Dune Erosion Impacts

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APPENDIX FIVE

Dune crest

Foredune

Tasmanian
Government

OBJECTIVES

This scenario was created to explore the level of protection afforded by the present (2015) Seven Mile Beach dune line, that separates Hobart Airport from the waters of Frederick Henry Bay, in the event of a major tsunami penetrating Frederick Henry Bay. Details of this tsunami are discussed elsewhere.

As a model was to be created capable of simulating erosion of these protective dunes at Seven Mile Beach, the opportunity was taken to investigate, at a lesser level of detail, the possible loss of protection at other potentially erosion prone sites in South Eastern Tasmania, as a guide to other sites that could warrant more detailed investigation in the future.

METHODOLOGY

Base Model

All scenarios in this review of Tsunami risk in South Eastern Tasmania share a common base model, developed by Rienco Consulting from an earlier model developed by Geoscience Australia (GA) in 2009. While sharing some content with the earlier GA model this new model included the latest available bathymetry and topography and added detailed spatially variable surface roughness data (Manning's n), in lieu of the single global value used in the earlier GA modelling. The domain boundary was retained, as used in the earlier GA modelling, but a more detailed distribution of mesh resolutions added in support of the various scenarios to be modelled. Details of this new base model (Scenario 2) are discussed elsewhere.

Scenario 5

As noted in the objectives, this Scenario was developed to explore erosion of the protective dune line along Seven Mile Beach during a major tsunami. As Anuga does not contain the necessary functionality to undertake this modelling, code in the form of an Anuga dune erosion operator was developed by Rienco Consulting to provide this functionality.

To enable this operator in the airport dunes, a polygon layer was created of the potential erosion zone. To provide the required level of detail near the airport, an extremely high resolution (10m triangles)

area was added in the potential dune erosion zone and a very high-resolution zone (20m triangles) added as a rectangular plot window in the general vicinity of the airport and dunes to ensure plots obtained were of an appropriate resolution.

In all other areas of potential interest, polygons containing the potential erosion zones were added to the erosion polygons layer (to enable the erosion operator) but resolutions were not increased above the basic coastal zone level (50m). Therefore, erosion modelling in these areas can provide a guide to the likelihood of dune erosion in these areas but will need to be subject to more detailed modelling, if the consequences of such erosion are significant.

The locations of the full range of dune erosion zones investigated are shown in Fig 3

Runtime Performance

The Scenario 5 model was run from an SSD on a hex core I7 Ubuntu PC with 64GB of memory. Initially this model was run with the parameter store_vertices_uniquely=TRUE but this created a very large (72GB) output (sww) file that presented difficulties when trying to view results. When reset and re-run with store_vertices_uniquely=FALSE the output file dropped to 26GB in size, which eliminated earlier viewing problems. The calculations are identical in both cases, and this parameter merely affects how the output is stored.

Both model runs took about 72 hours to simulate a four hour tsunami event.

File Structure

All model input data, the model code, model results and post processed results were separately provided on a usb drive to MRT in November 2016.

The file structure on this drive is as follows;

CHECKS
(Various files created and stored during the run associated with sanity checking what has been read in by the model during execution)

DATA
(Input files read in by the model scripts while building the model)

RESULTS
(the output sww file)

OBSERVATIONS

SPATIAL

(Various asci grid files of surface elevation at different times and water depth)

TIMESERIES

(Various xy plots of stage or depth at particular gauge locations, versus time)

SCRIPTS

(All python scripts needed to run the model (from model_run.py) are in this directory.

The simulation scripts have been written to permit execution on multiple cores. A simulation is typically run from the scripts directory in a terminal window as 'mpirun -np xx python model_run.py', where xx is the number of available processors.

The post processing scripts are run (on a single processor without mpi) from the same terminal window as python model_results_....py.)

SUMMARY

(This summary only)

Airport Dune Protection

As will be apparent in the following plots, the dune line along Seven Mile Beach would provide effective protection for the runway and terminal buildings in a tsunami event up to the magnitude of that modelled. For the most part, this arises because of the considerable reduction in the tsunami wave height as it travels into and through Frederick Henry Bay.

In the following Fig 1, the stage timeseries at a gauge located off the beach in Frederick Henry Bay shows a series of approaching waves all peaking below 3mAHD. As most of the Seven Mile beach dune line is at or above that level there are no significant breaches simulated in the model. The plan graphic shows the spatial distribution of wave heights as the first wave front reaches the beach. Some reflection and refraction patterning of the front is already evident in this graphic.

FIGURE 1: Airport Tsunami Stage Plot as First Wave Front Arrives
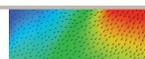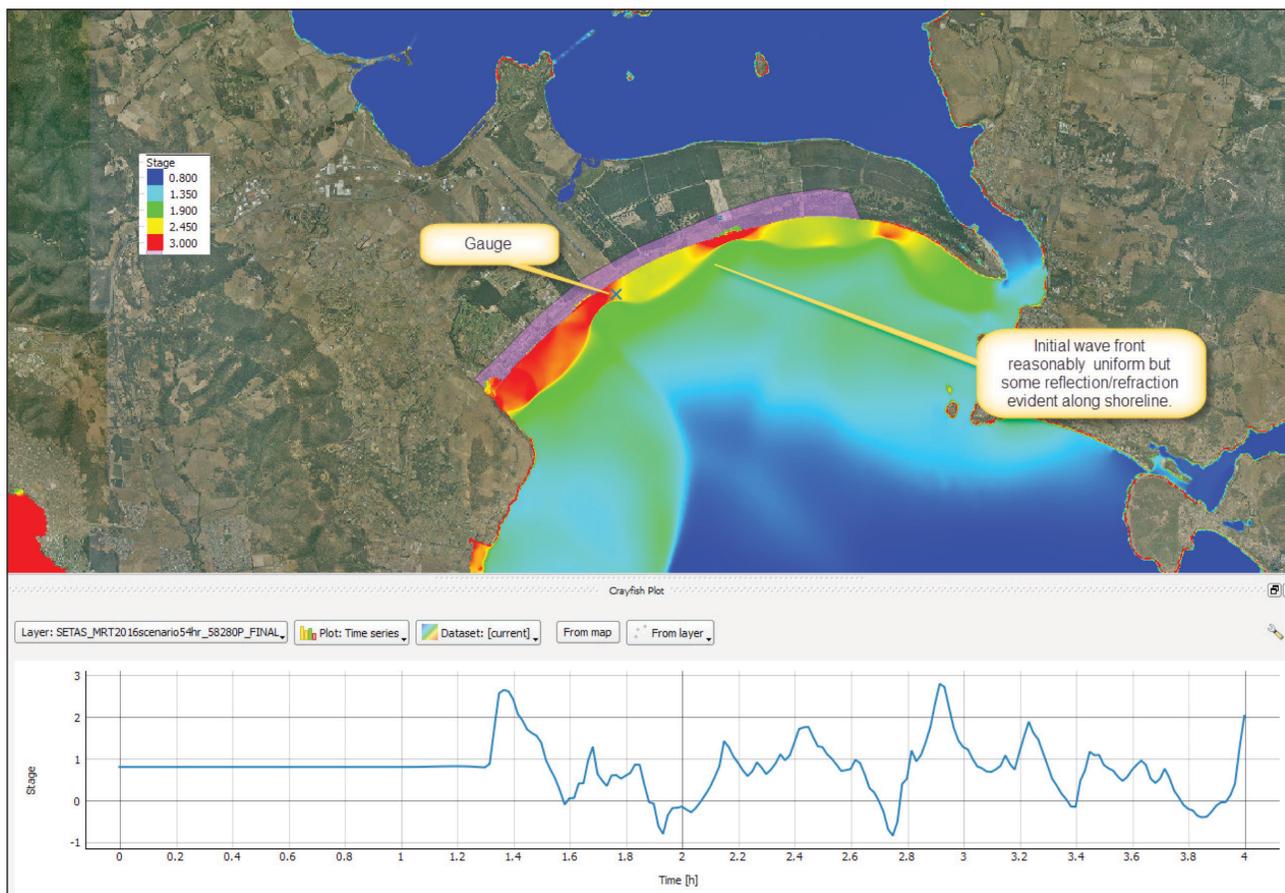
In Figure 2, the spatial disdtribution of wave heights is shown as the second highest wave front reaches the beach. As evident in this pattern, a considerably confused wave field now exists in the bay with little sense of an obvious front approaching the beach. There is considerable difference in the peak wave height at this instant along the beach but peak heights are again all below RL 3.00m AHD.

It is of importance to note, that significant portions of the dune line are however only marginally above the approaching wave run up height and relatively minor reduction in the dune height could create significant local breaches.

Other Dune Protection Areas

Generally

As noted in the Objectives, 12 other areas were included in this simulation to explore, in a preliminary manner, what other sites might exist on the South-East Coast that could be at increased risk from erosion of their protective dunes in a Tsunami. These additional sites were not modelled at the extremely high resolution that the Airport site was modelled at, creating modelling results that are therefore not as detailed as those available for the Airport site. They are however considered sufficient to highlight sites that may be worthy of further investigation.
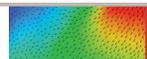
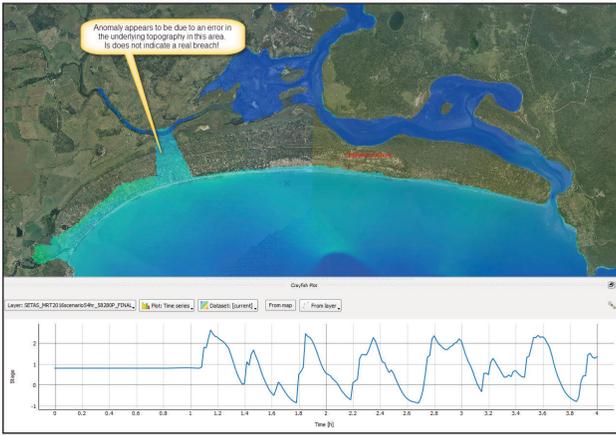Each additional site is shown on Figure 3 and discussed further in the following.

**FIGURE 2:** Airport Tsunami Stage Plot as Second Wave Front Arrives
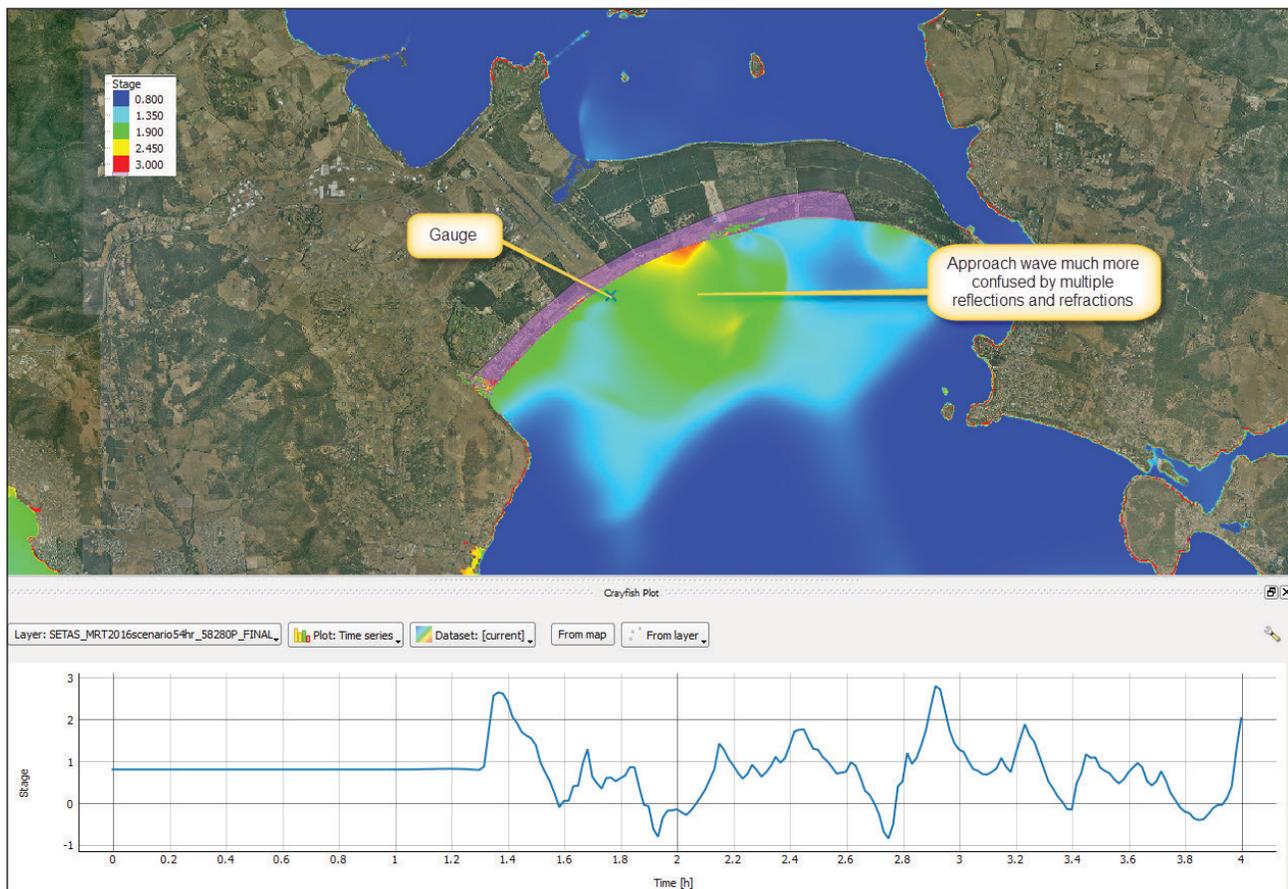
FIGURE 3: Sites Modelled in Scenario 5

Dolphin Sands Beach Dunes

Dolphin Sands is a development located in the dunes at the northernmost extent of Great Oyster Bay and while a candidate for dune erosion is heavily protected from a tsunami by Freycinet Peninsula and Schouten Island. This is readily evident in the much-reduced tsunami wave heights off the beach at this location. While an error in the underlying topography has created an anomalous breach, a quick comparison of peak wave height and land height indicates that the developed spit would not be overtopped or scoured in such an event.
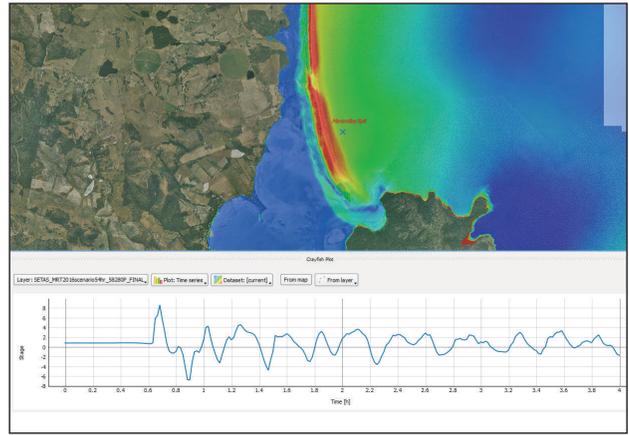
Marion Bay Spit Dunes

This modelling indicates that the tsunami would significantly overtop and erode the sand spit protecting Marion Bay, leading to elevated water levels in the Bay. While more detailed modelling will be required to confirm the resulting impacts, it seems likely that loss of the protective spit would increase the risk to residents and properties present on lower land around the bay's shore line. It is therefore considered prudent that tsunami impacts, including dune erosion, in this area be investigated in greater detail.
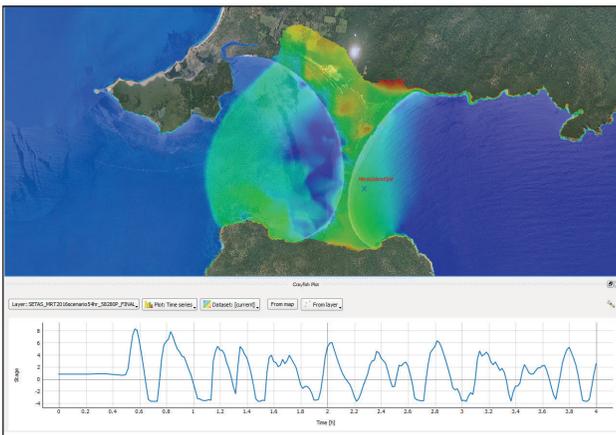
Maria Island Neck Dunes

The neck between north and south Maria Island provides the only land based access between the two island land forms.
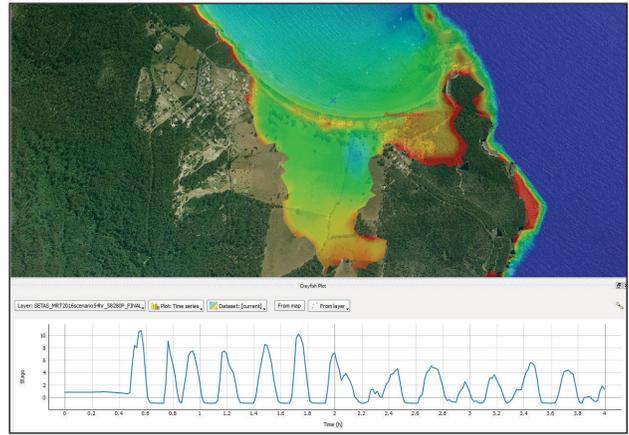
While this modelling indicates that the interconnecting neck would be overtopped and significantly eroded by the simulated tsunami, the consequences of doing so would not be high as there is no infrastructure on the spit and minimal development on the shores of the embayment to the west of the spit that could be adversely impacted by raised water levels associated with scour of the neck.
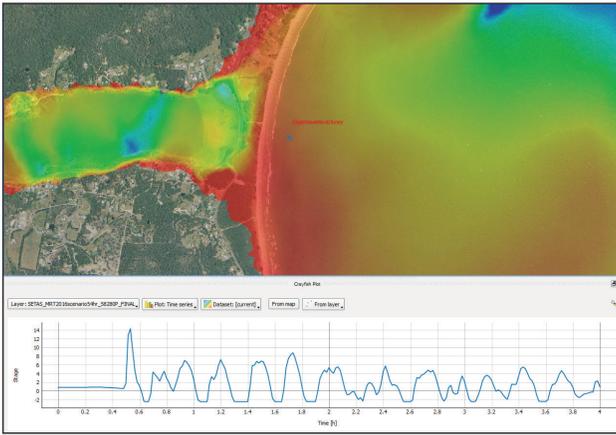
Eaglehawk Neck Dunes

Eaglehawk Neck provides the only road access to the Tasman Peninsula communities including the major tourist centre at Port Arthur. Loss of this access road would create considerable hardship for residents of the peninsula and loss of income from the present agricultural and tourist trade that the peninsula relies upon.

This modelling indicates that massive overtopping and erosion of these protective dunes is likely at this location. Given the extreme tsunami wave height at this location, it is most likely that the road would be destroyed during the event and the quantum of sand removed from the dunes would be such that the road (located on the lee side of the dunes) would be impassable for some considerable time. Given the consequences of such a road closure on access to and from the peninsula communities and damage to low lying properties along the otherwise protected waterway, it is also considered prudent that tsunami impacts, including dune erosion, in this area be investigated in greater detail.

Pirates Bay Beach Dunes

This modelling indicates that the protective dune line would be substantially overtopped and all but removed by the tsunami, exposing the existing residents, dwellings and infrastructure to considerable risk, in respect to both loss of life and property damage. Given the consequences of this level of inundation, it is considered that tsunami impacts in this area, including the impact of dune erosion, be investigated in more detail. .
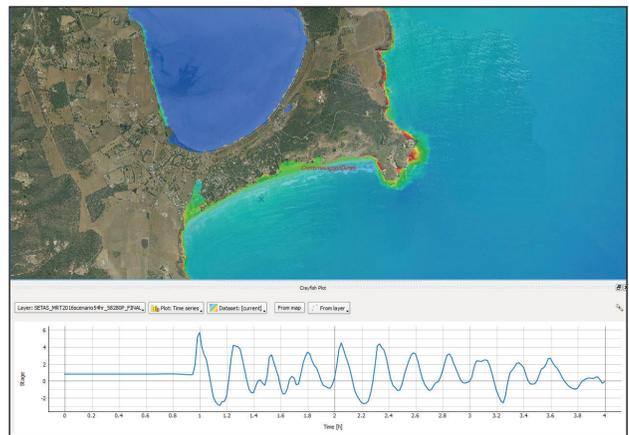

Cremorne Lagoon Beach Dunes

While the tsunami would inundate some properties behind Clifton Beach, this modelling indicates it unlikely that the land behind the beach would be overtopped. In addition, the area behind the beach is well vegetated reducing the likelihood of erosion of the underlying sands even if overtopped. Dune erosion is therefore unlikely to be a significant factor in respect to risk at this location.
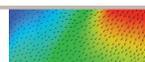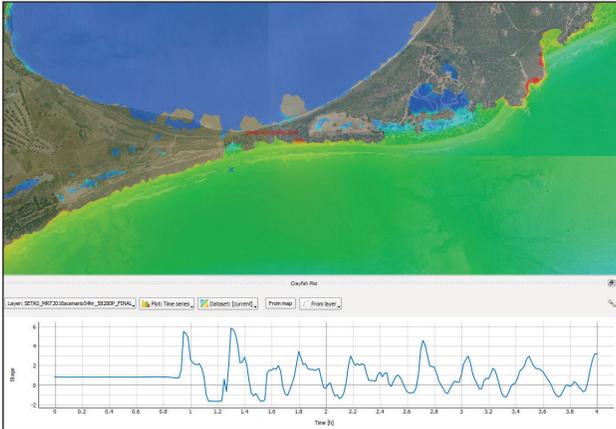
South Arm Neck Dunes

This modelling indicates that the dune line protecting the road between Lauderdale (to the north) and the villages of Opossum Bay and South Arm would likely be breached at a number of locations, depositing sand over the access road and raising the water level locally in Ralphs Bay above road level. As modelling does not indicate widespread overtopping of these dunes, overtopping will be heavily influenced by the actual (as distinct from modelled) dune topography. Since loss of road access to and from Opossum Bay and South Arm, for any length of time, would create many problems for the residents, it is recommended that tsunami impacts, including the impact of dune erosion, be investigated in more detail in this area.
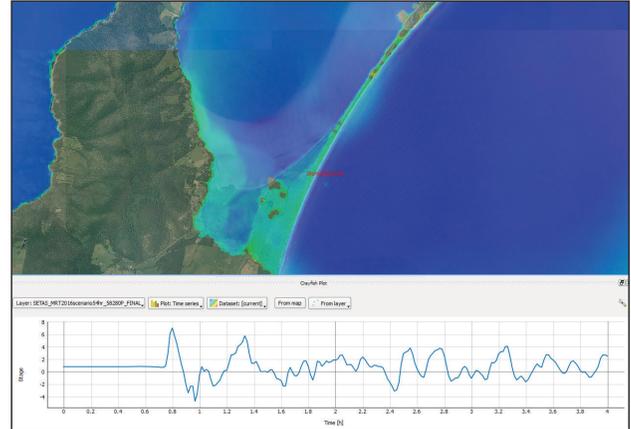
Bruny Island Neck Dunes

The only road connecting north and south Bruny has been constructed on the lee side of a sand spit that is protected by a continuous line of dunes. Loss of this access road would create considerable hardship for residents of the island and loss of income from the present agricultural and tourist trade that the island relies upon.
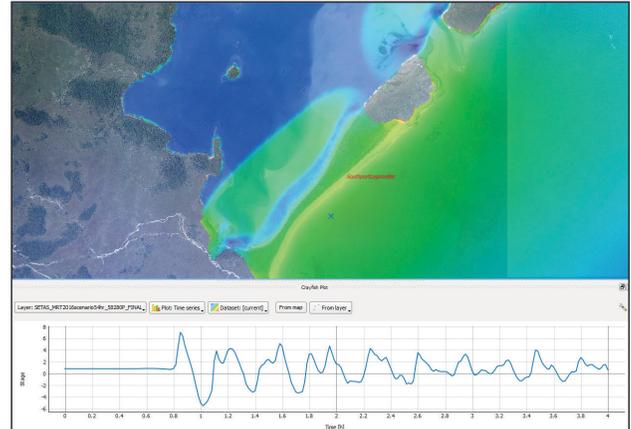
This modelling indicates that considerable overtopping and erosion of these protective dunes is likely, particularly in the southern half of the spit where dunes are lower. The quantum of sand removed from the dunes would be such that the road (located on the lee side of the dunes) would be impassable for some time, preventing access between the north and south of the Island. Given the consequences of such a closure, it is considered desirable that tsunami impacts, including dune erosion, in this area be investigated in greater detail.
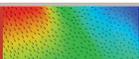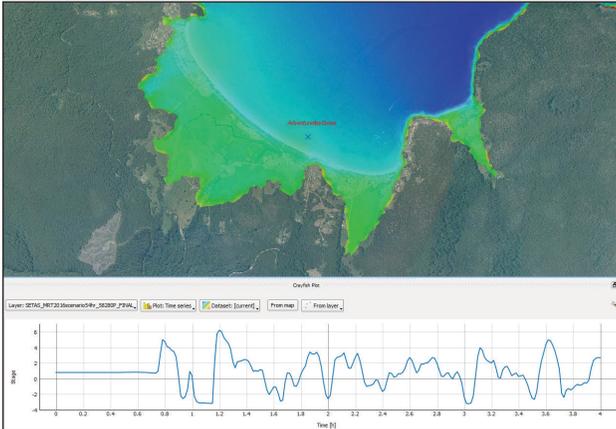
Adventure Bay Beach Dunes

This modelling indicates that the protective dune line would be substantially overtopped and all but removed by the tsunami, exposing the existing residents, dwellings and infrastructure to considerable risk in respect to both loss of life and property damage. Given the consequences of this level of inundation, it is considered desirable that tsunami impacts in this area, including the impact of dune erosion, be investigated in more detail in this area.

Southport Lagoon Spit Dunes

While this modelling indicates that there will be massive overtopping and scour of the low dune line protecting the lagoon, the consequences of doing so would not be high as there is no infrastructure on the protective dunes and minimal development on the shores of the lagoon itself. Such a level of overtopping and removal of the protective dunes and sand bar would however raise peak water levels in the lagoon during the tsunami and could significantly alter the protected nature of the lagoon and the ecosystems it supports.
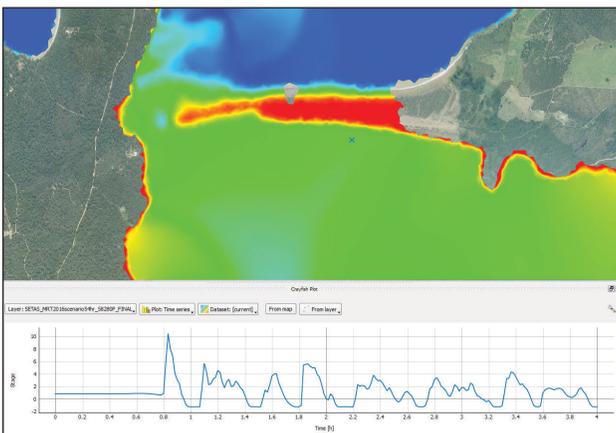
Cloudy Bay Spit Dunes

While this modelling indicates that there will be significant high-level overtopping and scour of the dune line protecting the lagoon, the consequences of doing so would not be high as there is no infrastructure on the protective dunes and minimal development on the shores of the lagoon itself. Such a level of overtopping and scour of the protective dunes would however raise peak water levels in the lagoon during the tsunami and could significantly alter the protected nature of the lagoon and the ecosystems it supports.
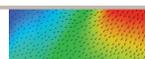
CONCLUSIONS

When tsunami modelling is extended to include the impact of erosion of protective dunes on penetration of a tsunami, some areas initially considered not at risk from the tsunami can be demonstrated to be very much at risk.

This Scenrio5 was developed to explore where increased risk from erosion of a protective dune line, during a tsunami, might exist.in South Eastern Tasmania.

Hobart airport, an area protected by a low dune line behind Seven Mile Beach, was modelled in detail as an extension of the runway is currently under consideration. 12 other sites were modelled at a lesser level of detail to identify sites where a significant increase in risk from dune erosion appears likely.

With respect to the airport site, the modelling indicates that the dune line along Seven Mile Beach, as existing in 2016, would provide effective protection for the airport runway and terminal buildings in a tsunami event up to the magnitude of that modelled. For the most part, this arises because of the considerable reduction in the tsunami wave height as it travels into and through Frederick Henry Bay.

With respect to other sites, where erosion of protective dunes could elevate exposure and risk during a tsunami;

Sites that modelling indicates are exposed to increased risk as a result of erosion of protective dunes and are therefore recommended for more detail investigation include;

— Marion Bay Spit Dunes
— Eaglehawk Neck Dunes
— Pirates Bay Beach Dunes
— South Arm Neck Dunes
— Bruny Island Neck Dunes
— Adventure Bay Beach Dunes

Sites that modelling indicates are likely exposed to erosion but are not recommended for more detail investigation due to limited consequences arising from erosion include;

— Maria Island Neck Dunes
— Cloudy Bay Spit Dunes
— Southport Lagoon Spit Dunes

Sites that modelling indicates would not be overtopped and exposed to erosion by the simulated tsunami and are therefore not recommended for further investigation include;

— Dolphin Sands Beach Dunes
— Cremorne Lagoon Beach Dunes

Prepared for and on behalf of

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October 23rd 2016