



Final Report

Korogoro Creek Entrance Management Plan

Kempsey Shire Council

3 March 2025



Document Status

Version	Doc type	Reviewed by	Approved by	Date issued
V01	Draft Report	ND	ND	08.12.2021
V02	Revised Draft	CJB	CJB	18.01.2021
V03	Final Draft	CJB	CJB	29.03.2022
V04	Final Report	CJB	CJB	03.03.2025

Project Details

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Document Number	21010360_R03_V04_Korogoro_EMP



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1 INTRODUCTION

1.1 Background

Korogoro Creek is a small coastal creek with no significant tributaries that runs through Hat Head, located within the Kempsey Local Government Area (LGA) on the mid-north coast of New South Wales. The entrance of the creek is untrained and historical records indicate that the entrance has been almost permanently open in recent decades.

However, in the past, the entrance has proved to be a highly dynamic area, with the entrance shoals and flood tide delta demonstrating a high level of mobility. Anecdotal reports have indicated that the entrance has closed on very rare occasions in the past, the most recent of which was believed to have occurred in the mid-1970s. It is also recognised that the estuary has potential to close in the future, albeit under very rare and exceptional circumstances. For this reason, the estuary is technically classified as an Intermittently Closed and Open Lake and Lagoon (ICOLL).

Therefore, an Entrance Management Plan (EMP) is required to outline to Council and the community if and when the estuary entrance should be managed, or other works undertaken – in the rare and exceptional event of entrance closure. With this in mind, the adoption of a flexible and adaptable 'best practice' EMP is crucial to ensure the environmental and social values of the estuary are protected. It provides specific focus on short-term life frames (of around 10-15 years), whilst acknowledging potential future changes related to climate change and sea level rise impacts.

This EMP has been prepared to ensure sustainable environmental and management outcomes for the estuary on behalf of Kempsey Shire Council (Council), with funding and technical assistance from the NSW Department of Climate Change, Energy, the Environment and Water (DCCEEW), and in consultation with various state agencies and other relevant stakeholders including local Hat Head community representatives.

1.2 The Area to Which this Plan Applies

The area covered by this EMP is shown in Figure 1-1. This EMP applies to the catchment of the estuary which comprises the waterway, foreshores and land adjacent to the estuary up to the tidal limit of the tributary creeks and the extent of the drainage catchment directly contributing to the estuary waterways. The area relevant to this EMP also includes the proposed access route along for excavator access to the estuary entrance.

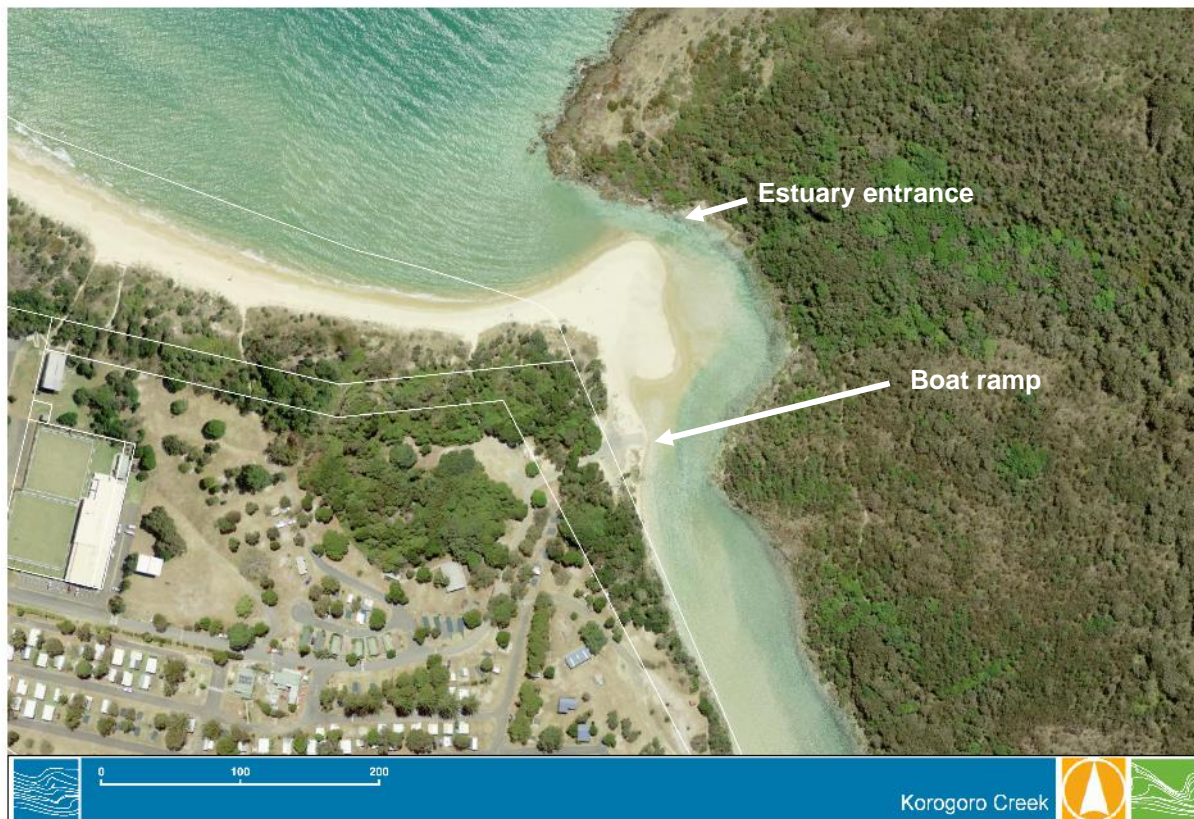


Figure 1-1 Area to which this plan applies

1.3 Objectives for Entrance Management

This EMP advocates minimum entrance intervention, with preference for returning to a “natural as possible” breakout regime, and recommends a procedure for management of the entrance that minimises the need for artificial opening in the long term. The objectives of the EMP are to:

- Ensure that entrance opening follows as natural a regime as possible within the constraints of flooding and property inundation;
- Responsibly and practically mitigate the impacts of coastal and catchment flooding;
- Gain broad based community understanding and support for management of the estuary entrance;
- Clarify responsibilities and accountabilities in relation to entrance management; and
- Document the protocols for entrance management that determines whether intervention is required.

1.4 Coastal Management Context

This EMP has been prepared as part of the broader Kempsey Shire Council Coastal Management Program (CMP). The CMP will cover the entire coastal zone of the Kempsey Shire LGA, including the open coastline and tidal waterways of its various estuaries.

A CMP is required for better outcomes in estuary systems management under the new NSW Coastal Reforms. A CMP initiates an integrated and coordinated estuary and catchment management approach that aims to maintain and enhance the social, cultural, economic and environmental values with coordination between local councils, state agencies and other relevant stakeholders.



Based on the recommendation of the Stage 1 Scoping Study (BMT WBM, 2020), Kempsey Shire Council with the support of DCCEEW has commissioned a CMP Stage 2 - entrance management study and plan.

The EMP will be included in the pending Kempsey LGA CMP, and implementation of recommended/supported entrance management actions will subsequently commence following Certification by the Minister and adoption of the CMP by Council.

2 STUDY AREA DESCRIPTION

Korogoro Creek runs through Hat Head National Park, and enters the ocean at the town of Hat Head, approximately 20 km south of South West Rocks (see Figure 2-1). The creek has no significant tributaries and extends from its entrance to the tidal limit 5.4 km upstream at the floodgates on Hat Head Road, which separates it from the Swan Pool wetlands.

Its catchment is approximately 18 km² which is largely undeveloped, as over 60% of the catchment is protected within the National Park. Developed areas of Hat Head make up only 4% of the catchment (GECO Environmental, 2009a). The estuary itself only covers an area of 0.2 km², and the hydrology is dominated by tidal flushing. Korogoro Creek is classified as a wave-dominated inter-barrier estuary with an open entrance. This means that tides flush out the lower estuary waters regularly, and the creek delivers floodwaters and sediments to the open coast (BMT WBM, 2020).

Korogoro Creek is hydraulically connected to the Macleay River system through the Macleay Flood Mitigation Scheme, and the creek is used to drain the Macleay River floodplain via floodgates that allow drainage of the Swan Pool (Figure 2-1). To prevent downstream flooding at Hat Head, a number of levees were constructed along the river, and an artificial ocean outlet was built to divert outflow via a control structure during flooding of the Macleay (BMT WBM, 2020).

Hat Head has a resident population of less than 500 people, but the population increases substantially during the peak holiday seasons due to the area's popularity as a holiday destination. Swimming, surfing, camping, fishing and boating are popular recreational pursuits of residents and visitors alike (GECO Environmental, 2009b).

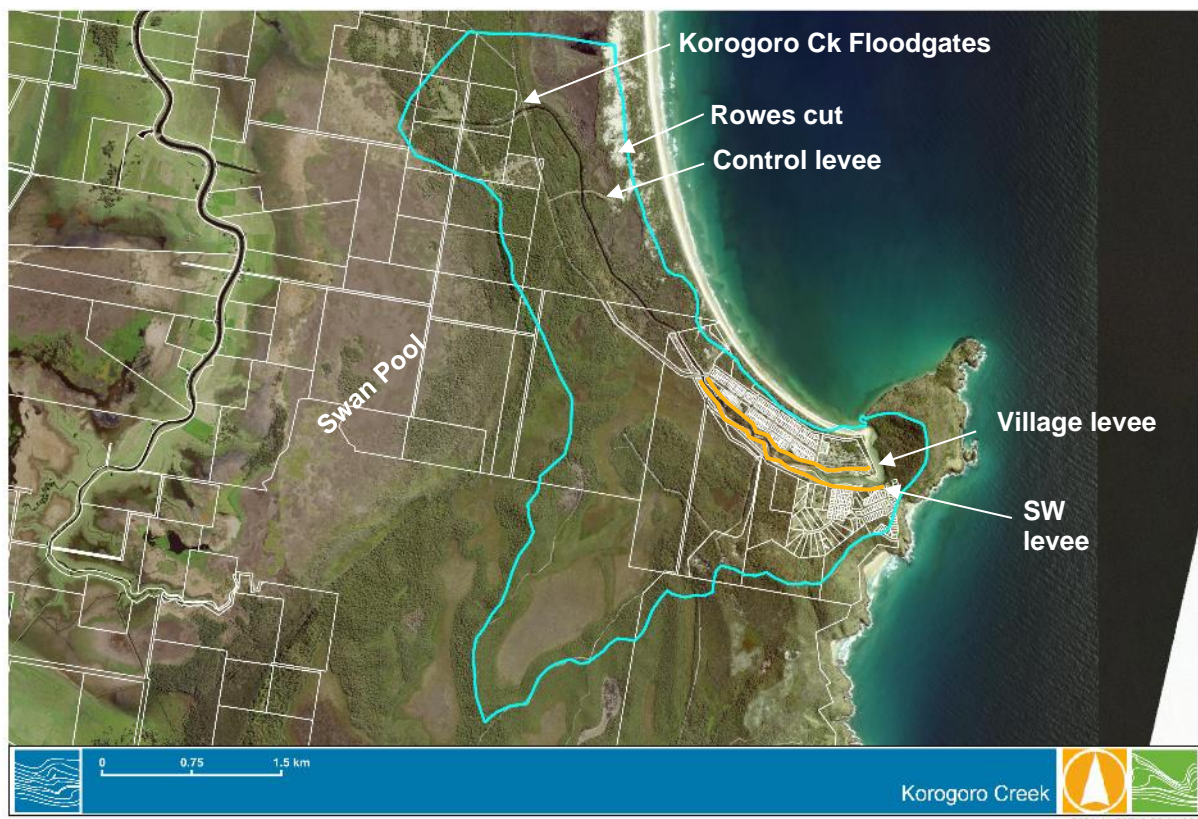


Figure 2-1 Korogoro Creek catchment (in blue) and flood mitigation structures



Figure 2-2 Korogoro Creek (source: DCCEEW, 2021)



Figure 2-3 Korogoro Creek estuary entrance

3 GOVERNANCE CONTEXT

3.1 Overview

Responsibility for undertaking artificial openings of ICOLL entrances usually lies with the local council under its duty of care to the local community, to manage water quality and land subject to flooding.

However, any works within an ICOLL entrance may require approval depending on land tenure and the applicable planning framework. Artificial entrance management is generally assessed under Part 5 of the EP&A Act, where the determining authority (e.g., council or a public agency) is responsible for assessing the environmental impacts. Therefore, tenure needs to be clearly established to determine responsibility for entrance management, and required approval processes (NSW DPI-Fisheries, 2020). A map of land tenure at the Korogoro Creek Entrance is provided in Figure 3-1 below, it shows that:

- The estuary entrance and the entrance berm are located on Crown land waterway.
- The broader estuary is bounded by Hat Head National Park, and Council-managed Crown land at the Holiday Park.



Figure 3-1 Land tenure at Korogoro Creek entrance

3.2 Legislation

The following legislation has been considered in development of this EMP.



3.2.1 Local Government Act 1993

Under Division 2 (Section 35) of the *Local Government Act 1993* (LG Act, community land is required to be used and managed in accordance with the following:

- The plan of management applying to the land (which will only have relevance to activities on Council Managed Reserves); and
- Any law permitting the use of the land for a specified purpose or otherwise regulating the use of the land.

The relevant Plan of Management (PoM) for Korogoro Creek would likely be the Kempsey LGA Coastal Management Program (CMP). This EMP forms part of the certified CMP.

3.2.2 Crown Land Management Act 2016

The Department of Planning, Housing and Infrastructure - Crown Lands (DPHI-Crown Lands) is responsible for the administration and/ or management of Crown land under the *Crown Land Management Act 2016* (CLM Act). Crown land includes submerged Crown land, seabed and subsoil to three nautical miles from the coastline of NSW that is within the limits of the coastal waters of the State. The CLM Act requires that environmental, social, cultural heritage and economic considerations be considered in decision-making about Crown land.

Council Managed Crown Land

Under the previous *Crown Lands Act 1989*, local councils proposing to remove gravel, sand or any other material (including by mechanical entrance management activities and/or maintenance dredging) on Crown land were required to obtain a licence from DPHI-Crown Lands under Part 4, Division 1 of the CLM Act.

However, under the new CLM Act (Specifically Division 3.4), for locations where a council has been appointed the Crown Land Manager of the subject Crown land, Council is authorised to manage the Crown land as if it were public land within the meaning of the LG Act. In the circumstances that a tenure from the Crown should no longer be required for the environmental management activity being undertaken by Council, the approval sections will therefore need to focus on the requirements of the LG Act

Crown Waterway

Where artificial entrance management works occur on Crown waterway or directly (Minister) managed Crown land, a PoM will have no effect, and a licence will be required under Section 1.15(1) the CLM Act.

3.2.3 Fisheries Management Act 1994

The objects of the *Fisheries Management Act 1994* (FM Act) are to conserve, develop and share the fishery resources of the State for the benefit of present and future generations.

Any proposal to artificially open / berm scrape an Intermittently Closed and Open Lakes and Lagoons (ICOLLs) is likely to trigger the dredging and reclamation provisions of Part 7, Division 3 of the FM Act - due to required excavation works at the berm. Therefore, a permit under s200 of the FM Act would be required to be obtained by Council for entrance opening works.

Alternatively, if the entrance opening works are authorised by another public authority (other than a local government authority) such as DPHI-Crown Lands, then s199 of the FM Act would prevail, and the public authority would be required to consult with and consider any matters concerning the proposed work that are raised by DPIRD-Fisheries prior to issuing the licence.

The provisions of Division 3, Part 7 of the FM Act are likely to be relevant to any works associated with the works to the opening of Korogoro Creek. The provisions relate to the protection of aquatic habitat. Although



flood mitigation works would be precluded from requiring consent under the ISEPP, the provisions of the FM Act are still applicable and as part of the Review of Environmental Factors (REF) process concurrence from DPIRD-Fisheries may be required for certain activities. Table 3-1 outlines the relevant provisions of the FM Act that would apply to works to the opening of the estuary.

Table 3-1 Activities requiring concurrence under the FM Act

Section	Activities
198-202	A permit under s200 of the FM Act would be required to be obtained by Council for entrance opening works. Alternatively, if the entrance opening works are authorised by another public authority (other than a local government authority) such as DHPI-Crown Lands, then s199 of the FM Act would prevail, and the public authority would be required to consult with and consider any matters concerning the proposed work that are raised by DPIRD-Fisheries prior to issuing the licence.
219-220	A permit is required when barriers to the movement of fish including water course crossings are to be constructed or modified. Any proposed works to the opening is unlikely to create a barrier to the movement of fish. However, such specifics would need to be confirmed within the REF.
204-205	Any works to the opening would likely be restricted to area of the sand berm. Any works must not affect mangroves or other protected marine vegetation. If marine vegetation would be harmed by flood mitigation works a permit must be sought from the Minister before works commence. Clause 205 (2) states that <i>A person must not harm any such marine vegetation in a protected area, except under the authority of a permit issued by the Minister under this Part.</i> It is unlikely that any such vegetation would be affected by activities associated with the works to the opening of Korogoro Creek, however the REF must confirm this.
Schedule 4, 4A, 5 and 6	The REF prepared for works associated with works to the opening would need to consider any presence of local threatened aquatic habitat for flora or fauna. Key Threatening Processes (KTPs) would need to be considered in preparation of the REF.

3.2.4 Coastal Management Act 2016

The *Coastal Management Act 2016* (CM Act) establishes the framework and sets forth the objectives for coastal management in New South Wales. The purpose of the CM Act is to manage the use and development of the coastal environment in an ecologically sustainable way, for the social, cultural and economic well-being of the people of New South Wales (DPIE, 2019).

The CM Act defines the coastal zone, comprising four coastal management areas:

1. Coastal wetlands and littoral rainforests area
2. Coastal vulnerability area
3. Coastal environment area
4. Coastal use area.

The CM Act establishes management objectives specific to each of these management areas, reflecting their different values to coastal communities. These coastal management areas are mapped as part of the State Environmental Planning Policy (Resilience and Hazards) 2021 (R&H SEPP) – and is depicted in Figure 3-2. This shows that:



- A significant portion of the estuary waterway and its catchment are classified as Coastal Wetlands;
- A significant portion of the estuary waterway and foreshore are classified as Coastal Environment Area (CEA) and Coastal Use Area (CUA);
- The estuary entrance falls within both the Coastal Use and Coastal Environment areas.

3.2.5 Marine Estate Management Act 2014

The *Marine Estate Management Act 2014* (MEM Act) forms part of the NSW Marine Estate Management Framework. The framework comprises statutory instruments, strategies, assessment, plans and policy settings, and is administered under the auspices of the Marine Estate Management Authority (MEMA).

The objective of the MEM Act is to provide for strategic and integrated management of the NSW marine estate, including the marine waters, coasts and estuaries (MEMA, 2018). The key legislative instruments under the act include:

- Marine Estate Management Regulation 2017;
- Marine Estate Management (Management Rules) Regulation 1999; and,
- Aquatic Reserves Notification 2015.

It should be noted that one of the objectives of the CM Act (and of the broader CMP process) is to support the objectives of the MEM Act.

3.2.6 Environmental Planning and Assessment (EP&A) Act 1979

Section 5.5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) states that a determining authority (in this case, Kempsey Shire Council), in its consideration of an activity shall examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of that activity.

Although flood mitigation works would be permitted without consent on any land (see Section 3.3.1), the requirements of Section 5 of the EP&A Act must be fulfilled. As part of the licencing process under the CLM Act, a determined environmental assessment, undertaken in accordance with the EP&A Act, must be submitted with any Crown Land licence application. DHPI - Crown Lands strongly recommends that Council consult with relevant agencies, including DPIRD-Fisheries, as part of preparing these environmental assessments. Feedback from agencies should be considered and incorporated into the assessment, as appropriate. Noting that under s199 of the FM Act, Crown land licence applications that involve 'dredging and reclamation' must be referred to DPIRD-Fisheries for their consideration, and before a licence can be issued

The assessment should consider the impacts associated with repeat openings over a long period and under a range of conditions, rather than a single opening, so that it does not have to be reproduced each time an opening is necessary.

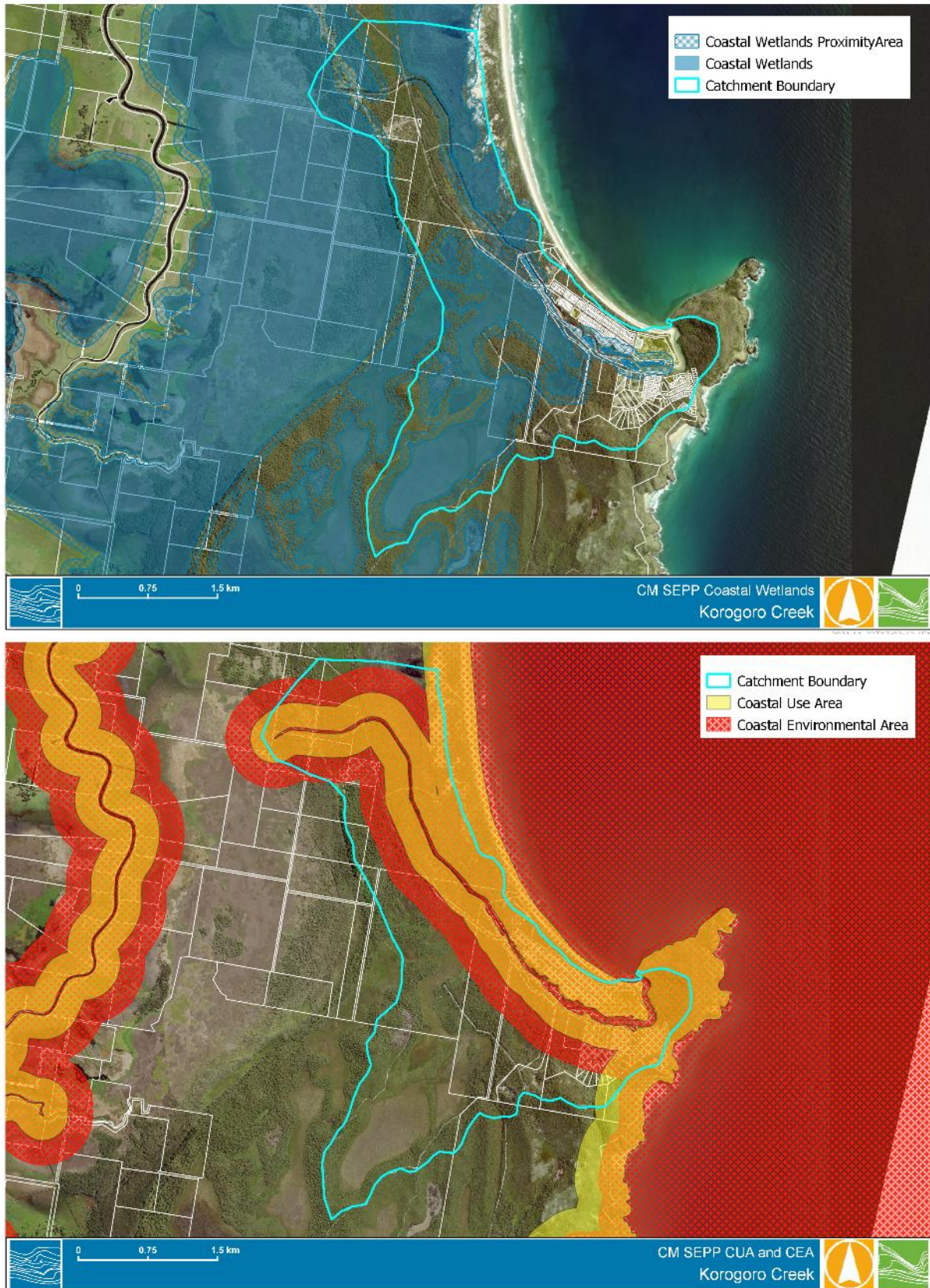


Figure 3-2 R&H SEPP mapping for Korogoro Creek



3.3 Policy Context

3.3.1 State Environmental Planning Policy (Infrastructure) 2007

The ISEPP aims to facilitate the effective delivery of infrastructure across the state. Division 7, Clause 50 of ISEPP permits development on any land for the purpose of flood mitigation work to be carried out by, or on behalf of, a public authority without development consent.

Kempsey Shire Council is proposing to use mechanical opening of the entrance of the estuary for flood mitigation purposes, and therefore the entrance management works would be defined as “infrastructure” works under Division 7, Clause 50 of the ISEPP.

Although flood mitigation works would be permitted without consent on any land, the requirements of Part 5 of the EP&A Act must be fulfilled, and Council would be required to prepare a REF for proposed works to opening of Korogoro Creek.

3.3.2 State Environmental Planning Policy (Resilience and Hazards) 2021

State Environmental Planning Policy (Resilience and Hazards) 2021 (R&H SEPP) updates and consolidates into one integrated policy a series of previously enforced SEPPs, including: SEPP 14 (Coastal Wetlands), SEPP 26 (Littoral Rainforests) and SEPP 71 (Coastal Protection), including clause 5.5. of the Standard Instrument – Principal Local Environmental Plan.

The R&H SEPP commenced on 3 April 2018 and gives effect to the objectives of the CM Act from a land use planning perspective, by specifying how development proposals are to be assessed if they fall within the coastal zone.

The R&H SEPP streamlines coastal development assessment requirements, identifies development controls for consent authorities to apply to each coastal management area to achieve the objectives of the CM Act, and establishes the approval pathway for coastal protection works.

The estuary entrance falls within both the coastal environment and the coastal use areas. Therefore, clauses 2.10 to 2.15 list matters that must be considered prior to granting development consent on land within these coastal management areas respectively. However, as noted in Section 3.3.1, development consent would not be required for the proposed works.

3.3.3 NSW DPIRD Policy and Guidelines for ICOLL Entrance Management

The NSW DPIRD Policy and Guidelines for Fish Habitat Conservation and Management 2013 state the following (NSW DPI-Fisheries, 2013):

1. Any proposals to artificially open ICOLLs must be authorised by a permit from the Minister or authorised by NSW DPIRD or other public authority after consultation with the Minister under the FM Act.
2. NSW DPIRD supports minimal interference with ICOLL barriers and advocates natural processes being allowed to operate to the greatest extent possible.
3. NSW DPIRD does not support the artificial opening of an ICOLL unless the proponent can demonstrate that the social, environmental, and economic benefits greatly outweigh any potential adverse impacts.
4. NSW DPIRD supports using estuary management plans and environmental assessment processes to analyse the issues relating to opening a particular ICOLL, and to develop an entrance management plan. Proposals for artificial openings which are to be carried out according to a formulated entrance management plan are more likely to be approved.



Furthermore, guidelines for mechanical opening from DPIRD include:

- The decision to open an ICOLL should be made on the basis of factual data on:
 - verified water levels and the nature and extent of associated flooding impacts - which should be referenced to a standard datum (e.g., Australian Height Datum) obtained from appropriately sited staff gauges, or automatic water level recorders, and
 - quantitative evidence of changes to relevant water quality parameters (especially nutrient and bacterial levels) produced by monitoring programs designed specifically to assess water quality pre- and post-opening.
- In the event that the criteria for an artificial opening are met, breaching should be conducted during a falling tide (if possible, around a spring tide) so that the potential for establishing an entrance channel long enough to flush the water body is achieved.
- In the long-term, local councils and government agencies should aim to reduce the need for artificial manipulation by taking active measures to remove, relocate or otherwise manage items of low-lying infrastructure that currently necessitate breaches below the natural breakout range, and adopting catchment management practices that:
 - reduce the inputs of nutrients and pollutants from point and diffuse sources,
 - prevent transfer of flood prone and riparian land on the margins of ICOLLs into private ownership,
 - prevent the future development or subdivision of flood-prone and riparian lands by adopting appropriate zonings and buffers in relevant land use planning instruments,
 - implement community awareness campaigns to gain broad based understanding and support for the environmentally responsible management of ICOLLs.
- NSW DPIRD will require proponents to carefully monitor the impacts of extraction activities including:
 - rates of sediment infilling post-works,
 - upstream and downstream impacts,
 - immediate habitat changes

3.4 Summary of Potential Approvals

- Works to the opening of the entrance for the purpose of flood mitigation are permitted without development consent under Clause 50 of the ISEPP.
- As the entrance management works are to occur on Crown waterway, an authorisation from DHPI-Crown Lands is required under Section 5.30 the CLM Act. As part of the DHPI-Crown Lands licence application process, the following would be required under the CLM Act:
 - A determined environmental assessment must be submitted with any Crown Land licence application. This assessment must also fulfill the requirements of Part 5 of the EP&A Act. Therefore, Council is required to prepare a REF for proposed works.
 - Furthermore, under s199 of the FM Act, Crown land licence applications that involve 'dredging and reclamation' must be referred to DPIRD-Fisheries for their consideration. As part of this process, Council would be required to consult with and consider any matters concerning the proposed work that are raised by DPIRD-Fisheries prior to DHPI-Crown Lands issuing a licence.
- It is recommended that an REF is prepared, and approvals obtained, on a rolling basis to allow a proactive planning approach to occur, rather than a reactive approach when water levels are rising.
- It may be possible for Council to obtain a head licence that covers entrance management works across all of their ICOLL estuaries.



4 HISTORICAL MANAGEMENT ARRANGEMENTS

4.1 Background

The Korogoro Creek Estuary Management Plan (GECO Environmental, 2009b) was developed in 2009 and sets out interim management protocols for the estuary. As the estuary has not closed since development of the interim protocols, it has not needed to be employed during this time. Maintenance dredging of the entrance has never been undertaken in Korogoro Creek. The protocols are based on the following principals:

- The general principle of non-interference applies, except where trigger conditions are met (as defined below).
- The general principles of consultation will apply, and Kempsey Shire Council will consult with key stakeholders prior to intervention. Intent to undertake works and reasons, including relevant trigger conditions, should be advertised to the community prior to work commencing.
- Dredged materials should be relocated from the estuary and spread along the beach foredune so that vegetation is not disturbed, and are not to be sold unless authorised.

4.2 Trigger Conditions for Artificial Entrance Opening

The 2009 Estuary Management Plan lays out two sets of trigger conditions which may potentially occur during a rare and unlikely event of entrance closure:

- **Water Quality:** These are based on the ANZECC (2000) guidelines for the protection of aquatic ecosystems in SE Australian estuaries and the NHMRC (2008) guidelines for recreational water quality. Specifically, the monitoring parameters and trigger levels are as per the ANZECC (2000) guidelines. In the event that the entrance closes, the water is to be sampled regularly. This includes physical parameter monitoring three times a week, and nutrient and bacterial sampling once a week until a trigger level is met or the entrance naturally opens. As stated in the 2009 plan:
 - “Artificial opening of the Korogoro Creek Entrance should occur if the mean of four consecutive samples exceeds the trigger value of any parameter (see Table 1), or that any one sample contains greater than 60 counts/100mL for Enterococci, or that 4 consecutive samples have shown a significant increasing (or decreasing in the case of pH) trend of any parameter over the sampling period.”
- **Flooding:** This is based upon the presence and extent of local flooding of infrastructure or property. Specifically:
 - “In the event that the entrance is closed and local flooding occurs, it is considered that if in the opinion of Council there is potential for damage to infrastructure or significant damage to property (i.e. structural damage) then intervention should occur.”

4.3 Trigger Conditions for Sand Clearance at Boat Ramp

There are additional conditions set forth in the interim protocols that trigger the clearance of sand at the boat ramp. This requires a more subjective assessment, due to dynamic conditions such as tidal currents, sediment supply, entrance conditions, currents and wave climate. It requires consideration of boating safety and ease of navigation for vessels of an appropriate size to the available facilities. However, the occurrence of either or both conditions does not require Council to necessarily interfere.

- **Boat Ramp Safety:** This condition relates to the safety of launching a vessel from the Korogoro boat ramp, as per:
 - “If after a complaint relating to the safety of launching or retrieving a vessel from the boat ramp is made it is deemed in the opinion of a NSW Maritime Officer to be unsafe, and that maintenance

dredging would resolve the safety issue, then it is appropriate for Council to consider dredging the area of the boat ramp.”

- This has historically been undertaken on a number of occasions. Sand extraction has historically been undertaken in the region identified in Figure 4-1. The works have been undertaken through a licence for sand extraction from DHPI-Crown Lands under Division 5, Section 5.30 of the CLM Act.
- An aerial photograph depicting the approximate extent of the works is provided in Figure 4-1. Past sand clearing has extended only to the area of waterway able to be reached by an excavator positioned at the boat ramp and the immediately adjacent foreshore. It is expected that up to 200 m³ of sand could be extracted during these clearance works.



Figure 4-1 Extent of sand clearance works at the boat ramp, and example of sand clearance in May 2016

- **Entrance Navigation:** This condition relates to ability of a vessel to navigate from the boat ramp into the ocean, as per:
 - “If after a complaint relating to navigation from the boat ramp to the main channel is made it is deemed in the opinion of a NSW Maritime Officer to be substantiated, and that maintenance dredging would resolve the navigation issue, then it is appropriate for Council in consultation with relevant Agencies to consider dredging for navigation purposes.”



5 MANAGEMENT ISSUES

5.1 ICOLL Entrance Dynamics

5.1.1 ICOLL Behaviour

Korogoro Creek can be considered an estuary for its entire length and has an untrained entrance that is believed to be almost always permanently open. Entrance closure has not been recorded in the 17 years of water level gauge records (which date back to 2004), and no entrance closures have been anecdotally observed or recorded throughout the 1980s or 1990s. However, engagement with the local community during development of this EMP has indicated that the estuary closed for a brief period in the 1970s, believed to be around 1975. This was likely associated with the energetic storm activity of the mid 1970s, which may have activated a major sand bypassing event around Korogoro Point, infilling the entrance with marine sands.

For this reason, the estuary is technically classified as an Intermittently Closed and Open Lake and Lagoon (ICOLL). However, as per the definition of an ICOLL, it may go through rare and infrequent periods of being separated from the ocean by a sand beach barrier or berm, which forms and breaks down depending on the movement and redistribution of sand and sediments by waves, tides, flood flows and winds (DPI, 2018).

The estuary entrance is generally located against the bedrock on the southern side of the creek (Figure 5-1), however it can move depending on shoaling patterns. The Korogoro Point headland interrupts the littoral and along-shore sediment transport processes along the coast, and is considered to be a major control point for the local coastal sediment transport regime. As discussed, it is likely that a major coastal storm event, or series of storm events is required to activate significant sand bypassing around the headland. As this has only been anecdotally observed once since the mid-1970s, it is likely that a significant and rare storm event is required to initiate this process.

The headland also creates a relatively protected nearshore wave climate that results in the entrance being sheltered from the prevailing easterly to south-easterly Tasman Sea swells. Consequently, entrance shoaling patterns are more influenced by swell and wind direction than longshore processes; entrance shoals generally build under north-easterly wave conditions and reduce under southerly conditions (GECO Environmental, 2007). The relatively low nearshore wave energy and estuary tidal prism contribute to keeping the estuary entrance open, although shoaling does occur (GECO Environmental, 2006).



Figure 5-1 November 2021 photograph of the entrance berm (photo facing northeast)

While the morphodynamic process at play in the estuary entrance are natural, locals have expressed concern with what they perceive to be continual sedimentation of the entrance. Anecdotal evidence and aerial photography suggest that there used to be deeper pools in some locations historically, particularly in the mid to low section of the estuary (GECO Environmental, 2009b). Local people express significant concern with possibility of entrance closure. Shoaling and sedimentation of the creek significantly reduces the accessibility for boats and closes off an important ocean access point for recreational and commercial boating.



Figure 5-2 Comparative aerial photographs showing the flood tide delta in 1942 (left) and 2003 (right), showing marine sands pushed through the entrance (source: GECO Environmental, 2009b)

5.1.2 Estuary Hydrodynamics

As the entrance is almost always permanently open, Korogoro Creek's water level is controlled by tides, with seawater moving into and out of the estuary with the semi-diurnal tidal cycle. Korogoro Creek's tidal limit is the floodgates on Hat Head Road, or the Korogoro Cut Floodgates, which is 5.4 km upstream from the entrance. Although tidal, the estuary experiences a significantly attenuated tide range compared to the open ocean due to hydraulic energy losses through the narrow and shallow estuary entrance – with the extent of the flood tide delta generally controlling the tidal range within the estuary. This is due to inefficient tidal exchange of water through the creek entrance. Tidal energy losses through the entrance result in the water volume entering the creek on each rising tide, and not fully draining on each falling tide. This process results in a higher mean water level inside the ICOLL compared to the mean sea level outside. This super-elevation varies based on entrance condition, the stage of the tidal spring-neap tide cycle and the volume of catchment inflows, and is typically around 0.1 m inside the creek.

Water levels at Korogoro Creek are measured by a water level gauge operated by Manly Hydraulic Laboratory (MHL) at the bridge approximately 500 m upstream of the entrance. Tidal planes for the estuary (MHL, 2002) are presented in Table 5-1. This data shows that when the estuary entrance is open, the tidal range within the creek is narrower than that of the open coast tides – with tide range of around 1.4 m (compared to around 2.1 m on the open coast). It should be noted that inspection of the water level gauge data indicates that the tidal planes require updating.

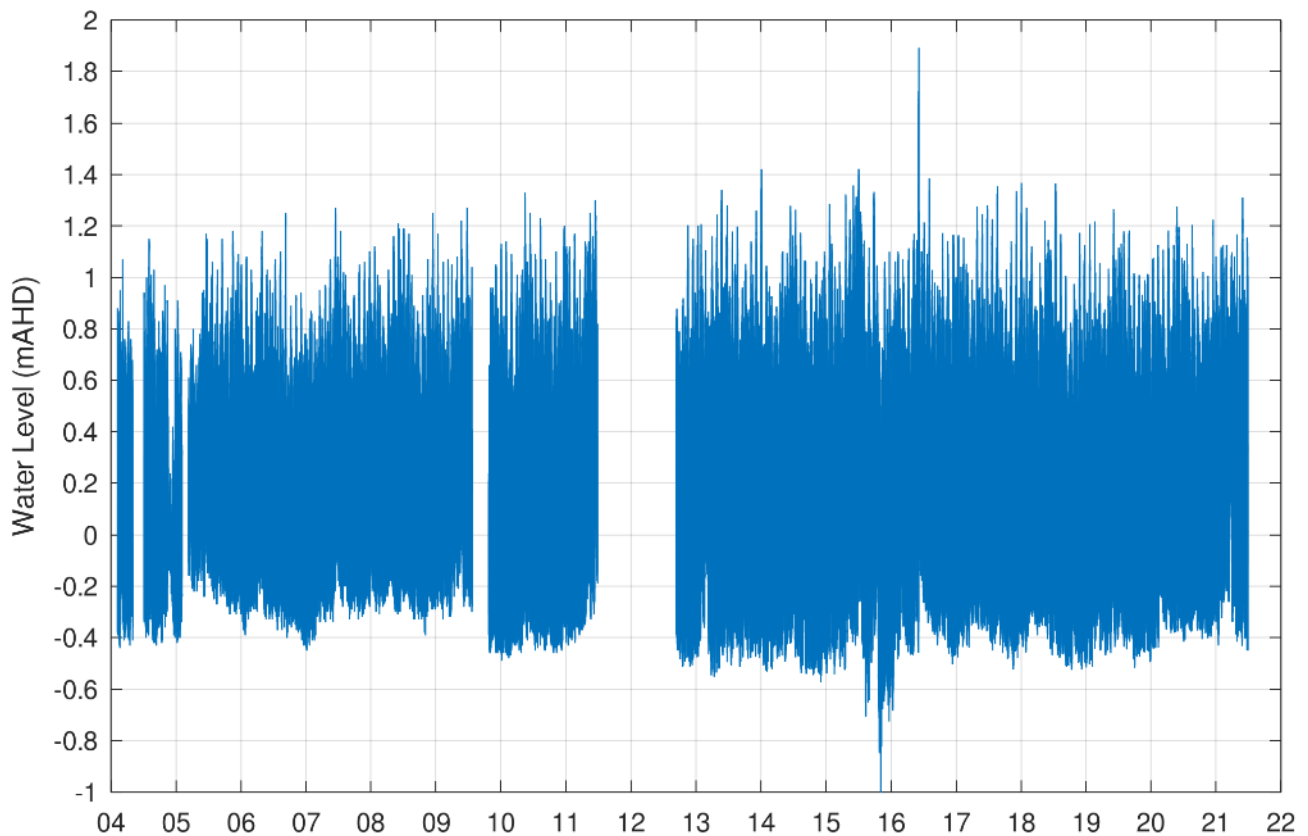


Figure 5-3 Estuary water levels from 2004 to 2020

Table 5-1 Tidal planes for Korogoro Creek estuary (source: MHL, 2002), in mAHD

Tidal Plane	Ocean Tide at Crowdy Head	Korogoro Creek
Higher High Water Spring Solstice (HHWSS)	1.14	0.87
Mean High Water Springs (MHWS)	0.69	0.54
Mean High Water Neaps (MHWN)	0.46	0.37
Mean Sea Level (MSL)	0.04	0.10
Mean Low Water Neaps (MLWN)	-0.50	-0.16
Mean Low Water Springs (MLWS)	-0.62	-0.33
Indian Spring Low Water (ISLW)	-0.94	-0.57

5.1.3 Natural Breakout Range

As there is no available recorded berm survey from historical entrance closures, there is little information available to determine the natural breakout range of the estuary when closed.

Hanslow et al (2000) provides some guidance regarding potential berm level, and berm level variability for ICOLLs on the NSW coast. Generally speaking, berm height is related to wave height, beach slope, and grain size – and berms that are exposed to higher wave energy, steeper slopes and coarser sediment like to experience higher vertical berm growth. The findings of Hanslow suggest that, in lieu of more detailed berm survey, a natural breakout range for the estuary may be between 1.8 to 2.2 m AHD. However, such estimates



are broad, and should be considered with caution. As Korogoro Creek entrance is provided significant wave sheltering from the Korogoro Point Headland, it is possible the natural breakout range could be lower than these estimates, and closer to the natural breakout range of the nearby Saltwater Creek and Lagoon, which has a natural breakout range between 1.2 and 1.8 m AHD.

5.2 Estuarine Flooding

5.2.1 The Macleay Valley Flood Mitigation Scheme

Korogoro Creek estuary has been significantly modified by a history of flood mitigation works, which were mostly completed in 1968 – including the construction of drains, floodgates and levees as a part of the flood mitigation scheme. The Macleay Valley Flood Mitigation Scheme was designed to protect low-lying areas from flooding throughout the catchment.

Hat Head is considered a High Flood Island in the Kempsey Shire Local Flood Plan, as it can flood but has rising road access out of the town. It has a levee built around the township that is designed to provide protection up to the 1% AEP flood level. There are a number of local components to the scheme at Korogoro Creek, and these are depicted in Figure 2-1 and described below:

■ **Korogoro Creek Floodgates and Swan Pool:**

- When it is operational, floodwaters are released by hydraulic pressure into Korogoro Creek from the floodgates at Swan Pool, which is a regionally significant floodplain wetland. Swan Pool has been managed for agricultural purposes, and as such has been drained and vegetated with dryland pasture species instead of natural water tolerant grasses and rushes. The water quality and ecological effects of this water release are poorly understood; however, it is believed that active management of the Swan Pool wetlands would improve the quality of runoff into Korogoro Creek (GECO Environmental, 2009b).

■ **The Control Levee (“The Choke”):**

- The control levee is located approximately 2 kilometres upstream of the Korogoro Creek Bridge. The levee is approximately 500 metres long and runs perpendicular across the Creek tying Hat Head Road into the coastal sand dunes. The levee is an earth bank fitted with a 7 cell 1.83m H x 2.44m W box culvert designed to limit the amount of flood water flowing through Korogoro Creek to the ocean outlet (Kempsey Shire Council, 2014). The levee's existing surface level averages at +4.0 m AHD, with an average crest width of 3.2 m.
- In order to further protect Hat Head village during extreme floods, outflow is diverted from Korogoro Creek via a control structure known as “the Choke,” which is manually wound sluice flood gates used to slow flood water. Water is then intended to also be diverted to Rowe's Cut, which is an artificial ocean outlet swale cut through the Hat Head dunes into the ocean.

■ **Rowes Cut:**

- Rowes Cut is located within the Korogoro Creek catchment, around 200 m north of the Korogoro Creek control levee between the Korogoro Creek Floodgates and the Hat Head Levee system. The cut itself comprises a constructed channel outlet cut from Korogoro Creek through the local Hat Head dune system to the ocean. It was originally designed to allow floodwaters to breakout through the sand dunes and discharge into the ocean. Rowes cut is located within Hat Head National Park, on National Parks and Wildlife Service (NPWS) land tenure.
- However, both the Lower Macleay Flood Study (Jacobs, 2019) and the Kempsey Shire Local Flood Plan (SES, 2017) note that Rowes Cut has not been used in many years, and has not been maintained over time. The cut is currently filled with sand and overgrown by vegetation, and it is uncertain if the channel would be able to function as originally intended at the present time. In order



to restore that kind of functionality, the cut swale would need to be reinstated by Council during or prior to a major flood event. Reinstating Rowes Cut would require appropriate environmental approvals and is on national park land.

■ **Hat Head Village Levee:**

- The Village Levee runs from the Korogoro Creek Bridge (on Hat Head Road at the entrance to the Village) along the northern bank of Korogoro Creek and terminates at high ground within the Caravan Park – see Figure 5-4. The levee is approximately 1.6 km long and as of a 2014 audit (Kempsey Shire Council, 2014) - its crest level varies between +2.2 m to +2.9m AHD. The Hat Head Control Levee and Headworks and Village Levee were initially constructed in 1968, and were later raised and reinforced in 1999. Maintenance works have been carried out over the years on an ad hoc basis (Kempsey Shire Council, 2014).
- Whilst crest levels of the levee are audited at regular intervals, it is noted that localised erosion of the levee crest and batters has historically been caused by vehicles driving across or along the levee to access the creek. Erosion of the levee is severe in some points creating low points and destabilised sections of the levee (Kempsey Shire Council, 2014). In fact, inspection of topographic LiDAR for this project indicates that the low point in the village levee, downstream near the caravan park may in fact be around +1.9 m AHD. This estimate is likely ± 0.1 m based in LiDAR accuracy.
- An impermeable plastic membrane within the levee is designed as a cut-off to prevent seepage of water through the levee. There are a number of concrete pipe culverts that run beneath the levee to remove stormwater from the town into Korogoro Creek. The flood flaps at the outlets are generally in good condition; however, the outlet drains are generally silted up resulting in the flood flaps being unable to operate effectively (Kempsey Shire Council, 2014).
- It is designed principally to protect against flooding from storm surge, and direct water through Korogoro Creek as a part of the flood mitigation and drainage system for the Belmore-Kinchela area (NSW SES, 2012).

■ **South-Western Levee:**

- The South-Western Levee extends some 1.8 kilometres downstream from the Korogoro Creek Bridge. The levee is effectively the embankment for Gap Road which is a two-lane sealed road. The crest of the levee is approximately 7 m wide with a 5 m wide sealed road pavement. As the road/levee is generally maintained in good condition, any defects associated with the structural integrity of the levee are minor and accordingly are of very low priority. Inspection of topographic LiDAR for this project indicates that the low point in this levee, downstream in the vicinity of Marlin Crescent, is around +2.2 m AHD.



Figure 5-4 Hat Head village levee (source: Kempsey Shire Council, 2016)

5.2.2 Flood Behaviour Design Flood Levels

Hat Head is affected by flooding in Korogoro Creek, which is influenced by flows from the southern floodplain into the creek combined with elevated ocean levels entering the creek entrance. The Lower Macleay Flood Study (Jacobs, 2019) was undertaken in 2019, and developed design flood levels for a range of Annual Exceedance Probabilities (AEPs) across the Lower Macleay Floodplain. Design flood levels for Hat Head are depicted in Table 5-2 below.

The results of the flood study indicate that during a design flood event, there exists a relatively steep hydraulic gradient in flood levels between the estuary entrance and the Hat Head Road bridge. This is due to the relatively shallow and narrow state of the creek, which of itself acts as a form of constriction for the energetic conveyance of flood waters. Table 5-2 shows that for a 5% AEP event, flood heights at the bridge may be up to 0.6 m higher than at the Holiday Park, which is around 0.2 m high than at the entrance. This is also demonstrated spatially in the 5% AEP design flood level map in Figure 5-5. This steep hydraulic gradient needs to be appropriately considered when determining appropriate water level triggers for entrance management.

Table 5-2 Design catchment flood levels in Korogoro Creek (Jacobs, 2019)

Event	Hat Head Rd Bridge (mAHD)	Holiday Park (mAHD)	Estuary Entrance (mAHD)
0.2 EY	1.8	1.3	1.1
5% AEP	2.3	1.7	1.4
1% AEP	3.0	2.6	2.4
0.2% AEP	4.3	4.1	3.5
PMF	7.2	6.8	6.0

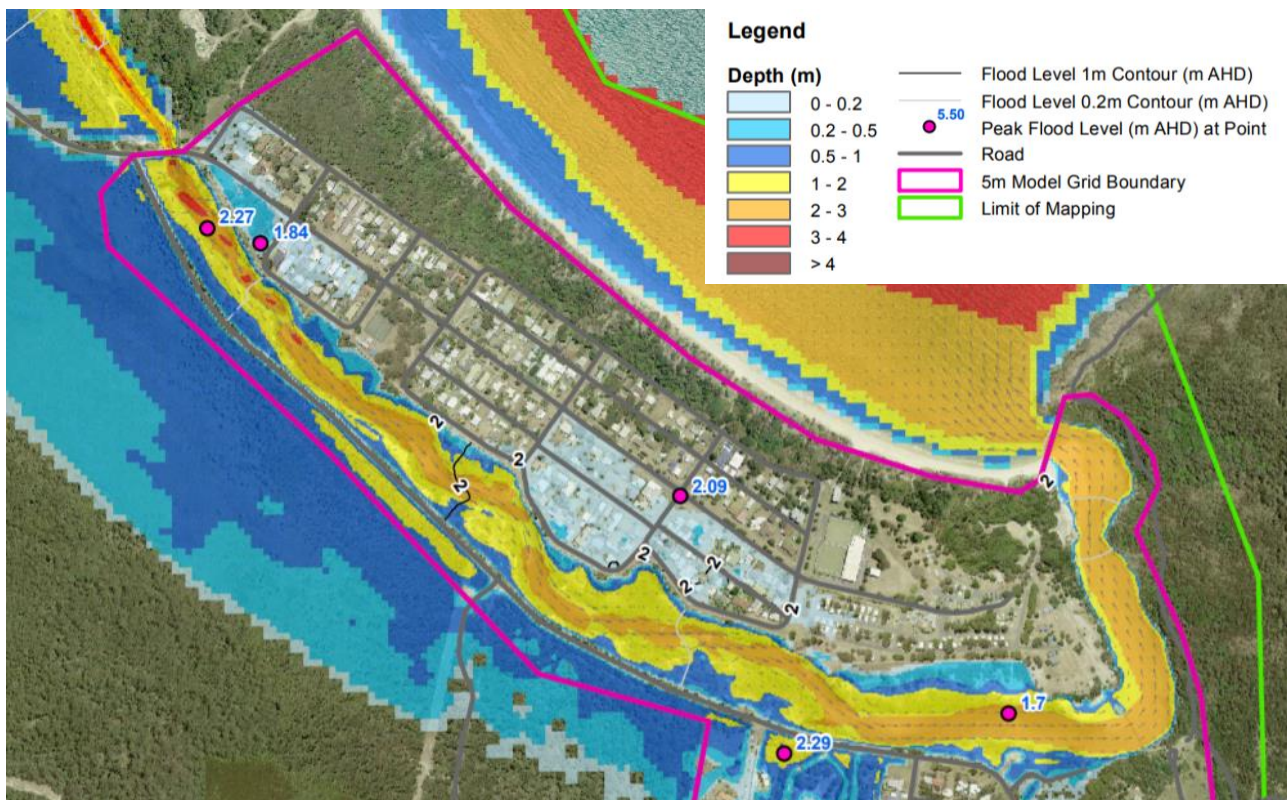


Figure 5-5 5% AEP flood levels and depths at Hat Head (Jacobs, 2019)

This table shows that, with the Hat Head Village level with containing a local minima of +1.9 m AHD, but more generally being around +2.2 m AHD - it would likely be overtopped in events rarer than the 5% AEP event.

The flood study (Jacobs, 2019) notes that local catchment runoff contributes to flooding of the levee-protected areas in the northern and southern parts of the village. These flows pond in the low-lying area behind the levee on both sides of the creek. This is the dominant source of flooding in the village up to around 5% AEP events, when the levees are not overtopped, and mainstream floodwaters are contained in the creek.

In the 1% AEP event the village on both sides of the creek are inundated typically to depths 0.6 – 1m and localised areas over 1 m. Depths in the village increase to over 2 m in the 0.2% AEP. This is predominantly due to floodwaters overtopping the levee and causing flooding of the village areas in both of these events (Jacobs, 2019).

Notably, the estuary is also affected by oceanic inundation. Design storm tide levels from the Kempsey Coastal Hazard Study are provided in Table 5-2. It shows that design storm tide levels also have potential to overtop the local levee system. This is a significant consideration for entrance management – as it demonstrates that entrance management itself is limited in its ability to mitigate inundation.

However, it should be noted that shoreline wave set-up is likely lower at Korogoro Creek entrance than the numbers reported in Table 5-2, due to the wave sheltering provided by Korogoro Point. However, a more precise estimate cannot be determined without numerical modelling.



Table 5-3 Design ocean flood levels at Hat Head (Korogoro Creek)

Event	Ocean Storm Tide Levels, excl. wave set-up (BMT WBM, 2013)	Ocean Storm Tide Levels, incl. wave set-up (BMT WBM, 2013)
5% AEP	1.43	2.5*
1% AEP	1.49	2.7*
0.2% AEP	1.52	2.9*

* wave set-up at the Korogoro Creek entrance is likely to be lower than for open coast locations exposed to easterly to south-easterly swells. Therefore, these total storm tide estimates are likely to be conservative at this location.

5.2.3 Historical Flood Events

The Macleay region is periodically prone to flooding due to its exposure to storm activity originating in the sub-tropics of the north and the mid-latitudes of the south. To the north are tropical cyclones, which occur during the summer months with depressions developing into easterly troughs. Further south, low pressure systems such as cut-off lows, migratory lows and east coast lows are a major source of severe weather, particularly in the colder months. These systems are all capable of generating storm surges and elevated coastal storm tides, as well as intense rainfall and associated catchment flooding.

The worst recorded flooding in Kempsey LGA occurred during the winters of 1949 and 1950. The 1949 flood reached a level of 8.42 m AHD at Kempsey, which is approximately a 1% AEP event, while the 1950 flood reached a level of 8.27 m AHD at Kempsey, which is a 2% AEP event. These floods caused extensive inundation and damage throughout the catchment, and floodwaters drained from inland areas to the ocean via the creeks and artificial cuts (Brown, 2017). Hat Head was more recently isolated by flooding for several days at a time in several events including in March 2001, May 2009, and June 2011 (NSW SES, 2012).

Flooding causes significant scouring of the Korogoro estuary entrance and channel. It has also been anecdotally noted that flood discharge can deliver poor quality water (i.e., filled with swamp sediments from Swanpool) into the creek (GECO Environmental, 2006).

Flooding around Korogoro Creek can be exacerbated by ocean conditions, such as high tides or storm surge. For example, during flooding in 1963, flood levels were higher in the lower catchments of Kempsey than in the 1949 flood which was associated with much higher rainfall (Dex Consulting). In fact, the highest recorded water levels at the Korogoro Creek gauge since 2004 were recorded during the June 2016 east coast low event. During this event a peak water level of 1.89 m AHD was recorded. This event was associated with over 250 mm+ of rainfall at the Kempsey Airport rain gauge in 48 hours, along with a storm tide level of +1.5 m AHD recorded at the Tweed Heads tide gauge (which excludes local wave set-up). This indicates that the observed water levels at the Korogoro gauge were the likely to be the result of combined coastal and catchment flooding.

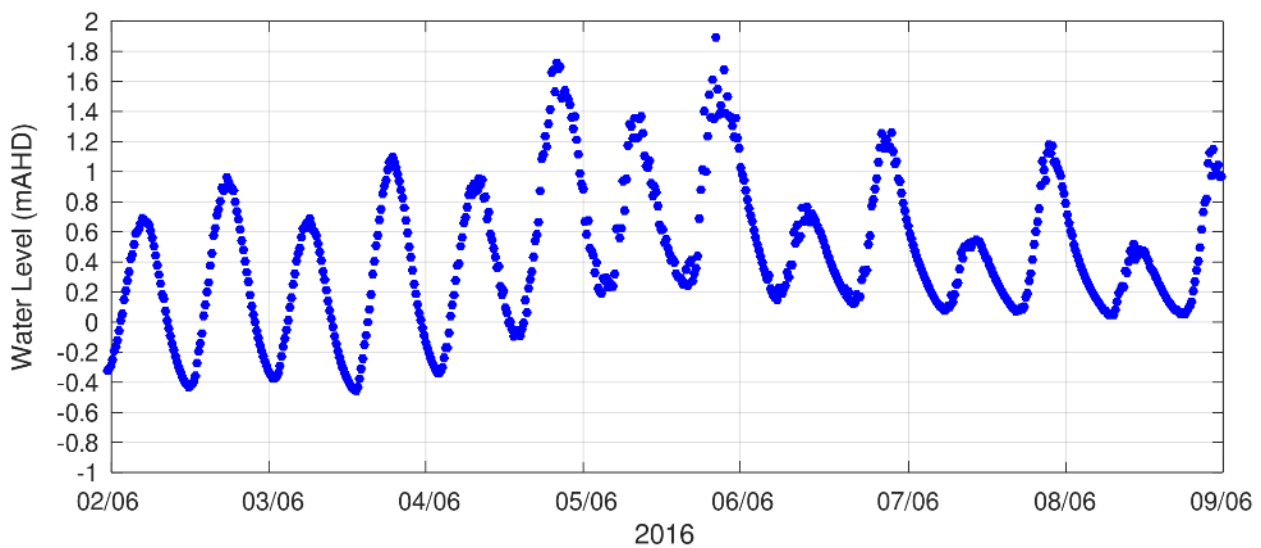


Figure 5-6 Recorded water levels during the June 2016 ECL event

5.2.4 Inundation of Assets

Due to the levees, there is not a serious problem with inundation within the township of Hat Head for lower AEP flood events. However, the road between Hat Head and Kinchela is subject to flooding, which can lead to the isolation of Hat Head for several days. In addition:

- Hat Head Sewage treatment system, which works on a vacuum pump, can malfunction when it fills with water from flooding and overland flows.
- Hat Head Holiday Park is flood liable according to the NSW SES Local Flood Plan (NSW SES, 2012).

Topographic contours and wastewater infrastructure for the site are mapped in Figure 5-7. The levels at which infrastructure around the park become inundated are summarised in Table 5-4.

Table 5-4 Inundation thresholds at Hat Head

Level (mAHD)	Affected infrastructure
1.7	Hat Head holiday park (noting that this is located behind the Hat Head Village Levee): <ul style="list-style-type: none"> Wastewater pump station PHH2
1.8	Hat Head holiday park (noting that this is located behind the Hat Head Village Levee): <ul style="list-style-type: none"> Up to 30 permanent holiday park cabin sites Wastewater pump station PHH4
1.9	Local minima in Hat Head Village Levee near caravan park (estimate based in LiDAR). Estimate likely ± 0.1 m based in LiDAR accuracy.
1.9	A significant number of residential properties (30+) within Hat Head village along Straight Street, Creek Street, Boronia Ave, and Oak Street.
1.9 - 2.2	A significant number of residential properties (40+) across the remainder of Hat Head village
2.2	Local minima in South-Western Levee (estimate based in LiDAR). Estimate likely ± 0.1 m based in LiDAR accuracy.



Figure 5-7 Local topographic contours and wastewater assets

5.3 Water Quality

5.3.1 Water Quality in the Estuary

Due to regular tidal flushing, the water quality of Korogoro Creek is generally considered to be moderate to good. However, it has been noted that water quality can decline when nutrient-rich, acidic and deoxygenated waters from Swan Pool drains to Korogoro Creek, such as when the flood gates are open. However, at present, the impacts of opening the Swan Pool on water quality and estuarine ecology are poorly understood (GECO Environmental, 2009b).

Monitoring of water quality in Korogoro commenced in 1994, and shows that the creek can experience periods of elevated nutrient concentrations, and particularly high nitrogen and ammonia. High nitrogen is linked to the treated effluent discharge via the dunes, from which 60% of the effluent discharged reaches the creek. Elevated Chlorophyll-a levels have been regularly recorded in the upper part of the creek by the Korogoro floodgates. At low tides, there is also reported low dissolved oxygen levels throughout the estuary, likely resulting from water seeping through the floodgates.

High faecal coliform counts have also occasionally been recorded, including high levels of faecal coliform entering from the southern side of Hat Head after moderate rainfall events. From 2003, an effluent disposal scheme went into effect in order to manage effluent discharge to sand dunes north of the township (GECO Environmental, 2009a).

Primary influences on estuary water quality include:



- Diffuse agricultural runoff, including pesticides, herbicides and fertiliser;
- Lack of significant aquatic vegetation in the upper estuary;
- Breakdown of large columns of vegetative matter from riparian and swamp vegetation;
- Stormwater discharge and runoff from urban and rural developments;
- Floodgates blocking passage of fish and marine species from upstream, and transferring lower quality water into the creek;
- Septic runoff, sewage overflows, and sewerage outlets; and
- Acid Sulfate Soils (ASS) exposure.

A water quality monitoring program is in place for Korogoro Creek, as recommended by the previous CZMP. The local sewage treatment plant (STP) has an ongoing water quality monitoring program in accordance with EPA consent. However, management of water quality following rainfall remains challenging, as water draining from the dunes has been associated with low dissolved oxygen levels, high nutrients (i.e., ammonia) and Chlorophyll-a, particularly by the Korogoro floodgates.

As waterway temperatures increase under future climate change and extreme floods occur more frequently, water quality is projected to decline in the Korogoro Creek estuary. This is due to increased water pollution, coupled with negative impacts on the local ecosystems from rising water temperatures and acidifying ocean waters (BMT WBM, 2020). Additionally, planned regional future development and urban release areas, as well as increases in tourism to the Kempsey region, have the potential to increase pollution and runoff for the creek.

5.3.2 Water Quality, Decanting and Fish Kills

During entrance breakout events, estuaries can experience a process whereby it is predominantly the surface water layer that drains, leaving behind hypoxic water trapped in deeper parts of the estuary basin. This process is commonly referred to as 'decanting' (Wiecek, 2001). Furthermore, the drawdown, or rush of water out of the estuary may cause a rapid decrease in oxygen in the water, by drawing the stagnant water out of the upper reaches of the estuary creeks and into the main basin. These processes result in a risk of fish kill events occurring, even in natural breakout situations.

In general, the occurrence of fish kills is highly unpredictable, however a significant mitigating factor is the size of the rainfall event (and hence the quantity of oxygenated freshwater inputs) that initiates breakout. Larger events will tend to cause greater flushing of hypoxic waters with overland runoff, and will also result in greater channel scour allowing fish easier passage to the ocean (DPIE, 2021).

Management approaches to reduce the likelihood fish kills include:

- Promotion of "natural openings" by scraping the beach berm prior to heavy rainfall – as opposed to "mechanical openings" where the entrance is directly opened by machinery; and
- Ensuring opening events coincide with rainfall (where possible).

It is important to note that while fish kills are often perceived to be the result of pollution or contamination of waters, there may also result from natural causes. NSW DPIRD maintains a database of fish kills in NSW. It contains over 1,400 records dating back to the early 1970s. The data suggests that on average 40 fish kills are reported to NSW DPIRD each year. Since many smaller kills go unnoticed and others remain unreported, the real number of kills is considered to be significantly larger (NSW DPI-Fisheries, 2013).

Fish kills have been recorded in the estuary, both before and after entrance openings, the most recent of which occurred after a breakout event in 2004. However, this is little data available regarding of the cause of this event or its overall impacts on estuarine ecology.



5.3.3 Water Quality and Entrance Management

Artificially opening estuary entrances is often perceived as a 'quick fix' to redress water quality problems stemming from causes such as inadequate stormwater treatment from urban areas or inadequate erosion control measures in the catchment. Best practice for estuary management is based on addressing the source of the water quality issues rather than treating the symptoms by artificially opening entrances to 'flush' an estuary.

ICOLLS, more than any other estuary type, have a wide range of naturally occurring physical and chemical water quality conditions – and opening ICOLLS to improve water quality and estuary health is generally not recommended and could (despite best intentions) have undesired negative impacts on the estuary. Some advice provided by DCCEE in regard to artificially opening ICOLLS, and water quality impacts includes (DPIE, 2021):

- Opening at Lower Water Levels:
 - As outlined above, tidal prisms and exchange in the estuary is relatively low. Therefore, water quality in the estuary basin will not be significantly improved by dry weather opening. Low-level opening will only impact water quality in the lower estuary reach (around the flood-tide delta), and only during incoming tides. Sediment, nutrient, debris and faecal contamination will continue to enter the estuary from the catchment, and therefore opening of the entrance will not improve water quality while catchment sources remain active.
 - Opening at low water levels is generally not recommended as there is not enough of a hydraulic head differential between the estuary and the ocean to sufficiently scour the entrance. Under such conditions rapid entrance reclosure is common, and therefore any potential water quality benefits are also short term and temporary.
- Opening at High or Moderate Water Levels:
 - If estuary breakout and opening occurs in response to relatively small rainfall events, then there is an increased risk of decanting surface water without sufficient catchment inflow to flush hypoxic bottom waters from the system. This increases the likelihood of fish kills.

Therefore, there is no need for flushing of the estuary to improve water quality under 'normal' conditions. Nevertheless, there may be instances where artificial opening is justified to address extreme water quality issues in the waterway, particularly where water quality poses a threat to human health and safety for primary recreation.

5.4 Estuarine Ecology

Korogoro Creek provides a number of diverse estuarine habitats including seagrass, saltmarsh, mangroves, intertidal muddy areas, channels, rocky reefs and boulder fields. A significant portion of the estuary waterway and foreshore is classified as Coast Wetlands under the R&H SEPP (see Figure 3-2).

The Coastal Saltmarsh habitat is considered to be an Endangered Ecological Community (EEC) under the *Biodiversity Conservation Act 2016* and warrants a high level of protection (GECO Environmental, 2009a). There is a high level of biodiversity, as shown by a summertime survey of aquatic fauna recording over 60 fish, reptile and invertebrate species (GECO Environmental, 2007).

There are small occurrences of littoral rainforest and wet sclerophyll forests in the protected headland and back dune (GECO Environmental, 2009a). They provide habitat for a number of fish species that move between the open ocean and estuary, as well as diverse crustaceans, marine reptiles and bird species.

The naturally open entrance serves as a fish nursery, and juvenile tropical fish inhabit the estuary in the warmer summer months. Other species with conservational significance reported in the estuary include osprey and



loggerhead turtles. As such, the main biodiversity objectives for Korogoro Creek, as identified in the 2009 Estuary Management Plan, are:

- Protection of and education related to the high conservation value terrestrial habitats in the area, including riparian vegetation, coastal saltmarshes, wetlands and littoral rainforests;
- Restoration of degraded habitats through revegetation, weed removal, drainage management, and access track consolidation;
- Protection of aquatic habitats including mangroves and saltmarshes; and
- Restoration of aquatic habitats by reducing threats such as human disturbance and undesired effects from the operation of the flood mitigation scheme.

5.5 Social and Recreational Values

Korogoro is highly valued for its recreational amenity, including boating, fishing, surfing and swimming. It is known for having a relatively safe navigational entry and exit to and from the ocean for fishing and boating, and has a well-used boat ramp close to the creek entrance. This is a primary tourism drawcard for the local region.

As of 2016, Hat Head has a permanent population of just over 300 residents (ABS, 2016), but the population can quadruple during peak tourist season in the area. This can result in a large increased demand on recreational facilities and local infrastructure, including water supply and wastewater. Holiday accommodation can be in very high demand during tourist seasons, putting pressure on local housing supply. Tourism is a fast-growing industry in Kempsey's small coastal towns such as Hat Head, providing both direct economic values and pressures on the town and estuary.

Ocean access from the estuary via boat is largely controlled by the depth of the estuary entrance. Access to the waterways is of very high importance for the local community, and local people have expressed significant concern in recent years regarding the safe navigability of the waterway. A key issue for navigability is that the estuary entrance is located in the vicinity of the Hat Head beach surf zone – where pronounced sand bars can form that limit navigable draft for entrance navigation (see Figure 5-8 and Figure 5-9). The formation of such bars is a natural process, and is a product of the entrance being located next to an energetic, open coast beach.

It should be noted that dredging to improve navigation waterway access is generally as a separate issue and responsibility to ICOLL entrance management – which is predominantly undertaken for the purposes of mitigating flooding and inundation.



Figure 5-8 Entrance bars affecting navigability of the waterway in October 2020



Figure 5-9 Entrance bars affecting navigability of the waterway in June 2009



In the past, Council has periodically intervened to remove excess sedimentation in the vicinity of the boat ramp. The sand clearance is undertaken under a permit from DHPI-Crown Lands. The historical procedures to perform sand clearance at the boat ramp are outlined in Section 4.3.

5.6 Cultural Heritage Values

Korogoro Creek is within the traditional lands of the Thunghutti (or Dunghutti) Aboriginal people. This area of the northeast coast of NSW provided productive land for the local populations, who would have used the estuaries as a valuable food source. Shell middens with Aboriginal cultural significance are preserved along the Kempsey coastline (GECO Environmental, 2009a). Archaeological site records data held by NPWS (Department of Parks and Wildlife Service, 1999) indicate that there are at least three recorded aboriginal sites in the vicinity of Korogoro Creek. These include:

- A shell midden located on Korogoro Headland near to the creek entrance.
- A former open campsite located within paperbarks north of the footbridge on the southern side of Korogoro Creek.
- A mythological site (large tree) within the grounds of the caravan park.

There is potential for Aboriginal sites or artefacts to exist in the study area that may not have been recorded in the AHIMS database, and thus not formally recorded. It is, however, unlikely that any such artefacts exist in the area that would be disturbed by the works due to the highly active nature of the entrance berm which can be subject to significant scouring.

Engagement with DHPI-Crown Lands has indicated that there is an Aboriginal Land Claim in lodged for the area of land containing adjacent to the entrance berm/ sand spit. In terms of the implementation phase of the EMP, where there are unresolved claims lodged on Crown land, any dealings/works on Crown land will generally require the consent of the relevant Local Aboriginal Land Council.

5.7 Effects of Climate Change

Many impacts of climate change are currently being felt by NSW's estuaries. Korogoro Creek will experience both broader impacts and specific local impacts, which are often inter-related. Management of the estuary will require understanding and accommodation of the long-term impacts of climate change. These include the following.

- **Mean sea level rise**, will pose a serious risk to coastal communities due to inundation and erosion. Between 1993 and 2009, the rate of global sea-level rise was estimated to be 3.2 ± 0.4 mm/year (Church & White, 2011). Depending on future carbon emission pathways, as defined by the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (IPCC, 2020) sea levels around eastern Australia could rise between 0.63 to 1.10 m by 2100. This will put at risk both developed and undeveloped areas, as ecosystems adjust to shifting conditions.
- **Estuarine hydrodynamics**: The resultant changes to tidal hydrodynamics from sea-level rise are likely to influence the water quality and mixing processes of estuaries. Sea-level rise will likely propagate tides and saline water further upstream, resulting in an increase in the extent of saltwater intrusion. Increased salinity may impact inland soils, freshwater and groundwater resources and nutrient retention (Glamore, Rayner, & Rahman, 2016). Changes in tidal prism and tidal velocities will also increase the susceptibility of the estuarine foreshore to erosion and influence water quality and geomorphology. Furthermore, variations in rainfall patterns are likely to have a far-reaching impact on the estuary systems, as freshwater flow is a large source of physical variability in the system.
- **Entrance morphodynamics**: Disruptions from sea-level rise, littoral sand transport, and changes to rainfall and flooding behaviour are likely to result in an upward and landward shift in the beach profile, and potentially increased size, height and extent of the entrance berm (Hanslow, Davis, You, & Zastawny,

2000). This may then require higher freshwater inputs to maintain an open entrance. As shown in Figure 5-10, an increase in mean sea level will result in an elevation of the base and maximum water levels, as well as the berm height within the ICOLL. This will cause inundation of the low-lying areas adjacent to the creek as the water level rises.

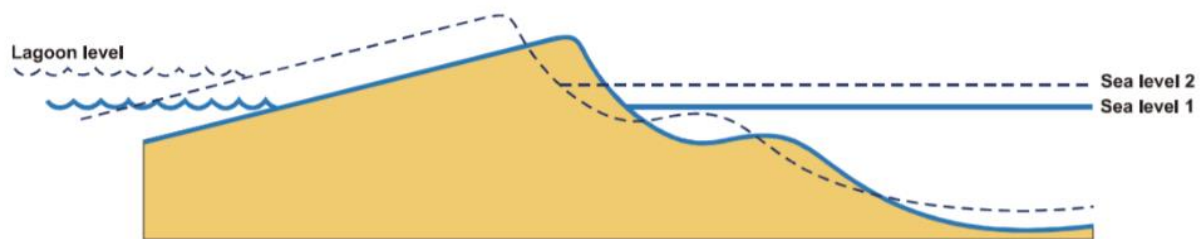


Figure 5-10 Upward and landward translation of an ICOLL berm under SLR (Hanslow, Davis, You, & Zastawny, 2000)

- **Tidal inundation:** As sea level rise increases it is expected that the frequency and severity of tidal inundation (also referred to as “sunny day flooding”) will increase over time. This may lead to the progressive drowning of intertidal environments and freshwater habitats and increase the rate of landward displacement of estuarine shorelines and riparian ecosystems.
- **Estuarine flooding:** With warmer weather, the storms and rainfall events are predicted to become increasingly intense in both the near and far future (IPCC, 2013). Combined with sea-level rise, this will have major implications for the severity of flooding in the estuary.
- **Ocean and estuarine impacts:** In addition to sea level rise, climate change is expected to result in changes to the water quality (i.e., temperature, salinity, turbidity, suspended solids) and chemistry (oxygen, nutrients, pH and alkalinity, Chlorophyll-a) of coastal and estuarine systems. This will also impact on heat budget; hydrodynamic and mixing in particular after rainfall; effect on sediment dynamics. This includes ocean acidification and the impacts of warmer oceans on soft coral and fisheries (Adapt NSW, 2019).
- **Estuarine water temperatures:** A recent study has found that estuaries along the NSW coast are warming very rapidly, with average temperatures increasing more than 2 degrees over the past 12 years, which has been accompanied by acidification (Scanes, Scanes, & Ross, 2020). Coastal lagoons and creeks are acidifying and warming more rapidly compared to other estuary types. As Korogoro Creek lies at the boundary between temperate and tropical habitats, it is also expected to experience a tropicalisation of both marine and coastal environments, as the extent of flora and fauna extends south with the warming climate.
- **Biodiversity**, can be impacted by increasing air and ocean temperatures, rising sea level, changing in ocean chemistry (i.e., due to ocean acidification), and decreasing water quality. In particular, coastal wetlands are particularly sensitive to climate change. These systems are usually unable to migrate inland as the shoreline recedes under sea level rise, and are subject to threats caused by changes in the hydrologic and climate regimes.

As part of Stage 2 of the CMP process, Kempsey Shire Council has undertaken Coastal Vulnerability Area (CVA) mapping for their LGA coastline. The development of the CVA map has included consideration of seven coastal hazards; (1) beach erosion, (2) shoreline recession (3) coastal lake or watercourse entrance instability, (4) coastal inundation, (5) coastal cliff or slope instability, (6) tidal inundation and (7) erosion and inundation under tides, waves, and catchment floodwaters (JBPacific, 2021).



6 STAKEHOLDER AND COMMUNITY ENGAGEMENT

6.1 Community Engagement

Entrance management typically draws high levels of community interest, and is often a controversial issue with a range of differing viewpoints across the community. The goal of the engagement with communities and other stakeholders is to obtain a high level of support for the EMP. Although it would be ideal to achieve total consensus in support, this is not always achievable with some polarised and intransigent viewpoints that exist across the community.

To achieve a high level of community support, the project employed a three-step community engagement approach allied with engagement with other stakeholders. The three steps are provided in Figure 6-1, and described in detail below.

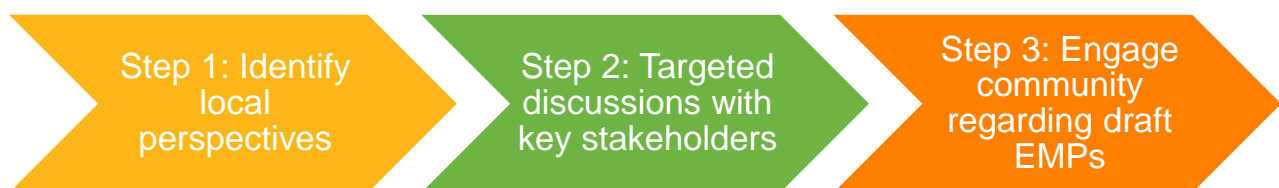


Figure 6-1 Community engagement process

Prior to the engagement, Kempsey Shire Council developed a *Your Say Macleay* webpage for the project – in order to provide the local community with information about the project and how it can be involved. The webpage included:

- A project bulletin and a three-minute informative video about the project and the principles of entrance management;
- A series of Frequently Asked Questions (FAQs) regarding entrance management and the NSW State Government's Policies on ICOLL management; and
- Links to information about the wider Kempsey Shire LGA CMP.

6.1.1 Step 1: Identification of Community Perspectives

The first step in the community engagement process was to identify local viewpoints and perspectives. The original intention for the project was to undertake an in-person community information session and workshop. However, COVID-19 restrictions during this stage of the project prevented the possibility of face-to-face engagement methods. Therefore, an online community survey was utilised for this task.

The survey was open from 9 August to 31 August 2021 in order to ascertain local community viewpoints and attitudes towards entrance management. A total of 29 responses during the survey period, and answers to key questions regarding entrance management are provided in Table 6-1.

These results demonstrated the relatively polarised viewpoints within the community with regards to entrance management approaches. In particular, "[The Estuary] should be left to open / close naturally" received mostly high levels of "Strongly Agree" and "Strongly Disagree", with no recorded neutral responses.

In order to ascertain community priorities, respondents were asked to rank their biggest, or most prominent concern regarding entrance management. Respondents ranked the various issues from (1) greatest concern, to (5) lowest concern.



Value judgements from the local community indicated that the highest priorities are towards “Maintaining good water quality”, which possessed an average score of 2.2, and “Maintaining natural ecosystems and environmental processes” (2.5). Other issues such as “Maintaining safe vessel navigation” (2.8) and “Minimising flooding” (3.2) scored lower in terms of priority – as depicted in Figure 6-2.

Table 6-1 Community survey question 1: How strongly do you agree that the estuary should be managed in this way? [Total: 29 respondents]

Entrance Management Approach	Definitely agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Definitely disagree
It should be left to open / close naturally	12	2	0	2	13
Mechanical opening if/when properties surrounding the estuary are under threat of flooding	18	3	4	1	4
Mechanical opening if/when water quality in the estuary is degraded	19	2	1	3	4
Mechanical opening to allow recreational vessel navigation in and out of the estuary	14	5	2	1	7

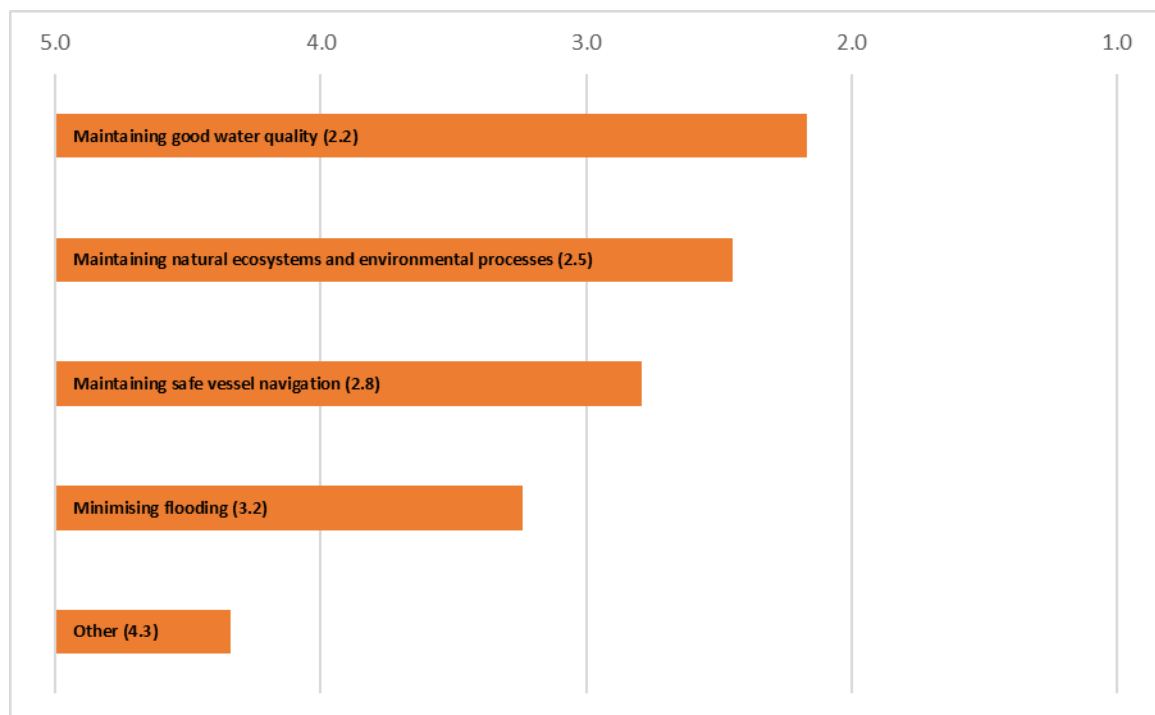


Figure 6-2 Community Survey Q4: Please rank your biggest concern regarding management of the entrance? (1 being the biggest concern)

An attempt was also made to engage with the Kempsey Local Aboriginal Land Council, however they were not available for discussion.

6.1.2 Step 2: Targeted Community Discussions

The second step of the engagement process involved undertaking targeted community discussions. A community meeting / information session was held on 2 November 2021 at the Korogoro Creek entrance – see Figure 6-3.



Figure 6-3 Community meeting at the Korogoro Creek entrance

The purpose of this targeted discussion session was to:

- Report back the findings of the Step 1 Community Survey;
- Provide information to the local community regarding the various issues involved in entrance management;
- Outline a draft position for management of the entrance; and
- Receive in person community feedback regarding the draft position and other related viewpoints/concerns.

A total of 15 community members attended the event and a range of viewpoints and responses were recorded, as summarised below.

Entrance Navigation

- A number of respondents were concerned about entrance navigation safety, with reports that it is at times very difficult and dangerous to navigate boats in and out of the creek due to presence of the entrance bar.
- There is a high value placed on navigational boating access, as the estuary is considered to be a primary ocean outlet for navigation for recreational and commercial boating. There was a strong belief amongst some community members that maintaining a navigable entrance is important for ensuring Hat Head is a well renowned tourist destination – and subsequent economic benefits for the town are realised.
- In general, there was a high level of concern for the rare, but possible scenario that the entrance may close at some point in the future. It was relayed to the community that closing of the entrance is a rare and exceptional circumstance – with only one anecdotal report of entrance closure since the 1970s.



- There is increasing interaction between waterway users, which will lead to increased conflict. Since boats have narrow windows of time that they can enter and exit the entrance, they are under pressure to move quickly, which may cause negative interactions with nearby surfers and swimmers sharing the creek and beach.

Flood Mitigation

- There is concern over potential flooding and isolation by floodwaters in Hat Head. It was noted that Rowes Cut has not been maintained, and so it could not currently be used as an ocean outlet if needed. If the road out of town is inundated, the village would be cut off by floodwaters. Flooding can also be exacerbated by high ocean water levels in addition to catchment runoff.
- There is a perception that freshwater flows and releases from the floodgates are not sufficient to keep the entrance open in the long term.
- There is also concern regarding ongoing degradation of the levees, due to illegal four-wheel drive access to the levee crest.
- It was stated that during the 2016 East Coast Low, the Hat Head village levee overtopped due to oceanic storm surge, as opposed to catchment flooding.
 - Records from the local water level gauge indicate that the maximum water level in the estuary reached around 1.9 m AHD (see Section 5.2). Topographical LiDAR indicates that the Hat Head village levee has a localised low point at around 1.9 m AHD (± 0.1 m) – and therefore the available environmental data are generally consistent with this observation. This may also indicate that the low point on the Hat Head village levee could potentially be as low as 1.8 m AHD.

Other Issues and Concerns

- Changing sediment dynamics are shifting the beach, causing erosion in several locations across the beach. Hat Head beach has experienced historical erosion in recent decades. The importance of naturally vegetated dunes for coastal protection of Hat Head was noted.

6.1.3 Step 3: Engage Community Regarding Draft EMPs

The final step in the engagement process will be to ascertain community feedback on the draft EMPs. The EMPs will be included as part of the wider Kempsey LGA CMP. Feedback on the EMPs will therefore be garnered from the local community when the CMP goes to public exhibition.

6.2 Stakeholder Engagement with Government Agencies

During development of the EMP, stakeholders were actively engaged from a range of relevant NSW State Government authorities. A key component of this engagement was a stakeholder workshop, undertaken on 23 August 2021. Attendees of the workshop included representatives from Council, DCCEW(BCS), DPIRD-Fisheries, DHPI-Crown Lands and Transport for NSW. Representatives from NPWS were not available to attend, but were engaged separately. The key objectives of the workshop were to:

- Identify management roles and, responsibilities and legislation in relation to entrance management;
- Confirm details of historical entrance management arrangements, and the “on-the-ground” reality of how those arrangements have been practically implemented;
- Discuss historical barriers and constraints to effective management, and opportunities to respond and adapt to future challenges; and
- Identify relevant stakeholders for additional engagement.



The workshop was highly interactive and participatory. Follow-up with stakeholders was undertaken on a regular basis throughout development of the EMP.



7 ENTRANCE MANAGEMENT APPROACH

7.1 Overarching Approach

Korogoro Creek has no official record of closing in recent decades, with only one anecdotal account of opening in the last 50 years. Nonetheless, it is acknowledged that the estuary has potential to close in the future, albeit under very rare and exceptional circumstances.

The overarching approach of this EMP is to advocate the general principle of minimal intervention. NSW DPIRD-Fisheries supports minimal interference with ICOLL barriers and advocates natural processes being allowed to operate to the greatest extent possible. This EMP therefore applies an approach of non-intervention - except where trigger conditions for intervention are reached.

Therefore, this EMP outlines the following:

- Decision making criteria for *if* and *when* entrance management intervention should occur; and
- Determining the most suitable method of *how* entrance management will be undertaken, namely:
 - Berm height management; or
 - Direct mechanical opening.

7.1.1 Decision Making Criteria (If and When)

Decision making in entrance management needs to consider environmental, social and economic factors including the range of viewpoints of the local community towards entrance opening. This EMP outlines guidance for entrance management based on the following matters of interest:

- Flood mitigation within the Hat Head township, with consideration of the presence of the Macleay River Flood Mitigation network and local levee system.
- Water Quality within the estuary – under rare circumstances where water quality may affect human health and safety during peak usage periods. Artificial opening of the estuary for these purposes should only take place if agreement between relevant public authorities is reached.

As discussed in Section 8.2, while the entrance management framework provided in this document provides a strong scientific basis for determining the most appropriate course of action – the decision of which approach to take will ultimately belong to Council, in conjunction with relevant public authority stakeholders (Section 8.3).

Approach to mechanical opening of the entrance (when closed) for navigational purposes: It should be noted that the position of NSW state government is that:

- Artificial intervention at ICOLL entrance barriers should be minimised to the greatest extent practical; and
- DPIRD-Fisheries does not support the artificial opening of an ICOLL unless the proponent (i.e., Council, or other agency) can demonstrate that the social, environmental and economic benefits greatly outweigh any potential adverse impacts (DPI, 2018).
- The decision to artificially open an ICOLL should be made on the basis of factual data related to the nature and extent of associated *flooding impacts*, and evidence of changes to relevant *water quality* parameters (especially nutrient and bacterial levels) (DPIE, 2021).

It is not the explicit position of the NSW state government that interference at ICOLL barriers is justified based on navigation requirements alone – particularly where other nearby ocean access points are available.

However, community and stakeholder engagement undertaken during this study demonstrates that there are strongly held and polarised views within the community with regards to entrance management. Therefore, in



the unlikely (or rare) event of entrance closure, it will be important to be responsive and communicate clearly with the Hat Head community.

A summary of the decision-making framework for the EMP is provided in Section 8. This framework shows that in the event of entrance closure, the first step will be for relevant agencies to consider relevant data and decide on potential management responses. The decision on the entrance management response should be then conveyed to the Hat Head community by DHPI-Crown Lands and DPIRD-Fisheries, in conjunction with Council.

7.1.2 Entrance Management Methods (How)

Entrance management is complex, and a flexible approach is therefore beneficial. The final course of action may be one of three potential options for entrance management, listed below in order of low intervention (most preferred) to high intervention (least preferred):

Option 1: Do Nothing

The overarching approach of this EMP is to advocate the general principle of minimal intervention and allowing the estuary to operate naturally to the greatest extent possible. This EMP therefore applies an approach of non-intervention - except where trigger conditions for intervention are reached.

Option 2: Berm Height Management

This involves managing the height of the berm such that it does not exceed a pre-determined level, using mechanical equipment to implement a “dry notch” or “saddle point” in the entrance berm which the water can then preferentially flow across. If maintained correctly, the notch would breach when the creek water level reaches the appropriate level during a runoff event.

This approach is intended to reduce the likelihood fish kills include promotion of natural openings by scraping the beach berm prior to heavy rainfall events and allowing the opening events to coincide with rainfall and freshwater inflows. Selection of an appropriate berm height management level should be in consideration of:

- Adoption of a “minimal interference” approach by implementing a berm height management level within the natural breakout range, thereby allowing the natural processes to operate to the greatest extent possible; and
- Responsible and practical mitigation of flooding and inundation impacts across the estuary - by ensuring that the berm height management level (also referred to as the “berm saddle level”) also considers the levels and nature of fringing foreshore infrastructure.

An added advantage of the berm height management approach is that as it involves managing the berm prior to a storm event it avoids having to activate machinery and conduct work at the berm during potentially dangerous conditions, such as heavy rainfall, energetic waves, and eroded beach states.

The approach of berm height management is strongly advocated by this EMP.

Option 3: Mechanical Opening

Direct mechanical opening has commonly been used in entrance management across NSW in recent decades. Whilst this method can often be expedient, it can also result in an increased risk of fish kills events, and rapid re-closing of the estuary. Therefore, there has been a recent shift in NSW towards managing ICOLL opening through berm height management – as opposed to direct mechanical opening.

However, as the entrance closure position & extent is not well understood for this system, due to the rarity of historical closure events, it will be important to be flexible when considering the logistical application of berm height management if entrance closure does occur. It is important to acknowledge that in some



circumstances, a direct mechanical opening approach may also be necessary or more appropriate. This may also include during times when degraded water quality poses a significant threat to human health and safety, or ecological processes - where there is a need to act urgently – as assets around the estuary are low-lying, and emergency situations are possible.

Therefore, a flexible approach is required - and in the event of entrance closure, Council should liaise with relevant agencies listed in Section 8.3, in order to determine the most suitable opening method.

7.2 Entrance Management for Flood Mitigation

7.2.1 Purpose and Limitations

Korogoro Creek is considered to be an important ocean outlet for the Macleay Valley Flood Mitigation Scheme. Therefore, the primary purpose of entrance management in the event of a closure would be to ensure that flood impacts at Hat Head are not exacerbated by a closed entrance condition.

However, it should be noted that entrance management is somewhat limited in its ability to mitigate rare and severe flooding (of around 1% AEP or more severe). As with many ICOLLs, it is highly likely that at Korogoro Creek the impact of the entrance condition on flood levels diminishes with increasing flood severity. Furthermore, entrance opening can exacerbate the impacts of ocean flooding from elevated storm tides.

Entrance management should therefore not be perceived or advertised as a “silver bullet” to alleviate all flooding within the estuary, and appropriate flood mitigation measures should consider the many components of the Macleay Valley Flood Mitigation Scheme. Rather, the process of entrance management is intended to mitigate the impacts of less severe inundation events – referred to as “nuisance flooding”.

7.2.2 The Berm Height Management Approach

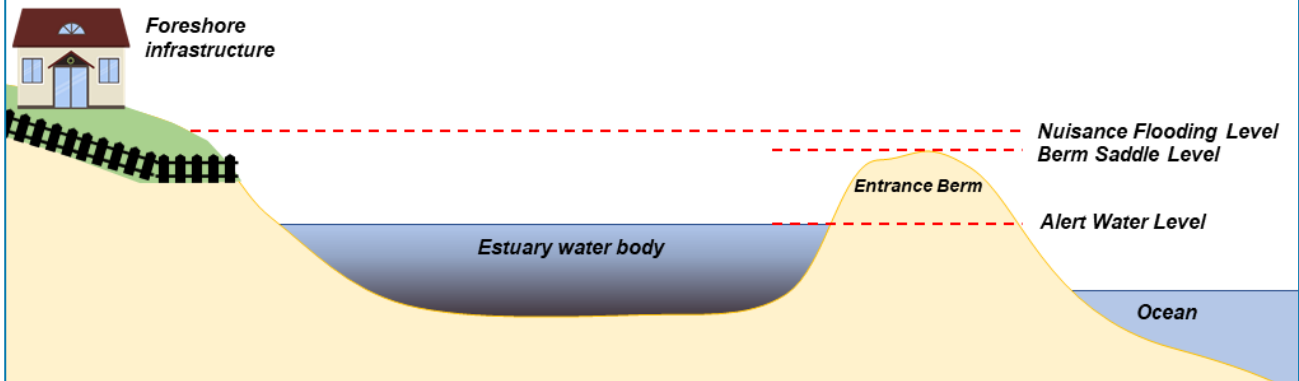
The approach of berm height management includes three main components:

- **The Alert Water Level:** When the estuary is closed, Council should immediately commence monitoring estuary water levels. When the recorded water level inside the closed estuary is high enough that the next major rainfall event could result in nuisance flooding – then the entrance management protocols should commence. Therefore, when the water levels reach the Alert Water Level, then Council should be on “alert” to start the entrance management process.
- **Berm Saddle Level:** If a significant rainfall event is forecast - 60+ mm event over the coming 72 hours - then Council should survey the level of the closed entrance berm. If the natural saddle point of the berm (i.e., the natural breakout level) is above this level – then the entrance berm is to be scraped so that it does not exceed this level. Later during a rainfall event, the estuary will overtop the entrance berm at this level and break out. This is intended to replicate the natural breakout process and reduce the risk of fish kill events.
- **The Nuisance Flooding Level:** This is the desired maximum level of nuisance inundation that scraping the entrance berm intends to minimise. The Berm Saddle Level and the Alert Water Level are essentially determined by working backwards from Nuisance Flooding Level.

These three components are described in the schematic in Figure 7-1. The specific levels for these triggers are provided in Table 7-1, along with justification for their adoption.



Prior to rainfall event: Once the Alert Water Level is reached, scrape the entrance berm to the Berm Saddle Level - to induce a natural opening later when rainfall occurs



During the rainfall event: Entrance berm naturally opens at the Berm Saddle Level with freshwater inflows

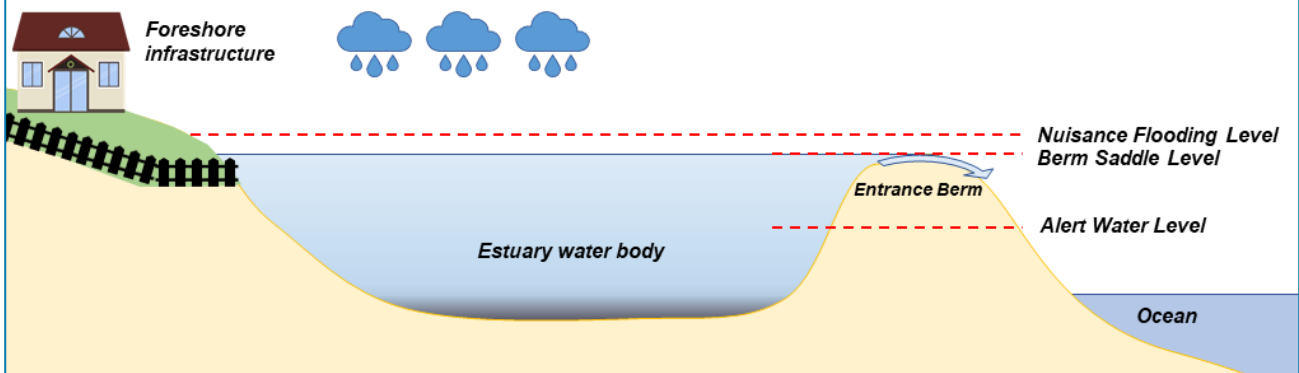


Figure 7-1 Berm height management - breakout process



Table 7-1 Flood mitigation trigger levels

<i>Description and rationale</i>		<i>Level (mAHD)</i>
<i>Flooding Level</i>	<p>The desired maximum level of flooding that scraping the entrance berm intends to prevent. In this instance, the intention is to where possible prevent overtopping of the Hat Head village levee during a 5% AEP event or lower. The ability of entrance management to mitigate more severe flooding will likely be limited.</p> <p>Topographical LiDAR indicates that the Hat Head village levee has a localised low point at around 1.9 m AHD (± 0.1 m) – see Section 5.2. However, there is some uncertainty around the exact level of the levee low point. Community reports of overtopping of the village levee during the June 2016 east coast low event (which peaked at 1.87 m AHD) suggest the low point could be closer to 1.8 m AHD.</p>	1.8
<i>Berm Saddle Level</i>	<p>The saddle level has been determined with consideration of potential overtopping of the Hat Head village levee. Results of the Lower Macleay Flood Study indicate that during peak conditions of a 5% AEP flood event, a steep hydraulic gradient in water level of around 0.4 m is likely to be present between the estuary entrance and the existing low point of the village control levee (see Section 5.2.2). During the onset of entrance breakout, this gradient is may be lower. Nonetheless, given the importance of preventing the levee from being overtopped, the berm saddle level should be set at 1.4 m AHD.</p> <p>A berm saddle level that is higher than this may increase the risk of catchment flooding. Conversely, it should be noted that that if the berm saddle level is set much lower than this, then it will increase the likelihood of storm tides entering the lake and putting infrastructure at risk.</p> <p>As there are no recorded historical entrance closures, there is little information available to determine if this saddle level is within the natural breakout range of the estuary. However, given the likely infrequent requirement of entrance management – it is not expected that adoption of this level would significantly impact on long term estuary function.</p>	1.4
<i>Alert Water Level</i>	<p>When the estuary is closed, Council should commence monitoring estuary water levels. When the recorded water level reaches this trigger value, Council should be on “alert” to start the entrance management process.</p> <p>It should be noted that due to the potential for ocean tide ingress during high spring tides, the estuary would be unlikely to be “fully” closed at a level lower than around +0.7-1.0 m AHD.</p>	1.0



7.3 Approach to Managing Estuarine Water Quality

7.3.1 Overview

As discussed in Section 5.3, the most effective and sustainable way of managing ICOLL water quality is through improved management of catchment and floodplain runoff into the estuary. This will likely be addressed in the forthcoming Kempsey Shire Council CMP.

However, artificial opening may (in rare cases) be required as a temporary measure to address extreme water quality issues where severe environmental and public health risks may exist. Korogoro Creek is highly valued and used by the local community for its safe primary contact recreational amenity opportunities, particularly during peak season.

However, it is often difficult to include triggers to address a broad range of potential water quality scenarios and associated uncertainties – and many EMPs do not include specific trigger values for opening estuaries based on water quality. A good example is the Woolgoolga Lake EMP (Coffs Harbour City Council, 2019b). A range of factors would need to be considered during a poor water quality event, such as:

- Environmental and public health risks posed by the water quality issue;
- The extent to which artificial opening will mitigate the water quality issue; and
- The consequent environmental and public health risks along the adjoining coastline following artificial opening of the estuary.

This EMP recommends that opening for water quality purposes should not be undertaken unless poor water quality can be evidenced through monitoring data. It is recommended that any water quality event is assessed on an individual basis and any decision to open should be made by Council with advice / approval from DCCEEW(BCS), and DPIRD-Fisheries. Artificial opening of the estuary should only take place if agreement between relevant agencies is reached.

7.3.2 Guidance for Management Decisions

Recommendations are provided below to guide discussions between stakeholders for a scenario where Council may consider opening the estuary on the grounds of water quality:

- Water quality conditions are more appropriate as a trigger for entrance management actions during high use periods when primary contact recreation is more prevalent - nominally for the period from September school holidays to Easter school holidays.
- Guidance is provided below in the form of ANZECC (2000) guidelines for primary contact recreation (such as swimming, bathing and other direct water-contact activities). The guidelines state that the estuary waters should generally be free from faecal contamination, pathogenic organisms and other hazards (e.g., toxic chemicals) to protect the health and safety of the users. Additional guidance is provided for protection of aquatic organisms, with regard to low dissolved oxygen and asphyxiation of aquatic organisms, particularly fish.

Table 7-2 ANZECC WQ guidelines

Water quality parameter	ANZECC (2000) Threshold Value	Monitoring Location(s)
Faecal coliforms	<ul style="list-style-type: none">■ Median from 4 consecutive samples taken during closure > 150 organisms /100mL; or■ Any one sample > 600 organisms/100mL	<ul style="list-style-type: none">■ Downstream



Water quality parameter	ANZECC (2000) Threshold Value	Monitoring Location(s)
Enterococci	<ul style="list-style-type: none"> Median from 4 consecutive samples taken during closure > 35 organisms /100mL; or Any one sample >60 organisms/100mL 	<ul style="list-style-type: none"> Downstream
pH	<ul style="list-style-type: none"> < 5.0 	<ul style="list-style-type: none"> Upstream Downstream
Dissolved Oxygen	<ul style="list-style-type: none"> < 4 mg/L 	<ul style="list-style-type: none"> Upstream (bed and surface) Downstream (bed and surface)

If any of the above thresholds are exceeded, then any decision to open should be made by Council with advice / approval from DCCEEW(BCS), and DPIRD-Fisheries. With regards to the opening method, the following is noted:

- Monitoring for dissolved oxygen (DO) is to be undertaken in the water column at both the bed and the surface. If monitoring indicates that DO levels in the estuary are highly stratified – then direct mechanical opening may increase the likelihood of estuary “decanting” and associated fish kills (see Section 5.3). In this scenario, berm height management may be a more suitable opening method.
- If monitoring for faecal coliforms and enterococci indicates a significant risk to human health and safety for primary recreation, then direct mechanical opening may be a more suitable approach so that risks are mitigated more readily – rather than scraping the berm and waiting potentially weeks or months for sufficient rainfall to facilitate an opening. However, this approach would need to be discussed with DCCEEW(BCS), and DPIRD – Fisheries.



8 ENTRANCE MANAGEMENT PROCEDURES

8.1 Roles and Responsibilities

The primary responsibility for implementation of the entrance management protocols is with Kempsey Shire Council. These responsibilities include obtaining relevant licences and approvals (see Section 3.4), direction and supervision of all works on site to ensure that they are carried out in accordance with these protocols and relevant standards and codes of practice.

8.2 Decision Making Framework

A summary of the decision-making framework is depicted in Figure 8-1. The framework is to be initiated, informed, and supported by monitoring of key environmental parameters. The decision needs to consider environmental, social, and economic factors including the range of viewpoints of the local community towards entrance management.

The procedures for entrance management include the following:

- **Notify** relevant public authorities that the entrance is closed, and that the monitoring and decision-making process has commenced;
- **Monitor** key environmental and social parameters that affect decision making;
- **Assess** environmental and social parameters against guidance set out in the framework;
- **Decide** on the most appropriate course of action based on available data;
- **Communicate** the course of action with relevant public authorities and the Hat Head community;
- **Act** based on an informed, consultative process; and
- **Reporting**: Monitoring and reporting are essential for informing future management and determining improvements to the procedure.

The framework in Figure 8-1 summaries a range of considerations, intended to provide guidance for the determination of eventual course of action. This is not intended as a rigid decision-making tool. Rather, flexibility is always beneficial, as “on the ground” conditions can change quickly, and a broad range of potential environmental, social and economic scenarios can exist in reality. Therefore, while the framework provides a strong scientific basis for determining the most appropriate course of action – the decision of which approach to take will ultimately belong to Council, in conjunction with relevant public authority stakeholders (Section 8.3).

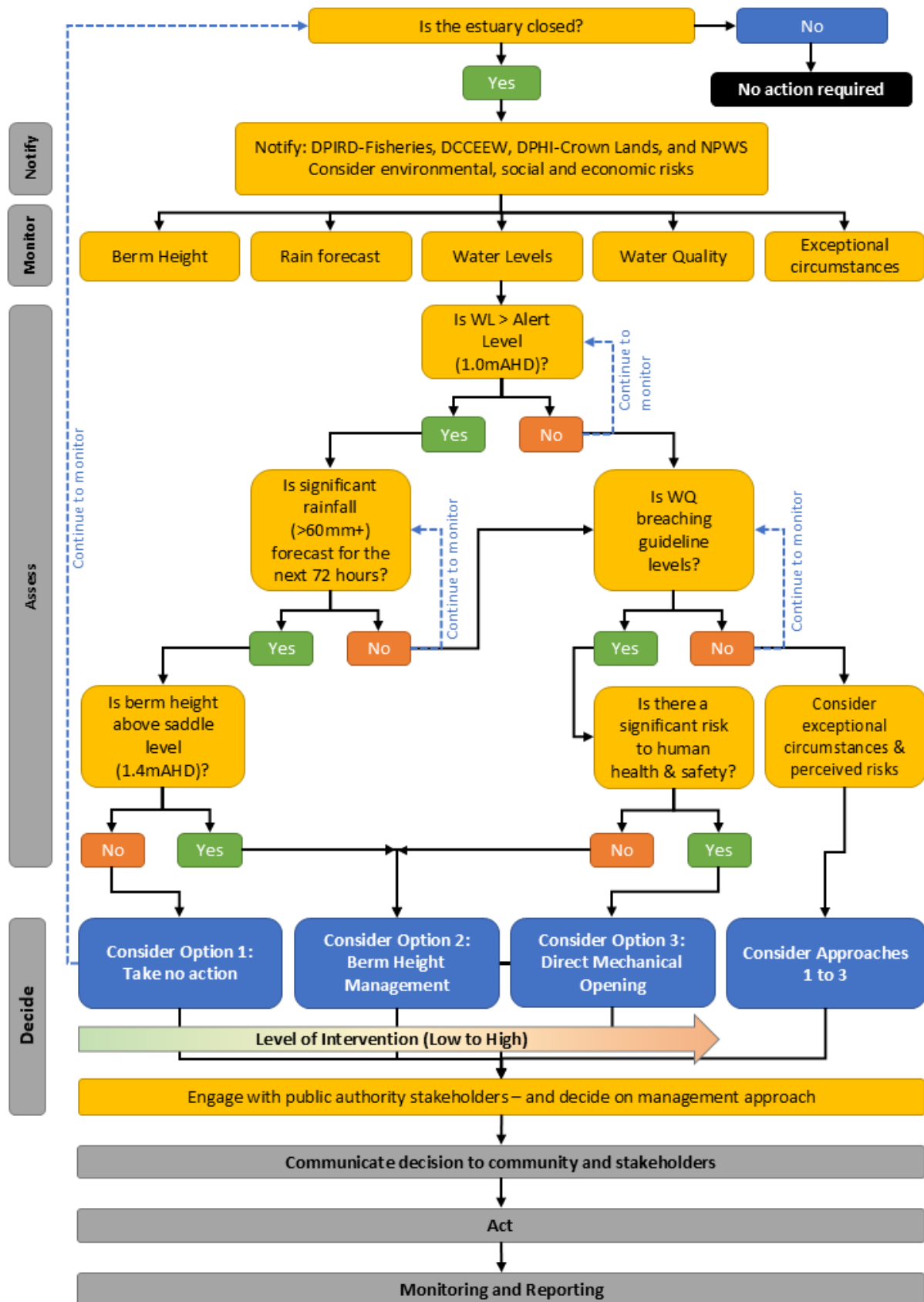


Figure 8-1 Overview of the entrance management decision-making framework



8.3 Notify

In the event of entrance closure, the first step will be for Council to notify the following agencies:

- DCCEEW(BCS);
- DHPI-Crown Lands;
- DPIRD-Fisheries; and
- NPWS.

Council should inform these agencies that the entrance is closed, and commence the entrance management decision making process. This process should consider the environmental and social parameters outlined in Section 8.4.

Whilst entrances closures are expected to be rare and exceptional events, it is important to acknowledge that there are strongly held and polarised views within the community with regards to entrance management. Therefore, a pragmatic and responsive approach to entrance closure is required.

8.4 Monitor

8.4.1 Water Levels

- When the estuary is closed, water levels should be monitored daily, with a focus on monitoring during and after rainfall events.
- **Estuary Water Levels:** Water levels in the estuary are automatically monitored and recorded by Manly Hydraulics Laboratory (MHL) - Hat Head Station (ID: 206465) - and reported online. The water level recorder is located at the footbridge, approximately 450 m upstream of estuary entrance. The instrument records the water level every 15 minutes and is visible on the MHL website (<https://mhl.nsw.gov.au/>).
- **Ocean Water Levels:** The nearest ocean tide gauge is located at Port Macquarie (Station ID: 207420), around 40 km south of the estuary entrance. This location is sufficiently proximate to be representative of the coastal ocean tide levels at the estuary entrance. Predicted tides can be accessed via at the BOM at: http://www.bom.gov.au/oceanography/projects/ntc/nsw_tide_tables.shtml

8.4.2 Rainfall Monitoring

- Predicted rainfall and other weather forecasts can be accessed via the Bureau of Meteorology (BOM) web page (<http://www.bom.gov.au/watl/>)

8.4.3 Water Quality Monitoring

- Once the estuary closes, Council officers are to carry out periodic water quality monitoring of the estuary. Water quality monitoring should be carried out on a weekly basis, and immediately after significant rainfall events (> 60 mm in 24 hours).
- In order to inform decision making in entrance management, it is recommended that water quality monitoring is undertaken for the following parameters:
 - Dissolved oxygen
 - pH
 - Faecal coliforms
 - Enterococci
- A hand-held water quality multi-probe is to be used to determine results for dissolved oxygen and pH. With respect to faecal coliforms and enterococci, water samples are to be collected and provided to a suitable microbiological laboratory for analysis. Sampling procedures shall be followed in accordance with laboratory requirements, with samples delivered to the lab not less than 24 hours after collection. Samples



are to be chilled during storage and transportation to the laboratory. With respect to bacteria, a combined sample using waters taken from all sampling sites (minimum of 3 within lower section of creek) should be provided to the laboratory for analysis.

- Water quality monitoring is recommended in two general areas:
 - Downstream near the estuary entrance and boat ramp; and
 - Upstream near the Korogoro Creek floodgates (just downstream of the gates themselves, near the tidal limit).

8.4.4 Entrance Condition and Berm Height

- Once the estuary has closed, Council's designated officers should assess the site and observe relevant factors, including:
 - The condition and extent of sand berm
 - Survey equipment should be used to survey levels of the berm, and determine the level (in mAHD) of the natural "saddle point";
 - The best location on the berm to undertake any potential scraping or opening works; and
 - Safety and access arrangements.

8.5 Assess: Decision Making Guidance

The framework in Figure 8-1 summaries a range of decision-making pathways, intended to provide guidance for the determination of eventual course of action. Based on the prevailing environmental and social conditions, the entrance management may be one of three potential options: (1) Do Nothing, (2) Berm Height Management, or (3) Direct Mechanical Opening.

The purpose of this section is to provide additional detail to support the framework in Figure 8-1.

Step 1: Water Level Monitoring

1. In the first instance, Council should monitor the water level of the estuary. The alert level of 1.0 m AHD will be based on water level data automatically monitored at 15-minute intervals by Manly Hydraulics Laboratory (MHL) at the Korogoro Creek gauge.
 - a. If the alert level of 1.0 m AHD is exceeded at the gauge, Council will monitor rainfall forecasts to predict if water levels are likely to rise significantly and pose a flood risk. **Proceed to Step 2.**
 - b. If the estuary water levels are below 1.0 m AHD at the gauge, then there is not considered to be an immediate nuisance flood risk.
 - i. At this point, other criteria for entrance opening may be considered. **Proceed to Step 3.**

Step 2: Forecast Rainfall and Berm Height Monitoring

2. Council should monitor rainfall forecasts, to assess if there is increased risk of inundation.
 - a. If a significant rainfall (>60mm+) is forecast for the next 72 hours, then:
 - i. Council should proceed to undertake site assessment to survey the height of the entrance berm and determine if berm scraping is required (see Section 8.4.4).
 - ii. If the lowest point in the berm (and thus the expected natural breakout level), is confirmed to be above the desired berm saddle level of 1.4 m AHD –**Consider Option 2: Berm**



Height Management: See Section 8.8 for berm scraping procedures. **Proceed to Step 5.**

1. Note that if an elevated ocean tide above the berm saddle level of 1.4 m AHD is forecast, then reducing the berm height in this scenario may allow ocean inundation to enter the estuary - and place infrastructure at risk. In this scenario, an intact berm will act as a barrier providing the estuary with protection. Therefore, the works should be timed appropriately in order to manage the balance of forecast rainfall and ocean tides.
- iii. If the lowest point in the berm (and thus the expected natural breakout level), is confirmed to be below the desired berm saddle level of 1.4 m AHD, then no physical action is required. During the next major rainfall event, the berm will naturally overtop at a low level - **Consider Option 1: Take No Action. Proceed to Step 5.**
 1. At this point, other criteria for entrance opening may be considered. **Proceed to Step 3.**

Step 3: Water Quality Monitoring

3. As outlined in Section 8.4.3, after the entrance closes, Council staff are to carry out water quality monitoring on a weekly basis, and immediately after significant rainfall events. Guidance is provided in Section 7.3 to help inform whether water quality parameters may precipitate an opening event.
 - a. If any of the water quality parameters breach guideline levels, then a range of factors need to be considered, such as:
 - i. Environmental and public health risks posed by the water quality issue;
 - ii. The extent to which artificial opening will mitigate the water quality issue; and
 - iii. The consequent environmental and public health risks along the adjoining coastline following artificial opening of the estuary.

Artificial opening of the estuary for water quality purposes should only take place if agreement between relevant agencies in Section 8.3 is reached.

The method of mechanical opening should consider potential ecological and human health risks. Some guidance is provided in Section 7.3 to inform decision making:

- iv. If monitoring for faecal coliforms and enterococci indicates a significant risk to human health and safety for primary recreation, then direct mechanical opening may be a more suitable approach. **Consider Option 3: Direction Mechanical Opening: Proceed to Section 8.8 for mechanical opening procedures. Proceed to Step 5.**
- v. Otherwise, or if monitoring indicates that DO levels in the estuary are highly stratified, then berm height management is recommended for opening to reduce the potential for fish kills. **Consider Option 2: Berm Height Management: Proceed to Section 8.8 for berm scraping procedures. Proceed to Step 5.**
- b. If none of the water quality parameters breach guideline levels, then there is unlikely to be sufficient environment or a human health risk to warrant artificial opening – and no action is required (**Consider Option 1: Take No Action**).
 1. At this point, other criteria for entrance opening may be considered. **Proceed to Step 4.**



Step 4: Exceptional Circumstances

4. While the framework provides a strong scientific basis for determining the most appropriate course of action – the decision of which approach to take will ultimately rest with Council, in conjunction with key stakeholders.

Whilst the framework provides guidance for entrance management from flooding and water quality perspectives, entrance management decision making needs to also consider exceptional circumstances that may present a risk to the environmental, social, and cultural values of the estuary such as chemical/pollutant spills, fish kills, algal blooms, or infrastructure related issues. Any such issues identified through monitoring or community & stakeholder engagement will be highlighted and forwarded to relevant authorising agencies for consideration in the decision making process.

In the unlikely (or rare) event of entrance closure, it will be important to be responsive and communicate clearly with the Hat Head community (see Section 8.7).

Proceed to Step 5.

8.6 Decide

Step 5: Decide

5. The framework in Figure 8-1 summaries a range of considerations, intended to provide guidance for the determination of the eventual course of action. While the framework provides a strong scientific basis for determining the most appropriate course of action – the decision of which approach to take will ultimately belong to Council, in conjunction with public authority stakeholders (Section 8.3).

8.7 Communicate

Step 6: Communicate

6. Once decided, the course of action should be communicated to relevant stakeholders and the community – prior to undertaking any specific course of action.
 - DCCEEW(BCS): To provide technical advice and confirm agreement with the proposed approach. Council should also confirm whether shorebirds are known to be nesting in the vicinity of the Saltwater Creek entrance. If nesting shorebirds are found to be breeding at the entrance site, entrance management works should take this into consideration.
 - DHPI-Crown Lands: As entrance berm and any proposed works would be undertaken on Crown land tenure.
 - DPIRD-Fisheries: To provide technical advice and confirm agreement with the proposed approach; and
 - NPWS: To provide technical advice and confirm agreement with the proposed approach.
 - a. Any matters concerning the openings that are raised by the above agencies should (where reasonable and feasible) be satisfactorily addressed by Council prior to the commencement of entrance opening works.
 - b. The decision should also clearly be communicated to the local community. Kempsey Shire Council should generate media release and social media communications to inform the community of the works.

Proceed to Step 7.



8.8 Act: Procedural Notes

Step 7: Act

This section provides procedural notes for entrance management options that require on ground works:

- Option 2: Berm Height Management and
- Option 3: Direct Mechanical Opening.

8.8.1 Option 2: Berm Height Management

Once the decision has been made to adopt an approach of berm height management, the following procedure should be undertaken:

- When a decision to take action is made, Council's personnel and machinery will be deployed to the entrance if the site assessment considers it appropriate and safe.
- The recommended access point for the 4WD backhoe operator to access the beach is via the accessway next to the boat ramp. The machine will access the site as much as possible via the established roads and access ways. Particular care should be taken to avoid damage to or disturbance of vegetated areas of sand dunes.
- Appropriate pedestrian safety measures are to be put in place during the works. This should take the form of either signage, or Council staff present on site to prevent pedestrian access within 20 m of machinery and the entrance.
- Survey equipment is to be used to survey levels of the berm and confirm a height above the nominated berm saddle level of 1.4 m AHD.
- The excavator / backhoe then proceeds to scrape the berm to the appropriate level while continually cross-referencing levels with survey equipment. The dry channel width should measure at least 5 m across. Figure 8-2 shows the recommended location of the works.
- Once the nominated berm saddle level is achieved, the operator is to smooth the dry channel batter slopes to make safe for pedestrian traffic.
- Although the volume of scraped sand is expected to be small, the excavated sand should be retained on the beach and not removed from the system. The sand should ideally be placed on Hat Head Beach, and spread evenly across the beach foredune in such a manner that no vegetation is disturbed.
- After the scraping works, Council personnel and machinery are to remain on stand-by, until:
 - The forecast rain eventuates, and the estuary opens of its own accord; or
 - The operation is cancelled by Council's designated officers.
- Decline in water quality at adjacent surf beaches may occur as a result of the estuary breakout. Council should consider the need to notify the community of this issue for at least the first 7 days after the opening has occurred.

8.8.2 Option 3: Direct Mechanical Opening

If the decision has been made to adopt an approach of direct mechanical opening, the following procedure should be undertaken:

- The mechanical opening is to be planned so that where possible the actual opening of the estuary occurs shortly after the tide turns from high to low, preferably for the lower of the two low tides of the day.



- The recommended access point for the 4WD backhoe operator to access the beach is via the accessway next to the boat ramp. The machine will access the site as much as possible via the established roads and access ways. Particular care should be taken to avoid damage to or disturbance of vegetated areas of sand dunes.
- Appropriate pedestrian safety measures are to be in place during the works. This should take the form of either signage, or Council staff present on site to prevent pedestrian access within 20 m of machinery and the entrance.
- The channel should generally be positioned as close as practical to the natural flow path of the estuary when open – adjacent to the bedrock on the eastern bank but without interference to the rock.
- The opening should be deep enough for scouring flow to develop, at least 1 m. The 4WD backhoe operator is to dig a 'pilot' excavation channel starting at the ocean end of the berm and moving progressively towards the creek. The pilot channel is to be around one bucket-width (commonly 2 m or less) and the bed should be graded down to the ocean. The last section of the channel (at the creek end) should be kept closed, and where possible, opened shortly after the next high turns from high to low tide (i.e., to the lower of the two low tides of the day). Figure 8-2 shows the recommended location of the works.
- In terms of timing, ideally the initial breaching should occur 30 minutes after the published high tide time (adjusted for daylight saving time when appropriate). Initiation of a breakout at this time is likely to result in the most effective and sustained mechanical breakout due to the increasing hydraulic head difference between the water in the creek and the ocean through the progression of the breakout. This will normally require commencement of excavation just after the preceding low tide, allowing for a total of 4 to 6 hours excavation time across the beach.
- Although the volume of scraped sand is expected to be small, the excavated sand should be retained on the beach and not removed from the system. The sand should ideally be placed on Hat Head Beach, and spread evenly across the beach foredune in such a manner that no vegetation is disturbed.
- Decline in water quality at adjacent surf beaches may occur as a result of the estuary breakout. Council should consider the need to notify the community of this issue for at least the first 7 days after the opening has occurred.

8.9 Monitoring and Reporting

Monitoring and reporting are essential for informing future management and determining improvements to the procedure. At a minimum the following should be recorded:

- Water level of estuary prior to opening (obtain from MHL water level recorder);
- Date and time of opening;
- Location and dimensions of works (width, depth, length);
- Ocean swell conditions (wave height and direction)
- Preceding rainfall;
- Date of natural closure of the entrance;
- Digital photographs of the opening and breakout development.

The information is to be recorded on a standard monitoring sheet, provided in Appendix A.

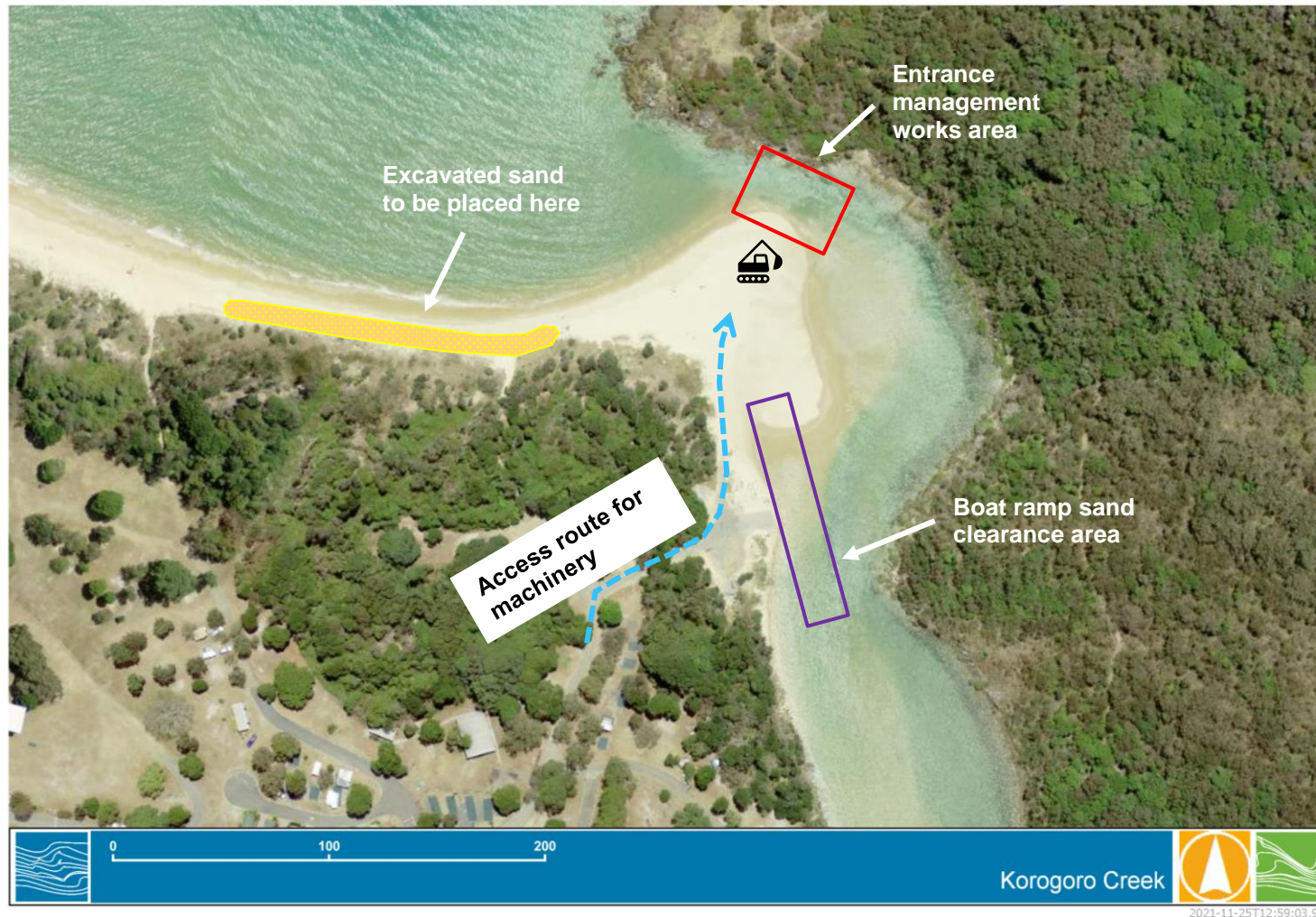


Figure 8-2 Entrance management schematic



9 SAND CLEARANCE AT THE BOAT RAMP

The shoaling patterns between the boat ramp and the entrance are highly variable being dependent upon tidal hydrodynamics, catchment inflows, littoral sediment supply, and near shore currents and wave conditions. Therefore, the requirement for sand clearance at the boat ramp necessitates a more subjective assessment of the conditions (GECO Environmental, 2009b). Historically, this process has been triggered as a result of a complaint, or series of complaints, to Council or Transport for NSW (Maritime). Note that receipt of a complaint does not infer a requirement upon Council to act as the ability to act will be dependent upon available funding and equipment and/or contractors to undertake the work.

The process is as follows:

1. The process is triggered as a result of a complaint, or series of complaints, to Council or Transport for NSW (Maritime) of excessive sand accumulation at the boat ramp that is impacting the ability to safely launch and retrieve vessels.
2. Council to confer with TfNSW (Maritime), and DHPI-Crown Lands and undertake a site inspection.
3. If it is deemed in the opinion of these stakeholders to be unsafe, and that sand clearance would resolve the safety issue, then it is appropriate for Council to consider sand clearance in the area of the boat ramp – under the existing DHPI-Crown Lands licence conditions.
4. Council is to arrange for appropriate earth moving equipment to be mobilised to the boat ramp. Removal of sand should be timed to coincide with the lowest tide practical in next spring tide phase.
5. Appropriate pedestrian safety measures are to be in place during the works. This should take the form of either signage, or Council staff present on site to prevent pedestrian access within 20 m of machinery and the boat ramp.
6. Although the volume of sand cleared from the boat ramp is considered to be small, the excavated sand should be retained within the coastal compartment and not removed from the system. The sand should ideally be placed on Hat Head Beach. Materials should be spread evenly across the beach foredune in such a manner that no vegetation is disturbed.

The approximate area for the works is depicted in Figure 8-2.



10 RECOMMENDATIONS

10.1 Review and Update of this Procedure

This EMP should be reviewed every ten years, or in response changes in the relevant legislation (as required). Review of the EMP should include analysis of all monitoring data collected over that period to ensure that predictions and assumptions outlined in it are adequate.

A review of the trigger level should also be in relation to the latest floor level data and levels of any other infrastructure on low lying land at risk of inundation from floodwaters. If any of the low-lying assets listed in this policy are removed or modified, the trigger level should be subject to review and the policy updated as required.

10.2 Long Term Management Approaches

Long term management of the entrance should also be considered in the context of findings and management actions the following major projects:

- The Lower Macleay Floodplain Risk Management Study and Plan. This should include periodic inspection and survey of the Hat Head levee system.
- The Kempsey Shire LGA CMP.

As per the advice of NSW DPIRD-Fisheries, the long-term approach of ICOLL management should be to reduce the need for artificial manipulation by taking active measures to remove, relocate or otherwise manage items of low-lying infrastructure that currently necessitate breaches below the natural breakout range, and adopting catchment management practices that:

- Reduce the inputs of nutrients and pollutants from point and diffuse sources,
- Prevent transfer of flood prone and riparian land on the margins of ICOLLs into private ownership,
- Prevent the future development or subdivision of flood-prone and riparian lands by adopting appropriate zonings and buffers in relevant land use planning instruments,
- Implement community awareness campaigns to gain broad based understanding and support for the environmentally responsible management of ICOLLs.



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APPENDIX A MONITORING FORM





Entrance Monitoring Form	
Opening date / time	
Natural opening, or Council initiated	
Berm Height Management, or direct mechanical opening?	
Opening Water Level (mAHD)	
Berm Height (mAHD)	
Summary of conditions (rainfall, swell etc)	
Type plant onsite & contractor	
Location of works	
Date / time works commenced	
Date / time works finished	
Date of subsequent closure	
Notes	

Melbourne

15 Business Park Drive
Notting Hill VIC 3168
Telephone (03) 8526 0800

Sydney

Suite 3, Level 1, 20 Wentworth Street
Parramatta NSW 2150
Telephone (02) 8080 7346

Brisbane

Level 5, 43 Peel Street
South Brisbane QLD 4101
Telephone (07) 3105 1460

Adelaide

1/198 Greenhill Road
Eastwood SA 5063
Telephone (08) 8378 8000

Perth

Ground Floor, 430 Roberts Road
Subiaco WA 6008
Telephone (08) 6555 0105

New Zealand

7/3 Empire Street
Cambridge New Zealand 3434
Telephone +64 27 777 0989

Wangaratta

First Floor, 40 Rowan Street
Wangaratta VIC 3677
Telephone (03) 5721 2650

Geelong

51 Little Fyans Street
Geelong VIC 3220
Telephone (03) 8526 0800

Wimmera

597 Joel South Road
Stawell VIC 3380
Telephone 0438 510 240

Gold Coast

Suite 37, Level 4, 194 Varsity Parade
Varsity Lakes QLD 4227
Telephone (07) 5676 7602

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