Karaaf Wetlands

Estuary Mouth Assessment

Report for Corangamite Catchment Management Authority

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Executive Summary

Increased stormwater flows from the urban development to the west of the Karaaf wetlands have been linked to dieback of saltmarsh and changed vegetation communities across the western section of the wetland complex. Dieback has occurred at places across the broader Karaaf, which is more likely the result of expected periods of estuary closure rather than from stormwater inflows. Many of Victoria's estuaries close from time to time as a response to natural processes and the estuary ecosystems, plants and animals are adapted to this.

This review tested the assumption that keeping the Thompson Creek estuary in an open condition would improve flushing of the wetland to the west of Point Impossible Road and assist recovery of the impacted saltmarsh vegetation.

The focus questions were:

1. Could opening the estuary allow more saline water mixing thereby increasing salinity in the areas of saltmarsh impacted by freshwater from stormwater inflows?
2. Could opening the estuary allow stormwater to be more readily flushed out of the wetland and thereby increase the salinity in the saltmarsh most impacted by freshwater flows?

To answer these questions, we have reviewed the available information and undertaken a detailed evaluation of the way in which inflows to the wetland interact with the vegetation communities, and how the water levels in Thompsons Creek affect this interaction.

Based on this review, the following outcomes are summarised:

- The most westerly section of the wetland which has been most impacted by stormwater flows, is where ground levels are above 1 m AHD and this means it is above the level of normal tidal inundation. These areas would previously have been seasonally inundated claypans where evaporation processes would dominate resulting in a saline environment.
- Increased stormwater inflows have increased the duration of freshwater inundation in these areas, and this has resulted in a change to the vegetation communities from more salt tolerant to more freshwater tolerant species.
- Tidal exchange will not increase saline mixing and increase salinity of either the surface or groundwater in these most westerly areas of the wetland due to their elevation above typical tidal levels and the lack of direct connection to Mullet Creek.
- Reducing stormwater inflows would reduce the duration of freshwater ponding in the most westerly section of the wetland. Whether this would return the system to a more saltmarsh dominated wetland is uncertain.
- Lowering of the water level in the estuary by artificially opening the mouth of Thompson Creek once it has closed is unlikely to be able to be achieved for an extended period until the water level in the estuary reaches ~1.7 m AHD and wave energy is low. At this level all the Karaaf wetland west of Point Impossible Road will be inundated. The estuary may also open naturally at this level.

- The duration of an estuary closure is a function of the magnitude of catchment flows. These flows are needed to "fill" the estuary to the level at which the conditions allow the mouth to open successfully.

Once closed, opening the entrance of the Thompson Creek estuary either naturally or artificially to lower the estuary water levels for an extended period can typically only be achieved when water levels in the estuary reach ~1.7 m AHD or higher. So, periods of inundation of the entire wetland complex west of Point Impossible Road will occur, with the potential for die-back of more saline dependent vegetation depending on the time it takes to fill the estuary to this level. This is a natural process for intermittently open and closed estuaries like Thompson Creek and occurs when catchment flows are low and wave energy can move sand onshore.

Once open and as long as it remains open, the water level in the estuary and wetland areas will drop to a level consistent with the new channel at the mouth. As the water drains out of the wetland, the most westerly section will retain some freshwater as it is not directly connected to Mullet Creek via a channel. The estuary opening alone does not flush more stormwater out of the wetland, increase the salinity of the local groundwater system, or alter the interaction between the stormwater inflows and the claypan areas at the westerly end of the wetland.

Overall, the conclusion of this review is that opening of the estuary will not mitigate the effects of increased stormwater inflows on the Karaaf wetlands to the west of Point Impossible Road.

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Acknowledgements

The Karaaf wetlands are located on the lands of the Wadawurrung People of the Kulin nation. We acknowledge them as the Traditional Owners of this place and pay respect to their Elders past, present, and future.

Glossary

Term	Definition
Annual Exceedance Probability (AEP)	The measure of the likelihood (expressed as a probability) of an event equalling or exceeding a given magnitude in any given year.
Astronomical tide	Water level variations due to the combined effect of the Earth's rotation, the Moon's orbit around the Earth and the Earth's orbit around the Sun.
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level. Introduced in 1971 to eventually supersede all earlier datums.
Berm	A near horizontal plateau on the beach face or backshore. The berm is formed by the deposition of beach material by wave action. The berm is located between the estuary lagoon and the ocean.
Berm crest	The highest point of a beach berm.
Chart Datum	Chart Datum is the plane from which depths on nautical charts are measured from. The Lowest Astronomical Tide (LAT) is generally accepted as the standard Chart Datum in Australia.
Estuary	The lower reaches of a waterway where the sea water is measurably diluted by freshwater and a salinity gradient extends some distance upstream.
EVC (Ecological Vegetation Class)	A vegetation classification system developed and used in Victoria since 1994.
HAT (Highest Astronomical Tide)	The highest tidal level which can be predicted to occur under average meteorological conditions and under any combination of astronomical conditions.
Hydraulic Gradient	The gradient between the water level in the estuary and the adjacent ocean level.
ICE (Intermittently Closed and Open Estuary)	A type of wave dominated estuary with an entrance that periodically closes to the ocean.
Lidar	Point land surface heights collected via aerial light detection and ranging (Lidar) survey. The spot heights are converted to a gridded digital elevation model dataset for analysis.
Mean Sea Level (MSL)	The average height of the surface of the sea at a tide station for all stages of the tide over a 19-year period, usually determined from hourly height readings measured from a fixed predetermined reference level..
MHWS Mean High Water Springs	The average height of the high waters of spring tides. Also called spring high water.
Neap Tide	The tides of decreased range occurring near the times of first and last quarter.
Spring Tide	The tides of increased range occurring near the times of full moon and new moon.
Storm tide	Coastal water level produced by the combination of astronomical tide and meteorological (storm surge) ocean water level.
Tidal Levels	A series of water levels that define standard tides, e.g. 'Mean High Water Spring' (MHWS) refers to the average high water level of Spring Tides.
Tidal Range	The difference between successive high water and low water levels. Tidal range is maximum during Spring Tides and minimum during Neap Tides.
Tide	The periodic rise and fall of the surface of oceans, bays, etc., due principally to the gravitational interactions between the moon, sun and earth.

1. Introduction

The Karaaf wetlands are part of the Thompson Creek estuary, covering 130 ha including 95 ha of saltmarsh vegetation. It is a subsection of the broader Breamlea Flora and Fauna Reserve saltmarsh system (Pathways, 2022). The wetlands are bounded by urban development of North Torquay to the west and the Thompson Creek estuary to the east (Figure 1).

Figure 1 Location of the Karaaf Wetlands and Thompson Creek

The urban development to the west of the wetlands has been linked to dieback of saltmarsh across the wetland complex due to increased stormwater inflows. Monthly inflow volumes from the developed catchment to the wetlands are generally in the order of 3-4 times the pre-development conditions (DesignFlow, 2022 and Water Technology, 2021). This stormwater inflow also makes up a higher proportion of the total inflow to the wetlands during the drier summer months and is potentially altering the salinity regime of the wetlands.

1.1. Scope of Work

The purpose of this review is to test the assumption proposed by Pathways (2022) that keeping the Thompson Creek estuary in open condition would improve flushing of the wetland and assist recovery of the impacted saltmarsh vegetation.

The focus questions are:

1. Could opening the estuary allow more saline water mixing thereby increasing salinity in the areas of saltmarsh impacted by freshwater from stormwater inflows?
2. Could opening the estuary allow stormwater to be more readily flushed out of the wetland and thereby increase the salinity in the saltmarsh most impacted by freshwater flows?

To answer these questions, we have reviewed the available information and undertaken a detailed evaluation of the way in which inflows to the wetland interact with the vegetation communities, and how the water levels in Thompsons Creek affect this interaction.

2. **Background**

2.1. **Vegetation Communities**

The current extent and quality of existing vegetation in the Karaaf wetlands was assessed and discussed in detail in Pathways (2022). Generally, the available EVC mapping reviewed was considered to provide an accurate representation of Coastal Tussock Saltmarsh, Saline Aquatic Meadow, Wet Saltmarsh Herbland and the combined area of Coastal Hypersaline Saltmarsh and Wet Saltmarsh Shrubland. The most recent EVC mapping from the Index of Wetland Condition (DEECA, 2021) is shown in Figure 2.

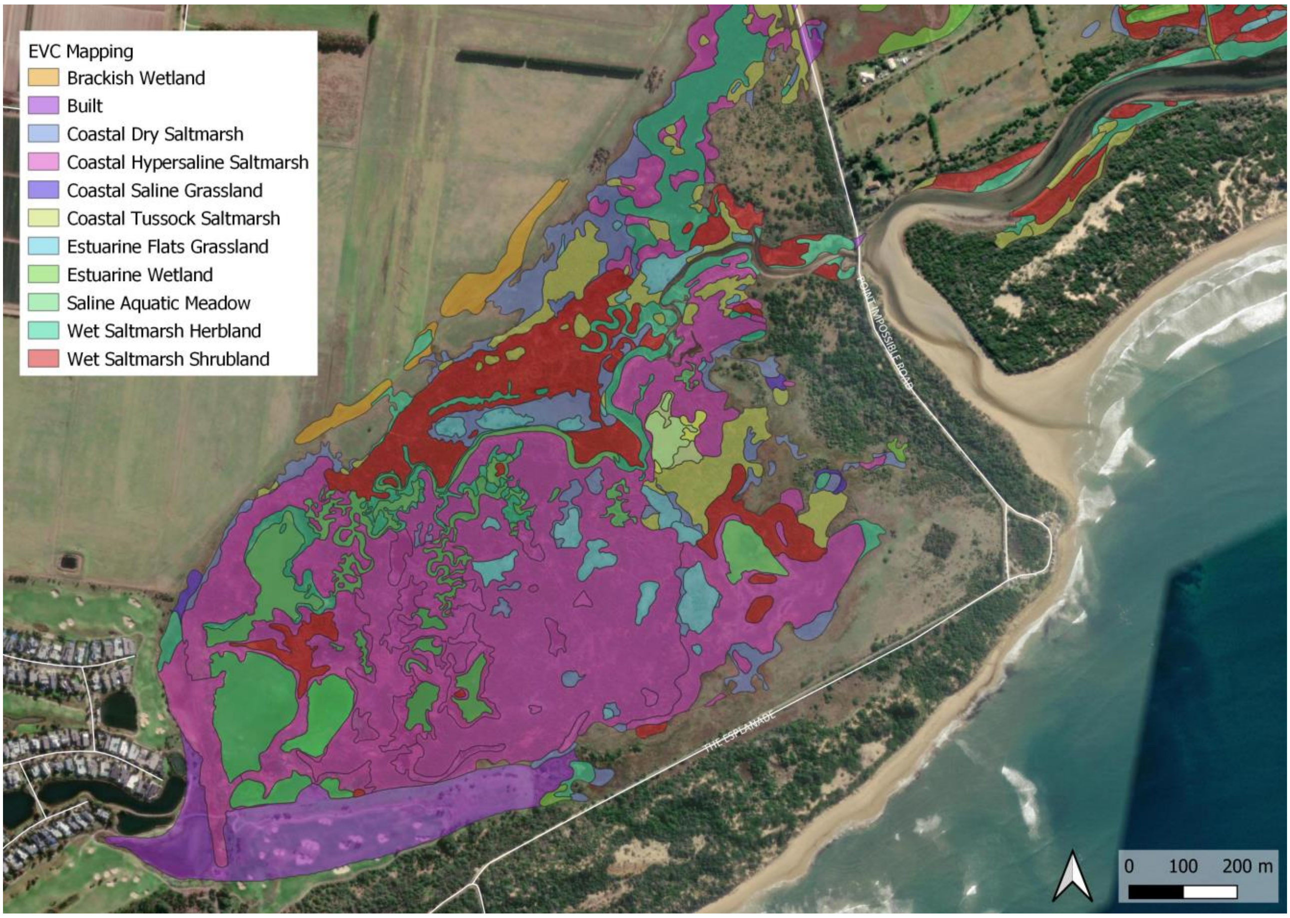

Figure 2 EVC mapping for estuarine fringing vegetation (DEECA, 2021)

Pathways (2022) considered that the mapped extents of Coastal Hypersaline Saltmarsh and Wet Saltmarsh Shrubland EVCs were no longer accurate, based on major dieback of glasswort shrubs that has occurred within the past five years.

2.2. **Water Sources**

The Karaaf wetlands receive inflows from several sources: catchment runoff including stormwater inflows, estuarine inflows, direct rainfall, and groundwater. Each of these sources is briefly discussed in this section for context, however the focus of this report is on estuarine inflows.

Catchment runoff

Catchment inflows from the urban development to the west have increased significantly above what would have occurred pre-development. The contributing urban catchment areas and stormwater system along with the inflow to the wetlands are schematically shown in Figure 3.

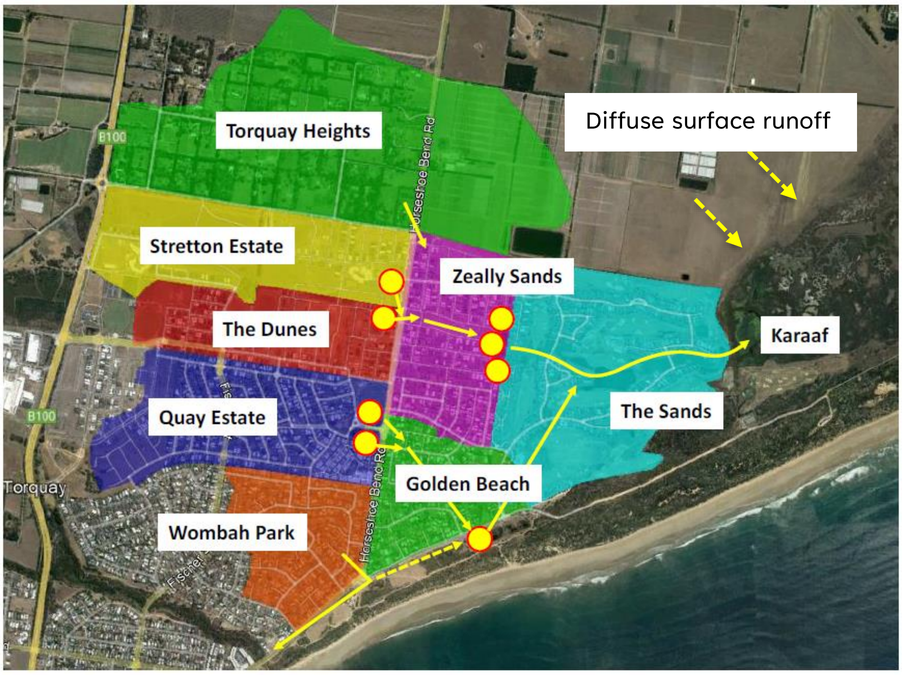

Figure 3 North Torquay catchment and treatment summary (DesignFlow, 2022)

Diffuse surface runoff from the farmland along the northern boundary of the wetland will also occur.

The stormwater enters the Karaaf wetlands after passing through several stormwater treatment ponds. The inflow to the wetland is via a low broad weir, Figure 4.

Figure 4 View of the overflow weir from the final stormwater wetland into the Karaaf Wetland

The estimated monthly stormwater volumes discharging to the wetlands are shown in Figure 5.

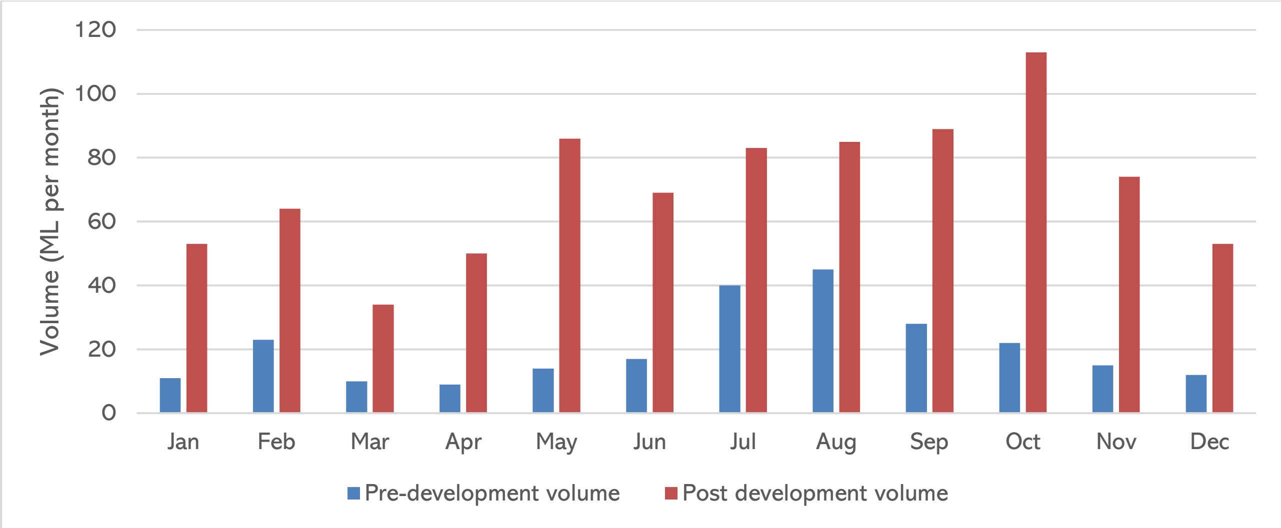

Figure 5 Monthly stormwater runoff volumes discharged to the Karaaf Wetlands (DesignFlow, 2022)

Estuarine inflows

The Karaaf wetlands are connected to Thompson Creek estuary via Mullet Creek. The construction of the road in the 1950s reduced the connection between the creek and the estuary to a single pipe culvert (Figure 6). A series of larger culverts were installed in 2004 to improve tidal exchange (Figure 7).

Original culvert connection through Point Impossible Road

View of the new culverts during construction

Figure 6 Photos of the original culvert connection and the new culverts during construction

Figure 7 Photo of the culverts beneath Point Impossible Road connecting Mullet Creek to the Thompson Creek estuary

Thomson Creek is an intermittently open and closed estuary, which is the dominant estuary type in Victoria. When the mouth of Thompson Creek is open (Figure 8) tidal exchange occurs between the estuary and the ocean and between the estuary and Mullet Creek.

Figure 8 Thompson Creek, Breamlea (N. Rosengren, 2016) in Barwon South West Scoping Study

The mouth of the estuary closes (Figure 9) when there is low flow in the creek, and a beach berm builds up to separate the estuary from the ocean. If the mouth remains closed for a long time, any freshwater inflow builds up behind the berm and the water levels in the estuary rises.

Under these conditions, the water flowing through the culvert into Mullet Creek becomes increasingly fresh and the water level in the wetlands rises with the estuary.

Figure 9 Aerial image from May 2019 showing the mouth of Thompson Creek closed

Rainfall

Direct rainfall results in localised ponding in low-lying areas of the wetland. Annual average rainfall is around 456 mm (Figure 10). Rainfall and the resultant runoff in the broader Thomson Creek catchment generate flows into the creek and influence the condition of the estuary mouth. Flows are much more variable than rainfall, as can be seen in Figure 10, with some years showing almost no flow for extended periods. Flow can be affected by abstraction and storage within the catchment.

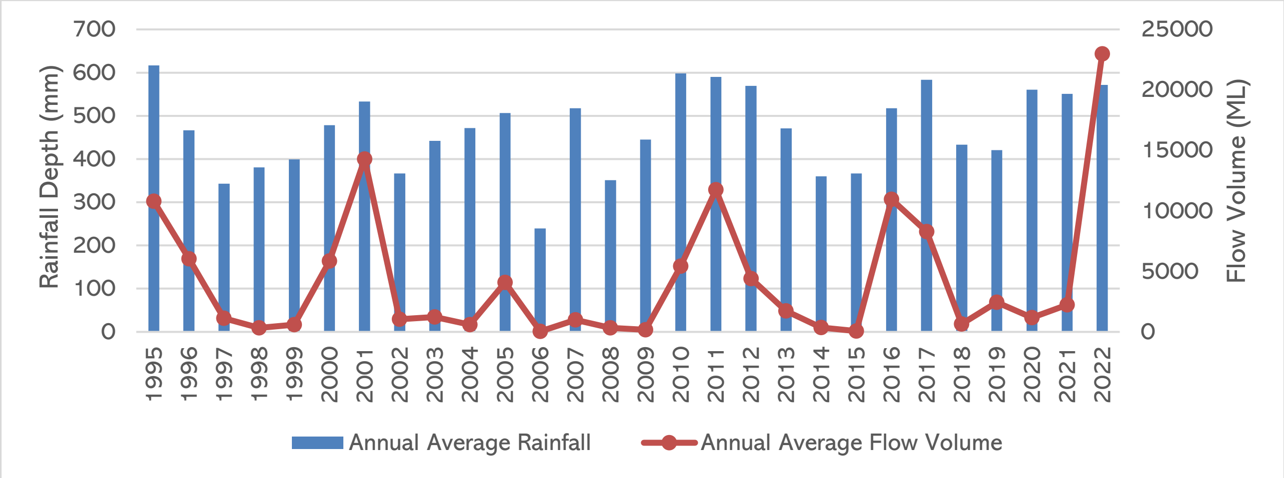

Figure 10 Rainfall and flows in the Thompson Creek catchment (235255 Thompson Creek @ Ghazeepore)

Groundwater

Depth to groundwater across the wetlands and adjacent areas is less than 5m and groundwater salinity is typically brackish (3,000 - 35,000 TDS) (A.S. Miner, 2008 as referenced in Pathways, 2022) and Visualising Victoria's Groundwater (https://www.vvg.org.au/). The Karaaf wetlands have been identified as a groundwater dependent wetland[1] (Figure 11).

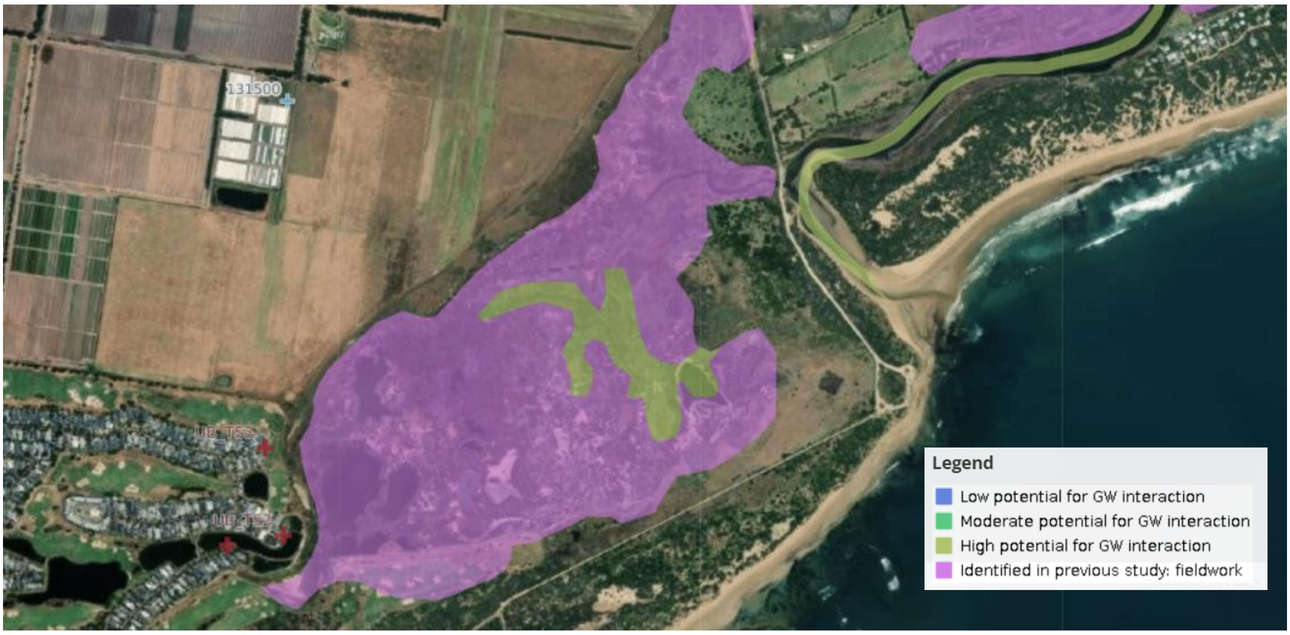

Figure 11 Groundwater dependent terrestrial vegetation – Karaaf Wetlands (https://www.vvg.org.au/)

[1] Ecosystems that rely on the surface expression of groundwater

2.3. **Wetland & Channel Levels**

The elevation of the wetland and the various tidal channels control how estuarine inflows are distributed into and through the wetland and the potential interaction with stormwater inflows. Two lidar datasets (from 2007 and 2019) were sourced and used to assess these levels by extracting a series of cross-sections, Figure 12. The elevation of the coastal berm at the mouth of Thompson Creek was also extracted from the data (labelled "Entrance").

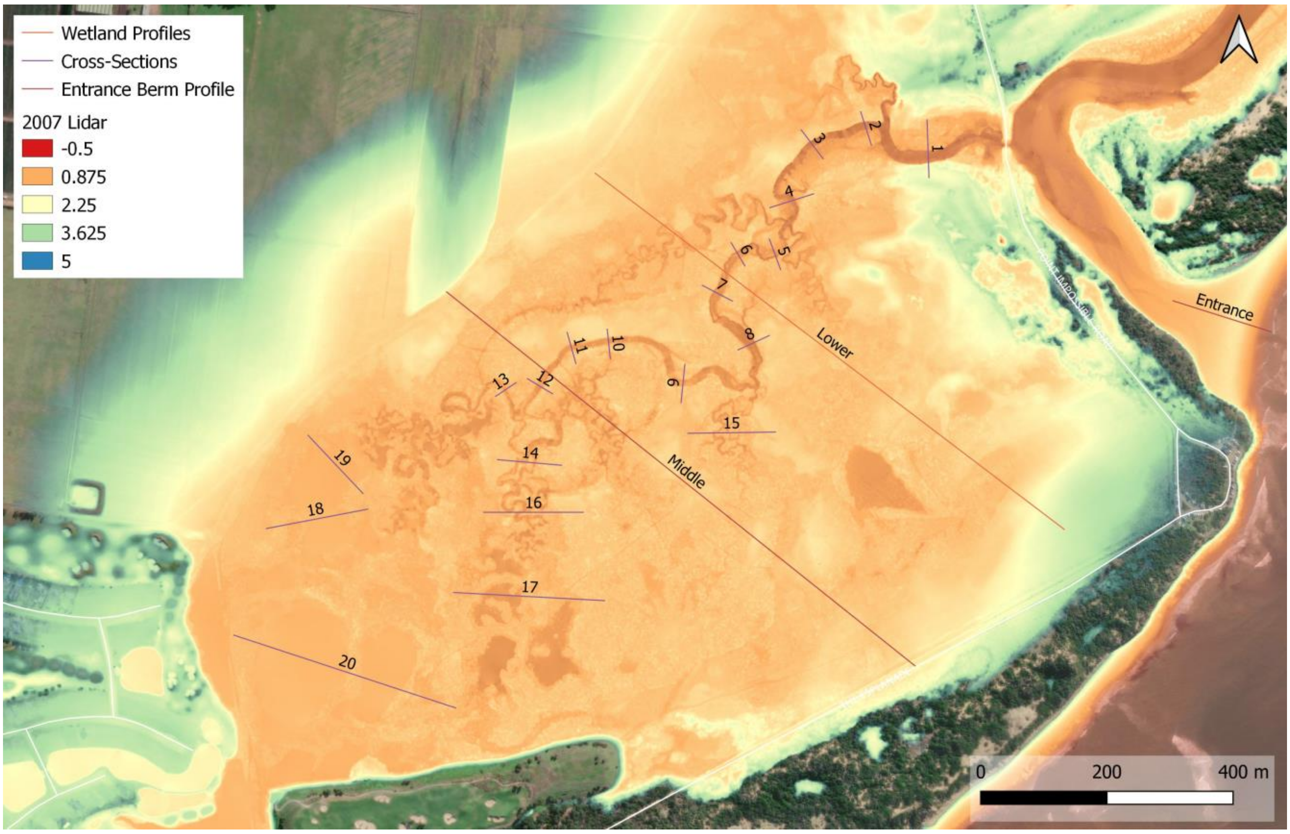

Figure 12 Ground levels and profile locations used in this review

Figure 13 shows the ground elevation across the middle wetland profiles for both the 2007 and 2021 lidar datasets. The water level in the tidal channels was slightly higher when the 2021 data was captured which is why the depth of the channels is not as well resolved in that dataset.

Figure 14 shows a long profile along Mullet Creek, from upper extent of the channel (left) to the culvert at Point Impossible Road (right).

The coastal berm levels are shown in Figure 15 with the 2021 berm being around 0.4m higher than the berm in 2007. In both lidar surveys the mouth was closed.

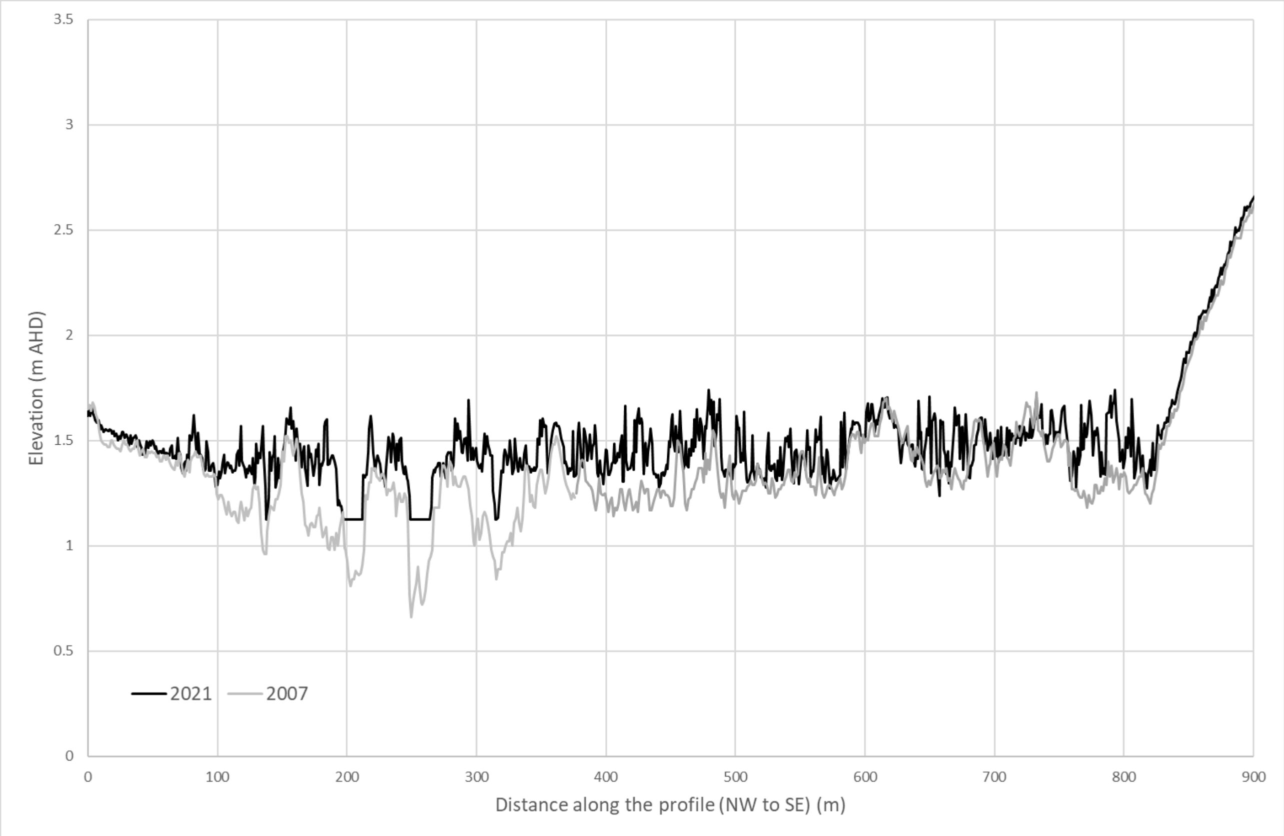

Figure 13 Ground elevation across the Karaaf wetlands along the “middle” profile

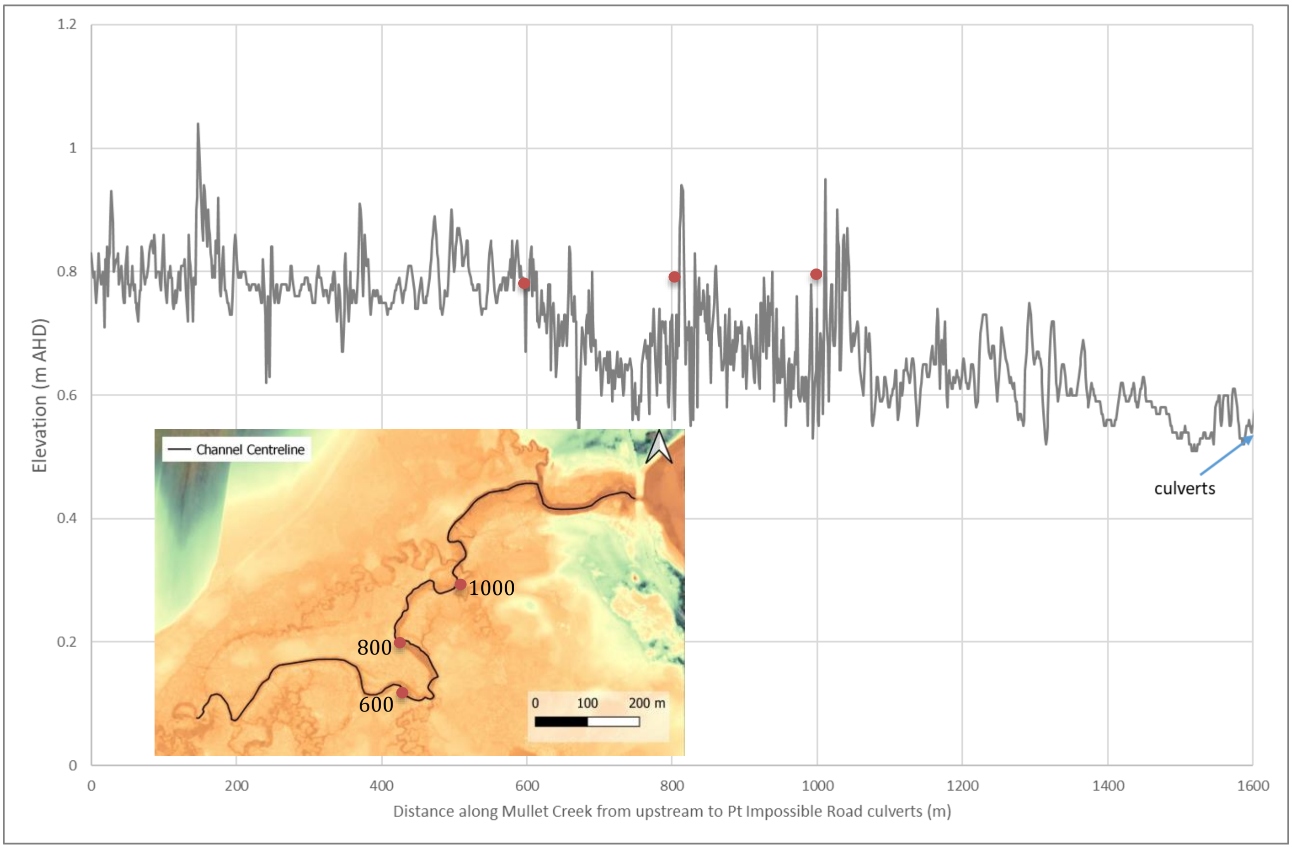

Figure 14 Long profile along Mullet Creek from the culvert to the most upstream extent

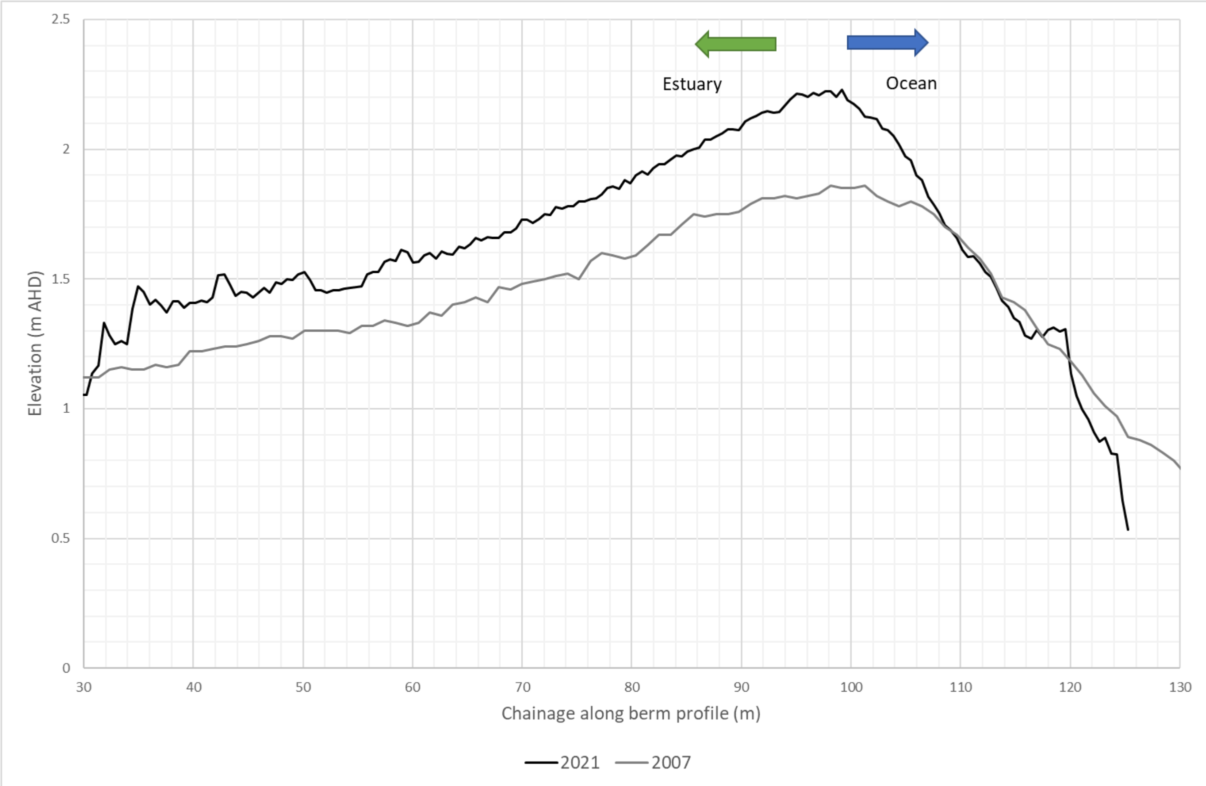

Figure 15 Entrance berm profiles from lidar captured in 2007 and 2021

2.4. Coastal Water Levels

Sea level data is available from the Lorne and Point Lonsdale tide gauges and predicted astronomical tide values are also provided at these sites. They are the closest tide gauges to the mouth of Thompson Creek and can be used to estimate the coastal water levels at the creek mouth and therefore what the tidal water levels are likely to be in the Karaaf wetlands. Tidal level information for both Lorne and Point Lonsdale are provided in Table 1. Note that the tidal levels have been converted from chart datum to m AHD to allow for comparison with the elevation data.

Table 1 Summary of astronomical tide levels for Point Lonsdale and Lorne (Ports Victoria, 2023)

Tidal Levels	Tide level (m AHD)	
	Point Lonsdale	Lorne
HAT	0.95	1.34
MHWS	0.62	0.84
MHWN	0.36	0.44

Measured sea level data may be different than the predicted tidal levels due to variations in atmospheric pressure and wind which can increase or decrease the water level compared to the predicted tidal level. This variation from the predicted tide is referred to as the "tidal anomaly" or "residual".

Where the tidal anomaly is associated with the presence of a storm system, we call it a "storm surge" which when combined with the tide gives a "storm tide" level. Figure 16 shows the tide (blue line) and the measured sea level (tide plus anomaly) for a six-week period in late 2022. Over this period the sea level was generally elevated, and a small "surge" occurred around the 20th of November. Because the surge occurred during the neap tide cycle the peak water level was only just above the MHWS level.

The 1% AEP storm tide for the Breamlea area is 1.75 m AHD assuming 0.0 m AHD for current mean sea level (Cardno, 2015).

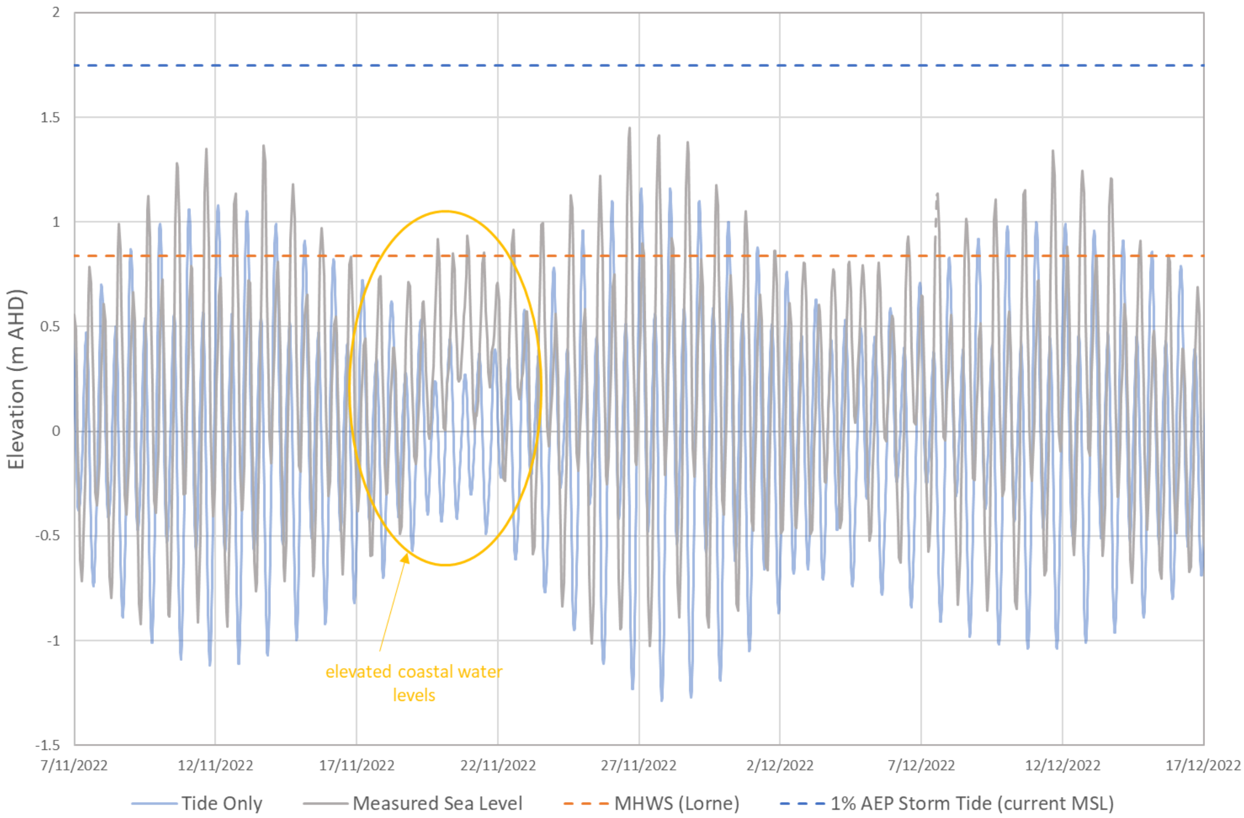

Figure 16 Example of astronomical tide and sea levels at Lorne compared to the MHWS and 1% AEP storm tide levels

3. **Technical Review**

The focus of this review is on estuarine flows within the wetland, and whether opening the mouth of Thompsons Creek would improve the ecological condition of the system. In this section we review the information on wetland and tidal channel levels with the tidal levels and the condition of the entrance.

3.1. **How does the tide interact with the wetland?**

When the mouth of Thompsons Creek is open, water from the coast can enter the estuary and water levels in the estuary vary in line with the tide. The upper extent of the tidal range is typically characterised in terms of the MHWS (mean high water springs) tidal level. As shown in Table 1, MHWS is around 0.84 m AHD at Lorne. As shown in the sea level data presented in Figure 16, the coastal water levels can be higher than the tidal level because of meteorological forcing and in the period shown the maximum sea level is close to 1.5 m AHD.

We can translate this into a tidal extent across the Karaaf wetlands by mapping these levels onto the elevation data, Figure 17. The 0.9 m contour (green) represents the area of the wetland that is regularly inundated by the tide. The 1.5 m contour (blue) represents an indicative upper limit of coastal inundation (entrance open) and matches well the general extent of the wetland.

Figure 17 Comparison of coastal water levels and elevations across the Karaaf wetlands

The most westerly area of the wetlands is above the typically tidal levels, and this aligns with the area most impacted by stormwater inflows through dieback of estuarine vegetation species (Figure 18). Any stormwater inflows to this most westerly area would not regularly interact with the tide and there are no tidal channels connecting these higher areas directly to Mullet Creek to allow the flows to drain directly into the creek.

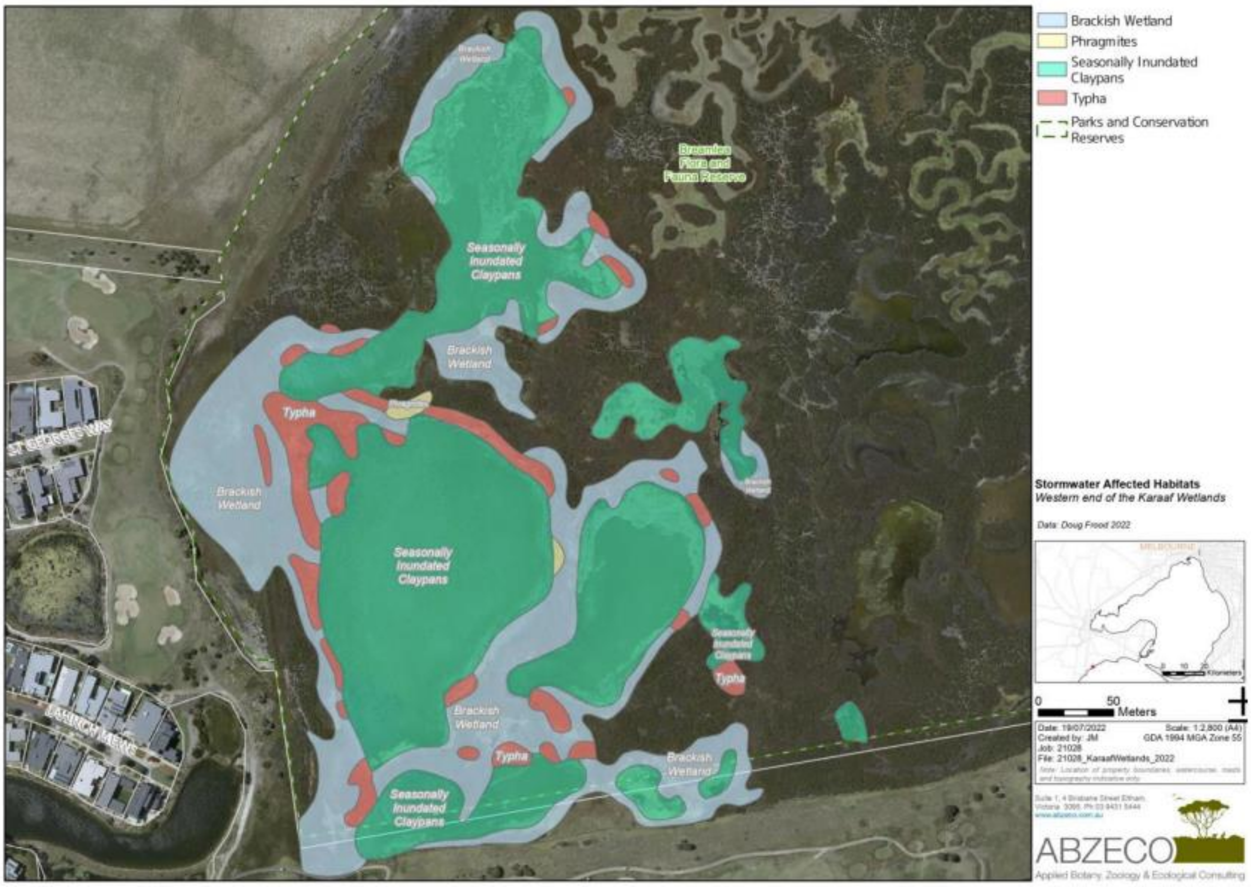

Figure 18 Vegetation communities modified by stormwater inputs (from Pathways, 2022)

Some diffuse overland flow and seepage of the stormwater through into the lower tidal areas would occur along with evaporation, however the potential for tidal flows to mix with the freshwater inflows is limited. Maintaining tidal exchange is the Thompson Creek estuary would not in itself improve the health of estuarine vegetation in these higher elevation areas at the most westerly end of the wetland.

This is further supported by recent observations on site, where the westerly section of the wetlands was completely dry (Figure 19) despite the estuary mouth being open (Figure 20).

Figure 19 Views across the most westerly section of the Karaaf wetlands with dry clay pan areas (photo: 30/03/23)

Figure 20 View looking towards the more easterly section of the Karaaf bordering Point Impossible Road (left) showing more varied vegetation communities and the current open mouth of the Thompson Creek (right) (photo: 30/03/23)

3.2. How does the mouth of the estuary affect water levels?

As mentioned in Section 2.2, the Thompson Creek estuary is an intermittently open and closed estuary (ICE) system. River and tidal flows are sometimes insufficient to erode a channel through the sandy berm that builds up at the mouth from wave action and the mouth "closes". Once closed, any river flows accumulate behind the berm and the water level in the estuary rises. The entrance will open naturally through overtopping from the catchment side when the water level in the estuary is higher than the berm; through wave overtopping from the ocean side; or by seepage and/or liquefaction of the berm. Artificial opening is when a new channel is physically constructed through the berm to reconnect the estuary to the ocean.

There is no preferred mouth state for an ICE as both open and closed conditions are part of the estuary cycle. These types of estuaries naturally experience closed and open periods, and a range of catchment inflows and water levels. However, reductions in catchment flows can increase the likelihood of the estuary closing.

From Figure 15 we can see that the berm can be as high as 1.8 to 2.2 m AHD when the estuary is closed, which means the water level in the estuary would increase to these levels before it can overtop the berm and reconnect with the sea. The 1.9 m AHD levels is plotted in Figure 17 which gives an idea of the increased extent of inundation as the water level rises above the expected tidal range.

For the water level in the estuary to increase requires freshwater inflows. These closure events typically occur when creek flows are low and wave energy is high (Figure 21) and as inflows are low the time it takes for the estuary to "fill - up" to the height of the berm can be in the order of weeks or months. The EstuaryWatch data indicates that when the estuary closed in 2014/15, 2018/2019 and 2021 it remained closed for anywhere from five to sixteen months. Figure 21 shows that when the entrance has closed for significant periods this corresponds with extended periods of very low flows in Thompson Creek. Data on mouth closures is not available from EstuaryWatch pre-2007, however data from Surf Shire Council referenced in Pathways (2022) indicates there were extended closures in 1994/1995.

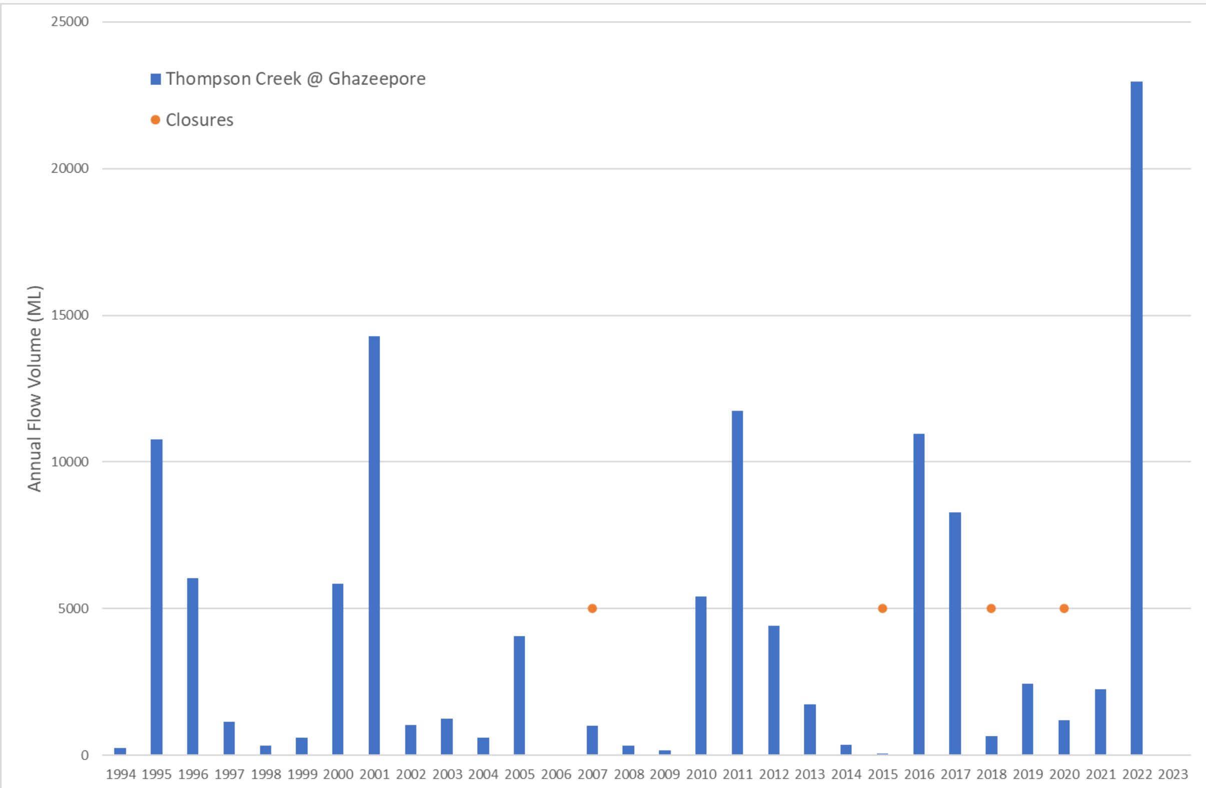

Figure 21 Comparison of annual flow volumes in Thompson Creek and record mouth closures

Freshwater inflows gradually inundate the entire extent of the Karaaf wetland during these closure events. The extended duration of this freshwater inundation can contribute to the dieback of saltmarsh vegetation across the broader wetland area as noted in Pathways (2022), however these ICE estuary systems close naturally and so changes in vegetation because of closures are also a natural process.

3.3. **When can the mouth be opened artificially?**

Artificially opening and sustaining an open mouth to Thompsons Creek has been suggested as a way of reducing the dieback of saltmarsh vegetation as it would allow the continuous exchange of more saline water with any freshwater inflows and limit the extended ponding of freshwater across the wetland when the mouth closes for extended periods.

However, as noted by McSweeney and Stout (2019) sometimes artificial openings will not achieve their goals of sustaining an open entrance or reducing inundation by reducing estuary water levels. If any estuary is opened when the water level variation between the estuary and the sea is low, there is a lack of potential energy which translates to a weak outflow through the channel. This outflow has insufficient velocity to erode sand offshore and the channel typically infills from wave-driven deposition within hours to days of opening.

Sometimes the channel may open but the water level in the estuary doesn't drop significantly. This occurs when the outflow expends more energy widening the channel instead of deepening it. As the channel bed remains high, drainage rates are slow, and the estuary is likely to close off again within days to weeks without substantially decreasing the estuary water level.

The length of the channel is important too as the longer the channel that must connect the estuary to the sea, the slower the outflow and the larger the volume of sand that needs to be eroded.

To be considered a "successful opening" the entrance channel must be maintained for an extended period to allow the water level in the estuary to be lowered and remain lowered. McSweeney and Stout (2019) analysed estuary openings across the Corangamite Catchment Management Authority region. They found that:

- The hydraulic gradient at the time of the opening controls the success of the artificial opening. Artificial openings are successful when the hydraulic gradient is > 0.019 (1:53); not successful at <0.015 (1:67); and mixed between these gradients.
- Estuaries naturally open when the gradient is > 0.022 m/m (grade 1:46).

Figure 22 presents this outcome graphically, while Figure 23 defines what the hydraulic gradient is.

Although the estuary opening may be initially successful, the duration over which it remains open is determined by the balance between the sand being transported offshore by the outflow and tidal currents and wave action bringing sand back onshore. High energy wave conditions could result in the mouth rapidly closing again.

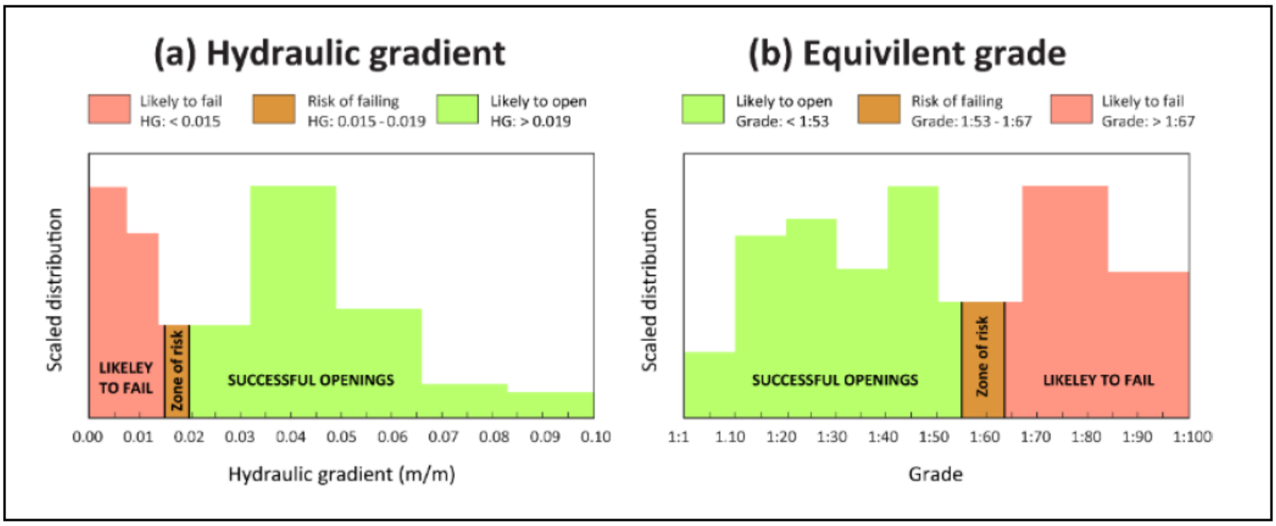

Figure 22 (a) hydraulic gradient; and (b) equivalent grade at which artificial openings are likely to be successful, unsuccessful and at risk of failing (from McSweeney and Stout, 2019)

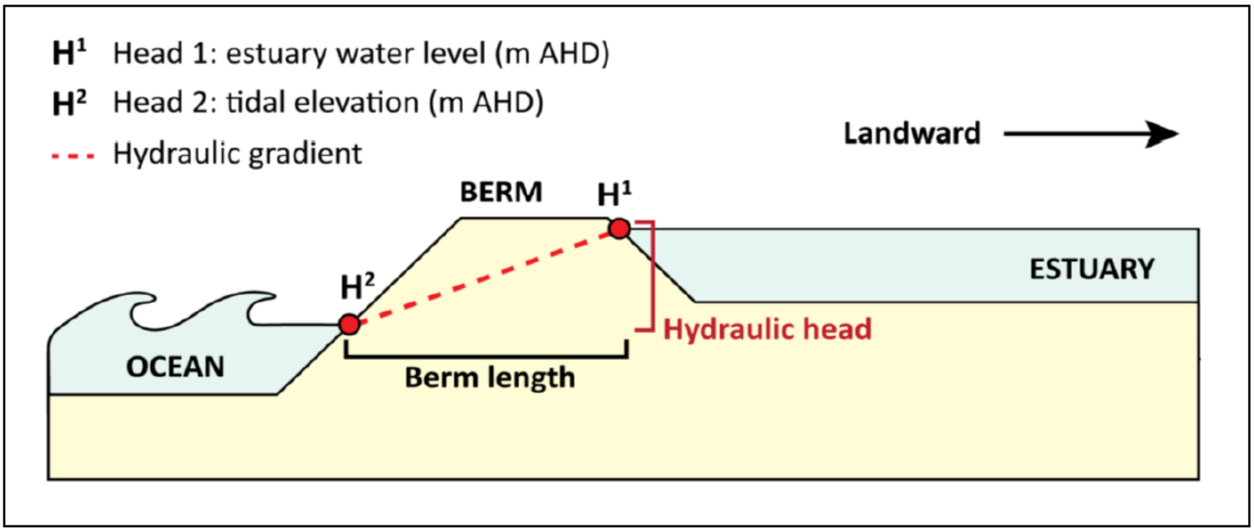

Figure 23 Explanation of hydraulic gradient – the energy slope between the estuary water level and the ocean water level (from McSweeney and Stout, 2019)

Applying these criteria to the mouth of Thompson Creek we can predict that for the entrance to be artificially opened and remain open for an extended period (assuming wave conditions are also suitable), the water level in the estuary must be at least 1.7 m AHD (Figure 24). Based on the previously recorded closures and openings of Thompson Creek, the duration of inundation likely to be experienced before conditions are suitable for artificially opening the estuary could be in the order of 8+ months.

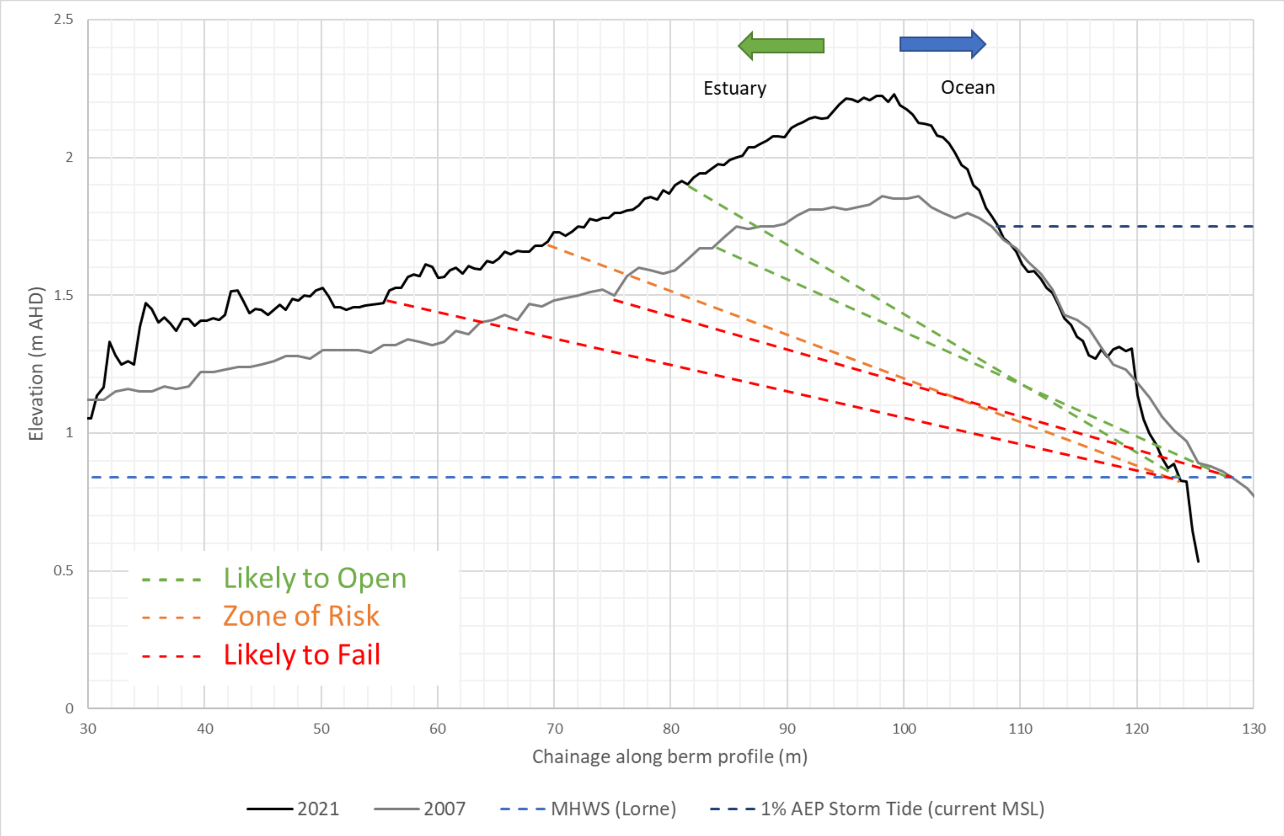

Figure 24 Prediction of the likely success of artificially opening Thompson Creek for different estuary water levels and berm configurations

3.4. What additional risks are there due to artificial openings?

Within an estuary two distinct layers of water can form, an oxygen-rich freshwater layer on top and an oxygen poor saline layer on the bottom. When the estuary is opened in this condition with no freshwater inflow, it results in the oxygenated layer on top being drained into the ocean, leaving behind an estuary filled with oxygen poor water which increases the risk of a fish kill. A natural opening poses a lower risk to environmental values as it is driven by natural factors that mitigate negative effects, such as rainfall induced freshwater inflows (CCMA, 2022). However, fish kills can occur when the estuary is closed too, because of low inflows and low dissolved oxygen.

4. **Conclusions**

4.1. **Summary of Findings**

Increased stormwater flows from the urban development to the west of the Karaaf wetlands have been linked to dieback of saltmarsh and changed vegetation communities across the western section of the wetland complex (Pathways, 2022). Dieback has occurred at places across the broader Karaaf, which is more likely the result of expected periods of estuary closure rather than from stormwater inflows. Many of Victoria's estuaries close from time to time as a response to natural processes and the estuary ecosystems, plants and animals are adapted to this.

The purpose of this review is to test the assumption that keeping the Thompson Creek estuary in an open condition would improve flushing of the wetland to the west of Point Impossible Road and assist recovery of the impacted saltmarsh vegetation.

The focus questions were:

3. Could opening the estuary allow more saline water mixing thereby increasing salinity in the areas of saltmarsh impacted by freshwater from stormwater inflows?
4. Could opening the estuary allow stormwater to be more readily flushed out of the wetland and thereby increase the salinity in the saltmarsh most impacted by freshwater flows?

To answer these questions, we have reviewed the available information and undertaken a detailed evaluation of the way in which inflows to the wetland interact with the vegetation communities, and how the water levels in Thompsons Creek affect this interaction. Based on this review, the following summary is provided:

- The most westerly section of the wetland which has been most impacted by stormwater flows, is where ground levels are above 1 m AHD and this means it is above the level of normal tidal inundation. These areas would previously have been seasonally inundated claypans where evaporation processes would dominate resulting in a saline environment.
- Increased stormwater inflows have increased the duration of freshwater inundation in these areas, and this has resulted in a change to the vegetation communities from more salt tolerant to more freshwater tolerant species.
- Tidal exchange will not increase saline mixing and increase salinity of either the surface or groundwater in these most westerly areas of the wetland due to their elevation above typical tidal levels and the lack of direct connection to Mullet Creek.
- Reducing stormwater inflows would reduce the duration of freshwater ponding in the most westerly section of the wetland. Whether this would return the system to a more saltmarsh dominated wetland is uncertain.
- Lowering of the water level in the estuary by artificially opening the mouth of Thompson Creek once it has closed is unlikely to be able to be achieved for an extended period until the water level in the estuary reaches ~1.7 m AHD and wave energy is low. At this level all the Karaaf wetland west of Point Impossible Road will be inundated. The estuary may also open naturally at this level.

- The duration of an estuary closure is a function of the magnitude of catchment flows. These flows are needed to "fill" the estuary to the level at which the conditions allow the mouth to open successfully.

4.2. Conclusions

Once closed, opening the entrance of the Thompson Creek estuary either naturally or artificially to lower the estuary water levels for an extended period can typically only be achieved when water levels in the estuary reach ~1.7 m AHD or higher. So, periods of inundation of the entire wetland complex west of Point Impossible Road will occur, with the potential for die-back of more saline dependent vegetation depending on the time it takes to fill the estuary to this level. This is a natural process for intermittently open and closed estuaries like Thompson Creek and occurs when catchment flows are low and wave energy can move sand onshore.

Once open and as long as it remains open, the water level in the estuary and wetland areas will drop to a level consistent with the new channel at the mouth. As the water drains out of the wetland, the most westerly section will retain some freshwater as it is not directly connected to Mullet Creek via a channel. The estuary opening alone does not flush more stormwater out of the wetland, increase the salinity of the local groundwater system, or alter the interaction between the stormwater inflows and the claypan areas at the most westerly end of the wetland.

Overall, the conclusion of this review is that opening of the estuary will not mitigate the effects of increased stormwater inflows the Karaaf wetlands to the west of Point Impossible Road.

5. References

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Appendix A

Available lidar datasets
Two lidar elevation datasets were available for this project:

- 2007 Surf Coast lidar captured in June/July 2007. Vertical accuracy +/-0.1m (**Error! Reference source not found.**).
- 2021 Golden Plains lidar captured between April to November 2021. Vertical accuracy +/-0.1m.

The Golden Plains lidar only covers approximately the northern half of the Karaaf wetlands, however it does include Thompson Creek and the entrance area. In the 2021 data the water level in Mullet Creek was slightly higher during the data capture and so the less of the channel bed is visible.

Site Visit Photos
The following photos were taken during the site visit on the 30th of March 2023.

Stormwater pond adjacent to wetland

Stormwater pond adjacent to wetland

Stormwater pond overflow to wetland


Pathway across salt pan and wetland on the golf course


View looking across the salt pan area of the golf course


View into the western section of the wetlands


View into the western section of the wetlands


View looking across the mid-section of the wetlands


View of Mullet Creek from Point Impossible Road


View of the culverts connecting Mullet Creek to the estuary


Looking upstream along Mullet Creek from the culverts


View looking upstream along Mullet Creek


View of Thompson Creek from Point Impossible Road


Looking upstream from the mouth of Thompson Creek