WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Coastal Hazard Vulnerability Assessment

2681 Princes Highway, Port Fairy

[redacted]

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Project Name	2681 Princes Highway, Port Fairy
Client	[redacted]
Client Project Manager	Abe McCarthy
Water Technology Project Manager	William Stevenson-Vissers
Water Technology Project Director	Toby Devlin
Authors	William Stevenson-Vissers
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15 Business Park Drive
Notting Hill VIC 3168
Telephone (03) 8526 0800
Fax (03) 9558 9365
ACN 093 377 283
ABN 60 093 377 283

Quality ISO 9001 SAI GLOBAL
Environment ISO 14001 SAI GLOBAL
OHS ISO 45001 SAI GLOBAL

ACKNOWLEDGEMENT OF COUNTRY

The Board and employees of Water Technology acknowledge and respect the Aboriginal and Torres Strait Islander Peoples as the Traditional Custodians of Country throughout Australia. We specifically acknowledge the Traditional Custodians of the land on which our offices reside and where we undertake our work.

We respect the knowledge, skills and lived experiences of Aboriginal and Torres Strait Islander Peoples, who we continue to learn from and collaborate with. We also extend our respect to all First Nations Peoples, their cultures and to their Elders, past and present.

Artwork by Maurice Goolagong 2023. This piece was commissioned by Water Technology and visualises the important connections we have to water, and the cultural significance of journeys taken by traditional custodians of our land to meeting places, where communities connect with each other around waterways.

The symbolism in the artwork includes:

- *Seven circles representing each of the States and Territories in Australia where we do our work*
- *Blue dots between each circle representing the waterways that connect us*
- *The animals that rely on healthy waterways for their home*
- *Black and white dots representing all the different communities that we visit in our work*
- *Hands that are for the people we help on our journey*

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1 INTRODUCTION

Water Technology has been engaged to assess the coastal vulnerability of a proposed development at 2681 Princes Highway, Port Fairy. This Coastal Hazard Vulnerability Assessment (CHVA) defines erosion and inundation hazard extents to assist and guide development of the property.

1.1 Datasets Used

This CHVA has relied on the following datasets:

- High-resolution topographic LiDAR elevation data (portland_2023mar04_dem1m_v10cm_epsg7854 and Vic_Nearshore_BATHY&LiDAR_CoastalDEM_2017)
- Latest Aerial Imagery – dated 06/01/2024 – sourced from NearMap
- Australian National Tide Tables (ANTT, 2024)
- Future Coasts – Port Fairy Coastal Hazard Assessment (Water Research Laboratory (WRL) 2013)
- Victorian State Government guidelines including the Marine and Coastal Policy, Victorian Planning Provisions, the Siting and Design Guidelines for structures on the Victorian coast, and others.

1.2 Site Details

The subject location is presented in Figure 1-1 with the local topography presented in Figure 1-2 (based on the available LiDAR data).

Figure 1-3 presents the corresponding cross section depicted in Figure 1-1. The minimum surface elevation of the property is approximately 0.6 m AHD with a maximum of approximately 16 m AHD on the southeastern corner of the property. The specific area of proposed development footprint has surface elevations ranging from approximately 3 m AHD to 6 m AHD. A large low-lying depression, with a minimum surface elevation of 0.6 m AHD, is located north of the proposed development footprint, with access to Princes Highway crossing this depression in topography.

The proposed area of development is setback from the Southern Ocean shoreline by approximately 80 m. Current infrastructure on the site consists of two single-storey sheds.

Figure 1-1 2681 Princes Highway, Port Fairy Study Area

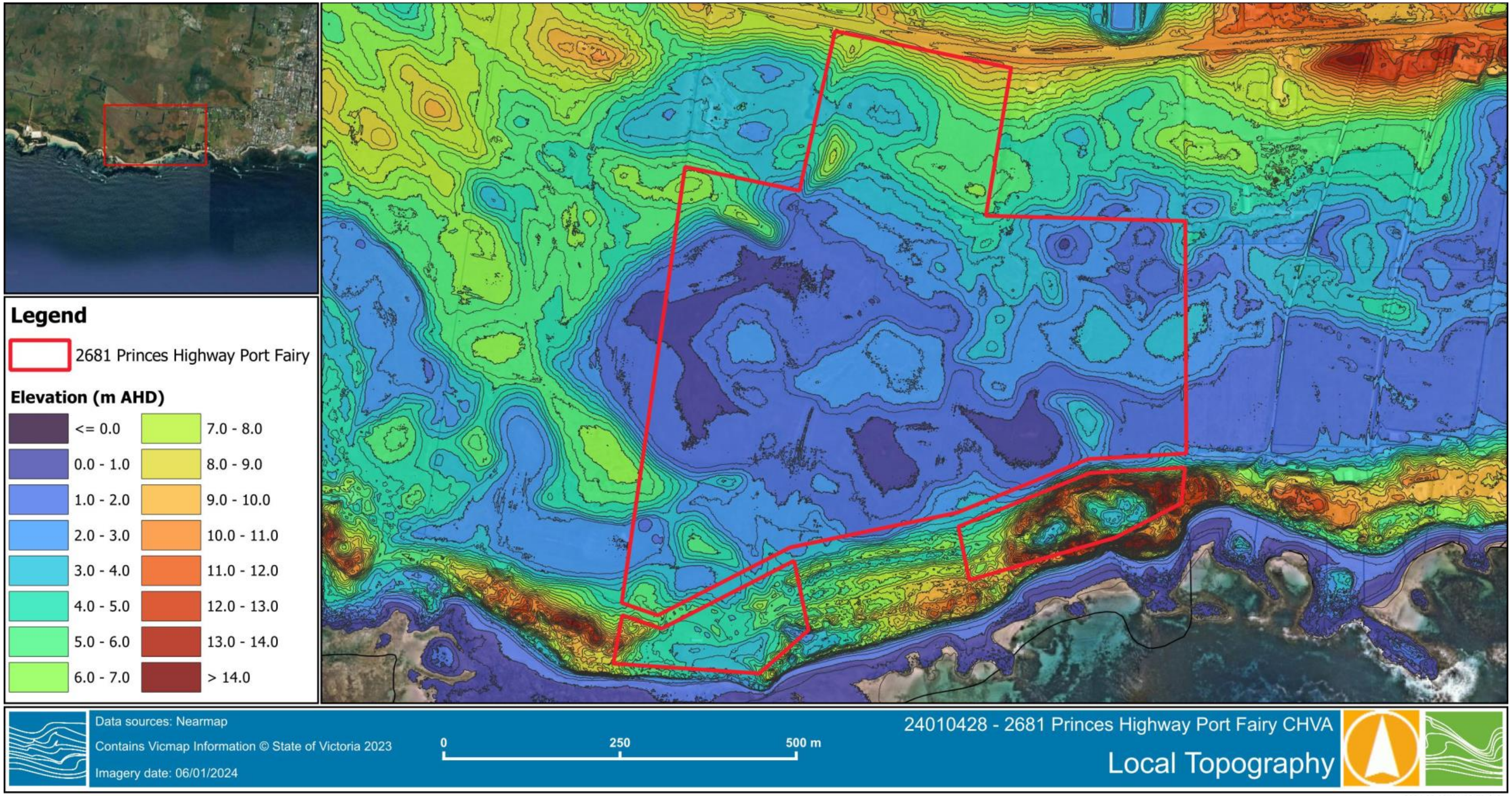

Figure 1-2 Local Topography

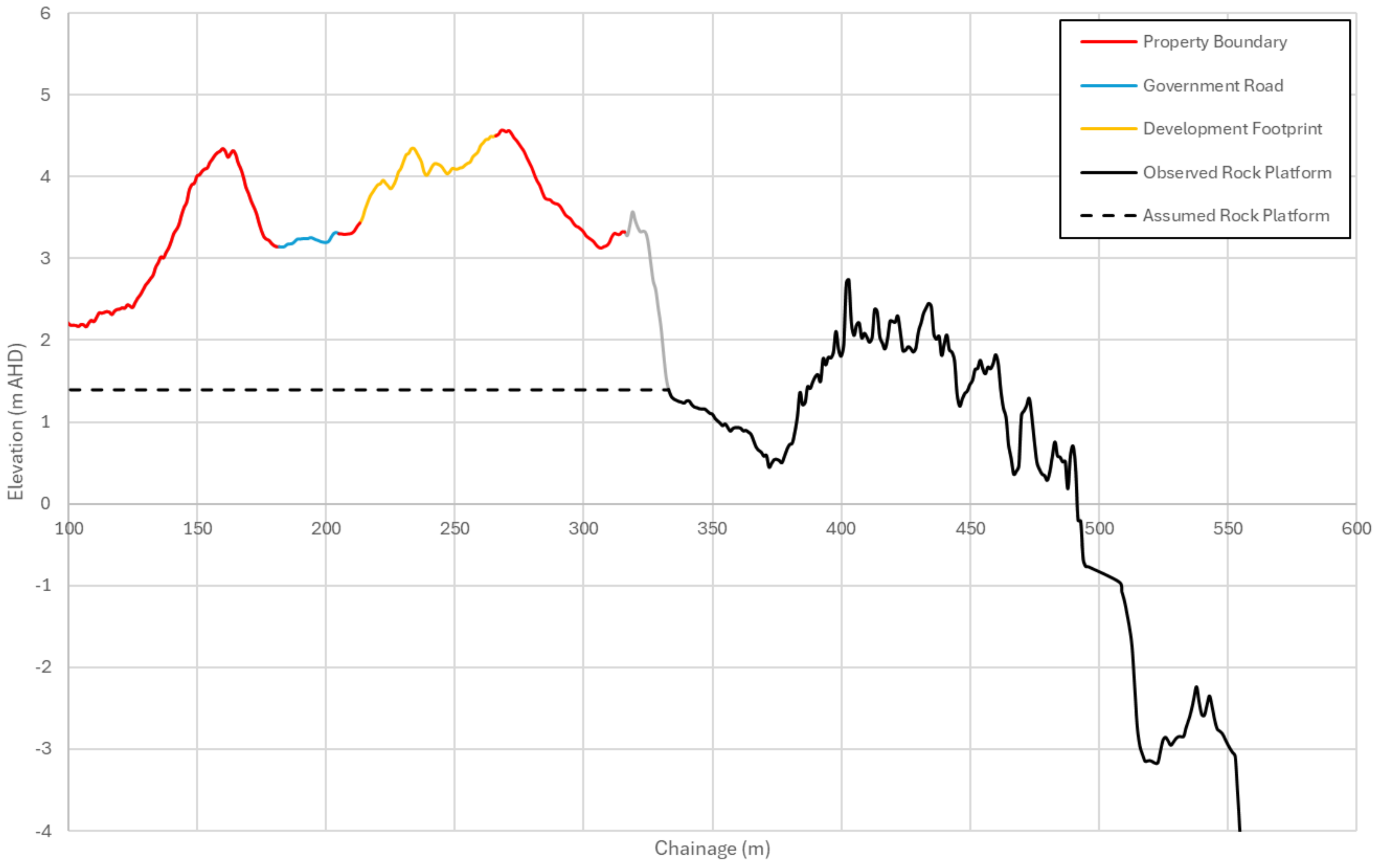

Figure 1-3 Cross Section of Development Site

1.3 Development Plan

The proposed development at the Subject Property includes the following features:

- Construction of a single storey residential dwelling, including a pool and basement/garage.
- Construction of separate machinery shed.
- Construction of access driveway connecting the development to Princes Highway north of the dwelling.
- The proposed Finished Floor Level (FFL) of the residential dwelling is **6.0 m AHD**.
- The basement/garage is proposed to have a FFL of **2.6 m AHD.**
- The machinery shed is proposed to have a FFL of **4.3 m AHD**.
- Relevant concept drawings are presented in Figure 1-4 and Figure 1-5 below.

Figure 1-4 Plan view of Proposed Development

Figure 1-5 Elevations of Proposed Development

2 COASTAL ENVIRONMENT

2.1 Water Levels

2.1.1 Astronomical Tides

Astronomical tide refers to the rise and fall of the sea surface due to gravitational attraction between Earth, Moon, and Sun. Water level variations in coastal areas due to the astronomical tide can be reliably predicted provided a reasonable length of continuous water level observations is available.

Table 2-1 shows tidal plane information for Port Fairy as derived from Australian National Tide Tables (ANTT, 2024) at Port Fairy.

Table 2-1 Tidal Planes at Port Fairy (ANTT 2024)

Tidal plane reference	Level (m AHD)
Highest Astronomical Tide (HAT)	0.8
Mean High Water Springs (MHWS)	0.5
Mean High Water Neaps (MHWN)	0.3

2.1.2 Storm Tides

The term storm tide refers to coastal water levels produced by the combination of astronomical and meteorological sea level forcing. The meteorological component of the storm tide is commonly referred to as storm surge and collectively describes the variation in coastal water levels in response to atmospheric pressure fluctuations and wind setup.

The Port Fairy Coastal Hazard Assessment (WRL, 2013) provides coastal inundation extents, comprised of a still water level (derived from McInnes et al. (2009)) and wave setup. Wave runup extents were also provided as an additional component.

The present-day storm tide levels of each component for profile Unnamed 3 (VIC 517), considered representative of the subject area, are presented in Table 2-2 below.

Table 2-2 Present-day 2% AEP Storm Tide Conditions

Still water level (m AHD	Wave Setup (m)	Total Storm Tide (m AHD)	Wave Runup (m AHD)
1.0	2.1	3.1	4.1

2.1.3 Sea Level Rise

Sea Level Rise (SLR) is the predicted increase in the mean sea level due to effects associated with climate change (glacial/ice-shelf melt, thermal expansion of the ocean, and isostatic rebound of the continental crust relative to ocean levels).

In Victoria, the Victorian Planning Provisions clause 13.01-2S requires that development plan for sea level rise of no less than 0.8 metres by 2100. The previous Coastal Hazard Assessment (WRL, 2013) assesses 0.8 m by 2080 and up to 1.2 m by 2100. This higher level is consistent with the most conservative projections provided by the latest IPCC reporting. Both have been assessed herein with the understanding that 0.8 m is the benchmark for 2100, with 1.2 m explored to understand ongoing changes in risk.

2.1.4 Dynamic Modelling

The Port Fairy CHA (WRL 2013) used a dynamic coastal inundation model that simulates overland flooding due to storm tides, in combination with sea level rise, wave setup, and overtopping of the coastal dunes. This approach is accurate and appropriate on the open coast. The backshore areas however are prone to flooding caused by overtopping of the dunes that eventually fills these locations with water. Many are otherwise not directly connected to the ocean during such inundation events.

The overtopping approach uses standard empirical tools to model the rates of overtopping. However, these have inherent uncertainties associated with the breaking of waves in the nearshore (e.g. where there are rocky reefs), the slope of the beach and the dune crest (dependent on recent erosion/accretion patterns).

Moreover, even with a given rate of overtopping, the flood effects are sensitive to the pattern of drainage. The simulated inundation scenario includes several overtopping events over an 8-day period. It is probable that the local drainage may therefore reduce the total extent of flooding in these areas. Therefore, the assessment of coastal inundation for backshore areas is likely to be conservative.

Conversely, coincident rainfall events, or large rainfall events immediately prior to a coastal inundation event, could exacerbate the flooding of such low-lying areas.

2.2 Shoreline Change

There are typically three components that contribute to shoreline changes which include:

- Storm erosion and recovery caused by large storm waves (often in combination with storm tides) that erode the beach. On beaches in equilibrium (i.e. no net loss of sediment from the beach compartment), this is a cyclical process where storms draw sand offshore into sandbars, that are then slowly worked back onto the beach during calmer conditions (beach ‘recovery’).
- Ongoing change in the shoreline position occurring in response to an imbalance in the sediment transport within a given beach compartment. This can be a steady loss or gain of sand (and respective retreat or accretion of the shoreline) or a beach ‘rotation’ that causes erosion at one end and accretion at the other on either a permanent or variable basis. Construction of coastal protection structures (such as seawalls) can exacerbate these changes as the shoreline is forced to maintain a certain alignment in these locations and the adjacent shoreline is made to adjust more dramatically in response; and
- Long-term shoreline recession due to sea level rise resulting in an increase in the volume of sand required to maintain a stable beach. Without the input of additional sand, the shoreline will retreat as sea levels increase. This process has been described by Bruun (1962), and while not applicable to all coastal areas, is a conservative assumption.

The Port Fary Coastal Hazard Assessment modelled the erosion extent for both present-day (storm erosion only) and with 0.8 m and 1.2 m of sea level rise (includes all three shoreline change components). The erosion extents with reference to the Subject Property is shown in Section 3.4.

2.2.1 Total Erosion Hazard

There are four main erosion hazard extents that can be considered for a shoreline, depending on the confidence in the underlying erosion processes:

- The SLR response part on its own. Due to the Bruun rule being largely inappropriate in this area, the increase in exposure of the shoreline to waves across the rock platform with the deeper water is likely to be the biggest influence of SLR at this site. No additional allowance for SLR has been considered in this assessment as the impact is captured in the modelling of future storm erosion.

- The total 'permanent erosion' assumes that the on-going shoreline change occurs at the same rate as in the past. It may be the case that the processes driving the long-term change increase or stabilise in the short- to medium-term. However, as the site becomes more exposed via SLR, an increase is more likely than stabilizing.
- The future storm erosion buffer. This includes a buffer of the 1% AEP storm event. There is a good level of confidence in these processes, but the chance of experiencing such a storm in a given future year is low (1%).
- The future Zone of Reduced Foundation Capacity (ZRFC). This includes an extent beyond the permanent erosion hazard where the land may be prone to additional slumping or failure under surcharge loads. Houses and similar structures in these areas may experience settling or partial foundation failure despite no direct erosion. The ZRFC is calculated based on the work of Nielson (1992) and assumes an angle of repose for the underlying sediments. It does not apply if suitable geotechnical information is available that demonstrates high-capacity underlying strata (such as bedrock).

2.3 Summary

Table 2-3 presents a summary of the coastal environmental conditions calculated for the Port Fairy area.

Note – present-day hazards are for the 2% AEP event, while future scenarios are 1% AEP events, as presented in the Port Fairy CHA (WRL 2013).

Furthermore, there is no existing scenario that models 0.8 m of SLR, with ongoing erosion trends projected to 2100. Therefore, for erosion this report considers the 2100 1.2 m SLR erosion numbers, but notes these will be conservative for the 'SLR response' component of erosion hazard.

Table 2-3 Coastal Environment Summary

Parameter	Present-day	2080 (0.8 m SLR)	2100 (1.2 m SLR)
MHWS (m AHD)	0.5	1.3	1.7
HAT (m AHD)	0.8	1.6	2.0
Still Water Level (m AHD)	1.0	1.9	2.3
Wave Setup (m)	1.5	2.1	2.1
Storm Tide Level (m AHD)	3.1	4.0	4.4
Wave Runup Level (m AHD)	4.1	5.2	5.6
Total Erosion Setback (m)	13	33	43

3 HAZARD EXPOSURE

3.1 Hazards Considered

For this site the following coastal hazards have been considered for assessment:

- Coastal Inundation
- Coastal Erosion

3.2 Site Considerations

A key consideration for this site is the low-lying land north of the development location, and the potential for this area to fill with inundation.

3.3 Inundation Hazard

Figure 3-1 shows the present-day 2% AEP and future (0.8 m and 1.2 m SLR by 2100) 1% AEP inundation levels and Figure 3-2 shows the 2100 (1.2 m SLR) 1% AEP wave runup hazard extent. These levels represent those presented in the Port Fairy Coastal Hazard Assessment.

These storm tide levels represent the “quasi-static” still water level and would be expected to persist for the duration of a high tide event. However, these inundation levels and associated extents do not include the transient impacts of wave runup. Wave runup and overtopping is likely to add an additional component to the short-term inundation hazard. An assessment of wave runup and overtopping potential would require a detailed survey of the final surface elevations, including any built landscape features that may block wave runup. Overtopping flow rates can be effectively mitigated with appropriate design of drainage infrastructure in the impacted area.

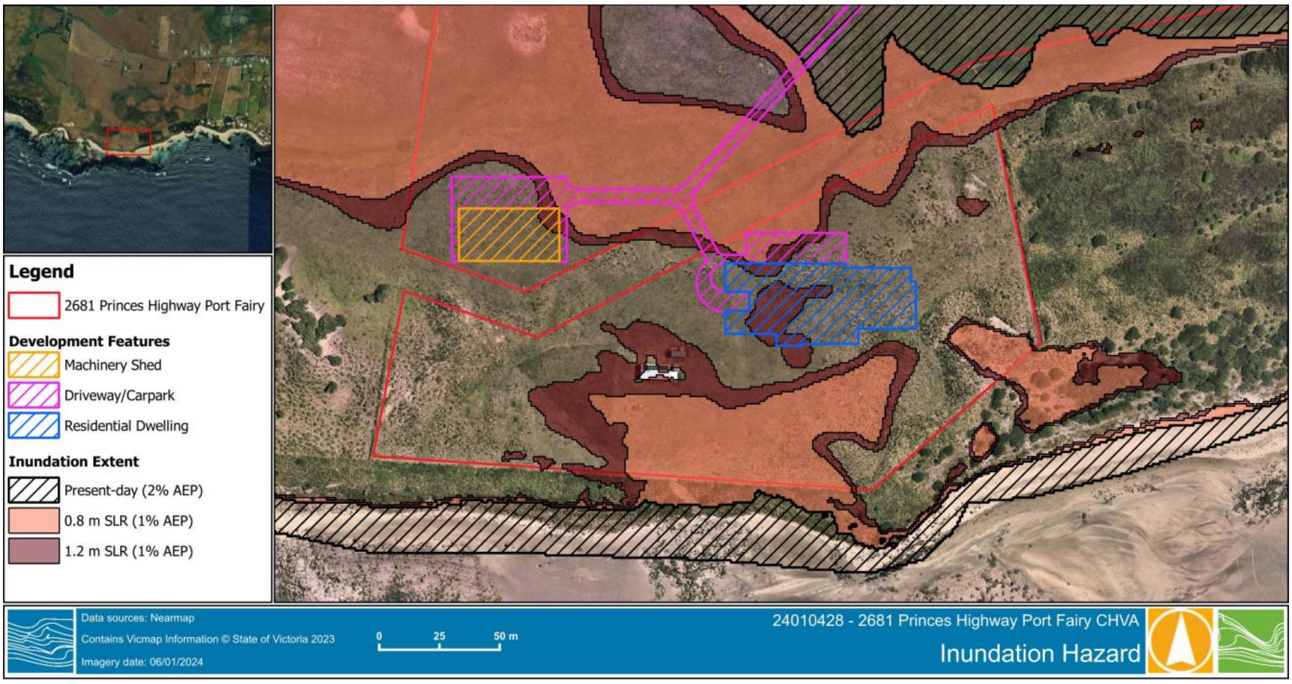

Figure 3-1 Inundation Hazard Extent

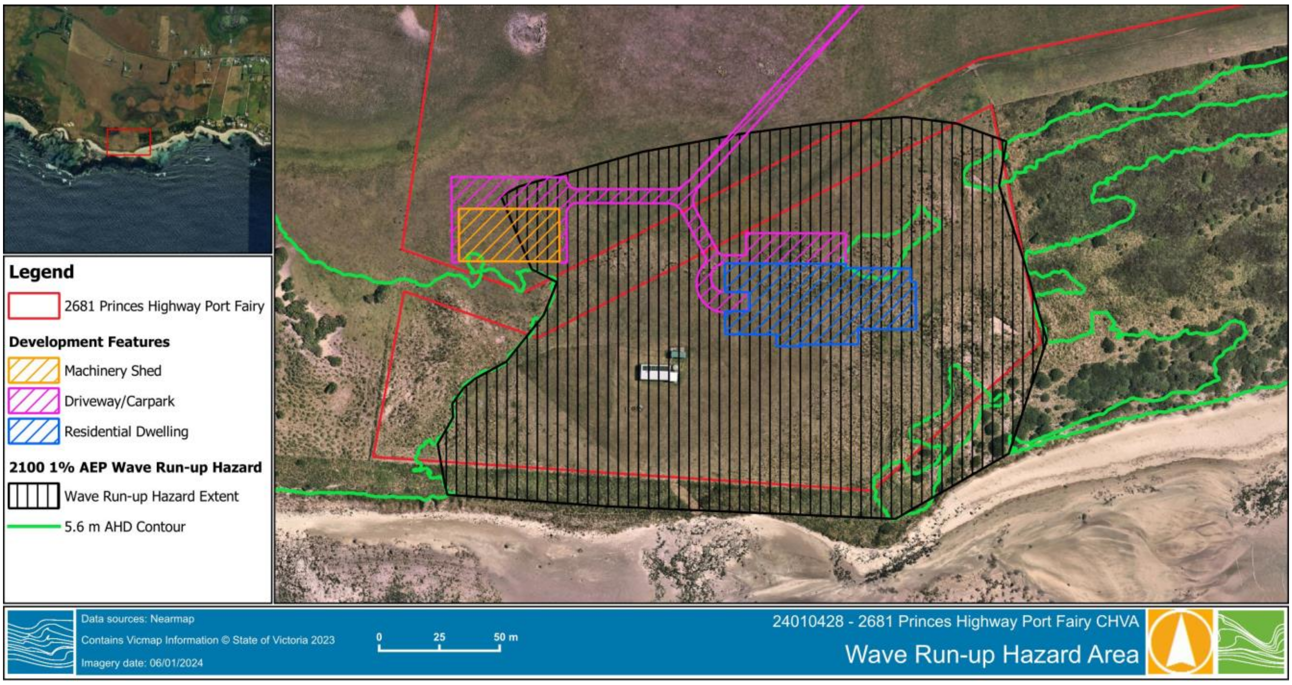

Figure 3-2 Wave Runup Hazard Extent

3.4 Erosion Hazard

Figure 3-3 shows the erosion hazard extents for the Subject Property in present-day and both 2100 SLR scenarios, as per the Port Fairy CHA (WRL 2013). This indicates that erosion is unlikely to impact the proposed area of development.

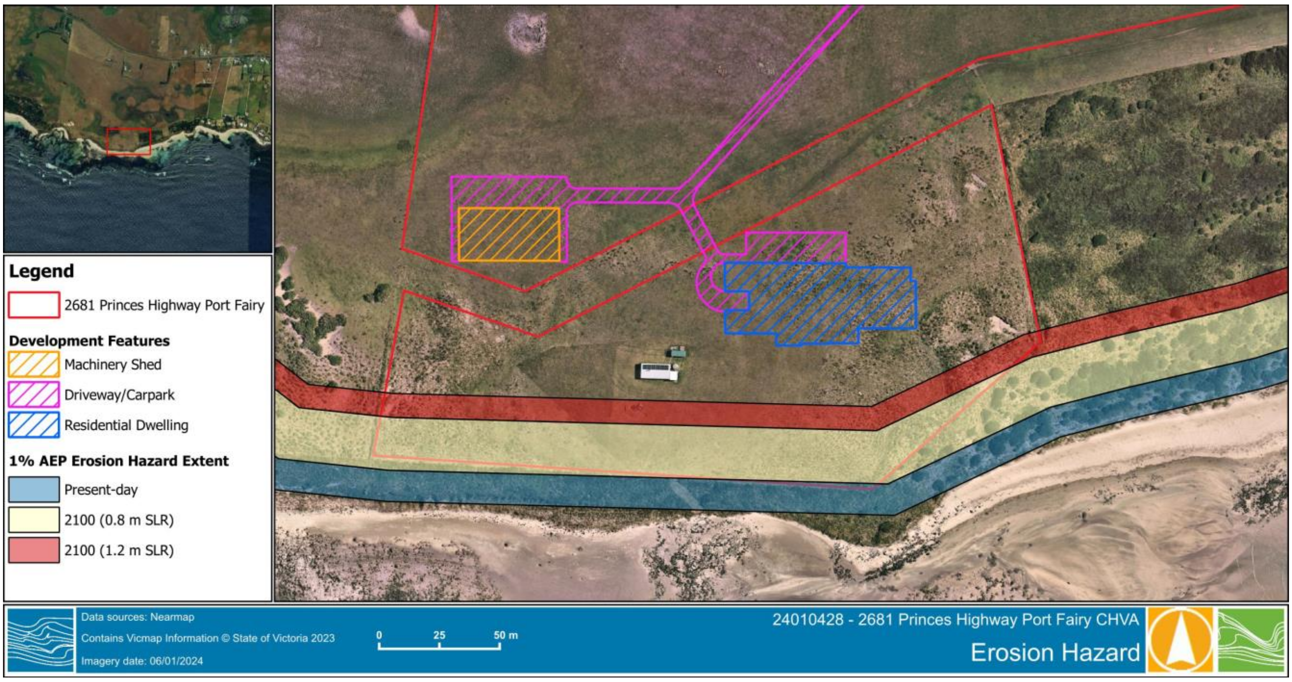

Figure 3-3 Erosion Hazard Extent

4 RISK ASSESSMENT

4.1 Overview

Risk Management is the term applied to a logical and systematic method of establishing the context, identifying, analysing, evaluating, treating, monitoring and communicating the risks associated with any activity, function or process in a way that will enable organisations to minimise losses and maximise opportunities (Standards Australia, 2018). Risk is identified as the product of the likelihood and consequence of an event impacting on an asset or objective.

Risk profiles have been developed by assigning scores to the consequence of each relevant coastal hazard and the likelihood of this coastal hazard impacting the site over a range of relevant timeframes this century. The risk profile is determined by applying the scores to a risk matrix such as the one shown in Appendix A. Appendix A also shows tables summarising the approach to considering the likelihood and consequences for a range of development structure types (habitable space, outdoor facilities, etc.).

Hazards have been addressed in isolation as is the standard for coastal hazard assessments. For example, even though 2100 may result in a new shoreline position, the inundation hazard is assessed relative to the current ground levels and shoreline.

The different site classifications are based on the existing site usage. An updated risk assessment can be completed following the design of the re-development plan.

4.2 Coastal Inundation Risk

The likelihood and consequence of coastal inundation hazard has been assessed based on review of the storm tide levels and existing topography. The risk ratings for coastal inundation hazard are shown in Table 5-1, with justifications below:

- The **Proposed Development footprint** of the dwelling and machinery shed are **not impacted** by present day 2% AEP storm tide conditions.
- The **Proposed Development footprint** of the dwelling and machinery shed are **not impacted** by 2100 0.8 m SLR 1% AEP storm tide conditions.
- The **Proposed Development footprint** of the dwelling and machinery shed are **impacted** by 2100 1.2 m SLR 1% AEP storm tide conditions under the pre-developed elevations. However, FFLs of these areas are higher than the flood levels and are therefore **not at risk** of being impacted.
- The **Proposed Accessway** is **impacted** by present-day and future storm tide conditions.
- Several areas of the **Proposed Development footprint** are **at risk** of being impacted by the effects of wave run-up, as these areas are below the peak elevation to which wave runup may impact. The rate of runup and overtopping will be low, and can be managed by appropriate drainage. However this is particularly important for areas such as the basement garage, which could otherwise accumulate inflowing water. This hazard is more similar to drainage of overland stormwater, and it is assumed it will be managed similarly.

Table 4-1 Coastal Inundation Risk Summary

Coastal Inundation Area	Specific Impact	Present-day Risk	2100 (0.8m) Risk	2100 (1.2m) Risk
Accessway	The driveway that provides sole access to the site crosses through several areas that are prone to inundation at present day. Under future SLR scenarios this issue will become worse with parts of these areas inundated by well over 1m of water depth. It is likely that under these conditions, there may be no safe road access for vehicles.	**Medium**	**Medium**	**Medium**
Habitable Space	Impacts during future storm tide conditions are limited as FFLs are above the future inundation levels.	**Low**	**Low**	**Low**
Basement/garage	Impacts during future storm tide conditions are limited to wave runup, and should be appropriately designed for. The entrance to the basement is otherwise above the future inundation levels.	**Low**	**Low**	**Low**
Machinery Shed	Impacts during 2100 1.2 m SLR 1% AEP storm tide are limited to small area in the northeast corner which is proposed to be an entryway.	**Low**	**Low**	**Low**

4.3 Coastal Erosion Risk

The likelihood and consequence of long-term coastal erosion/recession hazards at the site have been assessed based on the review of the coastal and oceanographic processes expected to impact the property this century. Table 4-2 presents the risk ratings for scenarios with the justification that the **Proposed Development footprint** is **not impacted** by the 2100 storm erosion hazard extent.

Table 4-2 Coastal Erosion Risk Summary

Coastal Inundation Area	Specific Impact	Present-day Risk	2100 (0.8m) Risk	2100 (1.2m) Risk
Accessway	No impact as assessed erosion does not reach accessways.	**Low**	**Low**	**Low**
Habitable Space	No impact as assessed erosion does not reach habitable space.	**Low**	**Low**	**Low**
Basement/garage	No impact as assessed erosion does not reach basement/garage areas.	**Low**	**Low**	**Low**
Machinery Shed	No impact as assessed erosion does not reach machinery shed location.	**Low**	**Low**	**Low**

5 COASTAL VULNERABILITY CONCLUSIONS

5.1 Coastal Vulnerability

The main conclusions relating the coastal hazard vulnerability at the site are as follows:

- The assessment of coastal erosion at the Subject Property indicates that:
  - The site is a **Low Risk** to property and life due to erosion by 2100 (1.2 m SLR) not impacting the development site.
- The assessment of coastal inundation at the Subject Property indicates that:
  - At present day, there is a **Low Risk** of coastal inundation of the development site.
  - By 2100:
    - The habitable space of the renovations is at a **Low Risk** of inundation under 1% AEP storm tides.
    - The basement/garage is at a **Low Risk** of inundation under 1% AEP storm tides. The FFL of this area is below the storm tide levels, however the garage entry is not impacted and therefore it is assumed water cannot penetrate into this area.
    - The machinery shed is at a **Low Risk** of inundation under 1% AEP storm tides as the area impacted during this event is of minor consequence.
    - Wave runup and overtopping have the potential to impact this site under future sea level conditions. It is expected that the basement entry ramp, and other low-points in the design will be designed to include appropriate drainage. As such, this risk can be mitigated, but should be expressly considered in the design of the site drainage.
    - There is no change in the assessed risk with 1.2 m of SLR versus 0.8 m. There is a change in the flood extents, and depth over the accessway, but not in a way that changes the impact to these areas.
  - The accessway is at a **Medium Risk** of inundation under present-day and future storm-tide conditions. The driveway should be designed to be above such conditions (not yet included in the concept plans). This may require design and modelling of the drainage performance under catchment rainfall conditions. Alternatively, an emergency access plan may be required to mitigate a potential risk.

5.2 Limitations and Conservatism

The following aspects present the conservativism of this assessment:

- This work relies on the existing dynamic modelling of coastal inundation effects. These do not and cannot account for combined hazard influences of inundation under future shoreline positions caused by erosion/accretion.
- No consideration has been given to the interactions between coastal flooding and direct rainfall on the catchment. It is possible that this may increase the total coastal inundation extents.
- No consideration has been given to existing or planned drainage infrastructure within the adjacent areas. It is possible that these may decrease the total coastal inundation extents.

6 REFERENCES

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7 DEFINITIONS AND DISCLAIMERS

The information contained in this report is subject to the disclaimers and definitions below.

1. The area referred to in this report at the development “site” or “property” is the land that Water Technology believes most closely represents the location identified by the client. The identification has been done in good faith and in accordance with information given to Water Technology by the client.

2. No warranty is made as to the accuracy or liability of any studies, estimates, calculations, opinions, conclusions, recommendations (which may change without notice) or other information contained in this report, and to the maximum extent permitted by law, Water Technology disclaims all liability and responsibility for any direct or indirect loss or damage which may be suffered by any recipient of other person relying on anything contained in or omitted from this report.

3. This report has been prepared for the sole use by the Client as stated and no responsibility is accepted by Water Technology with regard to any third party use of the whole, or of any part, of the contents of this report. Neither the whole or any part of this report, or any reference there to, may be included in any document, circular or statement without Water Technology’s written approval of the form and context in which it would appear.

4. The information provided represents the best estimates based on currently available information described. This information is subject to change as new information becomes available and as further studies area carried out

APPENDIX A
RISK DEFINITIONS

Table A-1 Likelihood Ranking

Likelihood Level	Description	Erosion	Inundation
1 – Very Unlikely (Rare)	Risk will occur in exceptional circumstances	Within ZRFC of permanent erosion hazard area	Temporary inundation by 0.01% AEP
2 – Unlikely	Risk not likely to occur within the period	At the edge of (+/-1m) 1% AEP storm erosion hazard buffer	Temporary inundation by 0.1% AEP
3 – Moderate	Risk may occur within the period	Within 1% AEP storm erosion hazard buffer	Temporary inundation by 1% AEP
4 – Likely	Risk likely to occur within the period	Within SLR response erosion hazard area	Temporary inundation by 10% AEP
5 – Almost Certain	Risk will occur within the period	Within permanent erosion hazard area	Permanent Inundation (Inter-tidal levels)

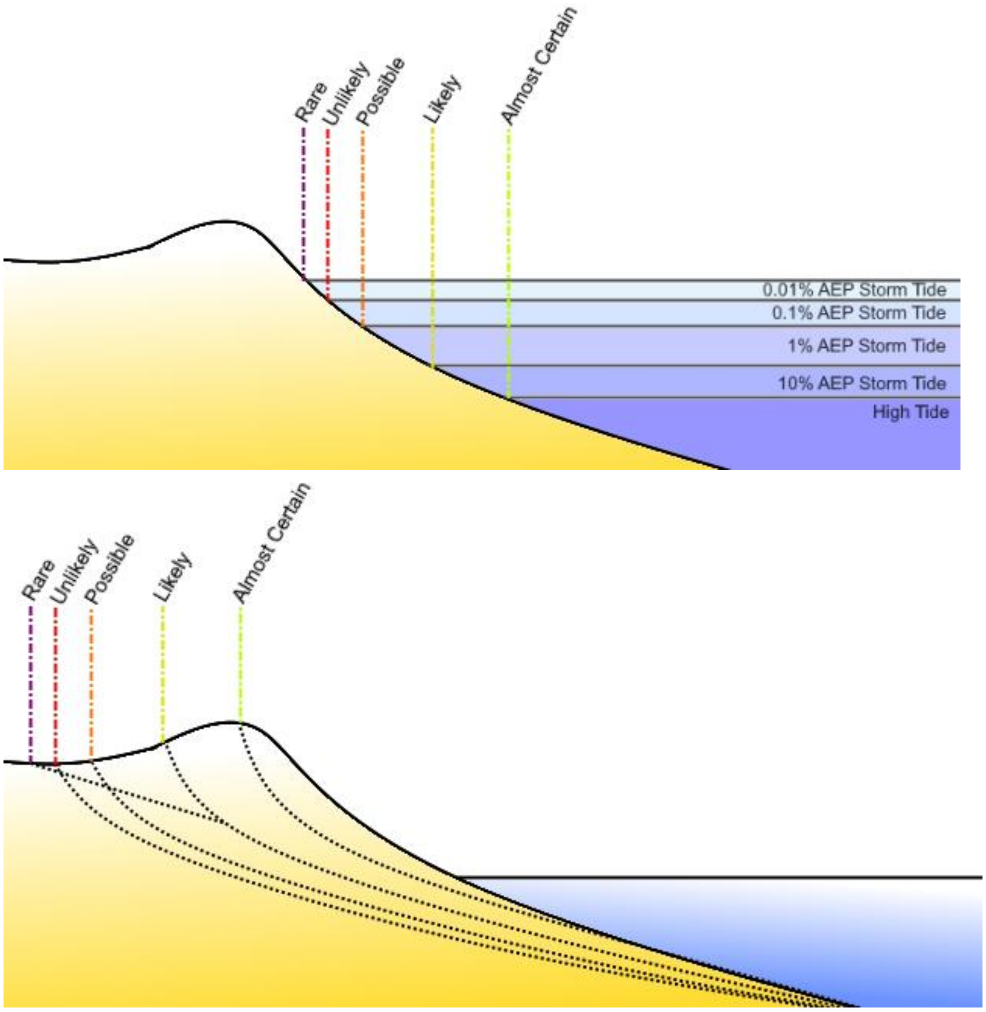

Figure A-1 Typical Hazard Extents for Inundation (Top) and Erosion (Bottom)

Table A-1 Consequence Table

Consequence Level	Accessway	Outdoor facilities	Garage/Storage areas	Habitable Space+
1 – Insignificant*	Temporarily impacted (<3 hrs) but alternatives available. Emergency access plan prepared	Temporarily impacted, no damage, some cleaning/maintenance required.	Areas surrounded by water, but floor level above inundation level	-
2 – Minor*	Temporarily impacted (<3 hrs). Shelter-in-place plan prepared	Temporarily impacted. Facilities damaged, or substantial cleaning and maintenance required.	Temporarily impacted, but resilient features included to accommodate hazard (e.g., waterproofing)	-
3 – Moderate	Access impacted permanently, but alternatives available	Permanent impact/loss of useful areas	Temporarily impacted and no resilient features	Temporary impact. Damage requires repairs, cleaning and maintenance. Safe evacuation / retreat possible.
4 – Major	Access impacted permanently. Or temporarily with additional risk factors (e.g., vulnerable persons)	Permanent impact/loss of high-value facilities	Permanent impact	Permanent impact. Safe evacuation / retreat possible
5 – Catastrophic	Access impacted permanently, and additional risk factors (e.g., vulnerable persons)	-	Impact and significant damage to high-value stored goods	Permanent impact, structural failure likely/imminent. May fail suddenly or be difficult to deconstruct.

*Erosion hazard has a minimum ‘Moderate’ consequence for any built infrastructure.
+Any damage to habitable space is considered a minimum of “Moderate” consequence

Table A-2 Consequence area type definitions

Area Types	Definition and examples
Accessway	Driveway, or access road (if only road in). Jetty/dock/airstrip if small island with limited facilities.
Outdoor Facilities	Non-habitable space, not used for storage. Landscaping, pools, decks, pergolas, helicopter pads, jetties, etc.
Garage and Storage areas	Non-habitable space, used for storage of materials/assets. Garage, shed, boat house, pool house, etc.
Habitable space	Areas where people may spend a reasonable amount of time, and expect shelter from the elements. Houses, granny flats, hospitality or commercial venues, offices, etc.

Table A-3 Risk Assessment Matrix (after AS 5334)

Likelihood	Consequences				
	1 – Insignificant	2 – Minor	3 – Moderate	4 – Major	5 – Catastrophic
5 – Almost Certain	Low	Medium	High	Extreme	Extreme
4 - Likely	Low	Medium	Medium	High	Extreme
3 – Moderate	Low	Low	Medium	High	High
2 – Unlikely	Low	Low	Medium	Medium	High
1 – Very Unlikely (Rare)	Low	Low	Low	Medium	Medium

Table A-4 Risk Profile Definition

Risk Profile	Definition
Low	Tolerable risk. A level of risk that is low and manageable without intervention
Medium	A level of risk that may require intervention to mitigate
High	A level of risk requiring significant intervention to mitigate
Extreme	A level of risk that is unlikely to be readily mitigated. Alternative options should be explored.