Tonkin+Taylor

19 November 2024
Job No: 1017033.2002

Auckland Council
Private Bag 92300
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Auckland 1142

Attention: Ila Daniels

Dear Ila

Harania (Tennessee Bridge) flood hazard and risk assessment
Additional information request

Auckland Council Healthy Waters submitted a resource consent application to Auckland Council under the Severe Weather Emergency Recovery (Auckland Flood Resilience Works) Order 2024 (AC-OIC) for the Harania – Tennessee Bridge Project on 8 November 2024. Whilst there are no formal mechanisms to request further information under the AC-OIC, Auckland Council have made an informal information request via email (from Ila Daniels, Campbell Brown Planning on 14 November 2024) in relation to flood hazard.

This letter provides a response to the request, specifically, the following seven questions:

1. *Provide an assessment of effects considering Climate change (use TP108 3.8, as I have not seen HW 2024 report, and it is unclear if this has been adopted/released) and 1m sea level rise*

2. *Assess the effects of passing more flow forward on habitable floors assuming climate change has occurred – Parkstone and Mary Place appear to be the two areas to focus on.*

3. *Run the 1% AEP and MLWS+1mSLR to give range of potential effects – this gives an upper and lower bound with Climate change and SLR to work with and comment on potential effects and likelihood, as per your existing report (i.e., your comments on 1.6m sea level).*

4. *Replicate Tables in Appendix B.1 for climate change*

5. *Recognise and comment on Joint Probability risk*

6. *Possibly comment on options for adaptive management for the sites, given that the age of the buildings, potential ability to respond to changing climate and they will likely need to adapt irrespective of this project. Can you say sea level rise is the main driver for adaption, not the project.*

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7. *Prepare a table/graphs of Habitable floors vs potential sea level (MHWS and MLWS) and with and without flood risk (see examples below) – happy to discuss – this may help to convey that the risk to these properties is more from coastal inundation not flooding from runoff.*

1 Background coastal information

This section provides some background information regarding water levels in the "Estuarine Embayment" area[1] upstream from Favona Road. In the estuarine embayment, water levels are predominantly influenced by coastal processes although rainfall events can also impact water levels due to restriction at the Favona Road culvert.

Table 1 provides a summary of existing coastal water levels and inundation levels and also the increased levels for 1m sea level rise. Note that the levels are provided in Auckland Vertical datum 1946 for consistency reasons with the prior hazard and risk assessment (T+T, 2024), Auckland Council's existing hydraulic model and the Mangere Inlet FHM (2019)[2].

Table 1 Coastal water levels (Auckland vertical datum 1946)

	Port of Onehunga Tide level					Extreme sea level in the Manukau Harbour (Auckland Council, 2020)[3]					
Condition	MSL	MHWN	MHWS	$MHWS_{10}$	HAT	2 yr ARI	5 year ARI	10 year ARI	20 year ARI	50 year aRI	100 year ARI
Existing	0.23	1.13	1.98	2.05	2.34	2.56	2.64	2.72	2.8	2.92	3.00
1m sea level rise	1.23	2.13	2.98	3.05	3.34	3.56	3.64	3.72	3.8	3.92	4.00

The 1m sea level rise scenarios are presented graphically in Figure 1-1.

[1] As identified in Figure 2.5 of Flood hazard and risk assessment (T+T, 2024)
[2] New Zealand Vertical Datum (NZVD) is the standard across Auckland. In the vicinity of the project NZVD = AVD46-0.284m
[3] Site 17 from Table 3-6 (Extreme sea-level in the Manukau Harbour)
https://www.aucklandcouncil.govt.nz/environment/what-we-do-to-help-environment/Documents/coastal-inundation-in-auckland.pdf

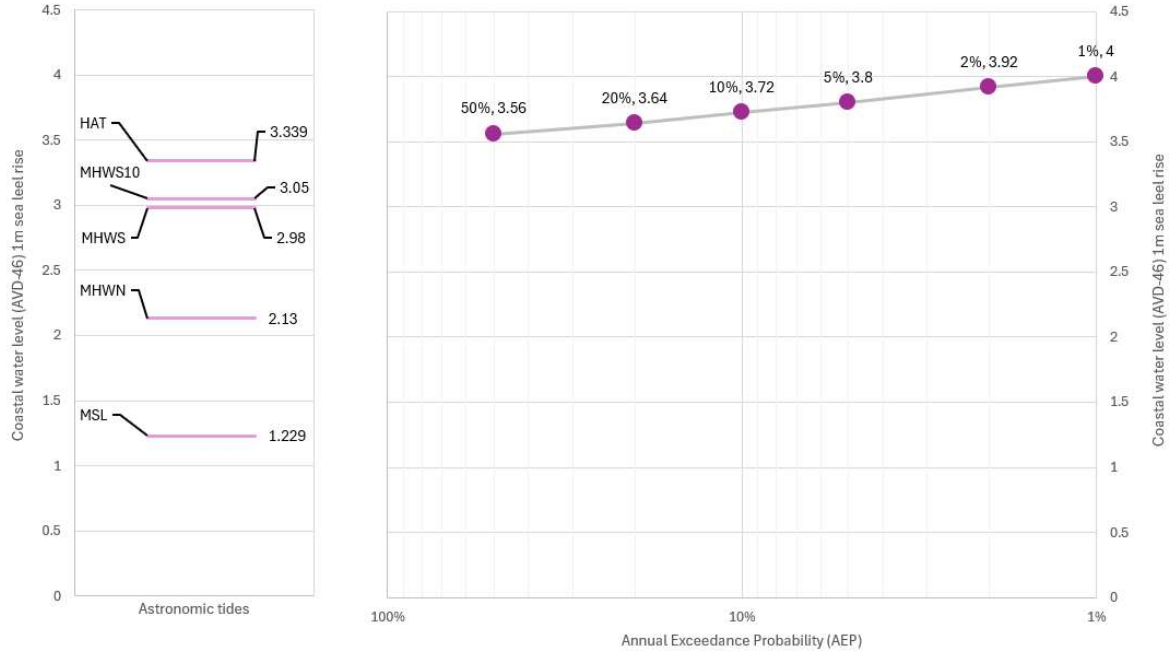


Figure 1-1 Coastal water levels and likelihood (Auckland vertical datum 1946)

Figure 1-2 shows the 3m and 4m (AVD-46) contour lines which can be used to identify the likely future MHWS and 1% AEP coastal inundation extents with 1m sea level rise respectively (based on information provided in Table 1). As a comparison, Auckland Council have identified the 1% AEP coastal inundation area with 1m sea level rise for the estuarine embayment area, which is reproduced in Figure 1-3.

The figures highlight that there are 30-35 properties within the future 1% AEP coastal inundation area (50% or more of property flooded) and that 100% of the property parcels at 3-9 Mary Place and 11, 22 and 24 Parkstone Place are inundated. The red 3 m contour line in Figure 1-2 also identifies the high potential for the Coastal Marine Area to move landward (to MHWS), which will have significant impacts on the properties at 3-9 Mary Place.

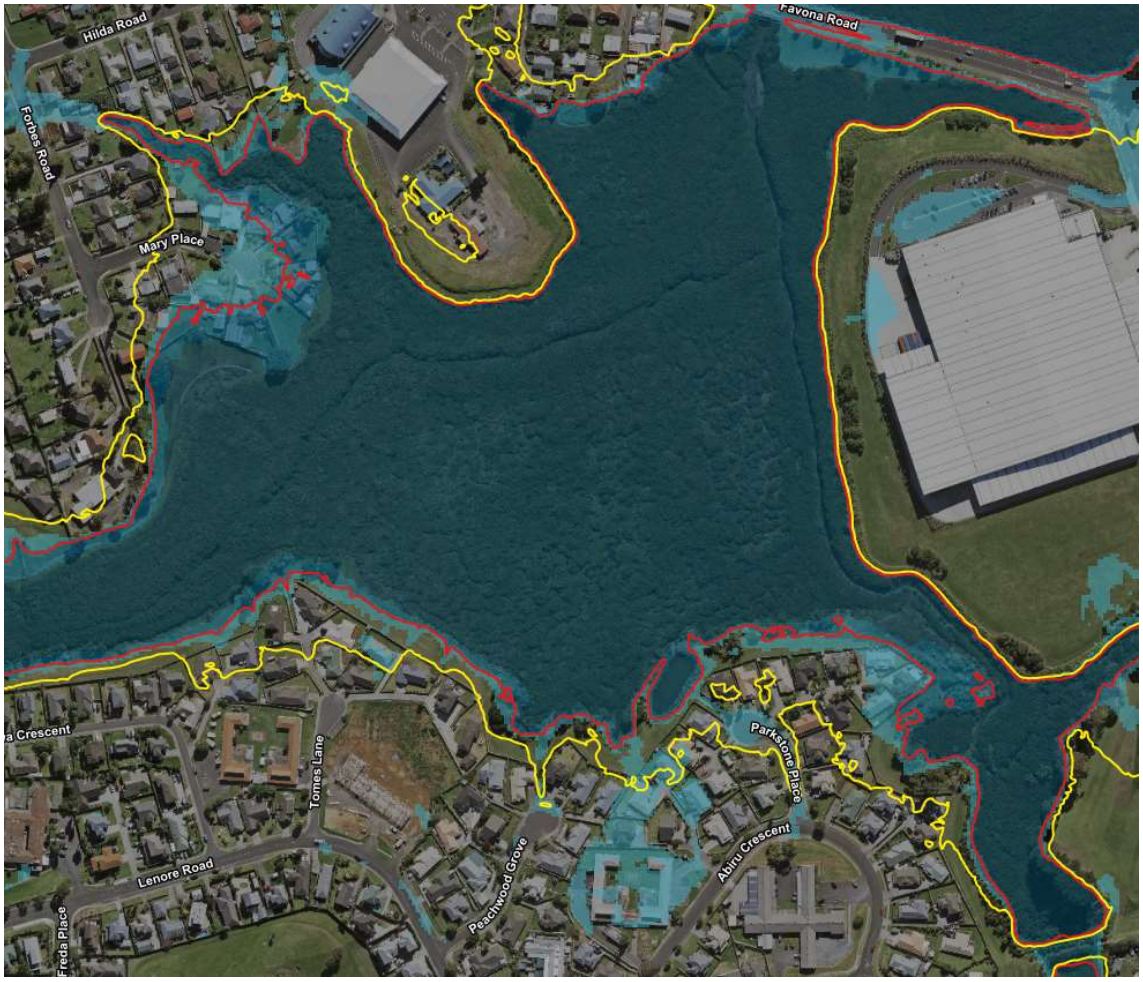
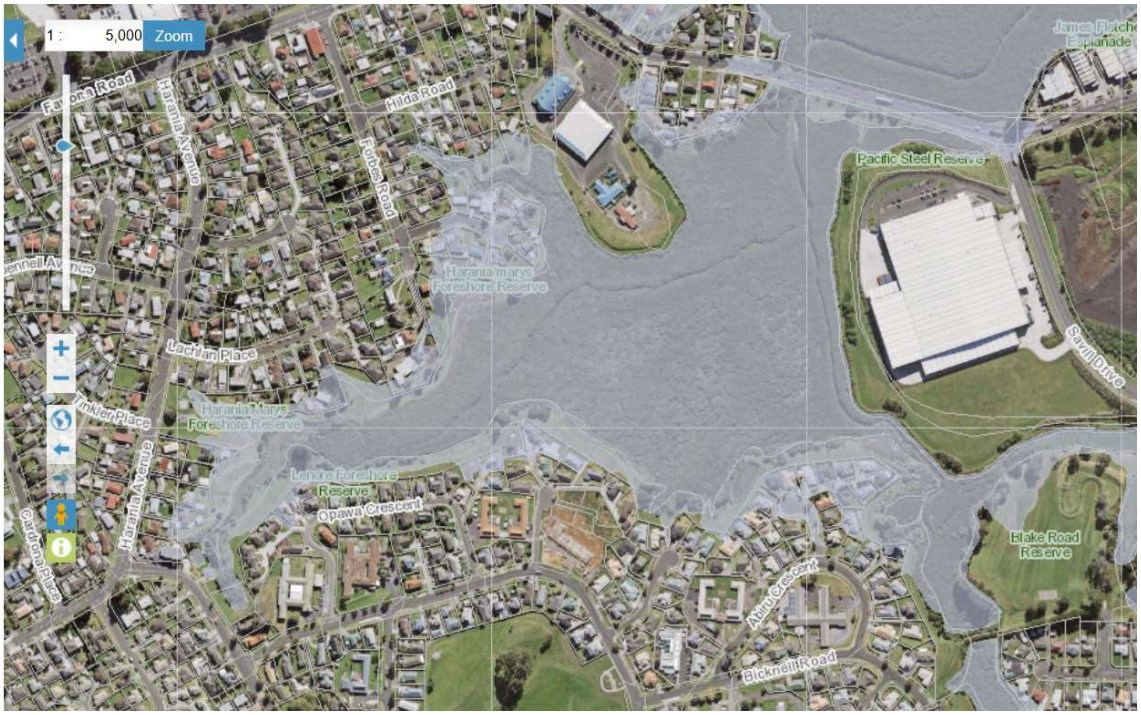


Figure 1-2 3m (red) and 4m (yellow) contour lines (AVD-46)



1%

Figure 1-3 AEP coastal inundation with 1m sea level rise (Source: Auckland Council Geomaps)

Table 2 shows the estimated year where median sea level rise could reach 1 m for a range of Shared Socioeconominc Pathway (SSP) scenarios with and without vertical land movement (VLM) using information from the SeaRise website. The information is also shown graphically in Figure 1-4. The information request related to 3.8° warming, which is associated with the highest emission scenario (i.e. SSP5-8.5M). Under this scenario, the median prediction for 1m of sea level rise is by 2090.

Table 2: Year where median sea level rise could reach 1 m for a range of emission scenarios

Scenario	Year
SSP3-7.0M	2100
SSP5-8.5M	2115
SSP1-2.6M + VLM	2130
SSP2-4.5M + VLM	2110
SSP3-7.0M + VLM	2095[4]
SSP5-8.5H+ + VLM	2080
SSP5-8.5M + VLM	2090

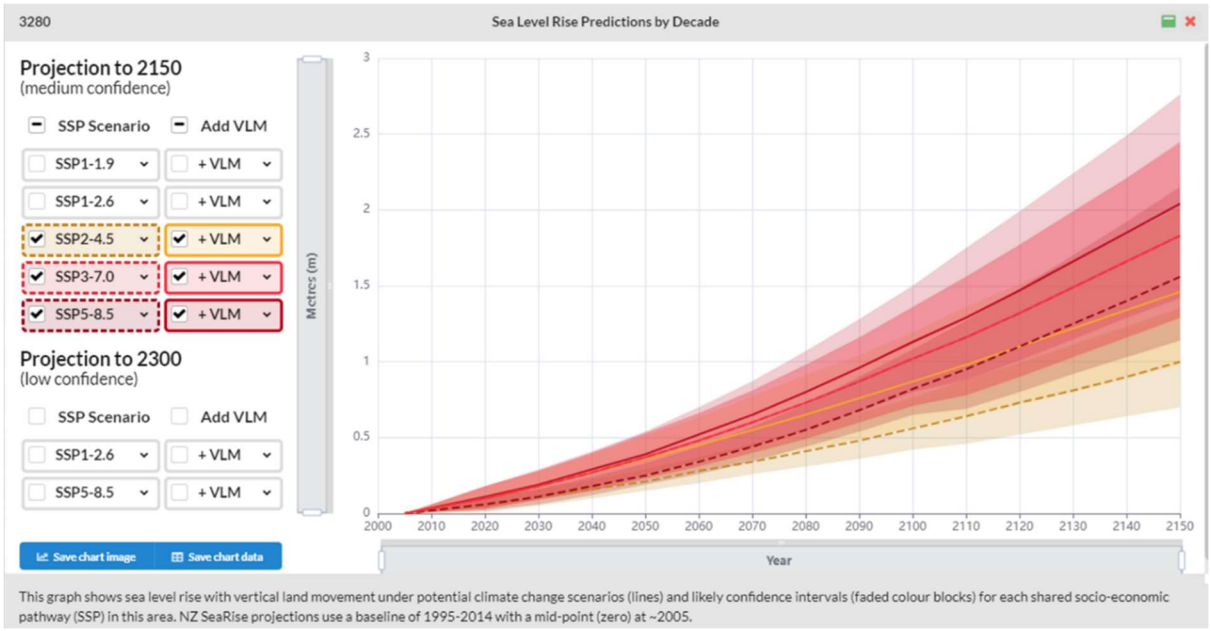


Figure 1-4 Projected median sea level rise values to 2150 with (solid lines) and without (dashed lines) vertical and movement and their uncertainty bands (shaded areas) at site 3280. Source: SeaRise website

[4] We note an anomaly with the SSP3-7.0 information from SeaRise website that does not appear to include VLM, so have adjusted the number.

2 Flood affected properties

An assessment of increased flood flows into the estuarine embayments as a result of the Tennessee Bridge project has been carried out using a downstream water level of 3.05m RL. This level is representative of $MHWS_{10}$ with 1m sea level rise as per the Auckland Council modelling specification[5]. As per the Tennessee Avenue flood hazard and risk assessment (T+T, 2024) rainfall depths of 224mm and 255mm were adopted for the assessment. These represent a 17% and 33% increase on rainfall adopted in the Mangere Inlet FHM (T+T, 2019) which were TP108 derived. The two additional scenarios are referred to as Scenario 5 and Scenario 6 and are presented in Figure 2-1 alongside the other scenarios developed in the prior hazard and risk assessment (T+T, 2024).

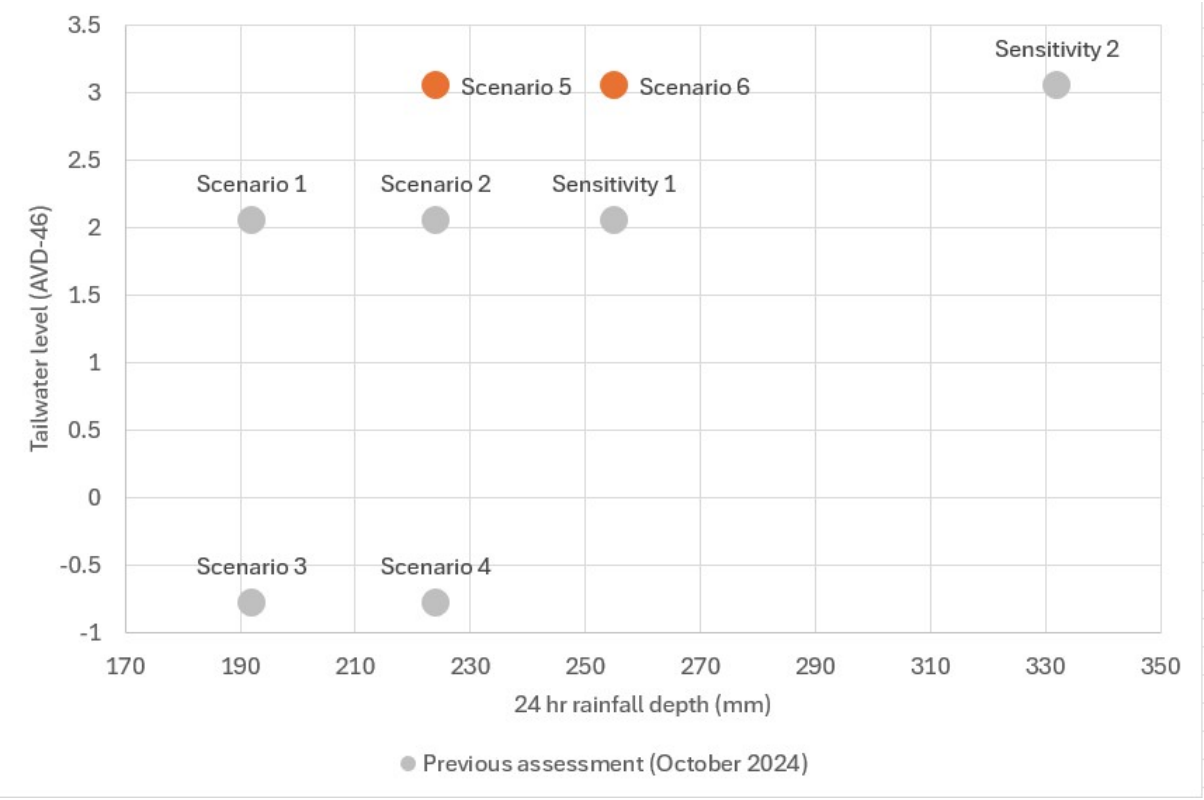


Figure 2-1 Scenario 5 and Scenario 6 rainfall and tailwater conditions

A comparison of the pre-development and post-development floodplain for Scenario 5 and Scenario 6 is provided in Appendix A and a comparison of flood levels relative to floor levels is provided in Appendix B for Mary Place and Parkstone Place properties.

The results show that the future peak water levels with a 3.05m RL tailwater level are approximately 3.35m – 3.45m RL in the vicinity of Mary Place, and 3.4m – 3.6m RL in the vicinity of Parkstone Place. The lower range is from Scenario 5 (224mm rainfall) and the upper from Scenario 6 (255mm rainfall). These water levels represent a 70-100mm increase around Mary Place in comparison with the predevelopment levels and a 130mm-190mm increase around Parkstone Place.

A comparison of coastal inundation flooding frequency and likely floor level exceedance frequency is shown in Figure 2-2. Floor levels are based on information provided in the Tennessee Avenue flood hazard and risk assessment (T+T, 2024).

[5] There are a variety of scenarios that cause 3.05m sea levels, for example a 2 year ARI coastal inundation level with 0.5m sea level rise. i.e. it is not only MHWS+1m.

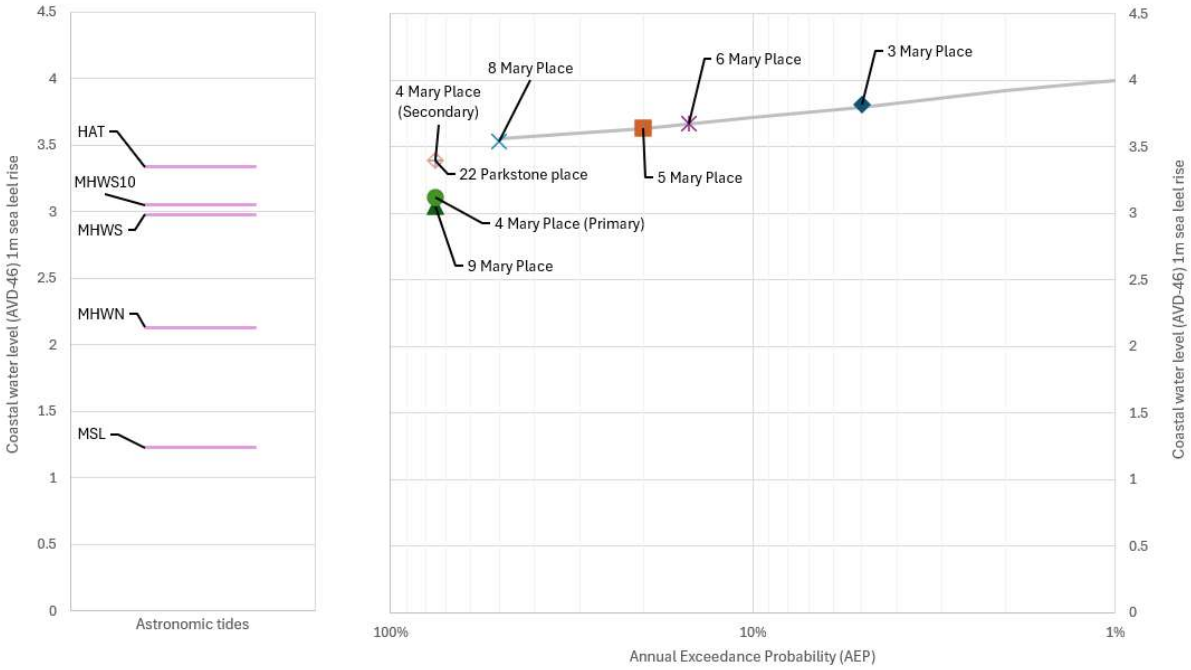


Figure 2-2 1% AEP coastal inundation with 1m sea level rise (Source: Auckland Council Geomaps)

2.1 Comparison of coastal inundation effects and catchment flood effects

Based on the coastal information provided in Table 1 and Figure 2-2, it can be seen that 3.6m RL is a coastal inundation level that is likely to be exceeded on average every 2 to 5 years under a 1m sea level rise scenario and it is 0.4m lower than the 1% AEP (100 year ARI) coastal inundation + 1m sea level rise (4.0m RL). This indicates that coastal process will dominate inundation risk in the areas of Mary Place and Parkstone Place.

The likelihood of a 1% rainfall event occurring at the same time as peak $MHWS_{10}$ water level is considerably lower than the 20-50% AEP (2-5 year ARI) coastal inundation levels. Furthermore, drawing on some conclusions from a joint probability assessment of storm and sea level in the Waitemata harbour (Maunsell, 2004), the likelihood of a 100 year ARI (1 % AEP) storm event and a 2% extreme coastal level is approximately 0.05% AEP (200 year ARI). In order for the 1% AEP storm flows to cause water levels in excess of the 1% AEP coastal inundation levels (4.0m RL), a 20-50 year ARI coastal water level would need to occur at the same time as the 1% AEP storm flows. The likelihood of this is very low and the Waitemata study indicated that it would be in the order of 2,000-6,000 year ARI (Maunsell, 2004).

2.1.1 Additional – low water discussion

Low tailwater levels in the Manukau Harbour (no sea level rise) were assessed for Scenario 5 and 6 for post-development scenarios. The “low tailwater” level was -0.77mm RL and was chosen for hydraulic model stability reasons rather than a particular tidal state (i.e. to keep water on the model boundary).

The results show that the post-development flood levels in the estuarine embayment are 2.27 m RL to 2.77m RL for Scenario 5 and 6 respectively.

The 2.27m RL water level in the estuarine embayment is approximately 300mm lower than the existing 2-year coastal inundation level and less than the existing highest astronomical tide (HAT) level. Under a 1m sea level rise scenario 2.27m RL is lower than MHWS and will be exceeded regularly each month.

The 2.77m RL water level in the estuarine embayment occurs solely due to coastal inundation in the 10-20 year ARI (10% - 5% AEP) scenarios. Under a 1m sea level rise scenario, 2.77m RL is lower than MHWS and will be exceeded a number of times each month.

3 Conclusion

In response to an informal information request under the AC-OIC, additional information has been provided in relation to the effects of climate change.

As requested, a 1m sea level rise scenario has been adopted for consideration. Using median projections for the high emission scenario, a 1m sea level rise is likely in the next 65 years (by ~2090). Under the 2090 1m sea level rise scenario, downstream inundation hazard will be dominated by coastal hazards and properties identified at 3-9 Mary Place and 22 Parkstone Place will experience flooding above floor level at increasing frequency[6]. Figure 2-2 identifies the likely flooding frequency for each property from coastal inundation, with five properties likely flooding above floor level more frequently than a 2 year ARI (50% AEP), two properties likely to flood above floor level in the 5-10 year ARI events (20%-10% AEP) and one property likely to flood in the 20 year ARI events (5% AEP).

In comparison with the relatively frequent coastal inundation, the 1% AEP rainfall event has been shown to impact downstream water levels by 300-400mm at Mary Place and 350-550mm at Parkstone Place, where the upper values indicate the higher rainfall (255mm) and the lower values indicating the lower rainfall (224mm). Water levels are 3.35m-3.45m RL in the vicinity of Mary Place and 3.4 – 3.6m RL in the vicinity of Parkstone Place. Water levels up to 3.6m RL are predicted to occur from coastal inundation on a 2-5 year ARI frequency (50% -20% AEP). The likelihood of 1% AEP rainfall events occurring at the same time as $MHWS_{10}$ has been assessed for the Waitemata Harbour has having a 200 year ARI frequency (0.05% AEP) and it seems reasonable to assume a similar likelihood for the Manukau Harbour.

Notwithstanding the above comments, the water levels represent a 70-100mm increase around Mary Place in comparison with the predevelopment levels and a 130mm-190mm increase around Parkstone Place. Therefore, post-development for an event of ~200 year ARI, there is a likely downstream flood level up to 3.6m RL, which is comparative to a coastal inundation event of 2-5 year frequency. This highlights the limited impact that flood flows will have on climate resilience and adaptation decisions for properties located in the coastal inundation area. Coastal processes will determine the climate resilience and adaptation measures in the Parkstone Place and Mary Place areas.

In the current climate, post-development flooding will be removed from 40 to 45 properties and reduced at a further six properties (T+T, 2024). Furthermore, up to 100 properties benefit from the Tennessee Bridge project using scenarios that may be representative of climate change (T+T, 2024). On the basis of the small influence that flooding has on downstream climate resilience we do not consider that the flood effects of the Tennessee Bridge project require specific mitigation.

[6] Floor level information was not available for 11 and 24 Parkstone Place.

4 References

Auckland Council. (2020). *Auckland's exposure to coastal inundation by storm-tides and waves; Auckland Council technical report TR2020/024.*

Maunsell. (2004). *Modelling tailwater study.* North Shore City Council.

T+T. (2024). *Blue Green Networks - Harania (Tennessee Bridge); Flood hazard and risk assessment.*

6 Applicability

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

Tonkin & Taylor Ltd

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Principal Consultant

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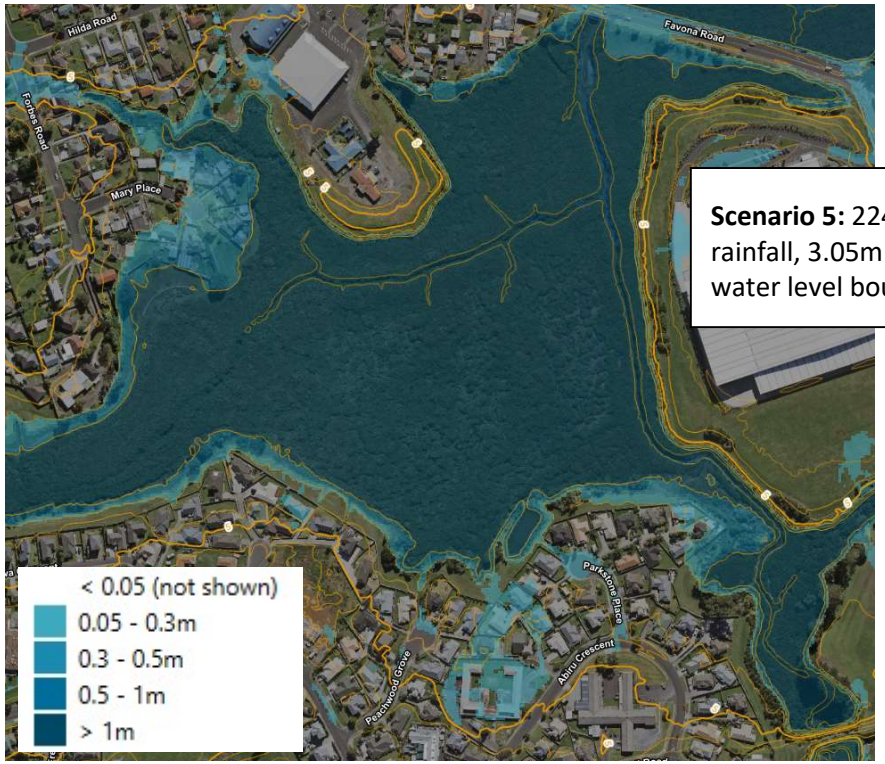
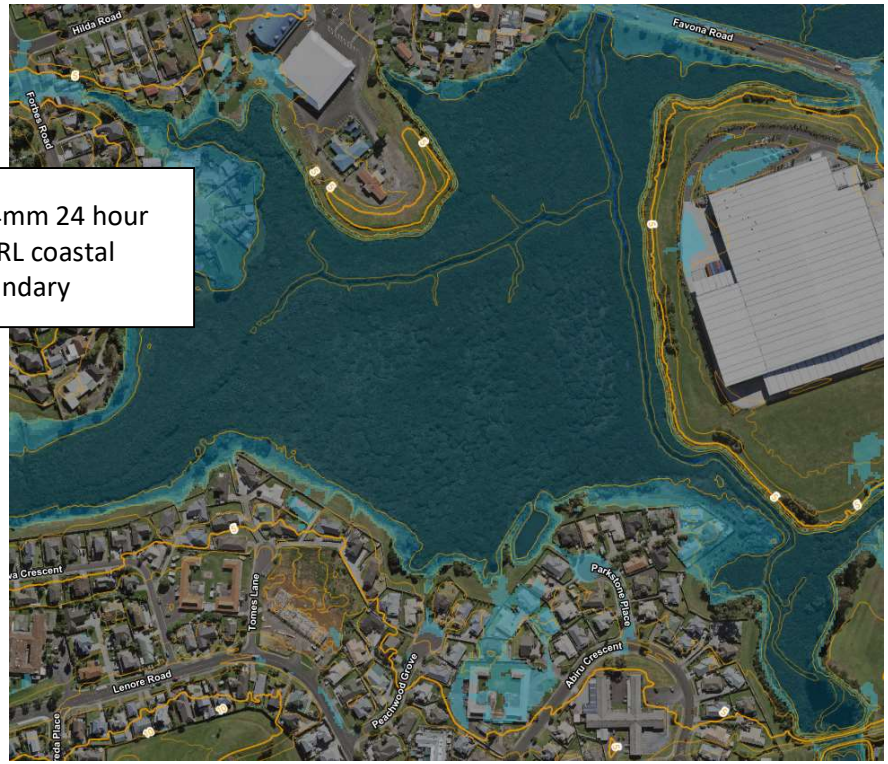
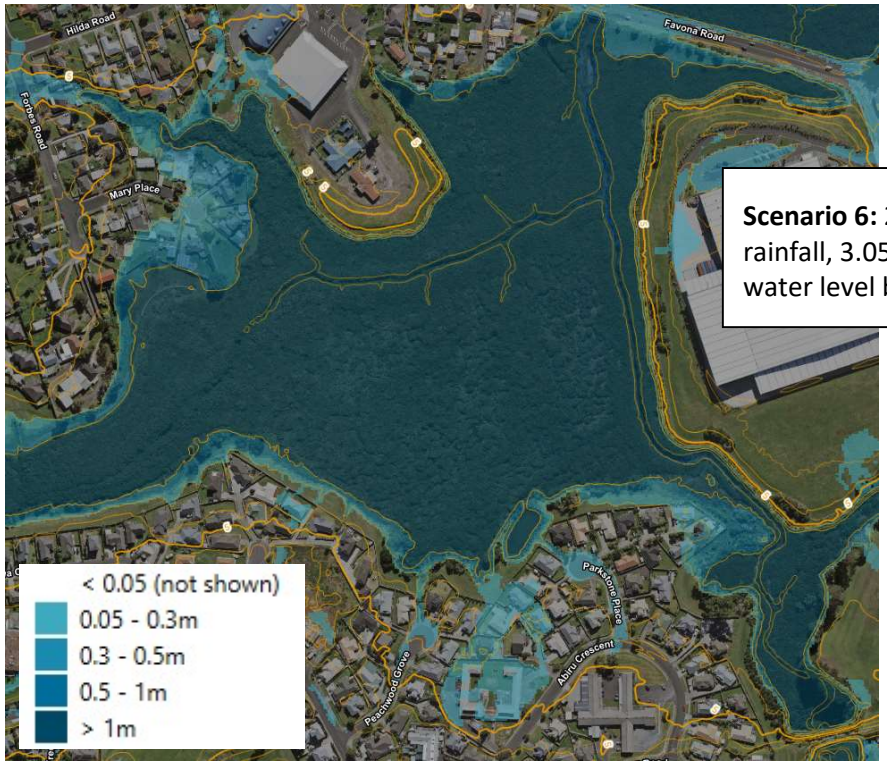
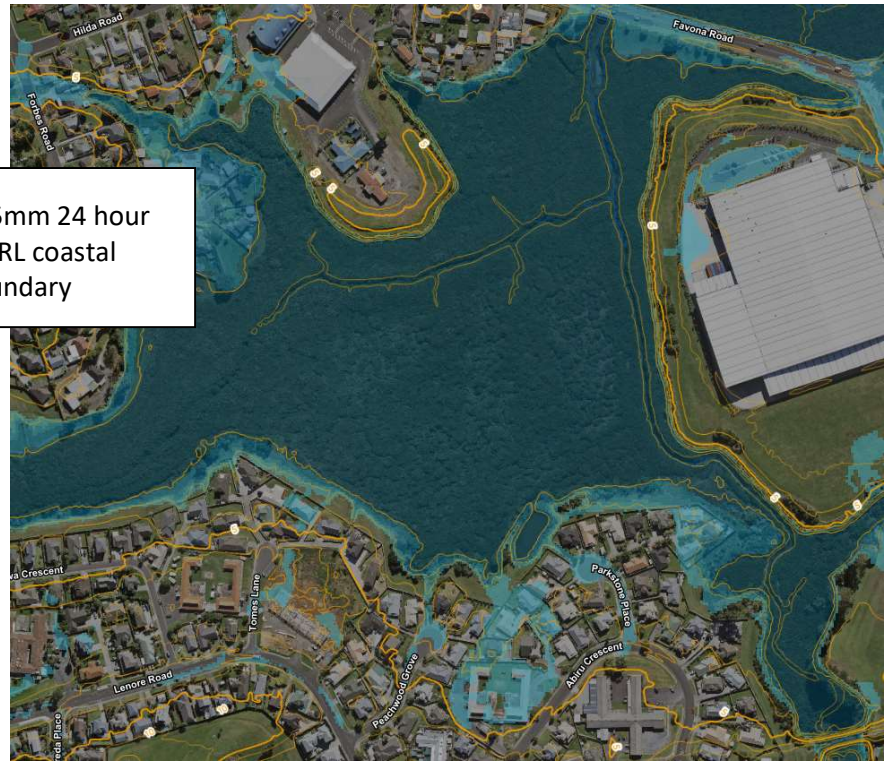
Appendix A Flood depth maps

Figure 6-1 Comparison of pre-development and post-development floodplain - Scenario 5

Predevelopment	Post-development
	

Scenario 5: 224mm 24 hour rainfall, 3.05m RL coastal water level boundary

Figure 6-2 Comparison of pre-development and post-development floodplain - Scenario 6

Predevelopment	**Post-development**
	

Scenario 6: 255mm 24 hour rainfall, 3.05m RL coastal water level boundary

Appendix B Supporting information for flood effects assessment at Mary Place, Favona (v2)

The following information provides additional information to Appendix B of the Flood hazard and risk assessment for Harania (Tennessee Bridge) dated 25/10/24.

- **Building flooding at Mary Place, and Parkstone Place, Favona**

As part of the Mangere Inlet FHM study (T+T, 2019) floor level surveys (Woods, 2017) were carried out at the 6 identified properties with flood effects located at 3-9 Mary Place and one property at 22 Parkstone Place.

Figure 6-3 and Figure 6-4 identifies the building footprints and surveyed levels for Mary Place and Parkstone Place respectively.

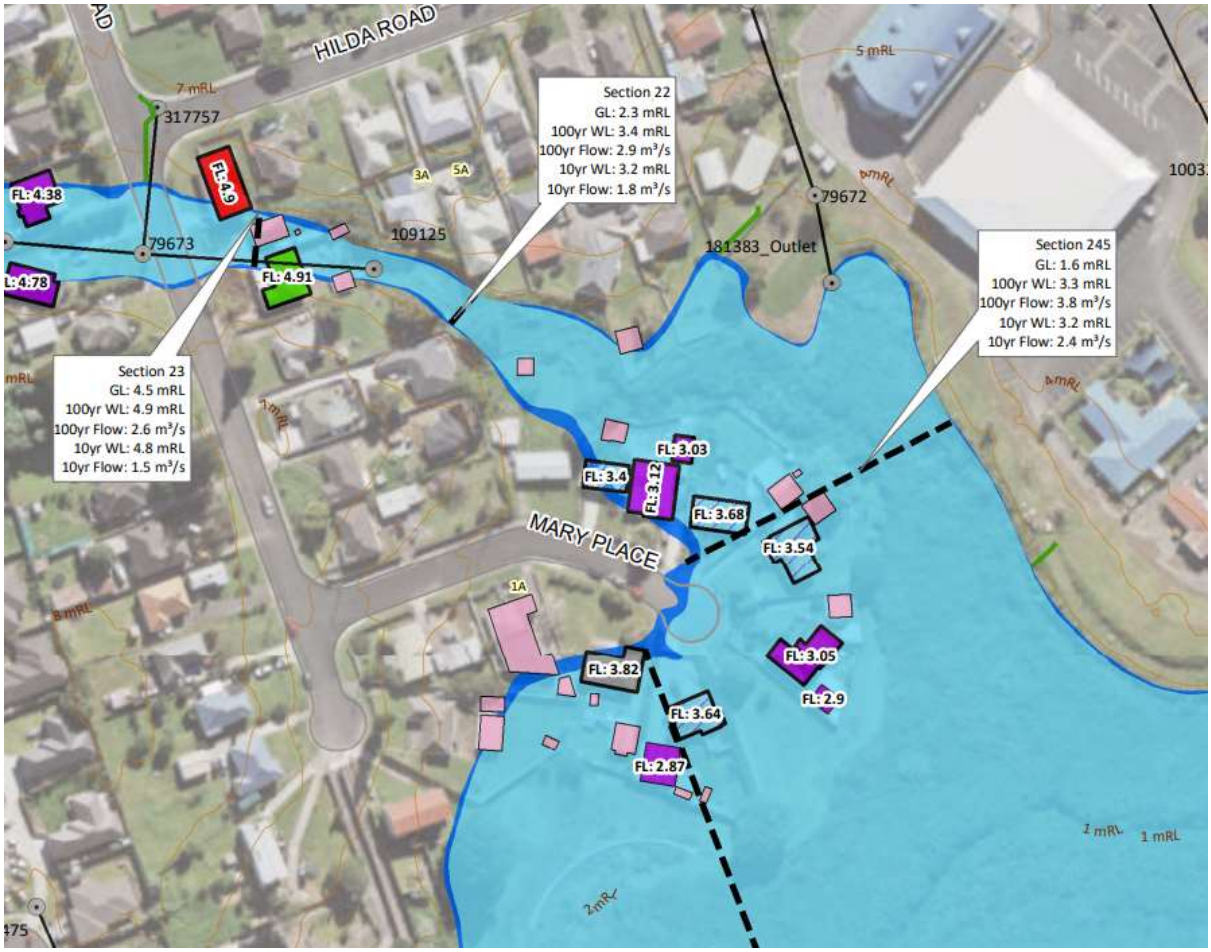


Figure 6-3 Floor levels of Mary Place properties (Mangere Inlet FHM (T+T, 2019))

Figure 6-4: Floor levels of Parkstone Place properties (Mangere Inlet FHM (T+T, 2019))

A comparison of the floor levels and flood levels from Scenario 2 is provided in Table 3.

Table 3: Comparison of building floor level and flood level at Mary Place and Parkstone Place properties

Address	Building Floor level (m RL AVD-46)		Flood level (mRL-AVD46) (Scenario 2)[7]		Additional commentary (Scenario 2)	Flood level (mRL-AVD46) 224mm rainfall 3.05m tailwater level		Flood level (mRL-AVD46) 255mm rainfall 3.05m tailwater level		Additional commentary (elevated sea level scenarios)
	Habitable	Outbuilding	Pre-dev	Post-dev		Pre-dev	Post-dev	Pre-dev	Post-dev	
3 Mary Place	3.82	Refer additional commentary	2.52	2.74	Habitable building located outside the predicted floodplain and above the predicted levels for all scenarios considered for this assessment. An outbuilding that is partially exposed to the Scenario 2 floodplain wasn't surveyed. The level of the outbuilding is likely above the level of the neighbours outbuilding[8] at 5 Mary Place (RL2.87 m) and therefore considered unlikely to flood.	3.31	3.38	3.34	3.45	Flooding below habitable floor level for all pre-development and post-development scenarios.
5 Mary Place	3.64	2.87	2.52	2.74	Habitable building located outside the predicted floodplain and above the predicted levels for all scenarios considered for this assessment. Outbuilding partially exposed to flooding although floor level is above the predicted flood level for all scenarios considered for this assessment.	3.31	3.38	3.34	3.45	Flooding below habitable floor level for all pre-development and post-development scenarios. Flooding above the floor level of the outbuilding for all pre-development and post-development scenarios.
9 Mary Place	3.05	2.9 Refer additional commentary	2.52	2.74	Habitable building located outside the predicted floodplain and above the predicted levels for all scenarios considered for this assessment. Two outbuildings appear partially exposed to predicted floodplain. One outbuilding was surveyed and is above the predicted flood level for all scenarios considered for this assessment. An additional low-height small "building" (~30 m^2) (appears to be mobile) raised off ground on the north-western side of the property. Assessed as non-habitable and likely similar level to the lower surveyed building. Considered low risk building and unlikely to flood.	3.31	3.38	3.34	3.45	Flooding above habitable and non-habitable floor levels for all pre-development and post-development scenarios.
8 Mary Place	3.54	Refer additional commentary	2.52	2.74	Habitable building located outside the predicted floodplain and above the predicted levels for all scenarios considered for this assessment. Additional building (usage uncertain although unlikely habitable) located on the north corner of the property although it is	3.31	3.38	3.34	3.45	Flooding below habitable floor levels for all pre-development and post-development scenarios. Flooding of the additional building (usage uncertain) appears likely for all pre-development and post-development scenarios (estimated from desktop assessment to be

[7] Scenario 2 was adopted because it provided the highest flood levels from the four scenarios evaluated for the purpose of October flood hazard assessment.
[8] Based on relative location, topography and local floodplain characteristics

Address	Building Floor level (m RL AVD-46)		Flood level (mRL-AVD46) (Scenario 2)[7]		Additional commentary (Scenario 2)	Flood level (mRL-AVD46) 224mm rainfall 3.05m tailwater level		Flood level (mRL-AVD46) 255mm rainfall 3.05m tailwater level		Additional commentary (elevated sea level scenarios)
	Habitable	Outbuilding	Pre-dev	Post-dev		Pre-dev	Post-dev	Pre-dev	Post-dev	
					not exposed to any of the floodplains considered for this assessment.					~300mm below the floor level of the habitable building)
6 Mary Place	3.68	Refer additional commentary	2.52	2.74	Habitable building located outside the predicted floodplain and above the predicted levels for all scenarios considered for this assessment. An additional buildings (appears to be a garage) was not surveyed although it is not exposed to any of the floodplains considered for this assessment.	3.31	3.38	3.34	3.45	Flooding below habitable floor levels for all pre-development and post-development scenarios. Flooding of the additional building (likely garage) appears likely for all pre-development and post-development scenarios (estimated from desktop assessment to be ~400mm below the floor level of the habitable building)
4 Mary Place	3.12 (primary) 3.4 (secondary)	3.03	2.56	2.76	There are potentially two habitable buildings located on this site. The larger building, referred to as primary is located outside the predicted floodplain and above the predicted levels for all scenarios considered for this assessment. The smaller building (secondary) is partially located within the predicted floodplain although the flood level is above all scenarios considered for this assessment. The outbuilding is a car port and has a surveyed floor level above all scenarios considered for this assessment.	3.32	3.38	3.35	3.45	Flooding above primary habitable building floor level for all pre-development and post-development scenarios. Flooding below secondary habitable building floor level for pre-development and post-development scenario with 224mm rainfall. Flooding above secondary habitable building floor level in a 255mm rainfall post-development scenario.
11 Parkstone Place	No information					3.35	3.48	3.39	3.58	Insufficient information to carry out a desktop assessment.
24 Parkstone Place	No information					3.34	3.45	3.38	3.55	Insufficient information to carry out a desktop assessment.
22 Parkstone place	3.4					3.33	3.41	3.36	3.51	Flooding above floor level predicted in post-development scenario. Flooding below floor level predicted for pre-development scenario.