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Townsville and Thuringowa City Councils

Townsville-Thuringowa Storm Tide Study

Final Report

Part A – Executive Summary

April 2007

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

Executive Summary

Aims

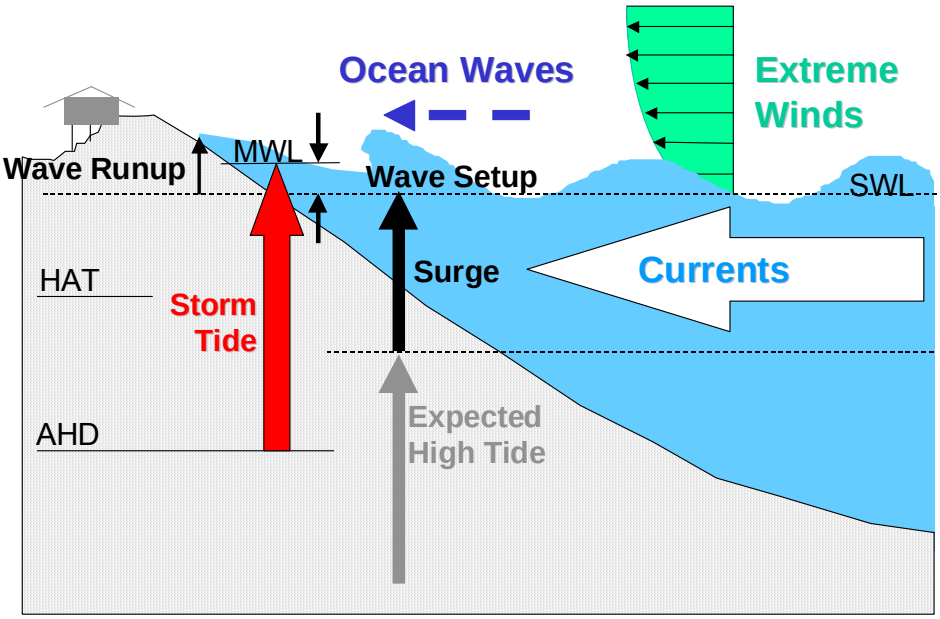
The Townsville-Thuringowa Storm Tide Study has been completed under the auspices of the Federal Government's Natural Disaster Risk Mitigation Program (NDRMP). The aim of this program is to minimise / reduce future costs associated with the occurrence of natural diasters through better planning processes.

For this study, the primary focus has been on the determination of inundation associated with a range of statistical storm tide events, and the levels of risk and exposure associated with predicted inundation.

In addition, the study was charged with developing a storm tide warning system (SEAtide), suitable for use by the Bureau of Meteorology (BoM) in managing storm tide threats in the Townsville/Thuringowa region.

Components of Storm Tide

Storm tide estimates comprise several elements, these being tide, surge, and wave setup, as illustrated below. An advantage offered by this study is that each component can be provided at each location, separately, or added together as storm tide. In addition, wave height predictions can be extracted from the model results. Localised wave runup has not been considered.



Methodology

A comprehensive analysis technique was applied, resulting in the prediction of storm tides associated with four recurrence intervals (50 years, 100 years, 500 years, and a 10,000 year event, which has been equated to the maximum likely storm tide event).

The methodology is in keeping with the Queensland Climate Change investigations, a report sponsored by the Bureau of Meteorology in Queensland and various State Government departments.

In keeping with this method, a series of mathematical models has been applied, resulting in the generation of calibrated wind, surge and hydrodynamic models. Results from these runs have been input into a parametric model, which was then run in a Monte-Carlo simulation, with 50,000 years of cyclones and storm tides simulated.

With respect to inland inundation, two prediction methods were utilised. Estimates of storm tide (with and without wave setup) were determined at 560m intervals along the coastline for each of the four design recurrence intervals. For the purposes of comparison, the values without wave setup were then extrapolated inland using GIS procedures.

Hydrodynamic modelling (Delft package) was then used to simulate the inland flow / penetration of the storm tide, with wind stress and friction effects accounted for. These model runs do not include wave setup, which applies only at points on the coast where the land height exceeds the predicted surge height. The DELFT model runs tend to provide higher levels inland, where low-lying land extends well inland, and where there are no hills or barriers to wind.

A comparison of predicted levels (extrapolated open coast without setup and DELFT overland flow method) was then made, with the higher of the two predictions adopted at all locations.

Data

Significant data resources were required to enable the completion of this project. These include a database of historical cyclones, offshore bathymetric (sea-floor) data, tidal data, topographic and cadastral data (provided by each Council), and knowledge of the location and details of key infrastructure.

Tropical Cyclone Climatology

This study has considered all available records with respect to cyclones passing within 500 km of Townsville, with reference to data dating back to the 1900s. However, given the lack of reliability of some of this data, statistical information has focussed on cyclones occurring since 1959/1960. During this time, some 45 cyclones have passed within 500 km, an average of 1.8 cyclones per season. The number of cyclones per season has varied from zero to five.

In assessing the climatology, consideration has been given to recorded intensities, probable maximum intensity, parameters such as radius to maximum winds, and the forward speed of cyclones.

Model Development

The model development process, referenced above in brief, uses four different modelling packages, three of which address the simulation of cyclonic winds and pressure, hydrodynamics (tides), and waves. A statistical model is then applied to generate the estimates of storm tide along the coastline.

The various models have been developed using a system of nested grids. The largest of these grids, which provides data as to the sea-bed and hence water depth, extends almost 800 km off-shore, and almost 1400 km along the coastline. The smallest grid is 30 km x 35 km, with a grid size of 55 m. The model development process is discussed in detail in Chapter 5 of the report. However, key features of this process include:

- Calibration to Cyclone Althea (1971)
- Verification against Cyclone Aivu (1989)
- Completion of sensitivity analysis model runs
- Modelling of over 350 theoretically possible cyclones, approaching on a number of different tracks.
- Simulation of a synthetic 50,000 year period (90,000 cyclones) using a statistical model.

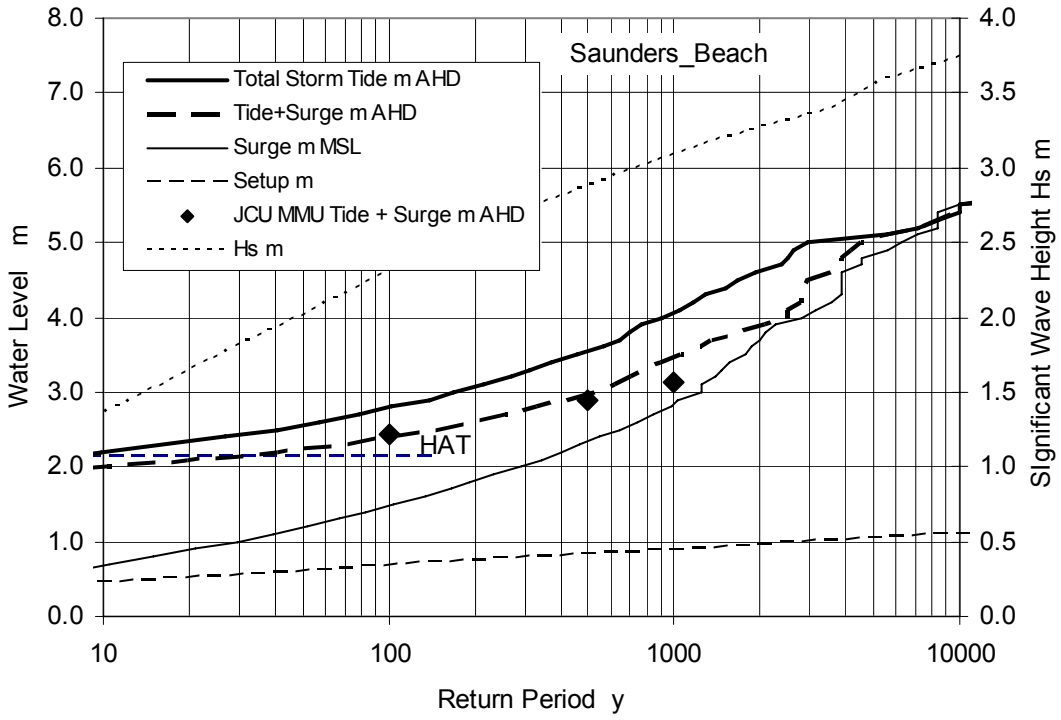
Storm Tide Levels

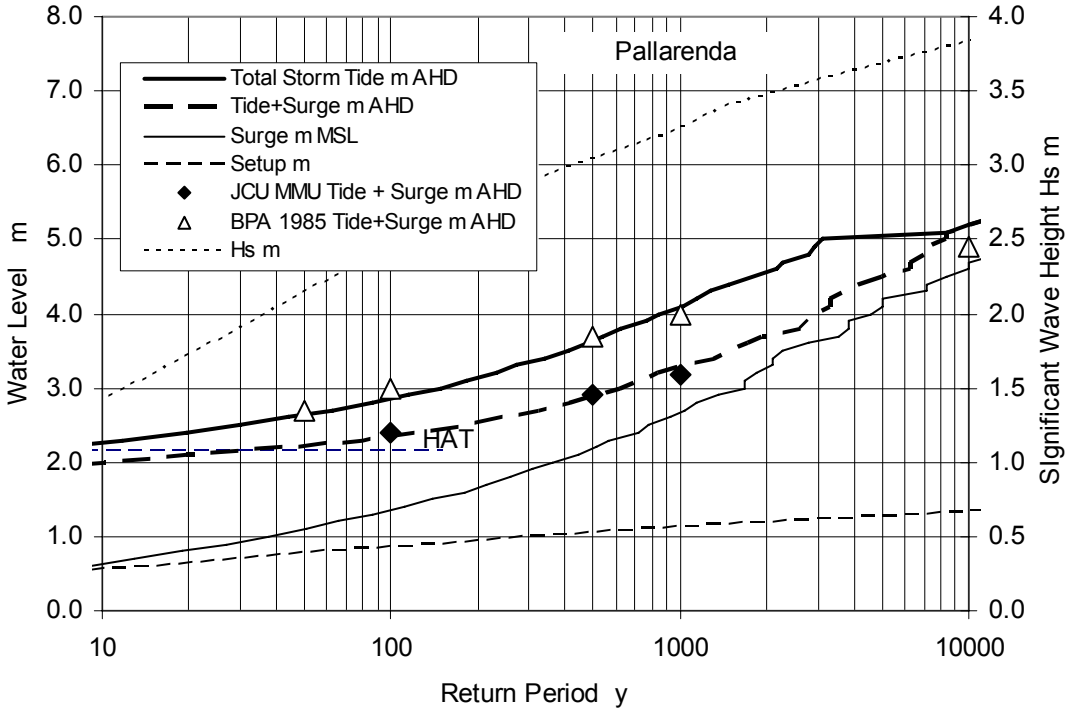
Storm tide levels have been estimated along the Townsville-Thuringowa coastline, extending inland to the maximum extent of inundation. A sample of the results in tabular form is presented below. Storm tide levels are presented relative to Australian Height Datum (AHD) and are inclusive of wave setup.

	Estimated Return Period of Total Storm Tide Level				
Site	**50 y**	**100 y**	**500 y**	**1000 y**	**10000 y**
Crystal_Creek	2.8	3.1	4.0	4.1	7.3
Balgal	2.7	3.0	4.0	4.5	6.2
Rollingstone	2.6	2.9	3.8	4.4	6.0
Mystic_Sands	2.7	3.0	4.0	4.7	6.2
Surveyors Creek	2.7	3.0	3.5	3.8	6.0
Toolakea	2.6	2.8	3.1	3.4	5.3
Bushland_Beach	2.6	2.9	3.6	4.0	5.3
Bohle_River	2.2	2.3	2.8	3.2	4.8
Pallarenda	2.6	2.9	3.6	4.1	5.2
Kissing_Point	2.7	2.9	3.8	4.3	5.5
North_Ward	2.7	3.0	3.9	4.4	5.4
Nelly_Bay	2.5	2.7	3.3	3.7	5.0

The figures below provide an illustration of the relative magnitude of each of the individual components of storm tide. Examples are presented for Pallarenda and Saunders Beach.

The figures also provide comparisons with previous JCU and BPA studies for estimated surge plus tide levels (not including wave setup). The present surge plus tide results are consistent with latest JCU estimates, and both are of the order of 0.5 m lower than BPA studies done in 1985. In many locations, this means that the present total storm tide levels (including wave setup) are similar to the 1985 studies estimates without allowance for wave setup.





Mapping

A comprehensive set of maps has been produced for each of the nominated events. These have been produced in several formats, illustrating inundation extent, water surface level and water depths at all locations within the affected area. Maps have been organised into a series of grids, with 8 maps covering the Townsville area, and 10 for Thuringowa. On a comparative basis, the 50 and 100yr events show little difference in the extent of inundation, whereas the 10,000 yr event demonstrates significant inundation. This is most evident along the Thuringowa coastline, where modelling suggests that several metres of water may be added inland as waters are funnelled into valleys.

Overall, the areas most affected by inundation include the Bohle River floodplain and Town Common, areas to the south of Ross River, and to a lesser extent, several of the beachside communities of Thuringowa (Ollera Ck, north of Balgal, Bluewater Ck). Significant low-lying areas between Toomulla and Toolakea (i.e. Leichardt Ck and Christmas Ck) are also affected.

Greenhouse Effect

Greenhouse effects have been considered in terms of higher sea levels, warmer air and sea temperatures, the resultant impact on the likely maximum intensity of cyclones, and the potential increase in the incidence of cyclones.

Vulnerability

The vulnerability assessment has been based on application of a review of the predicted and mapped storm tide levels, and the implications for critical infrastructure, as identified in consultation with Townsville and Thuringowa Councils. Tables have been produced for each area, summarising property and population at of death risk for the range of storm tide events considered.

Thuringowa Properties and Population at Risk from Storm Tide Inundation

Study Area	50 yr ARI		100 yr ARI		500 yr ARI		10,000 yr ARI	
	P I	**PAR**	**P I**	**PAR**	**P I**	**PAR**	**P I**	**PAR**
Mutarnee	0	0	0	0	0	0	0	0
Rollingstone	9	25	14	39	14	39	310	868
Clement	0	0	0	0	0	0	89	250
Bluewater	1	3	8	22	35	98	184	515
Yabulu	3	9	9	25	32	90	254	711
Mount Low	1	3	2	6	9	25	845	2366
Total	**14**	**40**	**33**	**92**	**90**	**252**	**1682**	**4710**

Note: **P I** denotes number of properties inundated.
PAR denotes population at risk.

Townsville Property and Population at Risk from Storm Tide Inundation

Study Area	50 yr ARI		100 yr ARI		500 yr ARI		10,000 yr ARI	
	P I	**PAR***	**P I**	**PAR***	**P I**	**PAR***	**P I**	**PAR***
Annandale	0	0	1	3	1	3	495	1386
Arcadia	0	0	0	0	1	3	57	160
Belgian Gardens	0	0	1	3	47	132	212	594
Bohle	0	0	0	0	0	0	4	11
Cluden	0	0	1	3	1	3	107	300
Cungulla	0	0	19	53	23	64	245	686
Currajong	0	0	0	0	18	50	883	2472
Garbutt	0	0	0	0	6	17	687	1924
Gulliver	0	0	0	0	0	0	199	557
Hermit Park	6	17	9	25	121	339	1073	3004

Study Area	50 yr ARI		100 yr ARI		500 yr ARI		10,000 yr ARI	
	P I	PAR*	P I	PAR*	P I	PAR*	P I	PAR*
Horseshoe Bay	0	0	0	0	0	0	14	39
Hyde Park	1	3	1	3	113	316	452	1266
Mount Louisa	0	0	0	0	0	0	8	22
Mt St John	1	3	1	3	1	3	2	6
Mundingburra	0	0	0	0	0	0	358	1002
Mysterton	0	0	0	0	4	11	308	862
Nelly Bay	3	8	4	11	5	14	34	95
North Ward	0	0	0	0	42	118	233	652
Oonoonba	0	0	13	36	206	577	437	1224
Pallarenda	0	0	0	0	0	0	292	818
Picnic Bay	0	0	0	0	1	3	24	67
Pimlico	0	0	0	0	67	188	694	1943
Railway Estate	2	6	131	367	1000	2800	1087	3044
Rosslea	0	0	0	0	0	0	336	941
Rowes Bay	0	0	0	0	4	11	101	283
South Townsville	0	0	46	129	320	896	623	1744
Townsville City	0	0	0	0	6	17	14	39
West End	2	8	3	8	38	106	436	1221
West Point	0	0	0	0	0	0	7	20
Wulguru	0	0	0	0	0	0	76	213
Total	**15**	**45**	**230**	**644**	**2048**	**5734**	**10196**	**28549**

It must be stressed that predictions for the 10,000 year event have a much greater band of uncertainty than those for the smaller events, and should be treated as broad estimates only.

In addition, a review of the Disaster Management Plan has been undertaken. Typically, the only items affected by the results of this study are evacuation routes, as evacuation centres appear to be outside inundation zones.

SEAtide Warning System

As part of this study, a storm tide warning system, known as SEAtide, has been developed. SEAtide has been provided to the Queensland Regional Office of the Bureau of Meteorology, which agreed to trial the system during the 2005/2006 cyclone season. The system allows predictions of storm tide at the coast, based on an estimation of the location, track and characteristics of the cyclone.

For predictions of inundation away from the coast (i.e. inland penetration of storm tide), it will also be necessary to reference the water surface maps produced as part of this study, noting that in some cases, levels may increase.

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