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Executive summary

Tauranga City Council (TCC) engaged Tonkin & Taylor Ltd (T&T) in February 2009 to undertake a Study analysing flood inundation levels within the City Council boundaries around Tauranga Harbour. This review Study is consistent with the Operative District Plan Method of:

6.1.8.2(2) - Harbour flooding levels will be reviewed at least every 5 years, taking into account of any new data collected, and sea level rise or fall projections.

The output is a GIS layer showing potential areas of inundation (Figure 6-3 page 27). T&T recommend that this replaces the operative Flood Hazard Area. T&T also recommend that it be incorporated through the Review of the Tauranga District Plan process and notified as part of the Proposed City Plan.

This Study uses the results from a previous 2008 T&T Study on the ‘Reassessment of the Tauranga District Inundation Levels’, including TCC’s LiDAR data to estimate wave run-up levels in specific areas around the Tauranga Harbour. Building on the outcomes of the T&T Study on the ‘Reassessment of the Tauranga District Inundation Levels’, and recommended inundation levels, more precise inundation levels have been proposed.

Through the T&T Study on the ‘Reassessment of the Tauranga District Inundation Levels’, inundation levels were calculated based on the Still Water Level (SWL) expected from a 2% AEP storm event (1 in 50 year flood level), combined with sea level rise estimated for 2100. A freeboard allowance was added to account for wave run-up and other local factors.

This Study used a digital terrain model derived from TCC’s LiDAR data, together with the numerical modelling results from the T&T Study on the ‘Reassessment of the Tauranga District Inundation Levels’ Study. Areas of shallow slope and/or high potential wave run-up have been identified. Analysis of ground slope over individual cross section profiles then enabled an improved assessment of wave run-up. To undertake this work the standard methodology published by the United States Federal Emergency Management Agency has been utilised.

Over most of the eastern shores of the Tauranga Harbour Study area, the recommended inundation levels remain unchanged from those determined through the T&T Study on the ‘Reassessment of the Tauranga District Inundation Levels’.

Many of these areas initially identified as having potential wave run-up are in fact flat floodplains. The frictional effects associated with these areas will however dissipate wave energy before significant run-up occurs.

Over other areas of the Harbour, the inundation level is based on the SWL and calculated wave run-up. A freeboard of 0.3 metres is also added to all areas to account for local effects not resolved within the numerical modelling.

The recommended inundation levels have also been verified against observations of wave debris lines following Cyclones Fergus and Drena. The observed wave debris

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1 The Report T&T, 2008. Reassessment of the Tauranga District Inundation Levels. Tonkin and Taylor Client report, Ref 22288 should be read in conjunction with the outcomes of this Study.
lines were found to match the predicted inundation levels relatively accurately. Only at one inner harbour location (Memorial Park) was the predicted inundation level higher than observed.
1 Introduction

1.1 Background

Tauranga City Council (TCC) is currently reviewing its Operative District Plan. Through the process to review the Operative District Plan the Council has considered it timely to undertake a review of the existing inundation areas in accordance with the Operative District Plan Method of:

- 6.1.8.2(2) – Harbour flooding levels will be reviewed at least every 5 years, taking into account of any new data collected, and sea level rise or fall projections and;
- as currently shown on the Operative Planning Maps for harbour inundation.

TCC commissioned Tonkin & Taylor Ltd (T&T) in 2008 to undertake a re-assessment of extreme inundation levels within the Tauranga Harbour. This current Study is based on the methodology and outcomes of a previous assessment carried out in 1999 by T&T. The 1999 Study identified areas that were at risk from harbour inundation. The outcomes of this work were utilised in defining areas at risk on the Operative District Plan Maps.

1.2 Scope of works

The scope of works of the present Study is to more accurately calculate wave run-up levels in specific areas. These can then be super-imposed onto the Still Water Level (SWL) to give more precise inundation levels. By intersecting the predicted inundation levels with a Digital Terrain Model (DTM) of the Tauranga Harbour, a line/polygon showing the expected area of inundation can be obtained. T&T recommend that this GIS layer replaces the operative Flood Hazard Area. T&T also recommend that it be incorporated through the Review of the Tauranga District Plan process and notified as part of the Proposed City Plan.

This Study utilises TCC’s LiDAR topographic data supplied to make a DTM of the Tauranga Harbour. This has allowed for a more accurate calculation of ground slope to be undertaken.
2 Context

The purpose of this Section is to set out a summary of the previous Studies and the parameters used in those Studies.

T&T undertook a re-assessment of extreme inundation levels within the Tauranga Harbour in 2008. This re-assessment was used to assist in considering any possible changes to the existing levels of inundation risk during 50 and 100 year return period storm events. The results were based on a numerical model to calculate inundation levels for 50 and 100 year return period storm events (more accurately termed the 2% and 1% annual exceedence period (AEP) events) to update an empirical model Study carried out in 1999 by T&T. The numerical model calculated sea level from:

- astronomical tides
- inverse barometer effect
- wind stress
- sea level rise of 0.2 m by 2050 and 0.50 m to 2100.

The resulting water level from combining these effects is referred to as the Still Water Level (SWL).

The 2008 Study provided very similar inundation levels to the empirical assessment method results presented in 1999, with the main differences due to increases in freeboard because of wave run-up effects which indicated potential overtopping areas which had not necessarily be used to define inundation levels at distances landward of the shoreline.

Additionally, a “freeboard” allowance of 0.25 metres was applied to account for local effects not resolved within the numerical model, including wave run-up as wave run-up is dependent on ground slope, requiring high resolution and accurate topographical data.

In the 2008 Study, the wave run-up was calculated using the equations of Mase presented in the USACE Coastal Engineering Manual (2006) to give the run-up from the highest 2% of waves (R2%). These equations typically over predict wave run-up and can be considered as the upper envelope of possible run-up.

It was therefore considered acceptable to retain the minimum inundation levels derived from the 1999 Study consistent with the Operative District Plan Methods of:

6.1.8.1(3) – Apply a rule restricting subdivision and development of land susceptible to flooding or inundation, and apply a minimum building floor height; and

6.1.8.2(2) – Council will monitor through its tide gauge network, and in conjunction with Environment Bay of Plenty, parameters that may affect harbour levels, although it was noted within the Study that the inundation extents would need further analysis and verification once TCC had relevant LiDAR survey data available.

For this assessment, T&T have increased the freeboard to 0.3 metres to provide allowance for local effects and potential sea level rise effects greater than the 0.5 metres. In T&T’s opinion, this provides consistency with the recommendations made in the recent Ministry for the Environment (2008) Coastal Hazard and Climate Change Guidelines.
3 Project data

3.1 Project coordinate system

Consistent with the methodology used in the 2008 T&T Study, the coordinate system used throughout this report is NZTM and Moturiki Datum (MD) in the vertical. Note that MD is 0.96 metres above Port of Tauranga Chart Datum.

3.2 Topographical data

This Study utilises LiDAR data to obtain a Digital Terrain Model (DTM), provided by TCC. From this, contour lines corresponding to modelled water level surfaces have been obtained. The DTM was also used to calculate ground slopes at specific locations. LiDAR data is an excellent source of data in that it provides high resolution coverage of the Study area (Tauranga Harbour). However, laser penetration through the water column is minimal, thus the topographical data is only accurate to the level of the water surface at the time the LiDAR was flown. Similarly, LiDAR picks out the highest point, which may be a roof top or tree canopy. This can be removed by post processing to obtain the ‘bare earth’ topographical surface. Bare-earth LiDAR is typically made by filtering out non-ground returns (buildings, trees and bushes, cars, and the like) from the raw laser returns using point classification, return number, and other criteria. In highly built-up areas, this processing can generate artificially smoothed lines, or pick out the incorrect elevation.

TCC’s LiDAR data that was provided for this Study provided has been post-processed to give bare-earth values. The DTM of the LiDAR data is shown in Figure 3-1.
Aerial photographs have been utilised as an additional source of information for this Study. For example, profiles have been taken across gardens and parks where possible, to avoid confusion in elevations due to non-point returns.

3.3 Area of study

The Study area includes the jurisdictional area of all of Tauranga City’s coastline within the Tauranga Harbour, identified as the Coastal Marina Area (i.e. not landward of CMA boundaries of streams and rivers). The boundaries of the Study area are shown in Figure 3-2 which gives the ward boundaries superimposed on the aerial photographs used.
Figure 3-2. Aerial photograph of Tauranga Harbour showing outline of City ward boundaries and Study area.
4 Methodology

The model results of the 2008 T&T Study were used to give a 10 metre x 10 metre grid of water surface elevations across the harbour for:

a) The SWL, corresponding to the combined tide and storm surge for a 2% AEP event, plus 0.5 metre to account for sea level rise to 2100. The 2% AEP was calculated from analysis of local tidal records.

b) The SWL plus estimated wave run-up. The outcomes of the 2008 T&T Study estimated the run-up of the highest 2% of waves across the whole of the harbour from:

\[ R_{2\%} = 1.86 H_0 \xi_0^{0.71} \]

Where:
- \( H_0 \) = significant wave height
- \( \xi_0 \) = the Irribarren number = \( S / (H_0 / L_0)^{0.5} \)
- \( S \) = slope of the upper beach face
- \( L_0 \) = deepwater wavelength = \( 1.56 T^2 \)
- \( T \) = wave period

Using advanced GIS techniques the water surface elevations were mapped onto the DTM of the LiDAR topographical data. The SWL water surface was made to intersect with the DTM surface, by extrapolating from the nearest grid node. The intersection of the two surfaces results in a ‘contour’ line. The process was repeated for the SWL+ wave run-up surface, resulting in a second line, further inland.

The horizontal distance, \( L \), between these two lines was then obtained. This is shown diagrammatically in cross section in Figure 4-1. The Figure also illustrates how the water surfaces and the DTM can have multiple intersects which required some manual analysis when determining the correct horizontal distance, \( L \).

![Figure 4-1. Diagrammatic cross section showing methodology of intersecting the SWL (dashed line) and SWL + wave run-up (dash-dot line) surfaces with the DTM (solid line). Extrapolation from the nearest model grid point was required (red lines). The topography can result in some areas having multiple intersects, as illustrated on the right hand side of the SWL line.](image-url)
Figure 4-2 shows a GIS map where points on the model grid have been colour coded according to the distance L. Distance L effectively gives a joint measure of ground slope and wave run-up potential. There is potential for significant wave run-up to occur over gently sloping areas (shown in red). Run-up may also be significant where there is a coastal bund and low lying areas landward of the bund which has some opening to the Tauranga Harbour, and therefore may be affected by inundation. Such a bund may be formed by a road embankment or causeway. It is in these areas that wave run-up is required to be determined more accurately than in the 2008 T&T Study.

For very shallow slopes, frictional effects reduce the wave energy and run-up. Thus areas of effectively flat slope, or protected from wave run-up by mangroves, were discounted from further analysis.

Due to the grid resolution and interpolation required, this calculation of L was not relied upon as an accurate measure. It was used only as a guide to identify areas for further analysis.

Cross section profiles through the DTM were taken at several locations within the ‘red’ zones of Figure 4-2. Profiles deemed to be ‘typical’ of the local area were chosen. Aerial photographs were used to assist in this. Also, profiles traversing open ground were selected in preference to built-up areas where the DTM may not be true ‘bare-earth’ LiDAR.

For these profiles, more accurate values of the distance L were obtained by drawing the water surface elevations on the cross section profile. Profiles having a distance L less than 10 metres were discarded from further analysis. Of the remaining profiles (shown in yellow in Figure 4-2), further analysis was undertaken. These are the labelled profiles in Figure 4-2.

A methodology recommended by the United States Federal Emergency Management Agency (FEMA 2007) was used. R’ was calculated as the difference between the SWL+wave run-up and the SWL lines. The inland (horizontal) limit of run-up is obtained from Figure 4-3, using a typical ground slope. The new vertical run-up prediction is then simply the inland limit of run-up multiplied by the ground slope.

Note that Figure 4-3 is in feet and for all the regions analysed in this Study, R’ is in the order of 0.7 metres (2 feet). This is verging on the lower limit of accurate applicability of this method.

In areas where backshore flooding could occur through breaches in causeways, or through culverts, the approach utilised was to evaluate the additional impact of wave run-up on driving water through the opening. This was undertaken using a broad crested weir equation to assess the additional flow over a tide, with the volume divided by the area landward of the barrier. If the resulting water level was significant, the inundation level was based on the flood still water level plus the additional set-up due to waves and a 0.3 m freeboard.

Section 5 presents the results of this analysis for each profile. The potential for inundation is discussed with particular regard to wave run-up. Where run-up is significant, new inundation levels are suggested.
Figure 4-2. Colour coded line showing the horizontal distance between where the SWL and SWL+run-up surfaces intersect the topographical surface. Red indicates where the distance is greater than 10 m and can therefore potentially lead to wave run-up.
Figure 4-3. FEMA (2007) method for calculating inland limit of wave run-up, based on theoretical wave run-up $R'$. 
5 Results: inundation maps and levels

In this Section, individual profiles are examined to assess potential wave run-up. For each profile, the SWL is presented and the ground profile plotted. The ground slope is analysed using the FEMA (2007) methodology and the new recommended inundation level presented.

5.1 The Mall, Mt Maunganui

Previously calculated SWL: 2.06 metres

The 2% AEP event and 2100 SLR SWL level for this area is 2.06 metres above MD, and the computed maximum wave run up is 2.90 metres (Figure 5.1). This value should remain for the shoreline within 20 metres of the SWL.

The area has a beach backed by a foreshore embankment, having a crest level of approximately 2.5 – 2.8 metres, which is above the SWL. However, the ground profile shows that behind the road the ground level may fall to below the SWL, making this area liable to inundation. A single representative ground profile is not applicable in this area, and four typical ground profiles are shown, with Profile 1 being to the north end of the Mall and 4 to the South. In general, the northern part of this area has a lower ground profile. Flood waters may reach this area by:

- breaching of the foreshore embankment (e.g. through beach access walkways);
- freshwater storm run-off (rain induced overland flow);
- wave run-up overtopping the foreshore embankment. The FEMA (2007) methodology indicates that a flood depth of 0.22 metres should be applied landward of the embankment crest “until it encounters other flooding” (e.g. due to rainwater).

The recommended inundation level landward of the Harbour edge is 2.6 metres, based on a SWL of 2.06 metres an additional 0.22 metres for inundation, plus a freeboard allowance of 0.3 metres (i.e. 2.6 metres RL with rounding).

Recommendation:

2.9 metres remains as a level for the area within 20 metres landward of the SWL, 2.6 metres for the area landward of this.
Figure 5-1. Profile for The Mall, Mt Maunganui.
5.2 Port South

Previously calculated SWL: 2.09 metres

The east facing shoreline of the Tauranga Port has potential for wave run-up effects adjacent the Harbour Bridge western approach. A typical section through the Port yard gives a slope of 0.0217, giving a wave run-up of 0.13 metres (approximately 6 metres inland run-up). The recommended inundation level for this area is SWL + 0.13 metres plus a freeboard allowance of 0.3 metres.

Recommendation:

Inundation level: 2.5 metres

Figure 5-2. Port South profile.
5.3 Tauranga Airport

Previously calculated SWL: 2.18 metres

The Harbour area of the Airport is characterised by very flat, low lying land. The typical profile shown in Figure 5-3 identifies the ground profile to vary between approximately 1.8 and 2.2 metres, which is generally less than the SWL. Under a 2% AEP event with 2100 SLR, this area will be inundated with up to 0.4 metres water depth for approximately 250 metres (up to the runway embankment). Waves will transverse this low-lying area, but will be subject to friction decay, so additional wave run-up will be minimal. Using the FEMA (2007) methodology, with a composite slope of 0.001, the estimated run-up at the runway embankment is calculated to be $5 \times 10^{-3}$ metres (i.e. negligible). The recommended inundation level for this area remains unchanged at the SWL plus a freeboard allowance.

Recommendation:

Inundation level remain at 2.5 metres

![Figure 5-3. Profile near the Tauranga Airport.](image-url)
5.4  Te Maunga oxidation ponds

Previously calculated SWL: 2.3 metres

The area adjacent to the Te Maunga Oxidation Ponds is flat and low-lying, intersected by drainage channels, bunds and fences. The profile shown is immediately north of the oxidation ponds, but is characteristic of the wider area. Most of the ground is below the SWL and is thus subject to potential inundation. However, wave run-up will be negligible due to the Harbour edge vegetation (mangroves) and frictional decay of waves over the shallow inundation area. The recommended inundation level for this area remains unchanged at the SWL plus a freeboard allowance.

Recommendation:
Inundation level 2.6 metres

![Figure 5-4. Profile of the area near the Te Maunga Oxidation Ponds.](image)
5.5 **Merivale**

**Previously calculated SWL: 2.3 metres**

The residential area by Merivale is low-lying, much of it below the SWL, however is protected by an embankment /walkway and foreshore reserve with bush. The embankment has a crest level above the computed maximum run-up height, thus direct harbour inundation should be minimal. However, there are a number of drainage channels to allow discharge of rainwater through the embankment. Harbour waters may enter the low-lying residential area by means of these channels. Coupled with rainwater, this area is subject to potential inundation though the effects of wave run-up. It is noted however that the effects of any inundation will be negligible.

The recommended inundation level for this area remains unchanged at the SWL plus a freeboard allowance. T&T note that in this area the provision of well maintained storm flood gates or similar structure/device/method may reduce the harbour inundation flood risk.

**Recommendation:**

*Inundation level 2.6 metres*

![Figure 5-5. Merivale Profile.](image)
5.6 **Memorial Park**

*Previously calculated SWL: 2.15 metres*

Memorial Park, and some of the surrounding residential areas has ground slopes which may potentially give rise to elevated inundation levels due to wave run-up. The ground has a typical slope of 0.0125. Using the FEMA (2007) methodology, the potential wave run-up is 0.1 metres (an inland run-up distance of approximately 7 metres). The recommended inundation level for this area is SWL + 0.1 m, plus a freeboard allowance of 0.3 m.

**Recommendation:**

*Inundation level: 2.6 metres*

![Figure 5-6. Memorial Park Profile.](image-url)
5.7 The Strand (Tauranga CBD)

Previously calculated SWL: 2.1 metres

The Strand harbour edge consists of a carpark which is potentially subject to inundation by the SWL and has a ground slope which could potentially give rise to elevated inundation levels due to wave run-up. Taking an average ground slope from the crest of the small bluff just above SWL to where the ground interests the SWL + wave run-up level (as shown), a slope of 0.0086 is calculated. Using the FEMA (2007) methodology, the inland incursion of the wave run-up is 11.6 metres. This is a potential vertical inundation level of approximately + 0.1 metres. The recommended inundation level for this area is SWL + 0.1 m plus a freeboard allowance of 0.3 m.

Recommendation:
Inundation level: 2.5 metres

![Figure 5-7. The Strand, Tauranga CBD Profile.](image-url)
5.8 Sulphur Point East

Previously calculated SWL: 2.00 metres

The eastern shoreline of Sulphur Point is low lying and potentially subject to inundation by the SWL between Marine Park and Chapel Street. The typical profile for this area is shown in Figure 5-8. The land elevation in this area is generally less than the SWL. Under a 2% AEP event with 2100 SLR, this area will be inundated approximately 200 m inland to the railway embankment. Waves will transverse this low lying area, but will be subject to frictional decay and additional run-up will be minimal. The recommended inundation level for this region should therefore remain unchanged at the SWL plus a freeboard allowance.

Recommendation:

Inundation level: 2.3 metres

Figure 5-8. Sulphur Point East Profile.
5.9 **Sulphur Point West**

Previously calculated SWL: 2.09 metres

The western shoreline of Sulphur Point is potentially subject to inundation by the SWL south of the sand stockpile site. The ground slope could potentially give rise to elevated inundation levels due to wave run-up. A typical section through the area gives a slope of 0.0116. Using the FEMA (2007) methodology, the inland incursion of the wave run-up is 7 metres. This is a potential vertical inundation level of approximately + 0.1 metres. The recommended inundation level for this area is SWL + 0.1 m plus a freeboard allowance of 0.3 m.

**Recommendation:**

**Inundation level: 2.5 metres**

![Figure 5-9. Sulphur Point West Profile.](image)
5.10 Takitimu Drive: Wharepai Domain

Previously calculated SWL: 2.05 metres

Along Takitimu Drive, the harbour edge consists of a road embankment protected by rock armouring. At Wharepai Domain, the road level is above the SWL, protecting a lower lying area behind the road, however there is a stormwater outlet where backflushing could occur. Above the SWL, the ground slope is approximately 0.05, which can potentially give a wave run-up height of 0.11 metres, (approximately 2.2 metres inland run-up). The recommended inundation level for the harbour margin in this area is SWL + 0.11 metres, plus a freeboard allowance of 0.3 metres. Landward of the harbour edge wave driving effects are not considered significant and therefore the landward level is based on the SWL plus freeboard.

Recommendation:
Inundation level 2.5 metres within 20 metres of SWL, 2.4 metres landward.

Figure 5-10. Takitimu Drive: Wharepai Domain Profile.
5.11 Takitimu Drive: Selywn Street

Previously calculated SWL: 2.05 metres

Further south, in the residential area of Selwyn Street, the ground slope of the road is 0.04, which gives a potential wave run-up of 0.1 metres (approximately 2.2 metres inland run-up). The area behind the road however drops significantly below the SWL. Although nominally protected from harbour flooding, including wave run-up, by the embankment, this area will be subject to potential flooding from the combined effects of rainwater and harbour waters penetrating through the embankment. The recommended inundation level for this area is SWL + 0.1 m for the embankment, and the SWL behind the embankment plus a freeboard allowance.

Recommendation:
Inundation level 2.5 metres within 20 metres of SWL, 2.4 metres landward

Figure 5-11. Selywn Street profile.
5.12 Takitimu Drive: South

Previously calculated SWL: 2.12 metres

At the south end of Takitimu Drive, the slope above the SWL is slightly lower at 0.026, giving a wave run-up of 0.5 m (approximately 2.2 m inland run-up). The land behind the embankment however does not fall below the SWL, although there is an opening to the floodplains of Kopurereua Stream. Thus the recommended inundation level for the coastal edge (20 m landward from the SWL) should be the SWL + 0.5 m plus a freeboard allowance of 0.3 m. For the low lying areas adjacent to the stream, there is the potential for an additional 0.1 m set-up above the calculated SWL, which should be included with freeboard to provide a sea inundation level of 2.5 m for the upland area.

Recommendation:

Inundation level 2.9 metres along the harbour edge (20 metres from SWL), 2.5 metres landward.

Figure 5-12. South Takitimu Drive profile.
5.13 Kulim Park

Previously calculated SWL: 2.11 metres

The north facing shoreline from Harbour Drive to Fergusson Park also has potential for wave run-up effects. A typical section through Kulim Park gives a slope of 0.01, giving a wave run-up of 0.07 metres (approximately 7 metres inland run-up). The recommended inundation level for this area is SWL + 0.07 metres plus a freeboard allowance of 0.3 metres.

Recommendation:

Inundation level: 2.5 metres

Figure 5-13. Kulim Park Profile.
6 Inundation map

For areas within Tauranga Harbour where potential wave run-up is low, and the ground slope is steep, the recommended inundation level remains as specified in the 2008 T&T Study. The SWL plus freeboard form this Study is reproduced in Figure 6-1 for the whole of the Tauranga Harbour (within the jurisdictional boundaries of TCC).

In areas where wave run-up potential is high and the ground slope is shallow, a new recommended inundation level is calculated in Section 5. This is the SWL plus calculated wave-run-up, where applicable. In addition, a free-board allowance of 0.30 metres has been added to account for local effects, boat/vehicle wakes and uncertainty for climate change. These levels are shown in Figure 6-2.

These two inundation maps have been combined in Figure 6-3. This figure identifies the horizontal location where the calculated inundation water level intersects the LiDAR derived DTM. Further ‘smoothing’ of this line has been undertaken by T&T to provide an inundation line/polygon suitable for publication in Proposed Tauranga City Plan.

Significant areas of inundation within developed urban/suburban areas include:

1) The Mall, Mount Maunganui;
2) Sulphur Point / Marsh St; and
3) Harbour Drive
Figure 6-1. Inundation levels, taken from the T&T 2008 Study (including freeboard estimated on wave run-up potential).
Figure 6-2. Aerial identifying areas where wave run-up will add to SWL inundation levels. The colour coding gives the recommended vertical inundation level including the effect of wave run-up, binned to the nearest 5 cm. In addition a ‘freeboard’ allowance of 0.30 metres has been added.
Figure 6-3 Final recommended harbour inundation lines, obtained by intersecting inundation levels with the LiDAR DTM.
7 Verification with Cyclones Fergus and Drena

A first order verification of the recommended inundation levels is presented in this Section.

Observations of flotsum lines following Cyclones Fergus and Drena over December 1996/January 1997 from Gibb (1997) have been compared to the numerical predictions of harbour inundation. By removing 0.5 metres (corresponding to SLR from 1990 to 2100) from the predicted inundation, gives the calculated inundation levels at approximately the time of Cyclones Fergus and Drena. The freeboard allowance of 0.25 metres has also been removed for this comparison. Figure 7.1 identifies both the calculated inundation levels and the observed flotsum levels from Gibb (1997). The results are relatively accurate, indicating that the calculated inundation levels do match those of a real event. Most of the computed points are within 0.1 metres of the levels observed by Gibb, which is within the expected error band of this methodology and Gibb’s observations. The largest discrepancy is in the Memorial Park area, where the calculated inundation level is 0.25 metres higher than observed by Gibb. This discrepancy is expected to be due to local effects not resolved by the numerical model, however the calculated level provides a conservative value in comparison to the observed level and is continued to be a recommended inundation level.
Figure 7-1. Comparison of inundation levels (in metres above Moturiki Datum) with Gibb’s(1997) observations of flotsum lines following Cyclones Fergus and Drena. The upper values are as given by Gibb (1997), the lower values in italics are the predicted inundation levels, with 0.5 metres SLR removed and no freeboard allowance.
8 Conclusions

Inundation maps for Tauranga Harbour are calculated for a 2% AEP event and Sea Level Rise corresponding to 2100. Results of numerical modelling undertaken by T&T in 2008 were used in conjunction with recently available LiDAR data. The effect of wave run-up in specific areas of the harbour was calculated using a methodology recommended by the United States Federal Emergency Management Agency.

Many of the areas initially identified as having potential wave run-up are in fact flat floodplain areas. Frictional effects will dissipate wave energy before significant run-up occurs over these areas. Thus, over most of the eastern shores of the Study area, the recommended inundation levels remain unchanged from the recommended 2008 levels.

In other areas of the Harbour, new inundation levels are recommended, including provision for the harbour edge (typically within 20 metres of the SWL) and another value for the low-lying areas landward of this zone.

The inundation level for these areas is based on the SWL and calculated wave run-up. A freeboard of 0.30 metres is also added to account both for local effects not resolved within the numerical modelling and possible accelerated climate change effects.

The recommended inundation levels have been verified against observations of flotsum lines following Cyclones Fergus and Drena. The observed lines were found to match the predicted inundation levels relatively accurately. Only in one inner harbour location (Memorial Park), was the predicted inundation level higher than observed (a conservative result).

These levels and extents of inundation hazard should be reviewed after the next Intergovernmental Panel on Climate Change (IPCC) review which is expected in 2013. This is in accordance with Policy 6.1.9.2(4) of the Operative Tauranga District Plan, although it is possible that no change will be recommended at that time.
9 Applicability

This report has been prepared for the benefit of Tauranga City Council with respect to the particular brief given to T&T and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

TONKIN & TAYLOR LTD
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10 References


