay Road becomes undermined and unpassable	• Binalong Bay Road becomes undermined and unpassable	
	Water and sewage			• Water mains are damaged such that potable water is unavailable in areas	
Long term (decades to a century)	River channel and floodplain	Scenario 1 is unlikely to occur over the long term.	• Flood patterns change across the floodplain as a result of the new channel	• Flood patterns change across the floodplain as a result of the new channel	
	Residential		• Loss of private residential land to new river channel	• Loss of private residential land to new river channel	
	Agricultural		• Loss of agricultural land to new river channel	• Loss of agricultural land to new river channel	
	Aquacultural		• Stocks are redistributed throughout the bay	• Stocks are redistributed throughout the bay	• Stocks are redistributed throughout the bay
	Local businesses and tourism		• Tourism is diverted away from Binalong Bay Road as Reids Road becomes preferable route	• Tourism is diverted away from Binalong Bay Road as Reids Road becomes preferable route	
	Binalong Bay Road		• Binalong Bay Road requires reconstruction and remains unpassable – Reids Road is used as an alternative	• Binalong Bay Road requires reconstruction and remains unpassable – Reids Road is used as an alternative	
	Water and sewage				

5.1 Consequence rating

In many cases, the value of damages and losses is closely linked to the number of assets negatively affected. Therefore, in the absence of a more detailed economic assessment, we have used spatial analysis and stakeholder engagement to identify the assets expected to be impacted by an avulsion under each scenario. This data has been linked to the relevant consequences and assists with understanding and comparing the relative consequences of an avulsion between scenarios. This analysis is presented in Table 2. We have assigned each scenario with an overall consequence rating, where 1 is the lowest rating (lowest relative consequence) and 4 is the highest (largest relative consequence).

Table 2. Consequence assessment for avulsion scenarios

Consequence categories	Proxy measure	Scenario				
		1	2	3a	3b	4
Loss of agricultural land and business disruptions	Area of agricultural land affected (ha)	N/A	1	5	7	0
Damage to residential properties, displacement due to property damage / inaccessibility, and loss of residential land	Number of residential land parcels affected	N/A	0	11	4	1
Loss of business income	Number of local businesses affected	N/A	1	0	1	>1
Damage to public assets and disruption to public services	Length of water mains affected (m)	N/A	0	140	0	0
	Number of sewage pump stations affected	N/A	0	1	0	0
Damage to roads, transport disruptions and loss of tourism	Yes / No	Yes	Yes	Yes	Yes	Yes
Overall consequence rating		N/A	2	4	3	1

This analysis indicates that scenario 3a is likely to have the highest economic consequences, with the highest count / area of assets affected in all consequence categories except 'Loss of agricultural land and business disruptions. Scenarios 2 and 4 are likely to have a lower level of consequences relative to scenario 3, with less residential properties, and public assets affected. Scenario 4 may have an impact on several aquacultural businesses, however, based on available information it is unclear to what degree and how many businesses would be affected.

Importantly, transport disruptions and losses of tourism may occur across all scenarios due to the inundation or undermining of Binalong Bay Road, limiting access to the Bay of Fires through Reid's Road. Although access would not be severed, such a disruption has the potential to deter many visitors. Given this impact occurs across scenarios, and the importance of tourism to the region (more than 200,000 people are estimated to have visited the Bay of Fires in 2022-23 based on Tasmanian Visitor Data) further examination of the consequences of disrupted access through Binalong Bay Road should be prioritised. A case study which draws on Tasmanian Visitor Data and explores the economic value of tourism to the region and the cost under different potential scenarios of reduced tourism would be a cost-effective way to start this process.

6 Potential management options

This section summarises possible management options for the George River avulsion. Many of the management options below were also identified in earlier investigations (Water Technology 2018). The most appropriate management options, or combination of management options, will depend on how the avulsion evolves over time, the course the George River avulsion takes and the risk tolerance of various stakeholders. Three broad strategies can be used to manage avulsions:

1. **Delay or prevent the avulsion.** Preventing an avulsion is challenging (or infeasible) and often requires an ongoing commitment to intensive river management. Delaying an avulsion by addressing the mismatch in capacity of the George River and the new course developing on the floodplain is more feasible. Delaying the avulsion requires limiting the decline in capacity of the George River while also limiting the increase in capacity of the channels developing on the floodplain.
2. **Initiate a controlled avulsion.** A controlled avulsion uses works to accelerate the development of the avulsion (i.e. increasing the likelihood the avulsion occurs in the short term) and controls which of the three alignments in Figure 3 the new channel occupies.
3. **Prepare for the consequences of avulsion.** Preparing for the consequences of avulsion relies on an understanding of the most likely alignment of the new channel post-avulsion, how the new channel alignment may impact flood hazard and floodplain assets, and how avulsion hazard interacts with hazards such as storm surge and sea level rise. Preparing for the consequences of avulsion can include relocating at-risk assets, limiting exposure to the hazard using planning controls and preparing the likely river corridor to host the George River.

Many of the management options (for example riparian and floodplain planting) are useful regardless of which of the three strategies above is pursued. Waterway managers may also choose to pursue multiple strategies at the same time, for example by delaying the avulsion while also preparing for the inevitable consequences. The management actions and the areas of the George River floodplain where each is implemented is summarised below, organised according to the approaches above.

6.1 Delay or prevent the avulsion

Preventing the avulsion from occurring is very expensive and ultimately, unlikely to succeed. Avulsion of the George River is a natural landscape scale process, driven by the continual process of channel creation and abandonment – this process formed the Goerge River floodplain. Maintaining the current alignment of the Goerge River would require extensive levees along the left bank. Levee construction is likely to accelerate the avulsion process by preventing sand carried by high flows from being deposited across the floodplain and forcing more sediment to be deposited in the bed of the George River. In this manner, levees may actually act to *accelerate* rather than prevent an avulsion.

Delaying the avulsion is more feasible. Actions that can be used to address the growing mismatch in capacity of the George River and the new channels on the floodplain are:

- Riparian planning along potential channel alignment on the floodplain and along the banks of channel that may be re-occupied. The riparian planting serves two purposes; increased roughness, which slows flow and limits floodplain scour or channel enlargement, and by increasing the strength of the floodplain soils, which also makes scour less likely.
- Extract sediment from the bed of the George River. Sediment extraction will limit the rate of bed level rise in the George River and/or lead to bed level lowering. Extraction is an ongoing measure, as new sand is continually delivered to the lower George River. If too much sand is extracted too quickly, then the falling bed level may trigger bank collapse in upstream and downstream reaches – which would act to undermine the strategy of delaying an avulsion.
- Works to repair breakout points in the left bank as they appear. Closing gaps that emerge in the left bank, where spill first occurs, reduces the likelihood that floodplain channels will connect with the George River.

- Replacing willow that has colonised the bed and banks of the George River with native vegetation. Willow spreads aggressively and tends to choke channels, reducing their capacity. Replacing willow with native vegetation ensures that the bank strength provided by willow is also replaced.
- Maintain the concrete weir(s) at the head of tidal channels beneath Binalong Bay Road. These weirs prevent those channels from migrating further onto the floodplain.

The indicative location the works outlined above are shown in Figure 9.

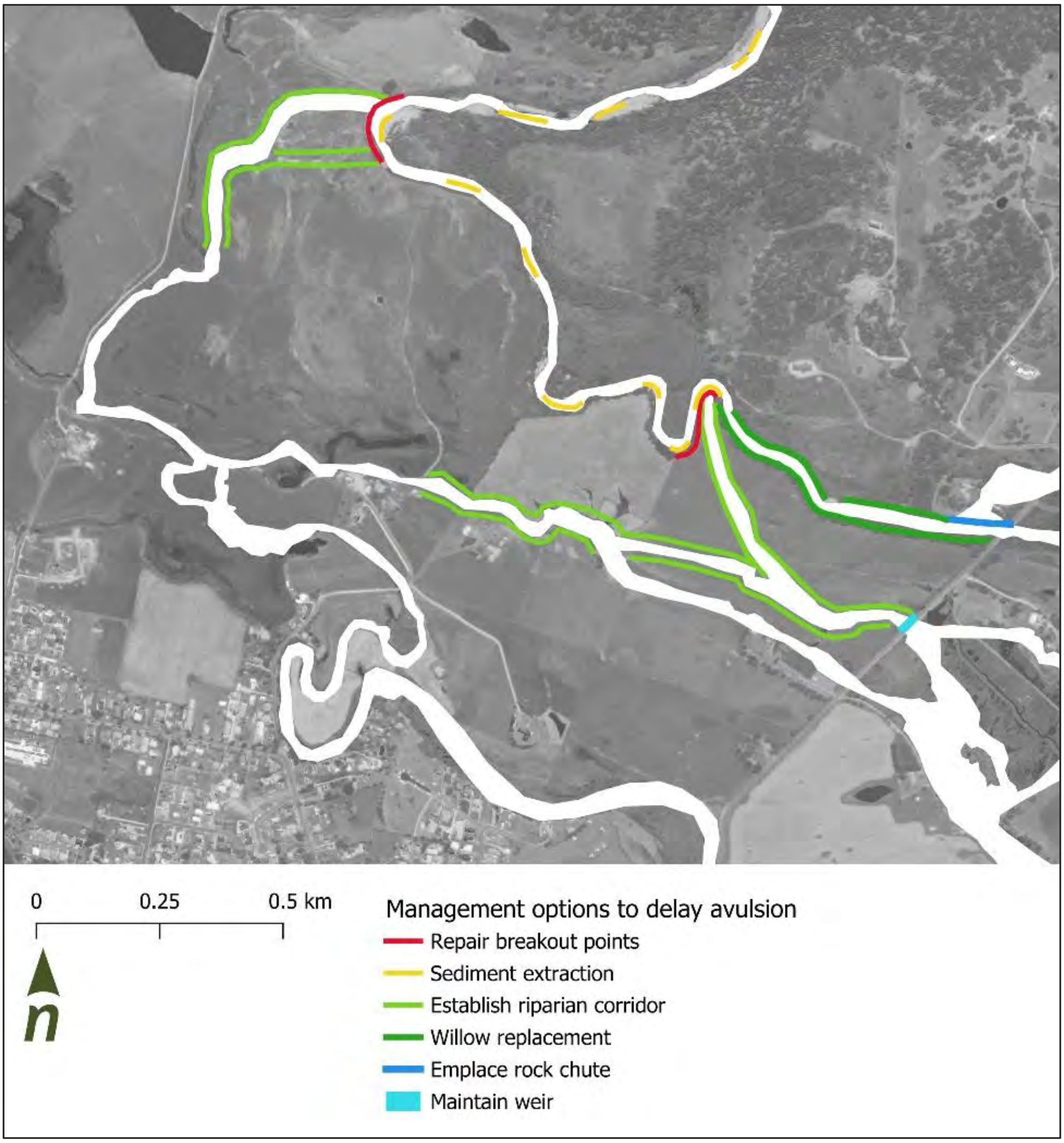

Figure 9. *Locations of management options to delay an avulsion.*

6.2 Initiate a controlled avulsion

Initiating a controlled avulsion along the alignment of scenario 2 (the most likely avulsion scenario) requires excavating a gap in the right bank of the George River to and armouring that gap with a rock chute to create an area of controlled spill. A new channel can be excavated on the floodplain, that connects the George River to one of the existing channels that flows beneath Binalong Bay Road. Dimensions of the new channel should approximate the pre-sand slug dimension of the lower George River. Appropriate channel design will need to ensure the channel alignment is stable, efficiently conveys the supplied sediment/sand slug to Georges Bay, that the channel has the potential to provide other environmental benefits, such as habitat and amenity values to community. Supporting works include riparian revegetation of new alignment. This strategy will also require works to upgrade the culverts beneath Binalong Bay Road. A possible alignment of a new channel is shown in Figure 10.

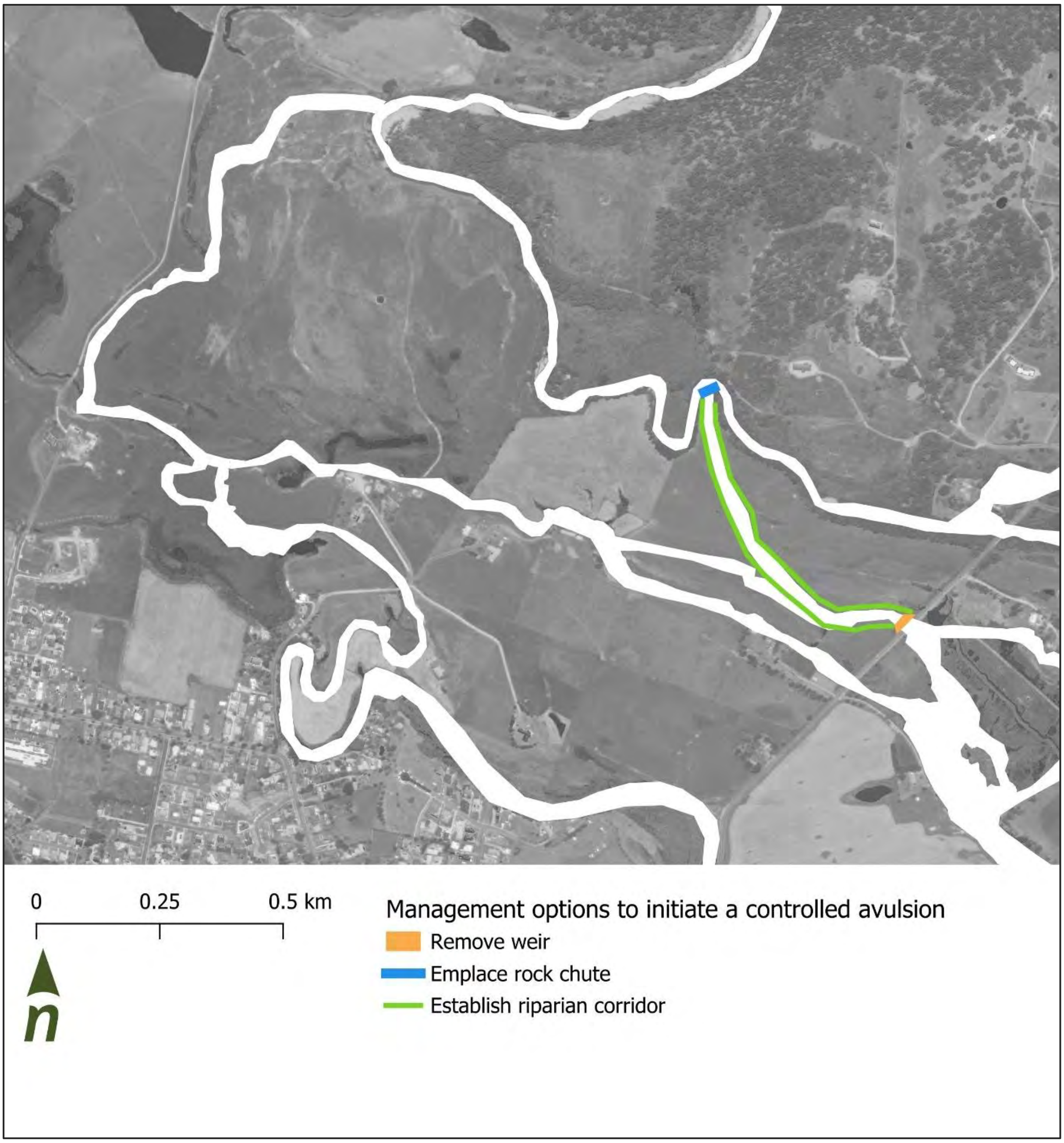

Figure 10. *Locations of management options to initiate a controlled avulsion away from the city of St Helens.*

6.3 Prepare for the consequences of avulsion

Preparing for the consequences of avulsion relies on using a combination of works to create a new riparian corridor along the most likely alignment of the new channel and planning mechanisms to reduce exposure to the hazard. Should scenario 3 eventuate then waterway managers have two options to minimise the impacts of the new channel alignment:

1. Control the alignment of the scenario 3 channel using levees (see Figure 11) to ensure that the new channel follows alignment 3B – along the George River floodplain and excavating a new channel to connect low-lying points of the floodplain (purple lines in Figure 11).
2. Allow the new channel to follow the 3A alignment and undertake bank armouring works in areas adjacent high value assets (e.g. residential buildings and roads), preventing channel widening and protecting assets.

Waterway managers can prepare for the consequences of avulsion by relocating assets away from the new flow path and preventing new assets from being constructed along possible alignments. Land zoning and planning provision may the most effective way to prevent new assets from being constructed.

Predations for avulsion should also consider the interaction between avulsion hazard and flood hazard and sea level rise. In particular, by upgrading Reids Road (C849) so that it is able to serve as a permanent replacement to Binalong Bay Road while planning for the decommissioning of the section of Binalong Bay Road that crosses the potential avulsion pathways.

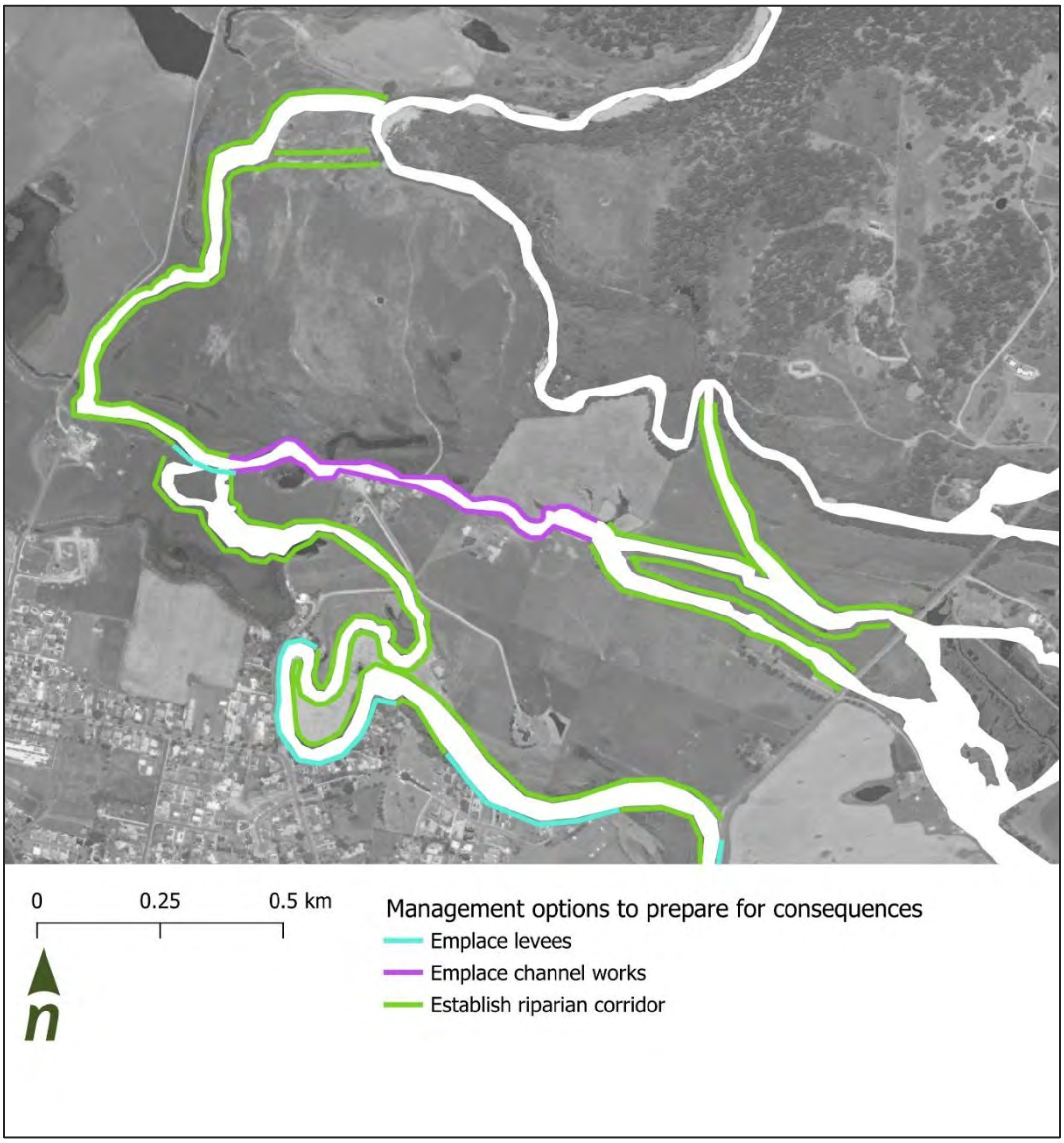

Figure 11. *Locations of management options to prepare for the consequences of an avulsion.*