



CHRISTENSEN
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Independent Operational Review of Wairoa River Bar Management

Te Wairoa Hōpūpū Hōnengenenge
Mātangi Rau - The long, bubbling,
swirling, uneven waters.

Prepared for
Hawkes Bay
Regional Council
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Executive Summary

1. Significant flooding affecting over 400 properties occurred in the area of Wairoa adjacent to Kopu Road on 26 June 2024.
2. The degree of opening and position of the Wairoa River mouth is known to have a significant impact on upstream flood levels and HBRC have a methodology in place for relocating the river mouth to a more hydraulically efficient position ahead of a flood arriving.
3. The methodology requires five key success factors to line up for the river mouth to be relocated including a 5 – 7 day lead time based on forecast rainfall as well as quiescent sea/wave conditions.
4. None of the prerequisite key success factors were aligned when the decision was made by HBRC on Monday 24 June to attempt a river mouth opening on Wednesday 26 June.
5. An alternative option of lowering the beach crest suggested by Pryde Contracting and also noted in a draft technical report recently received by HBRC was not pursued. HBRC had not interpreted Pryde's suggestion as an alternative option, rather as the first step in full mouth relocation.
6. Before works commenced on Tuesday 25 June the flood was forecast to be rising from that evening so it was reasonably apparent that for anything useful to be in place it had to be open and functional by the time works were completed that day.
7. This was not the case, and the works that had been completed were effectively dammed at the seaward end following the standard procedure for attempting a full mouth opening on the following day.
8. During the night large waves overtopped the beach crest and a larger than forecast 5-year flood rose in the Wairoa River.
9. From around 3:30am on Wednesday 26 June flood levels rose above the level of Kopu Road (3.7 mRL) and began to flood adjacent properties. Flood levels continued to rise up to 4.7 mRL at the Town Bridge until shortly after 9 am when a natural breach occurred through the beach crest, a new river mouth formed and flood levels rapidly receded.
10. HBRC did not have any functional breach points or pilot channels in place prior to the flood arriving. If such works had been in place, they would have been affected by the large waves overtopping the beach crest in the hours before the river had risen sufficiently to possibly make such breach points or pilot channels operational.
11. Due to the above wave action it is unknown what level of residual functionality, if any, would have still been evident if there had been any breach points or pilot channels constructed in the days leading up to the flood event.
12. If a breach had occurred through the remnants of a mechanically constructed breach point or pilot channel earlier than the one that naturally occurred around 9am, it is possible that flood levels could have been lower.
13. It is also possible that the wave action that occurred through the night might have prevented a breach occurring any earlier than it did naturally regardless of what breach points or pilot cuts or remnants of, had been in place.

Key Issues

14. The HBRC methodology for conducting a mouth relocation is too high risk due to the number of key success factors that have to line up to execute it successfully.
15. With the limited time available and knowledge of the timing of the incoming flood event an alternative method of lowering the beach crest on Tuesday 25 June might have been a more productive use of resources.
16. Any operational response that is dependent on the sea conditions being calm will be at risk of not being functional when it is needed due to the wave action filling in excavated areas as well as the waves reducing the ability of the river to scour out a new river mouth through the beach crest.

Recommendation

17. A simpler method for managing the Wairoa River mouth should be developed which either includes significant preparatory works whenever the river mouth is in an adverse position or just focuses on beach crest lowering, noting that it will still be contingent on the sea conditions being calm enough prior to and during the flood event for it to be successful.

1 Introduction

Christensen Consulting Limited has been commissioned by Hawke's Bay Regional Council (HBRC) to conduct an independent operational review of the Wairoa River bar management in the lead up to the Wairoa flooding event of 26 June 2024. The scope of work is described in the terms of reference (TOR) provided in APPENDIX A.

The purpose of the review as stated in the TOR is as follows -

1. *Consider the possible causes of flooding on 26 June 2024.*
2. *Comment on the extent to which the state of the river mouth contributed to the flooding event.*
3. *In light of the information and intelligence available, review and comment on the decision making of HBRC in the lead up to the event, specifically:*
 - a. *The timing of the attempt to open the river mouth (which in the event was planned for 26 June 2024),*
 - b. *The timing of preparatory work for a river mouth opening being commenced,*
 - c. *The methodologies adopted by HBRC in order to undertake an opening of the river mouth, and*
 - d. *Any other options available to HBRC to mitigate the risk of flooding.*
4. *Make any recommendations that the Reviewer considers necessary to ensure that any lessons identified from the events surrounding the 26 June 2024 flooding event are incorporated into the future management of the Wairoa River mouth.*

This report firstly presents the background context for management of the Wairoa River mouth including comparison with past practices and the practices of other regional councils across the country. Following this the methodology used to undertake this review is described including details of the documents that have been reviewed and meetings conducted to gather the necessary information to complete the review. A factual summary of the event is then provided followed by analysis and discussion to answer the four review questions as well as the consideration of counterfactuals to understand what could be done better in the future.

2 Background

2.1 Historic Practices

The management of the Wairoa River mouth has been an issue from the time it was first needed to be navigated by larger European ships over 150 years ago with many strandings on the bar¹. It was noted from these times that bar would scour out during a flood but quickly close back up again during heavy southerly storms¹. The method used in these times for reopening the river mouth was to wait for the existing mouth to completely block, allow the water level to build up upstream and then cut a new channel¹. This was a difficult operation, especially as the cut was most probably hand dug with shovels in the earliest days. Around 1915 two timber pile training walls were built in an attempt to establish a more permanent river mouth in the centre of where the main river channel intersected with the beach². The high energy coastal environment with large volumes of longshore sediment transport most likely overwhelmed these structures relatively soon after construction but there are still the remains of some of the piles on the river side of the Wairoa River bar evident today.

2.2 Previous circa 2000 Practices

In more recent times the practice as described in HBRC documents appeared to be more geared around doing preparatory work when the bar was in an inefficient location (west of Pilot Hill) and when there were low flows in the river rather than waiting for a flood to be forecast before doing anything.

“At times of low flow in the river and when the mouth is inefficient staff arrange for work to be undertaken in preparation for an opening. This involves excavating a partial opening so that less work is required when the right conditions are likely to arise”³

It appears that this method did not explicitly require waiting for a flood event to be forecast before undertaking this preparatory work. In this document it was also highlighted that there was a high risk of not achieving a successful opening at a time when it was critically needed i.e. when a flood was imminent and the mouth was in an inefficient position to the west of Pilot Hill.

It was also interesting to note from this same document that mechanically closing the existing mouth was considered “not possible” due to the highly erodible material that makes up the beach sediment that could be used to close it.

2.3 Current Practices

The current practice as described in the HBRC Lagoon & River Mouth Instructions is fairly broad but contains the following notes –

- If the mouth is partially closed or restricted, or is not in a very good position, then attention to weather forecasts and sea conditions is required as mechanical openings of this mouth may normally involve quite an extensive operation, sometimes-taking days to complete.
- The potential for damage due to flooding caused by a river mouth blockage is significant. Numerous small pastoral and residential properties in the Kihitu and Kopu Road areas are also affected. Access Roads into Whakamahia and Kihitu become blocked.

¹ Hoppolite J. (1999). Crossing the Bar – Aspects of the History of the Waikokopu and Opoutama blocks with special reference to the Waikokopu Harbour.

² Cited in T&T(2004). Wairoa River Mouth – Dynamics, Issues and Management.

³ HBRC 2000 Wairoa Flood Mitigation Regional Council Paper 19 December 2000.

- After taking the above into consideration, a significant head of water in the river along with favourable sea conditions is required for a successful mechanical opening. Ideally, all openings should be undertaken at low tide with a relatively flat sea.

Further details of a mouth opening procedure have also been provided by Pryde Contracting⁴ with additional details added around requiring a 5 – 7 day lead time, timing of the high tide being early in the day along with the need for the existing river mouth getting shallower due to low river flows and sea swell. Further specific details around the dimensions of the channel cut are provided including an upstream funnel shape tapering down to a 6 m width cut down to depth approximately 1 m below water level (circa 0 – 0.5 mRL). There is also noted a requirement for a seaward coffer dam for safety as well as to protect the excavation as the work continues for multiple days.

It is highlighted that due to the number of key factors that have to line up this is an extremely restrictive method in terms of the likelihood of success in execution. For all five of the critical success factors to occur at the same time puts this method in a category of somewhere ranging from “difficult to impossible to execute successfully”⁵.

It is interesting to note the evolution of the process from the circa 2000 process where previously preparatory works were done to get a channel set-up and ready when the mouth was in an adverse position whereas the current practice appeared to be dependent on waiting for a flood to be forecast before initiating any works. It would also appear from inspection of the current (post flood) set-up that there has been a return to the preparatory practice of the past of having the pilot channel set-up and ready with the seaward coffer dam in place that can be reasonably quickly cut-through when needed. I have been advised⁶ that the above preparatory work was completed in response to a forecast rainfall event around 16 July 2024 that did not eventuate to be a significant enough flood event that would satisfy the requirements for opening the coffer dam and attempting a mouth relocation.

An alternative process had been suggested by T&T in their draft report⁷ dated 14 June 2024 where the existing process could be retained but that if conditions were not right for a full river mouth opening then an alternative option of levelling the bar could be executed. It is noted that this report was commissioned under the Wairoa Flood Resilience Programme and was still in draft subject to community consultation and had not yet been considered for incorporation into the HBRC operational practices.

The levelling of the bar option requires far less earthworks than a full opening/mouth relocation with a cut likely required down to 2 – 2.5 mRL to achieve a crest with sufficient depth below the threshold for flooding around Kopu Road at 3.7 mRL. This is an important consideration to note as this type of alternative was suggested by Pryde Contracting on the Monday afternoon prior to them commencing earthworks the following day ahead of the flood on Wednesday. HBRC have noted⁶ that they did not interpret this as a suggestion for an alternative option from Pryde Contracting, but rather as part of the process of advancing a full mouth relocation.

2.4 Other Council Practices

It is interesting to note other regional councils' practices in regard to river mouth openings. Having completed previous review work on the Whakatane River mouth spit fuse I am familiar with the operational process⁸ which includes a provision for pre-emptive lowering of sand levels if they are getting too high so that there is less material to move when a flood is imminent. The Environment

⁴ Pryde Contracting (2024). Attempting a new river mouth opening on the Wairoa Bar.

⁵ Pryde Contracting pers comm. 9 August 2024.

⁶ HBRC (HBRC). HBRC Feedback on the Draft Report. Independent Operational River Wairoa River Bar Management 23 August 2024.

⁷ T&T (2024). Wairoa River Mouth – Dynamics, Issues and Management.

⁸ Bay of Plenty Regional Council (2023). Flood Warning Manual.

Canterbury protocol⁹ is generally more straight forward with crest lowering/breach points excavated 1 – 2 days prior to a flood.

The Greater Wellington Regional Council (GWRC) Code¹⁰ technique is different in that it is executed as a “dry weather” operation once a river mouth has migrated outside its optimum position. The process includes blocking off the existing river mouth and cutting a pilot channel with a landward coffer dam. Over several days the water level builds up upstream of the coffer dam which is then cut to allow the built-up water to erode out a new mouth.

The GWRC method is similar to what was done historically (late 1800’s early 1900’s) on the Wairoa River mouth but the current situation with the wastewater plant discharging on the outgoing tide into the river mouth and the need to wait for a complete mouth closure likely renders this method as not viable for Wairoa.

⁹ Environment Canterbury (2019). Canterbury Regional Code of Practice for River Mouth Openings.

¹⁰ GWRC (2019). Code of Practice for river management activities.

3 Methodology

This section describes the methodology used to undertake the review and includes details of the documents provided by HBRC and the meetings that have been held with HBRC, Wairoa District Council and Pryde Contracting.

3.1 Documents Reviewed

The following documents have been provided by HBRC –

- HBRC (2000). Wairoa Flood Mitigation Regional Council Paper – 19 December 2000.
- HBRC (2024). Memo – June 26 Flood Extents and Depths
- HBRC (2024). Memo – Summary of Forecasting for Wairoa Flood Event June 26, 2024.
- HBRC (2024). Wairoa Flooding Event – 26 June 2024 Timeline of Events Communications Compilation.
- HBRC (2024). Lagoon & River Mouth Locations, Access & Opening Instructions.
- T&T (2024). Wairoa River Mouth – Dynamics, Issues and Management.
- T&T (2024). Review of Physical Processes Influencing the 26 June Wairoa Flood – Data summary and analysis.
- Te Uru Kahika (2024). Wairoa Mouth Cutting Procedures – Summary comments based in initial site inspections.
- MetService forecasts 20 June 2024 to 24 June 2024.

3.2 Meetings Conducted

- HBRC 8 August 2024 – three meetings with HBRC officers responsible for forecasting and decision making around June 2024 event.
- Wairoa District Council – Meeting CEO, Mayor, Councillors and Roading Manager.
- Pryde Contracting – Office based meeting to discuss procedures and communications followed by site visit to eastern side of river mouth to travel access route and see current works.
- An open invitation was extended to Tātau Tātau o Te Wairoa to contribute their views but this was not taken up.

Following review of these documents and gathering of information from these meetings a number of questions were asked of HBRC. The questions and their responses are provided in APPENDIX B.

4 26 June 2024 Flood Event

It is noted that HBRC had identified the adverse position of the Wairoa River mouth from January 2024 and had been monitoring the river mouth as well as forecast rainfall and wave conditions since this time to assess opportunities for relocating the river mouth. Earlier minor flood events on 30 January and 22-23 May 2024 were not identified as being opportunities for attempting river mouth relocations.

The 30 January event was very minor with forecast rainfall being less than actual rainfall and a peak water level of 2 mRL measured at the Town Bridge being well under a mean annual flood¹¹. The 22-23 May 2024 event was more significant in terms of generating a 5-year return period flood but as with the 30 January event more rainfall fell than was forecast so it was not clear ahead of time that this event would have generated an opportunity for a mouth relocation. It was also noted by HBRC that this event coincided with quite large waves 2 - 2.5 m at Napier Port which would have likely been larger in Wairoa adding to the difficulty in relocating the river mouth¹¹.

With neither of the earlier events being identified as potential river mouth relocation opportunities the focus then becomes the June 2024 event. To set the context for the review of operational decisions a factual summary of the events and decision making from Friday 21 June to Wednesday 26 June is provided. This is followed by analysis of the likely causes of the event including the contribution of the river mouth/bar conditions. The key review questions are answered in Section 5 of the report regarding the timing and decision making by HBRC in their operational response along with consideration of counterfactuals for the purpose of considering alternatives for the future.

4.1 Flood Event Timeline

On Friday 21 June rainfall was forecast for the following week for the East Coast of the North Island and was predicted to be affecting catchments to the north of Wairoa and to the south into Central Hawkes Bay but not the Wairoa catchment itself (See Figure 4-1). Very large sea swell was also forecast for this event with wave heights of up to 7 m predicted by MetService. On the basis of this information HBRC put Pryde Contracting on stand-by. I note that two of the key conditions for a mouth opening were not in place at this point, namely no rain was actually forecast for Wairoa and there was significant swell predicted. HBRC made the decision to put Pryde Contracting on stand-by on the basis that it was prudent to be ready if the forecast rainfall and swell conditions changed in the coming days.

¹¹ HBRC response to questions See APPENDIX B.

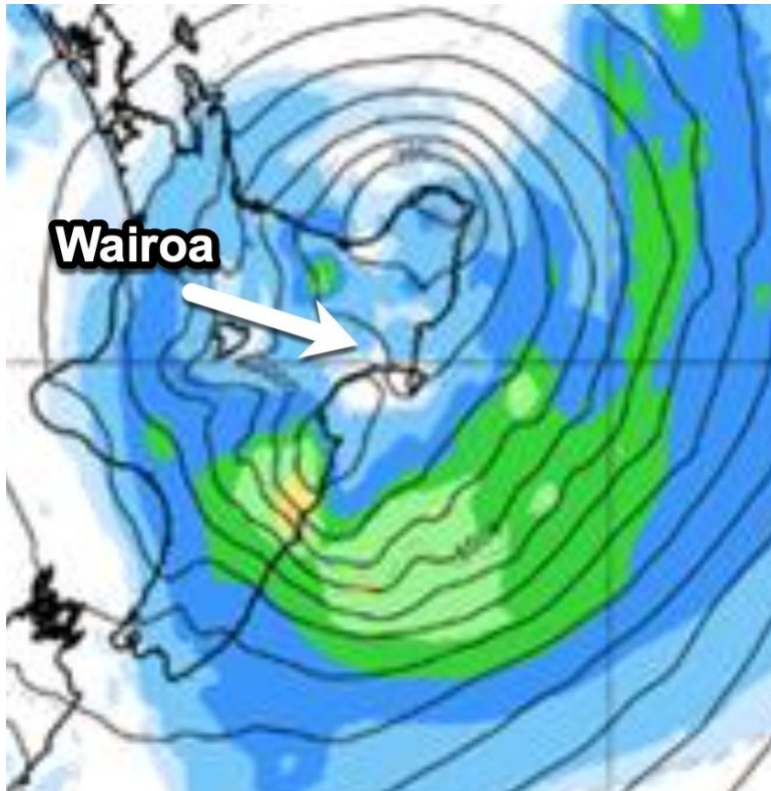


Figure 4-1 MetService Rainfall Forecast Friday 21 June 2024

On Monday 24 June MetService issue ORANGE rain warnings at 9:39am with predictions of 150 – 180 mm from 9am Tuesday to 9pm Wednesday for Hawkes Bay north of SH5. At 11:09am on Monday MetService issued a swell forecast warning for the East Coast of the North Island with 6 m nearshore waves predicted to occur from 1am Wednesday 26 June. The rainfall in itself was notable but not significant in that over a 36 hour duration it was likely to be less than a mean annual event (2.33-year return period), more problematic in terms of achieving a new river mouth opening was the very large waves predicted to occur ahead of any rise in river levels. Also problematic at this stage was the limited time available to progress any physical works ahead of the event on Wednesday.

At 1:40pm on 24 June the most up to date rainfall forecast was used to predict river flows which suggested a rising river level (above tidal fluctuations) from midday Wednesday. Shortly after this HBRC issued the instruction for Pryde Contracting to mobilise to site and commence work for an attempted mouth opening/relocation on Wednesday morning prior to the river rising. HBRC considered this to be a marginal call given the time available and the predicted sea conditions but deemed it a precautionary approach.

There were communications between Pryde Contracting and HBRC on Monday highlighting the existing river mouth as being deep and wide and difficult to close as well as the issues of the swell forecast and the time available to progress physical works on site. There was also the suggestion from Pryde Contracting that an alternative beach crest lowering option be pursued on Tuesday instead of the full mouth opening.

“Can you confirm that your request for the Wairoa Bar is that you want us to attempt a full open a new mouth and also attempt to close the existing. Or if we are removing sand from the potential new mouth spot to lower sand bar height?”¹²

¹² Text message 2:55pm Monday 24 June Pryde Contracting to HBRC.

It appears that HBRC had not interpreted the beach crest lowering as an alternative option but rather as a preparatory step towards a full mouth opening. The confirmation of instructions for Pryde Contracting came in an email from HBRC at 4:18 pm Monday 24 June providing the following –

Putting down in email form the plan for the next couple of days in regard to moving the Wairoa river mouth from;

- its current location on the western end of the Whakamahi Lagoon to
- the more beneficial location closer to the Eastern Ngamotu Lagoon.

Monday 24/06/2024

- Decision made by HBRC to attempt a reopening of the mouth
- Scheme manager in Wairoa to be HBRC primary point of contact (POC)
- Prydes Contracting engaged to be Contractor for the operation- Sam Pryde to be Contractor POC
- Prydes will start Mobilising equipment to site in afternoon
- Conversation with Sam Pryde-
- Equipment available
 - 1x Bull Dozer D8
 - 1x Excavator 20T
 - 2x Excavator 13T
- Option to organise a secondary Bull dozer from Gisborne- Weather and road condition dependant
- 1600- Meeting regarding Matariki Rain Intel Report
- Email (this one) sent out

- **Concerns as of Monday afternoon regarding Wednesday**
 - Lowtide: 0238
 - Sea State: 5.5-5.8m
 - On Shore Wind: 40-50 kts

Tuesday 25/06/2024

- Prydes to start moving Material over the course of the day
 - Lowering height of beach crest by the new opening
 - Moving material closer to the old mouth for closing
- Meeting will be held in the afternoon to discuss feasibility of continuing with Mouth relocation.
- *Depending on decision based on information on Tuesday afternoon the Wednesday timetable will adjust*

The above clearly lays out that a full mouth opening is to be attempted but does include “lowering height of beach crest by the new opening” as the primary activity for Tuesday. As already highlighted this could be interpreted as just being part of the standard procedure for a full mouth opening/relocation, noting that digging a pilot channel down to below water level for a full opening does require the removal of the beach crest.

Based on the above instruction, Pryde Contracting commenced transporting earthmoving equipment to both sides of the river mouth in-line with a full mouth opening protocol. It is highlighted that access to the eastern side of the bar is via a steep narrow farm track and then along the beach for a distance of approximately 4 km. Excavators and bulldozers cannot be transported to the actual worksite but have to track in from the start of the farm track.

The equipment that was deployed for the works was confirmed by Pryde Contracting as being –

- D5 bulldozer to the existing mouth;
- D6 bulldozer, 20T excavator & 13T excavator to eastern side to prepare new mouth.

At 11:30pm on Monday 24 June HBRC updated their flood forecast which had now increased to be more significant with a 1.7 m rise in river levels (above high tide) and importantly that rise in river levels was now starting earlier, from about 8pm on Tuesday 25 June. The forecast for 6 m swells remained unchanged. The timing of the rising river levels is most significant now as this now means that any attempted closure of the existing river mouth and cutting of a new river mouth needs to be complete by nightfall on Tuesday.

This was clearly not going to be possible with one day of earthworks and there could have been further clarity provided on the plan for the following day to maximise the effectiveness of what could be achieved. This is particularly regarding the deployment of one bulldozer to the existing mouth that could have been better utilised on the eastern side to lower the beach crest. Also, the use of a seaward coffer dam on the pilot channel being cut for the new mouth was at this point disadvantageous as there was no opportunity for being able to cut through the coffer dam on Wednesday morning prior to the flood.

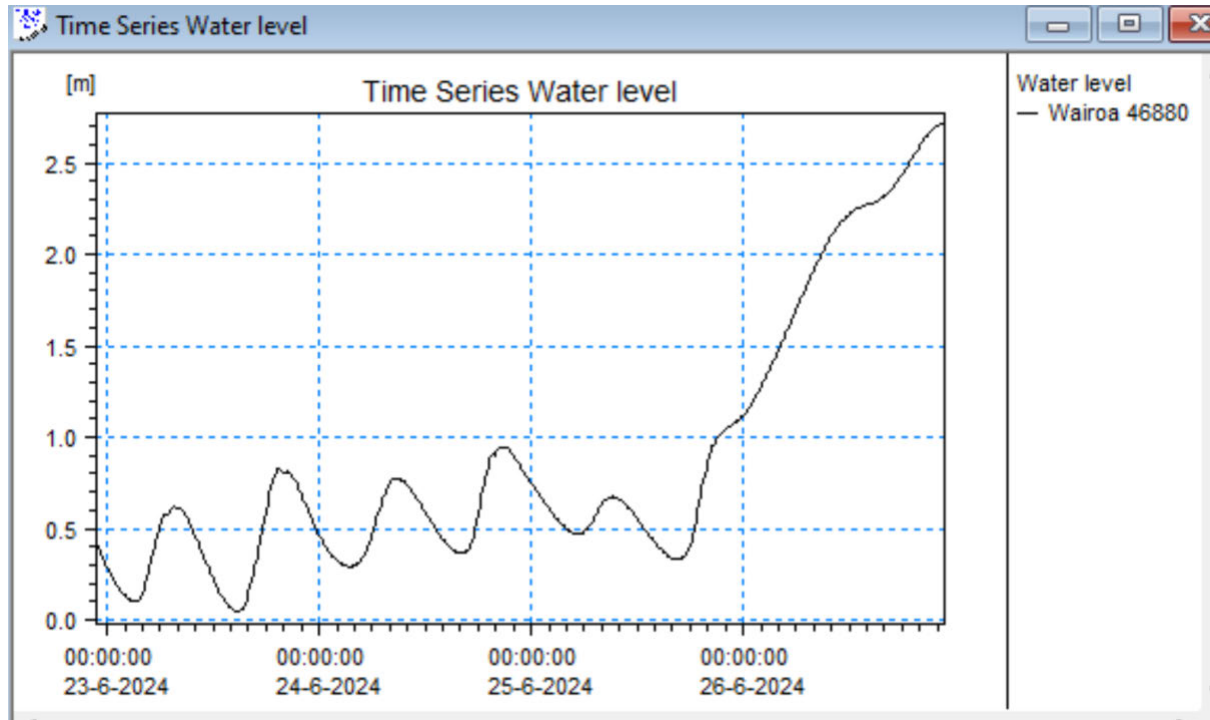


Figure 4-2 HBRC Wairoa River Level forecast 11:40pm Monday 24 June

Notwithstanding the above, Pryde Contracting went ahead on Tuesday 25th of June on the basis of the instruction for a full mouth opening procedure from HBRC which included deploying a bulldozer at the existing river mouth to start building up sand for an attempted closure on Wednesday morning as well as cutting an upstream pilot channel down to water level at the new mouth location with a seaward coffer dam.

Pryde Contracting worked until nightfall on Tuesday 25th of June and left the site under conditions that were already extremely dangerous with high winds, heavy rainfall and large waves starting to break over the crest of the beach. Notably the seaward coffer dam was in place on the pilot channel they had partially excavated during the day. For the purposes of explanation an example of a more fully formed upstream pilot channel cut with a seaward coffer dam is shown in Figure 4-3 below. This is likely a similar general arrangement as what was in place at nightfall on Tuesday 25th of June but with the upstream channel not developed to the same extent (depth or width).



Figure 4-3 Wairoa River bar seaward coffer dam and upstream pilot channel (9 August 2024)

For the commentary on what happened on Tuesday evening once Pryde Contracting left site the information provided by T&T¹³ will be drawn upon, particularly the likely wave environment during this period as well as the possible timing and dimensions of the breaches of the bar and the scouring of the existing river mouth.

The best summary of the likely wave environment over this period is shown in Figure 4-4 below which is taken from the T&T report. It is also noted in the T&T report that the modelled wave height predictions for this event could be underestimated by up to 30%.

¹³ T&T (2024). Review of Physical Processes Influencing the 26 June Wairoa Flood – Data summary and analysis.

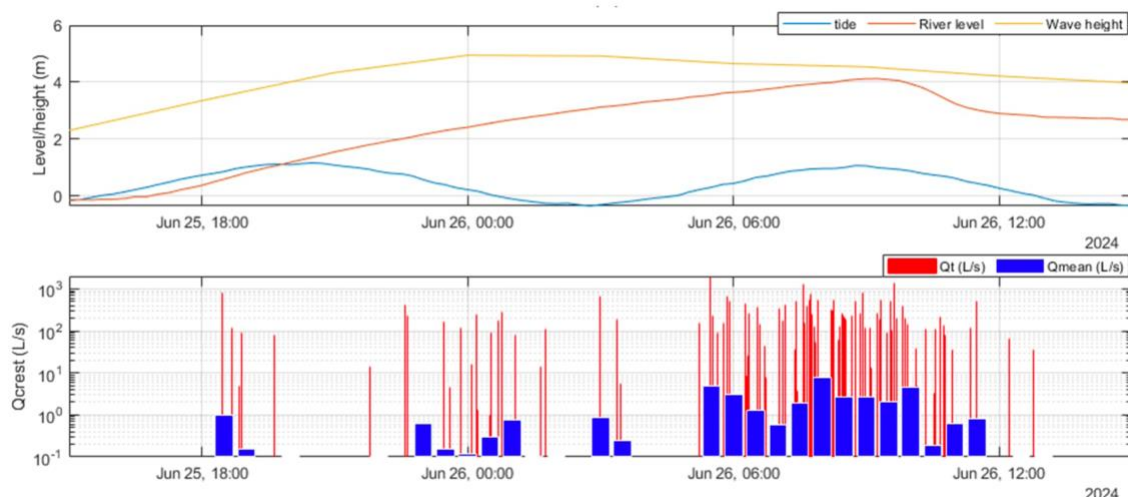


Figure 4-4 Modelled wave height and intensity of overtopping (Source T&T 2024).

The modelled wave heights show overtopping occurring as the wave heights increase after 6pm on Tuesday night with the rising tide which was high around 8pm. This is consistent with observations made by Pryde Contracting as they were leaving the site around this time. Further notable overtopping occurs around midnight as the wave height increases to 5 m and from around 4 am the most significant period of wave overtopping occurs with the rising tide and wave heights still around 5 m.

This overtopping is particularly important to note for considering counterfactuals later in this section of the report. This is for the reason that any overtopping that occurred prior to a breach or new mouth forming would have impacted the geometry of any preparatory earthworks whether they were a deep pilot cut with an opening to the sea (no seaward coffer dam) or a crest lowering at a higher level. The very large waves also possibly affected the ability of the river to erode and scour out a new channel through the beach crest and flow out against the incoming momentum of the waves.

While this wave overtopping is occurring two key things are occurring that impact the upstream flooding, the first being the overwashing of seawater into the lower river and secondly the sediment being moved which is affecting the existing bar as well as the crest of the beach and any temporary earthworks that have been put in place.

Also, importantly while this wave event is happening at the coast the rainfall that was forecast to be approximately 200 mm has now turned out to be 300 mm and a 5-year flood is rising in the Wairoa River. The river starts to rise at the Town Bridge from 7:30pm on Tuesday night, by 3:35am the level has risen above 3.7 mRL and is beginning to flood over Kopu Road. During this period the T&T modelling suggests that the existing river mouth is beginning to scour and widen starting from a width of approximately 60 m.

It is important to note for later analysis that at around midnight with the river level at around 2.5 mRL and the tide nearing low, that based on the T&T analysis that the river possibly had sufficient energy to overcome the wave conditions and begin eroding the existing river mouth. On this basis it is possible that if there had been another channel/breach point with sufficient depth open to the sea that it too might have scoured and enlarged over this period. However, it is also possible that the wave action was the dominant factor during this period and the river level needed to rise further to overcome the sea to erode the existing mouth or scour out a new one.

At 9:10am there is widespread flooding of lower Wairoa as the river has risen to 4.7 mRL and the existing river mouth has possibly eroded to be 120 m wide with a base level of -2.5 mRL. Shortly

after the peak of the flood the water levels rapidly drop most likely due to a large natural breach forming of approximately 120 m wide with a base level of -2.5 mRL being the same as the dimensions of the existing river mouth.

In addition to the existing river mouth and the large natural breach to its immediate east right out in front of Pilot Hill, there was another smaller natural breach further east (See Figure 1-1) but notably where Pryde Contracting had done there works there was no breach (See Figure 4-6). This was at least in part due the natural height of the surrounding beach crest as well as the seaward coffer dam that was in place.



Figure 4-5 Aerial image showing the existing river mouth and natural breaches that occurred during the event (Source FENZ UAV)



Figure 4-6 Location where works had been done the day before (Source FENZ UAV)

It is with the above context and interpretation of events that I provide the following commentary and analysis on the possible causes including the contribution of the state of the river mouth. The evaluation of HBRC decision making as well as counterfactuals for the purpose of considering alternatives in the future is provided in Section 5.

Tonkin and Taylor (T&T) have completed a thorough review¹³ of the 2024 flood event including the physical processes that influenced the extent and duration of flooding in the lower reaches of the Wairoa River. I have not attempted to replicate this work or undertaken a detailed review of the modelling used as the basis for its conclusions. However, I make the following comments based on the T&T work with specific reference to how the possible causes of the flood event and the state of the river mouth relate to the effectiveness of the HBRC operational response.

4.2 Possible Causes

The three key factors highlighted in the T&T report that interacted to cause the flooding are –

- flood flows;
- waves;
- the state of the river mouth.

From the information provided and discussion with HBRC staff the rainfall during this event generated a 5-year flood flow in the Wairoa River being a river level of 8 m at the Railway Bridge and an “ORANGE” warning level. This is not sufficient to cause flooding to the North Clyde area with that threshold being some 2 m higher (measured at the Railway Bridge) for a 20-year flood event and from the information I have been provided has not previously caused flooding in the lower Wairoa area around Kopu Road.

The waves that occurred during this event were likely more significant than the rainfall in terms of return period but there is uncertainty about how large they actually were as there are no direct measurements of wave height in close proximity to Wairoa. The T&T analysis used the MetOcean Solutions nowcast model to provide an estimate of the wave environment during this event. Based on this model the peak significant wave height at 10 m depth was estimated at 4.2 m.

However, T&T noted that this model underpredicted the wave height for this event by 20 - 40% based on the observed wave heights from the Napier wave buoy and that adding 30% to the modelled wave heights at Wairoa would result in approximately a 50-year return period wave event. This would be more aligned with anecdotal observations from locals who thought the waves were the largest in the past 30 years. Assuming that the waves and rainfall are independent variables the probability of a 5-year return period flood coinciding with a 50-year return period wave event is 0.4% or the equivalent of a 250-year return period event.

When the waves overtop the beach crest, they add additional water volume to the lower river that has to flow out again through the mouth and they also affect the beach crest with the T&T modelling suggesting a landward retreat of 10 - 24 m and crest lowering of 0.3 – 0.6 m. The overtopping also affects any temporary channel cuts that have been made and it is possible that excavations could have been infilled by the sand and gravel overwashing the beach crest.

T&T note in their report¹³ that the overtopping can be a “destructive force” when the beach barrier has a relatively low height compared to the waves, causing the crest to flatten as indicated by their modelling results above. Pryde Contracting also made the observation¹⁴ that the bigger seas were

¹⁴ Pryde Contracting pers comm 21 August 2024.

“destructive” and tended to cause erosion on the beach. However, T&T also note¹³ that it was possible that in some locations that crest may have built up due to the overtopping.

There is clearly uncertainty around what might have happened to any preparatory earthworks whether they had been a deeper pilot channel cut or a shallower crest lowering but what is known that there was effectively no preparatory earthworks in place and the river level had to reach 4.2 mRL (at the yacht club) before there was sufficient energy for the river to overcome the waves, overtop the beach crest and erode a natural breach for a new river mouth to form.

It is highlighted that the T&T modelling of the river does not include the wave action so the inundation that was observed is replicated in the model by applying the incoming flood flows with the estimated downstream tidal boundary with the river mouth and breach geometry that developed over the event including the scouring of the existing river mouth from before midnight. HBRC contend that inclusion of the very large waves occurring during this time provides a possible alternative explanation where the existing river mouth is becoming partially blocked over this period and it is not until when the breach naturally formed shortly after 9 am that there was sufficient energy for the river to overcome the sea.

4.3 State of River Mouth

T&T considered a range of scenarios to test the sensitivity to the state of the river mouth and breaches of the bar. A summary of the results from Table 4.2 of the T&T report is provided below.

Table 4-1 Flood Level Sensitivity to Mouth/Bar Conditions June 2024 Event¹⁶

Scenario	Peak Flood Level at Wairoa Yacht Club
No breach	4.7 mRL
Natural 120 m wide breach during event (what actually occurred)	4.2 mRL
Theoretical 16 m wide breach at - 2.5 mRL	4.1 mRL
Theoretical 16 m widening to 40 m breach at - 2.5 mRL	3.8 mRL
Theoretical 150 m wide breach in advance of flood	2.8 mRL

It is clear from these results that the state of the river mouth and timing of breaches of the bar have a significant effect on upstream flood levels. Based on the T&T modelling if no breach had occurred then flood levels would have been 0.5 m higher and the duration of inundation would have increased from 7 hours to 20 hours. Equally important to note is that if there had been an initial breach of only 16 m wide down to - 2.5 mRL that widened out to 40 m during the event the impacts of the flooding would have been significantly less with peak flood levels estimated to be only 100 mm above the threshold for flooding property around Kopu Road (3.7 mRL). At the other end of the scale if there had been a fully open 150 m wide breach in advance of the flood the levels would have dropped to 2.8 mRL.

The T&T modelling doesn't include the effects of waves and notably if there had been a fully open 150 m wide breach it is unclear how far upstream the wave action could have propagated and what

¹⁶ Table 4.2 Flood modelling results summary pg 47 T&T 2024 report.

additional volume of water would have been added to the lower river given the waves were overtopping the existing beach crest at a level of around 4.7 mRL.

The real unknown is what scale of breach could have developed during this event if there had been a full pilot channel open to the sea circa 6 m wide at 0 – 0.5 mRL or a crest lowering of circa 15 m wide at 2 – 2.5 mRL in place at nightfall on Tuesday. This is discussed in further detail in the following section.

5 HBRC Operational Response

This section specifically analyses the HBRC operational response to the June 2024 flood event, looking particularly at the timing of works relative to when the flood was forecast to occur.

5.1 Timing of River Mouth Opening Attempt

Based on the HBRC and Pryde Contracting methodologies that have been provided, an attempted river mouth opening requires five key factors to line up if there is to be any chance of success. For this particular event the local contractors were on stand-by from Friday 21 June due to the adverse position of the river mouth and the forecast for rain within the region but not specifically in the Wairoa catchment. The instruction to go-ahead was given at 2 pm on Monday 24 June with the flood forecasted to occur on Wednesday 26 June. The timing of the river mouth opening attempt is assessed based on the five key success factors as summarised in Table 5-1 below.

Table 5-1 Assessment of Key Success Factors for River Mouth Opening 24 June 2024

Key Success Factor	Satisfied/Not Satisfied for this event	Comments
5-7 days lead time for flood in the river	Not Satisfied	The flood was forecast to occur on Wednesday which effectively provided 1 day of physical works in preparation.
Low river flows	Not Satisfied	Flow on Waiau at Ardkeen ~ 50 m ³ /s which is 75% exceedance flow.
Restricted existing river mouth	Not Satisfied	Observations from Pryde Contracting that existing river mouth was wide and deep and unlikely to be able to be closed.
Calm sea conditions	Not Satisfied	Forecast was for very large waves on Tuesday evening.
High tide and flood rising during daylight hours	Not Satisfied	High tide prior to flood levels rising was 8 pm on Tuesday during hours of darkness at that time of year. The low tide on Wednesday was around 3am so also not possible to do any opening then.

As clearly demonstrated from the above table none of the key success factors for a river mouth opening were satisfied ahead of the 26 June event. As previously noted, the forecast of the timing of the flood event did change on Monday to be rising from late Tuesday instead of predictions from earlier in the day that suggested it wasn't going to start rising until midday Wednesday which would have provided some more time to progress the works.

HBRC describe their decision to progress with a mouth opening as precautionary due to the uncertainty in the conditions. I consider that at the point on Monday evening when the rainfall and resulting river flow forecast changed to show rising river levels from about 8pm on Tuesday night that potentially a more productive use of Tuesday might have been to try and lower a section of beach crest as much as possible and most importantly have it open to the sea with no coffer dam before nightfall on Tuesday.

There were communications from Pryde suggesting that crest lowering was what should be progressed on Tuesday but this was not interpreted as being an alternative method by HBRC and in the end a standard full mouth relocation procedure was followed. HBRC officers were monitoring works on the Tuesday and at no point did there appear to be specific instructions about ensuring any cut that had been formed was open to the sea.

5.2 Timing of Preparatory Work for a River Mouth Opening

Other than having the contractors on stand-by there was no preparatory work in terms of physical works to prepare for an opening. Even if the contractor had been instructed to commence works on the Friday prior to the flood event, four or the five key success factors still would not have lined up for a successful mouth opening on the following Wednesday.

5.3 Methodologies for Undertaking River Mouth Opening

It is useful to consider two counterfactuals for the purpose of understanding lessons that can be learnt from this event.

Counterfactual One – Earlier Deployment

If Pryde Contracting had been given the go-ahead on Friday and spent Saturday through to Tuesday doing earthworks to more fully prepare the site would the outcome have been any different?

It is likely that earthworks would have been further progressed with the possibility of a larger pilot cut of 6 m width down to 0 – 0.5 mRL and a seaward coffer dam established by Monday but the effectiveness of this would have at least in part been dependent on decision making on Tuesday. If it was recognised that the flood was coming that night and the seaward coffer dam needed to be removed then there could have been a full pilot cut channel open to the sea when the contractors left site on Tuesday.

The key unknown here is whether any part of the full pilot channel cut would have still been functional around midnight when the river reached around 2.5 mRL and the tide was low after around 6 hours of 4-5 m waves overtopping the beach crest. It is also unclear whether it would have been possible to safely mechanically breach the seaward coffer dam given the rising wave heights during Tuesday afternoon.

It is likely that the pilot channel could have been at least partially if not completely filled in by the early hours of Wednesday morning due to the overtopping waves. It is unknown whether there would have been sufficient remnants of it for it to breach any earlier than the natural breach around 9am on Wednesday the 26 June. It is also unknown whether the wave action could have also prevented an earlier breach occurring even if there had been remnants of preparatory earthworks evident.

Counterfactual Two – Crest Lowering

Instead of pursuing a full mouth opening including deploying a bulldozer to the western side of the bar could an alternative strategy of focussing all resources on a crest lowering on Tuesday with no seaward coffer dam been more effective?

The extent of work would have obviously been far more limited compared to the earlier deployment counterfactual but some degree of crest lowering from the existing crest level of around 4.7 mRL may have been achieved with one day's work with 3-4 large machines (bulldozers and excavators).

Possible dimensions of approximately 15 m wide lowering down to 2 – 2.5 mRL may have been achievable. The level would not have been as low as that what could have been achieved with multiple days of preparation and this would have been affected by the wave overtopping occurring from around 6 pm on Tuesday. Whether this could have been in place or sufficient remnants of it, particularly around the low tide at midnight causing a breach to occur is unknown. It is also unknown whether the wave action during the period from midnight through to 9am would have prevented a breach and a new mouth forming no matter what was in place.

What can be said for certain is that neither of the scenarios outlined in these counterfactuals were executed so there was effectively no mitigation in place in terms of a lowered section of beach crest or open pilot channel for this flood event. Whether this would have made any difference is unknown due to the large waves that occurred prior to the flood rising sufficiently and low tide conditions occurring for a breach to possibly form from these works. It is also possible that the river might not have had sufficient energy to overcome the large waves any earlier than when the natural breach occurred no matter what preparatory works were in place. Notwithstanding the above, having either option in place would have likely been better than nothing and at least provided the possibility of a breach occurring earlier in the event which might have reduced the extent and duration of flooding.

5.4 Other Options for Mitigating Risk of Flooding

In terms of operational responses there are two general options for managing the flood risk associated with the alignment of the Wairoa River mouth.

The first would be a return to past practices where preparatory works are undertaken when the mouth is in an inefficient location regardless of whether there is a flood forecast or not. This would see a full pilot channel down to below water level with a seaward coffer dam used to provide some degree of protection to the works. Once a flood is forecast the seaward coffer dam can be cut through within a relatively short period (circa 1 day). There is also the possibility of including an attempt to shut the existing mouth and the same time but this requires very low river flows and the existing bar to be almost closed naturally. It is probably more useful to prioritise equipment to cutting the seaward coffer dam rather than attempting to close the existing mouth which is unlikely to be successfully executed.

The second option would be to lower the beach crest to a level that will breach prior to flooding of Kopu Road. This option could likely be deployed at relatively short notice 1 – 2 days and be executed quickly with the appropriate earthmoving equipment. This technique would be similar to that used by other regional councils and was also suggested by Pryde Contracting and T&T⁷.

6 Conclusions & Recommendations

1. The state of the Wairoa River mouth significantly affects upstream flood levels with even a relatively modest 5-year return period flood coinciding with large waves able to cause significant upstream inundation when the river mouth is in an adverse position west of Pilot Hill.
2. Large waves coinciding with such an event are likely to limit the effectiveness of any operational response that relies on having a pilot channel open to the sea or a lowered section of beach crest in place prior to the flood rising.
3. During the June 2024 flood event there was effectively no mitigation in place in terms of a pilot channel with an opening to the sea or a section of lowered beach crest.
4. The occurrence of large waves overtopping the beach crest for approximately 6 hours prior to possible breaching conditions occurring would have likely compromised the performance of any such works had they been in place.
5. It is possible that large waves occurring through to the point when the natural breach occurred could have prevented any earlier breach regardless of what preparatory works or remnants of such works were in place.
6. The accuracy of long range rainfall forecasting is not sufficient to attempt a full-pilot channel mouth relocation procedure with a 5-7 day lead time.
7. The other very specific conditions required for a mouth relocation are far too restrictive on when it can be successfully executed for it to continue to be used as an effective method for managing flood risk for the lower parts of Wairoa.
8. A simpler method which consists of two general options should be considered and further developed -
 - a. Have the upstream section of pilot cut with a seaward coffer dam at the height of the beach crest in place at all times when the mouth is in an adverse position with the flood response activity limited to cutting the seaward coffer dam open the day prior to the flood and perhaps trying to close the existing river mouth at the same time;
 - b. Lower the crest of the beach barrier in advance of the flood requiring 1 – 2 days work.
9. Option 'a' would be an apparent return to the typical practice of the past and is more directed towards attempting to create a new mouth, whereas option 'b' is more about creating a lowered section for the river to break through for a specific flood event without trying to necessarily create a new river mouth.
10. Given the typically short lived nature of a river mouth in a favourable location and the risk and difficulties highlighted with trying to relocate the mouth it is possible that a simpler method of lowering the crest to create a weak point 1 – 2 days prior to a flood could be a better approach.
11. This approach would be consistent with that applied by other regional councils in New Zealand and provides a more agile and responsive method for managing the flood risk associated with the position and form of the Wairoa River mouth.
12. It is highlighted that as with any operational response there will be risks associated with it not being successfully deployed due to adverse weather conditions or other factors.

APPENDIX A – Terms of Reference

TERMS OF REFERENCE (TOR) FOR AN INDEPENDENT REVIEW INTO THE MANAGEMENT OF THE WAIROA RIVER MOUTH BY HAWKE'S BAY REGIONAL COUNCIL (THE REVIEW)

1. Introduction

Background:

On 26 June 2024 Wairoa was impacted by significant flooding resulting from a severe weather event.

On this occasion, the focus of the flooding was in the vicinity of the Wairoa River mouth, particularly affecting properties on the true right river bank.

This event resulted in significant damage to property and infrastructure, loss of livelihoods, and many whānau being displaced from their homes. Over 400 properties were affected by flooding and over 100 yellow placards have been issued, pursuant to the Building Act 2004.

The Wairoa community have raised concerns that the management of the Wairoa River mouth by Hawke's Bay Regional Council (HBRC) contributed to the flooding. The community are particularly concerned that the river mouth was largely closed and have suggested that it ought to have been mechanically opened before an attempt to open the bar was commenced on Tuesday 25 June 2024.

Purpose of the Review:

The purpose of this the Review is to:

1. Consider the possible causes of flooding on 26 June 2024.
2. Comment on the extent to which the state of the river mouth contributed to the flooding event.
3. In light of the information and intelligence available, review and comment on the decision making of HBRC in the lead up to the event, specifically:
 - a. The timing of the attempt to open the river mouth (which in the event was planned for 26 June 2024),
 - b. The timing of preparatory work for a river mouth opening being commenced,
 - c. The methodologies adopted by HBRC in order to undertake an opening of the river mouth, and
 - d. Any other options available to HBRC to mitigate the risk of flooding.
4. Make any recommendations that the Reviewer considers necessary to ensure that any lessons identified from the events surrounding the 26 June 2024 flooding event are incorporated into the future management of the Wairoa River mouth.

2. Scope of the Review

Area of Focus:

The Review is to look specifically at the management of the Wairoa River mouth in the lead up to the weather event of 26 June 2024 and the decisions made by HBRC about whether the bar should be mechanically opened and, if so, when.

Exclusions:

Wider considerations around the long-term management of the Wairoa River mouth are not within the scope of this review. This includes, as out of scope:

1. The ongoing assignment of responsibility for management of the river mouth; and
2. The prospect other management options for the Wairoa River mouth, such as coastal engineering options or improved landside resilience.

Time Period:

The time period within the scope of the review may be determined by the Reviewer. However, the focus of the review should be on the situation leading to the state of the river mouth on 26 June 2024, and not the longer term management of the river mouth.

3. Methodology

Data Collection:

The Reviewer may collect data and evidence in any way that they determine to be appropriate and expedient. This may include, but is not limited to:

1. Requesting documents and other information from HBRC. HBRC commits to providing requested documents, as priority, in a timely and fully transparent manner.
2. Undertaking interviews with HBRC staff. HBRC commits to taking all reasonable steps towards making staff available for such interviews.
3. Undertaking interviews with and/or requesting information from:
 - a. The Wairoa District Council,
 - b. Tātau Tātau o Te Wairoa,
 - c. Pryde Contracting Limited.

Data collected from all sources is to held in-confidence by the Reviewer.

Third party support:

Should the Reviewer consider that additional technical support is necessary to support the Review, the Reviewer is to raise this requirement with HBRC in order to confirm the appointment, scope and budget for any such support.

Other reviews:

The Reviewer may, as they determine appropriate, take account of any other relevant reviews relevant to the scope of the Review.

The Reviewer must take account of:

1. The HBRC-commissioned review into the flood modelling of the 26 June 2024 flooding event as undertaken by Tonkin + Taylor,
2. The HBRC-commissioned review into HBRC's standard operating procedures relating to the opening of the Wairoa River mouth as undertaken by Graham Campbell, and
3. If reasonably available in time for the Reviewer to consider, the findings of the Ministry for the Environment-commissioned review into Management of the Wairoa River Bar by Hawke's Bay Regional Council, as undertaken by Mike Bush, Bush International Consulting Ltd.

Reporting:

Prior to delivering the final report, the Reviewer must provide a final draft of the report to Hawke's Bay Regional Council for comment, allowing no less than 5 working days for such review/comment.

The Reviewer must also consider the natural justice rights of any person whose reputation or standing might reasonably be adversely affected by any comment made in the report. Any such person must be given the opportunity to review relevant extracts of the report and to provide comments to the reviewer. The Reviewer must take account of any comments made by an affected person.

4. Appointments**Reviewer:**

Kyle Christensen, Christensen Consulting Ltd, is appointed as the Reviewer.

Sponsor:

Dr Nic Peet, Chief Executive, HBRC, is the Sponsor of the Review.

Primary point of contact:

Matt McGrath, Chief Legal Advisor, HBRC, will be the primary HBRC point of contact.

5. Deliverables

The Reviewer will deliver a Final Report to the sponsor, which is to include:

1. An executive summary,
2. Key findings, and
3. Recommendations.

6. Timings

The final draft report is to be available for HBRC comment no later than 16 August 2024.

HBRC's comments will be submitted no later than 23 August 2024.

The final report is to be submitted to the sponsor no later than 30 August 2024.

7. Approval

These TOR are approved by the Sponsor on 11 July 2024.



Dr Nic Peet
Chief Executive

APPENDIX B – HBRC Responses to Questions

Christensen Review - Responses to written questions on alternative approach to river mouth realignment

Reviewer question:

One particular matter I'm trying to understand at the moment is the apparent requirement to wait for a flood to be forecast before initiating a mouth cut. I noted from the HBRC Lagoon and River mouth instructions that -

"For a successful realignment of the Wairoa bar, river needs to completely close, gain a substantial head of water, and then we recut to the old pile lines."

Whereas the Prydes methodology includes the requirement for a "substantial flush" of rainfall.

Based on the HBRC Lagoon and River mouth instructions and alternative "dry weather" methodology is conceivable. This would include mechanically closing the existing river mouth and then cutting a pilot channel for the new mouth with an upstream coffer dam that allows head to build up before naturally or mechanically breaching the coffer dam and allowing the new river mouth to form as the water temporarily stored in the lower reaches of the river flows out.

I've had a look at this in terms of potential storage, flow rates and scouring potential for the new channel. I figure you could get approximately 500 m³/s for an hour with a 2 m high coffer dam that could get you a 150 m wide river mouth. This is based on the assumption that the beach material is sand.

The above "dry weather" methodology is the standard procedure Greater Wellington Regional Council use.

Keen for comments on above.

Response:

We think that it overstates the situation to say that we are “waiting for a flood to be forecast”. Rather, we currently require expected rainfall that will build up the head pressure. We think that this is consistent with Pryde’s reference to a “substantial flush” of rainfall.

There are several reasons why a ‘dry weather’ approach is not likely to be successful in Wairoa.

The first reason is that the Wairoa District Council Wastewater Treatment Plant (WWTP) effluent disposal location is via a pipe located in the river, just upstream of Pilot Hill. The plant operates by discharge consent on outgoing tides. There is limited capacity to store effluent, resulting in a requirement to maintain some outflow. Condition 13 in the consent requires WDC to assist in the opening if the mouth is restricted.

13.	If rivermouth restriction is imminent, or has occurred, the Consent Holder must immediately contact the Council and enter into discussions to determine the options for mechanical opening of the rivermouth. If the Council deems it appropriate and chooses to take action, the Consent Holder shall provide all assistance as deemed necessary.
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We consider that a forced closure of the mouth would not align with the operation of the WWTP. The relevant parts of the resource consent are included further below for reference.

If, for some reason, this condition was able to be overcome, blocking the mouth without substantial rainfall (or river flow) is unlikely to result in a buildup of sufficient water level to scour a new mouth. The riverside bar is approximately 2 km long, with beach material which is generally porous mixed sand and gravel which allows substantial flow through the beach crest. While the river level would rise gradually, the most likely outcome would be an equilibrium barely above mean sea level.

Also, the surface area of the river side of the bar is in the order of at least 10 km², which, at a low flow (dry weather) condition, as an example with 15 m³/s inflow and a completely blocked mouth, the time taken to raise the upstream water level by 1 m would be in the order of at least 1 week, assuming no seepage through the bar. This is not practical in terms of the WWTP consent and is unlikely to be successful.

We note that the contractor (Pryde’s) comments that being able to close the mouth mechanically and create a dam can be difficult or impossible due to depth and width of the natural opening. Pryde’s provides comments that being able to close a mouth is only possible when a new mouth is opening and starting to scour. Having two mouths (original natural, and additional mechanical) generally results in the flow favouring the original natural mouth, and the mechanical mouth soon closes.

Here is the description provided by Pryde’s:

- One of the bulldozers would be transported back around to the existing river mouth, where it would start creating a large stockpile of sand right next to this river mouth.
- Depending on timing and weather conditions, a sea wall may be built in front of the job site for safety and progress protection purposes as the job continues (or overnight)
- The preferred time to open the bar up fully through to the sea, is typically a couple of hours after high tide. The sea level is dropping, and this gives the longest time till next hightide is, therefore giving the new river mouth the best chance to work.
- When the chosen opening time has happened, an excavator will be used to dig the last part of the channel away and the water will begin to flow out.
- At the moment when the new mouth is being opened up fully to the sea, the bulldozer located at the existing river mouth would begin to push the stockpiled sand into the mouth. The aim is to force the existing mouth shut by pushing the stockpile further and further across the mouth, till it is blocked.

Below is a copy of the relevant parts of the Wairoa District Council Resource Consent for Discharge from the Wastewater Treatment Plant:

In accordance with the provisions of the Resource Management Act 1991(RMA), and subject to the attached conditions, the Hearings Panel grants discharge and land use resource consents for the operation and maintenance of the Wairoa wastewater treatment plant and sewer pump station overflows to

Wairoa District Council
P O Box 54
Wairoa 4160

For the following activities and consent durations –

Authorisation Number	Activity Description	Location	Consent Duration
AUTH-123608-02	to discharge treated wastewater from the Wairoa Wastewater Treatment Plant to the Wairoa River within the coastal marine area via an outfall structure (pipeline) (Rule 160 – Regional Coastal Environmental Plan (RCEP))	Wairoa River, Wairoa (CMA) NZTM: E 1982570 – N 5667456	15 years

Median River Flow	<p>The Median River Flow is defined as a flow of 28.960 m³/s at the Marumaru monitoring site on the Wairoa River (above the Waiau confluence). Correspondingly, ½ the Median River Flow is 14.480 m³/s and 3 x the Median River Flow is 86.880 m³/s, also at Marumaru. Based on an analysis of flow data for Ardkeen, Marumaru and other areas for the period 2011 to 2017, the Median River Flow corresponds to a flow of 72.180 m³/s at Wairoa at Town Bridge.</p> <p><i>Advice Note: HBRC's hydrologists may adjust the estimate of the median flow at the Marumaru monitoring site from time to time to reflect changes indicated by more recent river flow data. However, it is unlikely that any changes would be needed prior to 5 years from the Resource Consents being granted.</i></p>
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OPERATIONAL MATTERS	
Discharge Volumes and Timing	
9.	<p>Subject to rivermouth restrictions (Conditions 11–15), this condition shall apply at all times prior to :</p> <ul style="list-style-type: none"> - the commencement of UV treatment and filtrations in accordance with Condition 47 and, - the commissioning of 30,000 m³ of additional storage and, - the commissioning of 50 ha of land-based irrigation. <p>(a) When flow in the Wairoa River is less than the Median River Flow the discharge of Treated Wastewater from the outlet structure shall:</p> <ul style="list-style-type: none"> i. be limited to 3,000m³ during any 24 hour period; ii. only occur during periods of ebb tide 30 minutes after high tide to 6 hours after high tide; iii. only occur after 6 pm during the months of April to November inclusive; iv. only occur after 7pm during the months of December to March inclusive; and v. shall cease by 4 am during the months of December to March inclusive; and vi. shall cease by 6 am at all times. <p>(b) When flow in the Wairoa River is between the Median River Flow and 3 x the Median River Flow the discharge of Treated Wastewater from the outlet structure shall:</p> <ul style="list-style-type: none"> i. be limited to 5,000m³ during any 24 hour period; ii. only occur during periods of ebb tide 30 minutes after high tide to 6 hours after high tide; and iii. can occur at any time of the day providing (i) and (ii) are met. <p>(c) When flow in the Wairoa River is above 3 x the Median River Flow the discharge of Treated Wastewater from the outlet structure can occur at any time and volume is not limited.</p>

10.	<p>Subject to rivermouth restrictions (Conditions 11–15), this condition shall apply at all times following:</p> <ul style="list-style-type: none"> - the commencement of UV treatment and filtrations in accordance with Condition 47 and, - the commissioning of 30,000 m³ of additional storage and, - the commissioning of 50 ha of land-based irrigation. <p>(a) When flow in the Wairoa River is less than ½ the Median River Flow the discharge of Treated Wastewater from the outlet structure shall:</p> <ul style="list-style-type: none"> i. be limited to 1,600 m³ during any 24 hour period; ii. only occur during periods of ebb tide 30 minutes after high tide to 6 hours after high tide; iii. only occur after 6 pm during the months of April to November inclusive; iv. only occur after 7pm during the months of December to March inclusive; v. shall cease by 4 am during the months of December to March inclusive; vi. shall cease by 6 am at all times;
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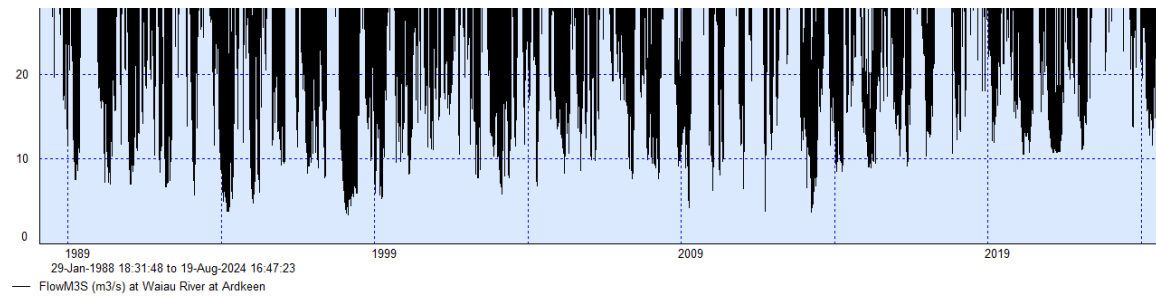
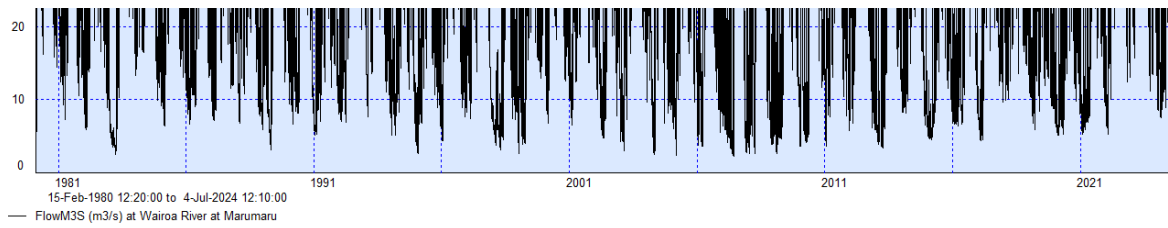


	<ul style="list-style-type: none"> vii. and occur on no more than 30 days discharge in December to March. <p>(b) When flow in the Wairoa River is more than ½ the Median River Flow and less than the Median River Flow the discharge of Treated Wastewater from the outlet structure shall:</p> <ul style="list-style-type: none"> i. be limited to 3,000 m³ during any 24 hour period; ii. only occur during periods of ebb tide 30 minutes after high tide to 6 hours after high tide; and iii. can occur at any time of the day providing (i) and (ii) are met. <p>(c) When flow in the Wairoa River is between the Median River Flow and 3 x the Median River Flow the discharge of Treated Wastewater from the outlet structure shall:</p> <ul style="list-style-type: none"> i. be limited to 5,000 m³ during any 24 hour period ii. only occur during periods of ebb tide 30 minutes after high tide to 6 hours after high tide; and iii. can occur at any time of the day providing (i) and (ii) are met. <p>(d) When flow in the Wairoa River is above 3 x the Median River Flow the discharge of Treated Wastewater from the outlet structure can occur at any time and volume is not limited.</p>
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	Rivermouth restriction
11.	<p>(a) Subject to 11(b) and 11(c) below, within 6 months of the commencement of the Resource Consents, the Consent Holder shall install and maintain in working order a camera to continuously record a view of the Wairoa rivermouth. A single daily image for 9 am shall be archived.</p> <p>(b) If, for the purpose of 11(a) above, the location of the rivermouth changes then the camera direction will need to change.</p> <p>(c) If, for the purpose of 11(a) above, a suitable camera location cannot be found, on each weekday the Consent Holder must view the rivermouth from an elevated position on Rangihoua (Pilot Hill) and visually assess the extent of river flow passing from the river to the sea.</p>
12.	<p>During times of rivermouth restriction, the Consent Holder shall cease the discharge of Treated Wastewater to the Wairoa River unless:</p> <p>(a) the ability to store excess Treated Wastewater has been exceeded; or</p> <p>(b) prior to storage capacity at the WWTP being exceeded, it is recognised that the maximum storage capacity is likely to be exceeded during a time when no discharge is allowed.</p> <p>In the event that 12(a) or 12(b) apply, the Consent Holder may resume the discharge of Treated Wastewater to the Wairoa River in accordance with Condition 9 or 10.</p>
13.	<p>If rivermouth restriction is imminent, or has occurred, the Consent Holder must immediately contact the Council and enter into discussions to determine the options for mechanical opening of the rivermouth. If the Council deems it appropriate and chooses to take action, the Consent Holder shall provide all assistance as deemed necessary.</p>
14.	<p>If the rivermouth is restricted and Treated Wastewater is likely to be discharged in accordance with Condition 12, prior to that discharge occurring, and as soon as reasonably practicable after becoming aware that a discharge will be necessary, the Consent Holder must notify the MWWP, Hawke's Bay District Health Board's Public Health Unit (DHB), Wairoa District Council's Environmental Health Officer (EHO), and the Council.</p> <p>Within 10 working days of a discharge undertaken in accordance with this condition ceasing, the Consent Holder shall provide the Council with written confirmation of the dates and times when a discharge commenced and ceased. This reporting shall also detail:</p> <p>(a) time of notification of Council, EHO, MWWP, and the DHB;</p>

	<p>(b) actions taken by the Consent Holder to limit and restrict river discharges occurring including, where appropriate, discharges to land as an alternative to the river; and</p> <p>(c) results of discussions with Council, including options, for mechanical opening of the rivermouth.</p>
15.	<p>(a) At least once in every 12-month period, when the rivermouth is restricted and Treated Wastewater is likely to be discharged in accordance with Condition 12, the Consent Holder shall take river water samples daily for the duration of rivermouth restriction.</p> <p>(b) Samples shall be collected from at least four locations (additional locations can be sampled at the Consent Holder's discretion) and be analysed for:</p> <ul style="list-style-type: none"> i. Enterococci; ii. faecal coliforms; iii. pH (field measurement); iv. salinity (field measurement); and v. temperature (field measurement). <p>(c) Reporting of the results shall be added to the Annual Monitoring Report.</p> <p>(d) The continuation of this programme may be reviewed after two monitored closures.</p> <p>(e) The BRM shall be invited to nominate kaitiaki to assist in the sampling required by this condition.</p>

Flow hydrographs from Marumaru and Ardkeen (shown below) indicate minimum flows are in the order of 5 m³/s from Waiau and 10 m³/s from Wairoa, giving a total of around 15 m³/s.

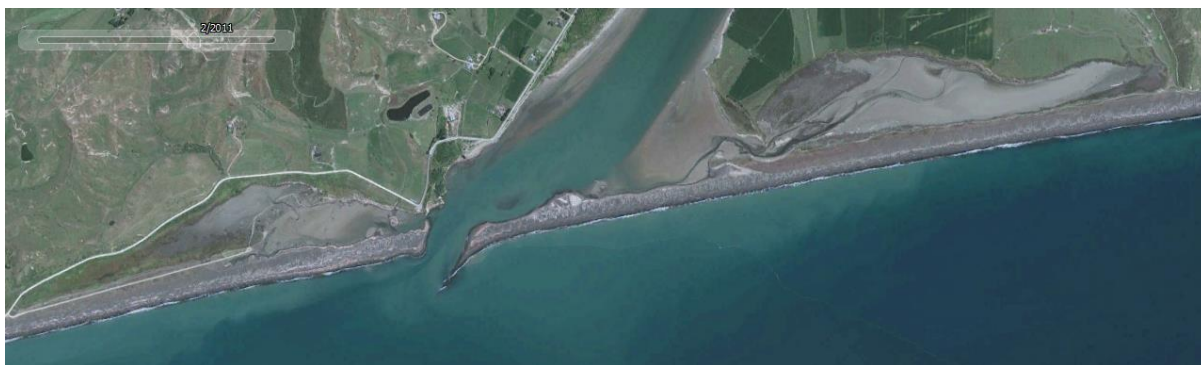


As noted in the WWTP resource consent, the median flow was calculated to be approximately 72 m³/s. The notes from Pryde's indicate the single action of a forced blocking of a natural mouth is unlikely to be successful due to the relatively high median flow causing a constant scouring effect on the mouth, so the action of pushing gravel into a flowing mouth results in the gravel being swept out to sea as opposed to creating a dam. The indication is that blocking a mouth is only successful as a combined action with creating a new mouth and directing water to the new mouth.

Sample Google Earth aerial photos



March 2004



February 2011



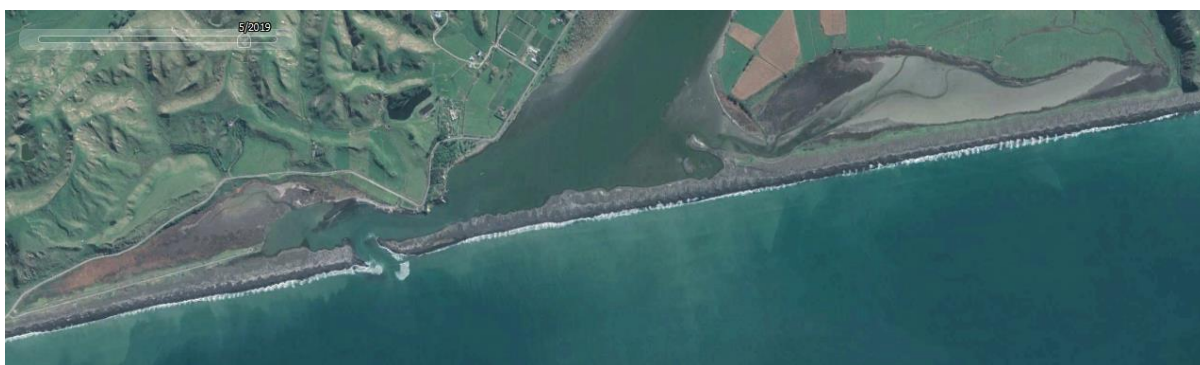
September 2012



October 2018



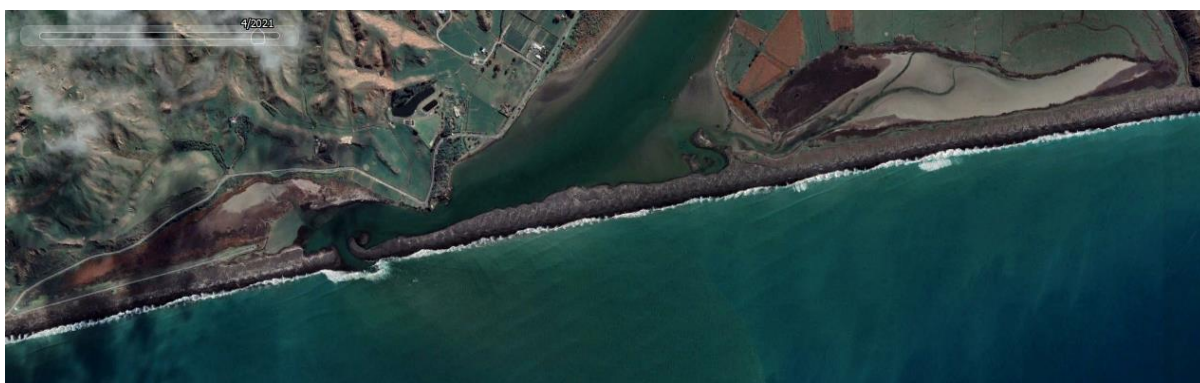
January 2019



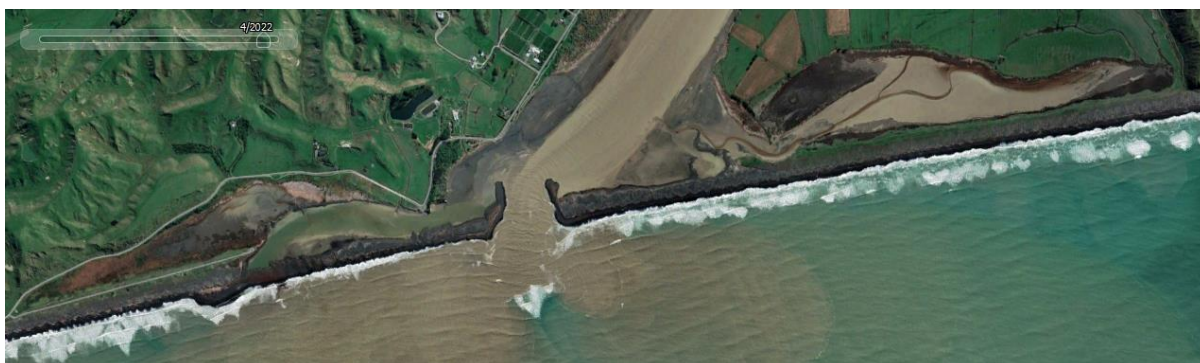
May 2019



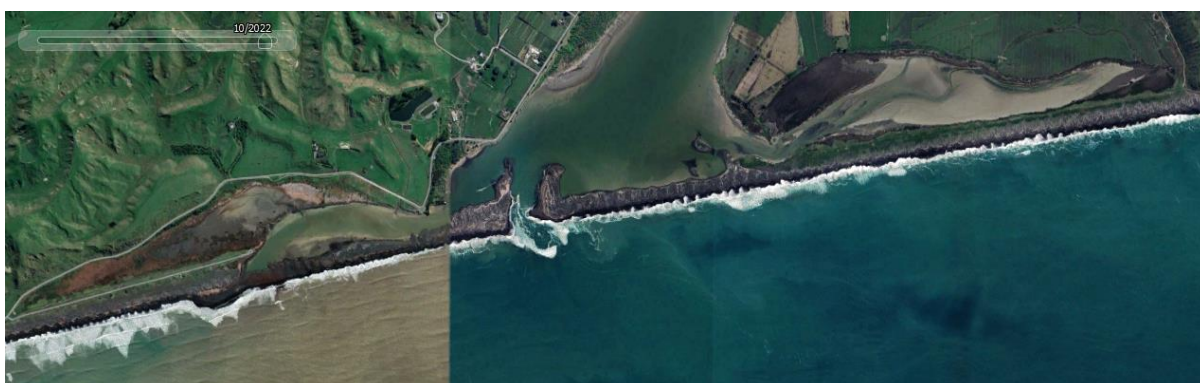
October 2019



April 2021



April 2022



October 2022



December 2022



February 2024

Mouth opening Jan 17, 2022



Mouth opening March 23, 2022



Christensen Review - Responses to written questions on Timeline and Communications Compilation

- 1. The timeline suggests there were no earlier opportunities to open the mouth between Jan – Jun 2024. I noted two small freshes in the river, the 22-23rd May and a smaller one on 30th Jan. Please comment on whether these events presented opportunities for a river mouth opening.***

Neither of these rainfall events appear to have been identified by Prydes or HBRC Operational staff as being opportunities for an attempted realignment of the river mouth. Accordingly, no flood forecasting was commissioned of the HBRC flood forecasters.

However, we note that the actual rainfall in both cases exceeded forecasts. So, the fact that the events would generate the required flow to assist a mechanical opening would be less likely to be identified ahead of time.

In any event, retrospective analysis (outlined below) of those events demonstrates that they were unlikely to have resulted in successful openings of the river mouth in a new location.

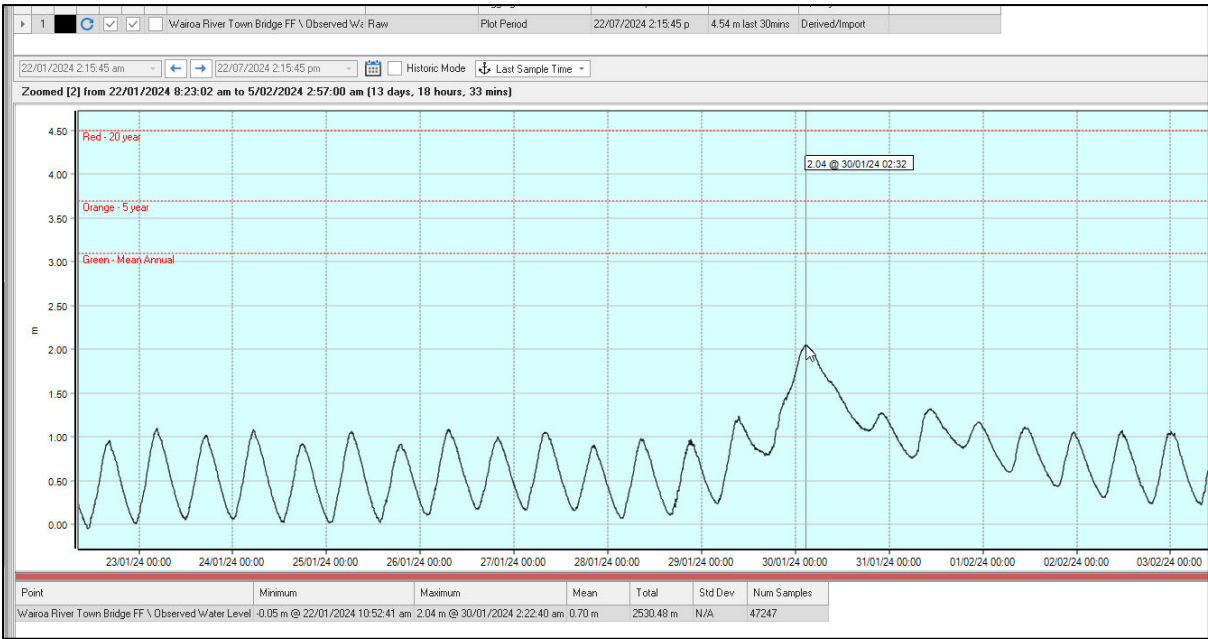
Note the elevation values in hydrotel shown below are based on HB1962 datum, whereas the LiDAR and other recent elevation data are based on NZVD16. The correction in this area is to subtract 0.2 m from the hydrotel data. Numbers below are read from hydrotel and are HB1962 datum unless specified.

30 January Event

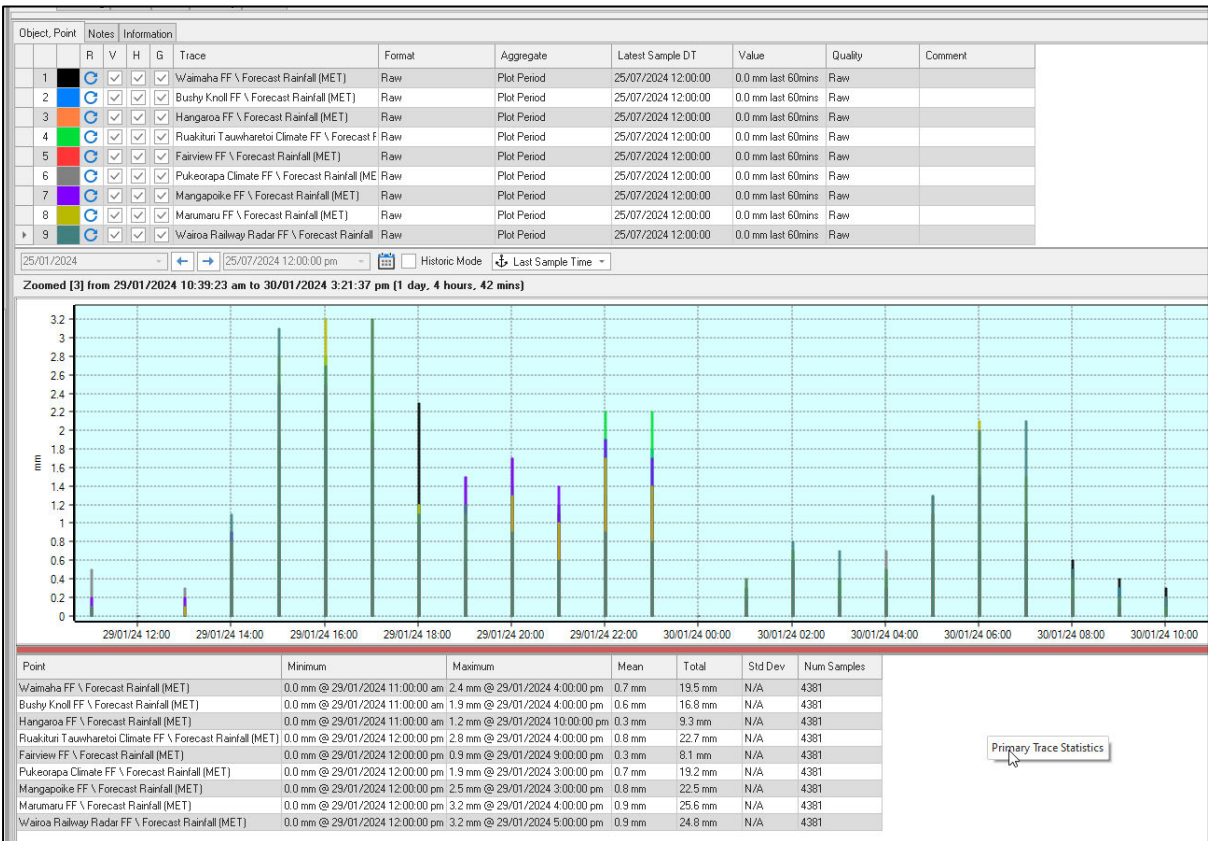
On this occasion, the forecast rainfall (which was relatively minor) was less than the actual rainfall, which was also relatively minor.

Water level at town bridge was up to elevation 2m (HB1962), (NZVD16 = 1.8 m), which is about 1 m below mean annual.

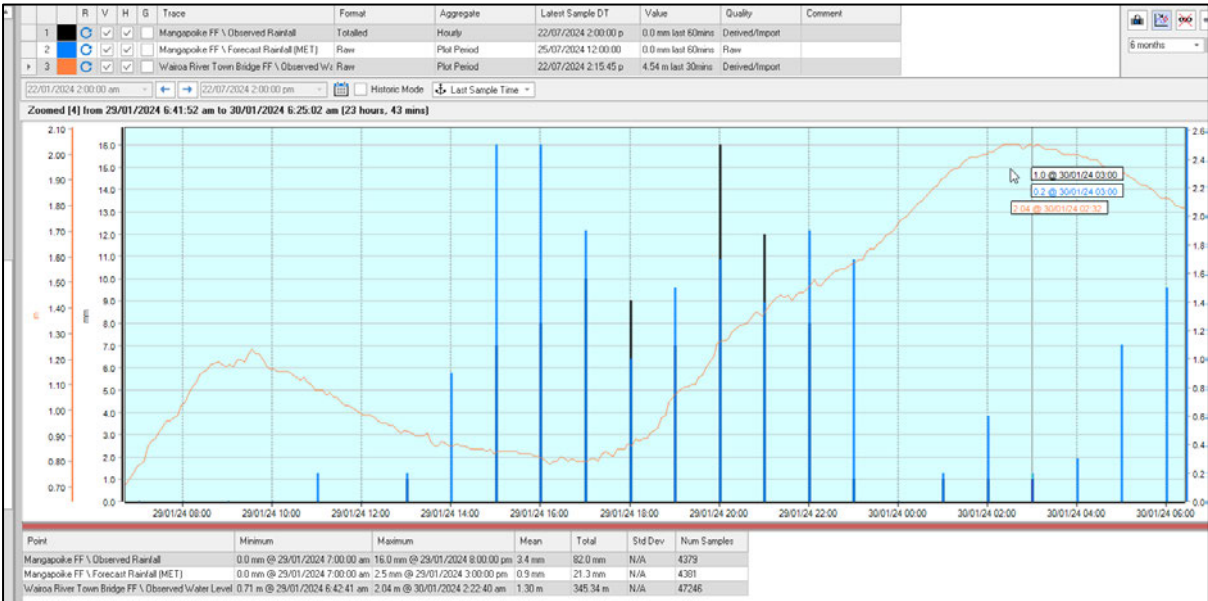
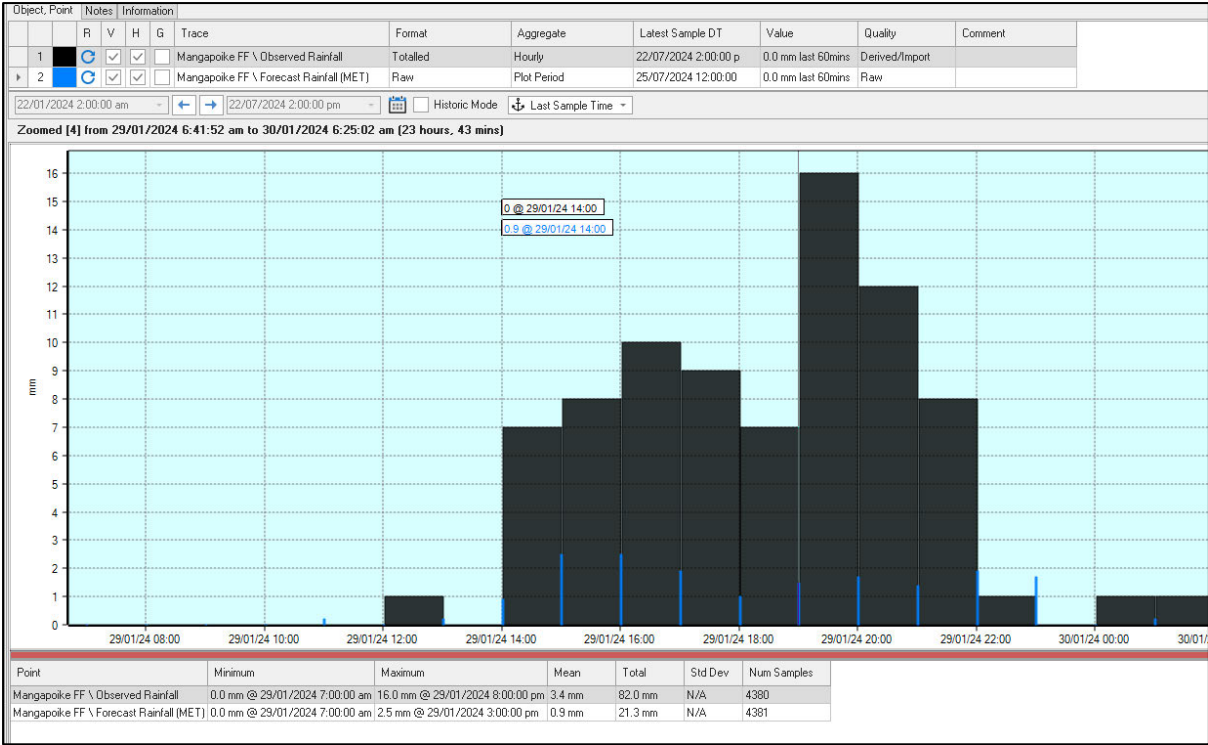
Peak level up to elevation 2 m at town bridge.



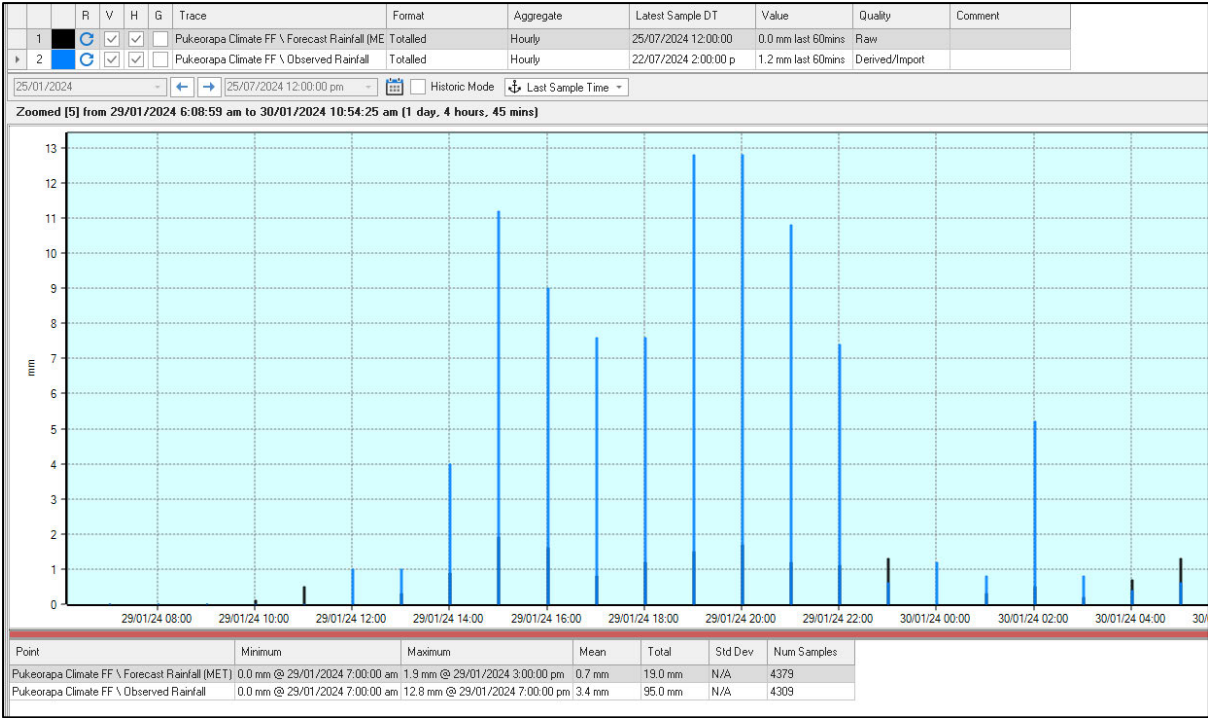
Forecast rainfall <25 mm



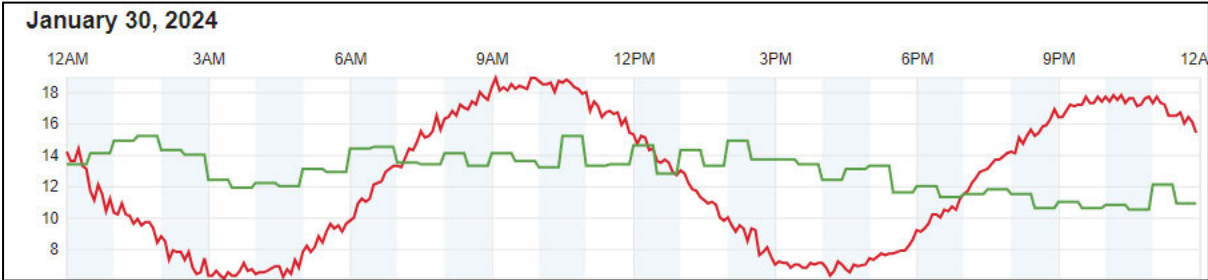
Example forecast at Mangapoke,



Example forecast at Pukeorapa



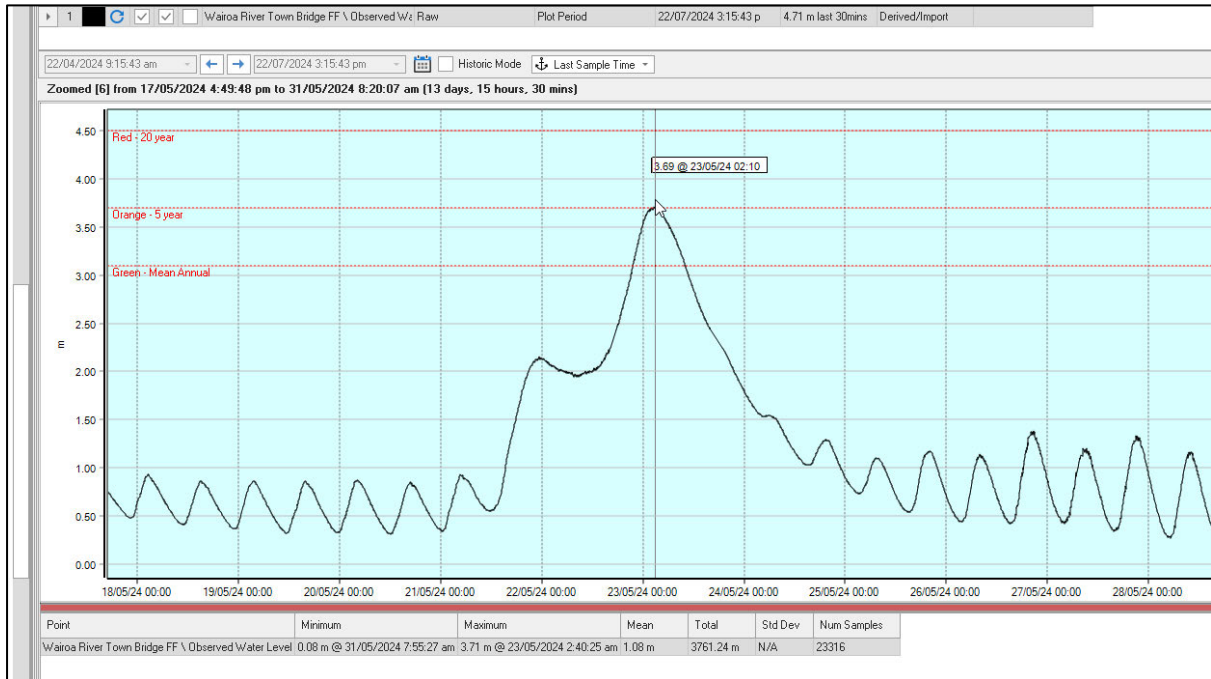
On Jan. 30, there was no significant swell at Napier. Green line is significant wave, divide left hand scale by 10 to get height in metres. Peak was about 1.5 m. Red is tide.



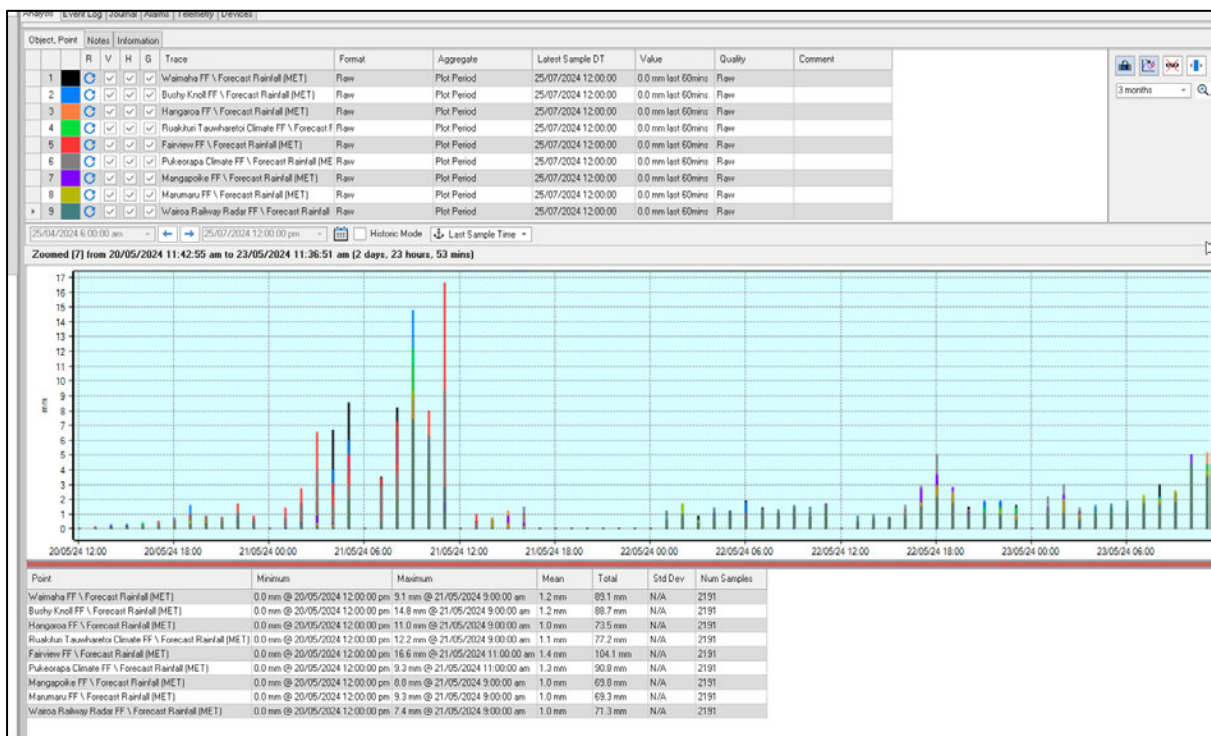
22-23 May Event:

Similarly, in May the actual rainfall exceeded what was forecast, as shown below. Any opportunity that this event presented for an opening is likely to have not been evident ahead of time.

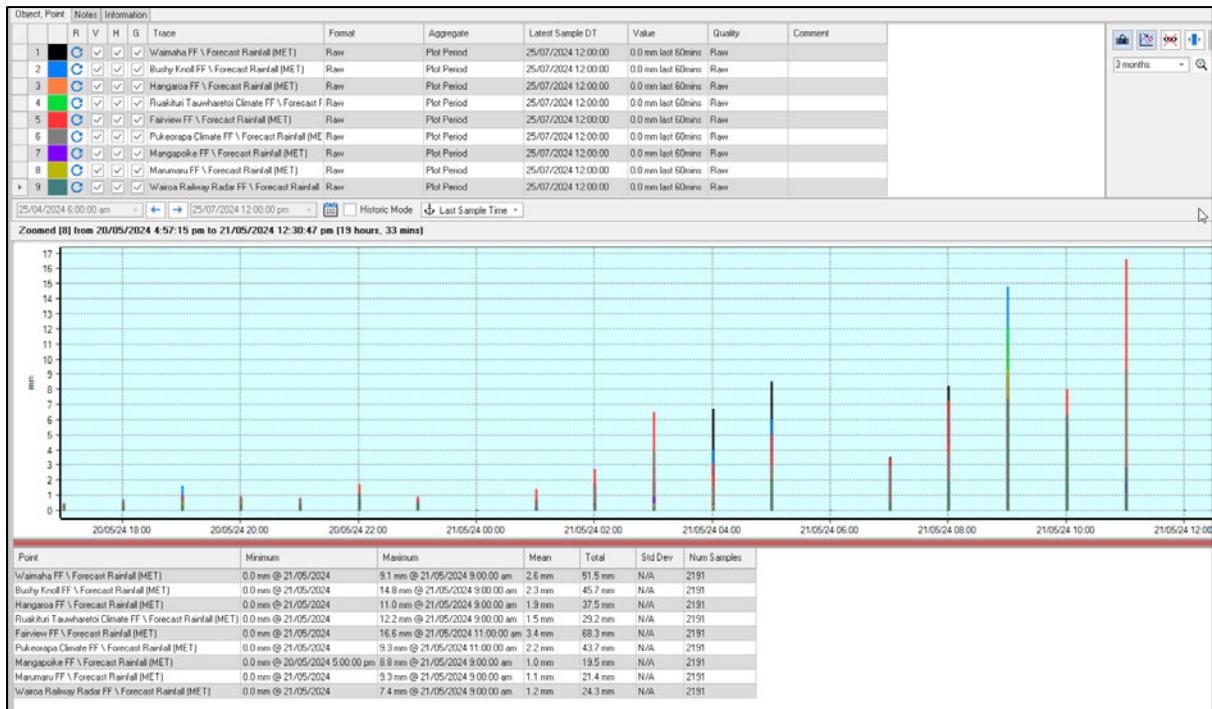
Additionally, in this instance, the sea state would likely have hindered an attempted opening of a new mouth.



Forecast rainfall (for 72 hours)

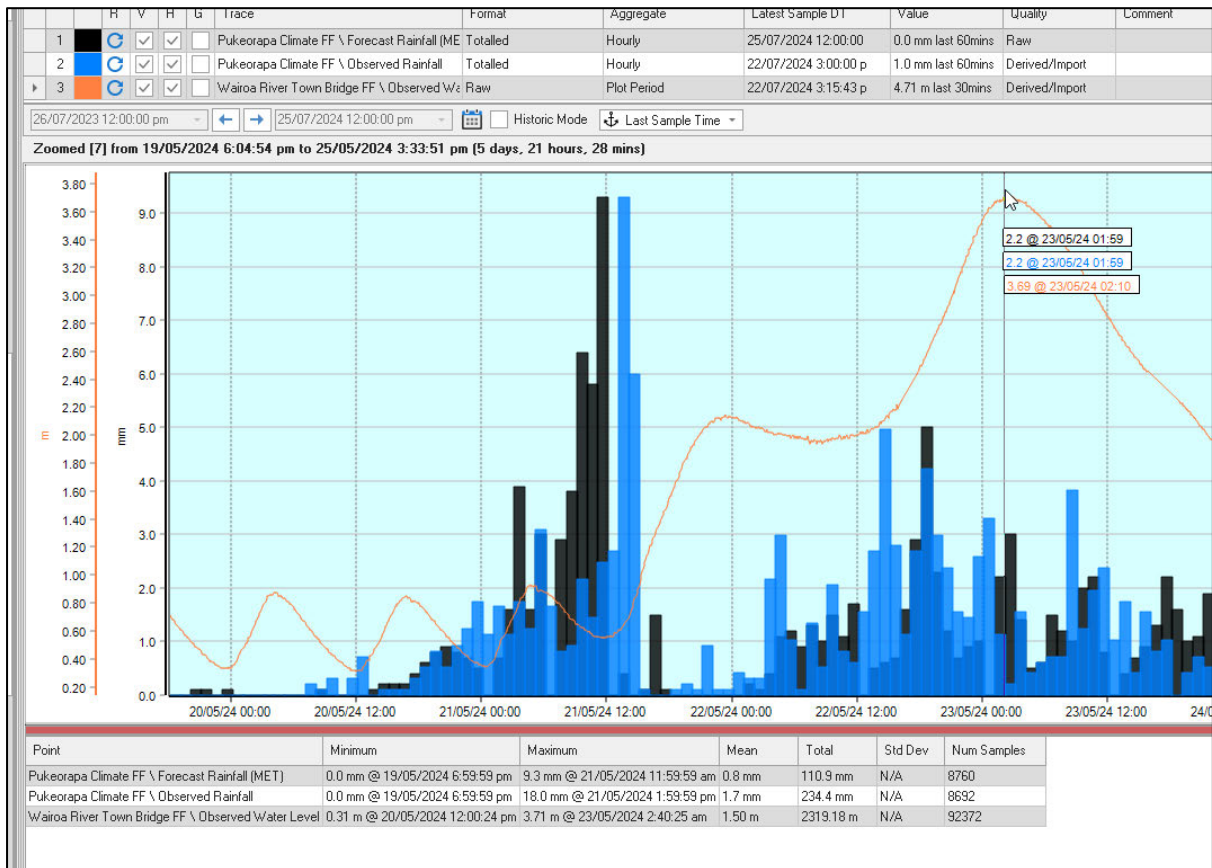


Forecast (19 hours)

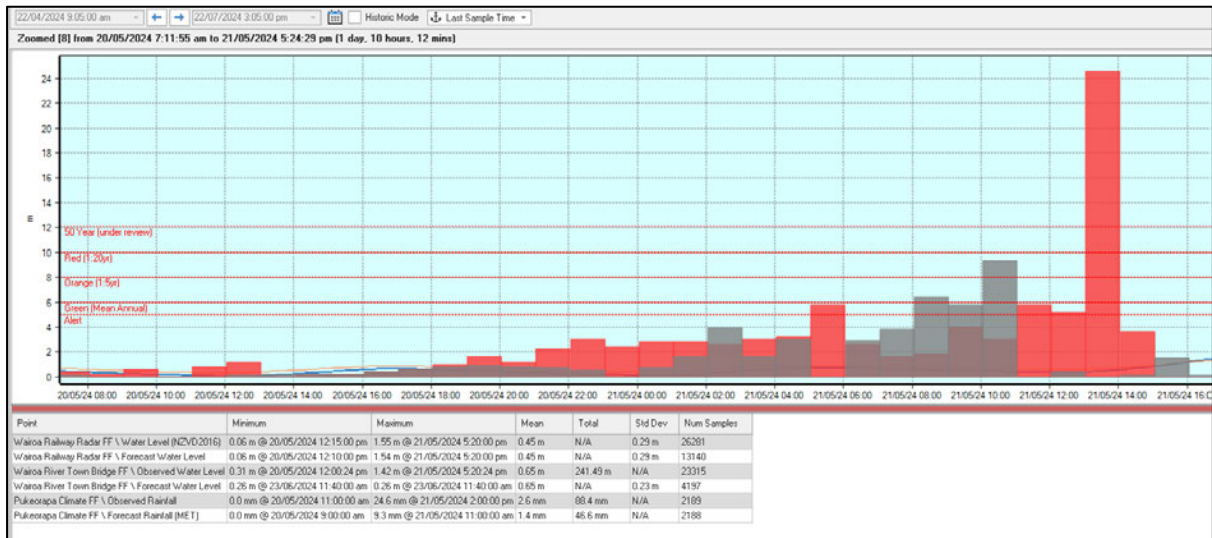


Sample Pukeorapa forecast, actual and WL at town bridge.

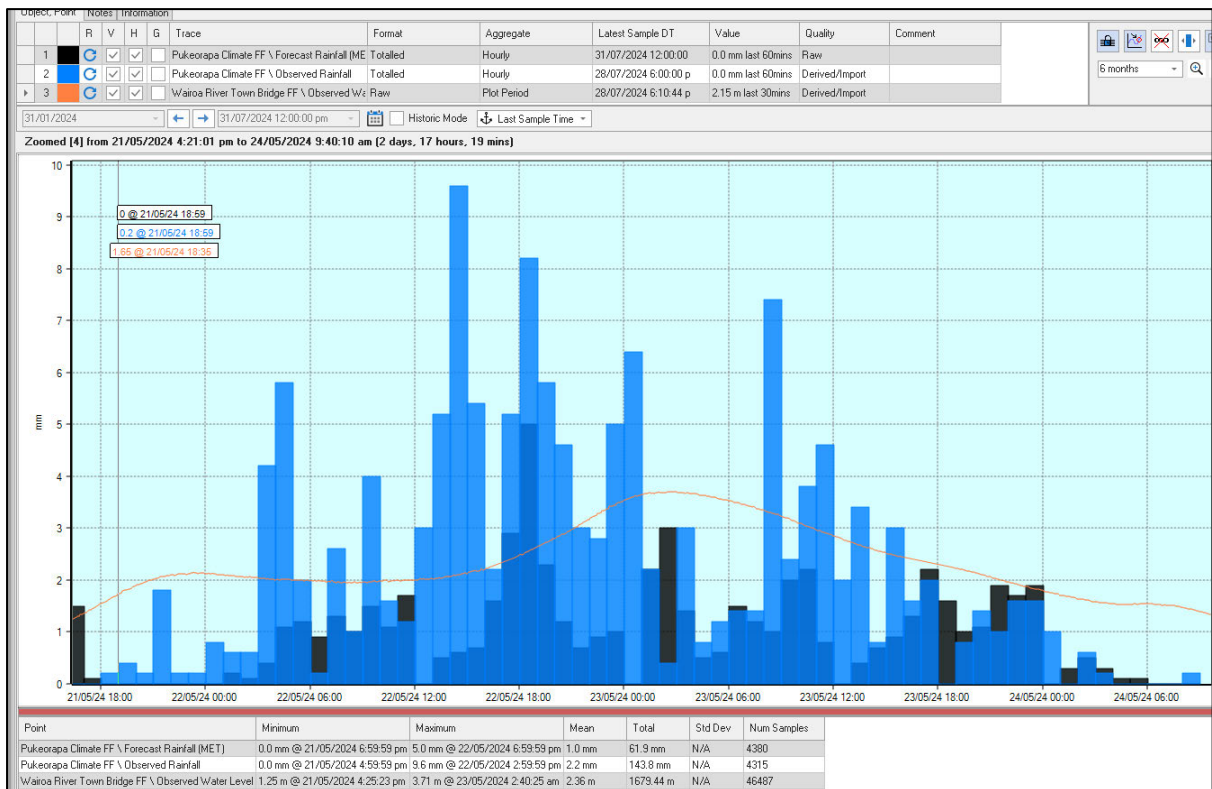
Note the first pulse of rain caused the river to rise to elevation 2.0m, next amount came on top of this to cause the rise to 3.8 m. Datum HB62. Subtract 0.2 to get NZVD16



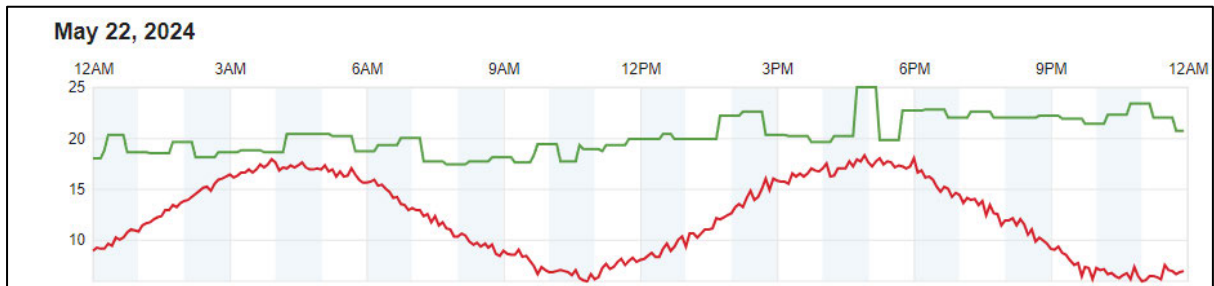
For that first pulse of rain, forecast was 46 mm, actual was 88 mm. This is still quite low, below mean annual.



Second pulse of rain forecast only 62 mm, but 143.8 mm actually fell.



Swell on May 22 was quite big in Napier, graph shows 2- 2.5 m at Napier Port. Swell in Wairoa was likely to be greater than this.



- 2. Related to the above there doesn't appear to be any definitive threshold for sufficient head/flow/forecast rainfall to attempt a mouth opening. Please comment and provide further details on this including past successful and failed attempts and the river flow conditions at the time.***

Because of the number of factors at play in this decision, having a threshold of forecast rainfall would not be a suitable approach to realignment of the bar. Factors considered, in accordance with the HBRC and Prydes instructions, include: forecast swell, forecast rainfall, head and flow. Therefore, there needs to be some flexibility in approaching this.

We note that previous attempts where there has been low flow, and even moderate swell, have resulted in the mouth relocation failing and the mouth reopening at the western location. This is the situation detailed in the 2022 example included in Prydes' instruction document.

- 3. There appears to be some inconsistency between the Prydes methodology and HBRC recommended timing for an opening. Prydes suggest a couple of hours after high tide whereas the HBRC timing appears to be focussed on low tide. Please comment on this.***

Ultimately, the activation of a new mouth at Wairoa be ideal on an outgoing tide with rising river level so the head differential assists the new mouth to develop as the tide falls to low.

Both documents appear to adopt a timing relative to the tides as a shorthand for this.

- 4. With regard to the above and accounting for the timing of high tide at 8:18pm on Tues 25th of June and a forecast for increasing river levels from midnight that night please comment on the decision to attempt an opening on the following day (Wednesday).***

The Wednesday timing was identified as the first realistic opportunity to relocate the mouth.

The decision to try to realign the river mouth was taken on Monday, when the forecast rainfall had increased. Earlier forecasts had not favoured an attempted opening.

Even when the decision was taken, this was a precautionary approach to a marginal situation as to whether an opening could have been successful. There remained significant uncertainty about the effectiveness of a relocation in these conditions, because the swell was also set to increase significantly.

5. ***Related to the above, my interpretation of the optimum opening procedures in terms of forecast river flow and tide would have required working through the night on the 25th with activity to close the existing river mouth from after high tide (8:18pm) combined with work in parallel to ensure the opening cut was well formed and ready for the rising river predicted from midnight. This timing has two key issues, namely the requirement for high risk earthworks during the hours of darkness along with the large sea swell forecast for this period. I note the Prydes methodology states midday high tide is preferred for optimal daylight hours to complete the operation along with calm sea state. Neither of these criteria are satisfied with a “working through the night” scenario. Please comment on the above including any H&S risk assessment undertaken for working through the hours of darkness.***

HBRC rely on the contractor’s own health and safety assessments.

No planning documents relating to work on mouth and lagoon openings appear to anticipate the activities taking place at night (including, notably, the emergency work on the shingle barrier at Haumoana during this same weather event). This likely reflects a consensus that the work can not reasonably be carried out during the hours of darkness.

Christensen Review - Responses to written questions on instructions to Prydes

Question 1: Based on the HBRC Lagoon & River Mouth Instructions it appears that the only option considered for managing the Wairoa River mouth is for a full mouth relocation to the centre of the river channel. Can you please confirm that prior to the June event that this was the only option being considered by HBRC for managing the Wairoa River mouth.

Response: The full mouth relocation option had been planned for several months, awaiting suitable conditions, and execution of that plan was attempted on this occasion.

A full mouth relocation to the centre of the river channel was the primary option, but an overflow channel or reopening at another location were also considered as options. These options were constantly considered and reviewed as part of ongoing and evolving assessment of forecast, conditions, time and resources, but were not pursued.

Question 2: Noting the above method has very specific requirements for successful execution can you please comment on the basis for the decision on Monday 24 June to go ahead with this method specifically discussing

- the time required to execute the operation ahead of the flood arriving,
- the forecast sea conditions; and
- and the state of the existing river mouth being wide and deep.

Response: It was understood by HBRC that it was marginal whether a mechanical realignment could have been successful. The decision to do so, when it became apparent that the river flow may allow for it, was precautionary approach since other conditions, particularly the forecast sea state, did not favour a successful opening.

At the time of the forecasts on Monday/Tuesday, the peak water level was due to arrive late Wed night/Thursday morning, giving 2 days (Tues and Wed) of time for the opening (or the best that Prydes could accomplish in that time). By Thursday the swell was also forecast to drop, giving a much greater chance of success. The rainfall ended up peaking earlier, which resulted in the river peaking earlier, overlapping with the peak swell.

Prydes' concerns about the time available were acknowledged by HBRC and the timing of the successful opening was kept under revision as the work progressed.

Similarly, the state of the existing river mouth was well known to HBRC having been reported on by Prydes at 1:15pm on the Monday the decision was made and reconfirmed by Prydes at 4:19pm that day.

Question 3: From communications on Monday 24 June it appears an alternative option of taking height of the crest was suggested by Prydes "...if HBRC were wanting to do anything, it's get a bulldozer into where the potential new bar mouth would be and push excess sand off the top of the bar down near sea level height." Please comment on HBRC's evaluation of this option suggested by Prydes.

Response: Notably, the quoted message also includes the bolded text: "... *Morning, Had a look at the river mouth just before. Water level still very low **and existing bar is looking more established.** Seems at this stage that, if HBRC were wanting to do anything, it's get a bulldozer into where the potential new bar mouth would be and push excess sand off the top of the bar down near sea level height. **That way, it's closer to being ready.**"*

It appears likely that this was not interpreted as being a recommended alternative to an attempted mechanical opening, rather it was seen as being preparatory work on a more established bar to allow for the planned opening work to take place if conditions allowed.

This is consistent with HBRC's instructions to Prydes for the eventual decision to attempt an opening that were conveyed by [REDACTED] at 4:18pm on Monday: *"Tuesday 25/06/2024- Prydes to start moving Material over the course of the day- Lowering height of beach crest by the new opening..."*

Question 4: Based on my discussion with Prydes their understanding was that the instructions on Monday 24 June from HBRC were for a full mouth relocation, including closing the existing mouth and following the standard procedure for an opening cut which includes keeping a high crest (coffer dam) on the seaward side of the works. Please confirm that this was the instruction from HBRC.

Response: The instructions were for a full mouth relocation, with an opening to be attempted on the Wednesday. Following Prydes concerns about the time available, the timing of the opening was kept under review.

There was no specific instruction from HBRC to close the existing mouth and keep a high crest on the seaward side of the works. However, it is understood that is part of Pryde's standard procedure for the activity.

Question 5: Were any HBRC staff on-site on Tuesday 25 June overseeing or checking the works being done and were there any updated instructions provided to Prydes during the day?

Response: Two staff from the Asset Management Team were present in Wairoa on the Tuesday. While not present on the bar, the Northern Schemes Manager monitored and oversaw the work being undertaken from nearby vantage points and through photos provided by Prydes. This is shown at pages 50-54 of the Compiled Communications document previously provided.