From:	Brett Beamsley
To:	DistrictPlan
Subject:	Re: Natural Hazards and Climate Change - Report Availability - Confirmation of attendance - IMPORTANT
Date:	Wednesday, 7 April 2021 5:48:01 pm
Attachments:	A technical review of the coastal inundation estimates for Raglan.pdf

HI
Please find my further submission attached, including a summary of what i seek with respect to defining risks to coastal inundation within Raglan Harbour.

Specifically, I eek a review and revision of the values used to define the inundation risk within Raglan Harbour, or a change to the value provided in my submission and consistent with a 1% AEP event for the environment (2.61 m above MVD-53+ 1 m Sea Level Rise) for defining High Risk Coastal Hazard (inundation) Area.

I confirm that i wish to be heard at the hearing,

Having participated as an expert witness in council hearings and within the Environmental Court i am familiar with the processes and requirements.

Cheers,

Dr. Brett Beamsley.

On Wed, 7 Apr 2021 at 17:36, Brett Beamsley <brettbeamsley@gmail.com> wrote:

> Hi,
>
> Can you please advise how i can lodge additional evidence / information for consideration before the 16th April?
>
> Cheers,
>
> Brett
>
> On Thu, 1 Apr 2021 at 09:08, DistrictPlan <districtplan@waidc.govt.nz> wrote:
>
> > Hi Brett,
> >
> > Thank you for your response, it is appreciated.
> >
> > Nga Mihi | Kind regards
> >
> > **Fletcher Bell**
> >
> > District Plan Administrator / Hearings Coordinator - Resource Management Policy Team
> >
> > **Waikato District Council**
> >
> > ¦ **P** 07 824 8633 ¦ **F** 07 824 8091 ¦ **Call Free** 0800 492 452 ¦ **M** 027 214 8052

A technical review of the coastal inundation estimates for Raglan Harbour.

Dr Brett Beamsley (MSc Hons, PhD – Physical Oceanography)

April 2021

Introduction

The proposed District Plan[1] adopts a risk-based approach to natural hazard management. The risk that natural hazards pose to the Waikato District is made up of several factors including:

a. the nature, magnitude and extent of the hazard,
b. the anticipated frequency or probability of the hazard event occurring; and
c. the exposure and vulnerability of the environment to the hazard, including the likely community losses/damages that could occur.

Within the District Plan, Waikato District Council, (2020) note that high quality up-to-date information is important for natural hazard risk management and requires the use of the best information available to identify land that may be subject to natural hazards (Chapter 15 (8) of the proposed District Plan).

Amongst other clauses, within the coastal region, Waikato District Council, (2020) places restrictions on new subdivisions in areas of high risk to flooding, coastal inundation or coastal erosion (Policy 15.2.1.1), by suggesting these should be avoided, while changes to existing land use need to consider a range of risk reduction options (Policy 15.2.1.1). Theses are sensible recommendations, however, rely heavily on the areas susceptible to flooding, coastal inundation or coastal erosion being as accurately defined as possible, and using the best information available.

Within the proposed District Plan, Nicolson, (2021), notes that five separate coastal overlay areas are shown on the maps, based on an assessment by Gibberd and Dahm, (2019) and Gibberd and Dahm, (2021). These include,

1. Coastal Sensitivety Areas (Erosion),
2. Coastal Sensitive Areas (Open Coast),
3. Coastal Sensitive Area (inundation),
4. High-Risk Coastal Hazard (Erosion) Area, and
5. High-Risk Coastal Hazard (Inundation)Area.

Nicolson, (2021), notes that the rules that apply to theses overlays are described in Chapters 15.7 though 15.10 of the District Plan. These clauses place a range of restrictions and define a series of discretionary activities beyond those identified in 15.2. With respect to High-Risk Coastal Hazards, Nicolson, (2021) defines these as areas where there is a current risk from coastal erosion or inundation with existing sea level and coastal processes in the short term (within the lifespan of the district plan). This does not represent a "worst-cast" potential risk within this timeframe but identifies areas at greatest risk (Nicolson, 2021).

High Risk Coastal Hazard (Inundation) Area and High Risk Coastal Hazard (Erosion) Area overlays identify land where there is *significant* risk (Chapter 15.1 (13)) from either coastal inundation or coastal erosion with existing sea level and coastal processes (Chapter 15.14).

The *Coastal Sensitivity Area (Erosion) and Coastal Sensitivity Area (Inundation)* overlays identify land that is *potentially vulnerable* (Chapter 15.1 (13)) to either coastal erosion or coastal inundation over a 100-year period to 2120, assuming a sea level rise of 1.0 metre.

There is no explicit definition of *significant*, nor what is considered with respect to *potentially vulnerable*, however it could be argued that given the period being considered (i.e., ~100 years), a 1%

[1] https://districtplan.waikatodc.govt.nz/pages/plan/book.aspx?exhibit=PDP02

AEP is relevant, which is consistent with the planning requirements for the Council and extends beyond the intended life of the District Plan.

Personal Background and statement

My Name is Dr. Brett Beamsley, and I have a PhD in physical oceanography, including Coastal Processes from The University of Waikato.

I reside at 41 Rose Street, Raglan, part of which has been defined as being at high risk of coastal inundation with the proposed District Plan (see Figure 0.1)

I have 25 years' experience in physical oceanography, coastal processes, ocean engineering applications and managing scientific studies both in New Zealand and internationally. My professional outputs include more than 30 peer reviewed papers and scientific publications (author and co-author) In addition he has been involved in more than 200 technical reports covering a broad range of topics, including sediment dynamic and transport (including morphological modelling), drill cuttings and dredged sediment disposal characteristics, hydrodynamics and wave processes, port, harbour and marina developments and extreme value analysis related to safety critical developments.

While is support the definition of coastal hazard delineations both from a personal and professional perspective, I note that the reliance by Gibberd and Dahm, (2019) and Gibberd and Dahm, (2021) on the work of Stephens et al., (2015) does not represent the use of the best information available to identify land that may be subject to natural hazards as required within the District Plan (Waikato District Council, 2020).

Specifically, Gibberd and Dahm, (2019) note that the coastal hazard assessment included a review of all available published and unpublished data available. This statement is incorrect.

Gibberd and Dahm, (2019) did not consider the increased length of available measure water level data at recording locations, including Raglan and Kawhia but rather relied on available published reports. As technical experts they negligently failed to undertake any additional analysis of these data to delineate coastal hazard areas more accurately.

It is critical that these data should have been reviewed and considered, as they provide.

1. The ability to collaborate water levels (including tides) at Kawhia and Raglan to ascertain the validity of applying Kawhia Harbour tidal signals to Raglan Harbour, and
2. Provide greater certainty in the extreme water level values used to define the areas potentially at risk of coastal inundation.

In addition to the above shortcomings, Gibberd and Dahm, (2019) have applied an overly conservative approach to defining high risk hazard delineations that is not consistent with the requirement of the district plan to define these areas where there is a current risk from coastal erosion or inundation with existing sea level and coastal processes in the short term (within the life-span of the district plan) and not represent a "worst-case" potential risk within this timeframe (Nicolson, 2021).

The relevance of these shortcomings is important, as comparatively small relative changes in the water level magnitudes used to delineate areas of high risk or sensitive to coastal inundations have a disproportionately large impact on coastal properties and what is permitted, what is a discretionary activity and what is a prohibited activity.

What I seek is the application of realistic and scientifically justifiable extreme water level values when defining inundation risks within the Raglan Harbour. Details of what those should be are included in this technical report and are provided in the Summary section.

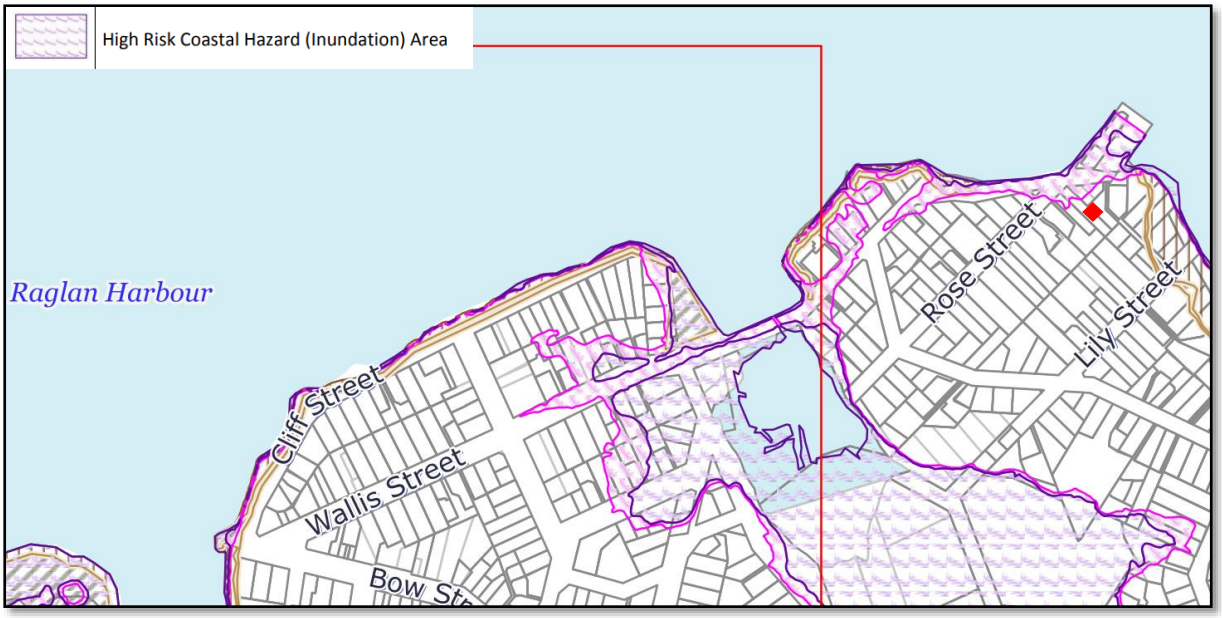

Figure 0.1 *High Risk Coastal Hazard (inundation) Area, Rose and Wallis Streat Raglan. Also shown is the location of 41 Rose Street (red dot).*

Review of technical documents defining coastal inundation levels.

Gibberd and Dahm, (2019) have undertaken an assessment of the Waikato District coastal hazard in order to inform the updating of the Waikato District Plan (see Nicolson, 2021), with an emphasis on defining areas potentially vulnerable to coastal erosion and flooding in the Waikato District.

Gibberd and Dahm, (2019) note that the identified hazards areas include areas of greatest risk with existing sea level, and additional areas that could be affected with projected sea level rise over the next 100 years.

Gibberd and Dahm, (2019) defied two coastal flood areas,

1. **High risk coastal erosion/Flood zones**, identifying the areas where there is *significant* risk from coastal erosion or flooding with existing sea level and coastal processes in the short term (within the lifespan of the District Plan).
2. **Coastal erosion/Flood sensitive zones**, identifying the areas potentially vulnerable to coastal erosion and flooding over the period to 2120, assuming sea level rise of 1.0 m.

These definitions are mirrored within the proposed District Plan (see Introduction). There is no explicit definition of *significant*, nor what is considered with respect to *potentially vulnerable*, however it could be argued that given the period being considered (i.e., ~100 years), a 1% AEP could be assumed.

This technical review examines the validity of (1) using Kawhia Harbour data to define water levels within Raglan Harbour, and (2) the applicability of the approach used to define high risk and sensitive coastal erosion and inundation.

Comparison between Kawhia and Raglan Harbour water levels

Gibberd and Dahm, (2019) rely on tidal analysis of the Kawhia Harbour water level station undertaken by Stephens et al., (2015) to define tidal levels withing Raglan Harbour. Stephens et al., (2015) only have a limited time-series of available water levels with which to determine the tidal levels within Kawhia Harbour. Data from both water level stations are continuously updated and should have been considered in any definition of hazard areas. The more contemporary data now available allows for a more accurate definition of the tides within the Harbour, and a comparison between the two harbours.

Tidal analysis has been undertaken using the same methodology as applied by Stephens et al., (2015) to data spanning through to December 2020, with a comparison between the tidal levels for Kawhia and Raglan harbour presented in Table 0.1, including comparing to the levels defined for Kawhia by Stephens et al., (2015). A comparison of the tidal curves for Kawhia and Raglan Harbours are provided in Figure 0.1.

Results indicate that,

1. Maximum tide height (which occurs approximately once every 18.6 years) for Kawhia Harbour is 1.98 m (relative to Mean Sea Level), this is 0.06 m greater than that reported by Stephens et al., (2015), which was 1.94 m. This difference is due to the longer duration available for analysis and defining the relevant tidal constituents. It can be expected that as more data is collected this value will be refined.
2. Tidal maxima's at the Raglan Harbour site are on average 0.07-0.11 m smaller than those at Kawhia Harbour, including the maximum tide height at Raglan being 0.11 m smaller than the more accurate maximum height at Kawhia (i.e., Maximum tidal height in Raglan Harbour is 1.87 m), and 0.11 m smaller than the value used by Gibberd and Dahm, (2019).

Table 0.1 Maximum measured sea-level for Kawhia as reported by Stephens et al., (2015) and applied by Gibberd and Dahm, (2019) and Nicolson, 2021, and that determined by considering available data through to December 2020, which represents a more accurate assessment of the maxima. Also provided is the Maximum tidal water level height for Raglan based on data through to December 2020.

	Maximum Tide (m)
Kawhia[1]	1.94
Kawhia	1.938
Raglan	1.87

1. As defined by Stephens et al., (2015) and applied by Gibberd and Dahm, (2019) and Nicolson, 2021,

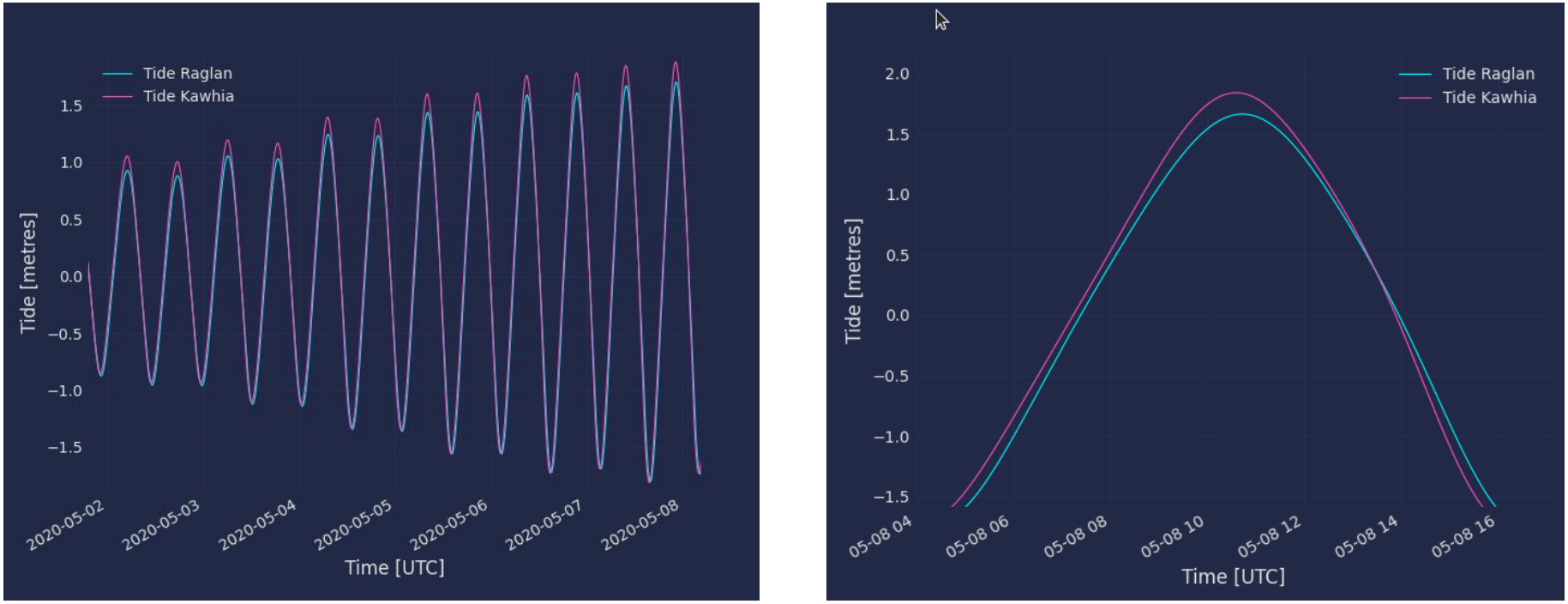

Figure 0.1 Measured tidal water levels comparison between Kawhia Harbour and Raglan Harbour illustrating that Raglan Harbour has a smaller tidal height than Kawhia.

Validity of approach used to define extreme water levels.

Gibberd and Dahm, (2019) do not consider any contemporary data when determining hazard zones, but rather rely on work undertaken by Stephens et al., (2015), which is more than 5-years old. This represents a shortcoming in the work of Gibberd and Dahm, (2019), and hence as applied by Nicolson, (2021) within the proposed District Plan, as defining extreme water levels accurately requires record lengths as long as possible. This provides greater confidence in the values obtained.

Gibberd and Dahm, (2019) apply that a significant *total* water level (i.e,. due to maximum tides, sea level anomaly, storm surge etc.) defined by adding together extreme measured values from each of the different water level components. This approach assumes that the populations are dependant, which is an incorrect assumption. Indeed, both Gibberd and Dahm, (2019) and Stephens et al., (2015) note that adding these events from these independent populations together would represent a return event considerably less likely that a 0.5% AEP storm tide, i.e. an event that is *considerably less likely* that a 1:200 year event (and probably closer to a 1:1000-10,000 year event), i.e. well beyond the 100 year planning window of the proposed District Plan (Nicolson, 2021), and likely to be more representative of a "worst-case" potential risk, which Nicolson, (2021) notes are not intended to be used to delineate hazard areas.

Gibberd and Dahm, (2019) use the added product of the independent population extreme events (which is an overly conservative approach within the context of the proposed District Plan) to define a broad area at risk from Coastal inundation with current sea level and coastal processes, and with a 1.0 m sea level rise. These values are provided in Table 0.2, are used to define;

1. **High risk coastal erosion/Flood zones**, identifying the areas where there is *significant* risk from coastal erosion or flooding with existing sea level and coastal processes in the short term (within the lifespan of the District Plan).
2. **Coastal erosion/Flood sensitive zones**, identifying the areas potentially vulnerable to coastal erosion and flooding over the period to 2120, assuming sea level rise of 1.0 m.

These values are obtained from 1) the maximum predicted tide height which has a 1/19 return period, and the maximum Storm Surge and Sea Level Anomalies associated with significant extreme water level events. Significantly, these maxima's are not associated with the same storms. The maximum storm surge of 0.899 m was associated with a storm on 6th May, 2013 while the maximum sea level anomaly was associated with an event on the 26th May, 2010. This highlights the fact that the populations of components that combine to create an extreme event are independent.

The actual proposed District Plan (Stage 2) appears to use a value of 3.8 m above MVD for the definition of the High Risk Coastal Hazard (inundation) Area (see Figure 0.2), with the proposed District Plan defining these as areas of significant risk from either coastal inundation or coastal erosion (Waikato District Council, 2020). Presumably, the discrepancy reflects some mitigation of the incorrect assumptions and uncertainties in the analysis of Gibberd and Dahm, (2019), however I am unaware of any justification for this discrepancy.

A more coherent approach would be to consider the populations as independent and undertake extreme value analysis on the combined water levels and assume a 1% AEP level when defining the hazard zone related to potential inundation.

To illustrate the impact of applying this more coherent approach, I have undertaken extreme value analysis of the contemporary data from both Raglan and Kawhia Harbour following the methodology presented in Stephens et al., (2015), including where appropriate defining the Tide, Storm Surge, Sea Level and Non-Tidal residuals. Annual Exceedance Probability statistics for the total water levels are

provided in Table 0.3, and suggest that, relative to the instrument datum (which in MVD-53) a 1% AEP water level is of the order 2.61 m for both Raglan and Kawhia. This represents a value that is ~0.39 m less than that proposed by Gibberd and Dahm, (2019) and as applied in the proposed District Plan (Waikato District Council, 2020). Significantly, these values are not to dissimilar to the 1% AEP storm tide predictions for Kawhia by Stephens et al., (2015), i.e. 2.63 m median value, with an upper 95% Confidence Interval of 2.67 m

To illustrate the potential impact of properties in the Wallis Street region, a comparison between the 1% AEP based on available data for Raglan and Kawhia for the existing sea level and that assuming 1 m sea level rise are illustrated in Figure 0.3, along with the area defined by Gibberd and Dahm, (2019) as being *broadly* at risk from coastal inundation and as defined as High Risk Coastal Hazard (inundation) Area by Waikato District Council, (2020). The High Risk Coastal Hazard (inundation) Area proposed by Waikato District Council, (2020) impacts significantly more coastal properties that would be suggested by considering a 1% AEP water level event and likely to represent a something more similar to a "worst-case" situation. This is inconsistent with the intention of the proposed District Plan to not represent a "worst-case" potential risk within this timeframe when defining hazard zones (Nicolson, 2021).

Table 0.2 Maximum measured sea-level components. The elevation maxima presented here are given relative to a zero Mean Sea Level. To calculate the elevation to MVD-53 add 0.13 m (After Stephens et al., (2015))

Location	Tide (m)	Storm Surge (m)[1]	Sea Level Anomaly (m)[2]	Sum (m)	With SLR (m)
Kawhia	1.939	0.899	0.16	2.998	3.998

1. Associated with a storm on the 6th May, 2013
2. Associated with a storm on the 26th May, 2010

Table 0.3 Annual Return Interval, and Annual Exceedance probability of extreme water elevations at Raglan and Kawhia based on data available through to December 2020. Values are reported as above MVD-53.

ARI	**AEP**	**Raglan (m)**	**Kawhia (m)**
1	100	2.4	2.46
10	10	2.53	2.56
25	4	2.56	2.58
50	2	2.59	2.59
100	**1**	**2.61**	**2.61**
1000	*0.1*	*2.65*	*2.63*
10000	*0.01*	*2.68*	*2.64*

Values beyond 1% AEP are shown for context and are likely to have significant uncertainty due to the length of the available data record.

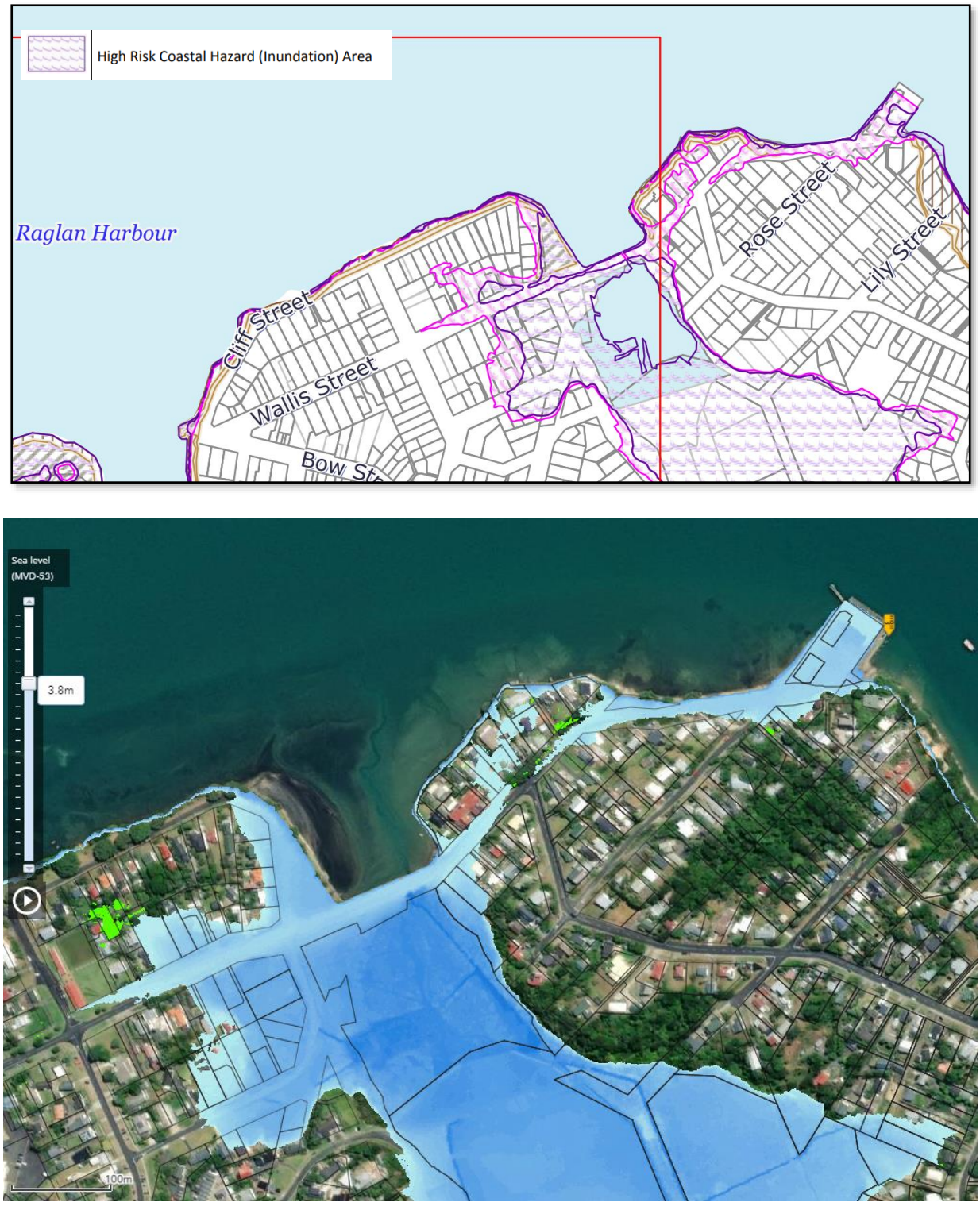

Figure 0.2 *Proposed District Plan High Risk Coastal Hazard (inundation) Area in the Wallis Streat area, Raglan.[2] (Top) and the predicted inundation assuming a static water level of 3.8 m above MVD (bottom)*

[2] https://wdcsitefinity.blob.core.windows.net/sitefinity-storage/docs/default-source/your-council/plans-policies-and-bylaws/plans/district-plan-review/proposed-district-plan-chapters/planning-maps/23-3-raglan-west.pdf?sfvrsn=48a780c9_2

Figure 0.3 Estimated coastal inundation levels under a 1% AEP for the existing sea level (A) and assuming a future sea level rise of 1.0 m (B). Also shown are the extreme inundation estimates of Gibberd and Dahm, (2019) for the existing sea level (C) and the proposed district plan High risk coastal erosion/Flood zones.

Summary

The use of Kawhia Harbour maximum tidal elevations to defining extreme water levels in Raglan is overly conservative and represents a value greater than the "worst-case" water level by approximately 0.7 m at best, and 0.11 m at worst. This is inconsistent with the intention of the proposed District Plan to not represent a "worst-case" potential risk within this timeframe when defining hazard zones (Nicolson, 2021).

Using a maximum tidal value larger than the actual maximum Raglan Harbour tidal value for defining hazard levels is an overly conservative approach which will lead to delineations being further inland than they should, thereby impacting more coastal properties, services and infrastructure.

Gibberd and Dahm, (2019) and hence Nicolson, (2021) rely on tidal analysis of the Kawhia Harbour water level station undertaken by Stephens et al., (2015) to define tidal levels withing Raglan Harbour. Stephens et al., (2015) only have a limited time-series of available water levels with which to determine the tidal levels within Kawhia Harbour. Data from both water level stations are continuously updated and should have been considered in any definition of hazard areas. The more contemporary data now available allows for a more accurate definition of the tides within the Harbour, and a comparison between the two harbours. Gibberd and Dahm, (2019) did not consider the increased length of available measure water level data at recording locations, including Raglan and Kawhia but rather relied on available published reports. Specifically, Gibberd and Dahm, (2019) note that the coastal hazard assessment included a review of all available published and unpublished data available. This statement is incorrect.

Further, the extreme water level values used to define the High Risk Coastal Hazard (inundation) Area proposed by Waikato District Council, (2020) represent an value that is based off work undertaken by Gibberd and Dahm, (2019) with an Annual Exceedance Probability that is both Gibberd and Dahm, (2019) and Stephens et al., (2015) is considerably less likely than a 0.5% AEP, or considerably less likely than a 1:200 year event. This is likely to represent a inundation level associated with an extreme water level value that is close to a "worst case", which is inconsistent with the intention of the proposed District Plan (Nicolson, 2021).

Analysis of the more contemporary water level data available at both Kawhia and Raglan undertaken following the methodology detailed in Stephens et al., (2015) suggests that a 1% AEP extreme water level event will have a magnitude of approximately 2.61 m above MVD-53. This value is similar to that proposed by Stephens et al., (2015) based of a shorter record. While some uncertainties exist in extrapolating the available time-series data out to 1% AEP levels, even at 95% CI the Storm Tide values are of the order 0.35-0.40 m smaller than those used by Gibberd and Dahm, (2019) and Nicolson, (2021) in defining High Risk Coastal Hazard (inundation) Area within the Raglan area.

A more realistic definition of the High Risk Coastal Hazard (inundation) Area would be based off a 1% AEP Storm Tide for Kawhia and Raglan (i.e. 2.61 m above MVD-53 + 1 m Sea Level Rise). This would be consistent with the planning requirements for the District Council and the intention of the proposed District Plan not to base hazard delineation on "worst case" situations, as illustrated in Figure 0.3.

As such, I seek a review and revision of the values used to define the inundation risk within Raglan Harbour, or a change to the value stated above (2.61 m above MVD-53+ 1 m Sea Level Rise) for defining High Risk Coastal Hazard (inundation) Area.

References

Gibberd, B., Dahm, J., 2021. Waikato District Coastal Hazards: Response to Submissions on Waikato District Plan Stage 2: Coastal Hazard Area Maps.

Gibberd, B., Dahm, J., 2019. Waikato District Council Coastal Hazards. Prepared for the Waikato District Council by Members of Focus Resource Management Group.

Nicolson, K., 2021. Section 42A Report: Report on submissions and further submissions on the Proposed Waikato District Plan: Hearing 27D: Coastal Hazards: Part 2 - Maps. Waikato District Council.

Stephens, S., Robinson, B., Bell, R., 2015. Analysis of Whitianga, Tararu and Kawhia sea-level records to 2014. NIWA.

Waikato District Council, 2020. Natural Hazards and Climate Change: Proposed Waikato District Plan (Stage 2). Waikato District Council.