FINAL REPORT

Tonkin + Taylor

New Plymouth District Plan Review: Coastal Management

Prepared for
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Prepared by
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Exceptional thinking together

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Executive summary

New Plymouth District Council (NPDC) have initiated a review of the New Plymouth District Plan with *Strategic Coastal Management* being an area of focus. To assist in this review, Tonkin & Taylor Ltd. (T+T) has been engaged to identify low lying areas on the New Plymouth District coast where the impacts of coastal storm surge and sea level rise will be evident. This assessment focusses particularly on areas where there is existing urban development.

The New Plymouth coast is susceptible to storm driven coastal inundation hazard resulting from a combination of high tide, storm surge, variation of sea level and wave set-up. This hazard may increase in the future due to projected increase in sea level rise associated with global climate change.

Previous assessment by Tate (2013) provided useful information on potentially vulnerable areas. However, the approach of summing individual components (known as a 'building block approach') is conservative, particularly when low probability components are combined. Further, some very high sea level rise scenarios (up to 2m) were adopted. The derived levels are therefore likely to over-predict potential coastal inundation extents when considering timeframes over the next 100 years and we do not recommend adopting these levels for planning purposes. However, the information presented in Tate (2013) on the effects of such flooding (land area, number and value of houses and people affected at different levels) could still be used together with updated extreme sea level information and additional information on social and environmental effects to assess resultant risk.

By considering key drivers of elevated coastal water levels along the New Plymouth coastline using a less conservative, probabilistic framework, extreme static water levels have been defined for 1yr, 10yr and 100yr annual recurrent interval (ARI) events. The levels have been defined for both present day sea levels and for future sea levels at 2065 (50 years) and 2115 (100 years) timeframes based on a range of sea level rise scenarios ranging from extrapolation of past rates to various IPCC future emission scenarios.

The extents of inundation have been mapped for areas with available topographic data (Oakura to Waitara, and Onaero and Urenui) for a range of elevated coastal water levels using a connected bathtub tool. Using this approach areas are flooded only where they connect to the coastal water body. This provides more realistic flooding extents by accounting for natural and human influenced (e.g. stopbanks) topography. The extents of inundation at Waitara have been assessed both including and excluding the recently constructed flood protection stopbanks. Due to the resolution of available topography (0.5m contours), inundation extents have been mapped at 0.25 m intervals and extreme values have been rounded up to the nearest 0.25m to determine the corresponding extent. Areas not covered by available topographic data should use the closest extreme static water level (see Table 3.2) together with local survey information to determine inundation levels and extents at site

Based on the assessed extreme static water levels and maps showing potential inundation extents (Appendix B), the majority of the urban areas along the New Plymouth District coast are unlikely to be inundated during the present day. Two exceptions to this are around Puke Ariki Landing and northern Brougham St in New Plymouth, where flood water would flow back up the Huatoki Stream Outlet and onto adjacent land in a 10yr ARI, or greater, event. Parts of Waitara would likewise flood at events greater than 10yr ARI without the protection of stopbanks. These banks prevent sea inundation of adjacent inland urban areas.

For the future time frames (2065 and 2115) widespread inundation of urban areas remains unlikely except for around the Puki Ariki Landing and northern Brougham St, parts of Motorua industrial area and large areas along the Waitara River banks if stopbanks do not remain effective. Furthermore, it is likely that some areas adjacent to streams (lower Waiwhakaiho River, lower Waiongana Stream,

Huatoki Stream, Onaero River and Urenui River) and behind foredunes (Fitzroy, Waiongana and Marine Reserve at Waitara) may be inundated. Bell Block and Onaero both have limited exposure to coastal flooding under the adopted sea level rise scenarios and coastal inundation is unlikely to occur for the assessed water levels.

Before use of these results within the District Plan review process, we recommend the following steps:

- Assess the condition of the Waitara River stopbanks and confirm they are connected and impermeable to flow.
- Use the event likelihoods and extent of inundation derived by this study to undertake a risk assessment taking into account the consequences (or impacts) of the inundation associated with different events. This will provide a quantitative measure of the coastal inundation hazard risk for different return periods and SLR scenarios.
- Engagement with stakeholders to assist in selecting appropriate event likelihood and future sea level rise scenarios for defining where and how development controls are applied within the district plan update. Maps corresponding to these specific scenarios can then be produced for use in the updated District Plan.

Following this current review process, additional assessments could be considered to improve confidence in the identified coastal inundation hazard areas.

- Using improved topographic information (likely LiDAR) when available to improve the resolution of mapping (currently assessed to the nearest 0.25m level).
- Consider the joint probability of coastal and terrestrial flooding for Waitara to more accurately define maximum potential inundation levels.

1 Introduction

The New Plymouth coast is susceptible to storm driven coastal inundation hazard resulting from a combination of high tide, storm surge, variation of sea level and wave set-up. This hazard may increase in the future due to increased rates of sea level rise associated with global climate change.

New Plymouth District Council (NPDC) have initiated a review of the New Plymouth District Plan with *Strategic Coastal Management* being an area of focus. To assist in this review, Tonkin & Taylor Ltd. (T+T) have been engaged to identify low lying areas on the New Plymouth District coast where the impacts of coastal storm surge and sea level rise will be evident. This assessment focusses particularly on areas where there is existing urban development.

Results of the assessment will be used to consider where and how development controls should be applied in the District Plan. Consultation on these matters will allow the proposed changes to be tested with wider community with a proposed district plan to be formally notified later in 2017.

This approach presents an opportunity to meaningfully engage with the community on what the current and future coastal hazards may look like, the potential consequences and the community's view on risk and appropriate development controls. This present assessment provides baseline data to begin such a conversation.

1.1 Study approach

The overall approach for identifying and prioritising low lying areas related to current and future potential land has been as follows:

1. Review of previous studies and existing information
2. Analysis of water level information at Port Taranaki and numerical hindcast wave data around the New Plymouth District coastline
3. Division of the Taranaki coastline into cells subject to similar wave energy and calculation of wave set-up and resulting extreme static coastal water levels
4. Review of available topographic data and information on flood protection works
5. Construction of a digital terrain model where topographic information was sufficient and identification of land elevation
6. Identification of areas subject to flooding under current and future extreme coastal water levels under different sea level rise scenarios
7. Recommendations for planning implications and further investigation where required.

The approach is summarised in Figure 1-1.

1.2 Previous studies

Tate (2013) assessed the effects of a rise in mean sea level on the New Plymouth coastline considering both coastal flooding and erosion. In considering coastal flooding, Tate combined a highest astronomical tide with a 50 year return period storm surge and 50 year return period wave set-up and run-up. To this, sea level rise was added at increments between 0.5 and 2 m.

Findings were that current maximum wave set-up levels could range from 3.7 to 3.9 m above TVD-70 (Taranaki Vertical Datum 1970) around the New Plymouth coastline and wave run-up levels from 4.8 to 5.4 m above TVD-70. These levels were increased by 0.5 to 2 m for the various sea level rise scenarios giving total static levels up to 5.9 m and run-up levels up to 7.4 m.

A digital terrain model was derived from available topographic data (0.5 m contours) and areas affected by different inundation levels mapped. The numbers of people and value of property affected was assessed for each increment. Findings were that infrastructure such as Port Taranaki, the CBD, New Plymouth Airport and sewerage systems could be affected by coastal inundation flooding along with populations in Waitara and other rivermouth settlements.

This study provides useful information on effects of coastal flooding at different levels. However, the approach used to define the extreme sea levels by summing tidal, storm surge and wave effect components (known as a 'building block approach') is conservative, particularly when low probability components are combined. Furthermore, wave runup effects only the coastal edge with energy rapidly dissipated and so run up levels should not be used to determine flood extents. Finally, some very high sea level rise scenarios (up to 2m) were included which exceed those recommended by guidance (i.e. MfE, 2008; IPCC, 2014).

The derived levels are therefore likely to over-predict potential coastal inundation levels when considering timeframes over the next 100 years and we do not recommend using these levels for planning. However, the information presented in Tate (2013) on the effects of such flooding (land area, number and value of houses and people affected at different levels) could still be used together with updated extreme sea level information and additional information on social and environmental effects to assess resultant risk.

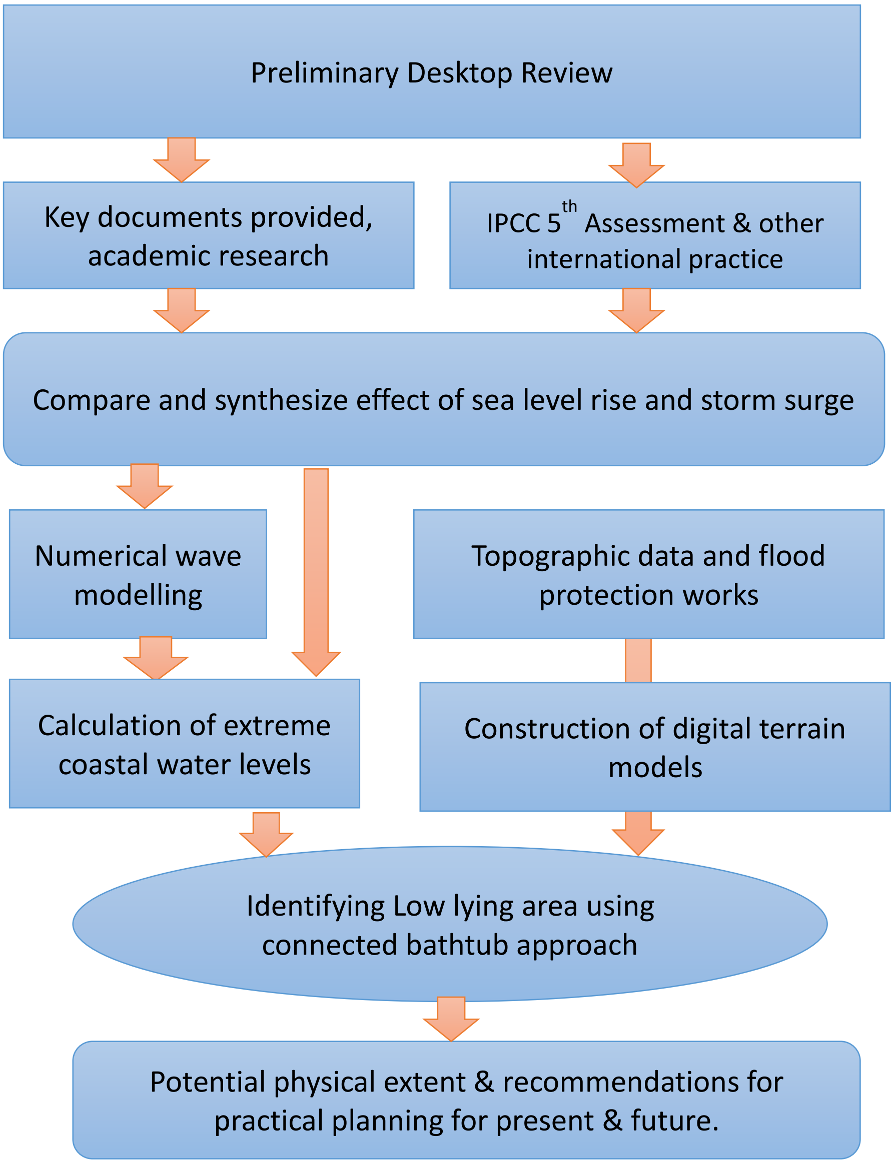

Figure 1-1: Overall approach for the identifying low lying areas

2 Background data

2.1 Topography

Topographic data has been supplied by Council in terms of TVD-70. This includes 0.5 m contour data between Oakura and Waitara and covering Onaero and Urenui and 10 m contour data elsewhere. Coverage extents are shown in Appendix B.

2.1.1 Stopbanks

A number of stopbanks have been recently constructed along the Waitara River, we understand for the primary purpose of reducing river flooding. Table 2.1 shows the stopbanks at Waitara as surveyed in June 2012 by BTW Company Ltd with locations shown in Figure 2-1. The table shows the stopbank types (earth, gabian wall or concrete wall), locations (street names) and elevation range of the stopbank crest in m TVD-70. For the purpose of flood analysis we have ***assumed that these stopbanks are impermeable*** up to the indicated elevation.

Table 2.1: Stopbank at Waitara as surveyed by BTW Company Ltd in June 2012

No	Stopbank material	Location	Elevation (m TVD-70)
1	Earth stopbank / gabian wall	Browne Street to McLean Street	6.28 - 9.04
2	Earth stopbank / Concrete wall	North Street to High Street East	5.75 - 6.15
3	Concrete wall	ANZCO (Stafford Street)	6.25
4	Earth stopbank / Gabian wall / Concrete wall	High Street to Norman Street	5.15 - 5.86
5	Gabian wall	West Quay	6 - 6.28
6	Earth stopbank	Marine Park (south-east side)	3.24 - 4.9
7	Earth stopbank	East Quay	5.15 - 5.54

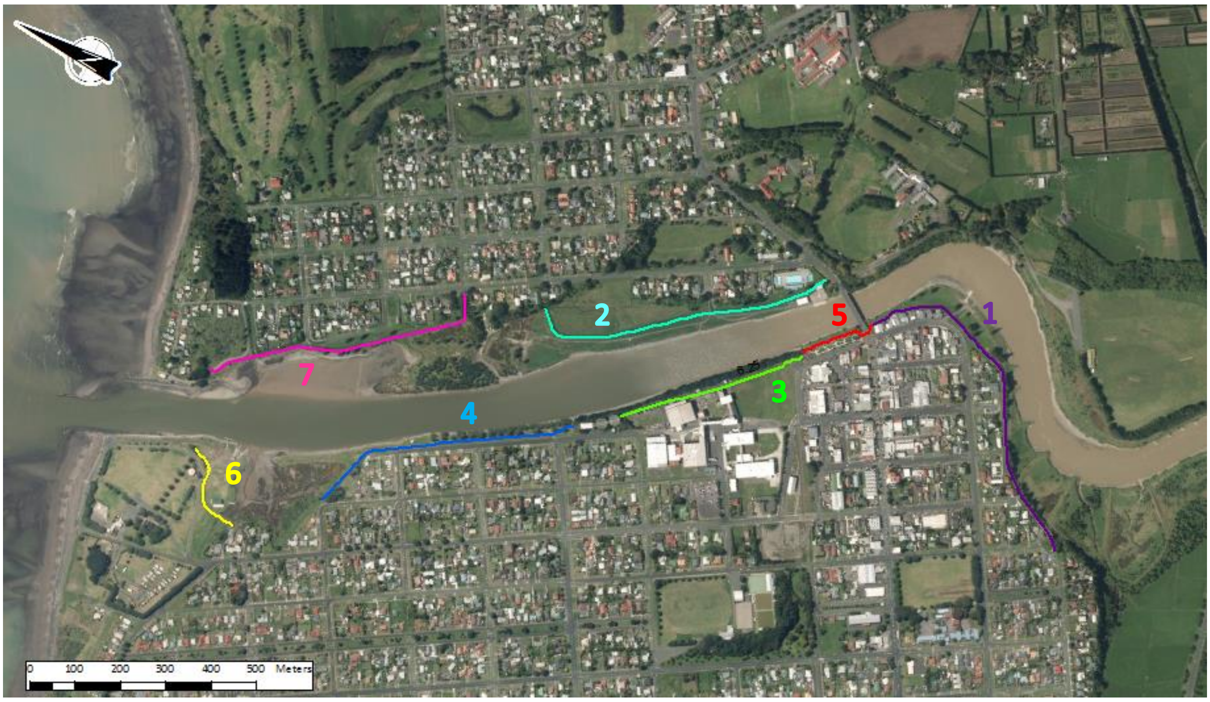

Figure 2-1: Stopbank locations as surveyed by BTW Company (June 2012)

2.2 Bathymetry

Bathymetric data is available for the New Plymouth District from hydrographic charts from LINZ (Figure 2-2).

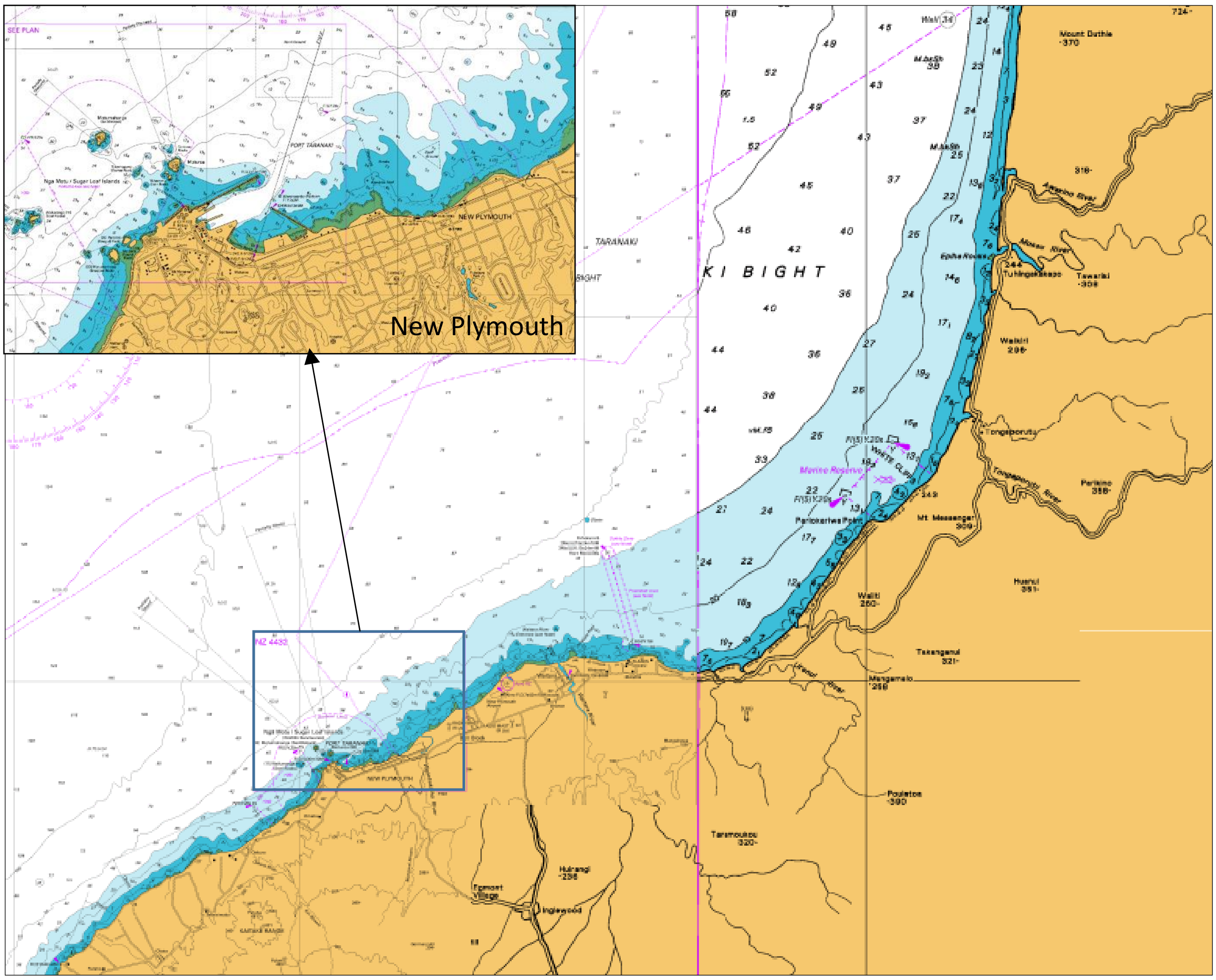

Figure 2-2: Bathymetry New Plymouth District (source: LINZ charts NZ4432, NZ443, NZ43 and NZ45)

2.3 Beach profile information

Beach profiles from 2003/2004 are available between Waiwakaiho to Urenui for the following locations:

- Waiwakaiho
- Bell Block
- Waitara
- Onaero
- Urenui.

These profiles have been used in combination with bathymetric information presented in Section 2.2 to construct representative profiles and assess wave set-up using both a numerical and empirical model (refer to Section 3.2.4). Figure 2-3 shows the resulting beach profiles used for the wave set-up assessment.

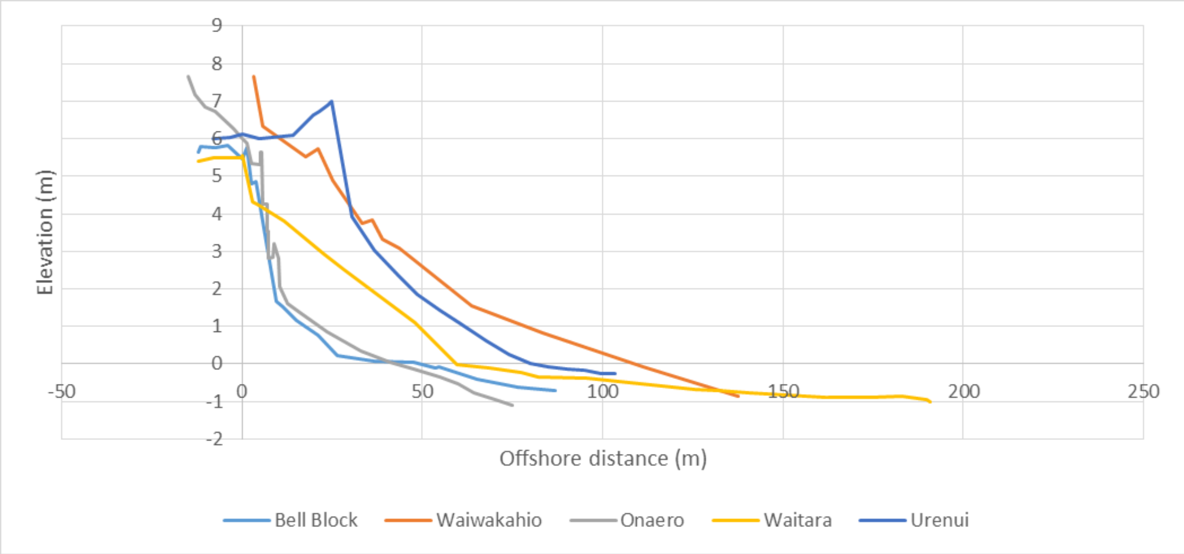

Figure 2-3: Resulting beach profile surveys (source: Taranaki Regional Council)

2.4 Water levels

The water level at any location varies across a range of timescales. Key components that determine water level are:

- Mean level of the sea including medium term fluctuations (e.g. ENSO and IPO effects)
- Astronomical tides
- Barometric and wind effects, generally referred to as storm surge
- Wave effects (wave breaking) can super-elevate water level through wave set-up and run-up.
- Long-term changes in sea level

2.4.1 Mean sea level

TVD-70 is a fixed survey datum based on the mean level of the sea level between 1918 and 1921 (Hannah, 2001). Bell et al. (2008) point out that the actual mean level of the sea from year to year varies depending on cyclical changes such as the 2-4 year El Nino-Southern Oscillation (ENSO) cycle and the 20-30 year Interdecadal Pacific Oscillation (IPO) and long-term sea level changes. LINZ (2015-16) give the present mean sea level at 0.125 m above TVD-70.

2.4.2 Astronomical tides

Water levels for Cadastral and Engineering purposes are recommended by Land Information New Zealand based on the average predicted values over the 18.6 year tidal cycle. These levels for Port Taranaki are given in Table 2.2 (LINZ, 2015-16) and show a spring tidal range of 3.3 m and neap tidal range of 1.7 m. The mean high water spring (MHWS) elevation is approximately 1.78 m TVD-70 or some 1.6 m above mean sea level (MSL).

Approximate tidal values are provided for the Waitara River Entrance, approximately 20 km ENE of Port Taranaki and for Opunake Bay approximately 40 km SSW of Port Taranaki. These show a slightly reduced tidal range at 94% of the Port Taranaki MHWS value for Waitara and 91% for Opunake with MHWS at 1.7 m and 1.5 m TVD-70 respectively. This indicates that values derived for Port Taranaki are likely to be conservative for areas at the north and south ends of the New Plymouth District coastline. We have therefore adopted the water level values for Port Taranaki in this study.

Table 2.2: Astronomical tidal levels for Port Taranaki (LINZ, 2015-16)

Tidal Description		CD[1]	TVD-70
HAT	Highest Astronomical Tide	3.9	2.09
MHWS	Mean High Water Spring	3.59	1.78
MHWN	Mean High Water Neap	2.79	0.98
MSL	Mean Sea Level	1.96	0.15
MLWN	Mean Low Water Neap	1.09	-0.73
MLWS	Mean Low Water Spring	0.29	-1.53
CD	Chart Datum	0	-1.815
LAT	Lowest Astronomical Tide	-0.03	-1.85

2.4.3 Storm surge

Storm surge results from the combination of barometric set-up from low atmospheric pressure and wind stress from winds blowing along or onshore which elevates the water level above the predicted tide (Figure 2-4). The combined elevation of the predicted tide and storm surge is known as the storm tide. Storm-surge applies to the general elevation of the sea above the predicted tide across a region but excludes nearshore effects of storm waves such as wave set-up and wave run-up at the shoreline.

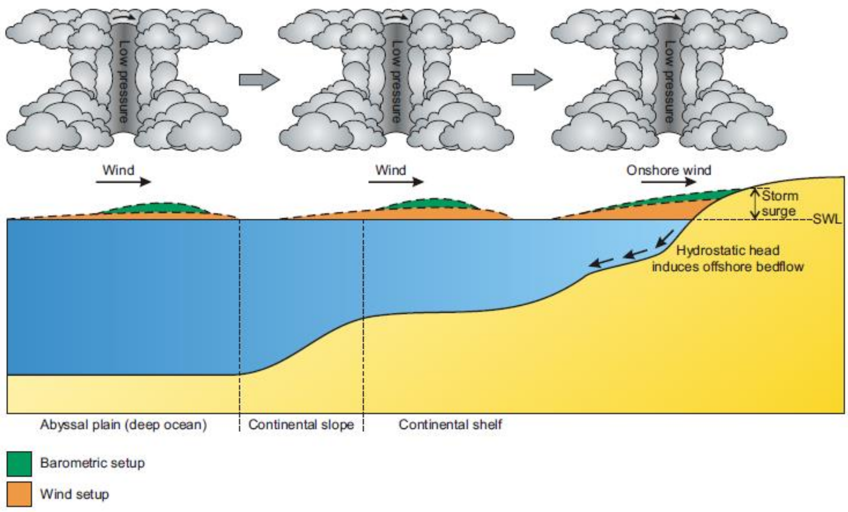

Figure 2-4: Processes contributing to storm surge

Metocean Solutions Ltd. have undertaken an analysis of the measured sea level data at Port Taranaki for the period 2002-2016[1]. The data was despiked and detided using the T_TIDE Matlab software package and the residual sea level data were used to estimate extreme surge levels, while the combination of both tidal and residual data were used to calculate the extreme total still water level elevation at several Annual Recurrence Intervals (ARIs). Resultant extreme storm surge and total still water level (SWL) for Port Taranaki are provided in Table 2.3 in terms of CD and TVD-70. The offset between CD and TVD-70 is based on an assumed mean sea level of 1.95 m above CD which includes the increase of the mean sea level since 1970 (~0.15 m). Table 2.3 shows 100yr ARI

[1] Data provided by Port Taranaki Limited at 20-min interval

levels of 2.34 m TVD-70, or approximately 0.56 m above MHWS. This shows the likelihood of a peak storm surge corresponding with a spring high is moderate to low.

Table 2.3: Extreme storm surge and total still water level (source: MetOcean, 2016)

ARI (years)	Surge (m MSL)	Total SWL (m CD[1])	Total SWL (m TVD-70)
1	0.52	3.87	2.05
5	0.64	3.98	2.16
10	0.69	4.02	2.21
25	0.76	4.08	2.26
50	0.81	4.12	2.30
100	0.86	4.16	2.34

[1]based on offset between chart datum (CD) and assumed mean sea level of 1.95 m (Metocean pers. comm. May 2016)

2.5 Waves

Bell et al. (2008) found that swell waves (peak period of 11 to 13 s) occur 40% of the time with dominant waves occurring from the westerly quarter along the North Taranaki coast. Wave heights near the coast become substantially reduced from offshore due to refraction and land shadowing.

Metocean Solutions Ltd. undertook a detailed analysis of wave hindcast data along the New Plymouth District coastline. A high resolution (0.007˚ by 0.007˚ in longitude and latitude) SWAN (Simulating WAves Nearshore) model was used. The hindcast extended over a 37-year period between 1979 and 2015 and provided 3-hourly frequency-direction wave spectra (refer Appendix A).

Wave heights were extracted at 12 locations (Figure 2-5) in 10 m water depth. Omni-directional return period values at ARIs of 1, 5, 10, 25, 50, and 100 years were calculated from the hindcast time series of significant wave height. Extreme wave characteristics for the 12 offshore locations are presented in Table 2.4 and show the 100 year ARI wave height to range from 2.97 m to 5.92 m with a wave period of 14.2 s period. Smallest waves occur in the lee of Port Taranaki due to wave shadowing of westerly waves.

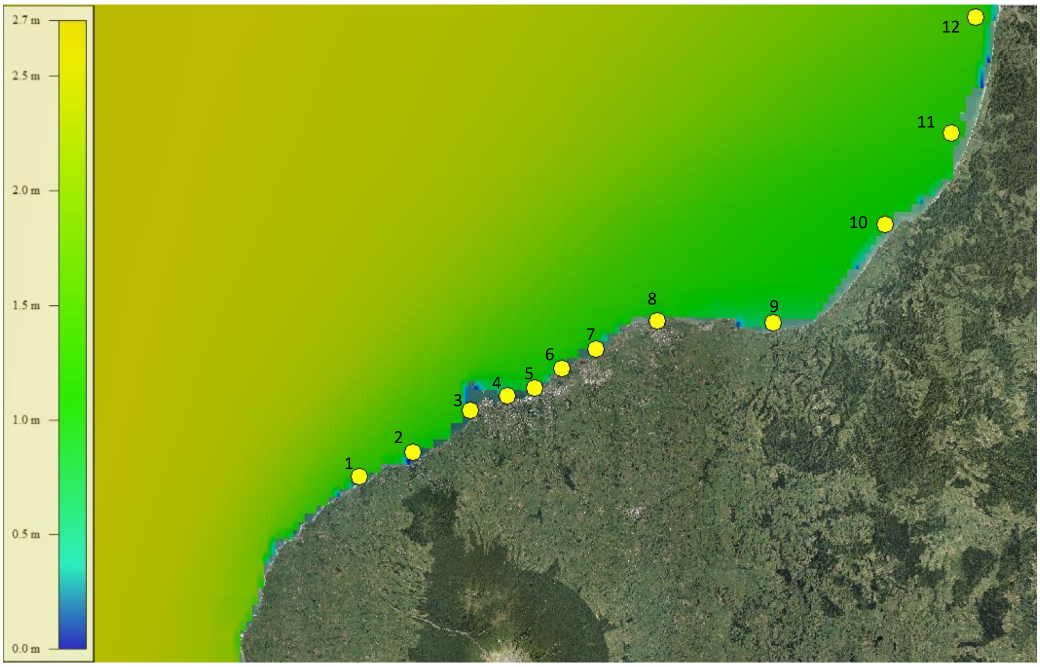

Figure 2-5: Mean significant wave height and locations of 12 representative reporting sites

Table 2.4: Extreme wave characteristics for offshore locations shown on Figure 2-5 (10m water depth) provided by MetOcean

Site	ARI (years)	H_s (m)	T_p (s)	Site	ARI (years)	H_s (m)	T_p (s)
	1	4.45	13.1		1	3.72	13.1
1	10	5.10	13.8	7	10	4.05	13.8
	100	5.50	14.2		100	4.19	14.2
	1	3.59	13.1		1	4.18	13.1
2	10	3.93	13.8	8	10	4.65	13.8
	100	4.10	14.2		100	4.87	14.2
	1	3.82	13.1		1	3.74	13.1
3	10	4.13	13.8	9	10	4.40	13.8
	100	4.49	14.2		100	4.83	14.2
	1	2.57	13.1		1	3.89	13.1
4	10	2.84	13.8	10	10	4.62	13.8
	100	2.97	14.2		100	5.09	14.2
	1	3.38	13.1		1	3.98	13.1
5	10	3.56	13.8	11	10	4.18	13.8
	100	3.63	14.2		100	4.24	14.2
	1	2.97	13.1		1	4.33	13.1
6	10	3.11	13.8	12	10	4.61	13.8
	100	3.17	14.2		100	4.70	14.2

2.5.1 Wave effect on water level

Wave set-up is a super-elevation of the mean water surface over normal 'still' water level due to wave action alone. Following wave breaking, on-shore directed momentum flux or radiation stress is induced due to dissipation of wave energy. To balance this momentum flux, a pressure gradient is created by elevation of the water level. Water level is highest at the beach face, and drops towards the break point, creating an offshore gradient (Figure 2-6). Methods used to assess wave set-up for this study are described in Section 3.2.4.

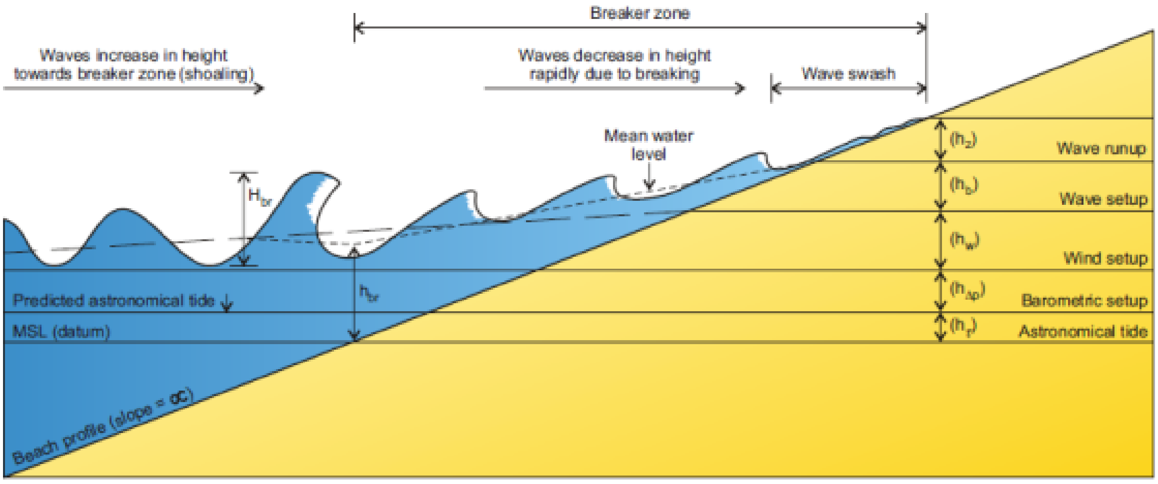

Figure 2-6: Schematic diagram showing components of wave set-up and run-up (Frisby and Goldberg, 1981)

Wave run-up occurs as waves travel across the surf zone and are then carried by momentum above the still water level until such forces are exceeded by gravity. Coastal run-up hazard differs from static flooding as run-up is a dynamic process. An incident wave running up the shoreface reaches a maximum potential height at the coastal edge before decreasing with distance inland due to friction and energy loss. It is therefore not recommended to use wave run-up when determining areas subject to static coastal inundation. This difference and its effect on flooding extents is illustrated in Figure 2-7.

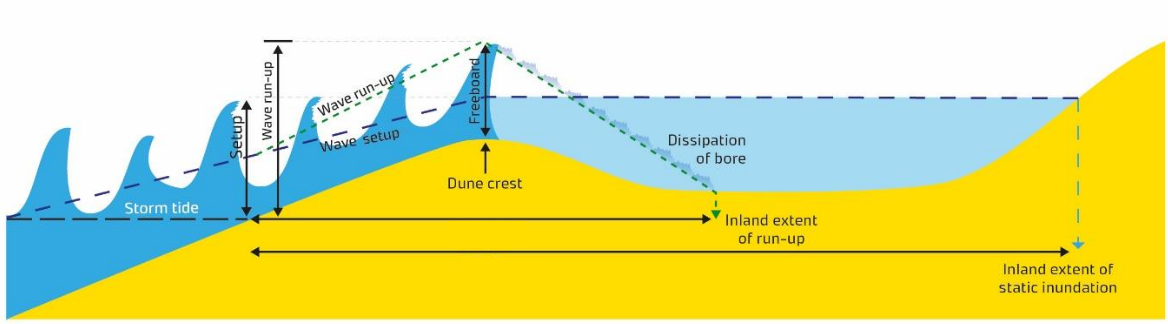

Figure 2-7 Difference in coastal inundation extents caused by wave setup (static inundation) and wave runup

2.6 Sea level rise

2.6.1 Historic changes

Relative sea level rise is influenced by both eustatic (global) changes in sea level due to thermal expansion of sea water and glacial and ice-sheet melt and local changes in land level due to isostatic adjustment, plate-tectonics and subsidence due to compaction of sediments. Taranaki is situated on a relatively stable tectonic block with low vertical uplift rates estimated from marine geological markers at around 0.2 to 0.3 mm/year (Berryman and Hull, 2003). Bell & Hannah (2012) found that relative SLR for Taranaki is +1.5 mm/yr (±0.2), which is slightly below the New Zealand average rate of 1.7 mm/year and may reflect the slight observed uplift.

2.6.2 Future sea level rise

Sea levels are predicted to rise at higher rates in the future as the planet warms, ocean water expands and glaciers and ice-sheets melt. The IPCC Assessment Report 5 (IPCC, 2014) provides a range of sea level rise predictions for various future emission scenarios known as Representative Concentration Pathways (RCPs). The four RCPs, RCP2.6, RCP4.5, RCP6, and RCP8.5, are named after a possible range of radiative forcing values in the year 2100 relative to pre-industrial values (+2.6, +4.5, +6.0, and +8.5 W/m^2, respectively). RCP2.6 represents a ‘low emission’ scenario, RCP 4.5 and 6.0 represent emission stabilisation (at around 2100) scenarios and RCP8.5 represents a scenario of increasing greenhouse gas emissions over time.

The Ministry of Environment (MfE, 2008) guideline recommends a base value sea level rise of 0.5 m in the 2090’s (relative to the 1980-1999 average) with consideration of the consequences of sea level rise of at least 0.8 m with an additional sea level rise of 10 mm per year beyond 2100. New MfE guidance on sea level rise is due later in 2016. In the interim, consideration of a range of possible emission scenarios is prudent with Table 2.5 presenting sea level rise values for 2065 and 2115 relative to the Port Taranaki mean sea level derived by LINZ (over the 1996-2014 period). Extrapolation of existing rates of sea level rise is also considered as a minimum possible rise.

Table 2.5: Projected sea level rise values (m) adjusted relative to 1996-2014 average MSL

Year	Existing historic rates	IPCC emission scenario		
		RCP8.5	RCP6.0	RCP2.6
2015	0.02	0.03	0.03	0.03
2065	0.09	0.34	0.26	0.25
2115	0.17	0.91	0.61	0.45

3 Extreme water level assessment

3.1 Methodology

The extreme static water level is the result of the wave set-up superimposed on the still water level or storm tide occurring at that time. While wave run-up causes periodic wave swash above the inundation level it does not typically contribute to static coastal inundation and has been excluded.

Extreme static water levels have been assessed for the New Plymouth District shoreline based on the following components:

$$Extreme\ static\ water\ level = ST + SU + SLR \tag{3-1}$$

Where:

ST = **storm tide** level defined by the combination of astronomical tide, storm surge and mean sea level fluctuations

SU = **wave set-up** caused by wave breaking and onshore directed momentum flux across the surf zone

SLR = **sea level rise** over the defined planning timeframes of present day, 50 and 100 years

The derivation of the individual components is described in Section 3.2 the methods used to assess and combine storm tide levels, wave set-up described in Section 3.3. The resulting extreme static water levels are presented in Section 3.4.

3.2 Component derivation

3.2.1 Planning timeframe

Three planning time frames were applied to provide information on current hazards and information at sufficient time scales for planning and accommodating future development:

- 2015 Extreme static water levels
- 2065 Extreme static water levels
- 2115 Extreme static water levels

3.2.2 Storm tide levels

Storm tide data was provided by Metocean Solutions Ltd. (refer to Section 2.4.3). An hourly time series of storm tide levels is constructed from the storm tide data from 2002 to 2016 that includes astronomical tide, storm surge and medium term fluctuations.

3.2.3 Waves

Extreme and typical characteristics have been provided by Metocean Solutions Ltd. (refer to Section 2.5) at 12 nearshore locations around the New Plymouth District. A full wave height time series has additionally been provided for a location offshore of Port Taranaki. Using the relationship between extreme wave heights at the offshore location and each of the nearshore sites, hourly time series of the wave height and period have been constructed for the 2002 to 2016 time period to match the water level time series.

3.2.4 Wave set-up

There are a range of methods available to calculate wave set-up including both numerical and empirical methods. Numerical models are likely to predict wave set-up more accurately than empirical formulations as they generally account for local seabed and beach gradient. However, to calculate wave set-up for every time step (refer Section 3.3) an empirical formulation is more efficient.

The empirical formulation as described in Section 3.2.4.1 has been adopted for this assessment and has been calibrated by correcting the calculated set-up level with set-up levels predicted by a numerical model (refer to 3.2.4.2) for several scenarios (refer to 3.2.4.3).

3.2.4.1 Empirical method

The Coastal Engineering Manual (USACE, 2006) provides a method to calculate wave set-up for open coast beaches based on the wave energy balance. The negative gradient in the onshore directed radiation stress is balanced by an offshore directed pressure force caused by wave set-up (refer to USACE, 2006). The Coastal Engineering Manual (CEM) provides a formulation to calculate both set-up at the still water line (Equation 3-2) and the maximum set-up (Equation 3-3):

$$\overline{\eta_s} = \overline{\eta_b} + \left[\frac{1}{1+\frac{8}{3\gamma_b^2}}\right] h_b \qquad (3\text{-}2)$$

Where:

$\overline{\eta_s}$ = Set-up at still water line (SWL)

$\overline{\eta_b}$ = Set-down at still water line (SWL)

γ_b = breaker index

h_b = breaker depth

$$\overline{\eta_{max}} = \overline{\eta_s} + \frac{d\eta}{dx}\Delta x \qquad (3\text{-}3)$$

Where:

$\overline{\eta_{max}}$ = maximum set-up

$\frac{d\eta}{dx}$ = Set-up gradient between $\overline{\eta_s}$ and $\overline{\eta_{max}}$ based on surfzone slope

Δx = Displacement between $\overline{\eta_s}$ and $\overline{\eta_{max}}$ based on beach face slope

This method is shown in Figure 3-1.

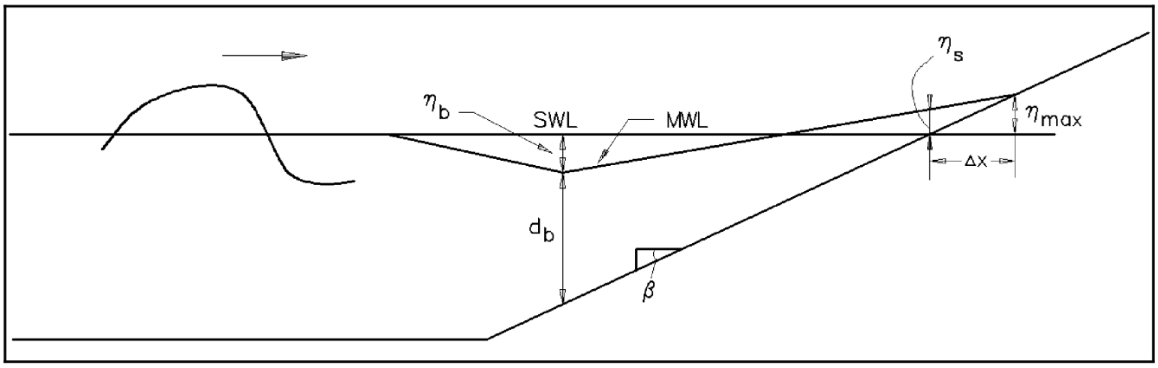

Figure 3-1: Wave set-up method (source: USACE, 2006)

Wave set-up at the still water line (SWL) is calculated based on the set down, breaking wave height and breaker depth. The method by USACE (2006) utilises a single slope (foreshore slope) to calculate wave set-up and set down at the SWL, and maximum wave set-up. According to Equation 3-3 maximum set-up is calculated based on the displacement and set-up gradient between set-up at

SWL and maximum set-up. USACE (2006) calculates Δx (Equation 3-3) on the foreshore slope. However, as the beach slope is steeper shoreward of the SWL we have used the specific beach face slope to calculate Δx in Equation (3-3).

3.2.4.2 Numerical method

The numerical cross-shore sediment transport and profile change model SBEACH (Storm Induced BEAch CHange) (Larson and Kraus, 1989) has been used to predict wave set-up. SBEACH considers the nearshore profile (extending from approx. -10m depth to dune crest) and time series or uniform values of wave height, wave period and water level. An example of SBEACH output is shown in Figure 3-2 including the nearshore profile and total water level (including wave set-up).

3.2.4.3 Calibration of empirical formulation

Input

Representative cross-shore profiles from the dune crest to the -10 m TVD-70 contour were used as input for the SBEACH model for each location (see Figure 2-5) based on available profile information (refer to Section 2.3). Beach profile information was supplemented by LINZ bathymetric charts where surveyed profiles do not extend to the -10m TVD-70 contour. For sites where beach profile information was unavailable, representative profiles were used selected from the available profile dataset. The surfzone and beach face slope used as input for the empirical method have been derived from the representative cross-shore profiles for each site.

Design storms for 1yr, 10yr and 100yr ARI events including corresponding water levels, wave height and period have been used as input into both the numerical and empirical model to predict wave set-up.

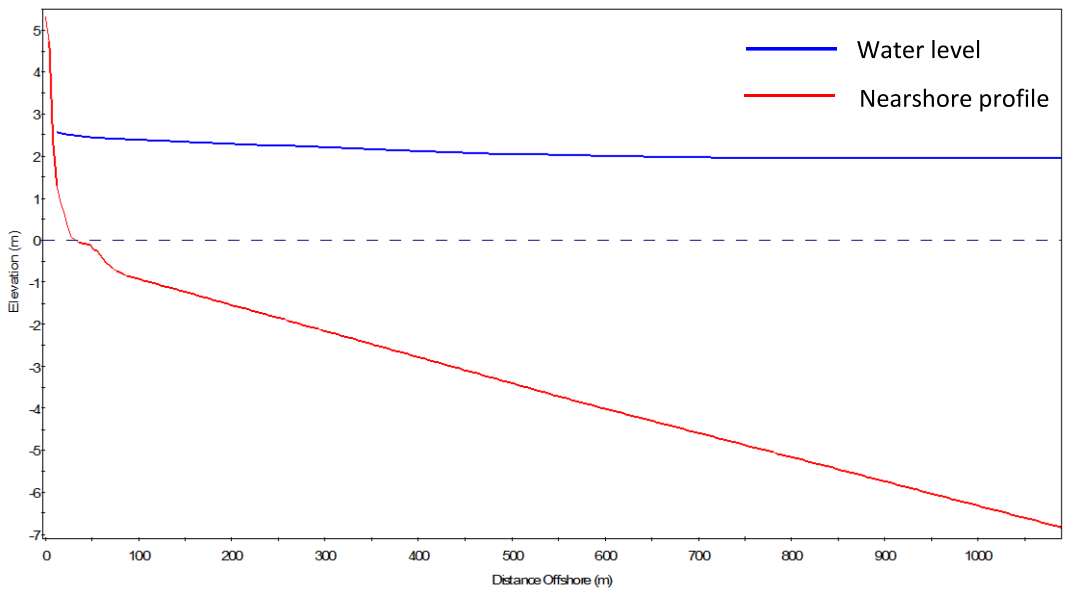

Figure 3-2: Example of SBEACH output including nearshore profile and water level (incl. wave set-up)

Results

Results in Table 3.1 show the average ratio between wave set-up predicted by SBEACH and the empirical CEM method for each site. As an example a ratio of 0.55 means that the wave set-up calculated with the CEM method (set-up is 1.26 m) should be multiplied with 0.55 to match wave set-up predicted by SBEACH (0.69 m). It is evident from Table 3.1 that the empirical CEM method over predicts wave set-up with ratios ranging from 0.52 to 0.77 with an average of 0.59.

Table 3.1: Ratio for wave set-up predicted by numerical (SBEACH) and empirical (CEM) methods for each location

Site	1	2	3	4	5	6	7	8	9	10	11	12
Ratio	0.54	0.52	0.51	0.71	0.69	0.71	0.5	0.77	0.54	0.55	0.53	0.52

3.2.5 Effects of sea level rise

For future planning timeframes (e.g. 50 and 100 years) we have adopted sea level rise values consistent with RCP2.6, RCP6.0 and RCP8.5 as set out in AR5 report on climate change (IPCC, 2014) and described in Section 2.6.2. Extrapolation of existing rates of sea level rise is also considered as a minimum possible rise. These values are added to the derived extreme static water levels for the future planning timeframes.

3.3 Probabilistic approach

Traditional *building block* approaches apply wave set-up resulting from an extreme event onto a corresponding (or lesser) extreme storm tide level. While there appears a partial dependence between wave height and storm surge, there will be less dependence between wave height and storm tide where the independent astronomical tide is a primary contributor. This is particularly true for short duration events (or sheltered coastlines exposed to only a portion of the event) where the storm peak may not coincide with a high tide.

The following approach has therefore been adopted to accurately quantify the combined water level resulting from these components for both the extreme static water level and extreme run-up level:

1. Develop equivalent hourly time series of water level (see Figure 3-3) based on the measured sea level data at Port Taranaki for the period 2002-2016 provided by Metocean Solutions Ltd. The sea level data includes the effect the astronomical tide, storm surge and any medium-term sea level fluctuations
2. Develop hourly time series of nearshore wave height (see Figure 3-3) based the 37-year hind cast time series provided by Metocean Solutions Ltd.
3. Calculate wave set-up for each time step (1hr) using the methods described in Section 3.2.4 (see wave set-up time series in Figure 3-3) and add to water level producing a static water level time series
4. Undertake an extreme value analysis (EVA) to derive the 'structural' or combined extreme values (see Figure 3-4). Analysis was undertaken using a peaks over threshold method and a Weibull distribution which has been found to most accurately represent wave-dominated extremes (Shand et al., 2009).

This approach provides a robust measure of the joint occurrence without requiring bivariate extreme value analysis which can introduce considerable additional uncertainty (Shand, 2011) with the dependence often biased by smaller events.

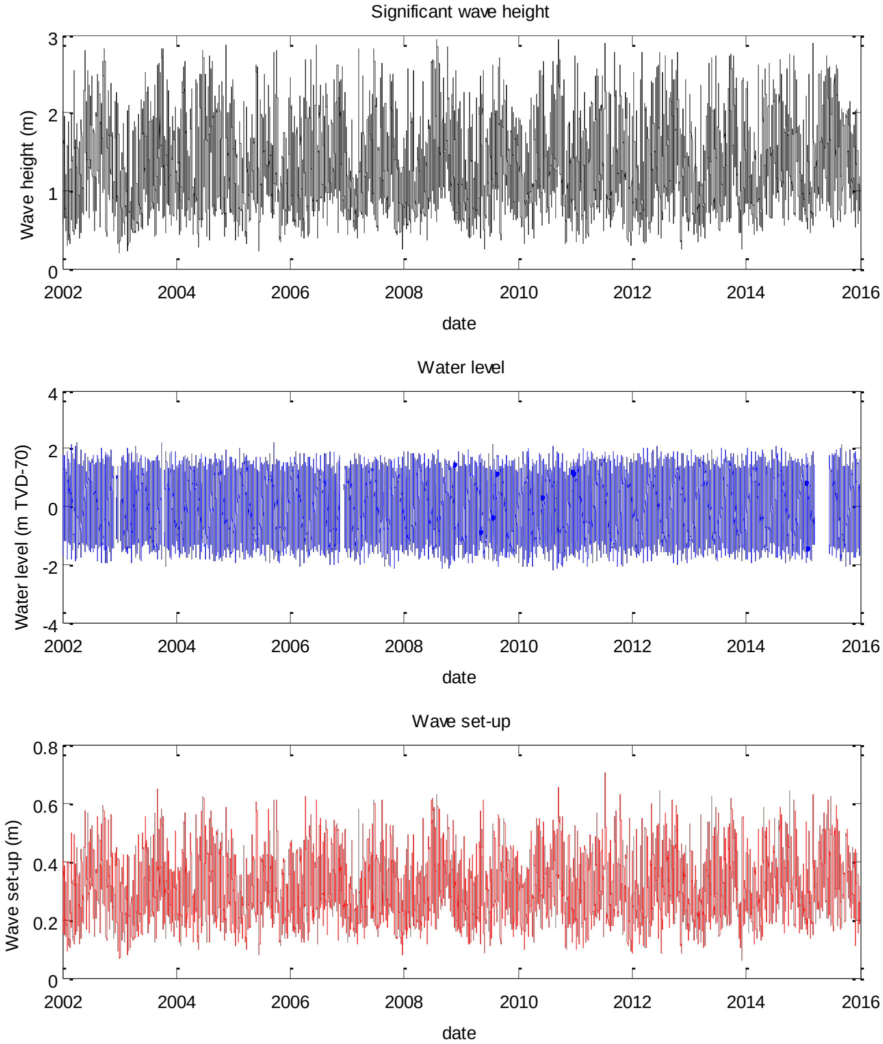

Figure 3-3: Example time series for New Plymouth including significant wave height, water level and wave set-up

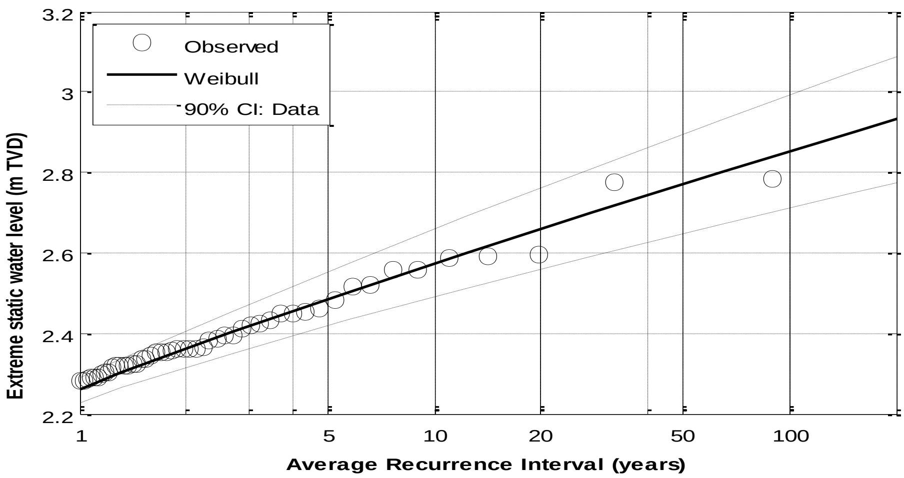

Figure 3-4: Example Extreme Value Analysis (EVA) curve for extreme static water level for New Plymouth

3.4 Extreme water level results

Table 3.2 shows the extreme static inundation levels for each site for the present day, 2065 and 2115 time frames considering various sea level rise scenarios. Results show that present day extreme coastal inundation levels range from 2.25 m TVD-70 for an annual event to 3.2 m TVD-70 for a 100 year ARI event. For the 2116 time frame considering the RCP8.5 SLR scenario extreme coastal inundation levels range from 3.2 m TVD-70 for an annual event to 4.1 m TVD-70 for a 100 year ARI event.

Table 3.2: Extreme static coastal inundation levels (m TVD-70) for current and future scenarios

Site	SLR Scenario		Existing Historic Rates		RCP 2.6 low emission		RCP 6.0 mid emission		RCP 8.5 high emission	
	Year	2015	2065	2115	2065	2115	2065	2115	2065	2115
	SLR relative to 1996-2014 MSL (m)		0.09	0.17	0.25	0.45	0.26	0.61	0.34	0.91
All	*MHWS*	1.78	1.9	1.9	2.0	2.2	2.0	2.4	2.1	2.7
	1yr ST + Setup	2.35	2.4	2.5	2.6	2.8	2.6	3.0	2.7	3.3
	10yr ST + Setup	2.7	2.8	2.9	2.9	3.1	3.0	3.3	3.0	3.6
1	*100yr ST + Setup*	3	3.1	3.2	3.2	3.4	3.3	3.6	3.3	3.9
	1yr ST + Setup	2.25	2.3	2.4	2.5	2.7	2.5	2.9	2.6	3.2
	10yr ST + Setup	2.55	2.6	2.7	2.8	3.0	2.8	3.2	2.9	3.5
2	*100yr ST + Setup*	2.8	2.9	3.0	3.0	3.2	3.1	3.4	3.1	3.7
	1yr ST + Setup	2.25	2.3	2.4	2.5	2.7	2.5	2.9	2.6	3.2
	10yr ST + Setup	2.55	2.6	2.7	2.8	3.0	2.8	3.2	2.9	3.5
3	*100yr ST + Setup*	2.85	2.9	3.0	3.1	3.3	3.1	3.5	3.2	3.8
	1yr ST + Setup	2.25	2.3	2.4	2.5	2.7	2.5	2.9	2.6	3.2
	10yr ST + Setup	2.6	2.7	2.8	2.8	3.0	2.9	3.2	2.9	3.5
4	*100yr ST + Setup*	2.85	2.9	3.0	3.1	3.3	3.1	3.5	3.2	3.8
	1yr ST + Setup	2.35	2.4	2.5	2.6	2.8	2.6	3.0	2.7	3.3
	10yr ST + Setup	2.65	2.7	2.8	2.9	3.1	2.9	3.3	3.0	3.6
5	*100yr ST + Setup*	2.95	3.0	3.1	3.2	3.4	3.2	3.6	3.3	3.9
	1yr ST + Setup	2.3	2.4	2.5	2.5	2.7	2.6	2.9	2.6	3.2
	10yr ST + Setup	2.6	2.7	2.8	2.8	3.0	2.9	3.2	2.9	3.5
6	*100yr ST + Setup*	2.9	3.0	3.1	3.1	3.3	3.2	3.5	3.2	3.8
	1yr ST + Setup	2.25	2.3	2.4	2.5	2.7	2.5	2.9	2.6	3.2
	10yr ST + Setup	2.55	2.6	2.7	2.8	3.0	2.8	3.2	2.9	3.5
7	*100yr ST + Setup*	2.8	2.9	3.0	3.0	3.2	3.1	3.4	3.1	3.7
	1yr ST + Setup	2.5	2.6	2.7	2.7	2.9	2.8	3.1	2.8	3.4
	10yr ST + Setup	2.9	3.0	3.1	3.1	3.3	3.2	3.5	3.2	3.8
8	*100yr ST + Setup*	3.2	3.3	3.4	3.4	3.6	3.5	3.8	3.5	4.1
	1yr ST + Setup	2.35	2.4	2.5	2.6	2.8	2.6	3.0	2.7	3.3
	10yr ST + Setup	2.65	2.7	2.8	2.9	3.1	2.9	3.3	3.0	3.6
9	*100yr ST + Setup*	2.95	3.0	3.1	3.2	3.4	3.2	3.6	3.3	3.9

Site	SLR Scenario		Existing Historic Rates		RCP 2.6 low emission		RCP 6.0 mid emission		RCP 8.5 high emission	
	Year	**2015**	**2065**	**2115**	**2065**	**2115**	**2065**	**2115**	**2065**	**2115**
	SLR relative to 1996-2014 MSL (m)		**0.09**	**0.17**	**0.25**	**0.45**	**0.26**	**0.61**	**0.34**	**0.91**
	1yr ST + Setup	2.35	2.4	2.5	2.6	2.8	2.6	3.0	2.7	3.3
	10yr ST + Setup	2.65	2.7	2.8	2.9	3.1	2.9	3.3	3.0	3.6
10	*100yr ST + Setup*	2.95	3.0	3.1	3.2	3.4	3.2	3.6	3.3	3.9
	1yr ST + Setup	2.25	2.3	2.4	2.5	2.7	2.5	2.9	2.6	3.2
	10yr ST + Setup	2.6	2.7	2.8	2.8	3.0	2.9	3.2	2.9	3.5
11	*100yr ST + Setup*	2.85	2.9	3.0	3.1	3.3	3.1	3.5	3.2	3.8
	1yr ST + Setup	2.3	2.4	2.5	2.5	2.7	2.6	2.9	2.6	3.2
	10yr ST + Setup	2.6	2.7	2.8	2.8	3.0	2.9	3.2	2.9	3.5
12	*100yr ST + Setup*	2.9	3.0	3.1	3.1	3.3	3.2	3.5	3.2	3.8

4 Coastal inundation mapping

4.1 Mapping methods

A digital terrain model (DTM) has been constructed to map extents of inundation for extreme static water levels. The 0.5 m contour data provided by Council (refer to Section 2.1) has been used to construct the DTM. It was not deemed appropriate to construct a DTM for areas covered by only 10 m contour data due to the very coarse nature of the data. Topographic information on stopbanks recently constructed adjacent the Waitara River (refer to Section 2.1.1) has been incorporated (R. Gunn, pers. comm. 05/2016) to the digital terrain model. It is assumed that stopbanks are impermeable to their crest level.

Using this 0.5m DTM, extents of inundation have been mapped for coastal water levels between 0.5 m TVD-70 and 4.5 m TVD-70 at 0.25 m intervals. This interval is limited by the resolution of the contour data and 0.25 m is a realistic interval without unrealistic interpolation. These inundation extents are shown for areas covered by the 0.5 m DTM in Appendix B. Flooding extents for Waitara have been assessed both including and excluding stop banks as the condition of stop banks is not currently known and this allows the benefits of the stop banks to be assessed.

Flooding extents for specific recurrence intervals events and SLR scenarios can be identified for current and future time periods (rounded up to the nearest 0.25m) for the urban areas on the maps included in Appendix B. These maps include tables with the assessed site specific extreme water levels and results are discussed in Section **Error! Reference source not found.**.

4.2 Results

Oakura

The 1yr, 10yr and 100yr ARI coastal static inundation levels for the present day are respectively 2.35 m, 2.7 m and 3 m TVD-70. For the 2065 time frame the coastal levels may range from 3.0 m to 3.3 m TVD-70 and for the 2115 time frame the coastal static inundation levels may range from 3.4 m to 3.9 m TVD-70 with both ranges depending on the sea level rise scenario.

Limited flooding of urban areas is evident for both present day 100yr ARI events (3.0 m TVD-70) and 100yr ARI events in 2115 (up to 3.9 m TVD-70). More extensive flooding occurs adjacent the Oakura Rivermouth at water levels above 3.4 m TVD-70 which may occur beyond 2065.

Moturoa

The 1yr, 10yr and 100yr ARI coastal static inundation levels for the present day are respectively 2.25 m, 2.6 m and 2.85 m TVD-70. For the 2065 time frame the coastal levels may range from 3.1 m to 3.2 m TVD-70 and for the 2115 time frame the coastal static inundation levels may range from 3.3 m TVD-70 to 3.8 m TVD-70 with both ranges depending on the sea level rise scenario.

The present day 100yr ARI coastal inundation level (2.85 m TVD-70) are unlikely to cause flooding of port areas. Flooding begins at 3.5 m TVD-70 and becomes significant above 4 m TVD-70. However, this is only likely to occur for the 2115 timeframe during 100yr ARI events.

New Plymouth

The 1yr, 10yr and 100yr ARI coastal static inundation levels for the present day are respectively 2.35 m, 2.65 m and 2.95 m TVD-70. For the 2065 time frame the coastal levels may range from 3.2 m to 3.3 m TVD-70 and for the 2115 time frame the coastal static inundation levels may range from 3.4 m to 3.9 m TVD-70 with both ranges depending on the sea level rise scenario.

Flooding within the New Plymouth urban area is limited to areas around Puke Ariki Landing and northern Brougham St with flood water flowing back up the Huatoki Stream Outlet and onto adjacent land at coastal levels above 2.5 m TVD-70. This water level is reached during a present day 10yr ARI event (2.6 m TVD-70). Flooding around East End Reserve and Lower Strandon begins above 4 m TVD-70 with water flowing up the Henui Stream outlet. However, this is unlikely to occur to the 2115 time frame considering 100yr ARI events and the RCP8.5 SLR scenario.

Fitzroy

The 1yr, 10yr and 100yr ARI coastal static inundation levels for the present day are respectively 2.3 m, 2.6 m and 2.9 m TVD-70. For the 2065 time frame the coastal levels may range from 3.1 m to 3.2 m TVD-70 and for the 2115 time frame the coastal static inundation levels may range from 3.3 m to 3.8 m TVD-70 with both ranges depending on the sea level rise scenario.

Flooding around Fitzroy is limited to areas behind the foredunes at levels above 4 m TVD-70 which is unlikely this century (2115 100yr ARI level is 3.9 m TVD-70). However, larger areas around the lower Waiwhakaiho River flood at levels above 3 m TVD-70 which is possible for future (2065 and 2115) sea levels.

Bell Block

The 1yr, 10yr and 100yr ARI coastal static inundation levels for the present day are respectively 2.25 m, 2.55 m and 2.8 m TVD-70. For the 2065 time frame the coastal levels may range from 3.0 m to 3.1 m TVD-70 and for the 2115 time frame the coastal static inundation levels may range from 3.2 m to 3.7 m TVD-70 with both ranges depending on the sea level rise scenario.

Bell Block has limited exposure to coastal flooding under these sea level rise scenarios and coastal inundation in unlikely to occur for the assessed water levels (refer to site 7 in Table 3.2).

Waiongana

The 1yr, 10yr and 100yr ARI coastal static inundation levels for the present day are respectively 2.25 m, 2.55 m and 2.8 m TVD-70. For the 2065 time frame the coastal levels may range from 3.0 m to 3.1 m TVD-70 and for the 2115 time frame the coastal static inundation levels may range from 3.2 m to 3.7 m TVD-70 with both ranges depending on the sea level rise scenario.

Land adjacent the lower Waiongana Stream is unlikely to flood during a present day 100yr ARI event (2.8 m TVD-70) and may flood above 3 m TVD-70 which is likely for future sea levels. Flooding of dwellings requires levels above 4 m TVD-70 which is unlikely this century (2115 100yr ARI level is 3.7 m TVD-70).

Waitara

The 1yr, 10yr and 100yr ARI coastal static inundation levels for the present day are respectively 2.5 m, 2.9 m and 3.2 m TVD-70. For the 2065 time frame the coastal levels may range from 3.4 m to 3.5 m TVD-70 and for the 2115 time frame the coastal static inundation levels may range from 3.6 m to 4.1 m TVD-70 with both ranges depending on the sea level rise scenario.

For Waitara inundation both including and excluding stopbanks (refer to Section 2.1.1) have been assessed and mapped. We have assumed that stopbank 3 and 4 (see Figure 2-1) are connected and that water is not able to flow between the two stopbanks. Considering a scenario excluding stopbanks inundation of the urban area is likely along both sides of the Waitara River for present day events and could potentially become significant beyond 2115. However, the recently installed stopbanks may mitigate this with flooding limited to the coastal margin of Waitara for 100yr ARI events for the 2115 time frame. The Marine Reserve may be flooded during 100yr ARI events for both the 2065 and 2115 time frames.

We note that this analysis has not including the effects of coincident river flooding which could elevate water levels further.

Onaero

The 1yr, 10yr and 100yr ARI coastal static inundation levels for the present day are respectively 2.35 m, 2.65 m and 2.95 m TVD-70. For the 2065 time frame the coastal levels may range from 3.2 m to 3.3 m TVD-70 and for the 2115 time frame the coastal static inundation levels may range from 3.4 m to 3.9 m TVD-70 with both ranges depending on the sea level rise scenario. Note that wave runup levels may be significantly higher with waves observed to often overtop the rock revetment at the carpark and to the west but effects are typically limited to the coastal edge with energy rapidly dissipated with distance inland (i.e. does not significantly contribute to static coastal flooding, refer Figure 2-7). However, overtopping flows can be hazardous to pedestrians at the coastal edge.

Onaero Beach has limited exposure to coastal flooding under these sea level rise scenarios and coastal inundation in unlikely to occur for the assessed water levels (refer to site 9 in Table 3.2).

Onaero Motorcamp

The 1yr, 10yr and 100yr ARI coastal static inundation levels for the present day are respectively 2.35 m, 2.65 m and 2.95 m TVD-70. For the 2065 time frame the coastal levels may range from 3.2 m to 3.3 m TVD-70 and for the 2115 time frame the coastal static inundation levels may range from 3.4 m to 3.9 m TVD-70 with both ranges depending on the sea level rise scenario.

Flooding of land adjacent Onaero River is possible at coastal water levels above 3 m TVD-70 which is unlikely for the present day (present day 100yr ARI level is 2.95 m TVD-70), but possible with future sea level rise (2115 100yr ARI level is up to 3.9 m TVD-70). However, increased future flooding with additional sea level rise is limited due to steep topography.

Urenui

The 1yr, 10yr and 100yr ARI coastal static inundation levels for the present day are respectively 2.35 m, 2.65 m and 2.95 m TVD-70. For the 2065 time frame the coastal levels may range from 3.2 m to 3.3 m TVD-70 and for the 2115 time frame the coastal static inundation levels may range from 3.4 m TVD-70 to 3.9 m TVD-70 with both ranges depending on the sea level rise scenario.

Flooding of land adjacent the Urenui River entrance may occur above 3 m TVD-70, although buildings are not affected. This is unlikely to occur for the present day time frame, but could become problematic for the future time frames (2065 and 2115) based on the assessed extreme static water levels shown in Table 3.2. More substantial flooding of the Urenui Beach Motorcamp and Golf Course and land further upstream occurs above 5 m TVD-70 which is unlikely under 100 year SLR predictions.

4.3 Consequences

The risk posed by a natural hazard such as inundation to a community is dependent not only on the likelihood of an event occurring but also to the consequence of such an event. Flooding may cause hazard to pedestrians and people in vehicles once flows exceed combinations of depth and velocity (ARR guidelines 2010) and damage to structures once flows exceed certain depths.

Financial consequence of flooding is typically determined using fragility function to calculate potential damage costs to a given structure and its contents for a different inundation depths. Examples of synthetic fragility functions for residential areas (FEMA HAZUS-MH model, 2015), industrial areas (RiskScape model, GNS-NIWA, 2015) and commercial areas (Mason and Phillips, 2011) are shown in Figure 4-2 and can be used to calculate damage percentage for flooding depth.

An example of inundation depth for a coastal water level of 4.0 m TVD-70 (approximately most extreme water level for a 100 yr ARI event at 2115 with a high emission SLR scenario) have been mapped to enable further assessment of flooding consequences and risk (see maps in Appendix B). These maps show generally little significant flooding (<0.5m depth) of urban areas except for Waitara for the scenario excluding the stopbanks. Damage percentages could be calculated and could be transformed into economic values using council's assets values.

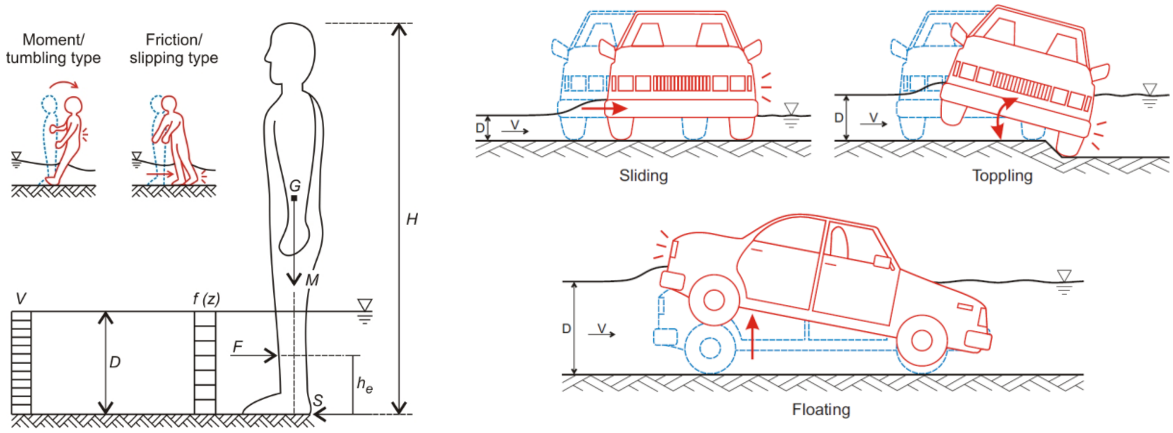

Figure 4-1: Typical modes of human and vehicle instability (Shand et al., 2010)

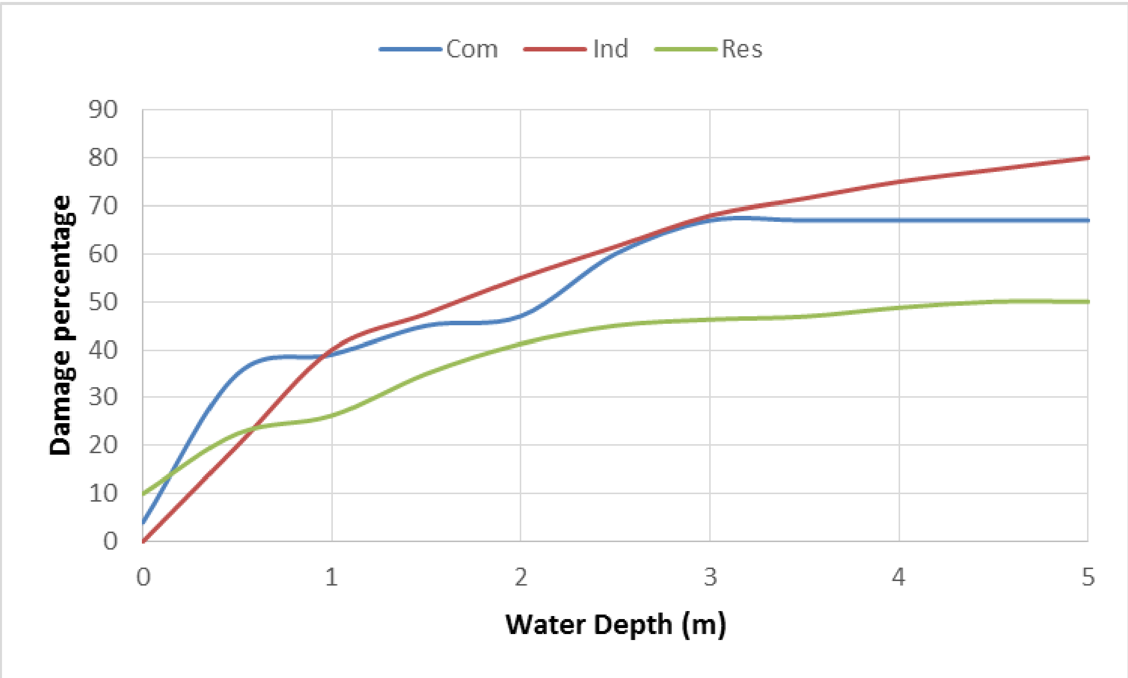

Figure 4-2: Synthetic fragility functions for commercial (Com), industrial (Ind) and residential (Res) damages

4.4 Unmapped areas and future topographic updates

Areas not covered by available topographic data should use the closest extreme static water level (see Table 3.2) together with local survey information to determine inundation levels and extents for individual sites.

Likewise, after future updates of topographic information are collected (i.e. using LiDAR), the existing extreme static water levels can be retained with only the mapped inundation extents updated.

5 Planning considerations

The need to review and update Council's technical information for coastal management will eventually translate into new coastal hazard provisions as part of the rolling review of the Operative New Plymouth District Plan (District Plan), due for notification in late 2017. From a planning perspective, this process will enable an alignment of coastal hazard provisions with the relevant direction provided in the Resource Management Act 1991 (RMA)[2], New Zealand Coastal Policy Statement 2010 (NZCPS)[3], the Regional Policy Statement 2010 (RPS)[4] and the provisions of international and national level guidance on the management of climate change and coastal hazards.

At a national level, the Resource Legislation Amendment Bill 2015 was introduced to Parliament towards the end of 2015 and is currently before a Select Committee. If enacted in its current form it will introduce the management of significant risks from natural hazards as a Section 6 matter of national importance. The Ministry for the Environment has also indicated that preparing a national guidance document on managing risks from natural hazard is a Government priority. However the indicative date for completion of this guidance is 2018. It is therefore timely for NPDC to evaluate its approach to planning provisions for coastal hazards.

5.1.1 Existing planning framework

The District Plan's existing objective and policy framework is focussed on coastal erosion as the most significant natural hazard risk, alongside (catchment) flooding and river erosion. Natural Hazards are currently addressed by the Natural Hazards Chapter by Issues 12 and 13. In summary, the objectives seek to:

- Avoid or mitigate any actual or potential effects of natural hazards on people, property and the environment via identifying hazards on planning maps, rules to control development, conditions on resource consents and monitoring and information gathering; and
- Ensuring that land use activities do not increase the likelihood or magnitude of natural hazard events (using similar methods described above).

Coastal hazards are also mapped by the Coastal Hazard Area overlay which is;

> *"the area of land adjacent to the coast which it is estimated, or may be subject to coastal erosion, inundation or sea level rise within the next 100 years."*

The District Plan also defines coastal hazard areas as:

> "*that area of land within the coastal environment, excluding the COASTAL MARINE AREA, where the COUNCIL considers it is appropriate to control activities to avoid the adverse effects of erosion, sea level rise and other coastal hazards on development within the next 100 years. COASTAL HAZARD AREAS are identified on the planning maps as HAZARDS Coastal(H1)."*

The subsequent rules which relate to this overlay relate to the erection of buildings and structures (Rules OL-10/11), excavation and filling and the clearance of vegetation (Rule OL-11), the establishment of a hazardous facility (Rule OL-12) and subdivision of land (Rule OL-13/14). Where rules cannot meet the permitted activity provisions, consent is required as a discretionary activity.

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[2] Including (but not limited to) those matters relating to natural hazards set out in The purpose of the RMA, Matters of National Importance, and Functions and Duties of territorial authorities.

[3] Specifically Policies 25, 26 and 27. We also note that the 2010 NZCPS promotes a precautionary approach to planning new development, infrastructure and services to avoid coastal hazard risks over the intended lifetime of the development. A precautionary approach to decision-making means you take into account the level of risk, use existing knowledge and account for uncertainties.

[4] Particularly Hazard Methods 15, 16 and 17 of the RPS.

NPDC has also approved its non-statutory document, the Coastal Strategy (2006), which sets a guiding image of what the coastal environment should look like in 20 years' time. One of the key strategic directions for the coastal environment identified in the strategy is to:

> *"avoid hazard areas, protect natural buffers and take a sustainable approach to hazards and risk to create more informed resilient and secure coastal communities"*

5.1.2 Proposed planning framework

In progressing planning provisions in a new District Plan for coastal hazards, international and national level guidance identifies that a risk-based approach to coastal hazard management in a planning framework is critical. The management of natural hazards is complex and such an approach provides the ability to address variability and uncertainty through:

- Focusing on the consequences of hazards. The potential consequences of allowing activities within areas affected by coastal hazard events vary according to the nature and scale of the proposed activity;
- Using appropriate resources, information and science that is fit for purpose;
- Clear communication of science and assumptions to key stakeholders and the community; and
- Appropriate application of timescales that are dependent on the type of risk being managed.

The development of objectives and policies should be focussed on reducing the risks to the community from coastal hazards, and recognising that different tools and approaches are required and appropriate in different situations (for example, for greenfield sites versus developed sites, and the timescales of that risk). A Policy framework such as this recognises that avoiding risk everywhere is impractical and seeks instead to ensure that development is appropriate with respect to the level of risk faced and the relative vulnerability of different activities.

It is important to first establish the overall framework of the new District Plan to understand how coastal hazard provisions would be nested within it. However, we have undertaken a high level review of objectives relating to coastal hazard management and provide the following examples for your consideration in the plan development process as a starting point for discussion:

- *Subdivision, use and development in coastal hazard zones is appropriate to the level of risk and the relative vulnerability of different activities;*
- *Natural defences against coastal hazards are protected and restored where appropriate;*
- *New regionally significant infrastructure and critical infrastructure is provided for in coastal hazard zones where there is a need to locate within the zone and where risks to people, property and the environment are mitigated as far as practicable.*

5.1.3 Other matters

NPDC may wish to consider the following process moving forward:

- Developing a clear understanding of NPDC's objective and policy approach to the new district plan. This would include reviewing the wider context of coastal hazard awareness and issues in New Plymouth District that should inform the district plan review;
- Review the existing NPDC District Plan provisions on coastal hazards to develop an understanding of the current provisions and in particular the basis on which they were established and their effectiveness and limitations (We would expect this would inform part of Council's section 32 analysis);
- Review the approach to coastal hazards using nationwide good practise examples. This is to gain an understanding of the approaches adopted by others, and how the proposed approach

by NPDC sits within the spectrum of good practise applied across the country. It would be useful to focus on districts where there may be some commonalities with the coastal hazard issues faced by the New Plymouth District. We expect that this will also be particularly useful for guiding discussions with the community;

- Undertake an informed consultation process with the community to assist in selecting appropriate event likelihood and future sea level rise scenarios for defining where and how development controls are applied within the district plan update; and
- Develop planning provisions that respond to community expectations and Council's strategic approach to coastal hazards.

6 Summary and recommendations

The New Plymouth coast is susceptible to storm driven coastal inundation hazard resulting from a combination of high tide, storm surge, variation of sea level and wave set-up. This hazard is predicted to increase in the future due to projected increase in sea level rise associated with global climate change.

Previous assessment by Tate (2013) provided useful information on potentially vulnerable areas. However, the approach of summing individual components (known as a 'building block approach') is conservative, particularly when low probability components are combined. Further, some very high sea level rise scenarios (up to 2m) were adopted. The derived levels are therefore likely to over-predict potential coastal static inundation levels when considering timeframes over the next 100 years and we do not recommend adopting for planning purposes. However, the information presented in Tate (2013) on the effects of such flooding (land area, number and value of houses and people affected at different levels) could still be used together with updated extreme sea level information and additional information on social and environmental effects to assess resultant risk.

By considering key drivers of elevated coastal water levels along the New Plymouth coastline using a less conservative probabilistic framework, extreme static water levels have been defined for 1yr, 10yr and 100yr annual recurrent interval (ARI) events. The levels have been defined for both present day sea levels and for future sea levels at 2065 (50 years) and 2115 (100 years) timeframes based on a range of future sea level rise scenarios ranging from extrapolation of past rates to various IPCC future emission scenarios.

The extents of inundation have been mapped for areas with available topographic data (Oakura to Waitara, and Onaero and Urenui) for a range of elevated coastal water levels using a connected bathtub tool. Using this approach areas are flooded only where they connect to the coastal water body. This provides more realistic flooding extents by accounting for natural and human influenced (e.g. stopbanks) topography. The extents of inundation at Waitara have been assessed both including and excluding the recently constructed flood protection stopbanks. Due to the resolution of available topography (0.5m contours), inundation extents have been mapped at 0.25 m intervals and extreme values have been rounded up to the nearest 0.25m to determine the corresponding extent. Areas not covered by available topographic data should use the closest extreme static water level (see Table 3.2) together with local survey information to determine inundation levels and extents for individual sites. Likewise, future updates of topographic information (i.e. using LiDAR), may require the mapped inundation extents to be updated.

Based on the assessed extreme static water levels and maps showing potential inundation extents (Appendix B), the majority of the urban areas along the New Plymouth District coast are unlikely to be inundated during the present day. Two exceptions to this are around Puke Ariki Landing and northern Brougham St in New Plymouth, where flood water would flow back up the Huatoki Stream Outlet and onto adjacent land in a 10yr ARI, or greater, event. Parts of Waitara would likewise flood at events greater than 10yr ARI without the protection of stopbanks. These banks prevent sea inundation of adjacent inland urban areas.

For the future time frames (2065 and 2115) widespread inundation of urban areas remains unlikely except for around the Puki Ariki Landing and northern Brougham St, parts of Motorua industrial area and large areas along the Waitara River banks if stopbanks do not remain effective. Furthermore, it is likely that some areas adjacent to streams (lower Waiwhakaiho River, lower Waiongana Stream, Huatoki Stream, Onaero River and Urenui River) and behind foredunes (Fitzroy, Waiongana and Marine Reserve at Waitara) may be inundated. Bell Block and Onaero both have limited exposure to coastal flooding under the adopted sea level rise scenarios and coastal inundation is unlikely to occur for the assessed water levels.

Before use of these results within the District Plan review process (described in Section 5), we recommend the following steps:

- Confirming Waitara River stopbanks extents

  Based on the BTW Company Ltd survey information the stopbanks along Queen Street and Waitara River do not appear to be connected. We have assumed these stopbanks to be connected for this assessment. However, if these stopbanks are not connected the extent of inundation would be similar to a scenario excluding stopbanks for the urban area along the true left side of Waitara River. It is therefore recommended to undertake a site inspection to confirm that these stopbanks are connected and to assess the general condition of all stopbanks.
- Risk assessment taking into account event consequence

  The risk posed by a natural hazard such as inundation to a community is dependent not only on the likelihood of an event occurring but also to the consequence of such an event. Flooding may cause hazard to pedestrians and people in vehicles once flows exceed combinations of depth and velocity and damage to structures once flows exceed certain depths. To assess the risk posed by the coastal inundation hazard (as required under the NZCPS (2010) Policy 25 and 27), we recommend that the consequence should be assessed for extreme sea levels for different return periods and SLR scenarios to provide a quantitative measure of the hazard risk. This could range from a simple evaluation of land area affected under each scenario or incorporate asset value (i.e. as assessed by Tate, 2013) or fragility functions to determine damage.
- Engagement with stakeholders

  This assessment has presented a range of inundation scenarios corresponding to storm events of various likelihood and a range of future sea level rise scenarios. These results, and the result of any subsequent risk assessment, should be presented and discussed with council and key stakeholders to assist in selecting appropriate event likelihood and future sea level rise scenarios for defining where and how development controls are applied within the district plan update. Maps corresponding to these specific scenarios can then be produced for use in the updated District Plan.

Following this current review process, additional assessments could be considered to improve confidence in the identified coastal inundation hazard areas.

- Improved topographic information

  The most detailed topographic information available for New Plymouth district are 0.5m contours with some areas having only 10m contour data available. This may result in conservative assessment as assessed extreme values are rounded up to the nearest 0.25m to define inundation extents. Mapping of extents of inundation could be substantially improved by obtaining LiDAR information for all coastal areas.
- Joint probability of coastal and terrestrial flooding for Waitara

  Coastal inundation levels within the Waitara River have been assumed similar to inundation levels on the Waitara open coast. This is potentially a conservative assumption with wave set-up unlikely to fully develop within the river mouth (Hanslow et al., 1997). However, terrestrial flooding has been excluded for this assessment and could potentially enhance coastal flooding. It is recommended to assess the joint probability of coastal and terrestrial flooding for Waitara to more accurately define maximum inundation levels.

7 Applicability

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

Tonkin & Taylor Ltd

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8 References

Berryman, K.R., Hull, A. (2003). Tectonic controls on Late Quaternary shorelines: a review and prospects for future research. In: Goff J.R., Nichol S.L., Rouse H.L. eds. The New Zealand coast. Palmerston North, Dunmore Press. Pp. 25-58.

Hannah, J. (2001). An assessment of New Zealand's height systems and options for future height datum. Report prepared for Land Information New Zealand.

Hannah, J. and Bell, R.G. (2012). Regional sea level trends in New Zealand. Journal of Geophysical Research 117: C01004.

Hanslow, D.J., Nielsen, P. and Hibbert, K. (1997). Wave setup at river entrances. Coastal Engineering 1996: pp. 2244-2257n

IPCC (2014). ''Climate Change 2014: Synthesis Report''. Report by Intergovernmental Panel on Climate Change.

Larson, M and Kraus, N C (1989), "SBEACH: Numerical Model for Simulating Storm-Induced Beach Change, Report 1: Theory and Model Foundation". *Technical Report CERC-89-9*, US Army Engineer Waterways Experiment Station, Coastal Engineering Research Center, Vicksburg USA.

LINZ (2015). Tidal Level Information for Surveyors. http://www.linz.govt.nz/geodetic/datums-projections-heights/vertical-datums/tidal-level-information-for-surveyors

Mason, M., Phillips, E., Okada, T. and O'Brien, J. (2011). Analysis of damage to buildings following the 2010-2011 Eastern Australia floods.

MetOcean Solutions Ltd (2016). North Taranaki extremes. Nearshore wave extremes and sea level extremes at Port Taranaki. Prepared for Tonkin + Taylor

Ministry for the Environment (2008). Coastal Hazards and Climate Change. A Guidance Manual for Local Government in New Zealand. 2nd edition. Revised by Ramsay, D, and Bell, R. (NIWA). Prepared for Ministry for the Environment. Viii+127 p.

Shand, T.D., Cox, R.J. and Blacka, M. (2010) Australian rainfall and runoff revision project 10: Appropriate safety criteria for people.

Shand, R., Shand, T.D, McComb, P. and Johnson, D. (2011). Evaluation of empirical predictors of extreme run-up using field data. 20th Australasian Coasts and Ports Conference Sept 2011.

Tate, W.G. (2013) The effect of a rise in mean sea level on the New Plymouth Coastline: A GIS investigation. Thesis for Masters in Philosophy, Massey University.

USACE (2006). Coastal Engineering Manual. Engineer Manual 1110-2-1100, U.S. Army Corps of Engineers, Washington, D.C.

Appendix A: Metocean assessment

- **Metocean summary report**
- **Metocean summary maps:**
    - **P50% significant wave height**
    - **P90% significant wave height**
    - **P99% significant wave height**
    - **Maximum significant wave height**

NORTH TARANAKI EXTREMES

Nearshore wave extremes and sea level extremes at Port Taranaki

Prepared for Tonkin & Taylor

MetOcean Solutions Ltd: Report P0285-01

April 2016

Report status

Version	Date	Status	Approved by
RevA	29/04/2016	Draft for internal review	Thiebaut
RevB	29/04/2016	Draft for client review	Beamsley

It is the responsibility of the reader to verify the currency of the version number of this report.

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1. INTRODUCTION

Tonkin & Taylor has commissioned a desktop study of the wave and sea level conditions in the northern coastal Taranaki region, New Zealand. The aim of the study is to characterise the expected ambient and extreme wave conditions within the coastal area and extreme water levels at Port Taranaki. The specific scope of work is detailed below:

- Description of the model and methods used.
- Delivery of extreme (up to 100-year Averaged Recurrence Intervals, ARI) and ambient wave height statistics for the northern coastal Taranaki region along the 10 m water depth contour at 5-10 km intervals for 12 sites (Figure 1.1, Table 1.1).
- Extreme water level analysis for the Port of Taranaki.
- Regional maps of median, P95, P99 and maximum significant wave height statistics of the study area.
- Full 37-year time series of wave parameters (i.e. significant wave height, peak wave period and mean wave direction at peak energy) at Site 6 in the centre of the study area.
- Time series of measured sea level at Port Taranaki.

This report is structured as follows. The data sources and an outline of the analysis methodology are provided in Section 2 and 3. The deliverables are detailed in Section 3. References cited in this report are listed in the final Section 4.

Table 1.1 Coordinates (WGS84) of the metocean data reporting sites along the northern Taranaki coastline.

Site	Longitude (deg E)	Latitude (deg N)
1	173.8839	-39.1257
2	173.9526	-39.1032
3	174.0098	-39.0671
4	174.0523	-39.0501
5	174.0880	-39.0361
6	174.1168	-39.0199
7	174.1577	-38.9974
8	174.2312	-38.9737
9	174.3385	-38.9749
10	174.4730	-38.8918
11	174.5668	-38.8081
12	174.5915	-38.7230

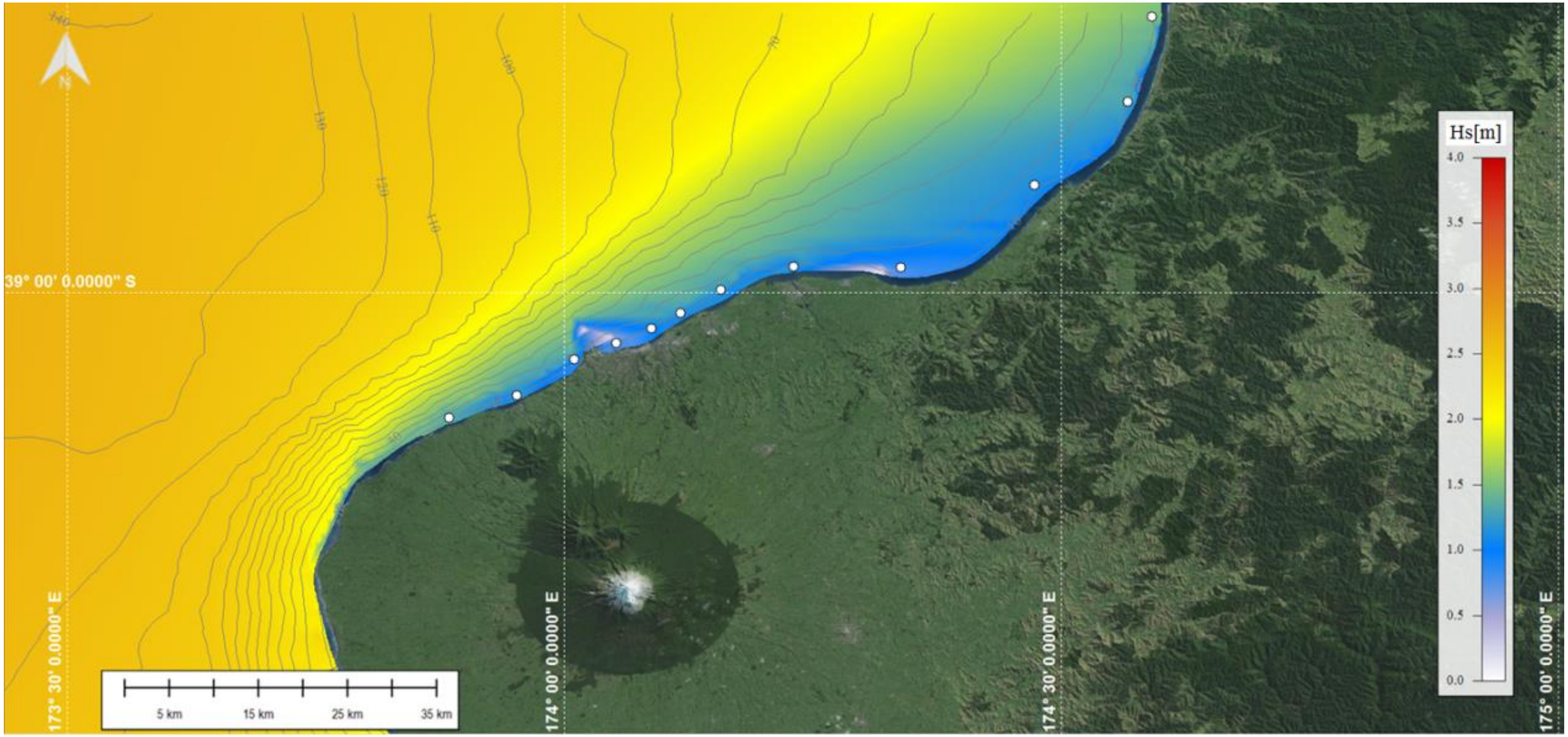


Figure 1.1 Median significant wave height (based on 37 years of hindcast wave data) of the study area including the 12 representative reporting sites (white dots), Site 1 is the southernmost site, while site 12 is the northermost. Coordinates of each site are given in Table 1.1.

2. WAVE DATA SOURCES AND METHODS

2.1. Model description

A high resolution (0.007˚ by 0.007˚ in longitude and latitude) SWAN (Simulating WAves Nearshore) model was used for the hindcast wave modelling. The hindcast extended over a 37-year period between 1979 and 2015 and provided 3-hourly frequency-direction wave spectra.

The high resolution Taranaki SWAN domain was nested to a regional SWAN domain of the entire New Zealand waters (at 0.05˚ by 0.05˚ resolution). The full spectral boundaries for the regional New Zealand SWAN domain were prescribed from MetOcean Solutions implementation of the global wave model WW3 (Tolman, 1991).

SWAN is a third generation ocean wave propagation model, which solves the spectral action density balance equation for wavenumber-direction spectra. This means that the growth, refraction, and decay of each component of the complete sea state, each with a specific frequency and direction, is solved, giving a complete and realistic description of the wave field as it changes in time and space. A detailed description of the model equations, parameterizations and numerical schemes can be found in Holthuijsen et al. (2007) or the SWAN documentation[1].

Physical processes that are simulated include the generation of waves by surface wind, dissipation by white-capping, resonant nonlinear interaction between the wave components, bottom friction and depth limited breaking. All 3rd generation physics are included. The Collins (1972) friction scheme is used for wave dissipation by bottom friction.

The solution of the wave field is found for the non-stationary (time-stepping) mode. Boundary conditions, wind forcing and resulting solutions are all time dependent, allowing the model to capture the growth, development and decay of the wave field.

The forcing near surface wind field was prescribed by a 37-year (1979-2015) regional atmospheric hindcast carried out by MSL. The WRF (Weather Research and Forecasting) model was established over all New Zealand at hourly intervals and approximately 12 km resolution, with a nested 4 km resolution domain over the central area of the North Island including the Taranaki region. The hindcast was specifically tuned to provide highly accurate marine wind fields for metocean studies around New Zealand. The WRF model boundaries were sourced from the CFSR (Climate Forecast System Reanalysis) dataset distributed by NOAA (Saha et al., 2010), which was available at hourly intervals and 0.31° spatial resolution. Validation of the WRF reanalysis has been undertaken at various locations around New Zealand.

[1] http://swanmodel.sourceforge.net/online_doc/online_doc.htm

2.2. Spectral parameters

The spectra were post-processed to calculate wave statistics for the total wave field. One-dimensional frequency spectra were defined by integrating over all directions:

$$S_n(f) = \int_{-\pi}^{\pi} E_n(f,\theta)d\theta \tag{2.1}$$

Spectral moments were calculated as:

$$m_x = \iint f^x E(f,\theta)df\, d\theta, \tag{2.2}$$

The significant wave height, H_s, mean direction at peak energy, θ_p, and peak wave period, $T_{p\,,}$ are defined as:

$$H_s = 4\sqrt{\int_0^{\infty} S_n(f)df}$$
$$\theta_p = \arctan \frac{\int_{-\pi}^{\pi} E_n(f_p,\theta)\sin(\theta)d\theta}{\int_{-\pi}^{\pi} E_n(f_p,\theta)\cos(\theta)d\theta} \tag{2.3 a,b,c}$$
$$T_p = 1/f_p$$

where f_p is the peak wave frequency of the one-dimensional spectra and $E_n(f_p,\theta)$ is the energy contained in the peak wave frequency band.

2.3. Wave extreme value analysis (EVA)

Omni-directional return period values at ARIs of 1, 5, 10, 25, 50, and 100 years have been calculated from the hindcast time series of significant wave height.

A *Peaks over Threshold* (POT) sampling method is used for event selection, applying the 98th percentile exceedence level as the threshold with a 24 hour window. For wave height EVA, the selected events were fitted to a Generalized Pareto distribution (GPD), with the location parameter fixed by the threshold and the Maximum Likelihood Method (MLM) used to obtain the scale and shape parameters. Note an arbitrary minimum number of 10 peaks was chosen for fitting reliable distributions.

Bivariate return period values were calculated for significant wave height and peak period. The method of (Repko et al., 2005) was employed, which considers the distribution of H_s and wave steepness (s). A joint probability distribution function (PDF) is calculated by multiplying marginal distributions of H_s and s (thus assuming they are independent), after which the PDF is transformed back into H_s / T_p space. In addition, a minimum wave steepness threshold of 0.005 is applied to exclude events with very long wave periods, which are not believed to be representative of extreme conditions. The marginal distributions for H_s and s are estimated by fitting the POT values to a Weibull distribution using the maximum likelihood method (as implemented in the WAFO toolbox[2]). Contours of the return period values were constructed from the joint PDF using the Inverse FORM method (Winterstein et al., 1993) at the 1, 5, 10, 25, 50, and 100 year levels.

[2]Available with supporting documentation at: http://www.maths.lth.se/matstat/wafo.

3. SEA LEVEL DATA SOURCES AND METHODS

3.1. Data description

Measured sea level data at Port Taranaki were provided by Port Taranaki Limited at 20-min interval for the period 2002-2016. The data was carefully despiked and detided using the T_TIDE Matlab software package (Pawlowicz et al., 2002). The residual sea level data were used to estimate extreme surge levels, while the combination of both tidal and residual data were used to calculate the extreme total still water level elevation at several ARIs (1, 5, 10, 23, 50, and 100 years). The details of the sea level extreme techniques are indicated in the following section 3.2.

3.2. Sea level extreme value analysis (EVA)

Residual water levels have been used to define the storm surge return period values. A POT sampling method has been used for event selection, applying the 98th percentile exceedence level as the threshold with a 24 hour window. For extreme value analysis, the 3-parameter Weibull distribution (shape parameters of $0.5 < k < 3.0$) were applied, with MLM used to find the best-fit of the sampled events to the model distribution

The total still water level return period values have been estimated by fitting a Weibul distribution to the empirical distribution obtained by combining the frequency distribution of tidal and surge elevations, as recommended by ISO (2005).

4. DELIVERABLES

The zipped file called “data_stats” contains wave and sea level information of the study area, as described in Table 4.1:

Table 4.1. Data and statistics delivered to Tonkin & Taylor. The symbol “*” indicates the site number, ranging from 1 to 12.

Files	Contents
folder: wave	
site_6_174.11684E_39.0199S.txt	37-year hindcast wave parameters at site 6.
wave_site_coordinates.xlsx	Coordinates of the 12 representative sites
ambient\wave_*_stat.xslx	Monthly and annual Hs statistics (in m) at site *. Note: e.g. P90 refers to 90th percentile Hs level.
ambient\rose_wave_*_annual.xlsx	Annual directional wave rose at site *. Directions are in the “coming from” convention.
extreme\wave_1_98prc_RPVs.xlsx	Extreme omni-directional annual Hs (m) and associated Tp (s) RPVs at site *.
extreme\wave_*_98prc_hs_fitting_omni.png	Comparison between empirical and fitted generalized Pareto cumulative distribution functions for Hs at Site *.
extreme\wave_*_98prc_RPV_FORM_omni.png	Contour plot of omni-directional bi-variate (Hs-Tp) return period values for ARI1, 5,10, 25,50 and 100-year for site *. The dark crosses indicate the deterministic Hs-Tp RPVs.
maps\hs_P50.png	Regional map of the median Hs for the 37-year hindcast period.
maps\hs_P90.png	Regional map of the 90th percentile Hs level for the 37-year hindcast period.
maps\hs_P99.png	Regional map of the 99th percentile Hs level for the 37-year hindcast period.
maps\hs_max.png	Regional map of the maximum Hs for the 37-year hindcast period.
folder: sea_level	
port_taranaki_sea_level.txt	E_total: Measured sea level data at Port Taranaki, relative to mean sea level. E_tide: tidal sea level data extracted from the measured sea level data. E_res: residual (non-tidal) sea level data extracted from the measured sea level data.
surge_RPVs.xlsx	Extreme positive and negative surge elevations at Port Taranaki.
total_sea_level_RPVs.xlsx	Extreme positive and negative total still water elevations (tide + surge) at Port Taranaki.
positive_surge_fitting.png	Comparison between empirical and fitted generalized Weibul cumulative distribution functions for maximum surge at Port Taranaki.
negative_surge_fitting.png	Comparison between empirical and fitted generalized Weibul cumulative distribution functions for minimum surge at Port Taranaki.
total_positive_el_fitting.png	Comparison between empirical and fitted generalized Weibul cumulative distribution functions for maximum total still water level at Port Taranaki.
total_negative_el_fitting.png	Comparison between empirical and fitted generalized Weibul cumulative distribution functions for minimum total still water level at Port Taranaki.

5. REFERENCES

Collins, J., 1972. Prediction of Shallow Water Spectra. J. Geophys. Res. 77, 2693–2707.

Holthuijsen, L.H., Booij, N., Ris, R.C., Haagsma, I.J., Kieftenburg, A.T.M.M., Kriezi, E.E., Zijlema, M., van der Westhuysen, A.J., 2007. SWAN cycle III version 40.51, Technical Documentation. Delft, 2600 GA Delft The Netherlands.

ISO, 2005. 19901-1: 2005, Petroleum and natural gas industries - Specific requirements for offshore structures - Part 1: Metocean design and operating conditions. Br. Stand. Inst.

Pawlowicz, R., Beardsley, B., Lentz, S., 2002. Classical tidal harmonic analysis including error estimates in MATLAB using T_TIDE* 1. Comput. Geosci. 28, 929–937.

Repko, A., Van Gelder, P., Voortman, H.G., Vrijling, J.K., 2005. Bivariate description of offshore wave conditions with physics-based extreme value statistics. Appl. Ocean Res. 26, 162–170.

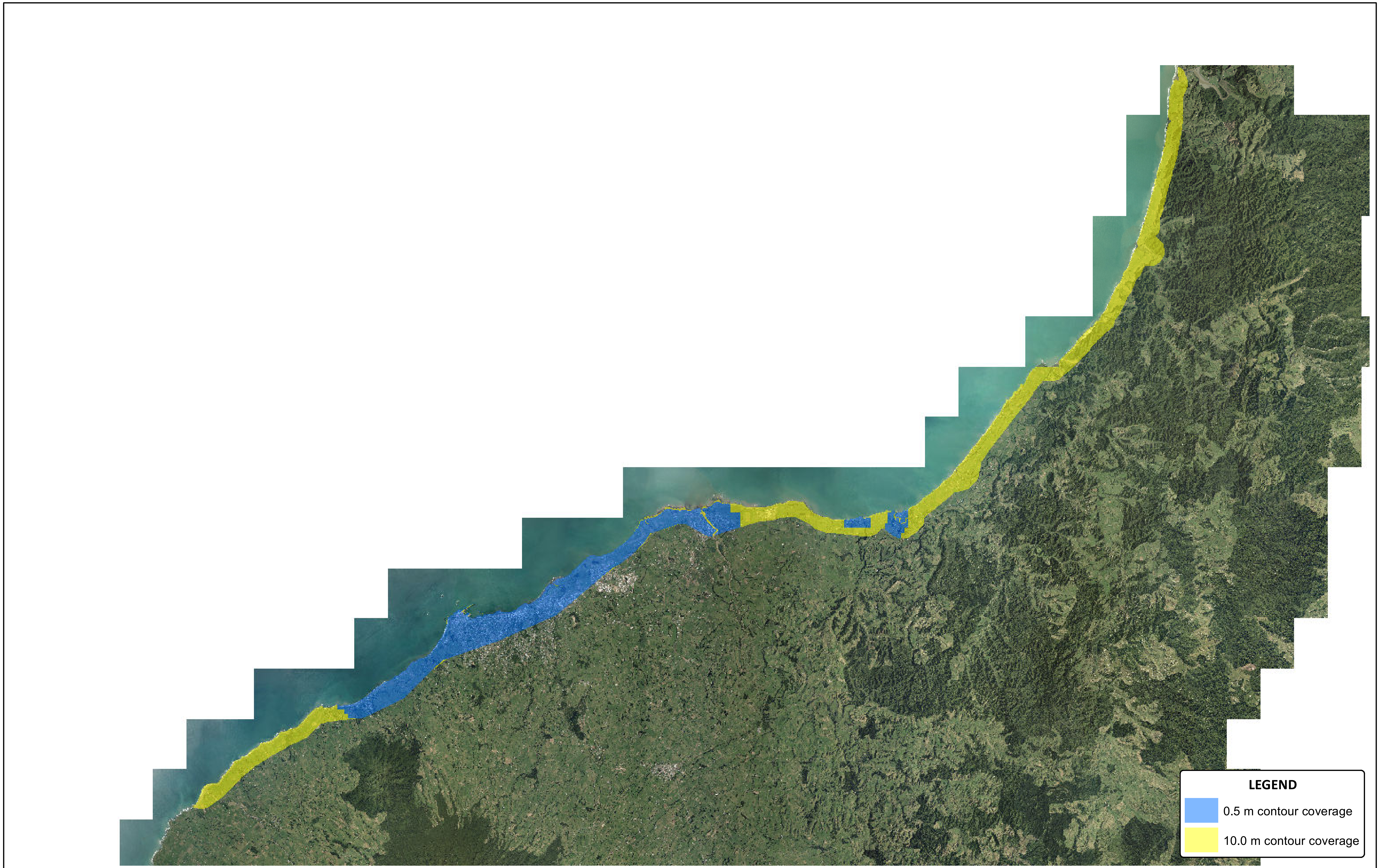
Saha, S., Moorthi, S., Pan, H.-L., Wu, X., Wang, J., Nadiga, S., Tripp, P., Kistler, R., Woollen, J., Behringer, D., Liu, H., Stokes, D., Grumbine, R., Gayno, G., Wang, J., Hou, Y.-T., Chuang, H.-Y., Juang, H.-M.H., Sela, J., Iredell, M., Treadon, R., Kleist, D., Van Delst, P., Keyser, D., Derber, J., Ek, M., Meng, J., Wei, H., Yang, R., Lord, S., Van Den Dool, H., Kumar, A., Wang, W., Long, C., Chelliah, M., Xue, Y., Huang, B., Schemm, J.-K., Ebisuzaki, W., Lin, R., Xie, P., Chen, M., Zhou, S., Higgins, W., Zou, C.-Z., Liu, Q., Chen, Y., Han, Y., Cucurull, L., Reynolds, R.W., Rutledge, G., Goldberg, M., 2010. The NCEP Climate Forecast System Reanalysis. Bull. Am. Meteorol. Soc. 91, 1015–1057. doi:10.1175/2010BAMS3001.1

Tolman, H.L., 1991. A Third-Generation Model for Wind Waves on Slowly Varying, Unsteady, and Inhomogeneous Depths and Currents. J. Phys. Oceanogr. 21, 782–797. doi:10.1175/1520-0485(1991)021<0782:ATGMFW>2.0.CO;2

Winterstein, S.R., Ude, T.C., Cornell, C.A., Bjerager, P., Haver, S., 1993. Environmental parameters for extreme response: Inverse FORM with omission factors, in: Proc., ICOSSAR-93, Innsbruck.

Appendix B: Coastal inundation maps

- **Extents of contour information**
- **Map locations**
- **Extent of Inundation for extreme coastal water levels**
- **Flood depths for coastal water level of RL4.0 m**



Notes: Aerial photograph sourced from LINZ and licensed under CC BY 3.0 NZ. Territorial Authorities sourced from Statistics New Zealand and licensed under CC BY 4.0

A3 SCALE 1:250,000

0 2.5 5 7.5 10 12.5 (km)

N

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DRAWN	KKSN	Jun.16
CHECKED	TDS	Jun.16
APPROVED		

ARCFILE
31423-100-NPDC001.mxd

SCALE (AT A3 SIZE)
1:250,000

PROJECT No.

NEW PLYMOUTH DISTRICT COUNCIL

DISTRICT PLAN REVIEW: COASTAL MANAGEMENT

Contour Coverage

FIGURE No.

Rev. 2

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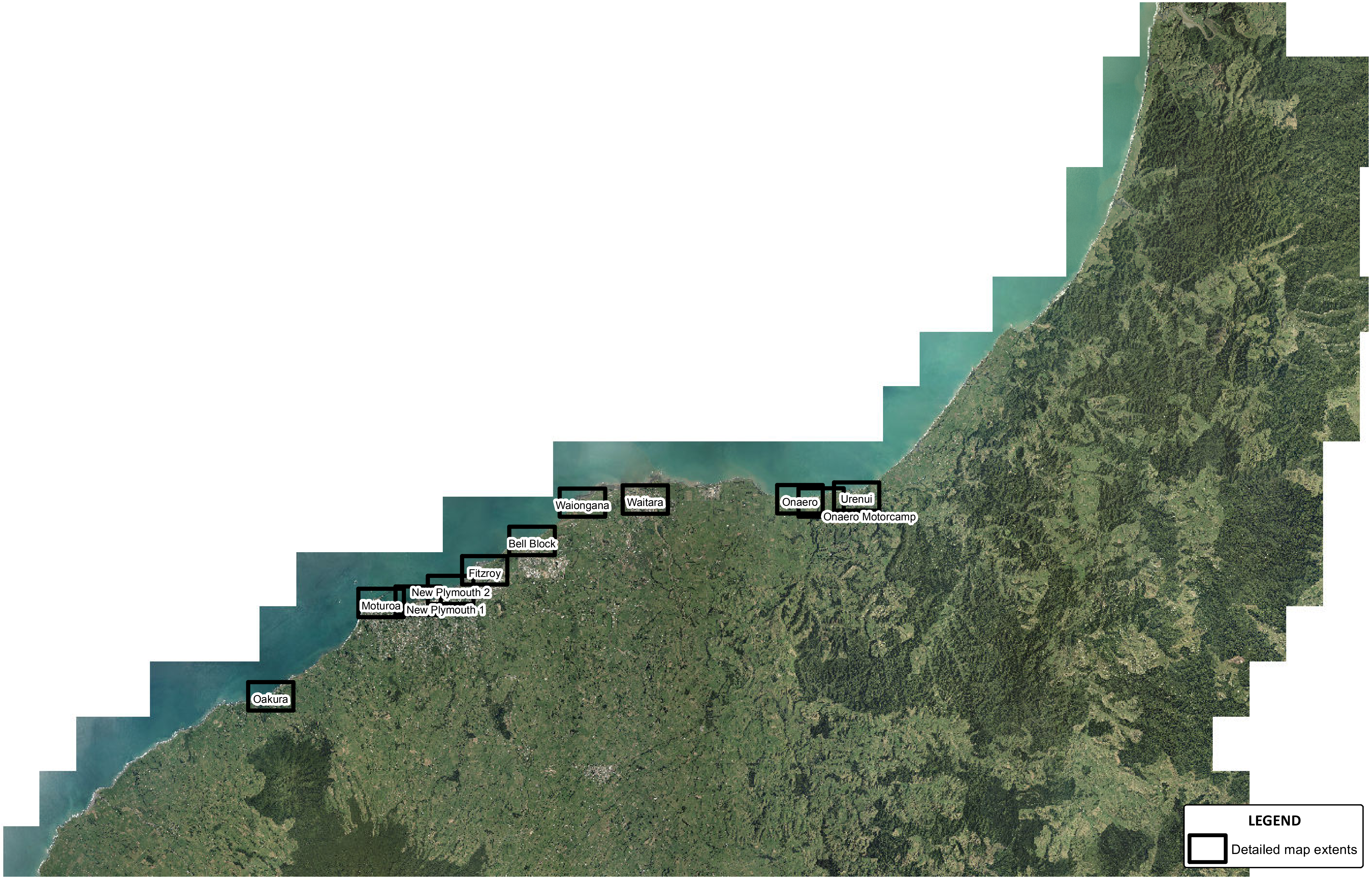

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A3 SCALE 1:250,000

0 2.5 5 7.5 10 12.5 (km)

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DRAWN	KKSN	Jun.16
CHECKED	TDS	Jun.16
APPROVED		
ARCFILE 31423-100-NPDC002.mxd		
SCALE (AT A3 SIZE) 1:250,000		
PROJECT No.		

NEW PLYMOUTH DISTRICT COUNCIL

DISTRICT PLAN REVIEW: COASTAL MANAGEMENT

Map locations

FIGURE No.

Rev. 2

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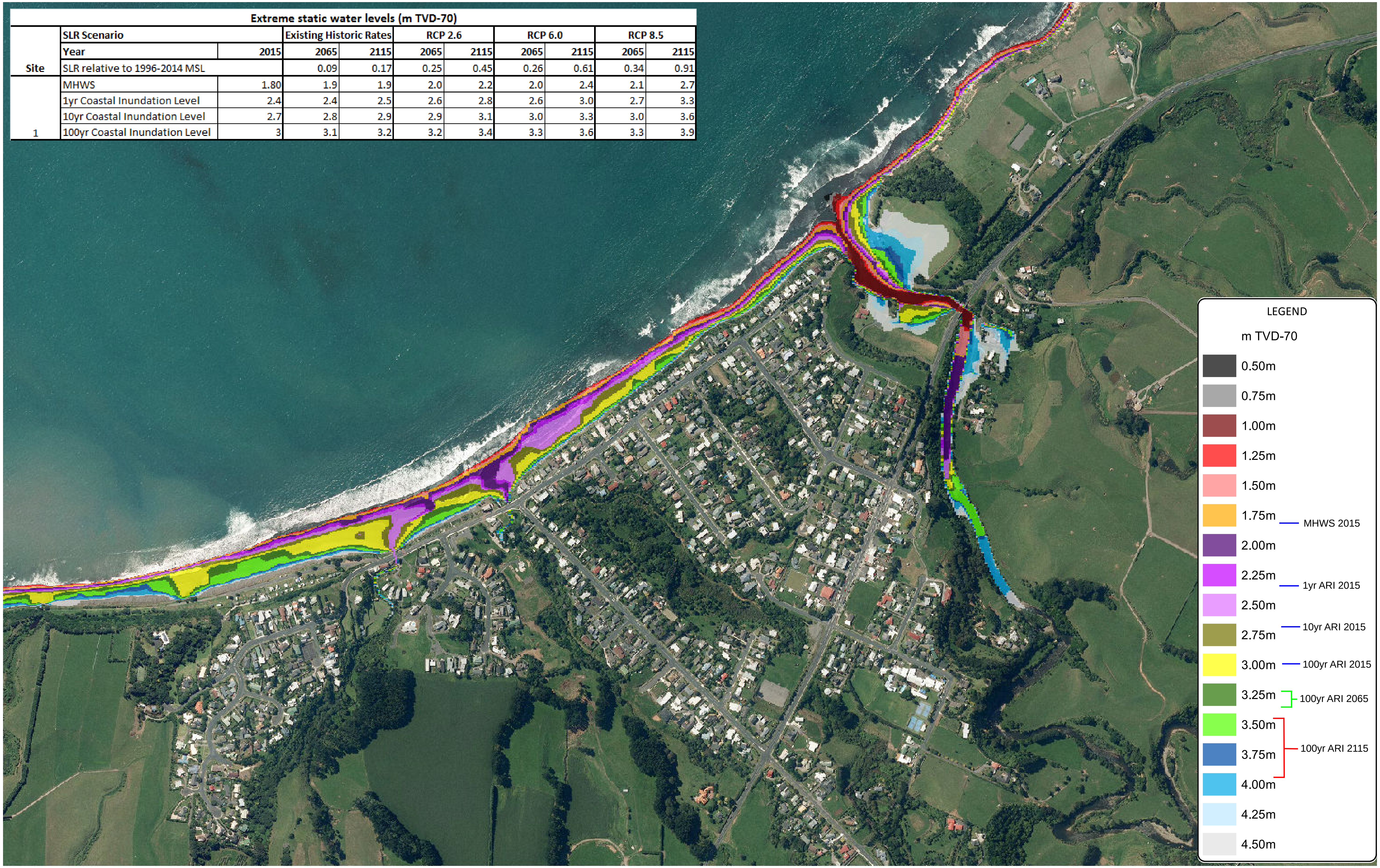
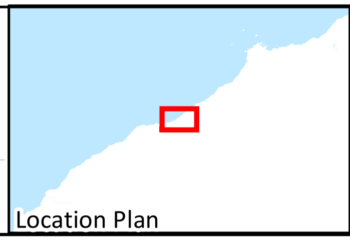
Extreme static water levels (m TVD-70)										
Site	SLR Scenario		Existing Historic Rates		RCP 2.6		RCP 6.0		RCP 8.5	
	Year	2015	2065	2115	2065	2115	2065	2115	2065	2115
	SLR relative to 1996-2014 MSL		0.09	0.17	0.25	0.45	0.26	0.61	0.34	0.91
	MHWS	1.80	1.9	1.9	2.0	2.2	2.0	2.4	2.1	2.7
	1yr Coastal Inundation Level	2.4	2.4	2.5	2.6	2.8	2.6	3.0	2.7	3.3
	10yr Coastal Inundation Level	2.7	2.8	2.9	2.9	3.1	3.0	3.3	3.0	3.6
1	100yr Coastal Inundation Level	3	3.1	3.2	3.2	3.4	3.3	3.6	3.3	3.9



Notes: Aerial photograph sourced from LINZ and licensed under CC BY 3.0 NZ. Territorial Authorities sourced from Statistics New Zealand and licensed under CC BY 4.0
Levels in terms of Taranaki Vertical Datum 1970 (TVD-70) = Mean Sea Level – 0.15m

A3 SCALE 1:7,500

0 0.2 0.4 0.6 0.8 (km)



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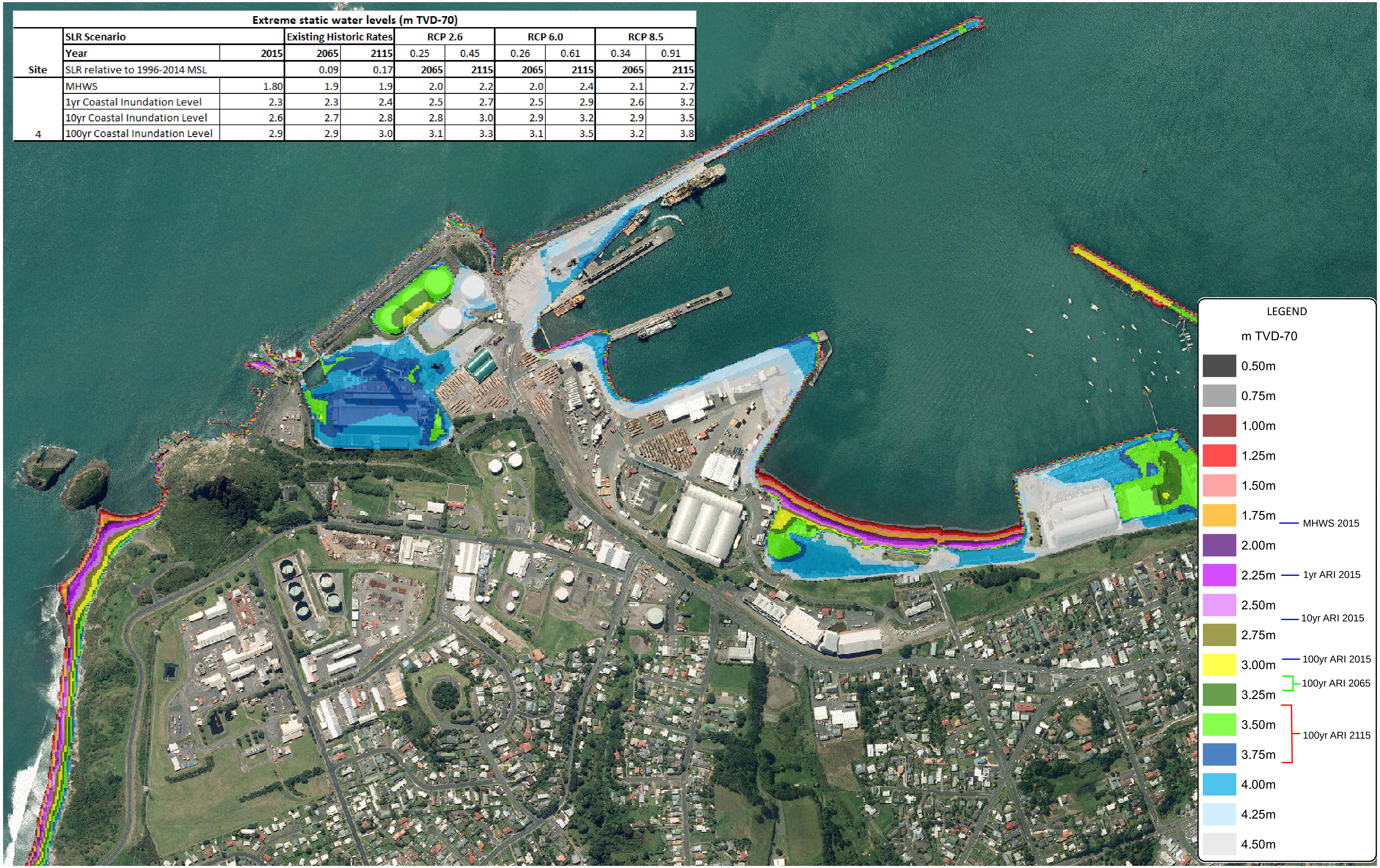
SCALE (AT A3 SIZE) 1:7,500		
PROJECT No.		

NEW PLYMOUTH DISTRICT COUNCIL
DISTRICT PLAN REVIEW: COASTAL MANAGEMENT
Extent of Inundation for Elevated Coastal Water Levels

FIGURE No. Oakura Rev. 2

Extreme static water levels (m TVD-70)

Site	SLR Scenario		Existing Historic Rates		RCP 2.6		RCP 6.0		RCP 8.5	
	Year	2015	2065	2115	0.25	0.45	0.26	0.61	0.34	0.91
	SLR relative to 1996-2014 MSL		0.09	0.17	2065	2115	2065	2115	2065	2115
	MHWS	1.80	1.9	1.9	2.0	2.2	2.0	2.4	2.1	2.7
	1yr Coastal Inundation Level	2.3	2.3	2.4	2.5	2.7	2.5	2.9	2.6	3.2
	10yr Coastal Inundation Level	2.6	2.7	2.8	2.8	3.0	2.9	3.2	2.9	3.5
4	100yr Coastal Inundation Level	2.9	2.9	3.0	3.1	3.3	3.1	3.5	3.2	3.8

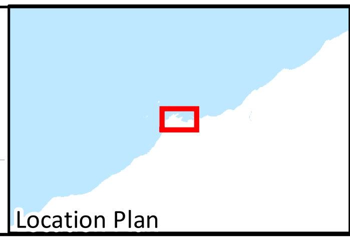


Notes: Aerial photograph sourced from LINZ and licensed under CC BY 3.0 NZ. Territorial Authorities sourced from Statistics New Zealand and licensed under CC BY 4.0
Levels in terms of Taranaki Vertical Datum 1970 (TVD-70) = Mean Sea Level – 0.15m

A3 SCALE 1:7,500

0 0.2 0.4 0.6 0.8 (km)

N



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APPROVED		

ARCFILE 31423-100-NPDC003.mxd
SCALE (AT A3 SIZE) 1:7,500
PROJECT No.

NEW PLYMOUTH DISTRICT COUNCIL
DISTRICT PLAN REVIEW: COASTAL MANAGEMENT
Extent of Inundation for Elevated Coastal Water Levels

FIGURE No. Moturoa
Rev. 2

Path: T:\Auckland\Projects\31423\31423.1000\WorkingMaterial\GIS\MapDocuments\31423-100-NPDC003.mxd Date: 22/06/2016 Time: 9:38:59 a.m.

Extreme static water levels (m TVD-70)

Site	SLR Scenario		Existing Historic Rates		RCP 2.6		RCP 6.0		RCP 8.5	
	Year	2015	2065	2115	0.25	0.45	0.26	0.61	0.34	0.91
Site	SLR relative to 1996-2014 MSL		0.09	0.17	2065	2115	2065	2115	2065	2115
	MHWS	1.80	1.9	1.9	2.0	2.2	2.0	2.4	2.1	2.7
	1yr Coastal Inundation Level	2.4	2.4	2.5	2.6	2.8	2.6	3.0	2.7	3.3
	10yr Coastal Inundation Level	2.7	2.7	2.8	2.9	3.1	2.9	3.3	3.0	3.6
5	100yr Coastal Inundation Level	3	3.0	3.1	3.2	3.4	3.2	3.6	3.3	3.9

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Levels in terms of Taranaki Vertical Datum 1970 (TVD-70) = Mean Sea Level – 0.15m

A3 SCALE 1:7,500

0 0.2 0.4 0.6 0.8 (km)

N

Location Plan

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ARCFILE 31423-100-NPDC003.mxd		
SCALE (AT A3 SIZE) 1:7,500		
PROJECT No.		

NEW PLYMOUTH DISTRICT COUNCIL

DISTRICT PLAN REVIEW: COASTAL MANAGEMENT

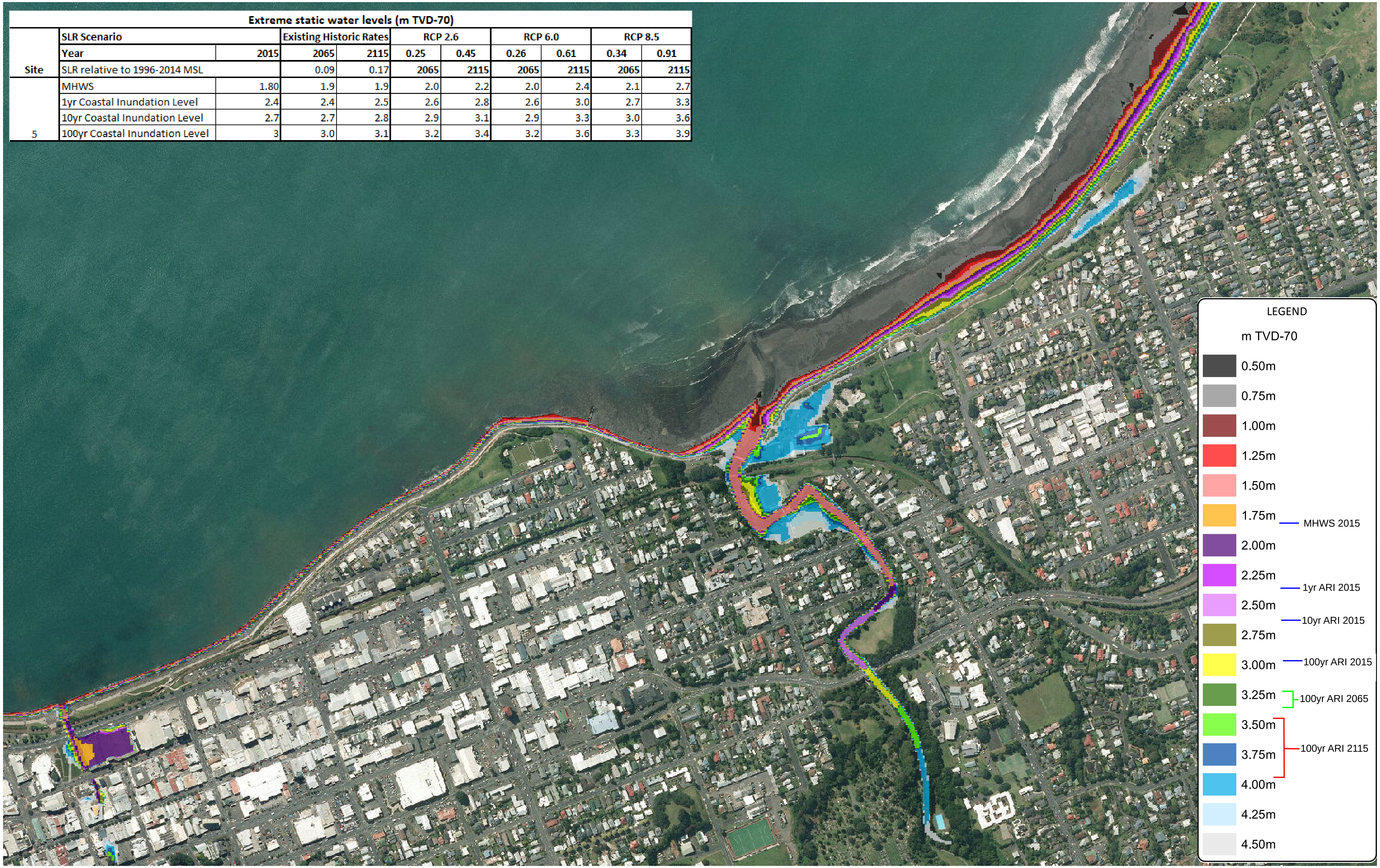
Extent of Inundation for Elevated Coastal Water Levels

FIGURE No. New Plymouth 1

Rev. 2

Path: T:\Auckland\Projects\31423\31423.1000\WorkingMaterial\GIS\MapDocuments\31423-100-NPDC003.mxd Date: 22/06/2016 Time: 9:39:12 a.m.

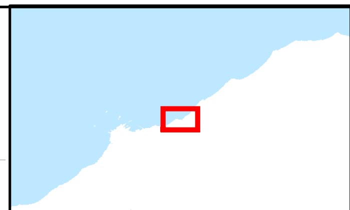
Extreme static water levels (m TVD-70)										
	SLR Scenario		Existing Historic Rates		RCP 2.6		RCP 6.0		RCP 8.5	
	Year	2015	2065	2115	0.25	0.45	0.26	0.61	0.34	0.91
Site	SLR relative to 1996-2014 MSL		0.09	0.17	2065	2115	2065	2115	2065	2115
	MHWS	1.80	1.9	1.9	2.0	2.2	2.0	2.4	2.1	2.7
	1yr Coastal Inundation Level	2.4	2.4	2.5	2.6	2.8	2.6	3.0	2.7	3.3
	10yr Coastal Inundation Level	2.7	2.7	2.8	2.9	3.1	2.9	3.3	3.0	3.6
5	100yr Coastal Inundation Level	3	3.0	3.1	3.2	3.4	3.2	3.6	3.3	3.9



Notes: Aerial photograph sourced from LINZ and licensed under CC BY 3.0 NZ. Territorial Authorities sourced from Statistics New Zealand and licensed under CC BY 4.0
Levels in terms of Taranaki Vertical Datum 1970 (TVD-70) = Mean Sea Level – 0.15m

A3 SCALE 1:7,500

0 0.2 0.4 0.6 0.8 (km)


Location Plan

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CHECKED	TDS	Jun.16
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ARCFILE 31423-100-NPDC003.mxd		
SCALE (AT A3 SIZE) 1:7,500		
PROJECT No.		

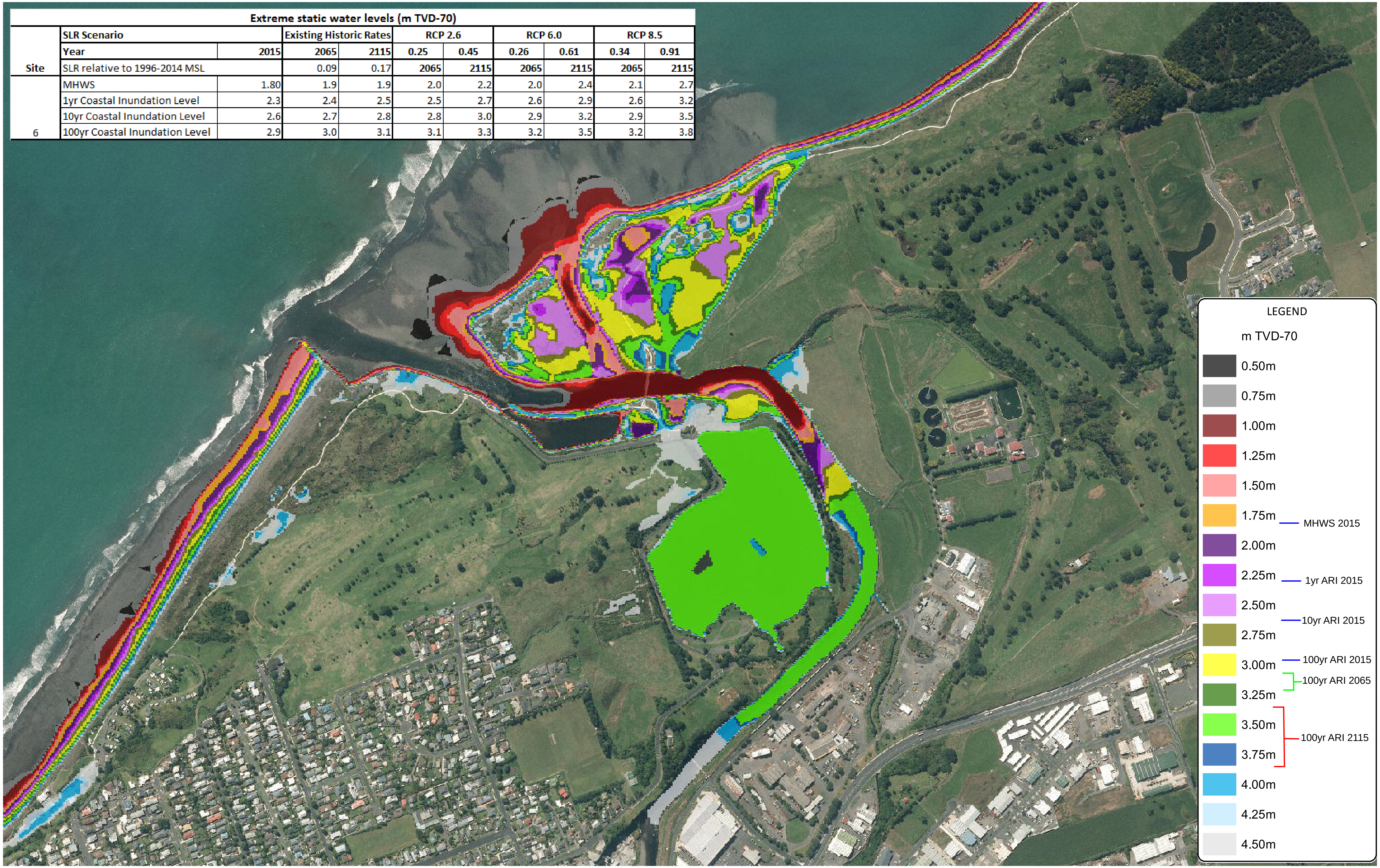
NEW PLYMOUTH DISTRICT COUNCIL
DISTRICT PLAN REVIEW: COASTAL MANAGEMENT
Extent of Inundation for Elevated Coastal Water Levels

FIGURE No. New Plymouth 2 Rev. 2

Path: T:\Auckland\Projects\31423\31423.1000\WorkingMaterial\GIS\MapDocuments\31423-100-NPDC003.mxd Date: 22/06/2016 Time: 9:39:24 a.m.

Extreme static water levels (m TVD-70)

Site	SLR Scenario		Existing Historic Rates		RCP 2.6		RCP 6.0		RCP 8.5	
	Year	2015	2065	2115	0.25	0.45	0.26	0.61	0.34	0.91
Site	SLR relative to 1996-2014 MSL		0.09	0.17	2065	2115	2065	2115	2065	2115
	MHWS	1.80	1.9	1.9	2.0	2.2	2.0	2.4	2.1	2.7
	1yr Coastal Inundation Level	2.3	2.4	2.5	2.5	2.7	2.6	2.9	2.6	3.2
	10yr Coastal Inundation Level	2.6	2.7	2.8	2.8	3.0	2.9	3.2	2.9	3.5
6	100yr Coastal Inundation Level	2.9	3.0	3.1	3.1	3.3	3.2	3.5	3.2	3.8



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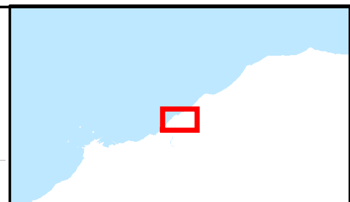
Levels in terms of Taranaki Vertical Datum 1970 (TVD-70) = Mean Sea Level – 0.15m

A3 SCALE 1:7,500

0 0.2 0.4 0.6 0.8 (km)

N


Location Plan

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ARCFILE 31423-100-NPDC003.mxd		
SCALE (AT A3 SIZE) 1:7,500		
PROJECT No.		

NEW PLYMOUTH DISTRICT COUNCIL

DISTRICT PLAN REVIEW: COASTAL MANAGEMENT

Extent of Inundation for Elevated Coastal Water Levels

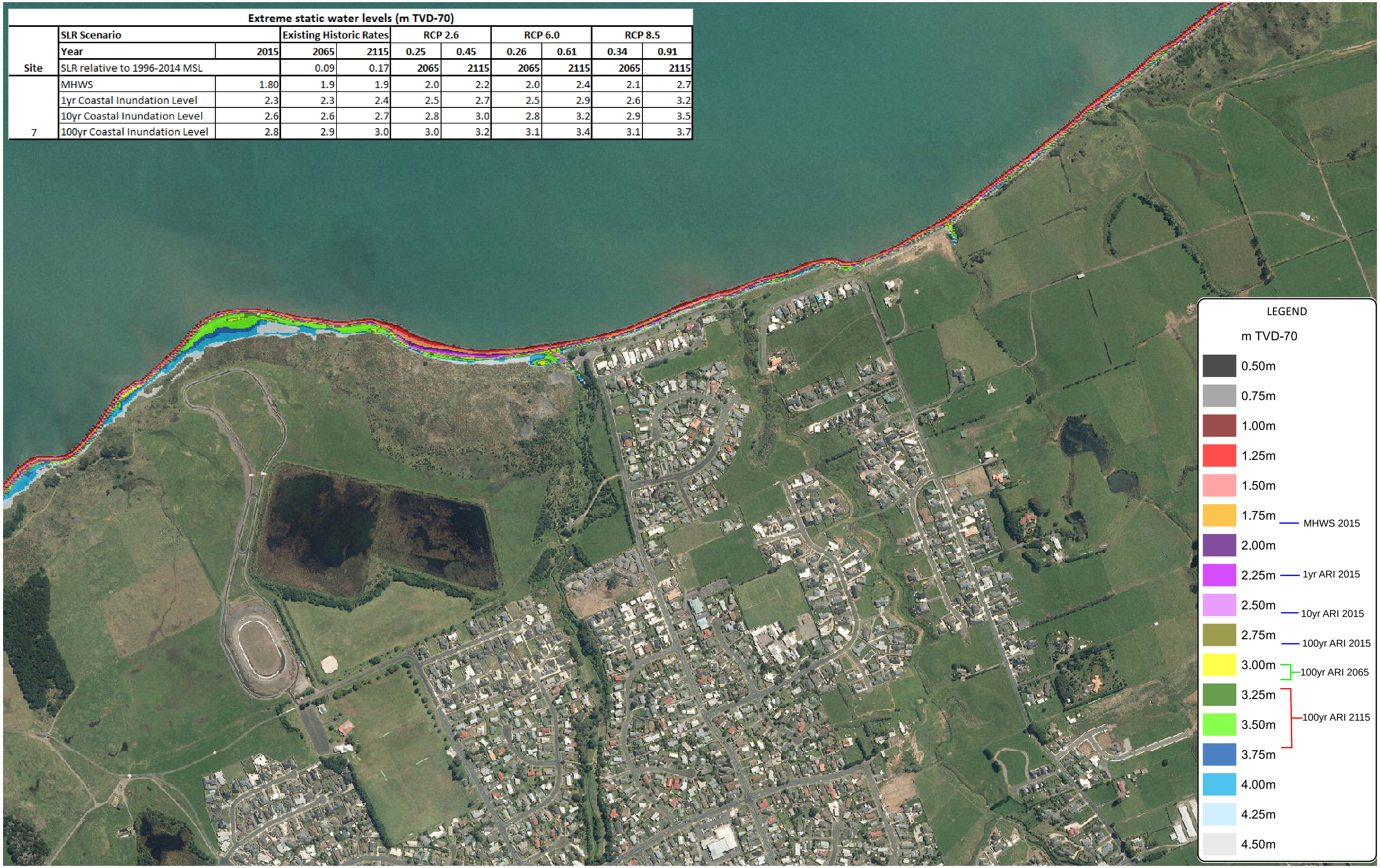
FIGURE No. Fitzroy

Rev. 2

Path: T:\Auckland\Projects\31423\31423.1000\WorkingMaterial\GIS\MapDocuments\31423-100-NPDC003.mxd Date: 22/06/2016 Time: 9:39:34 a.m.

Extreme static water levels (m TVD-70)

Site	SLR Scenario		Existing Historic Rates		RCP 2.6		RCP 6.0		RCP 8.5	
	Year	2015	2065	2115	0.25	0.45	0.26	0.61	0.34	0.91
Site	SLR relative to 1996-2014 MSL		0.09	0.17	2065	2115	2065	2115	2065	2115
	MHWS	1.80	1.9	1.9	2.0	2.2	2.0	2.4	2.1	2.7
	1yr Coastal Inundation Level	2.3	2.3	2.4	2.5	2.7	2.5	2.9	2.6	3.2
	10yr Coastal Inundation Level	2.6	2.6	2.7	2.8	3.0	2.8	3.2	2.9	3.5
7	100yr Coastal Inundation Level	2.8	2.9	3.0	3.0	3.2	3.1	3.4	3.1	3.7



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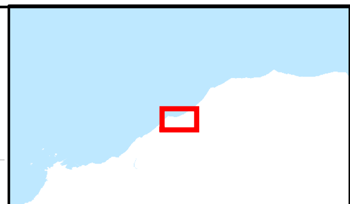
Levels in terms of Taranaki Vertical Datum 1970 (TVD-70) = Mean Sea Level – 0.15m

A3 SCALE 1:7,500

0 0.2 0.4 0.6 0.8 (km)


Location Plan

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PROJECT No.		

NEW PLYMOUTH DISTRICT COUNCIL
DISTRICT PLAN REVIEW: COASTAL MANAGEMENT
Extent of Inundation for Elevated Coastal Water Levels

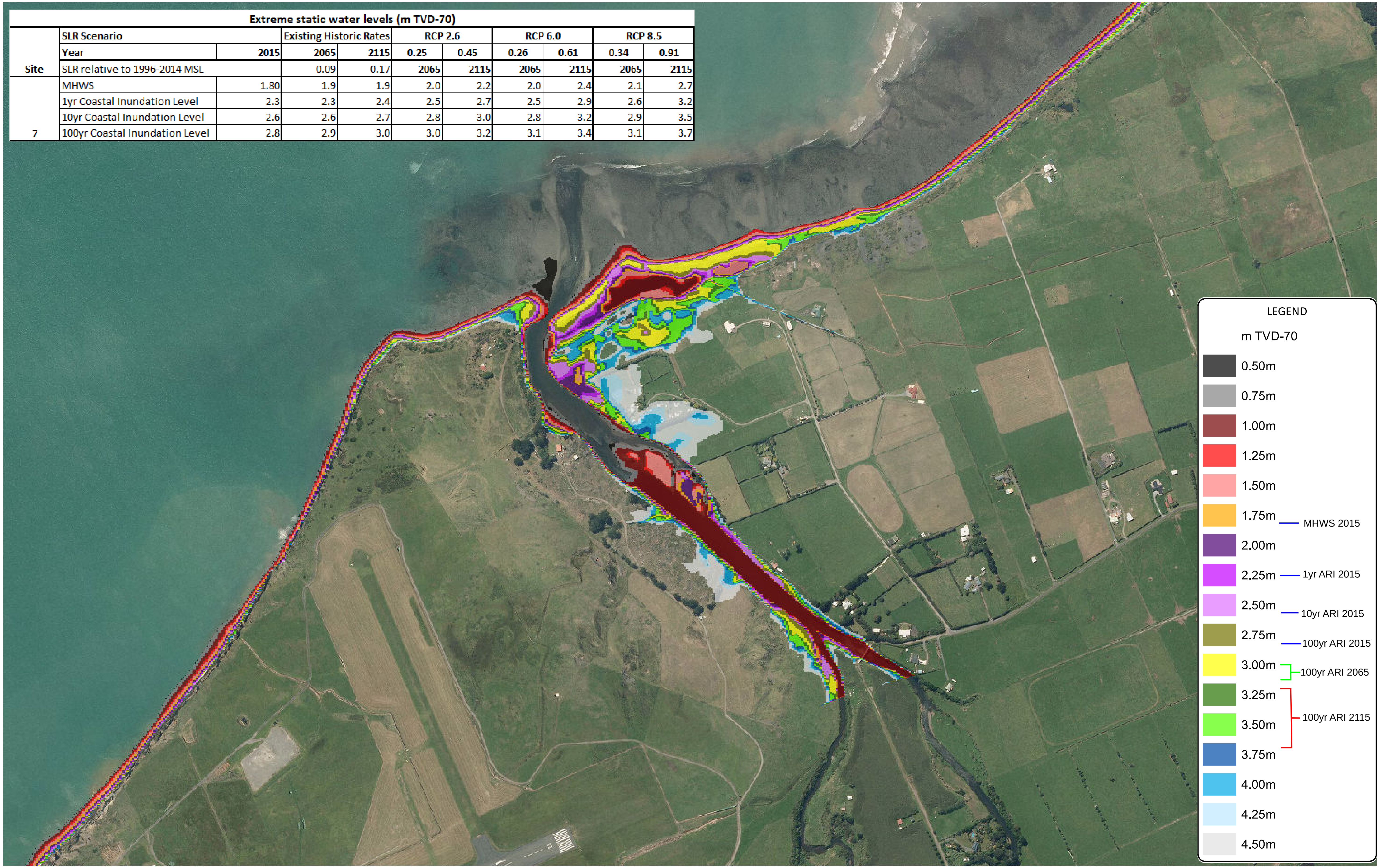
FIGURE No. Bell Block

Rev. 2

Path: T:\Auckland\Projects\31423\31423.1000\WorkingMaterial\GIS\MapDocuments\31423-100-NPDC003.mxd Date: 22/06/2016 Time: 9:39:45 a.m.

Extreme static water levels (m TVD-70)

Site	SLR Scenario		Existing Historic Rates		RCP 2.6		RCP 6.0		RCP 8.5	
	Year	2015	2065	2115	0.25	0.45	0.26	0.61	0.34	0.91
Site	SLR relative to 1996-2014 MSL		0.09	0.17	2065	2115	2065	2115	2065	2115
	MHWS	1.80	1.9	1.9	2.0	2.2	2.0	2.4	2.1	2.7
	1yr Coastal Inundation Level	2.3	2.3	2.4	2.5	2.7	2.5	2.9	2.6	3.2
	10yr Coastal Inundation Level	2.6	2.6	2.7	2.8	3.0	2.8	3.2	2.9	3.5
7	100yr Coastal Inundation Level	2.8	2.9	3.0	3.0	3.2	3.1	3.4	3.1	3.7



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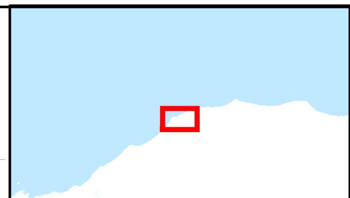
Levels in terms of Taranaki Vertical Datum 1970 (TVD-70) = Mean Sea Level – 0.15m

A3 SCALE 1:7,500

0 0.2 0.4 0.6 0.8 (km)

N



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PROJECT No.

NEW PLYMOUTH DISTRICT COUNCIL

DISTRICT PLAN REVIEW: COASTAL MANAGEMENT

Extent of Inundation for Elevated Coastal Water Levels

FIGURE No. Waiongana

Rev. 2

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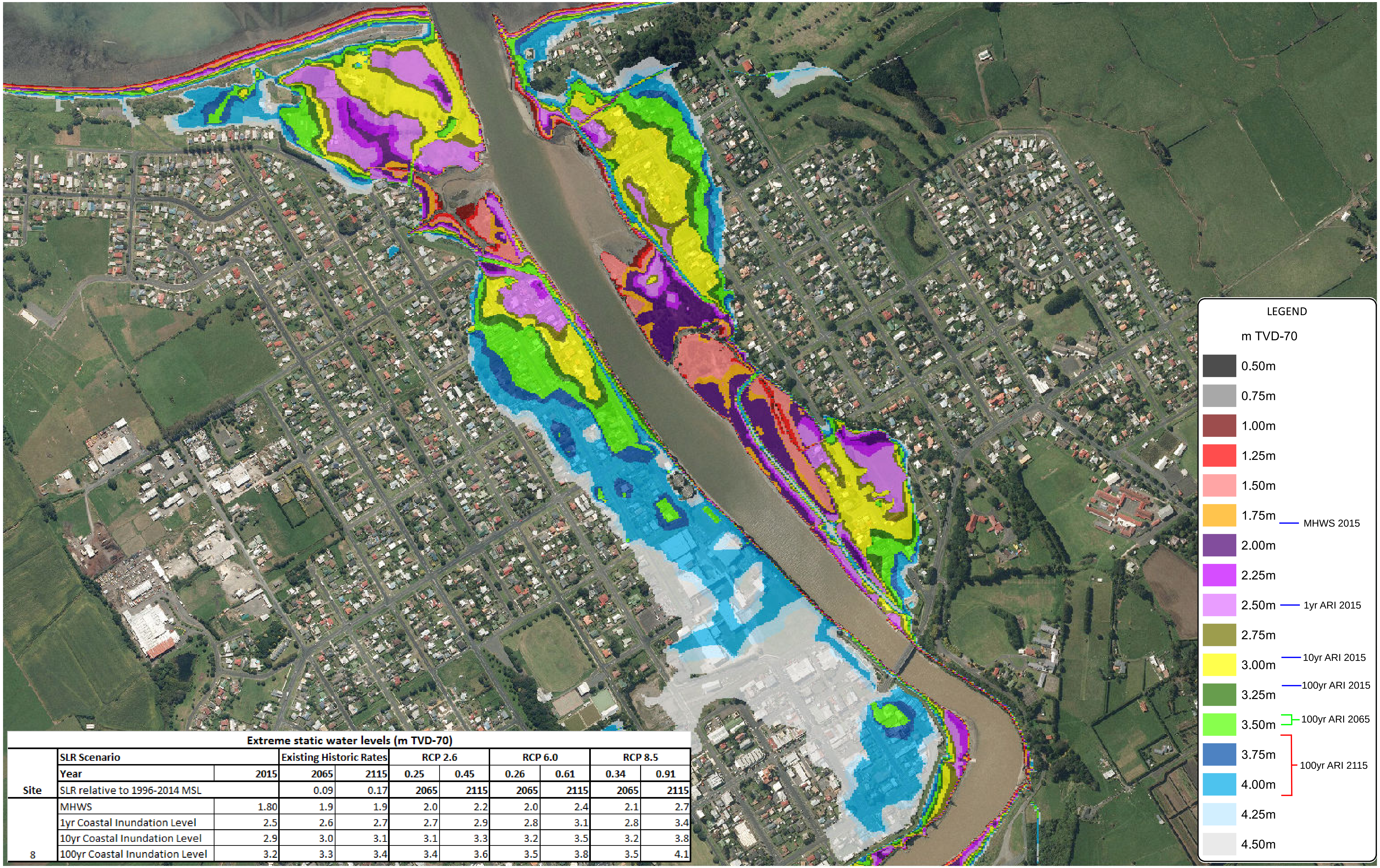

Extreme static water levels (m TVD-70)

Site	SLR Scenario		Existing Historic Rates		RCP 2.6		RCP 6.0		RCP 8.5	
	Year	2015	2065	2115	0.25	0.45	0.26	0.61	0.34	0.91
	SLR relative to 1996-2014 MSL		0.09	0.17	2065	2115	2065	2115	2065	2115
	MHWS	1.80	1.9	1.9	2.0	2.2	2.0	2.4	2.1	2.7
	1yr Coastal Inundation Level	2.5	2.6	2.7	2.7	2.9	2.8	3.1	2.8	3.4
	10yr Coastal Inundation Level	2.9	3.0	3.1	3.1	3.3	3.2	3.5	3.2	3.8
8	100yr Coastal Inundation Level	3.2	3.3	3.4	3.4	3.6	3.5	3.8	3.5	4.1

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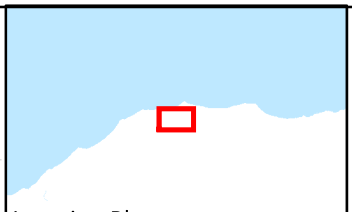
Levels in terms of Taranaki Vertical Datum 1970 (TVD-70) = Mean Sea Level – 0.15m

A3 SCALE 1:7,500

0 0.2 0.4 0.6 0.8 (km)

N



Location Plan

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SCALE (AT A3 SIZE) 1:7,500

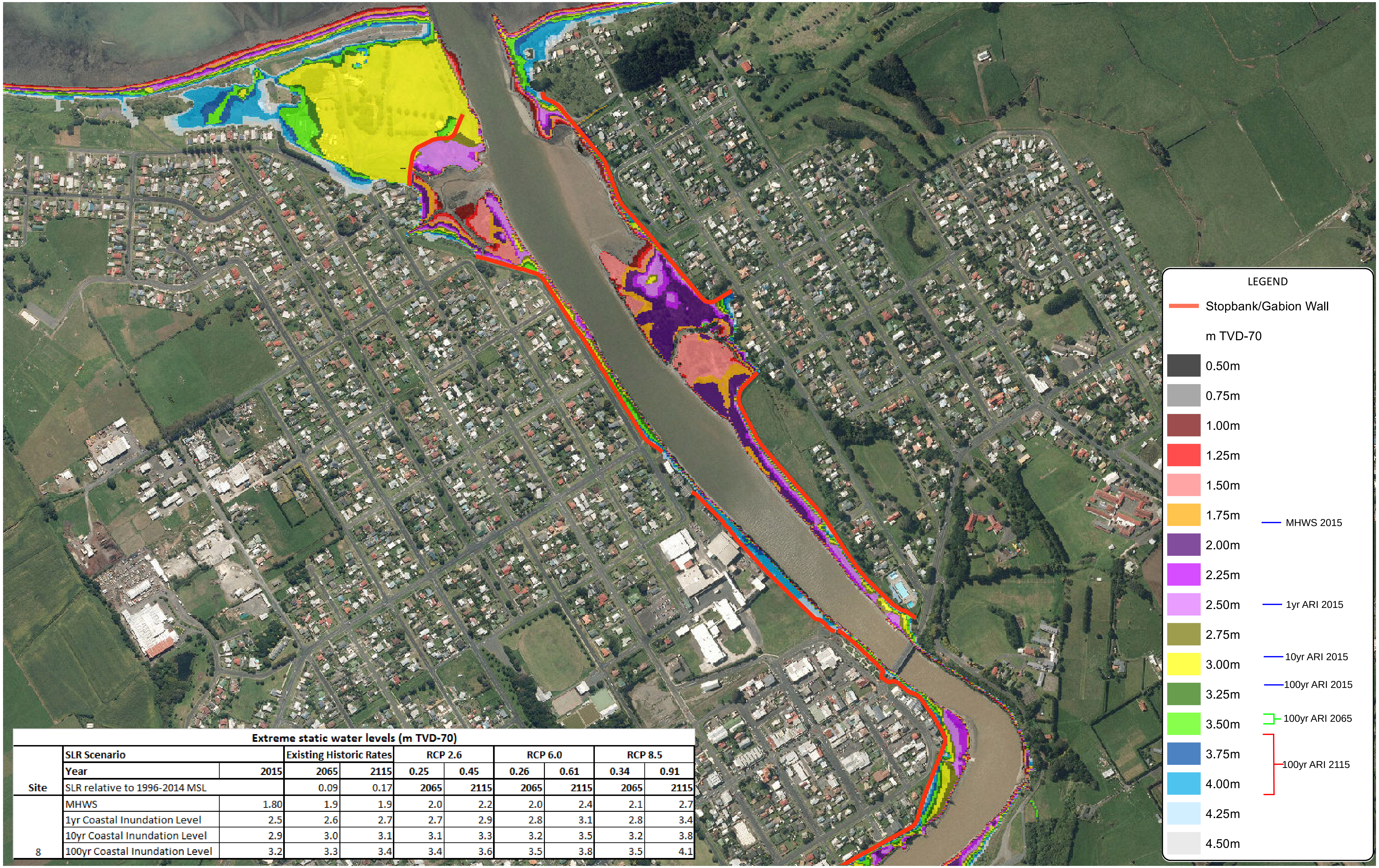
PROJECT No.

NEW PLYMOUTH DISTRICT COUNCIL
DISTRICT PLAN REVIEW: COASTAL MANAGEMENT
Extent of Inundation for Elevated Coastal Water Levels

FIGURE No. Waitara without Stopbanks and Gabion Walls

Rev. 2

Path: T:\Auckland\Projects\31423\31423.1000\WorkingMaterial\GIS\MapDocuments\31423-100-NPDC003.mxd Date: 22/06/2016 Time: 9:40:24 a.m.



Extreme static water levels (m TVD-70)

Site	SLR Scenario		Existing Historic Rates		RCP 2.6		RCP 6.0		RCP 8.5	
	Year	2015	2065	2115	0.25	0.45	0.26	0.61	0.34	0.91
Site	SLR relative to 1996-2014 MSL		0.09	0.17	2065	2115	2065	2115	2065	2115
	MHWS	1.80	1.9	1.9	2.0	2.2	2.0	2.4	2.1	2.7
	1yr Coastal Inundation Level	2.5	2.6	2.7	2.7	2.9	2.8	3.1	2.8	3.4
	10yr Coastal Inundation Level	2.9	3.0	3.1	3.1	3.3	3.2	3.5	3.2	3.8
8	100yr Coastal Inundation Level	3.2	3.3	3.4	3.4	3.6	3.5	3.8	3.5	4.1

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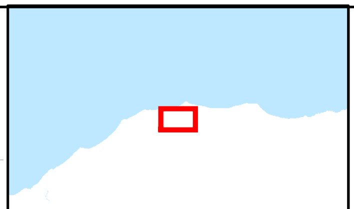
Levels in terms of Taranaki Vertical Datum 1970 (TVD-70) = Mean Sea Level – 0.15m

A3 SCALE 1:7,500

0 0.2 0.4 0.6 0.8 (km)



Location Plan

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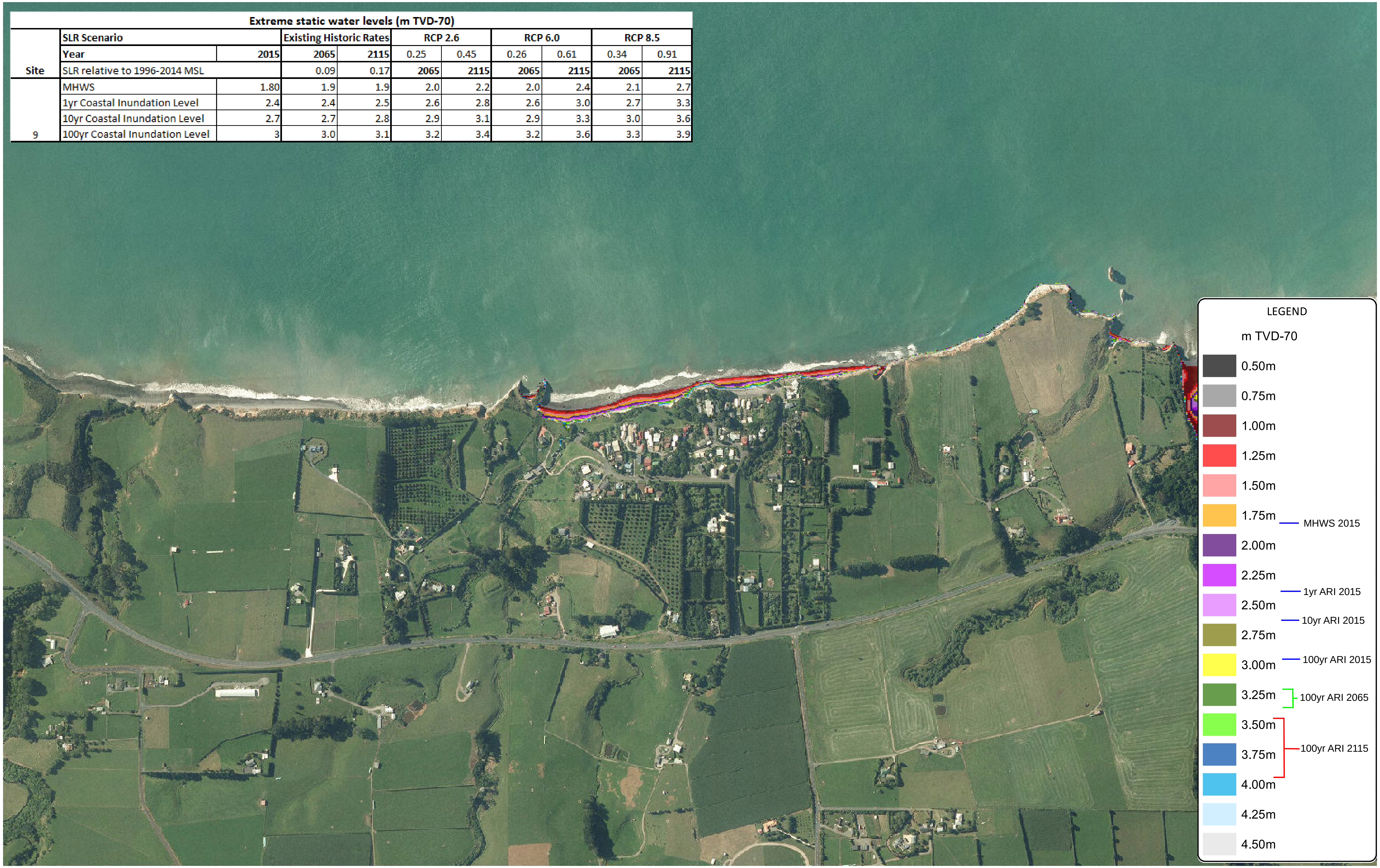
ARCFILE 31423-100-NPDC005.mxd
SCALE (AT A3 SIZE) 1:7,500
PROJECT No.

NEW PLYMOUTH DISTRICT COUNCIL
DISTRICT PLAN REVIEW: COASTAL MANAGEMENT
Extent of Inundation for Elevated Coastal Water Levels

FIGURE No. Waitara with Stopbanks and Gabion Walls
Rev. 2

Extreme static water levels (m TVD-70)

Site	SLR Scenario		Existing Historic Rates		RCP 2.6		RCP 6.0		RCP 8.5	
	Year	2015	2065	2115	0.25	0.45	0.26	0.61	0.34	0.91
Site	SLR relative to 1996-2014 MSL		0.09	0.17	2065	2115	2065	2115	2065	2115
	MHWS	1.80	1.9	1.9	2.0	2.2	2.0	2.4	2.1	2.7
	1yr Coastal Inundation Level	2.4	2.4	2.5	2.6	2.8	2.6	3.0	2.7	3.3
	10yr Coastal Inundation Level	2.7	2.7	2.8	2.9	3.1	2.9	3.3	3.0	3.6
9	100yr Coastal Inundation Level	3	3.0	3.1	3.2	3.4	3.2	3.6	3.3	3.9



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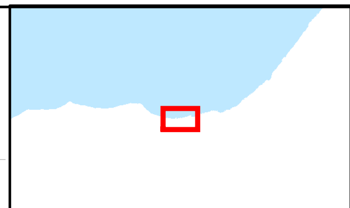
Levels in terms of Taranaki Vertical Datum 1970 (TVD-70) = Mean Sea Level – 0.15m

A3 SCALE 1:7,500

0 0.2 0.4 0.6 0.8 (km)



Location Plan

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ARCFILE 31423-100-NPDC003.mxd		
SCALE (AT A3 SIZE) 1:7,500		
PROJECT No.		

NEW PLYMOUTH DISTRICT COUNCIL

DISTRICT PLAN REVIEW: COASTAL MANAGEMENT

Extent of Inundation for Elevated Coastal Water Levels

FIGURE No. Onaero

Rev. 2

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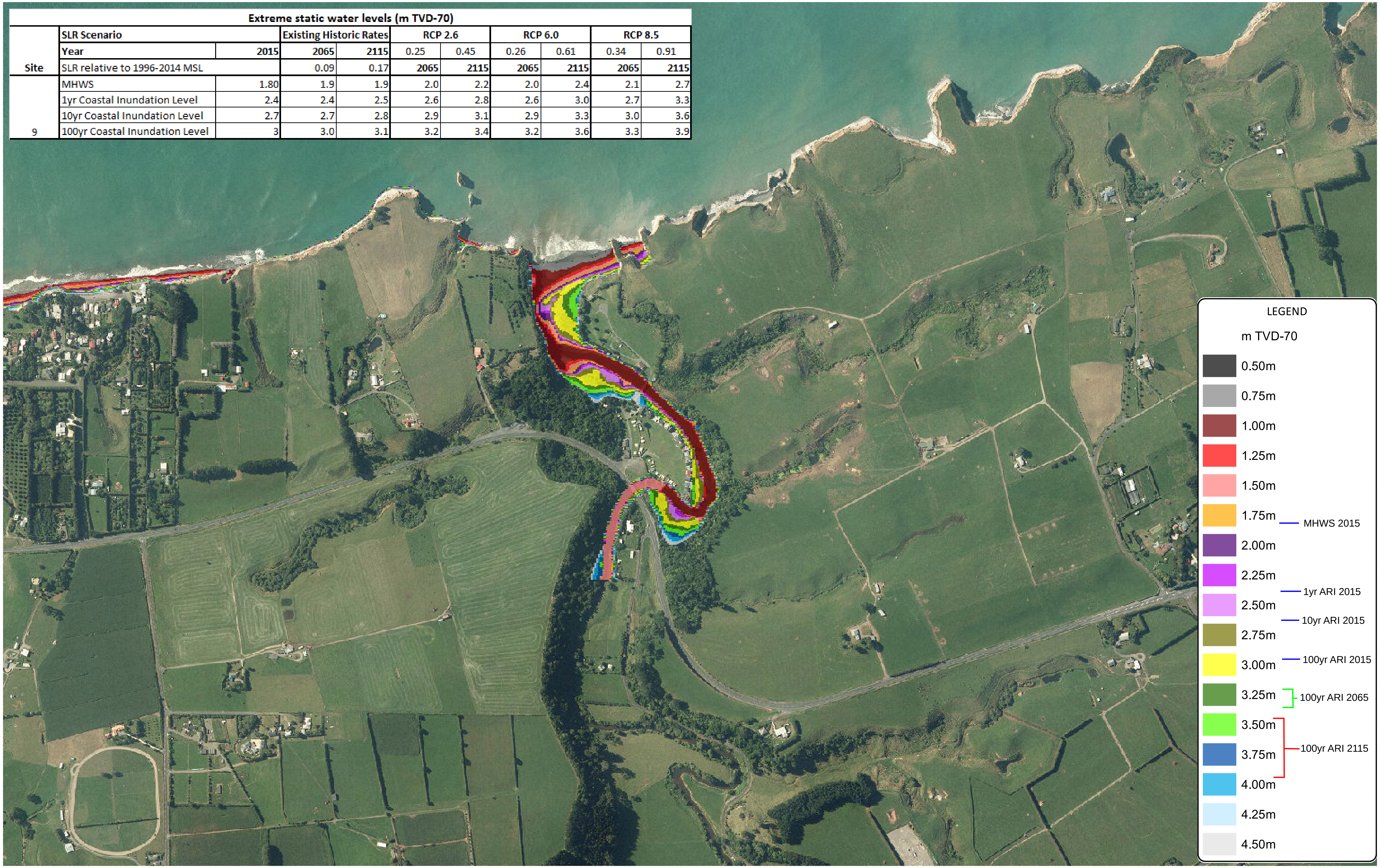
Extreme static water levels (m TVD-70)										
Site	SLR Scenario		Existing Historic Rates		RCP 2.6		RCP 6.0		RCP 8.5	
	Year	2015	2065	2115	0.25	0.45	0.26	0.61	0.34	0.91
	SLR relative to 1996-2014 MSL		0.09	0.17	2065	2115	2065	2115	2065	2115
	MHWS	1.80	1.9	1.9	2.0	2.2	2.0	2.4	2.1	2.7
	1yr Coastal Inundation Level	2.4	2.4	2.5	2.6	2.8	2.6	3.0	2.7	3.3
	10yr Coastal Inundation Level	2.7	2.7	2.8	2.9	3.1	2.9	3.3	3.0	3.6
9	100yr Coastal Inundation Level	3	3.0	3.1	3.2	3.4	3.2	3.6	3.3	3.9



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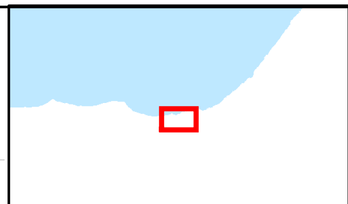
Levels in terms of Taranaki Vertical Datum 1970 (TVD-70) = Mean Sea Level – 0.15m

A3 SCALE 1:7,500

0 0.2 0.4 0.6 0.8 (km)



Location Plan

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CHECKED	TDS	Jun.16
APPROVED		
ARCFILE 31423-100-NPDC003.mxd		
SCALE (AT A3 SIZE) 1:7,500		
PROJECT No.		

NEW PLYMOUTH DISTRICT COUNCIL

DISTRICT PLAN REVIEW: COASTAL MANAGEMENT

Extent of Inundation for Elevated Coastal Water Levels

FIGURE No. Onaero Motorcamp

Rev. 2

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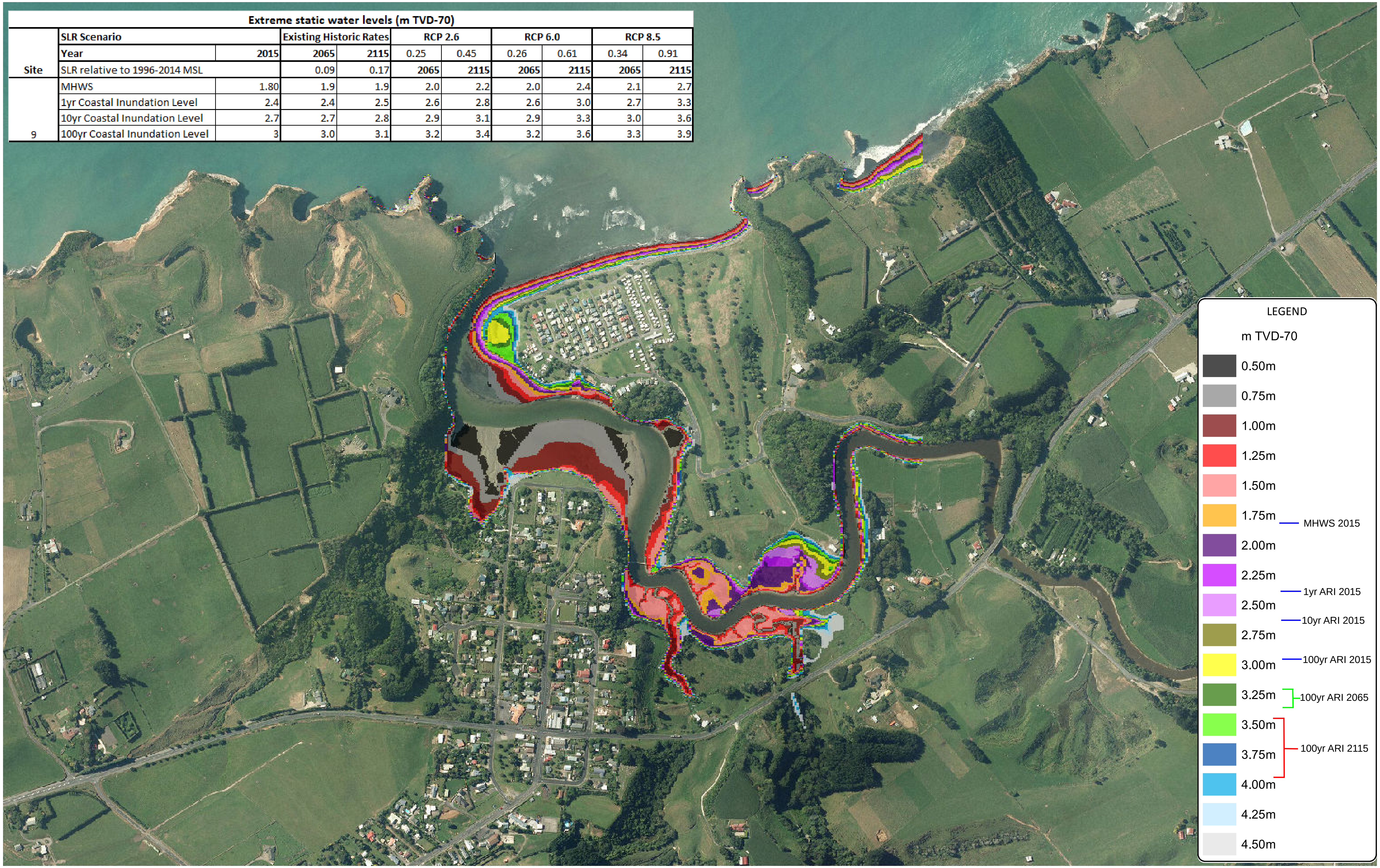
Extreme static water levels (m TVD-70)

Site	SLR Scenario		Existing Historic Rates		RCP 2.6		RCP 6.0		RCP 8.5	
	Year	2015	2065	2115	0.25	0.45	0.26	0.61	0.34	0.91
	SLR relative to 1996-2014 MSL		0.09	0.17	2065	2115	2065	2115	2065	2115
	MHWS	1.80	1.9	1.9	2.0	2.2	2.0	2.4	2.1	2.7
	1yr Coastal Inundation Level	2.4	2.4	2.5	2.6	2.8	2.6	3.0	2.7	3.3
	10yr Coastal Inundation Level	2.7	2.7	2.8	2.9	3.1	2.9	3.3	3.0	3.6
9	100yr Coastal Inundation Level	3	3.0	3.1	3.2	3.4	3.2	3.6	3.3	3.9



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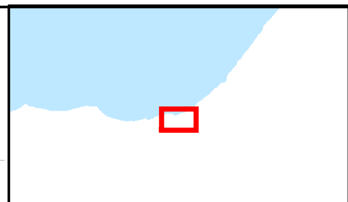
Levels in terms of Taranaki Vertical Datum 1970 (TVD-70) = Mean Sea Level – 0.15m

A3 SCALE 1:7,500

0 0.2 0.4 0.6 0.8 (km)



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DRAWN	KKSN	Jun.16
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ARCFILE 31423-100-NPDC003.mxd		
SCALE (AT A3 SIZE) 1:7,500		
PROJECT No.		

NEW PLYMOUTH DISTRICT COUNCIL
DISTRICT PLAN REVIEW: COASTAL MANAGEMENT
Extent of Inundation for Elevated Coastal Water Levels

FIGURE No. Urenui

Rev. 2

Path: T:\Auckland\Projects\31423\31423.1000\WorkingMaterial\GIS\MapDocuments\31423-100-NPDC003.mxd Date: 22/06/2016 Time: 9:40:44 a.m.

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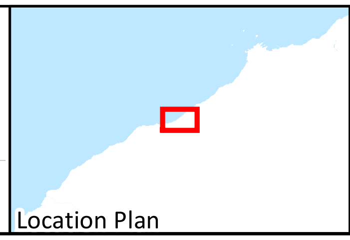
A3 SCALE 1:7,500

0 0.2 0.4 0.6 0.8 (km)

N



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ARCFILE 31423-100-NPDC004.mxd

SCALE (AT A3 SIZE) 1:7,500

PROJECT No.

NEW PLYMOUTH DISTRICT COUNCIL

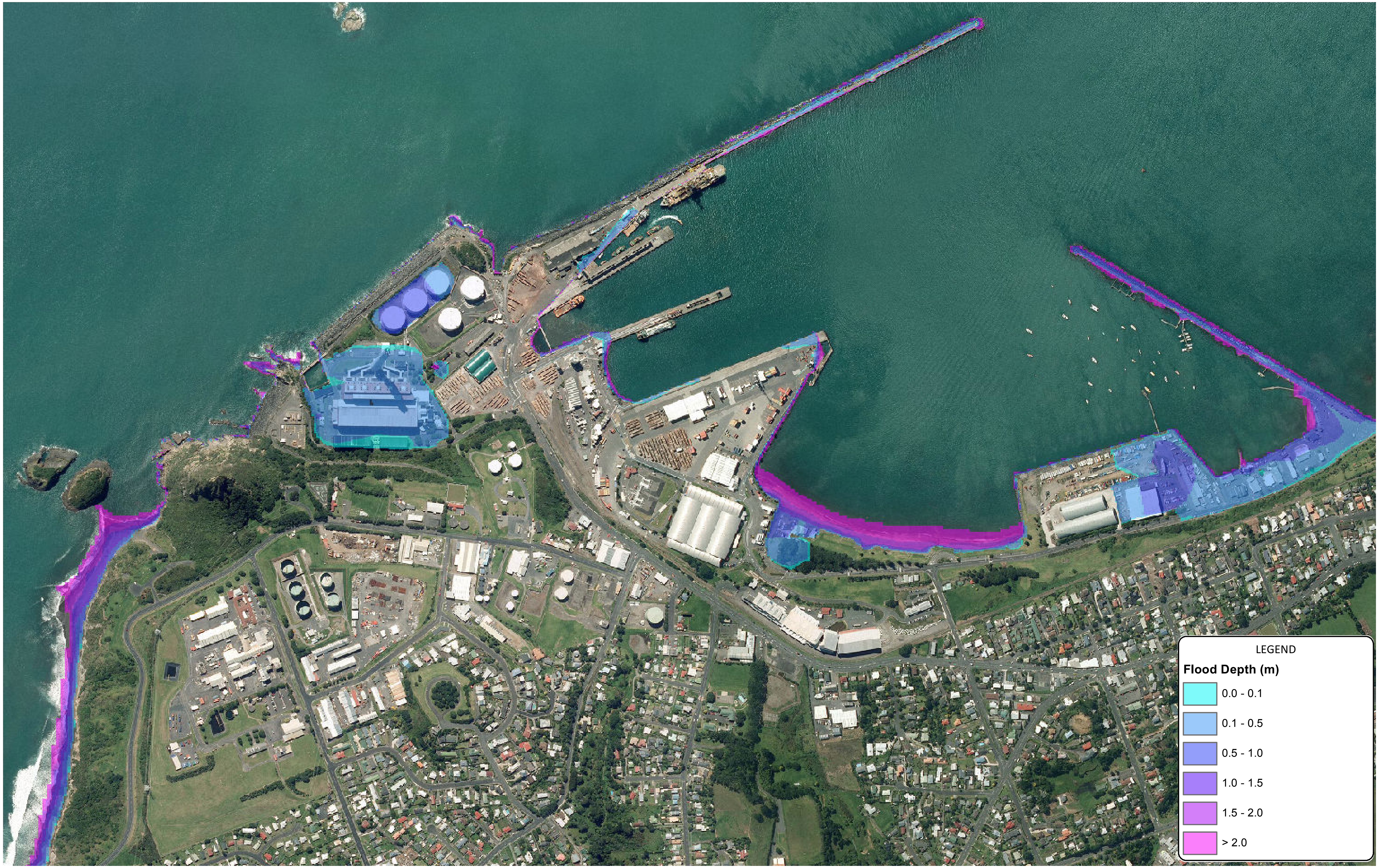
DISTRICT PLAN REVIEW: COASTAL MANAGEMENT

Flood Depth at 4.0m TVD-70 Water Level

FIGURE No. Oakura

Rev. 2

Path: T:\Auckland\Projects\31423\31423.1000\WorkingMaterial\GIS\MapDocuments\31423-100-NPDC004.mxd Date: 22/06/2016 Time: 11:27:15 a.m.



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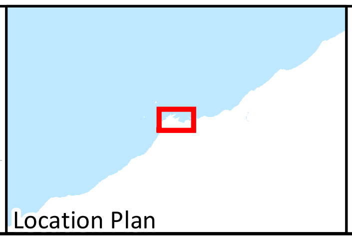
Levels in terms of Taranaki Vertical Datum 1970 (TVD-70) = Mean Sea Level – 0.15m

A3 SCALE 1:7,500

0 0.2 0.4 0.6 0.8 (km)



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ARCFILE 31423-100-NPDC004.mxd		
SCALE (AT A3 SIZE) 1:7,500		
PROJECT No.		

NEW PLYMOUTH DISTRICT COUNCIL

DISTRICT PLAN REVIEW: COASTAL MANAGEMENT

Flood Depth at 4.0m TVD-70 Water Level

FIGURE No. Moturoa

Rev. 2

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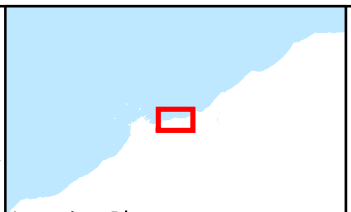
Levels in terms of Taranaki Vertical Datum 1970 (TVD-70) = Mean Sea Level – 0.15m

A3 SCALE 1:7,500

0 0.2 0.4 0.6 0.8 (km)

N



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SCALE (AT A3 SIZE) 1:7,500

PROJECT No.

NEW PLYMOUTH DISTRICT COUNCIL

DISTRICT PLAN REVIEW: COASTAL MANAGEMENT

Flood Depth at 4.0m TVD-70 Water Level

FIGURE No. New Plymouth 1

Rev. 2

Path: T:\Auckland\Projects\31423\31423.1000\WorkingMaterial\GIS\MapDocuments\31423-100-NPDC004.mxd Date: 22/06/2016 Time: 11:27:39 a.m.

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A3 SCALE 1:7,500

0 0.2 0.4 0.6 0.8 (km)

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ARCFILE 31423-100-NPDC004.mxd
SCALE (AT A3 SIZE) 1:7,500
PROJECT No.

NEW PLYMOUTH DISTRICT COUNCIL
DISTRICT PLAN REVIEW: COASTAL MANAGEMENT
Flood Depth at 4.0m TVD-70 Water Level

FIGURE No. New Plymouth 2
Rev. 2

Path: T:\AucklandProjects\31423\31423.1000\WorkingMaterial\GIS\MapDocuments\31423-100-NPDC004.mxd Date: 22/06/2016 Time: 11:27:49 a.m.

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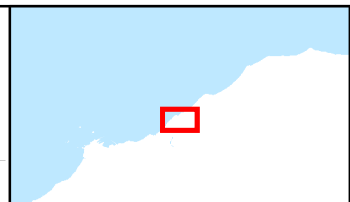
Levels in terms of Taranaki Vertical Datum 1970 (TVD-70) = Mean Sea Level – 0.15m

A3 SCALE 1:7,500

0 0.2 0.4 0.6 0.8 (km)



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ARCFILE 31423-100-NPDC004.mxd

SCALE (AT A3 SIZE) 1:7,500

PROJECT No.

NEW PLYMOUTH DISTRICT COUNCIL

DISTRICT PLAN REVIEW: COASTAL MANAGEMENT

Flood Depth at 4.0m TVD-70 Water Level

FIGURE No. Fitzroy

Rev. 2

Path: T:\Auckland\Projects\31423\31423.1000\WorkingMaterial\GIS\MapDocuments\31423-100-NPDC004.mxd Date: 22/06/2016 Time: 11:27:58 a.m.

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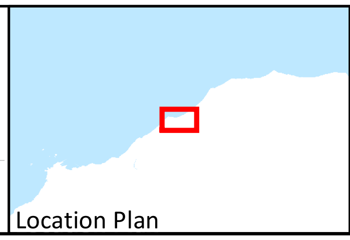
Levels in terms of Taranaki Vertical Datum 1970 (TVD-70) = Mean Sea Level – 0.15m

A3 SCALE 1:7,500

0 0.2 0.4 0.6 0.8 (km)

N



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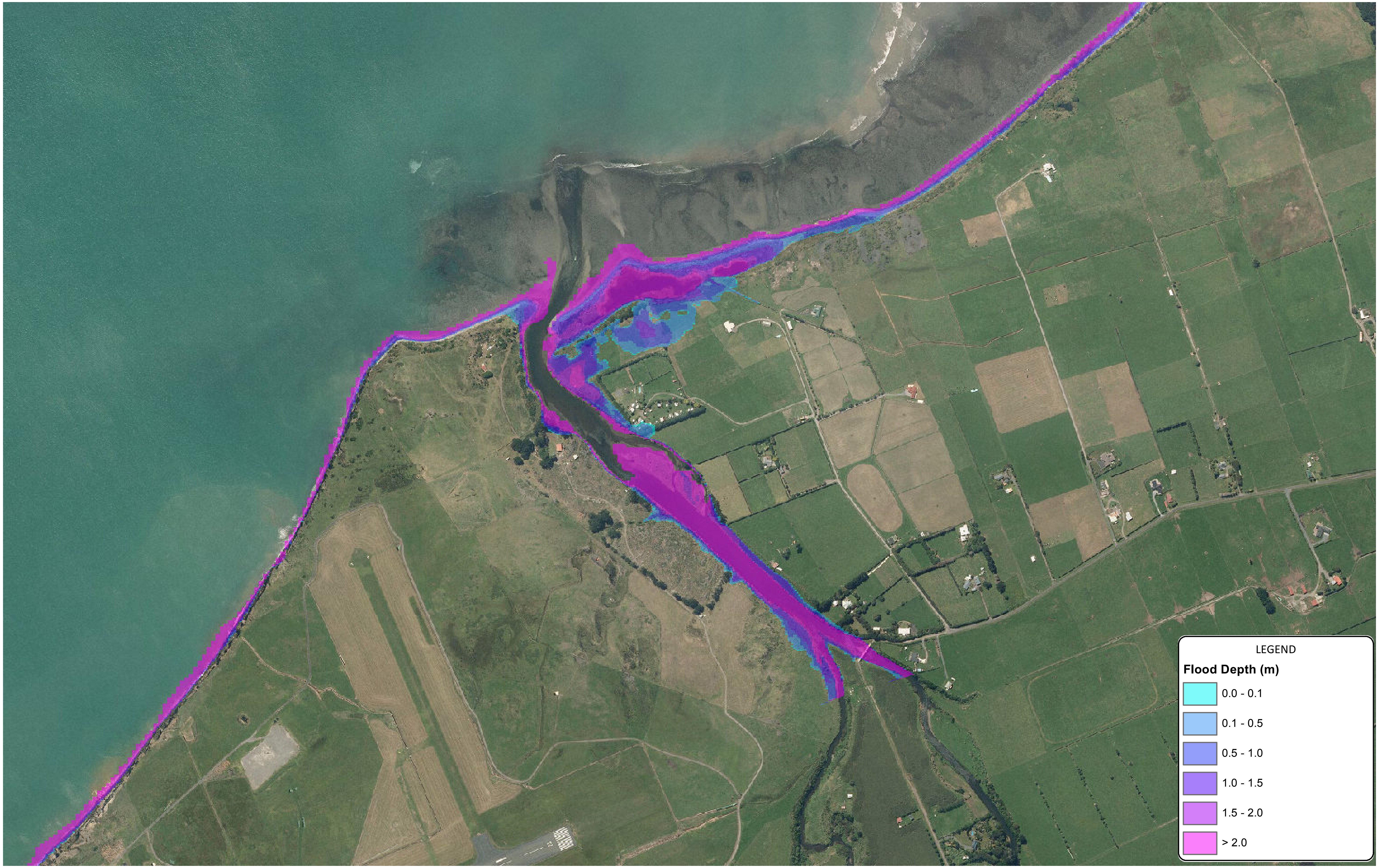
ARCFILE 31423-100-NPDC004.mxd		
SCALE (AT A3 SIZE) 1:7,500		
PROJECT No.		

NEW PLYMOUTH DISTRICT COUNCIL
DISTRICT PLAN REVIEW: COASTAL MANAGEMENT
Flood Depth at 4.0m TVD-70 Water Level

FIGURE No. Bell Block

Rev. 2

Path: T:\Auckland\Projects\31423\31423.1000\WorkingMaterial\GIS\MapDocuments\31423-100-NPDC004.mxd Date: 22/06/2016 Time: 11:28:08 a.m.



Notes: Aerial photograph sourced from LINZ and licensed under CC BY 3.0 NZ. Territorial Authorities sourced from Statistics New Zealand and licensed under CC BY 4.0
Levels in terms of Taranaki Vertical Datum 1970 (TVD-70) = Mean Sea Level – 0.15m

A3 SCALE 1:7,500

0 0.2 0.4 0.6 0.8 (km)

N

Location Plan

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ARCFILE 31423-100-NPDC004.mxd
SCALE (AT A3 SIZE) 1:7,500
PROJECT No.

NEW PLYMOUTH DISTRICT COUNCIL

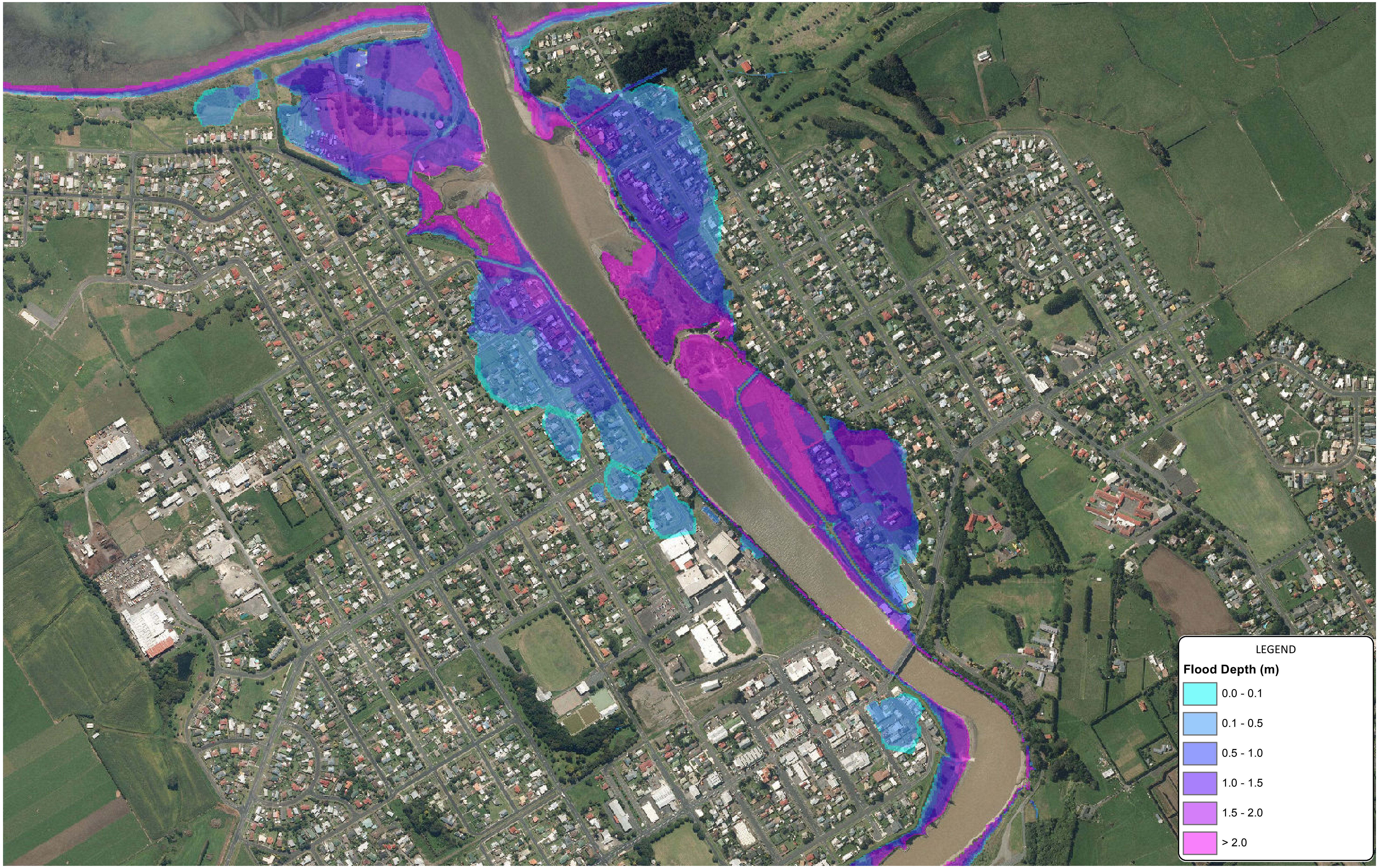
DISTRICT PLAN REVIEW: COASTAL MANAGEMENT

Flood Depth at 4.0m TVD-70 Water Level

FIGURE No. Waiongana

Rev. 2

Path: T:\Auckland\Projects\31423\31423.1000\WorkingMaterial\GIS\MapDocuments\31423-100-NPDC004.mxd Date: 22/06/2016 Time: 11:28:18 a.m.



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Levels in terms of Taranaki Vertical Datum 1970 (TVD-70) = Mean Sea Level – 0.15m

A3 SCALE 1:7,500

0 0.2 0.4 0.6 0.8 (km)

N

Location Plan

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SCALE (AT A3 SIZE) 1:7,500

PROJECT No.

NEW PLYMOUTH DISTRICT COUNCIL

DISTRICT PLAN REVIEW: COASTAL MANAGEMENT

Flood Depth at 4.0m TVD-70 Water Level

FIGURE No. Waitara without Stopbanks and Gabion Walls

Rev. 2

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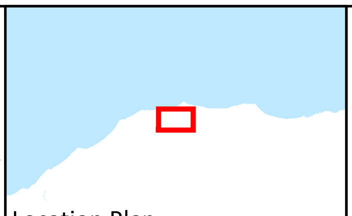
Levels in terms of Taranaki Vertical Datum 1970 (TVD-70) = Mean Sea Level – 0.15m

A3 SCALE 1:7,500

0 0.2 0.4 0.6 0.8 (km)



Location Plan

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ARCFILE
31423-100-NPDC006.mxd
SCALE (AT A3 SIZE)
1:7,500
PROJECT No.

NEW PLYMOUTH DISTRICT COUNCIL
DISTRICT PLAN REVIEW: COASTAL MANAGEMENT
Flood Depth at 4.0m TVD-70 Water Level

FIGURE No. Waitara with Stopbanks and Gabion Walls

Rev. 2

Path: T:\Auckland\Projects\31423\31423.1000\WorkingMaterial\GIS\MapDocuments\31423-100-NPDC006.mxd Date: 22/06/2016 Time: 11:35:55 a.m.

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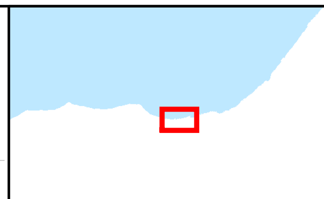
Levels in terms of Taranaki Vertical Datum 1970 (TVD-70) = Mean Sea Level – 0.15m

A3 SCALE 1:7,500

0 0.2 0.4 0.6 0.8 (km)



Location Plan

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ARCFILE 31423-100-NPDC004.mxd

SCALE (AT A3 SIZE) 1:7,500

PROJECT No.

NEW PLYMOUTH DISTRICT COUNCIL

DISTRICT PLAN REVIEW: COASTAL MANAGEMENT

Flood Depth at 4.0m TVD-70 Water Level

FIGURE No. Onaero

Rev. 2

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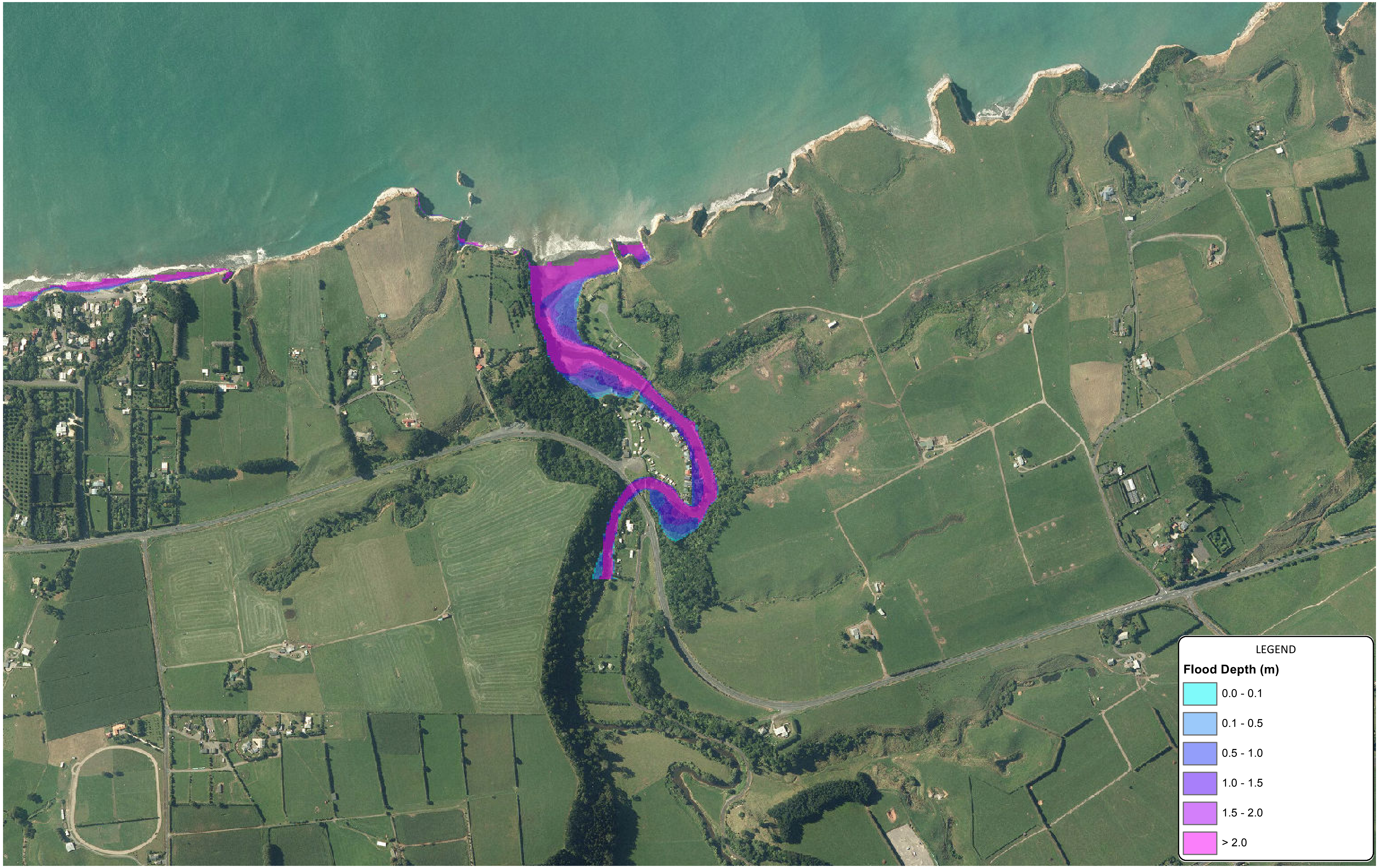

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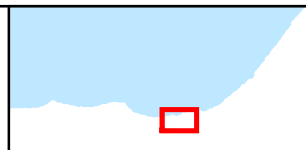
Levels in terms of Taranaki Vertical Datum 1970 (TVD-70) = Mean Sea Level – 0.15m

A3 SCALE 1:7,500

0 0.2 0.4 0.6 0.8 (km)



Location Plan

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ARCFILE
31423-100-NPDC004.mxd
SCALE (AT A3 SIZE)
1:7,500
PROJECT No.

NEW PLYMOUTH DISTRICT COUNCIL
DISTRICT PLAN REVIEW: COASTAL MANAGEMENT
Flood Depth at 4.0m TVD-70 Water Level

FIGURE No. Onaero Motorcamp

Rev. 2

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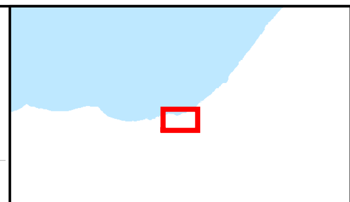
A3 SCALE 1:7,500

0 0.2 0.4 0.6 0.8 (km)

N



Location Plan

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ARCFILE
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SCALE (AT A3 SIZE)
1:7,500
PROJECT No.

NEW PLYMOUTH DISTRICT COUNCIL
DISTRICT PLAN REVIEW: COASTAL MANAGEMENT
Flood Depth at 4.0m TVD-70 Water Level

FIGURE No. Urenui

Rev. 2

Path: T:\Auckland\Projects\31423\31423.1000\WorkingMaterial\GIS\MapDocuments\31423-100-NPDC004.mxd Date: 22/06/2016 Time: 11:29:00 a.m.

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