Covering Note

This report contains sensitive information relating to location of Aboriginal Cultural Heritage sites. To protect this sensitive information Council has removed the relevant information that has been presented in the original report.

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St Georges Basin, Sussex Inlet, Swan Lake and Berrara Creek Coastal Management Program

Foreshore Erosion Assessment

Shoalhaven City Council

03/08/23

311015-00158

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advisian.com

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Company details

Advisian Pty Ltd
ABN 50 098 008 818

Level 17, 141 Walker Street
North Sydney NSW 2060
Australia

T: +61 2 9495 0500
F: +61 2 9810 5777

PROJECT 311015-00158 - CS-REP-002: St Georges Basin, Sussex Inlet, Swan Lake and Berrara Creek Coastal Management Program - Foreshore Erosion Assessment

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Executive summary

This report documents a detailed field-based assessment of erosion and foreshore issues affecting the estuary health of St Georges Basin, Sussex Inlet, Swan Lake and Berrara Creek. The shoreline has been inspected in detail, including from the water by boat and from land by foot, and features indicative of the coastal processes occurring at the various sites within the study area have been documented.

Key areas that have suffered from erosion include:

- Sussex Inlet – foreshore west of Nielson Lane, Croppers (the Big "S"), The Haven, Alamein, Little Manly, Christian's Minde
- St Georges Basin – especially the south-facing areas along the northern foreshore where the foreshore has been reclaimed with fill materials and where fringing vegetation is absent from the shoreline
- Berrara Creek – northern and eastern foreshores.

Causes of erosion throughout the study area include:

- erosion at outer side of channel bends, caused by natural channel meandering
- erosion at the toe of steep unstable sand banks, caused by vessel wash, slope instability and people accessing the dunes
- erosion of unstable fill materials that do not have sufficient stability to resist wave action
- erosion caused by outflanking of existing foreshore protection works
- erosion caused by wind waves at high water levels, undermining fringing vegetation and toppling of this vegetation by strong winds
- erosion caused by access to the foreshore (e.g. stock access at Wandandian Creek, lack of foreshore vegetation)
- erosion caused by vessel wash (near boat ramps and along Wandandian Creek).
- erosion caused by ad-hoc vessel storage, stormwater/catchment outflows.

Potential management actions for the erosion were assessed using the DPIE Decision Support Tool, with specific actions outlined and identified for each area where erosion has been documented. The management actions included:

- management of foreshore vegetation
- placing large woody debris
- cobble beaches
- maintenance and upgrade of existing foreshore works.

The detailed management suggestions from the Decision Support Tool are provided within this report for each hotspot erosion site, and detailed in Appendix B. Management opportunities and specific management actions for these sites will be reviewed as part of Stage 3 of the Coastal Management Program.

Historical rates of erosion and future erosion risk were assessed based on available information, although historical information was limited (particularly at Swan Lake and Berrara Creek). Erosion rates up to 1 m/year were estimated based on analysis of historical survey data and aerial photography at specific erosion hotspot locations identified from the fieldwork along the northern foreshore of St Georges Basin and at Sussex Inlet.

The analysis highlighted that erosion tended to occur along short discrete sections of shoreline, rather than uniformly along the entire foreshore, which demonstrates that specific management actions would likely be effective in addressing the erosion. It is likely that sea level rise due to climate change would exacerbate the erosion risk at all estuaries, as the main mechanism for the erosion is wave action occurring at high water levels.

1 Introduction

This report provides a summary of a detailed field-based assessment of erosion and foreshore issues affecting the estuary health of St Georges Basin, Sussex Inlet, Swan Lake and Berrara Creek. The shoreline has been inspected in detail, including from the water by boat and from land by foot, and features indicative of the coastal processes occurring at the various sites within the study area have been documented.

The foreshore erosion assessment has been carried out using a Decision Support Tool framework that has been developed specifically for bank erosion management in NSW estuaries (Hydrosphere Consulting 2020). The framework provides suggested management actions for particular sections of foreshore, based on factors including the severity and causes of erosion, whether there is infrastructure or environmental values at risk from the erosion, channel geometry, the substrate and any landward or seaward constraints to treatment.

Key areas where foreshore erosion has been identified have been mapped in detail and assessed through the Decision Support Tool, with the mapping and results of the assessment provided in Appendix B. The mapping identifies Council and private infrastructure and assets that are at risk along the foreshores of the three estuaries, as well as summarises the coastal processes affecting particular reaches of each estuary.

From the field assessment and Decision Support Tool, realistic management actions and techniques have been suggested, with some that can be implemented immediately to address the issues identified. Potential management actions have been mapped at the local level by breaking the estuary up into sections as described in this report.

1.1 Study Area

The study area for this assessment included:

- St Georges Basin foreshores, including Wandandian Creek
- Sussex Inlet foreshores
- Swan Lake foreshores
- Berrara Creek foreshore (downstream of Lakeway Avenue)

Each area of foreshore was divided into specific localities based on geographical location and morphological characteristics.

Previous studies of morphological changes and erosion within the St Georges Basin, Sussex Inlet, Swan Lake and Berrara Creek have been undertaken (documented within the St Georges Basin Revised Estuary Management Plan 2013 and Swan Lake and Berrara Creek Natural Resources Management Strategy (2002)). The previous erosion assessments as documented in these studies are summarised within this report for comparison with the observed present-day erosion.

2 Fieldwork

2.1 Fieldwork Methodology

A series of fieldwork campaigns was carried out to assess various sections of shoreline throughout the St Georges Basin, Sussex Inlet, Swan Lake and Berrara Creek estuaries. The fieldwork involved the following:

- a detailed walkover of all sections of foreshore at the estuaries, for the areas that were publicly accessible on foot.
- for areas that were not accessible by foot, observations were made by boat or kayak from the water where water access was available.
- for areas where foreshore access was not possible by boat or from land, observations were made using high-resolution aerial photographs using Nearmap photography. Aerial photography from different dates was examined to assess changes occurring at particular sites over time.

Individual sites were assigned a reach or bank segment ID based on geographic location, erosion characteristics and geomorphic characteristics, and erosion severity was characterised for each reach in each estuary. Foreshores in each reach for each estuary were assigned an erosion severity rating based on the field assessment and mapped in GIS according to the following severity ratings:

- **Negligible** (green) – negligible erosion observed (i.e. currently aggrading or stable – no erosion)
- **Low** (yellow) – erosion observed but assigned a severity rating of "low" (e.g. some erosion occurring but considered within natural parameters, low erosion rate, low scarp height or minor undercutting)
- **Moderate** (orange) – observed erosion assigned a severity rating of "moderate" (e.g. rate or scale of erosion is considered more than natural, elevated scarp height, considerable undercutting or minor evidence of slumping/block failure)
- **High** (red) – observed erosion assigned a severity rating of "high" (e.g. rate and scale of erosion is significant, significant scarp height, significant undercutting or evidence of significant slumping/block failure)
- **Extreme** (purple) – observed erosion assigned a severity rating of "extreme" (e.g. likely to be rare, represents largest scale of erosion occurring within the estuary with significantly accelerated rate and scale)

The detailed field assessment followed the Estuary foreshore erosion Decision Support Tool (DST) framework recently set up by the NSW Government to assess estuary foreshore erosion for Coastal Management Programs throughout NSW.

This project provides a pilot application used to validate the DST methodology and has presented an opportunity to finesse the application of the tool for use in other estuaries throughout NSW.

2.2 Estuary Decision Support Tool

The fieldwork for each site was documented using the Decision Support Tool (DST) for Bank Erosion Management in NSW Estuaries, documented in detail in Hydrosphere Consulting (2020). The tool uses an Excel interface to suggest specific management approaches for areas of foreshore which are affected by erosion, based on a detailed field assessment.

The DST was adapted for use in the field by creation of a fieldwork proforma, which allowed each bank segment to be documented rapidly in the field. The proforma (Figure 2-1) was used in conjunction with GPS and a hard-copy aerial photograph map to document the precise location of the assessment and individual bank segment location IDs. Standardised definitions were used for each bank segment ID, based on the definitions provided in the DST, to minimise the subjectivity of the assessment when being undertaken by different field officers.

The field assessment included the following information:

- **Estuary name and location ID**
- **Environmental impact of erosion** – assigned as negligible, low, medium or high
- **Infrastructure/commercial impact of erosion** – assigned as negligible, low, medium or high
- **Amenity/safety impact of erosion** – assigned as negligible, low, medium or high
- **Future trajectory of erosion** – based on field assessment of whether erosion was currently occurring, whether it was likely or not to occur in the future, whether it was continuous or whether it was accelerating
- **Contributing cause of erosion** – wind waves, ocean waves, vessel waves, river/tidal flow, stock access or public access.
- whether the reach is located in the **upper, mid or lower estuary**
- whether the erosion is occurring at the **top, upper or lower section of bank**
- the **channel geometry** at the site of the erosion (inside or outside bend, straight, or basin/broadwater)
- the **depth** at the erosion site (shallow <0.8m, moderate 0.8 – 1.5m, deep >1.5m).
- the **substrate** (natural soil type) at the erosion site (bedrock, cohesive, non-cohesive or unknown)
- whether there are any immediate **offshore or landward constraints** to treatment of the erosion
- whether **public access** to the foreshore is required at the site
- whether there are any **high value assets at risk** from erosion
- whether there is **a riparian vegetation community** at the site, and the width of the riparian vegetation zone

- whether there are any **existing erosion control** methods in use at the site and the effectiveness of these controls.

The field proforma is shown in Figure 2-1, and the standard definitions for each of the categories listed is shown in Appendix B. Completed field inspection proforma sheets for areas where significant foreshore erosion has been identified are provided in Appendix A.

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name		
Location ID (mark on map)		
Environmental Impact of erosion (negl., low, mod, high)	N L M H	
Infrastructure/Commercial impact	N L M H	
Amenity/Safety Impact	N L M H	
Future Trajectory	Not occurring, not likely Not occurring but likely Occurring and continuous Occurring and accelerating	
Current Erosion severity	N L M H E	
Contributing Cause (circle all that apply)	Wind waves Ocean waves Vessel waves River/tidal flow Sediment extraction Stock access Public access	
Upper, mid or lower estuary	U M L	
Location of erosion (Top, upper, lower bank)	T U L	
Channel geometry (inside bend, outside bend, straight, basin)	I O S B	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	S M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C NC U	
Immediate landward constraint to treatment?	Y N	
Any offshore constraint?	Y N	
Public access to foreshore required?	Y N	
High value asset at risk?	Y N	
Riparian vegetation community? (none, low, moderate, high)	N L M H	
Width of riparian vegetation	<2 <5 <10 <20 >20m	
Are weeds contributing to instability?	Y N	
Existing erosion control method?	None Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	N C PC PD I R	

Figure 2-1 – Bank erosion proforma used for fieldwork based on DST

The DST uses the input data from the field assessment to:

- assess environmental, safety/amenity and infrastructure/commercial risks from the erosion at each site
- determine from the risk assessment whether bank stabilisation works are appropriate
- score and shortlist various bank stabilisation techniques and
- assign an assessment score to each technique, as illustrated in Figure 2-2.

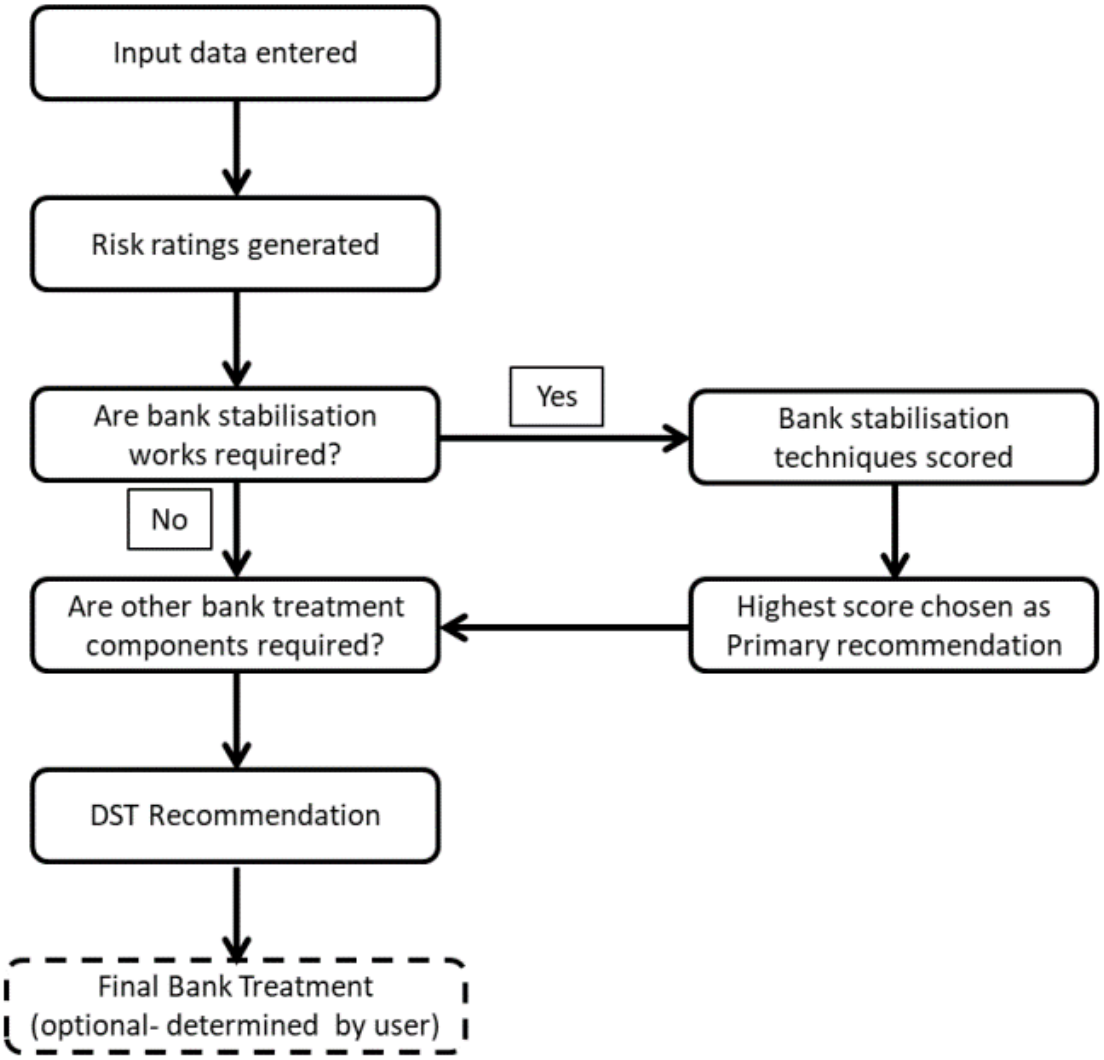


Figure 2-2 - Process used by Decision Support Tool to assign appropriate erosion treatment at each site (Hydrosphere Consulting, 2020)

3 Erosion Assessment – St Georges Basin

3.1 Introduction

The St Georges Basin Revised Estuary Management Plan (2013) identified that erosion from wind-generated waves is the main forcing mechanism at St Georges Basin, with the two worst affected erosion areas identified as John Williams Reserve and Basin View foreshore reserve, both of which are down-drift from boat ramps. Foreshore erosion was estimated by WBM (2003) at approximately 0.2 m/year, but it was noted that this may increase due to sea level rise causing the shoreline to recede landward of the existing vegetated strip, and due to loss of fringing vegetation.

The Plan provided a work schedule for foreshore remediation works within St Georges Basin, including sand nourishment, revegetation, monitoring and further investigation. The areas identified included:

- Western end of Basin View shoreline – sand nourishment
- Basin View shoreline east of new boat ramp – monitoring and further investigation
- Aloha caravan park shoreline – monitoring and further investigation
- Loralyn Avenue shoreline west of The Wool Lane – monitoring and further investigation
- Loralyn Avenue shoreline east of The Wool Lane – sand nourishment and revegetation
- Paradise Beach northern shoreline – sand nourishment and revegetation
- Paradise Beach southern shoreline – sand nourishment and revegetation
- Macleans Point shoreline – monitoring and further investigation
- Sanctuary Point shoreline – monitoring and further investigation
- John Williams Reserve shoreline – sand nourishment and rock/geotextile groyne at southern end
- Erowal Bay shorelines – monitoring and further investigation.

These key locations along the St Georges Basin foreshore have been inspected and documented using the DST, together with the remaining foreshores of St Georges Basin and Wandandian Creek. These are presented in detail below, from west to east.

The results of the erosion assessments are documented for each location within each estuary on the proforma sheets in Appendix A, where significant erosion was observed.

3.2 Key locations where foreshore erosion has been observed

Key locations where significant erosion was identified are shown in Table 3-1, and mapped in detail in Figure 3-1. Each location was entered into the Decision Support Tool, with management actions suggested by the tool for some of these locations.

Table 3-1 – Key locations in St Georges Basin where significant foreshore erosion was observed (red = "high", orange = "medium", yellow = "low", green = "negligible")

Bank segment ID	Erosion Severity	Environmental Impact	Infrastructure / commercial impact	Amenity / safety impact	Future Trajectory
W001 (Wandandian Ck upstream)	High	High	Low	Low	Occurring and continuing
BV03 (Mathie Street)	Medium	Medium	High	High	Occurring and continuing
BV02 (Basin View west of boat ramp)	Medium	Low	Low	Medium	Occurring and continuing
OEB01 (Old Erowal Bay Prentice Av)	Medium	Medium	Low	Low	Occurring and continuing
MP01 (Mcleans Point east)	Medium	Medium	Low	Low	Occurring and continuing
W002 (Wandandian Ck downstream)	Medium	Medium	Negligible	Negligible	Occurring and continuing
LAW01 (Loaralyn Ave East)	Medium	Low	Low	Low	Occurring and continuing
EB01 (Erowal Bay east)	Low	Low	Medium	Low	Occurring and continuing
STB01 (Blackett Park)	Low	Medium	Low	Low	Occurring and continuing
IP01 (Island Point)	Low	Low	Low	Low	Occurring and continuing
PB01 and PB02 (Paradise Beach)	Low	Low	Low	Low	Not occurring but likely
WB01 (Wrights Beach)	Low	Low	Negligible	Negligible	Not occurring but likely
EB02 (Erowal Bay west)	Low	Negligible	Negligible	Negligible	Not occurring but likely
Tullarwalla Lagoon and Inlet	Low	Negligible	Negligible	Negligible	Not occurring but likely

The locations are described in detail below, together with the suggested management approach based on the outcome of the Decision Support Tool.

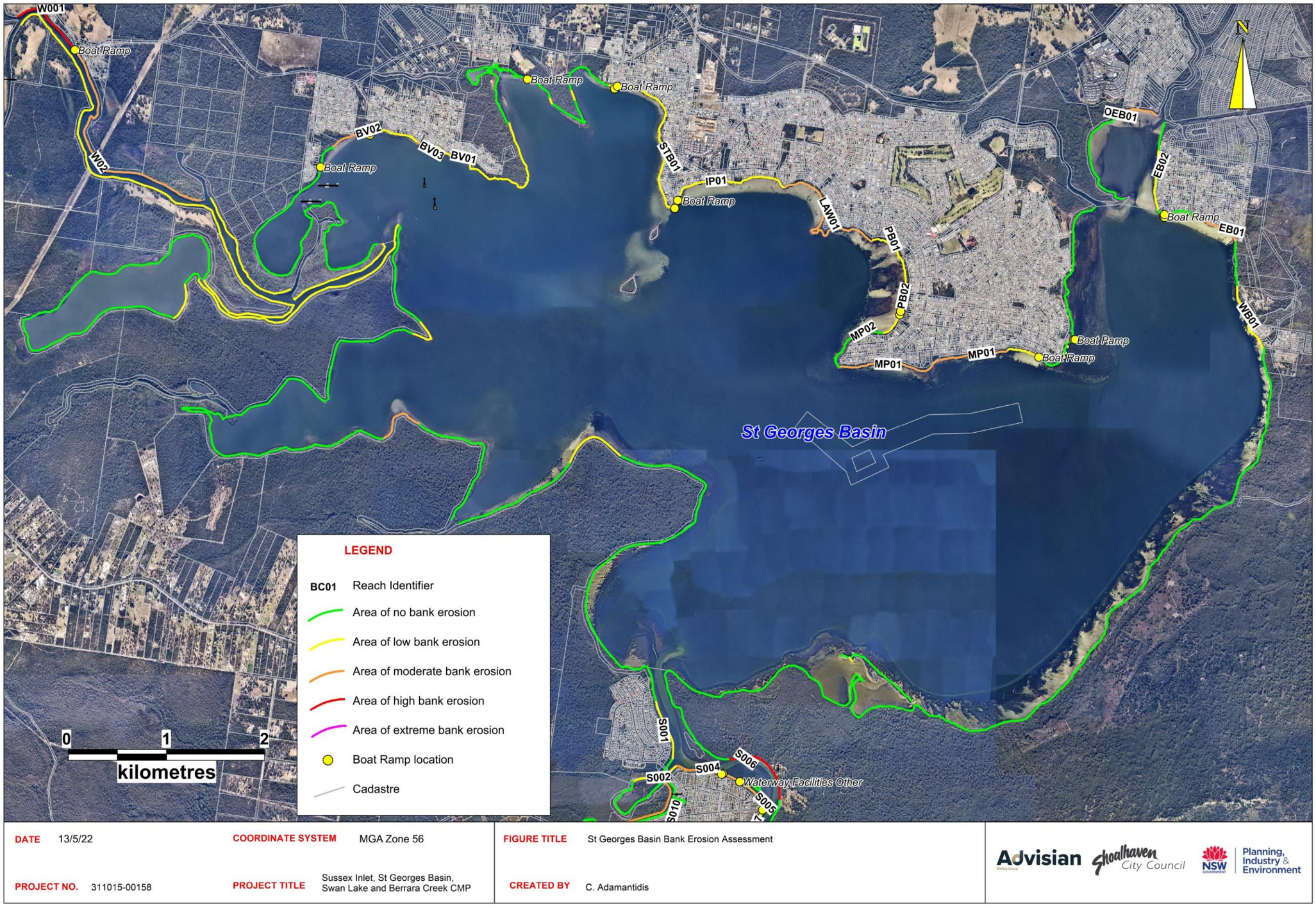


Figure 3-1 – St Georges Basin Erosion Assessment Map

3.3 Wandandian Creek

Bank erosion was observed along the upper reaches of Wandandian Creek, with the erosion severity characterised as "High" at this location. Moderate erosion was observed along part of the length of the upper reaches of the creek on the northern bank, with lower severity erosion along the southern bank and along the lower reaches of the creek. The outcomes of the field assessment for this site are outlined below.

3.3.1 Characteristics of site

Wandandian Creek is a tributary of St Georges Basin and was inspected by boat on 16 February 2022. Foreshore erosion was observed during the site inspection, particularly along the northern bank of the creek and on the outside bend. The area where this erosion was observed is shown in Figure 3-2 as bank section W001 and W002.

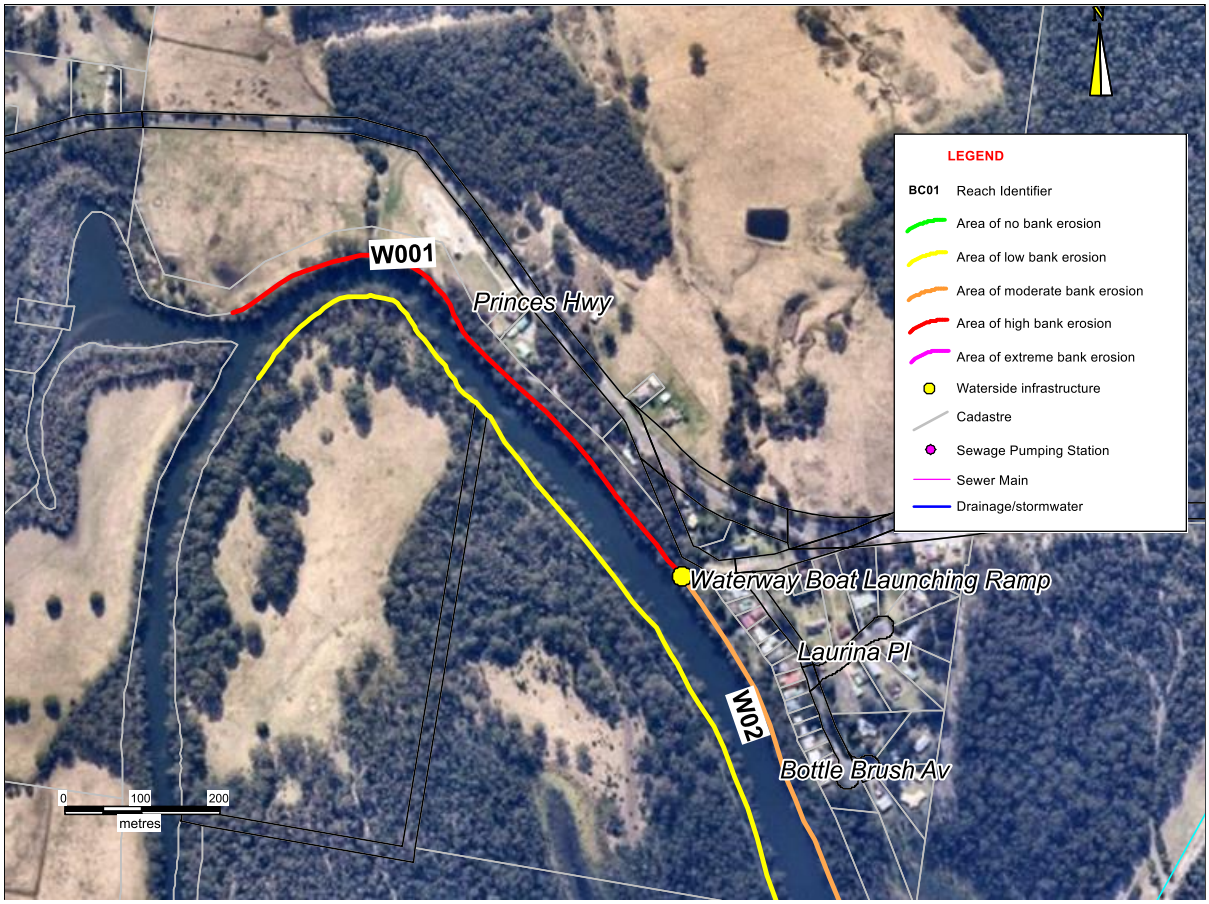


Figure 3-2 – Detail of W001 site at Wandandian Creek assessed as having erosion of high severity

A steep clay embankment was exposed along this site, with evidence of erosion occurring along the upper bank (above the mean water level) as well as undercutting of the banks and undermining of large casuarinas and other foreshore vegetation. There were locations where stock were able to access the foreshore directly, and where there was a lack of foreshore riparian vegetation (Figure 3-3). The depth adjacent to the bank was not known but was assessed to be at least 1.5 m as the channel is navigable by many recreational vessels. No existing foreshore erosion control methods were visible.

3.3.2 Causes of erosion

Causes of erosion at this site were assessed to include:

- vessel waves, as the site is exposed to boat wash from recreational vessels
- river and tidal flow, as the high erosion site is located on the outside of a channel bend where there is erosive pressure due to channel meandering
- direct access by stock to the foreshore at the upper reaches of the creek, despite the presence of fencing (stock were observed accessing the foreshore during the field inspection). Stock access to the foreshore results in trampling of vegetation and dislodgement of sections of the bank.
- lack of foreshore riparian vegetation at individual locations and the presence of weeds along the bank are considered to be impacting on estuary bank stability. Weed species can crowd out native riparian vegetation, and can have shallow roots which have limited ability to hold the banks together.

Figure 3-3 – Wandandian Creek at Bewong (site reference W001). Note direct access to foreshore by stock and lack of riparian vegetation along bank at right hand side of photo (16 February 2022).

3.3.3 Environmental, Cultural, Infrastructure and Amenity Impact

There is limited infrastructure exposed to erosion at this site. However, there has been a loss of riparian vegetation due to erosion, further exposing the banks, and sedimentation from the eroded banks has the potential to impact on water quality. There is a 4WD-access boat ramp along this section of the creek (Figure 3-4).

A review of the Aboriginal Heritage Information Management System (AHIMS) in February 2022 identified over 100 Aboriginal sites recorded in and around Sussex Inlet and St Georges Basin,

[redacted].

These sites comprise stone artefact scatters located on ridgelines and the foreshores of Wandandian Creek, that contain both local and traded stone (Shoalhaven City Council, 2013). While the exact location of these sites was not able to be identified from the water during the bank erosion inspections, the AHIMS search identified these to be in the sections of the creek that are experiencing low or moderate ongoing erosion. Given that these sites are generally located on the foreshore, they are likely to be vulnerable to ongoing erosion of the banks of Wandandian Creek.

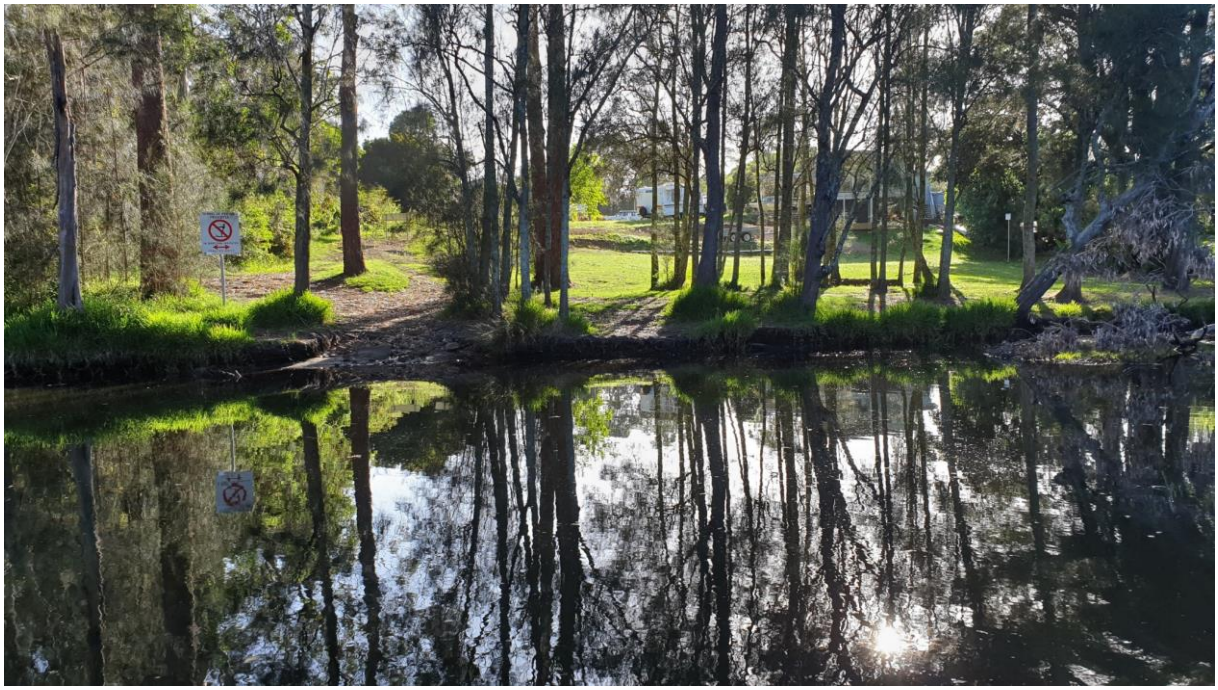


Figure 3-4 – 4WD access boat ramp at Bewong, Wandandian Creek. Note sign prohibiting towing of persons (site reference W002 - 16 February 2022).

3.3.4 Potential Management action from Decision Support Tool

The DST suggested the use of large woody debris to protect the bank in this area. The application of this management action is described in detail in the DST documentation (Hydrosphere Consulting 2020) and summarised in Appendix D. The purpose of large woody debris is to divert/alter and/or dissipate flows from the bank, to allow sediment to deposit and riparian vegetation to become established. An example of the application of this technique is shown in Figure 3-5. In conjunction with the use of large woody debris along the outside of the bend, maintenance of fencing to exclude stock from the riverbank and establishment of a riparian vegetation zone along the bank is suggested to reduce the erosion. Management controls already in place include prohibition of wake boarding and water skiing in this section of the creek.

It is noted that there are works planned under the NSW Medium-term Response Plan for Bushfire Recovery (DPIE, 2021) that include works to restore foreshores and riparian zones and provide additional resources for erosion and sediment control in the bushfire-affected catchment areas, and for the areas that were affected by the "Black Summer" bushfires of 2019-20. Any works undertaken to address bank stabilisation under the CMP need to be consistent with those works planned under the NSW Bushfire Recovery Program.

In the lower sections of the creek, collapsed foreshore vegetation is acting as natural "large woody debris" and would likely have a role in protecting the banks from further damage caused by vessel wash.

Figure 3-5 – Application of large woody debris at Hunter River, NSW. (Hydrosphere Consulting, 2020).

3.4 Tullarwalla Lagoon

Tullarwalla Lagoon and Tullarwalla Inlet were inspected from the water on 17 June 2022. The outcomes of the field assessment are outlined below.

3.4.1 Characteristics of site

The foreshores of the lagoon were observed to be largely in an undisturbed state, but there was some erosion observed on the southern foreshore of the lagoon, associated with a clearing which is used for 4WD and motorcycle access to the foreshore. The Lagoon is connected to St Georges Basin via Tullarwalla Inlet, where some bank erosion was observed, mainly comprising undercutting of foreshore vegetation. Some impacts from ad-hoc jetties and structures were observed during the site visit. The area inspected and severity of erosion is shown in Figure 3-6.

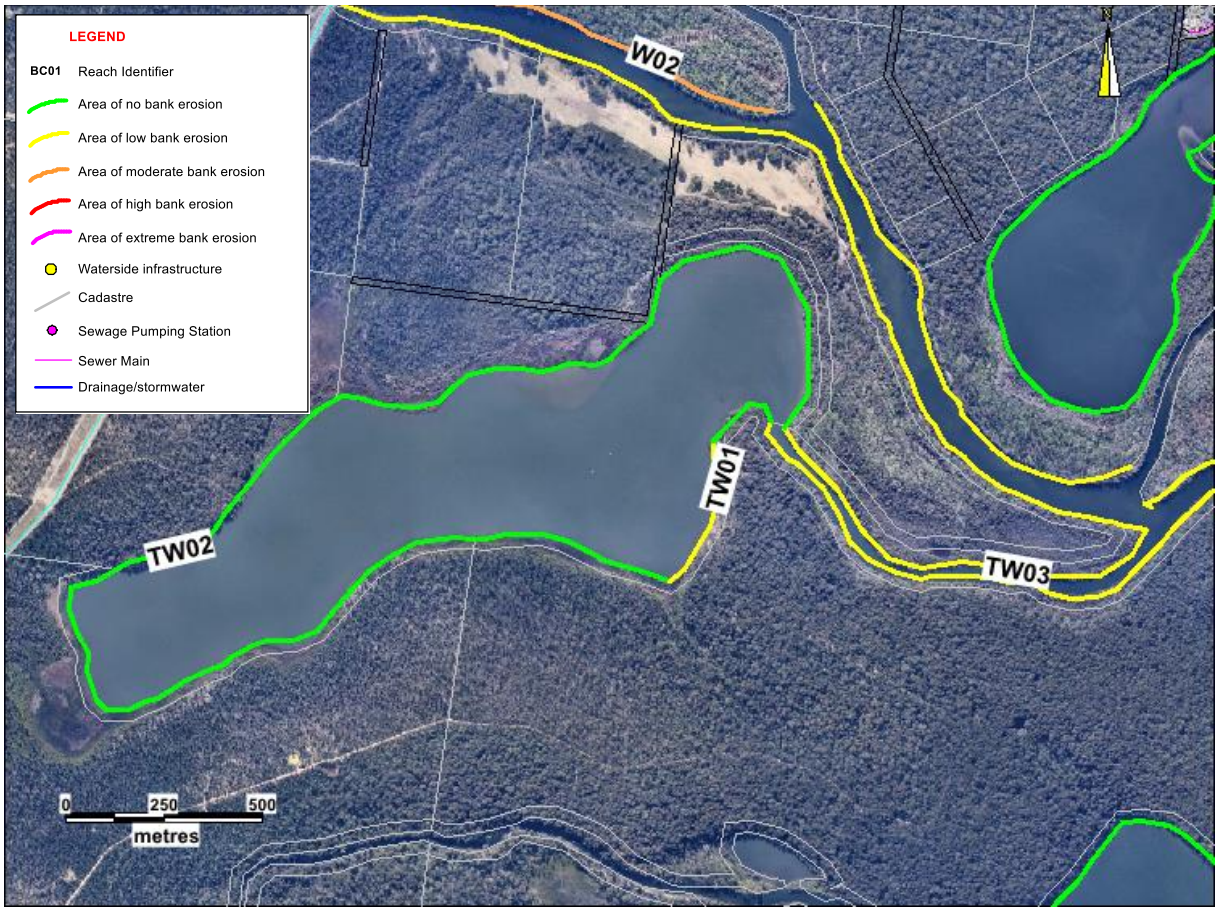


Figure 3-6 – Detail of observed erosion at Tullarwalla Lagoon

3.4.2 Causes of erosion

While there was little erosion observed along the natural, undisturbed foreshores of the lagoon, there was some erosion associated with loss of foreshore vegetation and access to the foreshore by 4WD and motorcycles observed (Figure 3-7). In addition, there was evidence of minor erosion around a foreshore camping site at the northern foreshore of the lagoon, although fencing was installed at this location to prevent direct vehicle access (Figure 3-8).

At Tullarwalla Inlet, erosion was observed along the creek banks, which was primarily undercutting of foreshore vegetation when the creek water levels are high. The vegetation was observed to be toppling into the creek at some locations (Figure 3-9). Ad-hoc mooring structures were observed along the creek, that were inundated at high tide (Figure 3-10).

It is considered that the causes of erosion observed here are vehicle access to the foreshore, and for Tullarwalla Inlet, undercutting of the banks by vessel wash or tidal flows when the water levels are high.

Figure 3-7 – Area at Tullarwalla Lagoon where foreshore vegetation has been cleared and vehicles access the foreshore (17 June 2022). Site reference TW01

Figure 3-8 – Area along northern lagoon foreshore where evidence of minor ongoing erosion, direct vehicle access to the foreshore is controlled by fencing. Site reference TW02.

Figure 3-9 – Undercutting of banks within Tullarwalla Inlet leading to loss of mature casuarinas (17 June 2022). Site reference TW03.

Figure 3-10 – Ad-hoc jetty along Tullarwalla Inlet, inundated at high tide (17 June 2022). Site reference TW03.

3.4.3 Environmental, Cultural, Infrastructure and Amenity Impact

The Tullarwalla Lagoon is of immense significance to the local Jerrinja people, [redacted] an AHIMS database search in February 2022 in the vicinity of the lagoon. These sites are along the western edge of the lagoon which was not assessed as being subject to erosion at present.

While erosion within the lagoon appears to be low, there may be an impact to water quality from additional sedimentation in the areas where direct vehicle access to the foreshore occurs. The continual undercutting of the banks of the Inlet may be a natural process to some degree, but may be exacerbated by vessel wash, as this area of the waterway is not subject to a speed limit (despite wake-boarding and towing of persons being prohibited in the waterway).

3.4.4 Potential Management Action from Decision Support Tool

The Decision Support tool suggested Fencing as the key erosion control method at the southern foreshore, to control direct access to the lagoon foreshore by vehicles. This control has been applied successfully on the northern foreshore of the lagoon (Figure 3-8).

No action is suggested for Tullarwalla Inlet, other than management controls, which could include limiting vessel speeds to 4 knots within the Inlet.

3.5 Basin View

Areas of moderate erosion were observed at Basin View, in particular at the foreshore west of the Basin View boat ramp and at the end of Mathie Street (Figure 3-11). The bank sections inspected in this area are denoted in Figure 3-11 as bank sections BV01, BV02 and BV03. Areas to the east of Basin View around Tallyan Point were inspected from the water on 17 June 2022, with low erosion observed around the Point. The outcomes of the field assessment for this site are outlined below.

3.5.1 Characteristics of site

The foreshore at Basin View is located along the north-western foreshore of St Georges Basin, and is moderately exposed to wave energy generated by southerly-southeasterly winds, with a 9 km long wind-fetch from the south-east. The foreshore was inspected on 28 November 2021, during a period of southerly winds (i.e. high wave exposure) and relatively high water levels within St Georges Basin. Along the foreshore on the western side of the boat ramp, areas where there was no riparian vegetation were actively eroding, and areas where foreshore vegetation was present were subject to undercutting and were also eroding, but at a slower rate. The site is backed by a public reserve, with shallow water depths in front of the banks and no erosion protection works installed.

At Mathie Street, moderate erosion was observed at the foot of the bank, which was partially protected by a rock revetment. Strewn building rubble has been placed on the upper section of the bank in an attempt to protect it (Figure 3-13).

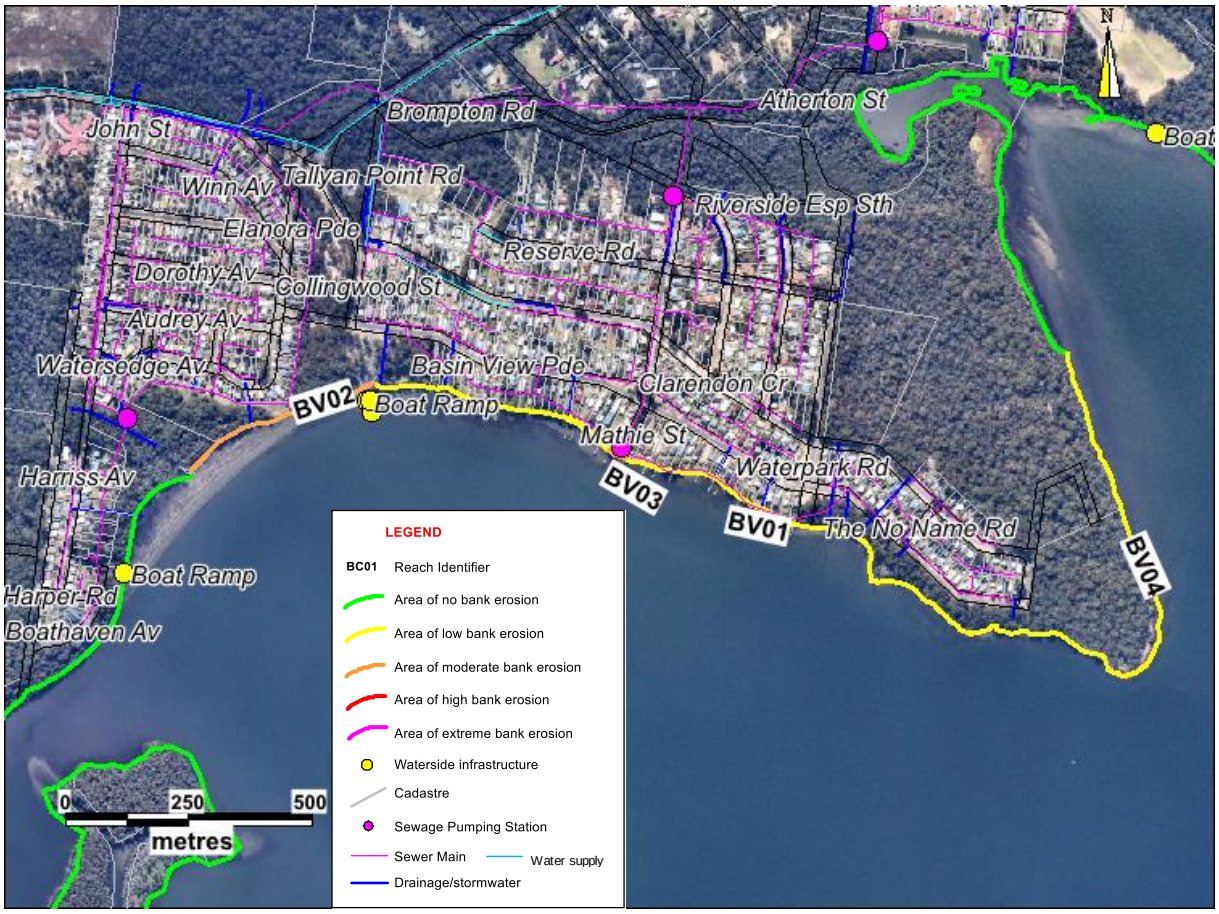


Figure 3-11 – Mapped foreshore erosion at Basin View

On the western side of Tallyan Point, areas of minor erosion were observed along the upper banks of the foreshore as indicated in Figure 3-14. This erosion is considered to be the result of localised clearing of vegetation from the upper banks, resulting in erosion caused by rainfall/runoff over the steep clay slopes. On the eastern side, minor undercutting of foreshore vegetation was observed, possibly caused by wind waves at high water levels or vessel wash (Figure 3-14).

Figure 3-12 – Basin View foreshore looking west from boat ramp. Note lack of riparian vegetation and undercutting of casuarinas in the background (28 November 2021). Site reference BV02.

Figure 3-13 – Basin View – Mathie Street foreshore. Top – building rubble at top of bank; bottom – rock revetment protecting foreshore infrastructure. Site reference BV03. (28 November 2021)

Figure 3-14 – Observed erosion at Tallyan Point. Top – western side of Point, erosion of slope due to clearing of vegetation. Bottom – undercutting of riparian vegetation. Site reference BV04. (17 June 2022)

3.5.2 Causes of erosion

Causes of erosion at Basin View west of the boat ramp were assessed to include the following:

- wind waves, generated by southerly and southeasterly winds, and
- vessel waves generated by traffic from the nearby boat ramp.

The lack of riparian vegetation at the site may be contributing to the erosion. Sections of the foreshore appear to have been reclaimed with topsoil or other fill, which is not as stable or resistant to erosion as the natural foreshores.

At the Mathie Street foreshore, erosion of the upper section of the bank may be a result of stormwater runoff from the paved Mathie Street access directly behind the site, with some minor erosion at the toe of the bank caused by wind waves.

At Tallyan Point, causes of erosion were assessed to be localised clearing of vegetation on the western side of the Point, and undercutting of foreshore vegetation on the eastern side caused by wind waves or vessel wash at high water levels.

3.5.3 Environmental, Cultural, Infrastructure and Amenity Impact

The foreshore erosion in the area west of the boat ramp has a moderate impact on foreshore amenity and safety in this area, with public access to the foreshore over the steep embankment difficult. There is an environmental impact of the erosion also, with erosion contributing to poor water quality at the site, and undermining of established riparian vegetation. A sewer main is located approximately 20 m landward of the eroded bank, but is not considered to be at threat from the erosion.

At Mathie Street, the presence of building rubble is considered to be a safety hazard and is having a negative impact on foreshore amenity.

A review of the Aboriginal Heritage Information Management System (AHIMS) in February 2022 revealed no registered aboriginal sites or places along this section of foreshore, although it is likely that undocumented sites exist.

3.5.4 Potential Management Action from Decision Support Tool

The DST suggested the establishment of a cobble beach to protect the bank in the area near the boat ramp. Cobble beaches use rock in the form of cobblestones for bank protection against moderate to high waves (Hydrosphere Consulting, 2020). The cobbles dissipate wave energy and are suitable for situations with low tidal range (<300mm), shallow depths, and where the cause of the erosion is wind waves or vessel waves (i.e. typical of the foreshores along the northern side of St Georges Basin). They also allow continued public access to the foreshore, and provide for a riparian zone for the planting of saltmarsh and fringing vegetation.

The suggested technique is illustrated in Figure 3-15 and summarised in Appendix D, with an example of its application at Lake Macquarie in Figure 3-16. Establishment of a crest at the top of the slope may help prevent undermining of the slope due to wave overtopping.

In conjunction with this technique, the DST suggested establishment of riparian vegetation.

At Mathie Street, maintenance of the existing rock revetment protection works, management controls for stormwater runoff from the upper portion of the slope and removal of the building rubble is suggested, in addition to the installation of a cobble beach at the toe of the slope.

For Tallyan Point, no action was suggested by the DST, other than management controls.

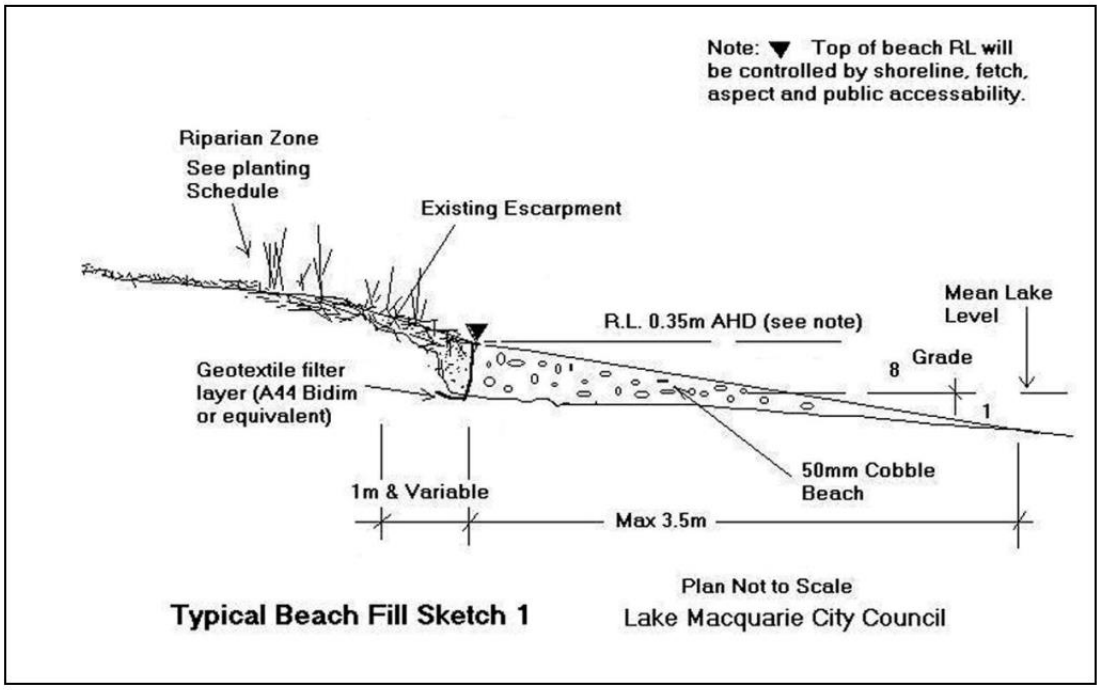


Figure 3-15 – Typical application of cobble beaches suggested to address erosion at Basin View (Walpole et al, 2009)

Figure 3-16 – Example application of cobble beach, Lake Macquarie NSW. Left – prior to treatment, right – post treatment (Walpole et al 2009).

3.6 Blackett Reserve and Pelican Point

Areas of erosion were observed at the west-facing foreshore at Blackett Reserve. While this erosion was mainly assessed in the field as being of low severity, it was assessed as having a moderate environmental impact with several large trees and at least one mangrove being undermined. (Figure 3-18). The outcomes of the field assessment for this site are outlined below.

3.6.1 Characteristics of site

The foreshore at Blackett Reserve is located along the northern foreshore of St Georges Basin in an area facing west, with a fetch distance of up to 4 km towards the southwest across the Basin. Parts of the site are backed by private residences, with a variety of water access infrastructure installed and some residences with foreshore erosion protection structures installed. Blackett Reserve backs the site north from Rauch Close and encompassing the frontage at the Aloha Caravan Park to Kevin Crescent. West from Kevin Crescent, the only public access point on this foreshore is at The Basin Road (refer Figure 3-21), where there is a boat ramp and public jetty. Water depths in front of the banks are shallow, but short sections of foreshore erosion protection works exist at a number of locations including at Blackett Reserve (Figure 3-19) and at the jetty at the Aloha Caravan Park (Figure 3-21). Minor erosion protection works comprising rock fillets have been installed at The Basin Road jetty site also (Figure 3-22). A critical wastewater main passes along the foreshore within the actively eroding area at Blackett Park (Figure 3-20).

West of this area, foreshores around Pelican Point and Home Bay were observed from the water on 17 June 2022 during site inspection. This area was not observed to be experiencing significant erosion, although minor erosion was observed in an area that had been cleared (Figure 3-23). The presence of ad-hoc navigation structures servicing the waterfront properties around Panorama Road was observed, though not contributing to any erosion (Figure 3-24).

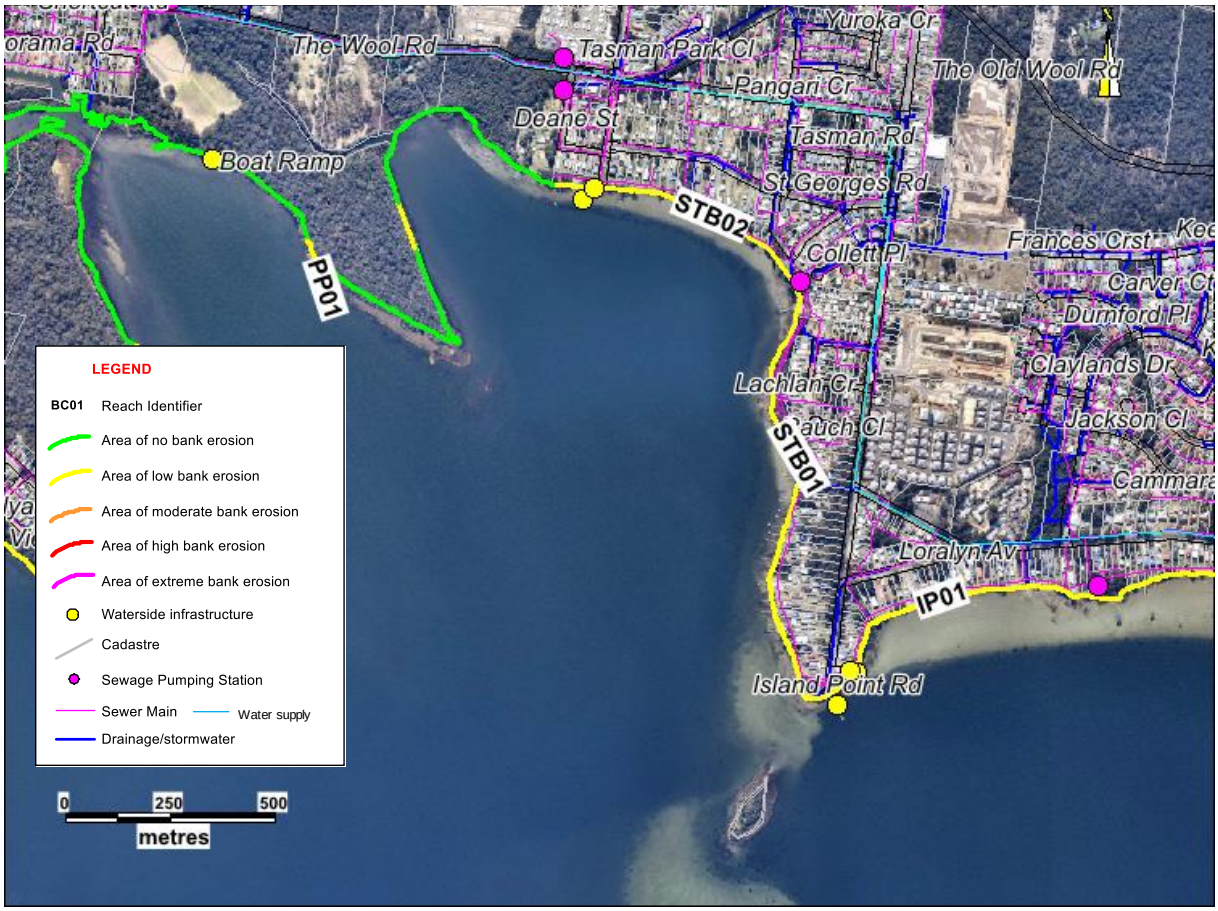


Figure 3-17 – Mapped foreshore erosion at St Georges Basin village, including Blackett Reserve and Pelican Point

Figure 3-18 – Blackett Reserve with mangrove and casuarinas left detached from the banks due to erosion (28 November 2021) Site reference STB01..

Figure 3-19 – Seating and concrete foreshore access area being undermined by erosion (Blackett Reserve, 28 November 2021). Site reference STB01.

Figure 3-20 – Blackett Reserve showing active erosion and sewer infrastructure in the erosion zone (28 November 2021). Site reference STB01.

Figure 3-21 – Aloha Caravan Park frontage showing foreshore erosion protection works, jetty and beach area in background. A litter boom is installed in front of a stormwater outlet in the area circled in the image (28 November 2021). Site reference STB01.

Figure 3-22 – Minor rock works installed at The Basin Road foreshore public access area (28 November 2021). Site reference STB02.

Figure 3-23 – Minor erosion observed at Pelican Point, 17 June 2022. Site reference PP01.

Figure 3-24 – Ad-hoc navigation aid installed at Home Bay near Panorama Road (17 June 2022). Site reference PP01.

3.6.2 Causes of erosion

Causes of erosion at Blackett Reserve were assessed to include the following:

- wind waves from southerly and south-westerly winds across the Basin, particularly when water levels within the Basin are high
- lack of stabilising foreshore vegetation to hold the banks together.

3.6.3 Environmental, Cultural, Infrastructure and Amenity Impact

The foreshore erosion in the Blackett Reserve area has a medium environmental impact, with established trees and mangroves on the foreshore that are in danger of being undermined. A wastewater pressure main and access point is located within the active erosion area and is considered to be at threat should the erosion continue to progress.

A review of the Aboriginal Heritage Information Management System (AHIMS) in February 2022 [redacted], but the locations of these do not appear to be in the areas that were observed in the field to be actively eroding. Non-aboriginal heritage items exist in the area, including the World War II Flying Boat Base at Island Point Road, and a former boarding house and St Georges Basin Post Office at Deane Street, although neither of these is considered to be at threat from foreshore erosion.

3.6.4 Potential Management Action from Decision Support Tool

The DST suggested the establishment of a cobble beach to protect the bank for the eroding sections along the Blackett Reserve foreshore. The establishment of the cobble beach would dissipate wave energy and provide protection to the root zones of the established trees at the site (refer Appendix D).

Management controls, e.g. the establishment of no-mow zones, have shown some success at other sites (e.g. at Paradise Beach) and there is an opportunity to introduce these controls in areas where established foreshore vegetation is being undermined (e.g. at the location in Figure 3-18).

3.7 Macleans Point and Paradise Beach

Areas of moderate erosion were observed along the south-facing foreshore at Macleans Point, in particular along the foreshore west of Palm Beach (site MP01, Figure 3-25). The south-facing foreshores at Loralyn Avenue and Walmer Avenue at Paradise Beach (site LAW01) are also undergoing moderate levels of bank erosion. The outcomes of the field assessment for this site are outlined below.

3.7.1 Characteristics of site

The foreshore at Macleans Point and at Walmer Avenue faces south across St Georges Basin in an area exposed to a southerly fetch distance of 4 km across the Basin. The site is backed by The Basin Track, a newly-upgraded foreshore walking track that connects Sanctuary Point in the east with Island Point in the west. At Macleans Point, the foreshore is backed by a riparian zone comprising mainly casuarinas, with residences located on higher ground some distance landward of the riparian zone. At Loralyn Avenue and Walmer Avenue, the foreshore is backed by a public reserve, with some areas having been established as "no-mow" riparian zones and some areas being devoid of riparian vegetation. Water depths in front of the banks are shallow and no erosion protection works are installed along either of these frontages. Wastewater infrastructure is located close to the erosion zone at Macleans Point as can be seen in Figure 3-26.

Erosion is not uniform along this foreshore, with areas designated as "no mow zones" where riparian vegetation is intact generally faring better than the areas where there is no riparian vegetation making the banks more exposed to wave energy.

Figure 3-25 – Mapped foreshore erosion at Macleans Point and adjacent to Loralyn Avenue, Sanctuary Point

Figure 3-26 – Macleans Point foreshore looking west (28 November 2021). Top – area of active bank erosion where established riparian vegetation has been undermined. Bottom – sewer infrastructure and Basin walking track within area subject to inundation. Site reference MP01.

3.7.2 Causes of erosion

Causes of erosion at Macleans Point, Loralyn Avenue and Walmer Avenue were assessed to include the following:

- wind waves from southerly winds across the Basin, particularly when water levels within the Basin are high
- destabilisation and undercutting of the banks due to the presence of weeds and damage to foreshore vegetation
- incorporation of unstable fill into the banks
- public access leading to trampling of vegetation by foot traffic, and dragging of small craft over the banks leading to destabilisation of the bank, as well as ad-hoc storage of private craft (Figure 3-27).

Figure 3-27 – Erosion at Loralyn Avenue. Note adhoc storage of kayaks on the foreshore (28 November 2021). Site reference LAW01.

3.7.3 Environmental, Cultural, Infrastructure and Amenity Impact

The foreshore erosion in this area has a moderate environmental impact, with some undermining of established trees on the foreshore. There is some wastewater infrastructure located within the erosion zone (Figure 3-26) and parts of the newly-upgraded Basin walking Track are considered to be at threat should the erosion continue to progress.

A review of the Aboriginal Heritage Information Management System (AHIMS) in February 2022 revealed no registered aboriginal sites or places along this section of foreshore, although it is likely that undocumented sites exist.

3.7.4 Potential Management Action from Decision Support Tool

The DST suggested the establishment of a cobble beach to protect the banks and dissipate wave energy (refer Appendix D).

Riparian vegetation management is also suggested in conjunction with the use of cobble beaches in the more eroded areas where public access to the foreshore is required. Existing erosion protection measures have been implemented in some areas along this foreshore and have had some success, as shown in Figure 3-29 (rock fillets to protect root zones of mangroves and casuarinas) and Figure 3-30 (no-mow zones to establish saltmarsh and riparian vegetation). Seagrass wrack also provides a role in breaking up wave energy and preventing erosion in areas where public access is not required (refer Figure 3-28). Note that in the areas where public access is not required, the use of fallen trees to dissipate wave energy reaching the bank may be more appropriate than the use of a cobble beach.

Figure 3-28 – Seagrass wrack helping to break up wave energy and protect banks from erosion (Macleans Point, 28 November 2021). Site reference MP01.

Figure 3-29 – Use of rock fillets to protect casuarina roots from undermining and provide erosion protection to Basin Track (northern end of Macleans Point, 28 November 2021). Site reference MP02.

Figure 3-30 – No-mow zones to control bank erosion. Top – No-mow zone at Walmer Avenue – note effectiveness compared to adjacent area outside zone. Bottom – no-mow area and educational signage at Paradise Beach (28 November 2021). Site reference PB02.

3.8 Sanctuary Point and John Williams Reserve shoreline

The St Georges Basin Estuary Management Plan (2013) identified monitoring and further investigation of erosion at Sanctuary Point, and the establishment of sand nourishment and a rock/geotextile groyne at the southern end of the John Williams Reserve shorelines.

Advisian inspected these areas in November 2021, and identified that the Sanctuary Point shoreline north of the boat ramp has fared relatively well with respect to foreshore erosion, with healthy riparian vegetation and no significant erosion observed in this area (Figure 3-31).

For the area south of the boat ramp (John Williams Reserve), the groynes appear to have been successful in preventing further erosion of the shoreline, and appear to create a sheltered zone in their lee which breaks up wave energy prior to reaching the shoreline as well as providing intertidal habitat (Figure 3-32).

It is suggested that these measures continue to be monitored, however, to date they appear to have been successful for these locations.

Figure 3-31 – Sanctuary Point foreshore, south of boat ramp. Note gentle slope, well-established foreshore vegetation and no-mow zone (28 November 2021). Site reference SP01.

Figure 3-32 – Foreshore at John Williams Reserve. Note sheltered area provided in lee of groyne (top). Groyne is semi-submerged to provide intertidal habitat (bottom). (28 November 2021). Site reference SP01.

3.9 Old Erowal Bay (Prentice Avenue)

Areas of moderate erosion were observed at Old Erowal Bay, in particular at the foreshore adjacent to Prentice Avenue reserve (Figure 3-33) at the bank section denoted as OEB01. The outcomes of the field assessment for this site are outlined below.

3.9.1 Characteristics of site

The foreshore at Old Erowal Bay is located along the northern foreshore of St Georges Basin, within a section of Erowal Bay cut off from the main area of St Georges Basin. The site is backed by a public reserve, with shallow water depths in front of the banks and no erosion protection works installed. The site is assessed to be suffering from moderate foreshore erosion.

Figure 3-33 – Mapped foreshore erosion at Old Erowal Bay (Prentice Avenue Reserve)

Figure 3-34 – Old Erowal Bay foreshore. Top – at Prentice Avenue Reserve, bottom - looking east along foreshore from reserve area. Note undercutting of casuarinas leaving them vulnerable to toppling and loss of root ball leading to soil loss from the bank (28 November 2021). Site reference OEB01.

3.9.2 Causes of erosion

Causes of erosion at Old Erowal Bay were assessed to include the following:

- southerly winds leading to toppling of established vegetation, causing loss of stabilising roots from bank. This occurred where large casuarina trees at the edge of the bank were being undermined by erosion, and where there was a lack of a well-established riparian zone with a mix of different vegetation types to hold the banks together.
- undercutting of banks from wind waves at high water levels.
- minor scarping in areas devoid of riparian vegetation.

3.9.3 Environmental, Cultural, Infrastructure and Amenity Impact

The foreshore erosion in the area west of the boat ramp has a moderate environmental impact due to undermining of established riparian vegetation. A wastewater pressure main is located immediately landward of the eroded bank and may become at threat should the erosion continue to progress.

A review of the Aboriginal Heritage Information Management System (AHIMS) in February 2022 revealed the presence of [redacted], which is experiencing moderate bank erosion. The sites at Old Erowal Bay are said to be open archaeological campsites (Shoalhaven City Council, 2013).

3.9.4 Potential Management Action from Decision Support Tool

The DST suggested the establishment of a cobble beach to protect the bank and root zones of the casuarinas in this area (refer Appendix D). While cobbles may be an appropriate method where public access to the foreshore is desired, it may be more practical to simply establish foreshore vegetation in areas where direct foreshore access may not be necessary.

Establishment of shallow-rooted riparian vegetation such as saltmarsh in the shallow intertidal areas in front of the bank, together with the establishment of a no-mow zone, would also be likely to be successful. An example where this technique has been successful in a nearby area with similar foreshore characteristics is shown in Figure 3-35. For the areas backed by casuarina woodland rather than grass reserves, establishment of deeper-rooted fringing estuarine vegetation such as mangroves may also prove successful in dissipating wave energy and act as a wind break to protect the casuarinas from being undermined and toppled by strong winds. The use of logs or placement of large woody debris at these sites would assist in enabling the estuarine vegetation to become established by providing some protection against wave energy and a more conducive environment for sedimentation rather than erosion to take place within this zone. The effects of mangroves in the nearshore in protecting the foreshore from undermining can be seen in Figure 3-35.

Figure 3-35 – Riparian vegetation protecting banks from undercutting and wind erosion. Note establishment of saltmarsh in now-mow zone in front of reserve, and established mangroves fronting casuarinas providing protection from foreshore erosion (Sanctuary Point, 28 November 2021). Site reference SP01.

3.10 Erowal Bay (Wharf Road)

Areas of moderate erosion were observed at Erowal Bay, in particular along the foreshore east of the boat ramp (Figure 3-36) in the section of bank denoted as EB01. The outcomes of the field assessment for this site are outlined below.

3.10.1 Characteristics of site

The foreshore at Erowal Bay is located along the northern foreshore of St Georges Basin in an area exposed to a southerly fetch distance of 6 km across the Basin. The site is backed by private residences, with a variety of foreshore erosion protection works and water access infrastructure installed. The only public access point on this foreshore is at Wharf Road (refer Figure 3-37). Water depths in front of the banks are shallow and no erosion protection works are installed at the Wharf Road reserve. A critical wastewater main passes along the foreshore within the actively eroding area. The site is assessed to be suffering from moderate foreshore erosion.

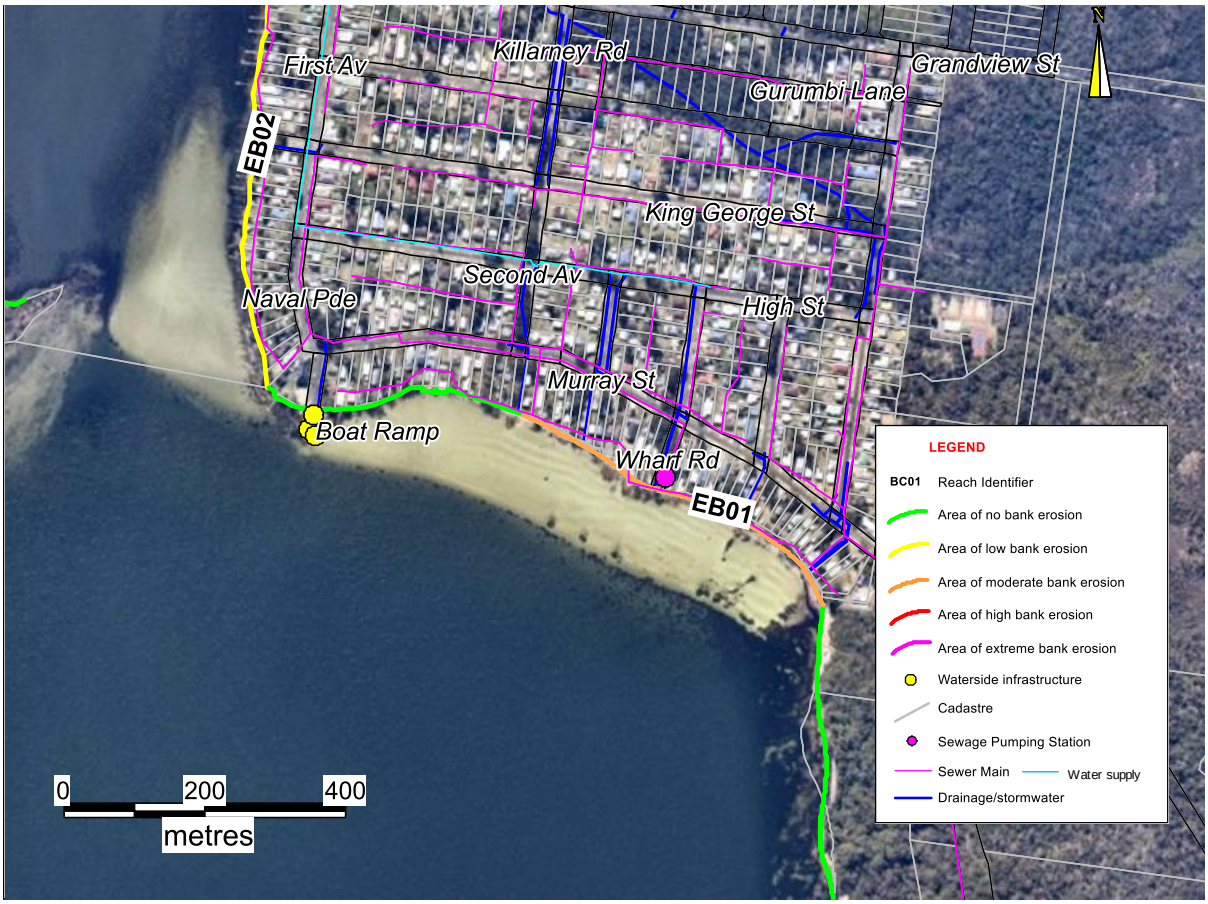


Figure 3-36 – Mapped foreshore erosion at Erowal Bay

Figure 3-37 – Erowal Bay foreshore at Wharf Road (28 November 2021). Site reference EB01.

3.10.2 Causes of erosion

Causes of erosion at Erowal Bay were assessed to include the following:

- wind waves from southerly winds across the Basin, particularly when water levels within the Basin are high.
- some runoff from rainfall and stormwater at Wharf Road leading to overland erosion on the upper parts of the slope.
- edge effects of erosion due to the presence of adjacent hard foreshore protection structures.
- incorporation of unstable fill material into the bank which is not able to withstand the effects of erosion
- lack of riparian vegetation to hold the banks together and reduce the erosive impact of wind waves.

3.10.3 Environmental, Cultural, Infrastructure and Amenity Impact

The foreshore erosion in this area has a low environmental impact, however there are established trees on the foreshore that are in danger of being undermined. A wastewater pressure main and access point is located within the active erosion area and is considered to be at threat should the erosion continue to progress.

A review of the Aboriginal Heritage Information Management System (AHIMS) in February 2022 revealed no known aboriginal sites or places along this section of foreshore, although it is possible

that undocumented sites may exist. Documented open camp sites occur further south at Wrights Beach and north along the foreshores of Erowal Bay and near The Wool Road at Old Erowal Bay.

3.10.4 Potential Management Action from Decision Support Tool

The DST suggested the establishment of a cobble beach to protect the bank at the Wharf Road foreshore (refer Appendix D).

Due to the presence of critical infrastructure in the erosion zone, the cobble beach could be combined with rock erosion protection for the sewer, as shown in the example in Figure 3-38. The elements of the protection would need to be designed to withstand the wave action expected at the site. An option may comprise the incorporation of a salt-marsh berm as per the Environmentally Friendly Seawalls Guide (NSW Office of Environment and Heritage, 2012) and use logs from fallen trees at the site to dissipate wave energy.

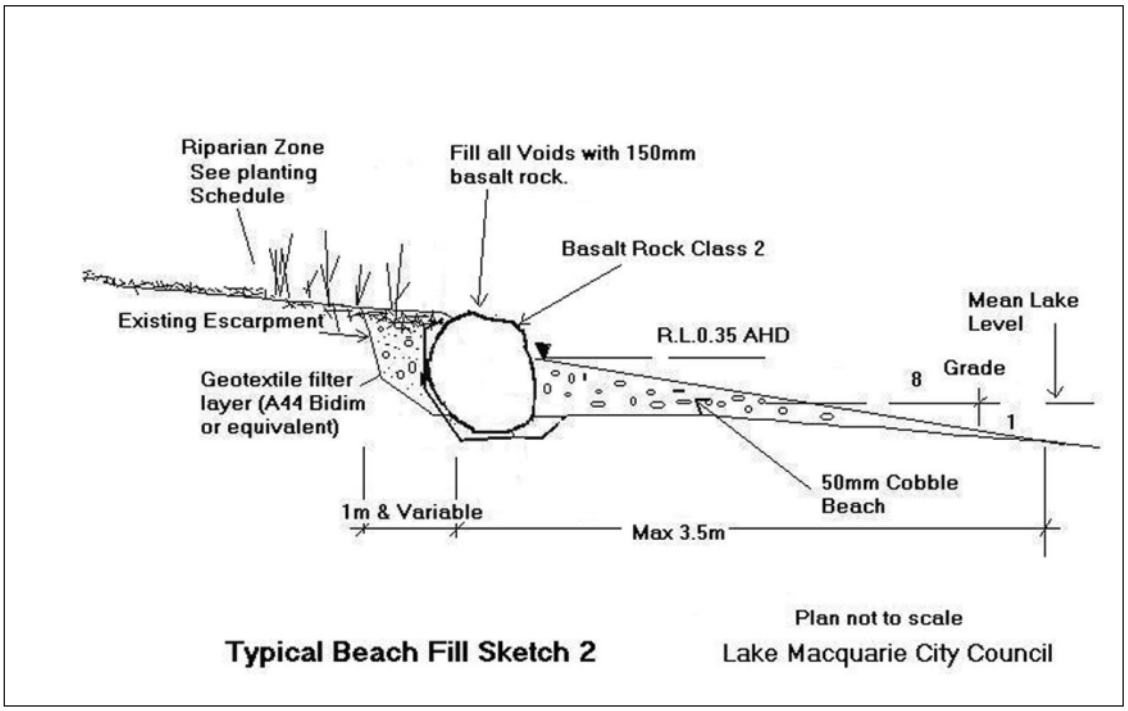


Figure 3-38 – Example of cobble beach combined with basalt rock protection for the sewer infrastructure (Lake Macquarie, NSW. Walpole et al. 2009)

4 Erosion Assessment - Sussex Inlet

4.1 Introduction

The St Georges Basin Revised Estuary Management Plan (2013) identified bank erosion at Sussex Inlet from three large unvegetated dune slip faces at Little Manly, The Haven and The Big Dipper (Big "S"), said to be natural areas of erosion caused by channel meander but exacerbated slightly by human activity (e.g. pedestrians trampling over the dunes, vessel wash).

Manly Hydraulics Laboratory (1997) provided the results of an investigation into the causes and remedial measures appropriate for addressing the unstable dune face adjacent to The Haven on the Sussex Inlet foreshores. Other dune instabilities occur along the channel margins and these were assessed also. A detailed assessment of the available historical information was undertaken, which found that the dune instabilities had been occurring for at least the last fifty years (prior to 1997).

MHL (1997) found that the unstable dune slopes occur where the channel intersects the landward face of old windblown dunes which have been revegetated. The back slope of these dunes is at the natural tipping angle for sand and they are inherently unstable. The present instability appears to be caused by constant removal of the toe of the dune at levels below the high water mark, as a result of wave and current processes operating within the channel. Wakes from boats within the channel would be contributing also. The unconsolidated dune face is not supported at the base which has resulted in the dune face readjusting to a new equilibrium slope and destabilising the surface vegetation. The report found that it is not possible to stabilise the dunes at the current slope, without incorporating protection of the toe of the dune at the waterline.

A range of options for addressing the stabilisation of erosion at The Haven, The Big Dipper and Little Manly were prepared and costed (MHL 1997). The suggested strategy for The Haven was to restrict access and undertake ongoing monitoring, as the erosion of the dune face did not appear to be having any major impacts on the estuary processes and the use of the estuary.

This report provides a detailed erosion assessment for the entire foreshore of Sussex Inlet, including numerous locations not documented in previous studies, which have been inspected and documented using the DST. The locations are presented in detail below, from downstream to upstream.

The results of the erosion assessments are documented for each location within each estuary on the proforma sheets in Appendix A, where significant erosion was observed.

4.2 Key locations where foreshore erosion has been observed

Key locations where significant erosion was identified are shown in Table 4-1, and mapped in detail in Figure 4-1. Each location was entered into the Decision Support Tool, with management actions suggested by the tool for some of these locations.

Table 4-1 – Key locations in Sussex Inlet where significant foreshore erosion was observed (red = "high", orange = "medium", yellow = "low", green = "negligible")

Bank segment ID	Erosion Severity	Environmental Impact	Infrastructure / commercial impact	Amenity / safety impact	Future Trajectory
S011 (Little Manly)	High	High	Low	Medium	Occurring and continuing
H01 (The Haven u/s)	High	Medium	Low	Medium	Occurring and continuing
H03 (Big S, Haven d/s)	High	Medium	Low	Medium	Occurring and continuing
S006 (u/s Christians Minde)	High	Medium	Negligible	Negligible	Occurring and continuing
S012 (Alamein)	Medium	High	Medium	Medium	Occurring and continuing
S004 (u/s Nielson L)	Medium	Medium	Low	Medium	Occurring and continuing
S010 (Chris Creek)	Medium	Medium	Low	Low	Occurring and continuing
H05 (Croppers)	Medium	Low	Low	Medium	Occurring and continuing
S005 (d/s Nielson L)	Medium	Low	Low	Low	Occurring and continuing
H02 (Haven central)	Low	Low	Low	Low	Not occurring but likely
H04 (Haven u/s croppers)	Low	Low	Low	Low	Occurring and continuing
S001 (Fairview Cres)	Low	Low	Low	Low	Occurring and continuing
S003 (Badgee d/s bridge)	Low	Low	Low	Low	Occurring and continuing
S008 (River Rd)	Low	Low	Low	Low	Occurring and continuing
S009 (island in Quays)	Low	Low	Low	Low	Not occurring but likely
S007 (RSL foreshore)	Low	Negligible	Low	Low	Not occurring not likely
S002 (Badgee Lagoon)	Low	Low	Negligible	Negligible	Occurring and continuing

The locations are described in detail below, together with the suggested management approach based on the outcome of the Decision Support Tool.

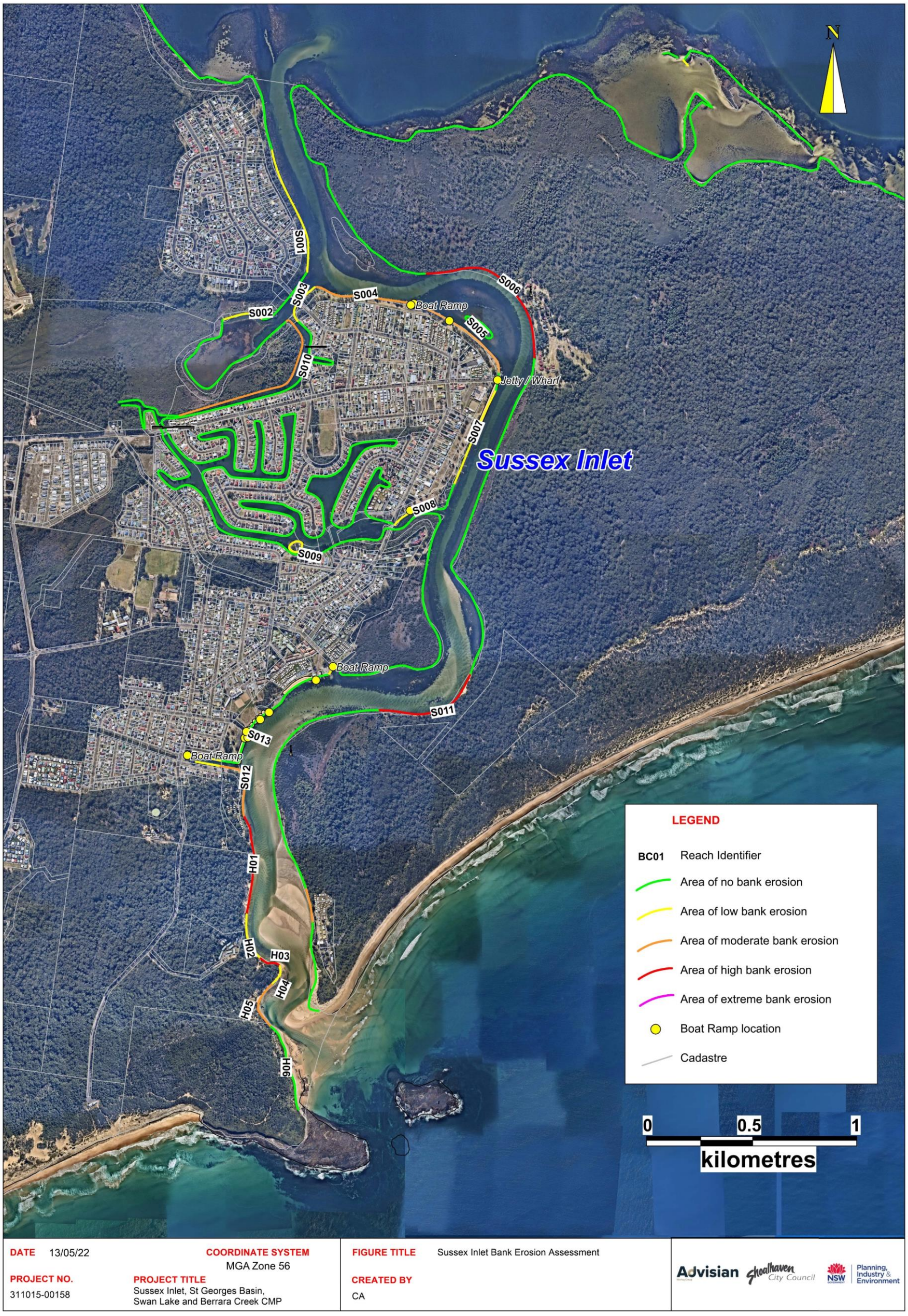


Figure 4-1 – Sussex Inlet Erosion Assessment Map

4.3 The "Big S" and Croppers Cabins

Slope instability due to erosion of the toe of a steep sandy slope was observed in this section of the estuary, with the erosion severity characterised as "Medium" at this location. The outcomes of the field assessment for this site are outlined below.

4.3.1 Characteristics of site

The site H05 is located on the outside of a bend at the entrance channel to Sussex Inlet, immediately upstream of the Croppers Cabins site. The site is backed by a steep, high coastal bluff/sand dune and has a timber toe protection retaining wall installed along part of its length. The timber wall has partially failed, due to pressure on the wall caused by the weight of fill behind the wall (Figure 4-5). The area where this erosion was observed is shown in Figure 4-6. The site is sometimes exposed to swell waves when the ocean tailwater levels are elevated and the entrance bar has been washed away by floods.

At Site H04, an old concrete seawall is present that may be contributing to erosion on its ends due to edge effects (Figure 4-3).

Figure 4-2 – Detail of H05 site at Croppers Cabins assessed as having erosion of moderate severity

4.3.2 Causes of erosion

Causes of erosion at the sites H04 and H05 were assessed to include:

- people accessing the dunes – including sand sliding
- vessel wash
- ocean waves eroding the toe of the existing slope
- slope instability due to the lack of stabilising vegetation and collapse of the slope due to toe scour
- meandering of the deepest section of channel toward this shoreline as a result of the growth of the flood tide delta on the opposite shore, fed by longshore sediment transport from Bherwerre Beach
- outflanking of the existing concrete seawall at site H04.

Figure 4-3 – Erosion at northern end of Croppers foreshore (H04), caused by edge effect from concrete seawall and the site exposure to ocean waves through the entrance (1 December 2021)

4.3.3 Environmental, Cultural, Infrastructure and Amenity Impact

There is limited infrastructure exposed to erosion at this site. However, there has been a loss of riparian vegetation due to erosion, and an impact on foreshore amenity and safety, particularly an impact on alongshore pedestrian access due to the presence of collapsed debris from the slope above.

A review of the Aboriginal Heritage Information Management System (AHIMS) in February 2022 [redacted], that may be at risk from foreshore erosion. While the exact nature of the site was not able to be observed during the

fieldwork for the erosion assessment, aboriginal cultural heritage within Booderee National Park which borders the eastern foreshore of St Georges Basin and Sussex Inlet includes shell middens and camp hearths plus oral history and cultural associations with the landscape (Director of National Parks, 2015).

The Conjola National Park Plan of Management (NPWS, 2009, p. 15) notes that "*A former Australian Railways Union (ARU) camp site is located on Farnham Headland at Sussex Inlet. This site dates back to the early 1900s. The ARU (now called the Public Transport Union) moved to its present site on the eastern side of the inlet about fifty years ago. Although there are no remains of the huts on Farnham Headland there are footings present and some interesting glass bottle retaining walls. The walls are deteriorating and present a public safety risk. There are also some exotic plants on the site. These will be assessed and either controlled or removed to prevent their spread*". NSW NPWS (2009) notes for historic heritage within the National Park including the ARU camp site that the remaining features be recorded, assess its significance and risk to public safety and take any necessary safety or conservation measures.

4.3.4 Potential Management Action from Decision Support Tool

The DST suggested the maintenance of existing controls for site H05, specifically the repair of the existing timber toe protection wall. This has proved successful in slowing erosion of the unstable slope but the failed sections of wall would need to be rebuilt, and some fill behind the wall removed if possible to reduce the pressure on the wall. As per The Haven, measures to stabilise the sections of unstable sandy slope above the banks in this area could also be considered.

A concept for reconstruction of this wall is provided in Figure 4-4. The details for this, including depth and sizing of footings are subject to detailed engineering assessment.

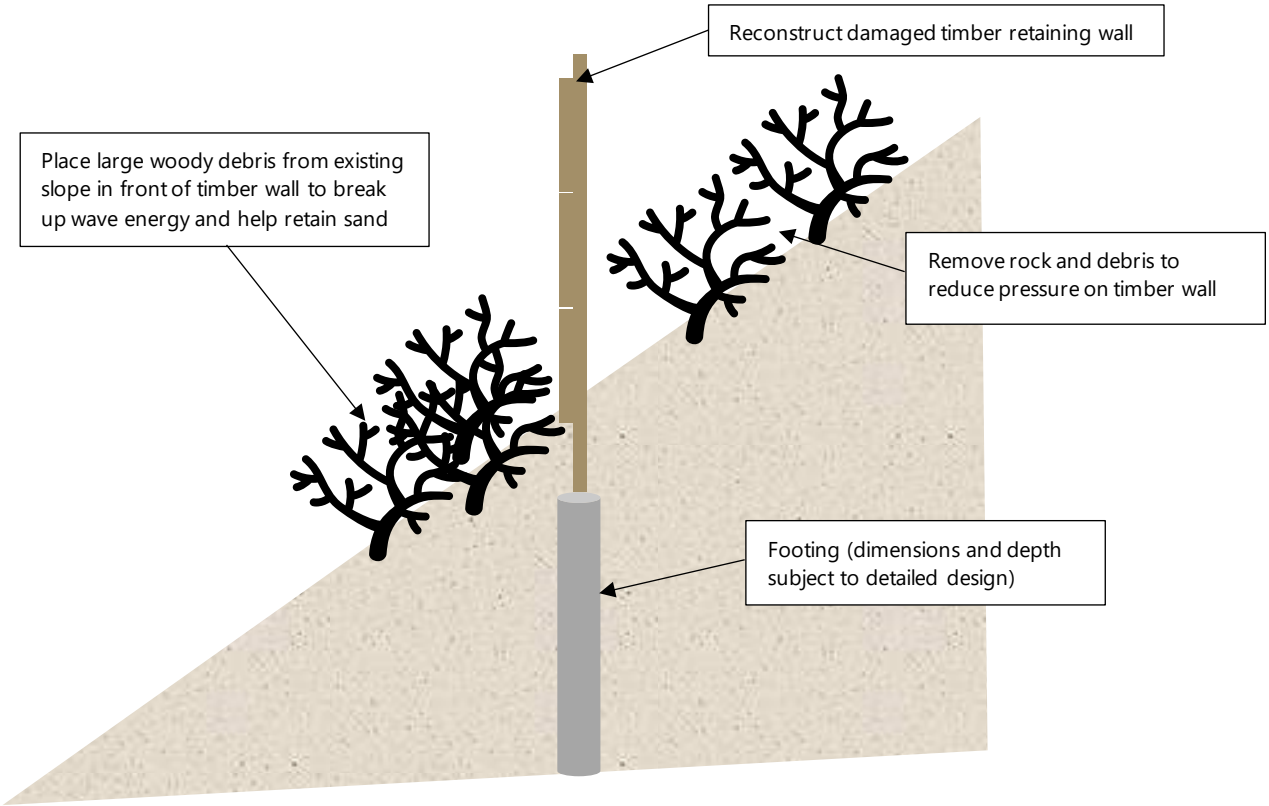


Figure 4-4 – Concept for repair of existing timber toe retaining wall

At Site H04, which is where the old concrete retaining wall is located, the DST suggested "do nothing" and management controls. It is considered that the existing concrete wall is ineffective in preventing erosion, and may be contributing to erosion on either end due to edge effects. However, the section of foreshore is subject to ocean swell waves through the entrance to Sussex Inlet at high tide, so removal of this wall is not suggested at this time as it may be providing some residual value in preventing collapse of the toe of the bank.

Figure 4-5 – Timber toe protection wall damaged due to overturning, caused by high earth pressures (detail on top) (1 December 2021). Site reference H05.

Figure 4-6 – Erosion at The Haven shoreline north from Croppers Cabins (1 December 2021). Site reference H05.

Figure 4-7 – Evidence of dune slumping caused by slope instability (1 December 2021). Site reference H05.

4.4 The Haven

Bank erosion was observed along the stretch of channel on the western bank in the lower estuary known as "The Haven" (Figure 4-10), with the erosion severity characterised as "High" along most of the foreshore at this location. The outcomes of the field assessment for this site are outlined below.

4.4.1 Characteristics of site

The Haven is a sandy area located along the outside of a bend in the lower estuary entrance channel at Sussex Inlet. The area forms a natural bay as a result of a local bend in the channel. It is backed by a steep, unstable high sand dune which is affected by slope instability. The central section of the bend was renourished in 2017 with sand dredged from shoals in other sections of the navigation channel, and a series of geotextile groynes were installed to hold this sand in place and prevent further migration of the navigation channel westward toward the unstable dune. While the groynes and nourished sand were in place in the central section of the bend and were successful in reducing erosion in this area (Figure 4-10), the northern and southern ends of the bend (i.e. upstream and downstream of the groyne field) were subject to high erosion due to slope instability and toe erosion of the sand slope caused by channel migration, river and tidal flows and vessel wash. The area where this erosion was observed is shown in Figure 4-8 as bank sections H01, H02 and H03.

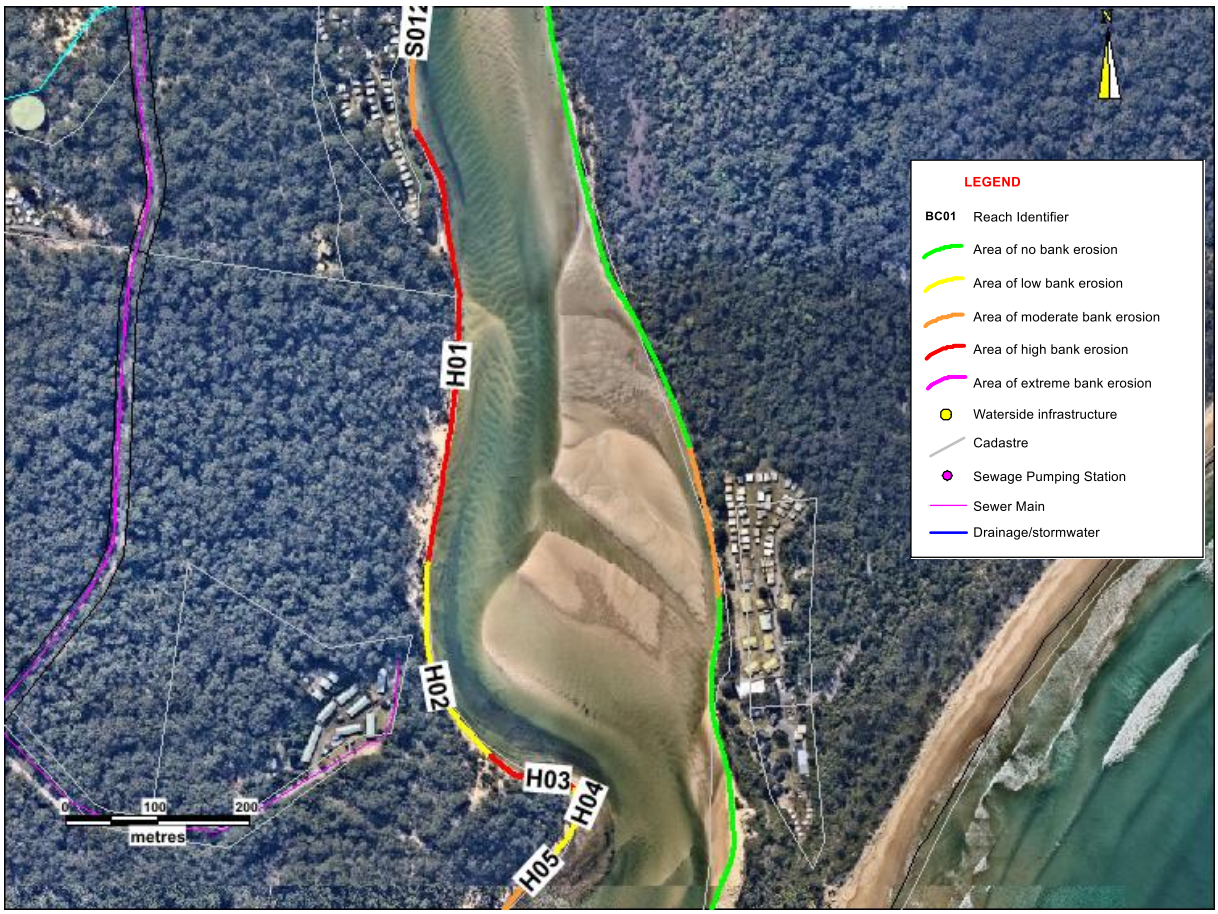


Figure 4-8 – Detail of H01 and H03 site at The Haven assessed as having erosion of high severity

4.4.2 Causes of erosion

Causes of erosion at this site were assessed to include:

- people accessing the dunes – including sand sliding

- erosion of the toe of the bank caused by vessel waves, as the site is exposed to boat wash from recreational and commercial vessels. Vessel waves cause erosion of the toe of the bank which becomes undermined and collapses into the navigation channel.
- river and tidal flow, as the high erosion site is located on the outside of a channel bend where there is erosive pressure under high tidal and river flows due to natural channel meandering
- slope instability and lack of stabilising vegetation on the exposed sand slope, caused by wind erosion, geotechnical instability and rainfall/runoff on the unvegetated dune

Figure 4-9 – Foreshore at The Haven, looking north (1 December 2021). Site reference H01.

Figure 4-10 – Foreshore at The Haven, looking south. Note use of geotextile groynes combined with sand nourishment undertaken in 2017 which has protected the toe of the slope from erosion, pushed the navigation channel away from the eroding slope and improved access and amenity (1 December 2021). Site reference H02.

4.4.3 Environmental, Cultural, Infrastructure and Amenity Impact

While there is limited infrastructure exposed to erosion at this site, there has been a loss of foreshore amenity at this popular recreation area due to difficult foreshore access as a result of the collapsed sand slope and debris, as well as damage to established foreshore vegetation. Sedimentation from the eroded sand slope has the potential to impact on seagrasses and to reduce the depth of the navigation channel.

A review of the Aboriginal Heritage Information Management System (AHIMS) in February 2022 revealed the presence of a known aboriginal site along the foreshore near The Haven, that may be at risk from foreshore erosion. While the exact nature of the site was not able to be observed during the fieldwork for the erosion assessment, aboriginal cultural heritage within Booderee National Park which borders the eastern foreshore of St Georges Basin and Sussex Inlet includes shell middens and camp hearths plus oral history and cultural associations with the landscape (Director of National Parks, 2015).

Figure 4-11 – The Haven, southern end, looking south. Note erosion occurring due to slope instability and wave action at the toe of the slope (1 December 2021). Site reference H03.

4.4.4 Potential Management Action from Decision Support Tool

The DST suggested the use of geotextile sand containers to protect the bank in this area. These could comprise a downstream and upstream extension of the geotextile groyne field already in place to further push the channel away from the toe of the slope and prevent further erosive pressure on the slope. This concept is illustrated in Figure 4-12.

In conjunction with the use of additional sand-filled geotextile containers, renourishment of the groyne field could be used to provide toe protection to the eroding slope with sand won from future maintenance dredging activities elsewhere in the navigation channel, or the use of large woody debris or brush matting sourced from collapsing vegetation at the site could be used to provide protection to the toe of the slope.

The existing sand slope is at its natural angle of repose, and previous attempts at slope stabilisation have met with limited success due to the steepness of the terrain. Without reducing the gradient of the slope, slope stabilisation would likely be difficult to achieve at this site. The use of dune fencing combined with brush matting and planting of dune vegetation in upper sections of the slope may allow vegetation to become established on the dune by creating terraced areas on the slope where the gradient is reduced and slope stability is improved.

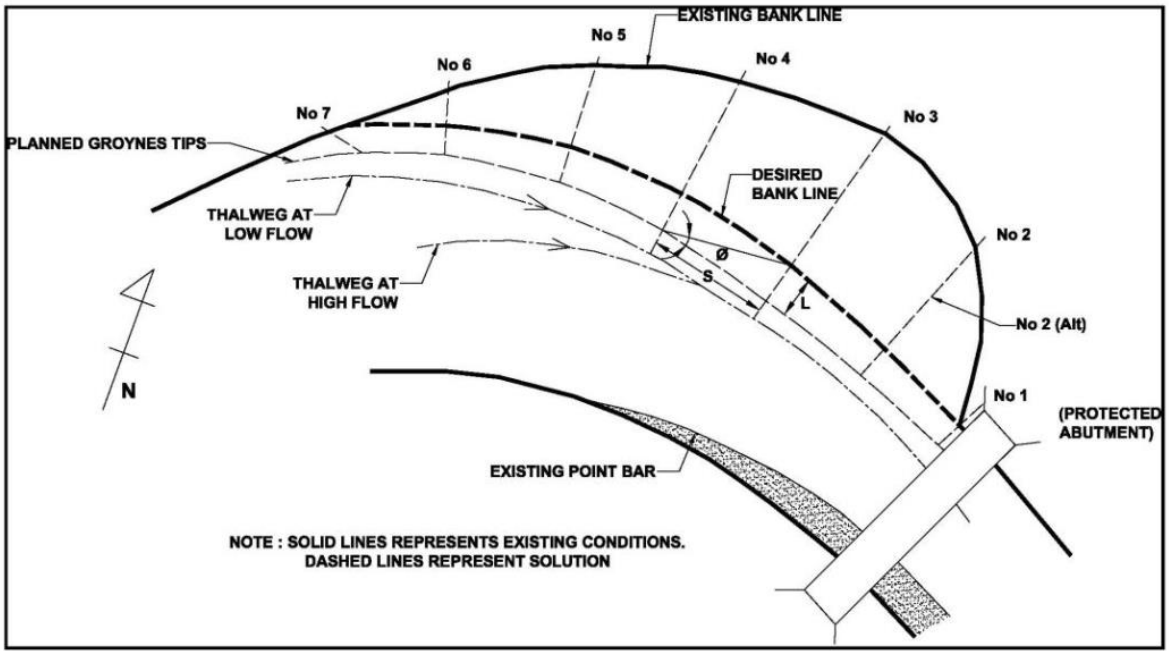


Figure 4-12 – Use of groynes to deflect flows away from the eroding bank on the outside of the bend (Lila et al 2009)

Figure 4-13 – The Haven, looking north. Note presence of seagrasses in the nearshore (1 December 2021). Site reference H03.

4.5 Alamein

Bank erosion was observed along the foreshore at Alamein, with the erosion severity characterised as "High" or "Moderate" at this location. The outcomes of the field assessment for this site are outlined below.

4.5.1 Characteristics of site

The foreshore at Alamein is backed by a holiday resort with cabins close to the foreshore, and a series of mooring structures and jetties along the foreshore. The foreshore is protected in some places by ad-hoc bank protection works or building rubble, but is undermined severely by erosion in other areas. The area where this erosion was observed is shown in Figure 4-14 as bank section S012.

Figure 4-14 – Detail of S012 site at Alamein caravan park assessed as having erosion of moderate - high severity

The main navigation channel is immediately adjacent to the site and a tributary discharges into the estuary along the northern side of the site.

4.5.2 Causes of erosion

Causes of erosion at this site were assessed to include:

- vessel waves, as the site is exposed to boat wash from recreational vessels

- river and tidal flow, as the navigation channel is located immediately adjacent to the site
- public access to the foreshore leading to trampling of the banks and impacts due to the presence of adhoc structures, which can cause erosion due to wave reflections and edge-effects
- lack of foreshore riparian vegetation.

Figure 4-15 – Top: Alamein foreshore at Sussex Inlet, looking north. Bottom: detail of eroded area showing undercutting of slope (1 December 2021). Site reference S012.

Figure 4-16 – Alamein foreshore looking south. Note adhoc mooring structures and building rubble on slope (1 December 2021). Site reference S012.

4.5.3 Environmental, Cultural, Infrastructure and Amenity Impact

The erosion at this site is having a significant impact on the environment, amenity and infrastructure (Figure 4-15). Safe access to the foreshore is limited by the presence of a steep erosion scarp and undermined collapsing trees, and foreshore infrastructure is considered to be under threat from the erosion.

A review of the Aboriginal Heritage Information Management System (AHIMS) in February 2022 revealed no registered aboriginal sites or places along this section of foreshore, although it is likely that undocumented sites exist.

4.5.4 Potential Management Action from Decision Support Tool

The DST suggested the use of geotextile containers to protect the bank in this area. These could be in the form of groynes similar to those at The Haven combined with beach nourishment or use of cobble beaches, or geotextile container bank protection to replace the adhoc protection works currently in place at the site. The measures could be combined with appropriate riparian vegetation that still allows foreshore access by park users. Sections of rock revetment or timber seawalls could be used in selected locations where the banks are undermined and infrastructure is at threat. A key consideration for this area is the need for any erosion protection works to allow for the provision of ongoing access to registered moorings along this foreshore.

4.6 Little Manly

Bank erosion was observed along the outside of a bend in the channel known as "Little Manly", with the erosion severity characterised as "High" at this location. The bank presents as a collapsing unstable dune face at this location, with erosion extending over approximately 400 m downstream of the exposed sand embankment. The outcomes of the field assessment for this site are outlined below.

4.6.1 Characteristics of site

Little Manly is an exposed sand bank on an outside bend of the main channel of Sussex Inlet. The area is backed by Booderee National Park and the eroding area extends over around 500 m, mostly encompassing the banks downstream of the exposed sand face. The site was inspected by boat on 7 December 2021. Foreshore erosion was observed during the site inspection, along the outside bend coinciding with the area where the deepest section of the navigation channel was close to the bank. The area where this erosion was observed is shown in Figure 4-17 as bank section S011.

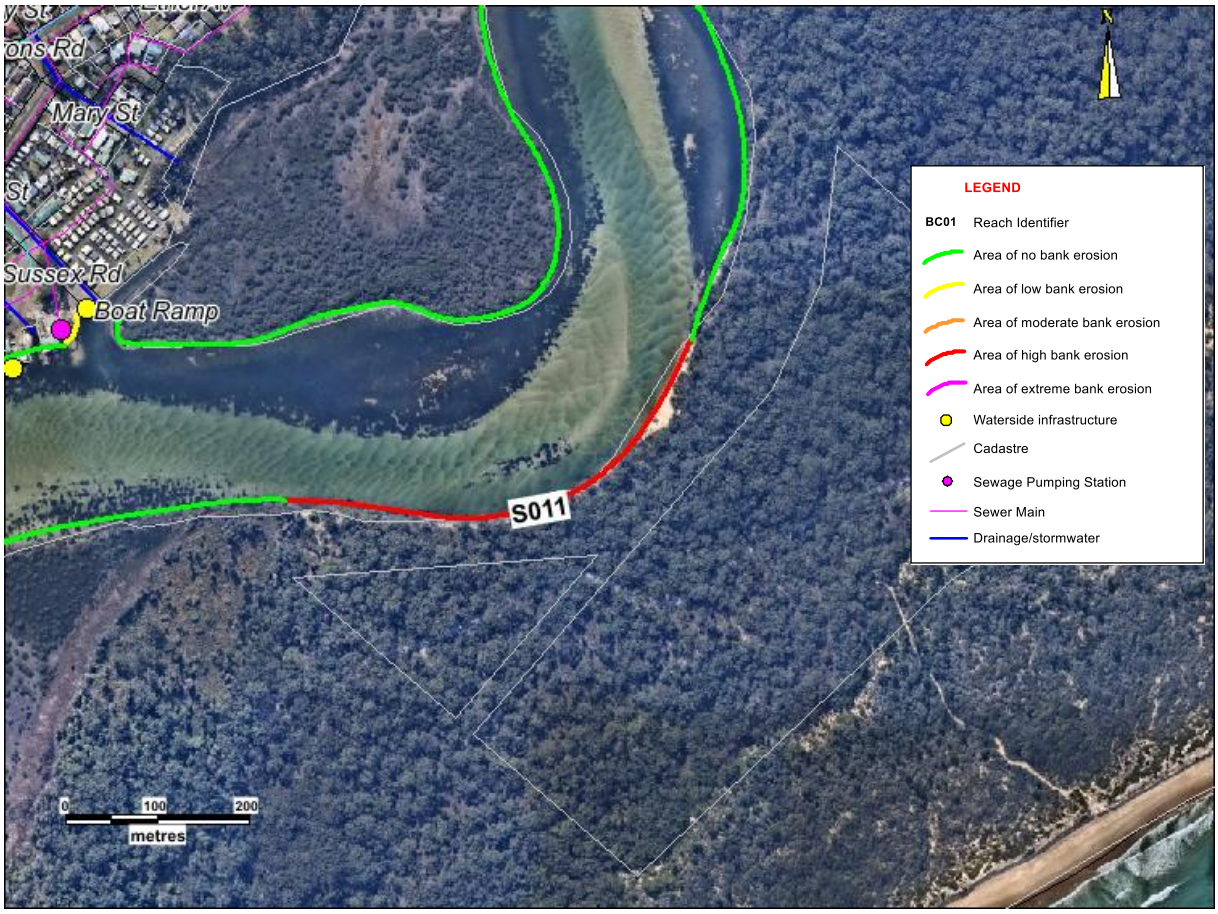


Figure 4-17 – Detail of S011 site at Little Manly assessed as having erosion of high severity

The area is characterised by an unstable, steep, exposed sand dune on the upstream side, and a sandy flat area downstream with a vertical erosion escarpment along the bank extending for some 500 m distance.

4.6.2 Causes of erosion

Causes of erosion at this site were assessed to include:

- vessel waves, as the site is exposed to boat wash from recreational vessels as the navigation channel is directly adjacent to the bank at this location. Vessel waves cause erosion of the toe of the bank which becomes undermined and collapses into the navigation channel.
- river and tidal flow, as the high erosion site is located on the outside of a channel bend where there is erosive pressure due to channel meandering.
- for the sandy dune area, the dune is a relict transgressive dune feature from Bherwerre Beach which is at its natural angle of repose and is too steep for establishment of dune vegetation. Further, the dune is used as a recreation area and is further destabilised by public access onto the dune (Figure 4-20).

4.6.3 Environmental, Cultural, Infrastructure and Amenity Impact

There is limited infrastructure exposed to erosion at this site. However, there has been a loss of riparian vegetation due to erosion, further exposing the banks, and sedimentation from the eroded banks has the potential to impact on seagrasses and cause shoaling of the navigation channel. The instability of the exposed sandy slope and risk of collapse can be a safety hazard for people using the slope for activities such as sandboarding.

A review of the Aboriginal Heritage Information Management System (AHIMS) in February 2022 [redacted], that may be at risk from foreshore erosion. Aboriginal cultural heritage has been previously identified elsewhere within Booderee National Park which borders the eastern foreshore of St Georges Basin and Sussex Inlet. This includes shell middens and camp hearths plus oral history and cultural associations with the landscape (Director of National Parks, 2015).

Figure 4-18 – Active slope instability at Little Manly from afar (top) and close up (bottom) (7 December 2021). Site reference S011.

Figure 4-19 – Active bank erosion downstream of Little Manly (7 December 2021) Site reference S011.

Figure 4-20 – Area at Little Manly is popular for recreation, unstable slope could be a safety hazard (7 December 2021). Note slope being used for sand-boarding. Site reference S011.

4.6.4 Potential Management Action from Decision Support Tool

The DST suggested the use of large woody debris to protect the bank in this area. The application of this management action is described in detail in the DST documentation (Hydrosphere Consulting 2020) and summarised in Appendix D. This would help prevent further migration of the channel toward the east and reduce the erosive pressure on the bank. An example of the application of this technique is shown in Appendix D, and the natural self-armouring of the bank in the same way is shown in Figure 4-21. In conjunction with the use of large woody debris along the outside of the bend, management controls to reduce the impact of boat wash and to prevent public access onto the unstable dune are suggested.

Figure 4-21 – Area at Little Manly where large woody debris is providing natural protection to the toe of the bank. Site reference S011 (7 December 2021).

4.7 Downstream from Nielson Lane

A medium level of bank erosion was observed downstream of the Nielson Lane boat ramp, although most of this foreshore was in good condition with only isolated areas suffering from erosion. The outcomes of the field assessment for this site are outlined below.

4.7.1 Characteristics of site

The site is in better condition than the area upstream of the boat ramp, and only limited mooring infrastructure is located in this area. The bank is located in the lee of an island in the channel and is relatively protected from vessel waves due to the cross-over of the main navigation channel to the eastern side of the river in this location. The area where this erosion was observed is shown in Figure 4-22 as bank section S005. Foreshore erosion protection works and a public jetty which appear to be in good condition are located at the southern end of this section of foreshore, at the end of Jacobs Drive adjacent to the Sussex Inlet Marine Centre. Isolated pockets of foreshore erosion occur where there is no riparian vegetation along the bank.

Figure 4-22 – Detail of S005 site between Nielson Lane and Sussex Marine Centre at Jacobs Drive assessed as having erosion of moderate severity

4.7.2 Causes of erosion

Causes of erosion at this site were assessed to include:

- vessel waves, as the site is exposed to boat wash from recreational vessels departing and arriving at the Neilson Lane boat ramp
- wind waves, as the channel is wide and parts of the foreshore are exposed to a relatively long wind fetch
- lack of foreshore riparian vegetation at individual locations and the presence of weeds along the bank are considered to be impacting on estuary bank stability.

Figure 4-23 – Undermining of trees and instability due to weeds, just east of Neilson boat ramp (27 November 2021). Site reference S005.

Figure 4-24 – Erosion at Sussex Inlet, just north of Sussex Marine Centre (27 November 2021). Site reference S005.

4.7.3 Environmental, Cultural, Infrastructure and Amenity Impact

There is limited infrastructure exposed to erosion at this site, apart from several private mooring jetties. The public reserve is exposed to erosion in some areas with a minor impact on foreshore amenity.

A review of the Aboriginal Heritage Information Management System (AHIMS) in February 2022 revealed no known aboriginal sites along this section of foreshore. However, the foreshore reserve is listed in the Shoalhaven LEP as a listed non-aboriginal heritage site, containing the former Kemp's boatshed. The site is shown in Figure 4-23.

Figure 4-25 – Area north of Sussex Marine Centre where good cover of riparian vegetation has been maintained, with minimal bank erosion (27 November 2021). Site reference S005.

4.7.4 Potential Management Action from Decision Support Tool

The DST suggested maintaining foreshore vegetation as a control for erosion in this area. The effectiveness of foreshore vegetation against bank erosion for this site is illustrated in Figure 4-24 and Figure 4-25. Some areas that have suffered from acute erosion (e.g. in Figure 4-23) may benefit from the inclusion of minor rock works or sand nourishment to fill in these sections.

4.8 Upstream from Nielson Lane

Bank erosion was observed along the section of foreshore upstream from Nielson Lane, with the erosion severity characterised as "Medium" at this location. Erosion was not continuous along the entire bank but some sections were more visibly impacted than others. The outcomes of the field assessment for this site are outlined below.

4.8.1 Characteristics of site

The foreshore upstream from the Nielson Lane boat ramp fronts the main urban area of Sussex Inlet and is backed by a reserve with numerous private mooring structures operated by the holiday resorts adjacent to the foreshore. Foreshore erosion protection structures installed along parts of this site include timber logs, rock revetments backed with geotextile, beach nourishment and rock fillets. Foreshore erosion at this site was identified by the participants at the CMP community workshops in March 2022. The area where this erosion was observed is shown in Figure 4-26 as bank section S004.

Figure 4-26 – Detail of S004 site at upstream from Nielson Lane boat ramp assessed as having erosion of moderate severity

4.8.2 Causes of erosion

A typical view of the foreshore at this location is shown in Figure 4-27. It can be seen that the foreshore here comprises a grass-covered sandy/fill embankment, with a vertical face to the waterway indicating undercutting of the bank at this location.

Foreshore erosion in this location is being caused primarily by the meandering and migration of the deepest section of the main tidal channel of Sussex Inlet. Further, the area is subject to boat wakes and wind waves as well as erosion due to the public accessing boats. As can be seen in Figure 4-28, the bed of the channel displays large sand waves attesting to significant sand transport under strong tidal velocities that are too high to allow for the establishment of seagrass. Significant bank erosion is

occurring on the outside of the channel bends. While the erosion is a relatively slow, natural process, it is of such a large scale that the *ad hoc* works of mini groynes, timber logs, geobags, tree planting, *etc.*, being done to protect the bank from erosion are entirely ineffectual.

Wind waves that can impact the site are limited by a fetch distance of approximately 500 m to the northwest, and a 400 m fetch to the northeast, which would limit extreme wave heights at the site to around 0.4 m, with a similar magnitude of waves generated by boat wakes from boating activity within the main channel of Sussex Inlet. These waves have sufficient energy to exacerbate the existing erosion occurring along sections of unprotected sandy foreshore near the site.

The foreshore upstream from the Nielson Lane boat ramp fronts the main urban area of Sussex Inlet and is backed by a public reserve with numerous private mooring structures operated by the holiday resorts adjacent to the foreshore. Foreshore erosion protection structures installed along parts of this foreshore include timber logs, rock revetments backed with geotextile, beach nourishment and rock fillets.

Foreshore erosion at this site was identified as a significant issue by the participants at the CMP community workshops in March 2022. The existing foreshore protection works are subject to undermining and overtopping. The existing structures are *ad-hoc* and have not been designed to address the underlying causes of the erosion. Further, the scale of the erosion process in this area is too large to be managed effectively using *ad-hoc* measures.

For this foreshore, it is desirable to maintain sufficient access to the waterway for the community while providing effective protection against bank erosion. A large scale strategy for managing this foreshore is needed, and would likely involve the design of a consistent measure or set of measures to deal effectively with the scale of erosion being experienced along this foreshore, boat access and environmental considerations.

Figure 4-27 – View of the foreshore looking east (27/11/2021). Site ref S004.

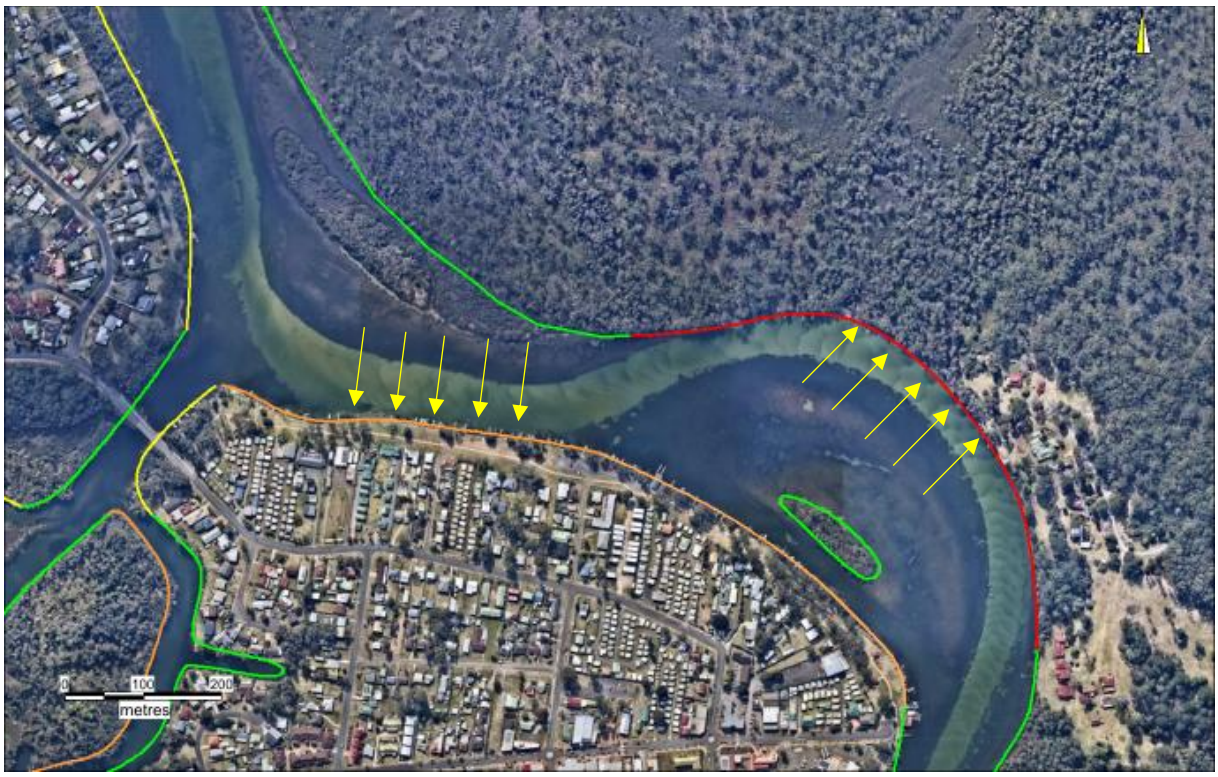


Figure 4-28 – Meandering of channel mechanism for foreshore erosion along the Sussex Inlet foreshore

In addition to the underlying main cause of erosion being tidal flows and channel meandering occurring at a large scale, the following processes are contributing to the erosion experienced at this site:

- vessel waves, as the site is exposed to boat wash from recreational vessels and is located immediately adjacent to the deepest section of the navigation channel.
- the use of unstable reclaimed fill within the bank, which is unsuitable for use as unprotected foreshore.
- lack of foreshore riparian vegetation,
- high levels of private vessel access leading to trampling of the banks and vegetation,
- storage of small private craft leading to trampling/destabilisation of the banks and foreshore vegetation
- numerous mooring structures are considered to be impacting on estuary bank stability, through dragging of vessels onto banks to access moorings and additional bank scour induced by currents and waves interacting with these structures (Figure 4-29 – Typical foreshore area upstream of Nielson Lane boat ramp, looking east. Note private mooring and vessel launching structures and failed geotextile bank protection (27 November 2021). Site reference S004.).

Figure 4-29 – Typical foreshore area upstream of Nielson Lane boat ramp, looking east. Note private mooring and vessel launching structures and failed geotextile bank protection (27 November 2021). Site reference S004.

Figure 4-30 – Foreshore protection works at Sussex Inlet, upstream of Nielson Lane boat ramp, looking west (27 November 2021). Site reference S004.

4.8.3 Environmental, Cultural, Infrastructure and Amenity Impact

The erosion at this site is considered to be having a moderate impact on the environment, amenity and safety at this location. The foreshore in this area is heavily used by the local community and provides access to the water servicing the nearby holiday accommodation. However, the long-term future impact of this erosion is likely to be substantial.

A review of the Aboriginal Heritage Information Management System (AHIMS) in February 2022 revealed no registered aboriginal sites along this section of foreshore. However, the foreshore reserve is listed in the Shoalhaven LEP as a non-aboriginal heritage site, containing the former Kemp's boatshed (which is located on the downstream side of the Nielson Lane boat ramp).

Figure 4-31 – Use of rock fillet/groyne at western end of foreshore, creating a foreshore access area and improving amenity (27 November 2021). Site reference S004.

4.8.4 Potential Management Action from Decision Support Tool

The DST suggested maintenance of the existing bank protection as the primary management action for this area of foreshore. Alternative management actions included the establishment of a cobble beach to protect the bank in this area (refer Appendix D). Other alternatives suggested by the DST for this site included geotextile sand containers, rock revetment or provision of a timber wall.

However, a cobble beach is likely not appropriate for this site, for the following reasons:

- The cobble beach at a 1 in 8 slope, if 0.5 to 1.0m high will extend 4 to 8m into the waterway. This would smoother seagrass and impact on navigation.
- A steeper sloping rock, geobag, or timber log wall might be more appropriate for this foreshore. A flatter cobble beach may lead to more overtopping, killing more grass in the lee.
- This area is a high-use recreation area valued by the community, with the grassy reserve interfacing with the waters' edge. It may be appropriate to assess trees that have been undermined to be considered for lopping to reduce the risk of them toppling over and taking the bank with them. New trees can be planted (e.g. casuarinas) at around 2 m back from the foreshore, together with low riparian vegetation along the immediate foreshore between defined access points and where there are existing trees that have been undermined.

As this site is likely to continue to experience erosion from channel meandering into the future at a large scale, smaller-scale management actions as identified in the DST would not be appropriate to mitigate the erosion that is likely to continue to be experienced at this site. A large-scale management strategy for this foreshore is required, recognising that foreshore erosion protection works will have a finite design life, due to the process causing the erosion. This would need to be the subject of a

detailed investigation, however it could comprise a series of shore-normal groynes such as those already in place at The Haven to further push the centreline of the channel away from the toe of the slope and prevent further erosive pressure on the bank. This concept is illustrated in Figure 4-12.

Alternatively, an environmentally friendly seawall design incorporating public access / boat access points and habitat features could be considered for this section of foreshore.

4.9 Christian's Minde

Bank erosion was observed along an outside bend of the main Sussex Inlet channel, adjacent to and upstream of the "Christian's Minde" estate on the eastern bank, with the erosion severity characterised as "High" at this location. The outcomes of the field assessment for this site are outlined below.

4.9.1 Characteristics of site

The site was inspected by boat on 7 December 2022. Foreshore erosion was observed during the site inspection, particularly along the bank upstream of the Christian's Minde estate, particularly where the navigation channel was immediately adjacent to the bank. The area where this erosion was observed is shown in Figure 4-32 as bank section S006.

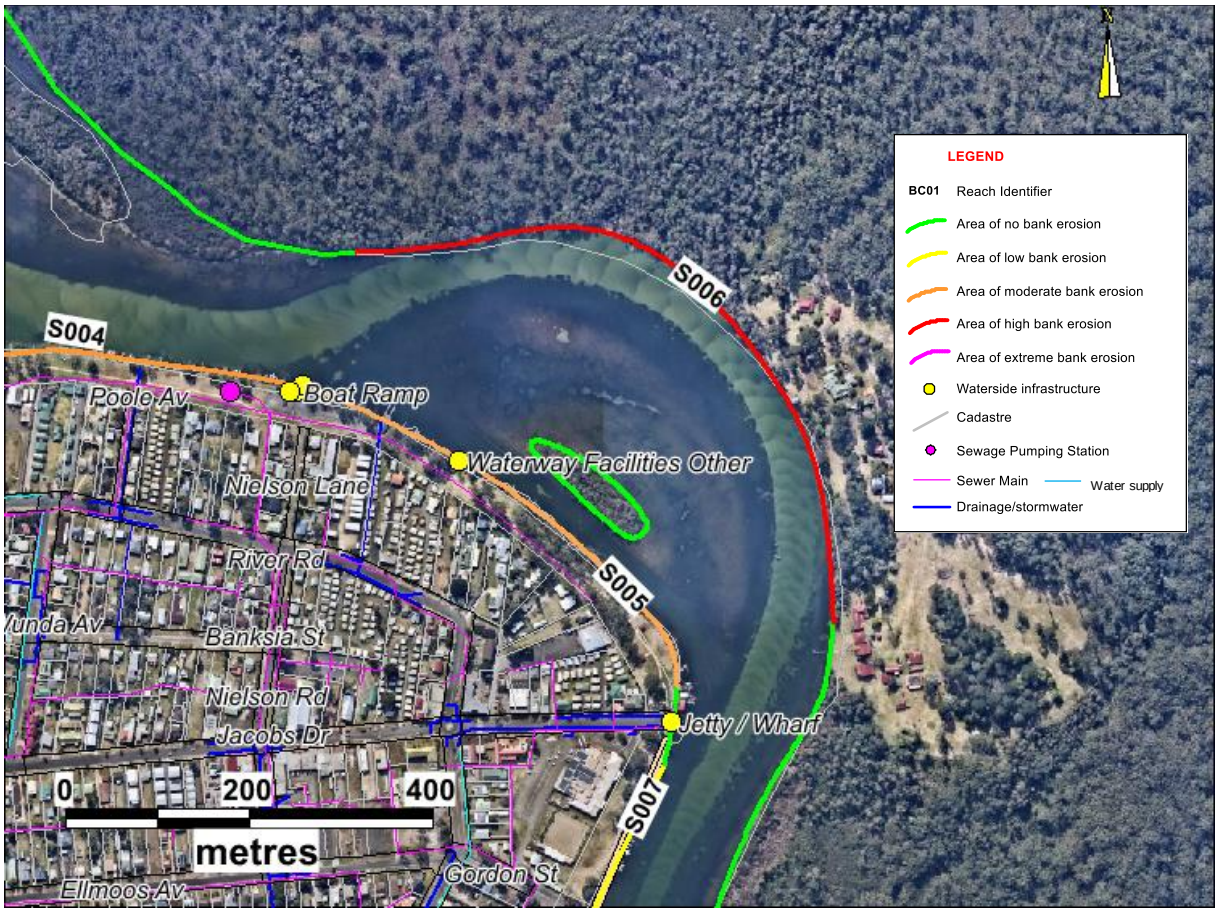


Figure 4-32 – Detail of S006 site at Christian's Minde assessed as having erosion of high severity

The area is characterised by a sandy flat area with a vertical erosion escarpment along the bank extending for some 500 m distance, coinciding with a sharp bend in the river and located immediately adjacent to the navigation channel. Erosion is estimated to be occurring at the rate of around 0.6 m/year at this site, based on the 4.5 m retreat of the foreshore as measured from aerial photography between August 2014 and December 2021 (Figure 4-33).

Figure 4-33 – Measured retreat of shoreline upstream from Christian's Minde, August 2014 – December 2021 (Nearmap, 2022). Site reference S006.

4.9.2 Causes of erosion

Causes of erosion at this site were assessed to include:

- river and tidal flow, as the high erosion site is located on the outside of a channel bend where there is erosive pressure due to channel meandering
- vessel waves, as the site is exposed to boat wash from recreational vessels
- lack of foreshore riparian vegetation at individual locations where this has been damaged by erosion and the presence of weeds along the bank are considered to be impacting on estuary bank stability.

Figure 4-34 – Area upstream of Christian's Minde. Note undermining of large trees and formation of vertical erosion scarp (7 December 2021). Site reference S006.

4.9.3 Environmental, Cultural, Infrastructure and Amenity Impact

There is limited infrastructure exposed to erosion at this site, apart from some waterside infrastructure including a jetty and boatshed which are part of the Christian's Minde estate. There has been a loss of riparian vegetation due to erosion, further exposing the banks, and sedimentation from the eroded banks has the potential to impact on water quality and navigability due to reduced depths in the navigation channel. The site is outside Council's area of jurisdiction and is located within the Jervis Bay Territories, administered by the Commonwealth.

The Christian's Minde estate is listed on the Commonwealth Heritage List / Register of the National Estate (non-statutory). Being on the eastern side of the Inlet, it is within the territory of the ACT and not administered by Council. There is also a recorded Aboriginal site in the general vicinity of this foreshore that could be at risk from erosion.

Figure 4-35 – Area of Christian's Minde showing jetties and no-wash zone (7 December 2021). Site reference S006.

4.9.4 Potential Management Action from Decision Support Tool

The DST suggested the use of large woody debris to protect the bank in this area. The application of this management action is summarised in Appendix D. This would help prevent further migration of the channel toward the east and reduce the erosive pressure on the bank. In conjunction with the use of large woody debris along the outside of the bend, management controls to reduce the impact of boat wash and to prevent public access onto the unstable dune are suggested.

Another action in the short term may comprise an assessment of trees that have been undermined and are close to toppling, and lopping of a select few of these to prevent them from toppling over leading to the loss of several metres of bank, as can be seen from the measured bank retreat from the Nearmap aerial photography analysis in Figure 4-33. However, the primary suggested management action is to establish a healthy riparian zone and for further migration of the channel slowed or halted through placement of large woody debris along the banks, as removal of individual trees is not likely to be an action that Council can carry out sustainably or in the long term due to limited resources.

4.10 Ralph Lucas Waterway

Bank erosion was observed along the northern bank of the Ralph Lucas Waterway, with the erosion severity characterised as "Medium" at this location. The outcomes of the field assessment for this site are outlined below.

4.10.1 Characteristics of site

Ralph Lucas Waterway is a dredged channel within Sussex Inlet which connects to the inlet via Badgee Lagoon and was inspected by boat on 7 December 2021. Foreshore erosion was observed during the site inspection, particularly along the northern bank of the creek. The area where this erosion was observed is shown in Figure 4-36 as bank section S010. The site is heavily trafficked by recreational vessels as it represents the main access channel between the Quays residential canal estate and Sussex Inlet. The southern foreshore is an urban area largely protected by private erosion protection structures, whereas the northern foreshore is a natural vegetated bank that has been undermined by erosion.

Figure 4-36 – Detail of S010 site at Ralph Lucas Waterway assessed as having erosion of moderate severity.

4.10.2 Causes of erosion

The main cause of erosion at this site was assessed to be vessel waves, as the site is exposed to boat wash from recreational vessels and heavy vessel traffic being the only access to the Quays estate. In addition, as the channel is an artificially dredged channel, the channel foreshores are likely to not have much natural resistance to erosion.

4.10.3 Environmental, Cultural, Infrastructure and Amenity Impact

There is limited infrastructure exposed to erosion along the northern foreshores at this site. However, there has been a loss of riparian vegetation due to erosion, further exposing the banks, and sedimentation from the eroded banks has the potential to impact on water quality. Within the Sussex Quays, there are many foreshore residential properties, most with seawall in varying conditions that provide some measure of protection for infrastructure against erosion. Isolated damage to seawalls within the Quays estate was noted during the site inspections in this area.

A review of the Aboriginal Heritage Information Management System (AHIMS) in February 2022 [redacted], which may be at risk from erosion.

4.10.4 Potential Management Action from Decision Support Tool

The DST suggested the use of large woody debris to protect the bank in this area. The application of this management action is described in detail in the DST documentation (Hydrosphere Consulting 2020) and summarised in Appendix D. Management controls already in place include a 4-knot speed limit for vessels to reduce the impact of vessel wash on the banks in this area.

Figure 4-37 – Typical view of channel at Ralph Lucas Waterway, showing undercutting of foreshore vegetation by vessel wash (7 December 2021). Site reference S010.

Figure 4-38 – View at the entrance to Ralph Lucas Waterway. Note 4 knot speed limit and no-wash zone signage (7 December 2021). Site reference S010.

4.11 Other locations

Other locations within Sussex Inlet that were subject to erosion included:

- isolated areas of erosion along the foreshore of Sussex Inlet fronting the RSL club (Figure 4-39), with overtopping of the existing timber log protection and erosion in areas where there were gaps in the riparian vegetation
- damage and erosion to the timber seawall at Lions Club boat ramp fish-cleaning table (Figure 4-42)
- isolated damage to seawalls within the Quays estate (Figure 4-43)
- some minor erosion along the northern foreshore of Badgee Lagoon, likely caused by boat wash and wind waves.

The DST has suggested the use of riparian vegetation management as well as maintenance of existing controls for these areas.

Figure 4-39 – Foreshore near Sussex Inlet RSL club showing erosion behind timber log bank protection (27 November 2021). Site reference S007.

Figure 4-40 – Erosion at foreshore south of Sussex Inlet RSL, looking south (27 November 2021). Site reference S007.

Figure 4-41 – Area of healthy riparian vegetation with no erosion, south of Sussex Inlet RSL (27 November 2021). Site reference S007.

Figure 4-42 – Lions Park foreshore with erosion damage to timber retaining wall at boat ramp fishing table (16 March 2022). Site reference S013.

Figure 4-43 – Damaged retaining wall at Sussex Inlet Quays (7 December 2021) Site reference S010.

5 Erosion Assessment - Swan Lake

5.1 Introduction

The Swan Lake and Berrara Creek Natural Resources Management Strategy (Shoalhaven City Council, 2002) identified erosion of tracks and old gravel pits in the national park as contributing to sedimentation in the creek and lake, as well as some bank erosion along the more heavily used recreational areas on the eastern shore of Swan Lake. A series of management actions were suggested, including accommodating natural processes of lake and creek erosion but reducing human-induced erosion by disallowing development that could cause bank erosion and retaining/establishing riparian vegetation zones along the lake banks.

This report provides a detailed erosion assessment for the foreshore of Swan Lake.

The results of the erosion assessments are documented for each location within each estuary on the proforma sheets in Appendix A, where significant erosion was observed.

5.2 Key locations where foreshore erosion has been observed

Key locations where significant erosion was identified are shown in Table 5-1, and mapped in detail in Figure 5-1. Each location was entered into the Decision Support Tool, with management actions proposed by the tool for some of these locations.

Table 5-1 – Key locations in Swan Lake where significant foreshore erosion was observed (red = "high", orange = "moderate", yellow = "low", green = "negligible")

Bank segment ID	Erosion Severity	Environmental Impact	Infrastructure / commercial impact	Amenity / safety impact	Future Trajectory
SW02 (upper entrance channel)	Low	Low	Low	Low	Not occurring but likely
SW01 (lower entrance channel)	Moderate	Low	Negligible	Negligible	Not occurring but likely

The locations are described in detail below, together with the suggested management approach based on the outcome of the Decision Support Tool.

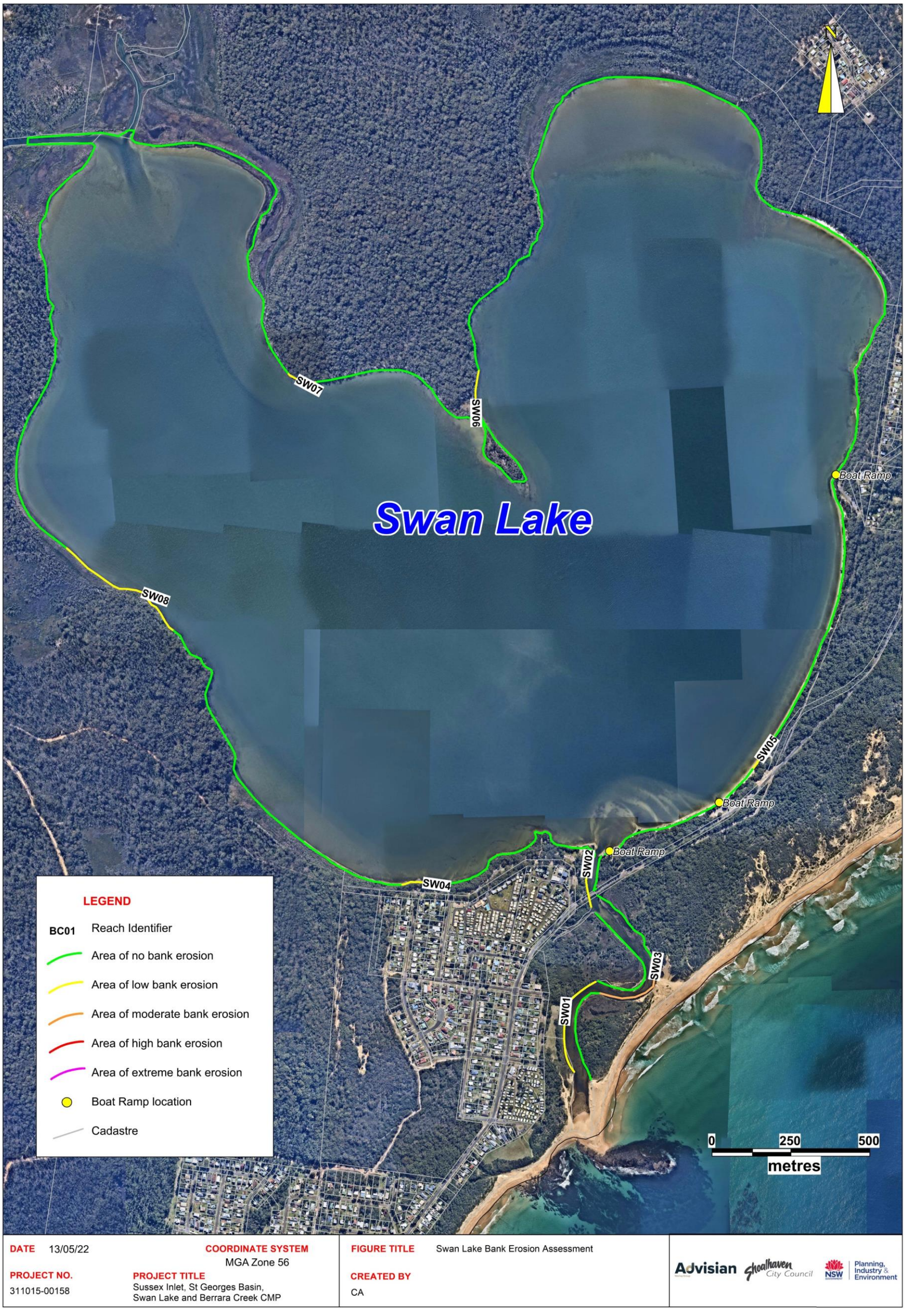


Figure 5-1 – Swan Lake Erosion Assessment Map

5.3 Upper Entrance Channel

There was minor bank erosion observed at the upper section of the entrance channel, on the western bank adjacent to the reserve at Goonawarra Drive and on the western bank on the upstream and downstream sides of the Swan Lake Bridge. The field assessments for this area were undertaken on 1 December and 7 December 2021, as well as from a vessel on 17 June 2022.

The outcomes of the field assessment for this site are outlined below.

5.3.1 Characteristics of site

The site is backed by a recreation reserve (Errol Bond Reserve) on the upstream side of the Swan Lake bridge, with a sewage pumping station immediately landward of the bank. The site is sandy with clay at the lower levels, with erosion mainly occurring along the upper sections of the bank. The area where this erosion was observed is shown in Figure 5-2. No foreshore erosion protection works were installed at the site, except for some rock protection on either side of the bridge associated with the bridge abutments.

There is a small beach area adjacent to the car-park at Errol Bond Reserve where there are aboriginal middens. The community use this area to access the beach and launch unpowered vessels and canoes, which has caused some damage to the middens (Figure 5-3).

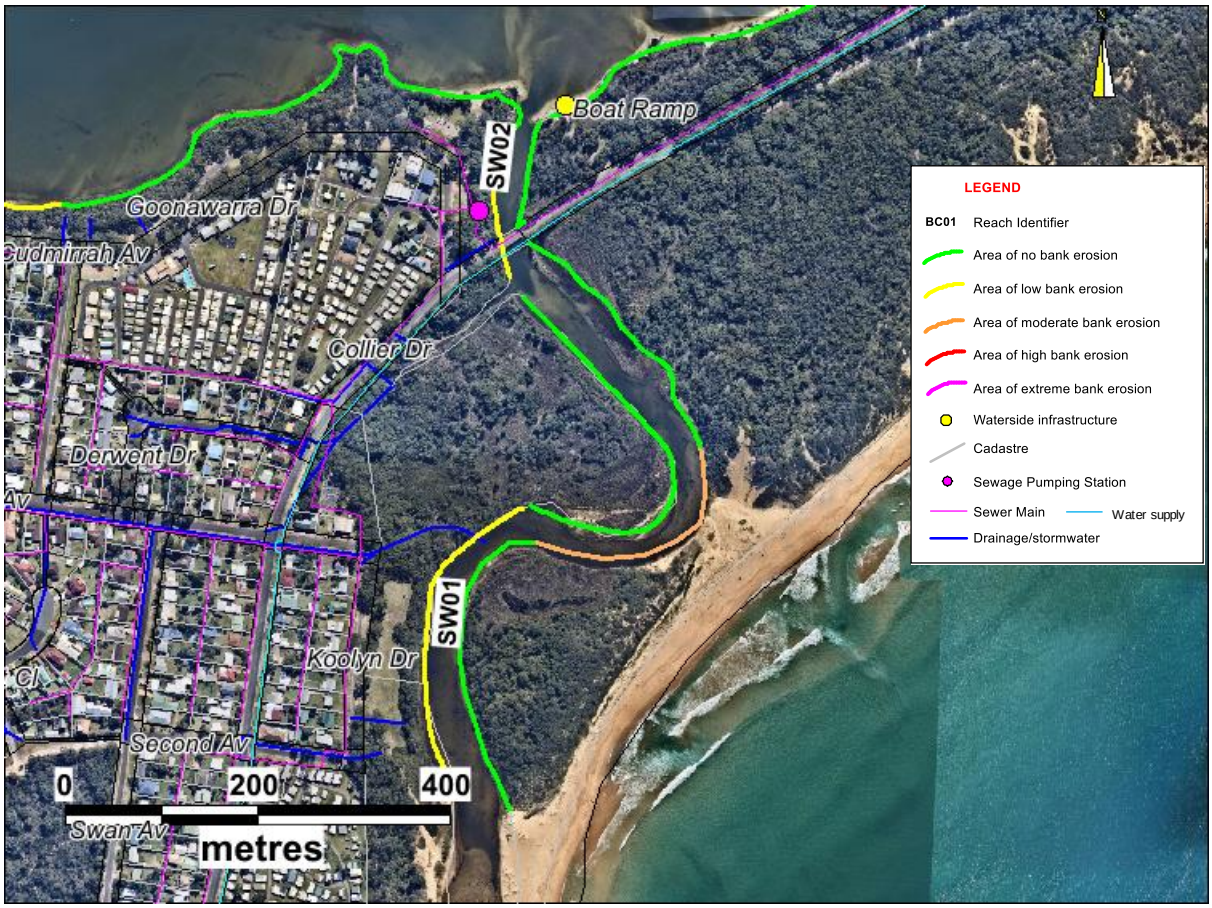


Figure 5-2 – Detail of Swan Lake entrance channel assessed as having erosion of low severity

This figure has been removed to protect culturally sensitive information that has been presented in the original report.

If you have questions about how Council manages sensitive information, please contact Council on 1300 293 111.

Figure 5-3 – Area adjacent to aboriginal midden where some damage to the midden is being caused by foreshore access. Site reference SW02 (1 December 2021).

5.3.2 Causes of erosion

Causes of erosion at this site were assessed to include river and tidal flow when the lake levels are high and scour occurs due to lake outflow, as the site is located on the outside of a channel bend where there is erosive pressure due to channel meandering.

At Errol Bond Reserve, there is some damage occurring to the aboriginal midden at the corner of the inlet channel, as this area is being used for access into the water by unpowered craft.

Figure 5-4 – Minor bank erosion on southern bank of upper Swan Lake channel. Top: Looking upstream from bridge, bottom: Looking downstream from bridge (7 December 2021). Site reference SW02.

5.3.3 Environmental, Cultural, Infrastructure and Amenity Impact

A sewage pumping station is located adjacent to the site, however, is not considered to be at threat from the erosion. There has been some minor undercutting of foreshore erosion at the site, and

foreshore access to this section of the channel is not available due to the steepness of the bank and presence of foreshore riparian vegetation (Figure 5-4).

A review of the Aboriginal Heritage Information Management System (AHIMS) in February 2022 [redacted] There are no declared Aboriginal places. As an example of the Aboriginal site, the Cudmirrah Berrara Swanhaven Progress Association Inc. (undated) describe the discovery of an Aboriginal burial site in 2006 along the edge of Swan Lake in Errol Bond Reserve Cudmirrah and when water levels are low in Swan Lake, some grinding stones and the remains of a series of fish traps are also visible. There has been some erosion damage to the aboriginal midden located at the foreshore near the upstream end of the inlet channel.

5.3.4 Potential Management Action from Decision Support Tool

The DST did not suggest that any action is required to address erosion at the site. However, some protection of the midden may be warranted at the access point to the water. An option for protection could involve moving the location of the beach access point westward so that it does not impact the midden, and plant riparian vegetation to prevent erosion damage to the midden.

5.4 Lower Entrance Channel

Bank erosion was observed along the western bank of the lower reaches of the entrance channel, with the erosion severity characterised as "Low" at this location. At "The Gap", the lower entrance channel has been observed to be meandering and migrating toward the sea, resulting in moderate erosion of the landward side of the dunes at this location. The outcomes of the field assessment for this site are outlined below.

5.4.1 Characteristics of site

The lower entrance channel experiences high velocity outflows when the lake entrance is open to the sea, as can be seen in Figure 5-5. Minor foreshore erosion and undercutting was observed along the western bank, on the outside of a bend near the entrance berm. The erosion is within a clay embankment and is causing minor undercutting of the bank as can be observed in Figure 5-6.

Moderate erosion to the dunes is occurring on the outside of the bend at "The Gap", with evidence of wave overtopping occurring at this location, and migration of the channel bend toward the sea, narrowing the width of the beach berm at this location as evidenced by historical aerial photography and bathymetric survey data (Figure 5-7).

Figure 5-5 – Swan Lake lower entrance channel when entrance is open (18 March 2022). Site reference SW01.

5.4.2 Causes of erosion

Causes of erosion at this site were assessed to include:

- river and tidal flow when the lake entrance is open under high water levels, as the erosion site is located on the outside of a channel bend where there is erosive pressure due to channel meandering. The sudden breach in the entrance berm caused by deliberate lake openings can result in rapid flow velocity through the entrance area which results in erosive pressure at this bank.
- Ongoing seaward migration of the inlet channel bend at "The Gap" caused by river and tidal flow, eroding the landward side of relict beach dunes at this location.

5.4.3 Environmental, Cultural, Infrastructure and Amenity Impact

There is limited infrastructure exposed to erosion at this site. However, there is the risk of a loss of riparian vegetation due to erosion. There is also an increasing risk of a breach in the beach occurring at "The Gap" due to the narrowing of the berm here over time. This risk is addressed in the Swan Lake Entrance Management Policy Review Report (Advisian 2022).

A review of the Aboriginal Heritage Information Management System (AHIMS) in February 2022 i[redacted] which may be at risk from foreshore erosion.

5.4.4 Potential Management Action from Decision Support Tool

The DST suggested that no specific action is required to protect the bank in this area. However, it is suggested that the erosion be monitored and that the management protocols for opening the lake entrance be reviewed to minimise the risk of erosion caused by rapid drawdown of the water levels within the lake.

Figure 5-6 – Minor bank erosion at lower Swan Lake channel (16 February 2022). Site reference SW01.

Figure 5-7 – Erosion occurring at "The Gap", caused by seaward migration of inlet channel bend toward relict beach dunes. Note evidence of wave overtopping of the beach berm at this location (top), 17 June 2022. Site reference SW03.

5.5 Other locations

The Swan Lake and Berrara Creek Natural Resources Management Strategy (Shoalhaven City Council, 2002) noted that there was some bank erosion along the more heavily used recreational areas on the eastern shore of Swan Lake. These areas were inspected and at the time of the inspection, little to no erosion was observed. There was evidence that erosion can occur when water levels are high (Figure 5-8, Figure 5-9), but the erosion is considered to be minor, with no active management required.

The entire foreshore of Swan Lake, including the northern foreshores that are managed by the NSW National Parks and Wildlife Service, was inspected from a vessel on 17 June 2022. Most of the foreshore was in good condition, being in a natural state with little disturbance and with little bank erosion observed. However, small areas of minor erosion were observed at the following locations:

- minor erosion at Swanhaven, where small ad-hoc structures have been constructed for launching of non-powered craft (Figure 5-10)
- minor erosion along sections of the northern foreshore, which appear to have been caused by loss of riparian vegetation as a result of the Black Summer bushfires in 2019-20 and subsequent undermining of fire-damaged vegetation by wind waves and/or vessel wash (Figure 5-11)
- undermining of a large tree on the southern foreshores of Swan Lake, which is at risk of toppling and removing a large section of bank. It is noted that this tree provides roosting habitat for local birds (Figure 5-12).

No action is suggested for these areas, other than monitoring their condition and monitoring the impact of and considering removal of unauthorised launching structures.

Figure 5-8 – Minor bank erosion at upper bank at Swan Lake Ski Beach (top, site reference SW05), Dyball Reserve (bottom, site reference SW02), 1 December 2021

Figure 5-9 – Evidence of flooding and undermining of foreshore vegetation at high water levels, Swan Lake near Cudmirrah Avenue (16 February 2022). Site reference SW04.

Figure 5-10 – Ad-hoc launching structure and vessel storage at Swanhaven (17 June 2022), site reference SW05.

Figure 5-11 – Bushfire-impacted areas at island on northern foreshore experiencing undermining of vegetation. Note damage to speed limit sign caused by bank erosion (17 June 2022). Top: Site reference SW06, bottom: Site reference SW07.

Figure 5-12 – Dead trees at risk of toppling causing destabilisation of bank. Note that these trees are used as roosting habitat for birds (17 June 2022). Top: site reference SW04, bottom: site reference SW08.

6 Erosion Assessment - Berrara Creek

6.1 Introduction

The Swan Lake and Berrara Creek Natural Resources Management Strategy (Shoalhaven City Council, 2002) identified erosion of tracks and old gravel pits in the national park as contributing to sedimentation in the creek, as well as bank erosion adjacent to the Berrara Flats Reserve. A series of management actions were recommended, including accommodating natural processes of lake and creek erosion but reducing human-induced erosion by disallowing development that could cause bank erosion and retaining/establishing riparian vegetation zones along the creek banks.

This report provides a detailed erosion assessment for the entire foreshore of Sussex Inlet, including numerous locations not documented in previous studies, which have been inspected and documented using the DST.

The results of the erosion assessments are documented for each location within each estuary on the proforma sheets in Appendix A, where significant erosion was observed.

6.2 Key locations where foreshore erosion has been observed

Key locations where significant erosion was identified are shown in Table 6-1, and mapped in detail in Figure 6-1. Each location was entered into the Decision Support Tool, with potential management actions suggested by the tool for some of these locations.

Table 6-1 – Key locations in Berrara Creek where significant foreshore erosion was observed (red = "high", orange = "medium", yellow = "low", green = "negligible")

Bank segment ID	Erosion Severity	Environmental Impact	Infrastructure / commercial impact	Amenity / safety impact	Future Trajectory
BC03 (Berrara Beach Holiday Chalets)	Medium	Medium	Low	Low	Occurring and continuing
BC07 (opposite Fishermans Rock at powerlines)	Medium	Medium	Medium	Low	Occurring and continuing
BC01 (just upstream entrance)	Low	Low	Low	Medium	Occurring and continuing
BC02 (upstream beach access)	Low	Low	Low	Low	Occurring and continuing
BC04 (Berrara Waters)	Low	Low	Low	Low	Occurring and continuing
BC05 (Lakeland Avenue)	Low	Low	Low	Low	Occurring and continuing
BC06 (Southern bank opposite Lakeland Avenue)	Low	Low	Negligible	Negligible	Occurring and continuing

The locations are described in detail below, together with a potential management approach based on the outcome of the Decision Support Tool.

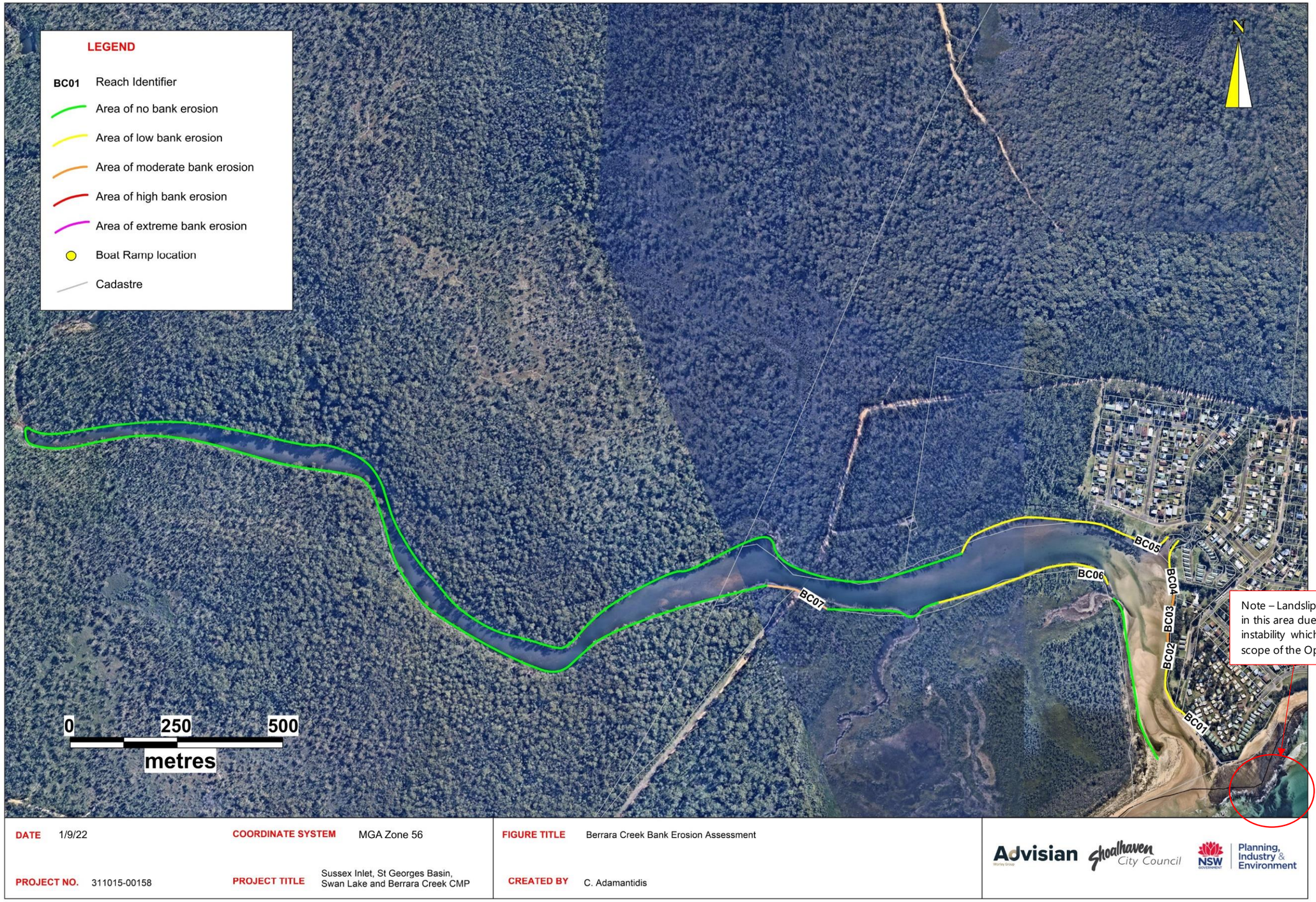


Figure 6-1 – Berrara Creek Erosion Assessment Map

6.3 Area just upstream entrance (BC01)

Erosion was observed in the area just downstream of the beach accessway from the car park, with the erosion severity characterised as "Low" but with a moderate amenity impact at this location. The outcomes of the field assessment for this site are outlined below.

6.3.1 Characteristics of site

At this site, a concrete pedestrian walkway provides access to the foreshore from the beach carpark. Erosion was considered to be the result of a combination of ocean waves when the creek entrance is open, rainfall/stormwater from the area above the site and public access. The area where this erosion was observed is shown in Figure 6-1.

The bank in this area is a sandy dune which has been overrun by weeds. A stormwater pit located above the site was observed to be full of sediment, and would likely overflow in heavy rain, leading to concentration of rainfall and runoff onto the concrete pedestrian pathway.

Photos of the erosion observed at this site are shown in Figure 6-2 and Figure 6-3.

Further seaward of this site, several landslips were observed along the siltstone headland. These landslips are caused by geotechnical slope instability and are within the scope of the Open Coast CMP.

6.3.2 Causes of erosion

Causes of erosion at this site were assessed to include:

- ocean waves, as the site is exposed to swell waves when the creek entrance is open
- river and tidal flow during times when there are high flows in the creek
- rainfall and runoff flows being concentrated onto the slope by the presence of the concrete footpath and overflow from the stormwater pit at the top of the bank
- lack of foreshore riparian vegetation and the presence of weeds along the bank.

Figure 6-2 – Erosion looking upstream from Berrara Creek beach access (1 December 2021). Site reference BC01.

Figure 6-3 – Active erosion at beach access from carpark (1 December 2021). Site reference BC01.

6.3.3 Environmental, Cultural, Infrastructure and Amenity Impact

There is limited infrastructure exposed to erosion at this site. However, the erosion is having an impact on foreshore amenity and is also impacting the safety of the beach accessway, with a steep drop at the end of the access and potential for undermining of the footpath.

A site inspection was carried out by Advisian in collaboration with the Local Aboriginal stakeholders, representing the Jerrinja Tribe and were part of the bush care group, on 15 March 2022. During this inspection, a number of areas of midden material and former camp sites were observed at the Berrara Creek site. 'Extremely high' cultural significance presides over the subject area.

6.3.4 Potential Management Action from Decision Support Tool

The DST suggested the use of beach nourishment/beach scraping to protect the bank in this area. Replacement of sand at the toe of the slope, together with management actions to address stormwater runoff and improve foreshore vegetation management would improve the erosion at this location. An upgrade of the access track at this location to reduce the impact of concentrated rainfall/runoff flows and improve foreshore access is suggested.

6.4 Area just upstream beach access (BC02)

Bank erosion was observed just upstream of the beach access, with the erosion severity classified as "low" at this location. The outcomes of the field assessment for this site are outlined below.

6.4.1 Characteristics of site

This site is characterized by a thin layer of sand overlying a clay embankment. The slope above the site is steep and is subject to undercutting caused by outflows from the lake, as well as rainfall/runoff from the upper sections of the slope. The area where this erosion was observed is shown in Figure 6-1.

6.4.2 Causes of erosion

Causes of erosion at this site were assessed to include:

- river and tidal flow
- rainfall/runoff from upper sections of the slope.

The slope was observed to be more stable than the area immediately upstream, due to the more gentle gradient and in-tact nature of the foreshore vegetation. However, some minor undercutting of the toe of the slope was observed (Figure 6-4).

Figure 6-4 – Active bank erosion upstream of beach access from carpark (1 December 2021). Site reference BC02.

6.4.3 Environmental, Cultural, Infrastructure and Amenity Impact

There is only a low impact on foreshore amenity and sedimentation in the lake at this site as a result of the minor undercutting of the banks. During an inspection with representatives from the Jerrinja people on 15 March 2022, midden material was observed within the banks at this location. 'Extremely high' cultural significance presides over the subject area, and Aboriginal people have a very strong connection to this area.

6.4.4 Potential Management Action from Decision Support Tool

The DST suggested that no action be required to reduce erosion at this site, as erosion is considered to be progressing at a slow pace and does not have a significant impact on the environment and foreshore amenity at the site.

6.5 Berrara Beach Holiday Chalets (BC03)

Bank erosion was observed along the eastern bank of Berrara Creek at the foreshore fronting the Berrara Beach Holiday Chalets, with the erosion severity characterised as "Moderate" at this location. The outcomes of the field assessment for this site are outlined below.

6.5.1 Characteristics of site

The site is backed by a vertical clay embankment, on a siltstone platform above the mean water level that presents a relatively inerodible layer. Sections of foreshore were observed to be detaching from

the bank due to undercutting caused by either wave action or outflows when the creek levels are high. The area where this erosion was observed is shown in Figure 6-1.

A steep clay embankment was exposed along this site, with evidence of erosion occurring along the upper bank (above the mean water level) as well as undercutting of the banks and undermining of large casuarinas and other foreshore vegetation. There were locations where building rubble was visible within the slope.

6.5.2 Causes of erosion

Causes of erosion at this site were assessed to include:

- river and tidal flow, as the high erosion site is located on the outside of a channel bend where there is erosive pressure due to channel meandering
- rainfall/runoff from the slope above the site were assessed to be contributing to bank instability, as well as undercutting of the banks when water levels and flow velocities in the creek are high
- lack of foreshore riparian vegetation and the presence of weeds along the bank are also considered to be impacting on estuary bank stability.

6.5.3 Environmental, Cultural, Infrastructure and Amenity Impact

There are some cabins above the site that could become exposed to the erosion at this site. There has been a loss of riparian vegetation due to erosion, further exposing the banks, and sedimentation from the eroded banks has the potential to impact on water quality. Parts of the bank have been protected using rock revetment, although this protection is not continuous. Access to the foreshore is currently unsafe due to the steep embankment at the site. The exposed building rubble along the banks at this location may present a safety hazard for waterway users.

A review of the Aboriginal Heritage Information Management System (AHIMS) in February 2022 revealed no registered aboriginal sites or places along this section of foreshore, although it is likely that undocumented sites exist. 'Extremely high' cultural significance presides over the subject area, and Aboriginal people have a very strong connection to this area.

6.5.4 Potential Management Action from Decision Support Tool

The DST suggested use of rock revetment combined with riparian vegetation management in this area to help stabilise the banks.

As the bank is currently being undercut and is unstable, use of a rock revetment to prevent further undercutting could be considered where infrastructure is at risk. Alternatively, stabilisation of the slope by cutting it back to a stable angle could be considered and the top of the bank slope planted with stabilising vegetation. Consultation with the Jerrinja people is suggested prior to cutting back the slope to avoid any damage to artefacts within the banks.

Collapsed foreshore vegetation could be used as "large woody debris" to protect the toe of the slope from undercutting due to tidal flows.

Figure 6-5 – Bank erosion showing sections of bank detaching from foreshore and high vertical erosion scarp (1 December 2021). Site reference BC03.

Figure 6-6 – Building rubble holding bank together at site BC03 (1 December 2021)

6.6 Berrara Waters foreshore (BC04)

Bank erosion was observed along this reach of Berrara Creek, with the erosion severity characterised as "low" at this location. The outcomes of the field assessment for this site are outlined below.

6.6.1 Characteristics of site

This site is adjacent to a small tributary and is affected by outflow from the creek. The site is characterised by a vertical clay embankment, and is fronted by shallow water and a mudstone intertidal platform (Figure 6-7). Erosion was minor compared with the site BC03 further downstream but there was minor undercutting of the banks observed with the risk of undermining of large casuarinas and other foreshore vegetation. Isolated piles of building rubble were observed at this location.

6.6.2 Causes of erosion

Causes of erosion at this site were assessed to include:

- river and tidal flow from the main creek as well as from outflows from the tributary immediately north of the site.
- public access to the foreshore causing trampling of vegetation and destabilisation of the banks.

Figure 6-7 – Minor erosion and vertical scarp at Berrara Waters foreshore with use of adhoc building rubble to contain erosion (1 December 2021). Site reference BC04.

6.6.3 Environmental, Cultural, Infrastructure and Amenity Impact

There is limited infrastructure exposed to erosion at this site. However, there is a foreshore reserve immediately adjacent to the site and the requirement for public access to the foreshore from the adjacent Berrara Waters cabins. The environmental impact at the site is assessed to be low.

'Extremely high' cultural significance presides over the subject area. Aboriginal people have a very strong connection to this area. While a review of the Aboriginal Heritage Information Management System (AHIMS) in February 2022 revealed no registered aboriginal sites or places along this section of foreshore, it is likely that undocumented cultural sites and artifacts exist. Aboriginal people have a very strong connection to this area.

6.6.4 Potential Management Action from Decision Support Tool

The DST suggested riparian vegetation management as the main erosion management technique to be used at this site. However, it is noted that the substrate is rocky in front of the banks in this area, and that riparian vegetation may fail to establish in this area. Use of rock fillets beneath the undermined sections of bank may be a more appropriate action for this area.

6.7 Berrara Lagoon Reserve at Lakeland Avenue (BC05)

Bank erosion was observed along the Berrara Creek frontage at the Berrara Lagoon Reserve at Lakeland Avenue, with the erosion severity characterised as "Low" at this location. However, the erosion is having some impact on recreational amenity and the local environment at the site. The outcomes of the field assessment for this site are outlined below.

6.7.1 Characteristics of site

The site fronts a recreation reserve at Lakeland Avenue, which is used as a main public access area to the foreshore. The site has a relatively flat gradient and is fronted by a sandy foreshore area. A designated unpaved boat ramp is located at the upstream end of the site, as well as a community playground.

The site is located opposite the creek entrance and could be subject to swell waves propagating into the entrance, as well as wind waves across a fetch distance of 500 m.

There are two small stormwater outlets discharging onto the beach that are contributing to minor beach scour. The site is also used for ad-hoc storage of kayaks as can be seen in Figure 6-9.

6.7.2 Causes of erosion

Causes of erosion at this site were assessed to include:

- wind waves, as the site is exposed to a fetch distance of 500 m
- some swell waves when the entrance area is open
- lack of foreshore riparian vegetation at individual locations and ad-hoc kayak storage/access
- some stormwater erosion at the outlets discharging on the beach.

Figure 6-8 – Loss of mature trees due to erosion at Berrara Lagoon Reserve (1 December 2021). Site reference BC05.

Figure 6-9 – Ad-hoc kayak storage and undercutting of bank at Berrara Lagoon Reserve (1 December 2021). Site reference BC05.

6.7.3 Environmental, Cultural, Infrastructure and Amenity Impact

There has been a loss of riparian vegetation due to erosion and undercutting (Figure 6-8) and some scour due to stormwater discharge. A review of the Aboriginal Heritage Information Management System (AHIMS) in February 2022 revealed no registered aboriginal sites or places along this section of foreshore, although it is likely that undocumented sites exist. 'Extremely high' cultural significance

presides over the subject area. 'Extremely high' cultural significance presides over the subject area and Aboriginal people have a very strong connection to this area.

Figure 6-10 – Stormwater outflow at Berrara Lagoon reserve contributing to foreshore erosion (1 December 2021). Site reference BC05.

6.7.4 Potential Management Action from Decision Support Tool

The DST suggested the use of riparian vegetation as a management control for this site. In addition, management actions that would benefit the site include:

- provision of kayak storage/kayak skid to prevent damage to foreshore vegetation from dragging of kayaks across the foreshore
- establishment of formalised access points to the beach with a riparian vegetation zone to be established along other sections of the foreshore to become established.
- capture of stormwater runoff upstream of the site or through the use of a swale adjacent to the boat ramp area.

6.8 Opposite Fishermans Rock (BC07)

Bank erosion was observed along the Berrara Creek frontage opposite Fishermans Rock, with the erosion severity characterised as "Moderate" at this location. Powerlines cross the creek at this location. The outcome of the field assessment for this site is provided below.

6.8.1 Characteristics of site

The site is located opposite Fishermans Rock, on a reasonably straight stretch of the creek, fronted by shallow water, a sandy foreshore and a clay upper bank. The site is at the end of a service trail where powerlines cross the creek, and is cleared of vegetation as can be seen in Figure 6-11. The erosion is in the form of a gully leading toward the banks of the creek, with significant sedimentation of the creek occurring.

6.8.2 Causes of erosion

It is considered that the erosion at this site is being caused primarily by rainfall/runoff from the service road, which is a natural focal point for high velocity flows from rainfall. There is a lack of vegetation at the end of the service road, and while there have been some measures installed to slow down the flow (Figure 6-12), these have been insufficient to reduce the erosion.

6.8.3 Environmental, Cultural, Infrastructure and Amenity Impact

It is considered that the erosion has the potential to impact on the powerlines, as well as the function of the service road. In addition, clay sediments from the service road can enter the creek, causing sedimentation and impacting on water quality.

A significant Aboriginal site along the northern (opposite) foreshore of Berrara Creek is the Fishermans Rock complex, where there is a midden containing fragments of mussels and mud oysters plus axe-grinding grooves in the sandstone (NPWS, 2022). The Conjola National Park Plan of Management notes that this site is vulnerable to erosion, souveniring of artefacts, vandalism and lighting of fires (NPWS, 2009). The Plan of Management also provides a number of strategies regarding management of protection of Aboriginal sites and values through consultation with and involvement by Aboriginal community organisations and representations. The area around Fishermans Rock is not subject to erosion but documented Aboriginal sites exist on both sides of the creek at this location, including the area around the service road where erosion was observed.

6.8.4 Potential Management Action from Decision Support Tool

The DST suggested that protection be installed locally, in the form of geotextile containers, to repair the impact of the erosion and reduce the infrastructure risk at this location.

It is suggested that the eroded gully could be repaired by filling (with gravel, and covered with compacted topsoil) and revegetated with riparian vegetation, in accordance with the area along the natural sections of bank adjacent to the site. In conjunction, drainage from the road needs to be redirected to prevent further erosion of the site, either by using additional gravel sills along the road, or installation of a dish drain to direct drainage away from the creek banks.

Figure 6-11 – Erosion at BC07, opposite Fishermans Rock, 17 June 2022. Site reference BC07.

Figure 6-12 – Gravel "hump" for controlling runoff along the power line service trail (17 June 2022) Site reference BC07.

6.9 Other locations

Minor erosion was observed at the opposite side of the creek, in the area managed by National Parks (BC06). The erosion is observed to be a result of outflow from the lake and mainly natural causes, but may be affected by vessel waves launched at the boat ramp and also by destabilisation of foreshore vegetation caused by the bushfires in 2020. Monitoring of the banks is suggested for this area.

7 Historical Changes and Future Erosion Risk

Historical aerial imagery has been analysed to assess morphological changes in the estuaries over time, and to assess whether erosion has been continuing, accelerating, or stabilising.

Erosion rates were analysed based on available information (historical aerial photography and historical survey data) at the following locations:

- Sussex Inlet – Croppers (the Big "S"), The Haven, Alamein, Little Manly, Christian's Minde
- St Georges Basin – entire northern foreshore

Limited data was available at Swan Lake or Berrara Creek to enable an assessment of historical erosion rates, although a comparison between aerial photos from 2015 and 2022 was made, as well as an assessment of survey data for Swan Lake from 2001.

Note that the ability to assess changes in the rate of erosion over time, as well as likely future erosion risk (20 years, 50 years, and 100 years and beyond) is limited due to a lack of suitable data. However, it is likely that the erosion risk would increase, due to damage to fringing vegetation and wave action occurring further up the banks, because of an increase in future water levels caused by sea level rise.

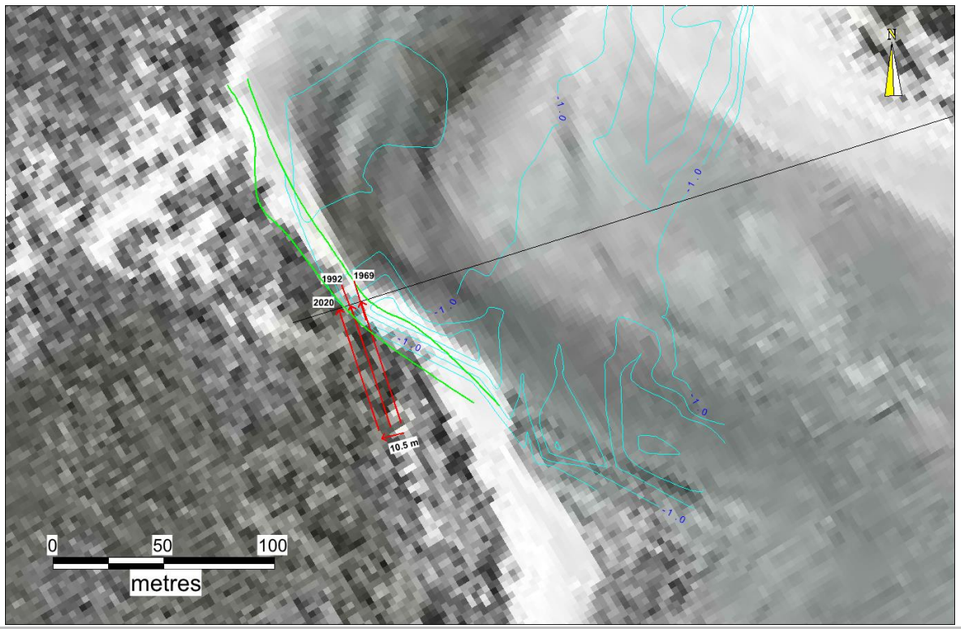
7.1 Sussex Inlet

Historical aerial photography was available for analysis from the Sussex Inlet entrance area, as well as survey data throughout the Inlet from 1992 that was able to be compared directly with survey data collected in 2021. The 1992 survey comprised a series of transects throughout the estuary, whereas the 2021 survey comprised a full bathymetric and feature survey of the Sussex Inlet channel.

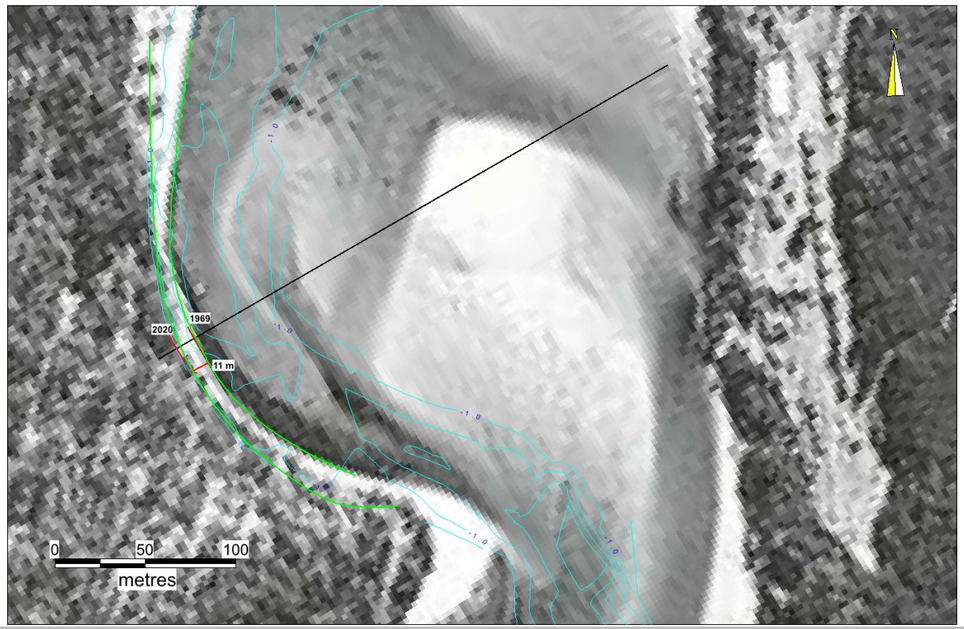
The two survey data sets were compared to assess the rate of shoreline retreat that has occurred in the erosion "hotspots" identified from the fieldwork. This was supplemented with reference to georeferenced aerial photography from 1969. From the analysis (Figure 7-1), the following recession distances and average rates of erosion measured from 1992 to 2021 were obtained:

- Croppers (the Big "S") – 10.5 m recession between 1969 and 2020 (0.2 m/y)
- The Haven – 11 m recession between 1969 and 2020 (0.2 m/y)
- The Haven (upstream) – 20 m recession between 1969 and 2020 (0.4 m/y)
- Little Manly – 27 m recession between 1992 and 2020 (1.0 m/y)
- Christian's Minde – 4.5 m recession between 2014 and 2021 (0.6 m/y, refer Figure 4-33).

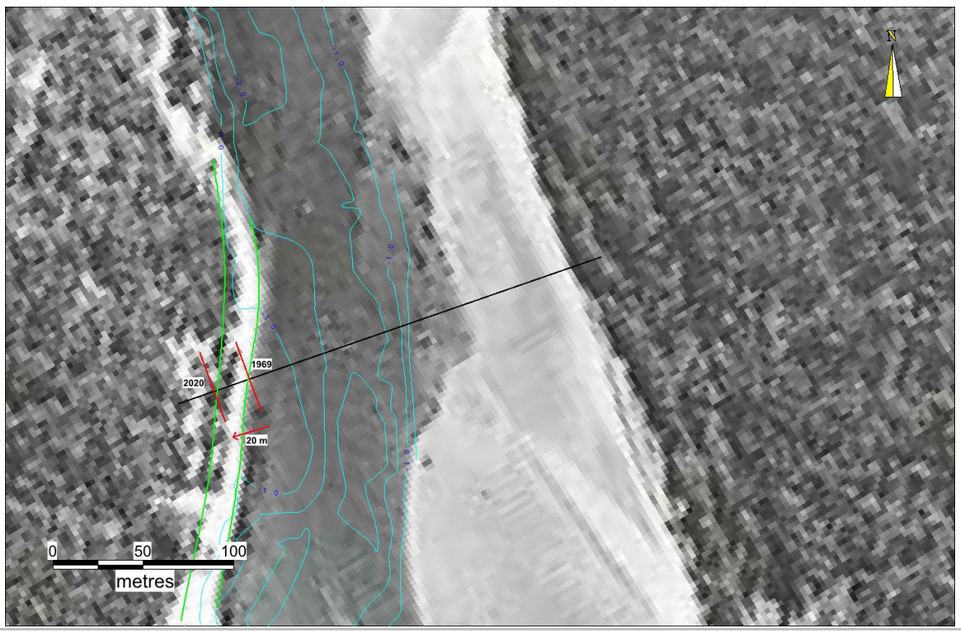
Further survey information and further foreshore inspections would be required to determine whether the rate of erosion is accelerating at these locations. However, without remedial measures, it is considered that foreshore erosion would continue at these locations at a rate at least equal to the estimated rates above. The rate of erosion would likely accelerate with future sea level rise, as the main mechanism for the erosion is wave action occurring at high water levels.



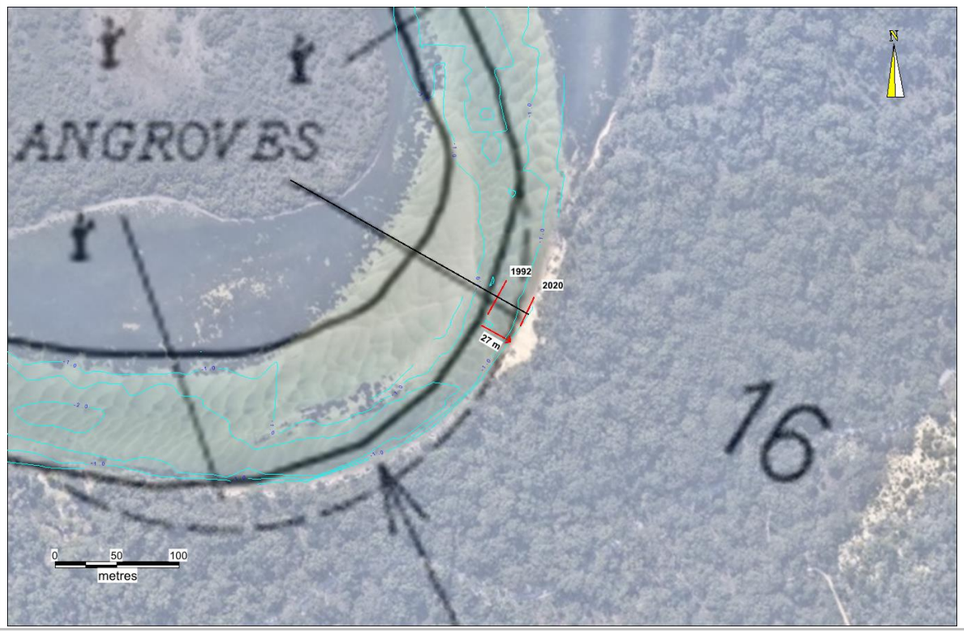
Croppers (the Big "S")



The Haven



The Haven (upstream)



Little Manly

Figure 7-1 – Average rates of shoreline recession at Croppers Big "S", The Haven, Little Manly, 1992 – 2020 (aerial photography from 1969).

7.2 St Georges Basin

Foreshore erosion rates at St Georges Basin were assessed by comparing the shoreline obtained from digitised photogrammetry as plotted in the 1993 survey, with the shoreline from high-resolution aerial photography from 2022. The accuracy of the location of the 1993 shoreline is not guaranteed, so the erosion rates provided are estimates only.

It was found that erosion was occurring at the hot spots identified from the fieldwork, with the rates varying at different locations. Average rates of erosion between 1993 and 2021 are plotted in Figure 7-2 for key locations around St Georges Basin and ranged from zero up to 1.0 m/year.

The rates of erosion at various locations were:

- Basin View (0.2 m/y - 0.4 m/y)
- Blackett Reserve, St Georges Basin (0.4 m/y)
- St Georges Basin near boat ramp (1.0 m/y)
- Paradise Beach (0.5 m/y)
- Macleans Point (south) (0.7 m/y – 1.0 m/y)
- Sanctuary Point (0.3 m/y)
- Old Erowal Bay (0.5 m/y)
- Erowal Bay (0.7 m/y)
- Wrights Beach (0.7 m/y).

It is noted that some areas appear to have been stabilised successfully with foreshore works or vegetation, and that erosion may no longer be occurring (e.g. at Sanctuary Point). However, further survey information and further foreshore inspections would be required to determine whether the rate of erosion is accelerating or has slowed down at these locations. Without remedial measures, it is considered that foreshore erosion would continue at some of these locations at a rate at least equal to the estimated rates above. Generally, the rate of erosion would likely accelerate with future sea level rise, as the main mechanism for the erosion is wave action occurring at high water levels and the associated loss of stabilising foreshore vegetation.

Figure 7-2 – St Georges Basin Erosion Rates

7.3 Swan Lake

There was little data available to assess historical erosion at Swan Lake. A bathymetric survey from 2001 was compared against 2022 aerial photography in GIS to assess whether the spatial location of the foreshore has changed, but changes were not able to be resolved from this analysis.

A comparison of high-resolution aerial photography from 2015 and 2022 (Figure 7-3) revealed that there were no significant changes along the foreshore within the main waterbody of Swan Lake, but that there was evidence of sedimentation rather than erosion. The main change that was apparent was the migration of the bend in the channel toward the ocean barrier at the location known as "the gap", as shown in Figure 7-3. This change was also detected from the comparison of 2022 aerial photography with survey data from 2001. There has also been the loss of a sandbank near the entrance, likely a result of the flooding that occurred in March 2022.

It is considered that continued meandering of the channel could lead to more frequent breakout of the Lake at "the gap", and that the future potential for erosion or sedimentation to occur on the lake is linked to management of the entrance, with some evidence of long-term sedimentation occurring.

7.4 Berrara Creek

No historical survey was available at Berrara Creek for comparison. However, a comparison of high-resolution aerial photography from 2015 and 2022. There was evidence of foreshore erosion at Lakeland Avenue, Berrara Waters and the western foreshores of the creek, with a loss of foreshore of around 4 m at Lakeland Avenue and Berrara Waters (close to the outflow from a small tributary), and loss of a sandbank on the western side of the main creek channel.

The comparison between 2015 and 2022 aerial photography for Berrara Creek is provided in Figure 7-4. It is considered that flood flows from within the catchment area have the greatest potential to cause future foreshore erosion, and that the area around Lakeland Avenue and Berrara Waters have the highest rates of erosion in the estuary. Sea level rise due to climate change would likely worsen erosion in these parts of the estuary, which are low-lying and not well protected by foreshore vegetation.

Figure 7-3 – Swan Lake Entrance Channel Morphological Change, 2015 – 2022 (aerial photography Nearmap, August 2015)

Figure 7-4 – Berrara Creek Morphological Change, 2015 – 2022 (aerial photography Nearmap, April 2022)

8 Potential Management Actions

A summary of the erosion assessment at each location, together with potential management actions, is provided below in Table 8-1 for St Georges Basin, Table 8-2 for Sussex Inlet, Table 8-3 for Swan Lake and Table 8-4 for Berrara Creek.

The potential management actions will be developed further during Stage 3 of the CMP process.

Table 8-1 – Potential Management Actions for addressing erosion at St Georges Basin

Estuary	Bank segment ID	Erosion Severity	Environmental Impact	Infrastructure / commercial impact	Amenity / safety impact	Future Trajectory	Main Causes	Existing Management Controls	Additional Management Controls
St Georges Basin	W001 (Wandandian Ck upstream)	High	High	Low	Low	Occurring and continuing	• Vessel waves • River and tidal flow • Direct access by stock to foreshore • Lack of riparian vegetation and weeds	• Works planned under the NSW Medium-term Response Plan for Bushfire Recovery (DPIE, 2021) that include works to restore foreshores and riparian zones and provide additional resources for erosion and sediment control in the bushfire-affected catchment areas. and for the areas that were affected by the "Black Summer" bushfires of 2019-20 • Vessel speed limits and prohibition of wake boarding/water skiing	• Use of large woody debris along the banks to divert/alter and/or dissipate flows from the bank, to allow sediment to deposit and riparian vegetation to become established • In conjunction with the use of large woody debris along the outside of the bend, maintenance of fencing to exclude stock from the riverbank and establishment of a riparian vegetation zone along the bank where this is absent. • Allow collapsed foreshore vegetation which is acting as natural "large woody debris" to remain as this would likely have a role in protecting the banks from further damage.
St Georges Basin	BV03 (Mathie Street)	Medium	Medium	High	High	Occurring and continuing	• Stormwater runoff from Mathie Street • Toe erosion caused by wind waves	Rock revetment	• Maintenance of existing rock revetment • Removal of building rubble • Stormwater runoff management
St Georges Basin	BV02 (Basin View west of boat ramp)	Medium	Low	Low	Medium	Occurring and continuing	• Wind waves, generated by southerly and southeasterly winds • Vessel waves generated by traffic from the nearby boat ramp • Localised clearing/lack of riparian vegetation	None	• Installation of cobble beach • Establishment of riparian vegetation
St Georges Basin	OEB01 (Old Erowal Bay Prentice Av)	Medium	Medium	Low	Low	Occurring and continuing	• Southerly winds leading to toppling of established vegetation, causing loss of stabilising roots from bank. This occurred where large casuarina trees at the edge of the bank were being undermined by erosion, and where there was a lack of a well-established riparian zone with a mix of different vegetation types to hold the banks together. • Undercutting of banks from wind waves at high water levels. • Minor scarping in areas devoid of riparian vegetation.	None	• Installation of cobble beach • Establishment of riparian vegetation where public access to foreshore not required • Establishment of shallow-rooted riparian vegetation such as saltmarsh in the shallow intertidal areas in front of the bank, together with the establishment of a no-mow zone, would also be likely to be successful • Use of large woody debris along the banks to divert/alter and/or dissipate flows from the bank, to allow sediment to deposit and riparian vegetation to become established
St Georges Basin	MP01 (Mcleans Point east)	Medium	Medium	Low	Low	Occurring and continuing	• Wind waves from southerly winds across the Basin, particularly when water levels within the Basin are high • Destabilisation and undercutting of the banks due to the presence of weeds and damage to foreshore vegetation • Incorporation of unstable fill into the banks • Public access leading to trampling of vegetation by foot traffic, and dragging of small craft over the banks leading to destabilisation of the bank, as well as ad-hoc storage of private craft	• Rock fillets to protect root zones • No-mow areas and saltmarsh planting has been successful over short sections of bank	• Cobble beach to provide protection to root zone of undermined trees • Fallen trees to dissipate wave energy reaching the bank where public foreshore access not required • Management controls including no-mow zones where foreshore vegetation is being undermined
St Georges Basin	W002 (Wandandian Ck downstream)	Medium	Medium	Negligible	Negligible	Occurring and continuing	• Vessel waves • River and tidal flow	• Vessel speed limits and prohibition of wake boarding/water skiing	• Allow collapsed foreshore vegetation which is acting as natural "large woody debris" to remain as this would likely have a role in protecting the banks from further damage.
St Georges Basin	LAW01 (Loaralyn Ave East)	Medium	Low	Low	Low	Occurring and continuing	• Wind waves from southerly winds across the Basin, particularly when water levels within the Basin are high	• Rock fillets to protect root zones • No-mow areas and saltmarsh planting has been successful over short sections of bank	• Cobble beach to provide protection to root zone of undermined trees • Fallen trees to dissipate wave energy reaching the bank where public foreshore access not required

Estuary	Bank segment ID	Erosion Severity	Environmental Impact	Infrastructure / commercial impact	Amenity / safety impact	Future Trajectory	Main Causes	Existing Management Controls	Additional Management Controls
							• Destabilisation and undercutting of the banks due to the presence of weeds and damage to foreshore vegetation • Incorporation of unstable fill into the banks • Public access leading to trampling of vegetation by foot traffic, and dragging of small craft over the banks leading to destabilisation of the bank, as well as ad-hoc storage of private craft		• Management controls including no-mow zones where foreshore vegetation is being undermined
St Georges Basin	EB01 (Erowal Bay east)	Low	Low	Medium	Low	Occurring and continuing	• Wind waves from southerly winds across the Basin, particularly when water levels within the Basin are high • Some runoff from rainfall and stormwater at Wharf Road leading to overland erosion on the upper parts of the slope • Edge effects of erosion due to the presence of adjacent hard foreshore protection structures • Incorporation of unstable fill material into the bank which is not able to withstand the effects of erosion. • Lack of riparian vegetation to hold the banks together and reduce the erosive impact of wind waves	None	• Cobble beach and rock revetment to protect critical sewer infrastructure incorporating elements from Environmentally Friendly Seawalls Guide (OEH 2012)
St Georges Basin	STB01 (Blackett Park)	Low	Medium	Low	Low	Occurring and continuing	• Wind waves from southerly and south-westerly winds across the Basin, particularly when water levels within the Basin are high • Lack of stabilising foreshore vegetation to hold the banks together.	None	• Management controls including no-mow zones where foreshore vegetation is being undermined • Cobble beach to provide protection to root zone of undermined trees
St Georges Basin	IP01 (Island Point)	Low	Low	Low	Low	Occurring and continuing	• Wind waves from southerly and south-westerly winds across the Basin, particularly when water levels within the Basin are high • Lack of stabilising foreshore vegetation to hold the banks together.	None	• Management controls including no-mow zones where foreshore vegetation is being undermined
St Georges Basin	PB01 and PB02 (Paradise Beach)	Low	Low	Low	Low	Not occurring but likely	• Wind waves from southerly winds across the Basin, particularly when water levels within the Basin are high • Destabilisation and undercutting of the banks due to the presence of weeds and damage to foreshore vegetation • Incorporation of unstable fill into the banks • Public access leading to trampling of vegetation by foot traffic, and dragging of small craft over the banks leading to destabilisation of the bank, as well as ad-hoc storage of private craft	• Rock fillets to protect root zones • No-mow areas and saltmarsh planting has been successful over short sections of bank	• Cobble beach to provide protection to root zone of undermined trees • Fallen trees to dissipate wave energy reaching the bank where public foreshore access not required • Management controls including no-mow zones where foreshore vegetation is being undermined
St Georges Basin	WB01 (Wrights Beach)	Low	Low	Negligible	Negligible	Not occurring but likely	Wind waves	None	Riparian Vegetation Management
St Georges Basin	EB02 (Erowal Bay west)	Low	Negligible	Negligible	Negligible	Not occurring but likely	Wind waves	None	Riparian Vegetation Management
St Georges Basin	Tullarwalla Lagoon and Inlet	Low	Negligible	Negligible	Negligible	Not occurring but likely	• Vehicle access to foreshore • Undercutting of banks by vessel wash and tidal flows at high water levels.	Area along northern lagoon foreshore where direct vehicle access is controlled by fencing	Bollards similar to already installed at northern foreshore to control direct access to the lagoon foreshore by vehicles

Table 8-2 – Potential Management Actions for addressing erosion at Sussex Inlet

Estuary	Bank segment ID	Erosion Severity	Environmental Impact	Infrastructure / commercial impact	Amenity / safety impact	Future Trajectory	Main Causes	Existing Management Controls	Additional Management Controls
Sussex Inlet	S011 (Little Manly)	High	High	Low	Medium	Occurring and continuing	• Vessel waves, as the site is exposed to boat wash from recreational vessels as the navigation channel is directly adjacent to the bank at this location. Vessel waves cause erosion of the toe of the bank which becomes undermined and collapses into the navigation channel • River and tidal flow, as the high erosion site is located on the outside of a channel bend where there is erosive pressure due to channel meandering • For the sandy dune area, the dune is a relict transgressive dune feature from Bherwerre Beach which is at its natural angle of repose and is too steep for establishment of dune vegetation. Further, the dune is used as a recreation area and is further destabilised by public access onto the dune	None	• Use of large woody debris/brush matting sourced from collapsing vegetation at the site to provide protection to the toe of the slope • Management controls to reduce the impact of boat wash and prevent public access onto the unstable dune slope
Sussex Inlet	H01 (The Haven u/s)	High	Medium	Low	Medium	Occurring and continuing	• People accessing the dunes – including sand sliding • Erosion of the toe of the bank caused by vessel waves, as the site is exposed to boat wash from recreational and commercial vessels. Vessel waves cause erosion of the toe of the bank which becomes undermined and collapses into the navigation channel. • River and tidal flow, as the high erosion site is located on the outside of a channel bend where there is erosive pressure under high tidal and river flows due to natural channel meandering • Slope instability and lack of stabilising vegetation on the exposed sand slope, caused by wind erosion, geotechnical instability and rainfall/runoff on the unvegetated dune	None	• Upstream extension of existing geotextile groyne field along foreshore • Renourish with sand won from future dredging if available • Use of large woody debris/brush matting sourced from collapsing vegetation at the site to provide protection to the toe of the slope
Sussex Inlet	H03 (Big S, Haven d/s)	High	Medium	Low	Medium	Occurring and continuing	• People accessing the dunes – including sand sliding • Erosion of the toe of the bank caused by vessel waves, as the site is exposed to boat wash from recreational and commercial vessels. Vessel waves cause erosion of the toe of the bank which becomes undermined and collapses into the navigation channel • River and tidal flow, as the high erosion site is located on the outside of a channel bend where there is erosive pressure under high tidal and river flows due to natural channel meandering • Slope instability and lack of stabilising vegetation on the exposed sand slope, caused by wind erosion, geotechnical instability and rainfall/runoff on the unvegetated dune	None	Use of large woody debris/brush matting sourced from collapsing vegetation at the site to provide protection to the toe of the slope
Sussex Inlet	S006 (u/s Christians Minde)	High	Medium	Negligible	Negligible	Occurring and continuing	• Vessel waves, as the site is exposed to boat wash from recreational vessels • River and tidal flow, as the high erosion site is located on the outside of a channel bend where there is erosive pressure due to channel meandering	None	• Establishing a healthy riparian zone and for further migration of the channel slowed or halted through placement of large woody debris along the banks • Management controls to reduce the impact of boat wash

Estuary	Bank segment ID	Erosion Severity	Environmental Impact	Infrastructure / commercial impact	Amenity / safety impact	Future Trajectory	Main Causes	Existing Management Controls	Additional Management Controls
							• Lack of foreshore riparian vegetation at individual locations where this has been damaged by erosion and the presence of weeds along the bank are considered to be impacting on estuary bank stability		
Sussex Inlet	S012 (Alamein)	Medium	High	Medium	Medium	Occurring and continuing	• Vessel waves, as the site is exposed to boat wash from recreational vessels • River and tidal flow, as the navigation channel is located immediately adjacent to the site • Public access to the foreshore leading to trampling of the banks and impacts due to the presence of adhoc structures, which can cause erosion due to wave reflections and edge-effects • Lack of foreshore riparian vegetation	• None, ad-hoc building rubble	• The Decision Support Tool (DST) suggested the use of geotextile containers to protect the bank in this area. These could be in the form of groynes similar to those at The Haven combined with beach nourishment or use of cobble beaches, or geotextile container bank protection to replace the adhoc protection works currently in place at the site • The measures could be combined with appropriate riparian vegetation that still allows foreshore access by park users. Sections of rock revetment or timber seawalls could be used in selected locations where the banks are undermined and infrastructure is at threat. A key consideration for this area is the need for any erosion protection works to allow for the provision of ongoing access to registered moorings along this foreshore
Sussex Inlet	S004 (u/s Nielson L)	Medium	Medium	Low	Medium	Occurring and continuing	• Foreshore erosion in this location is being caused primarily by the meandering and migration of the deepest section of the main tidal channel of Sussex Inlet, due to tidal flows • Vessel waves, as the site is exposed to boat wash from recreational vessels and is located immediately adjacent to the deepest section of the navigation channel. • The use of unstable reclaimed fill within the bank, which is unsuitable for use as unprotected foreshore. • Lack of foreshore riparian vegetation, • High levels of private vessel access leading to trampling of the banks and vegetation, • Storage of small private craft leading to trampling/destabilisation of the banks and foreshore vegetation • Numerous mooring structures are considered to be impacting on estuary bank stability, through dragging of vessels onto banks to access moorings and additional bank scour induced by currents and waves interacting with these structures	• Rock groynes, geotextile, timber log seawalls	• A large-scale management strategy for this foreshore is required, recognising that foreshore erosion protection works will have a finite design life, due to the process causing the erosion. This would need to be the subject of a detailed investigation, however it could comprise a series of shore-normal groynes such as those already in place at The Haven to further push the centreline of the channel away from the toe of the slope and prevent further erosive pressure on the bank. DST suggestions only provide short-term management actions and included: • Maintenance of existing protection • A sloping rock, geobag, or timber log wall • This area is a high-use recreation area valued by the community, with the grassy reserve interfacing with the waters' edge. It may be appropriate to assess trees that have been undermined to be considered for lopping to reduce the risk of them toppling over and taking the bank with them. New trees can be planted (e.g. casuarinas) at around 2 m back from the foreshore, together with low riparian vegetation along the immediate foreshore between defined access points and where there are existing trees that have been undermined
Sussex Inlet	S010 (Ralph Lucas Waterway)	Medium	Medium	Low	Low	Occurring and continuing	• Vessel waves • Soft soils due to the location being a dredged channel	4-knot vessel speed limit	• Use of large woody debris/brush matting sourced from collapsing vegetation at the site to provide protection to the toe of the slope
Sussex Inlet	H05 (Croppers)	Medium	Low	Low	Medium	Occurring and continuing	• People accessing the dunes – including sand sliding • Vessel wash • Ocean waves eroding the toe of the existing slope	Timber toe protection wall	• Reconstruct/maintain failed sections of timber toe protection wall • Use of large woody debris/brush matting sourced from collapsing vegetation at the site to provide protection to the toe of the slope.

Estuary	Bank segment ID	Erosion Severity	Environmental Impact	Infrastructure / commercial impact	Amenity / safety impact	Future Trajectory	Main Causes	Existing Management Controls	Additional Management Controls
							• Slope instability due to the lack of stabilising vegetation and collapse of the slope due to toe scour • Meandering of the deepest section of channel toward this shoreline as a result of the growth of the flood tide delta on the opposite shore, fed by longshore sediment transport from Bherwerre Beach		• The use of dune fencing combined with brush matting and planting of dune vegetation in upper sections of the slope may allow vegetation to become established on the dune by creating terraced areas on the slope where the gradient is reduced and slope stability is improved
Sussex Inlet	S005 (d/s Nielson L)	Medium	Low	Low	Low	Occurring and continuing	• Vessel waves, as the site is exposed to boat wash from recreational vessels departing and arriving at the Neilson Lane boat ramp • Wind waves, as the channel is wide and parts of the foreshore are exposed to a relatively long wind fetch • Lack of foreshore riparian vegetation at individual locations and the presence of weeds along the bank are considered to be impacting on estuary bank stability.	None	• Maintaining foreshore vegetation
Sussex Inlet	H02 (Haven central)	Low	Low	Low	Low	Not occurring but likely	• People accessing the dunes – including sand sliding • Erosion of the toe of the bank caused by vessel waves, as the site is exposed to boat wash from recreational and commercial vessels. Vessel waves cause erosion of the toe of the bank which becomes undermined and collapses into the navigation channel • River and tidal flow, as the high erosion site is located on the outside of a channel bend where there is erosive pressure under high tidal and river flows due to natural channel meandering • Slope instability and lack of stabilising vegetation on the exposed sand slope, caused by wind erosion, geotechnical instability and rainfall/runoff on the unvegetated dune	• Geotextile groynes and beach nourishment undertaken in 2017	• Use of large woody debris/brush matting sourced from collapsing vegetation at the site to provide protection to the toe of the slope. • The use of dune fencing combined with brush matting and planting of dune vegetation in upper sections of the slope may allow vegetation to become established on the dune by creating terraced areas on the slope where the gradient is reduced and slope stability is improved
Sussex Inlet	H04 (Haven u/s croppers)	Low	Low	Low	Low	Occurring and continuing	• People accessing the dunes – including sand sliding • Vessel wash • Ocean waves eroding the toe of the existing slope • Slope instability due to the lack of stabilising vegetation and collapse of the slope due to toe scour • Meandering of the deepest section of channel toward this shoreline as a result of the growth of the flood tide delta on the opposite shore, fed by longshore sediment transport from Bherwerre Beach • Outflanking of the existing concrete seawall at site H04	• Old concrete seawall	• Use of large woody debris/brush matting sourced from collapsing vegetation at the site to provide protection to the toe of the slope. • The use of dune fencing combined with brush matting and planting of dune vegetation in upper sections of the slope may allow vegetation to become established on the dune by creating terraced areas on the slope where the gradient is reduced and slope stability is improved

Table 8-3 – Potential Management Actions for addressing erosion at Swan Lake

Estuary	Bank segment ID	Erosion Severity	Environmental Impact	Infrastructure / commercial impact	Amenity / safety impact	Future Trajectory	Main Causes	Existing Management Controls	Additional Management Controls
Swan Lake	SW02 (upper entrance channel)	Low	Low	Low	Low	Not occurring but likely	• River and tidal flow when the lake levels are high and scour occurs due to lake outflow, as the site is located on the outside of a channel bend where there is erosive pressure due to channel meandering • At Errol Bond Reserve, there is some damage occurring to the aboriginal midden at the corner of the inlet channel, as this area is being used for access into the water by unpowered craft	None	• Moving the location of the beach access point westward so that it does not impact the midden • Planting riparian vegetation to prevent erosion damage to the midden
Swan Lake	SW01 (lower entrance channel)	Moderate	Low	Negligible	Negligible	Occurring and continuing	• River and tidal flow when the lake entrance is open under high water levels, as the erosion site is located on the outside of a channel bend where there is erosive pressure due to channel meandering. The sudden breach in the entrance berm caused by deliberate lake openings can result in rapid flow velocity through the entrance area which results in erosive pressure at this bank • Ongoing seaward migration of the inlet channel bend at "The Gap" caused by river and tidal flow, eroding the landward side of relict beach dunes at this location	None	• Ongoing monitoring of erosion • Review of lake entrance management protocols

Table 8-4 – Potential Management Actions for addressing erosion at Berrara Creek

Estuary	Bank segment ID	Erosion Severity	Environmental Impact	Infrastructure / commercial impact	Amenity / safety impact	Future Trajectory	Main Causes	Existing Management Controls	Additional Management Controls
Berrara Creek	BC03 (Berrara Beach Holiday Chalets)	Medium	Medium	Low	Low	Occurring and continuing	• river and tidal flow, as the high erosion site is located on the outside of a channel bend where there is erosive pressure due to channel meandering • rainfall/runoff from the slope above the site were assessed to be contributing to bank instability, as well as undercutting of the banks when water levels and flow velocities in the creek are high. • lack of foreshore riparian vegetation and the presence of weeds along the bank are also considered to be impacting on estuary bank stability.	None	• As the bank is currently being undercut and is unstable, use of a rock revetment to prevent further undercutting could be considered where infrastructure is at risk. • Alternatively, stabilisation of the slope by cutting it back to a stable angle could be considered and the top of the bank slope planted with stabilising vegetation. Consultation with the Jerrinja people is suggested prior to cutting back the slope to avoid any damage to artefacts within the banks. • Collapsed foreshore vegetation could be used as "large woody debris" to protect the toe of the slope from undercutting due to tidal flows.
Berrara Creek	BC07 (opposite Fishermans Rock at powerlines)	Medium	Medium	Medium	Low	Occurring and continuing	• rainfall/runoff from the service road, which is a natural focal point for high velocity flows from rainfall. There is a lack of vegetation at the end of the service road	Rock fillets on service road to reduce velocity of runoff flows	• It is suggested that the eroded gully be repaired by filling (with gravel, and covered with compacted topsoil) and revegetated with riparian vegetation, in accordance with the area along the natural sections of bank adjacent to the site. • In conjunction, drainage from the road needs to be redirected to prevent further erosion of the site, either by using additional gravel sills along the road, or installation of a dish drain to direct drainage away from the creek banks
Berrara Creek	BC01 (just upstream entrance)	Low	Low	Low	Medium	Occurring and continuing	• ocean waves, as the site is exposed to swell waves when the creek entrance is open • river and tidal flow during times when there are high flows in the creek • rainfall and runoff flows being concentrated onto the slope by the presence of the concrete footpath and overflow from the stormwater pit at the top of the bank • lack of foreshore riparian vegetation and the presence of weeds along the bank.	None	• beach nourishment/beach scraping to protect the bank in this area. Replacement of sand at the toe of the slope • management actions to address stormwater runoff and improve foreshore vegetation management • An upgrade of the access track at this location to reduce the impact of concentrated rainfall/runoff flows and improve foreshore access is suggested.
Berrara Creek	BC02 (upstream beach access)	Low	Low	Low	Low	Occurring and continuing	• river and tidal flow • rainfall/runoff from upper sections of the slope.	• None	• None suggested
Berrara Creek	BC04 (Berrara Waters)	Low	Low	Low	Low	Occurring and continuing	• river and tidal flow from the main creek as well as from outflows from the tributary immediately north of the site. • public access to the foreshore causing trampling of vegetation and destabilisation of the banks.	• None	• riparian vegetation management • However, it is noted that the substrate is rocky in front of the banks in this area, and that riparian vegetation may fail to establish in this area. Use of rock fillets beneath the undermined sections of bank may be a more appropriate action for this area
Berrara Creek	BC05 (Lakeland Avenue)	Low	Low	Low	Low	Occurring and continuing	• wind waves, as the site is exposed to a fetch distance of 500 m • some swell waves when the entrance area is open • lack of foreshore riparian vegetation at individual locations and ad-hoc kayak storage/access • some stormwater erosion at the outlets discharging on the beach.	• None	• provision of kayak storage/kayak skid to prevent damage to foreshore vegetation from dragging of kayaks across the foreshore • establishment of formalised access points to the beach with a riparian vegetation zone to be established along other sections of the foreshore to become established. • capture of stormwater runoff upstream of the site or through the use of a swale adjacent to the boat ramp area.
Berrara Creek	BC06 (Southern bank opposite Lakeland Avenue)	Low	Low	Negligible	Negligible	Occurring and continuing	• River and tidal flows	None	None suggested

9 Conclusion

This report documents a detailed field-based assessment of erosion and foreshore issues affecting the estuary health of St Georges Basin, Sussex Inlet, Swan Lake and Berrara Creek. The shoreline has been inspected in detail, including from the water by boat and from land by foot, and features indicative of the coastal processes occurring at the various sites within the study area have been documented.

Key areas that have suffered from erosion include:

- Sussex Inlet – foreshore west of Nielson Lane, Croppers (the Big "S"), The Haven, Alamein, Little Manly, Christian's Minde
- St Georges Basin – especially the south-facing areas along the northern foreshore where the foreshore has been reclaimed with fill materials and where fringing vegetation is absent from the shoreline
- Berrara Creek – northern and eastern foreshores.

Causes of erosion at these areas include:

- Sussex Inlet
    - erosion at outer side of channel bends, caused by channel meandering
    - erosion at the toe of steep unstable sand banks (Little Manly and The Haven), caused by vessel wash, slope instability and people accessing and sliding on the dunes
    - erosion of unstable fill materials that do not have sufficient stability to resist wave action (Sussex Inlet upstream of Neilson Lane boat ramp)
    - erosion caused by outflanking of existing foreshore protection works (Lions Club boat ramp)
    - erosion caused by toppling of fringing foreshore vegetation, caused by undercutting of the banks, especially where riparian zones are narrow.
- St Georges Basin
    - erosion caused by wind waves at high water levels, undermining fringing vegetation and toppling of this vegetation by strong winds, especially where riparian zones are narrow
    - erosion of unstable fill materials that do not have sufficient stability to resist wave action
    - erosion caused by outflanking of private foreshore structures
    - erosion caused by access to the foreshore (e.g. ad-hoc vessel storage, stock access at Wandandian Creek, lack of foreshore vegetation)
    - erosion caused by vessel wash (near boat ramps and along Wandandian Creek).
- Berrara Creek

- erosion caused by lack of foreshore vegetation, ad-hoc vessel storage, stormwater/catchment outflows.

Potential management actions for the erosion were assessed using the DPE Decision Support Tool, with specific actions outlined and identified for each area where erosion has been documented. The management actions included:

- management of foreshore vegetation
- large woody debris
- cobble beaches
- maintenance of existing foreshore works.

While the Decision Support Tool generally provided suggested management actions that were useful, there were some instances where the suggested actions from the Decision Support Tool were not supported by observations on site, due to the specific conditions at some sites. Specific management actions for these sites will be assessed as part of Stage 3 of the Coastal Management Program.

Historical rates of erosion and future erosion risk were assessed based on available information, although historical information was limited (particularly at Swan Lake and Berrara Creek). Erosion rates up to 1 m/year were estimated based on analysis of historical survey data and aerial photography at specific erosion hotspot locations identified from the fieldwork along the northern foreshore of St Georges Basin and at Sussex Inlet. The analysis highlighted that erosion tended to occur along short discrete sections of shoreline, rather than uniformly along the entire foreshore, which demonstrates that specific management actions would likely be likely be effective in addressing the erosion. It is likely that sea level rise due to climate change would exacerbate the erosion risk at all estuaries, as one of the main mechanisms for the erosion is wave action occurring at high water levels. At Sussex Inlet, the main mechanism for foreshore erosion is meandering of the channel due to tidal flow, with erosion occurring on the outer side of channel bends.

10 References

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Appendix A
Fieldwork Datasheets

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name Berara Ck	1/12 10.10 am	
Location ID (mark on map) BC01		
Environmental Impact of erosion (negl., low, mod, high)	N (L) M H	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N L (M) H	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	
Current Erosion severity	N (L) M H E	
Contributing Cause (circle all that apply) Stormwater pit needs maintenance is full of sediment	Wind waves (Ocean waves) Vessel waves (River/tidal flow) Sediment extraction Stock access (Public access) (Rainfall/run off)	
Upper, mid or lower estuary	U M (L)	
Location of erosion (Top, upper, lower bank)	T (U) (L) whole bank?	
Channel geometry (inside bend, outside bend, straight, basin)	(I) O S B	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	(B) C (NC) U layer of sand over rock	
Immediate landward constraint to treatment?	Y (N)	
Any offshore constraint?	Y (N)	
Public access to foreshore required?	(Y) N	
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N (L) M H	
Width of riparian vegetation	<2 (<5) <10 <20 >20m	
Are weeds contributing to instability?	(Y) N	
Existing erosion control method?	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	(N) C PC PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name Berrara CK BC02	1/12 10.70am	
Location ID (mark on map) BU02		
Environmental Impact of erosion (negl., low, mod, high)	N (L) M H	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N (L) M H	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and slow) Occurring and continuous Occurring and accelerating	
Current Erosion severity	N (L) M H E	
Contributing Cause (circle all that apply)	Wind waves Ocean waves Vessel waves (River/tidal flow) Sediment extraction Stock access Public access	
Upper, mid or lower estuary	U M (L)	
Location of erosion (Top, upper, lower bank)	T U (L)	
Channel geometry (inside bend, outside bend, straight, basin)	I O (S) B	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	(B) C NC U	
Immediate landward constraint to treatment?	(Y) N ~~Road~~ Very steep slope	
Any offshore constraint?	Y (N)	
Public access to foreshore required?	Y (N)	
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N (L) M H	
Width of riparian vegetation	(<2) <5 <10 <20 >20m	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method?	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	(N) C PC PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name Bevara Ck	BC03	
Location ID (mark on map) BC03 1/12	10.30am	
Environmental Impact of erosion (negl., low, mod, high)	N L M H	Sediment
Infrastructure/Commercial impact	N L M H	
Amenity/Safety Impact	N L M H	
Future Trajectory	Not occurring, not likely Not occurring but likely Occurring and continuous Occurring and accelerating	
Current Erosion severity	N L M H E	
Contributing Cause (circle all that apply)	Wind waves Ocean waves Vessel waves River/tidal flow Sediment extraction Stock access Public access	loss of vegetation.
Upper, mid or lower estuary	U M L	
Location of erosion (Top, upper, lower bank)	T U L	
Channel geometry (inside bend, outside bend, straight, basin)	I O S B	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	S M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C NC U	
Immediate landward constraint to treatment?	Y N	
Any offshore constraint?	Y N	
Public access to foreshore required?	Y N	
High value asset at risk?	Y N	steep slope above, caravan park
Riparian vegetation community? (none, low, moderate, high)	N L M H	
Width of riparian vegetation	<2 <5 <10 <20 >20m	
Are weeds contributing to instability?	Y N	
Existing erosion control method?	None Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	– asbestos?
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	N C PC PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name Berrima Ck 2/12 11.00am		
Location ID (mark on map) BC04		
Environmental Impact of erosion (negl., low, mod, high)	N (L) M H	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N (L) M H	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	
Current Erosion severity	N (L) M H E	
Contributing Cause (circle all that apply)	Wind waves Ocean waves Vessel waves (River/tidal flow) Sediment extraction Stock access Public access	wet weather flow from tributary
Upper, mid or lower estuary	U M (L)	
Location of erosion (Top, upper, lower bank)	T U (L)	
Channel geometry (inside bend, outside bend, straight, basin)	I O S B Tributary Mouth	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C (NC) U Sandy	
Immediate landward constraint to treatment?	Y (N)	
Any offshore constraint?	Y (N)	
Public access to foreshore required?	(Y) N Reserve	
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N (L) M H	
Width of riparian vegetation	(<2) <5 <10 <20 >20m	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method? Riparian veg - 5m strip similar to existing further down	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	(N) C PC PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name Berrara Ck BCO5		
Location ID (mark on map) BCO5 11.05am		
Environmental Impact of erosion (negl., low, mod, high)	N (L) M H	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N (L) M H	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) ← Slow Occurring and accelerating	
Current Erosion severity	N (L) M H E	
Contributing Cause (circle all that apply)	(Wind waves) Ocean waves Vessel waves River/tidal flow Sediment extraction Stock access (Public access)	Formalise kayak storage ?
Upper, mid or lower estuary	U M (L)	
Location of erosion (Top, upper, lower bank)	T (U) L	
Channel geometry (inside bend, outside bend, straight, basin)	I (O) S B	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C (NC) U	Sand/clay
Immediate landward constraint to treatment?	Y (N)	
Any offshore constraint?	Y (N)	
Public access to foreshore required?	(Y) N	Reserve
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N (L) M H	
Width of riparian vegetation	<2 (<5) <10 <20 >20m	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method? Revegetation, riparian veg Access control kayak storage – kayak skid? – Specific locations/actions for CMP.	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	N C PC PD I R	

– formal access
– capture runoff

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name Benara CR		
Location ID (mark on map) BC06 7/12 11am		
Environmental Impact of erosion (negl., low, mod, high)	N (L) M H	
Infrastructure/Commercial impact	(N) L M H	
Amenity/Safety Impact	(N) L M H	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	
Current Erosion severity	N L M H E	
Contributing Cause (circle all that apply)	(Wind waves) Ocean waves Vessel waves (River/tidal flow) Sediment extraction Stock access Public access	
Upper, mid or lower estuary	U M (L)	
Location of erosion (Top, upper, lower bank)	T U (L)	
Channel geometry (inside bend, outside bend, straight, basin)	(I) O S B	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C (NC) U	
Immediate landward constraint to treatment?	Y (N)	
Any offshore constraint?	Y (N)	
Public access to foreshore required?	Y (N)	
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N L M (H)	
Width of riparian vegetation	<2 <5 <10 <20 (>20m)	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method?	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	(N) C PC PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name Swan Lake 16/2/22		
Location ID (mark on map) SW01 lower entrance (west)		
Environmental Impact of erosion (negl., low, mod, high)	N (L) M H	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N (L) M H	
Future Trajectory	Not occurring, not likely (Not occurring but likely) Occurring and continuous Occurring and accelerating	
Current Erosion severity	N (L) M H E	
Contributing Cause (circle all that apply)	Wind waves Ocean waves Vessel waves (River/tidal flow) Sediment extraction Stock access Public access	
Upper, mid or lower estuary	U M (L)	
Location of erosion (Top, upper, lower bank)	T (U) L	
Channel geometry (inside bend, outside bend, straight, basin)	I (O) S B	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B (C) NC U	
Immediate landward constraint to treatment?	(Y) N reserve	
Any offshore constraint?	(Y) N channel	
Public access to foreshore required?	Y (N)	
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N L (M) H	
Width of riparian vegetation	<2 (<5) <10 <20 >20m	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method?	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	(N) C PC PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name Swan Lake 16/2/22		
Location ID (mark on map) SW02 (Upper entrance channel)		
Environmental Impact of erosion (negl., low, mod, high)	N (L) M H	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N (L) M H	
Future Trajectory	Not occurring, not likely (Not occurring but likely) Occurring and continuous Occurring and accelerating	
Current Erosion severity	N (L) M H E	
Contributing Cause (circle all that apply)	Wind waves Ocean waves Vessel waves (River/tidal flow) Sediment extraction Stock access Public access	
Upper, mid or lower estuary	U M (L)	
Location of erosion (Top, upper, lower bank)	T U (L)	
Channel geometry (inside bend, outside bend, straight, basin)	I O (S) B	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C (NC) U	
Immediate landward constraint to treatment?	(Y) N	
Any offshore constraint?	(Y) N channel	
Public access to foreshore required?	Y (N)	
High value asset at risk?	(Y) N Pumping Station	
Riparian vegetation community? (none, low, moderate, high)	N (L) M H	
Width of riparian vegetation	<2 (<5) <10 <20 >20m	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method?	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	(N) C PC PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name	HOI The Haven	
Location ID (mark on map)	HOI 1/12 2.50pm	
Environmental Impact of erosion (negl., low, mod, high)	N L (M) H – steep dune	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N L (M) H – bare sand, kids riding on slope	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	
Current Erosion severity	N L M (H) E slope instability	
Contributing Cause (circle all that apply)	Wind waves Ocean waves (Vessel waves) River/tidal flow Sediment extraction Stock access (Public access)	too steep no vegetation not really bank erosion – vessel waves at the toe
Upper, mid or lower estuary	U M (L)	
Location of erosion (Top, upper, lower bank)	(T) U L	
Channel geometry (inside bend, outside bend, straight, basin)	I (O) S B	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	S (M) D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C (NC) U sand dune	
Immediate landward constraint to treatment?	(Y) N steep slope	
Any offshore constraint?	Y (N)	
Public access to foreshore required?	(Y) N	
High value asset at risk?	Y (N) sandy	
Riparian vegetation community? (none, low, moderate, high)	N L (M) H slope very steep;	
Width of riparian vegetation	<2 <5 <10 <20 >20m	try to replant?
Are weeds contributing to instability?	Y (N)	
Existing erosion control method? planting? brush matting? more groynes?	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	(N) C PC PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name The Haven 1/12 2.40pm		
Location ID (mark on map) H02 (groynes)		
Environmental Impact of erosion (negl., low, mod, high)	N (L) M H	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N (L) M H	
Future Trajectory	Not occurring, not likely (Not occurring but likely) Occurring and continuous Occurring and accelerating	
Current Erosion severity	N (L) M H E	
Contributing Cause (circle all that apply)	Wind waves Ocean waves (Vessel waves) (River/tidal flow) Sediment extraction Stock access Public access	
Upper, mid or lower estuary	U M (L)	
Location of erosion (Top, upper, lower bank)	T (U) L	
Channel geometry (inside bend, outside bend, straight, basin)	I (O) S B	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	S (M) D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C (NC) U Sandy	
Immediate landward constraint to treatment?	(Y) N Slope, steep, sandbags	
Any offshore constraint?	(Y) N Channel	
Public access to foreshore required?	(Y) N	
High value asset at risk?	(Y) N stormwater?	
Riparian vegetation community? (none, low, moderate, high)	N L (M) H	
Width of riparian vegetation	<2 <5 (<10) <20 >20m	
Are weeds contributing to instability?	(Y) N Grass, asparagus fern	
Existing erosion control method? — more sand → beneficial reuse / opportunistic use of sand? → more groynes?	None Rock Revetment Rock Fillets (Geotextile sand containers) Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures (Groynes) — geotextile Cobble Beaches Seawall Concrete Other (acceptable) (Beach Nourishment) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	N (C) PC PD I R → C	

Green & gold Bell frogs
→ implications of water levels on this habitat.

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name Sussex Inlet H03	1/2	
Location ID (mark on map)		
Environmental Impact of erosion (negl., low, mod, high)	N L (M) H	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N L (M) H	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	
Current Erosion severity	N L M (H) E	
Contributing Cause (circle all that apply) Slope stability	Wind waves Ocean waves (Vessel waves) (River/tidal flow) Sediment extraction Stock access Public access	
Upper, mid or lower estuary	U M (L)	
Location of erosion (Top, upper, lower bank)	(T) (U) L	
Channel geometry (inside bend, outside bend, straight, basin)	I (O) S B	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	S (M) D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C (NC) U	
Immediate landward constraint to treatment?	(Y) N Steep slope	
Any offshore constraint?	(Y) N channel	
Public access to foreshore required?	(Y) N	
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N L M (H)	
Width of riparian vegetation	<2 <5 <10 <20 (>20m)	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method?	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	(N) C PC PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name Sussex Inlet HO4	1/12 3.20pm	
Location ID (mark on map)		
Environmental Impact of erosion (negl., low, mod, high)	N (L) M H	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N (L) M H	
Future Trajectory episodic, ocean waves	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	
Current Erosion severity	N (L) M H E	
Contributing Cause (circle all that apply)	Wind waves (Ocean waves) Vessel waves River/tidal flow Sediment extraction Stock access Public access	
Upper, mid or lower estuary	U M (L)	
Location of erosion (Top, upper, lower bank)	T (U) L	
Channel geometry (inside bend, outside bend, straight, basin)	I O S B	entrance bar
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C NC U	Sand on bedrock
Immediate landward constraint to treatment?	(Y) N	Existing damaged concrete retaining wall
Any offshore constraint?	Y (N)	
Public access to foreshore required?	(Y) N	
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N (L) M H	
Width of riparian vegetation	(<2) <5 <10 <20 >20m	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method?	None Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches (Seawall) — damaged concrete seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	N C PC PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name Coppers HO5 1/12/21		
Location ID (mark on map) 3.40pm		
Environmental Impact of erosion (negl., low, mod, high)	N (L) M H	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact Timber wall - aesthetic issue safety.	N L (M) H	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	
Current Erosion severity	N L (M) H E	
Contributing Cause (circle all that apply)	Wind waves (Ocean waves) Vessel waves (River/tidal flow) Sediment extraction Stock access Public access	Slope instability
Upper, mid or lower estuary	U M (L)	
Location of erosion (Top, upper, lower bank)	(T) U L	
Channel geometry (inside bend, outside bend, straight, basin)	I (O) S B	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C (NC) U	Sand on bedrock
Immediate landward constraint to treatment?	(Y) N	Steep slope, clay slope
Any offshore constraint?	Y (N)	
Public access to foreshore required?	(Y) N	
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N (L) M H	
Width of riparian vegetation	<2 <5 (<10) <20 >20m	
Are weeds contributing to instability?	(Y) N	
Existing erosion control method? - Could cut wall lower? - repair overturning sections.	None Rock Revetment Rock Fillets Geotextile sand containers (Timber walling) Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	N C PC (PD) I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name Sussex Inlet		
Location ID (mark on map) Fairview Cres.	SI001 27/11	3.15pm
Environmental Impact of erosion (negl., low, mod, high)	N (L) M H	
Infrastructure/Commercial impact	N (L) M H	Small private jetties
Amenity/Safety Impact	N (L) M H	public Reserve
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	Lack of foreshore vegetation
Current Erosion severity	N (L) M H E	
Contributing Cause (circle all that apply)	(Wind waves) Ocean waves Vessel waves (River/tidal flow) Sediment extraction Stock access Public access	
Upper, mid or lower estuary	(U) M L	Close to entrance of St. Georges Bay
Location of erosion (Top, upper, lower bank)	T U (L)	
Channel geometry (inside bend, outside bend, straight, basin)	I O (S) B	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C (NC) U	
Immediate landward constraint to treatment?	Y (N)	
Any offshore constraint?	(Y) N	private jetties
Public access to foreshore required?	(Y) N	public reserve
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N (L) M H	Casuarinas, scattered
Width of riparian vegetation	<2 <5 (<10) <20 >20m	some mangroves
Are weeds contributing to instability?	(Y) N	lawn grass
Existing erosion control method?	None Rock Revetment Rock Fillets Geotextile sand containers Timber walling (Log/timber revetment) Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble (Tyres) Unacceptable (other)	large number logs providing partial protection Tyres seen in some areas.
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	N C (PC) PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name 27/11 3.40pm	Sussex Inlet	
Location ID (mark on map)	SD02 Badgee Lagoon	
Environmental Impact of erosion (negl., low, mod, high)	N (L) M H	
Infrastructure/Commercial impact	(N) L M H	
Amenity/Safety Impact	(N) L M H	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	Some casuarina trees undermined
Current Erosion severity	N (L) M H E	
Contributing Cause (circle all that apply)	(Wind waves) Ocean waves (Vessel waves) (River/tidal flow) Sediment extraction Stock access Public access	
Upper, mid or lower estuary	(U) M L	
Location of erosion (Top, upper, lower bank)	T (U) L	
Channel geometry (inside bend, outside bend, straight, basin)	I O S (B)	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	S M (D)	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C NC (U)	
Immediate landward constraint to treatment?	(Y) N	Foreshore veg
Any offshore constraint?	Y (N)	
Public access to foreshore required?	Y (N)	
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N L M (H)	Highly vegetated
Width of riparian vegetation	<2 <5 <10 <20 (>20m)	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method?	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	Natural area, but accelerated currents due to constriction caused by bridge.
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	(N) C PC PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name 27/11 3.50pm	Susser Inlet	
Location ID (mark on map)	5003	
Environmental Impact of erosion (negl., low, mod, high)	N (L) M H	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N (L) M H	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	
Current Erosion severity	N (L) M H E	Mangroves undermined
Contributing Cause (circle all that apply)	(Wind waves) Ocean waves (Vessel waves) River/tidal flow Sediment extraction Stock access Public access	
Upper, mid or lower estuary	U (M) L	
Location of erosion (Top, upper, lower bank)	T U (L)	
Channel geometry (inside bend, outside bend, straight, basin)	I (O) S B	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C (NC) U	
Immediate landward constraint to treatment?	Y (N)	
Any offshore constraint?	Y (N)	
Public access to foreshore required?	(Y) N	
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N (L) M H	Occasional mangroves
Width of riparian vegetation	(<2) <5 <10 <20 >20m	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method?	None Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures (Groynes) Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	N C PC (PD) I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name Sussex Inlet 27/11 4.00pm		
Location ID (mark on map) S004		
Environmental Impact of erosion (negl., low, mod, high)	N L (M) H	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N L (M) H	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	
Current Erosion severity	N L (M) H E	
Contributing Cause (circle all that apply)	(Wind waves) Ocean waves (Vessel waves) River/tidal flow Sediment extraction Stock access (Public access)	
Upper, mid or lower estuary	U (M) L	
Location of erosion (Top, upper, lower bank)	T U (L)	
Channel geometry (inside bend, outside bend, straight, basin)	I O (S) B	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C (NC) U	
Immediate landward constraint to treatment?	Y (N)	
Any offshore constraint?	(Y) N	Private jetties
Public access to foreshore required?	(Y) N	Public reserve
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N (L) M H	Occasional casuarina but mostly cleared
Width of riparian vegetation	(<2) <5 <10 <20 >20m	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method?	None (Rock Revetment) Rock Fillets (Geotextile sand containers) Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	Single layer of rock detached from bank.
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	N C PC PD (I) R	Erosion is continuing behind rock protection

Numerous private jetties, numerous vessels tied up, public foreshore reserve used by waterfront resorts

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name Sussex Inlet 27/11 4.15pm		
Location ID (mark on map) 5005		
Environmental Impact of erosion (negl., low, mod, high)	N (L) M H	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N (L) M H	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	
Current Erosion severity	N L (M) H E	
Contributing Cause (circle all that apply)	Wind waves Ocean waves (Vessel waves) River/tidal flow Sediment extraction Stock access Public access	
Upper, mid or lower estuary	U (M) L	
Location of erosion (Top, upper, lower bank)	T (U) (L)	
Channel geometry (inside bend, outside bend, straight, basin)	I O (S) B	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	S (M) D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C (NC) U	
Immediate landward constraint to treatment?	Y (N)	
Any offshore constraint?	(Y) N	Private jetties
Public access to foreshore required?	(Y) N	
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N (L) M H	Casuarinas
Width of riparian vegetation	(<2) <5 <10 <20 >20m	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method?	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris (Revegetation) – eastern end of site just u/s of Marine centre revegetation has worked well, but upstream of this toward Nelson Boat Ramp is affected by moderate erosion Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	N C PC (PD) I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name Sussex Inlet		
Location ID (mark on map) S006 27/11 4.15pm		
Environmental Impact of erosion (negl., low, mod, high)	N L (M) H	Loss of mature trees
Infrastructure/Commercial impact	(N) L M H	
Amenity/Safety Impact	(N) L M H	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	
Current Erosion severity	N L (M) (H) E	
Contributing Cause (circle all that apply)	Wind waves Ocean waves (Vessel waves) (River/tidal flow) Sediment extraction Stock access Public access	~~Inside bend~~ Outside bend where channel is meandering
Upper, mid or lower estuary	U (M) L	
Location of erosion (Top, upper, lower bank)	T U (L)	
Channel geometry (inside bend, outside bend, straight, basin)	I (O) S B	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	~~S~~ M (D)	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C (NC) U	
Immediate landward constraint to treatment?	(Y) N	Riparian veg.
Any offshore constraint?	(Y) N	Navigation channel
Public access to foreshore required?	Y (N)	
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N L M (H)	
Width of riparian vegetation	<2 <5 <10 <20 (>20m)	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method?	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	(N) C PC PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name Sussex Inlet		
Location ID (mark on map) S007 27/11 4:30pm		
Environmental Impact of erosion (negl., low, mod, high)	(N) L M H	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N (L) M H	
Future Trajectory	Not occurring, not likely (Not occurring but likely) Occurring and continuous Occurring and accelerating	
Current Erosion severity	N (L) M H E	
Contributing Cause (circle all that apply)	Wind waves Ocean waves (Vessel waves) River/tidal flow Sediment extraction Stock access Public access	
Upper, mid or lower estuary	U (M) L	
Location of erosion (Top, upper, lower bank)	T U (L)	
Channel geometry (inside bend, outside bend, straight, basin)	I O (S) B	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C (NC) U	
Immediate landward constraint to treatment?	Y (N)	
Any offshore constraint?	(Y) N Private Jetties	
Public access to foreshore required?	(Y) N	
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N L (M) H	
Width of riparian vegetation	<2 (<5) <10 <20 >20m	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method?	None Rock Revetment Rock Fillets Geotextile sand containers Timber walling (Log/timber revetment) Large woody debris (Revegetation) Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	Where riparian vegetation was intact, no erosion was visible. Area was very low lying and shared path was flooded.
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	N C (PC) PD I R	

Riparian vegetation protected the bank effectively.

Proforma for Bank Erosion

Sussex Inlet 7/12	Response (circle)	Comment
Estuary name SOO8 Near River Rd.		
Location ID (mark on map) SOO8		
Environmental Impact of erosion (negl., low, mod, high)	N (L) M H	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N (L) M H	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	
Current Erosion severity	N (L) M H E	
Contributing Cause (circle all that apply)	Wind waves Ocean waves (Vessel waves) River/tidal flow Sediment extraction Stock access Public access	
Upper, mid or lower estuary	U (M) L	
Location of erosion (Top, upper, lower bank)	T U (L)	
Channel geometry (inside bend, outside bend, straight, basin)	I O (S) B	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	S (M) D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C NC (U)	
Immediate landward constraint to treatment?	(Y) N Reserve boat ramp	
Any offshore constraint?	(Y) N channel	
Public access to foreshore required?	(Y) N	
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N (L) M H	
Width of riparian vegetation	(<2) <5 <10 <20 >20m	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method?	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	(N) C PC PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name Sussex Inlet 7/12		
Location ID (mark on map) S009 Island in Quays		
Environmental Impact of erosion (negl., low, mod, high)	N (L) M H	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N (L) M H	
Future Trajectory	Not occurring, not likely (Not occurring but likely) Occurring and continuous Occurring and accelerating	
Current Erosion severity	N (L) M H E	
Contributing Cause (circle all that apply)	Wind waves Ocean waves (Vessel waves) River/tidal flow Sediment extraction Stock access Public access	
Upper, mid or lower estuary	U (M) L	
Location of erosion (Top, upper, lower bank)	T (U) L	
Channel geometry (inside bend, outside bend, straight, basin)	I O S B Island	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C (NC) U	
Immediate landward constraint to treatment?	Y (N)	
Any offshore constraint?	Y (N)	
Public access to foreshore required?	(Y) N	
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N (L) M H	
Width of riparian vegetation	(<2) <5 <10 <20 >20m	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method?	None (Rock Revetment) Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	N C (PC) PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name Sussex Inlet Chris Ck		
Location ID (mark on map) S010		
Environmental Impact of erosion (negl., low, mod, high)	N L (M) H	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N (L) M H	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	
Current Erosion severity	N L (M) H E	
Contributing Cause (circle all that apply)	Wind waves Ocean waves (Vessel waves) River/tidal flow Sediment extraction Stock access Public access	
Upper, mid or lower estuary	U (M) L	
Location of erosion (Top, upper, lower bank)	T U (L)	
Channel geometry (inside bend, outside bend, straight, basin)	I O (S) B	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	S (M) D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C (NC) U	
Immediate landward constraint to treatment?	Y (N)	
Any offshore constraint?	(Y) N channel	
Public access to foreshore required?	Y (N)	
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N L M (H)	
Width of riparian vegetation	<2 <5 <10 <20 (>20m)	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method?	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	(N) C PC PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name Sussex Inlet 7/12		
Location ID (mark on map) 5011 Little Manly		
Environmental Impact of erosion (negl., low, mod, high)	N L M (H)	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N L (M) H	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	
Current Erosion severity	N L M (H) E	
Contributing Cause (circle all that apply)	Wind waves Ocean waves (Vessel waves) (River/tidal flow) Sediment extraction Stock access Public access	
Upper, mid or lower estuary	U (M) L	
Location of erosion (Top, upper, lower bank)	T (U) (L)	
Channel geometry (inside bend, outside bend, straight, basin)	I (O) S B	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	S (M) D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C (NC) U	
Immediate landward constraint to treatment?	Y (N)	
Any offshore constraint?	(Y) N channel	
Public access to foreshore required?	Y (N)	
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N L M (H)	
Width of riparian vegetation	<2 <5 <10 <20 (>20m)	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method?	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	(N) C PC PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name Sussex Inlet 7/12		
Location ID (mark on map) Alamein S012		
Environmental Impact of erosion (negl., low, mod, high)	N L M (H)	
Infrastructure/Commercial impact	N L (M) H	
Amenity/Safety Impact	N L (M) H	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	
Current Erosion severity	N L (M) H E	
Contributing Cause (circle all that apply)	Wind waves Ocean waves (Vessel waves) River/tidal flow Sediment extraction Stock access (Public access)	
Upper, mid or lower estuary	U M (L)	
Location of erosion (Top, upper, lower bank)	T (U) L	
Channel geometry (inside bend, outside bend, straight, basin)	I O (S) B	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	S (M) D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C (NC) U	
Immediate landward constraint to treatment?	(Y) N	Caravan Park
Any offshore constraint?	(Y) N	channel
Public access to foreshore required?	(Y) N	
High value asset at risk?	(Y) N	
Riparian vegetation community? (none, low, moderate, high)	(N) L M H	
Width of riparian vegetation	(<2) <5 <10 <20 >20m	
Are weeds contributing to instability?	(Y) N	
Existing erosion control method?	None Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) (Building rubble) Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	N C PC PD (I) R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name St George Basin 28/11 9.15am		
Location ID (mark on map) WB01 Wrights Beach		
Environmental Impact of erosion (negl., low, mod, high)	N (L) M H	
Infrastructure/Commercial impact	(N) L M H	
Amenity/Safety Impact	(N) L M H	
Future Trajectory	Not occurring, not likely (Not occurring but likely) Occurring and continuous Occurring and accelerating	
Current Erosion severity	N (L) M H E	
Contributing Cause (circle all that apply)	(Wind waves) Ocean waves Vessel waves River/tidal flow Sediment extraction Stock access Public access	
Upper, mid or lower estuary	(U) (M), L	
Location of erosion (Top, upper, lower bank)	T (U) L	
Channel geometry (inside bend, outside bend, straight, basin)	I O S (B)	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C (NC) U Bedrock shallowly overlain by sand	
Immediate landward constraint to treatment?	Y (N)	
Any offshore constraint?	Y (N)	
Public access to foreshore required?	(Y) N Caravan Park	
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N (L) M H Casuarinas	
Width of riparian vegetation	(<2) <5 <10 <20 >20m	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method?	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	N C (PC) PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name St Georges Basin		
Location ID (mark on map) Erowal Bay EB01		
Environmental Impact of erosion (negl., low, mod, high)	N (L) M H	
Infrastructure/Commercial impact	N L (M) H	
Amenity/Safety Impact	N (L) M H	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	
Current Erosion severity	N L (M) H E	
Contributing Cause (circle all that apply)	(Wind waves) Ocean waves Vessel waves River/tidal flow Sediment extraction Stock access Public access	Stormwater runoff.
Upper, mid or lower estuary	(U) M L	
Location of erosion (Top, upper, lower bank)	T (U) L	
Channel geometry (inside bend, outside bend, straight, basin)	I O S (B)	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B (C) NC U	clay
Immediate landward constraint to treatment?	(Y) N	Sewer & stormater
Any offshore constraint?	Y (N)	
Public access to foreshore required?	(Y) N	only public access here.
High value asset at risk?	(Y) N	sewer
Riparian vegetation community? (none, low, moderate, high)	(N) L M H	
Width of riparian vegetation	(<2) <5 <10 <20 >20m	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method?	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) (Building rubble) Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	(N) C PC PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name St Georges Basin 28/11 10.00am		
Location ID (mark on map) EB02 Gowal Bay		
Environmental Impact of erosion (negl., low, mod, high)	(N) L M H	
Infrastructure/Commercial impact	(N) L M H	
Amenity/Safety Impact	(N) L M H	
Future Trajectory	Not occurring, not likely (Not occurring but likely) Occurring and continuous Occurring and accelerating	
Current Erosion severity	N (L) M H E	
Contributing Cause (circle all that apply)	(Wind waves) Ocean waves Vessel waves River/tidal flow Sediment extraction Stock access Public access	
Upper, mid or lower estuary	(U) M L	
Location of erosion (Top, upper, lower bank)	T U (L)	
Channel geometry (inside bend, outside bend, straight, basin)	I O S (B)	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B (C) NC U	
Immediate landward constraint to treatment?	Y (N)	
Any offshore constraint?	(Y) N Jetties	
Public access to foreshore required?	(Y) N	
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N (L) M H Casuarinas	
Width of riparian vegetation	(<2) <5 <10 <20 >20m	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method? Casuarina roots are stabilising the banks but risk of undercutting	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	N C (PC) PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name St Georges Basin 28/11 10.20am		
Location ID (mark on map) OEB01 Old Gravel Bay	Prentice Ave Reserve	
Environmental Impact of erosion (negl., low, mod, high)	N L (M) H	
Infrastructure/Commercial impact	(N) L M H	
Amenity/Safety Impact	N (L) M H	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	
Current Erosion severity	N L (M) H E	
Contributing Cause (circle all that apply)	(Wind waves) Ocean waves Vessel waves River/tidal flow Sediment extraction Stock access Public access	wind, uprooting casuarinas, with shallow root system undercut by waves
Upper, mid or lower estuary	(U) M L	
Location of erosion (Top, upper, lower bank)	T U (L)	
Channel geometry (inside bend, outside bend, straight, basin)	I O S (B)	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B (C) NC U	clay
Immediate landward constraint to treatment?	Y (N)	
Any offshore constraint?	Y (N)	
Public access to foreshore required?	(Y) N	Public reserve
High value asset at risk?	Y (N)	cables ~ 10m inland
Riparian vegetation community? (none, low, moderate, high)	N L (M) H	
Width of riparian vegetation	<2 <5 <10 (<20) >20m	Casuarinas
Are weeds contributing to instability?	Y (N)	
Existing erosion control method?	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	(N) C PC PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name St Georges Basin 28/11 12 noon		
Location ID (mark on map) McLeans Pt. MP01		
Environmental Impact of erosion (negl., low, mod, high)	N L (M) H	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N (L) M H	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	
Current Erosion severity	N L (M) H E	
Contributing Cause (circle all that apply)	(Wind waves) Ocean waves Vessel waves River/tidal flow Sediment extraction Stock access Public access	
Upper, mid or lower estuary	(U) M L	
Location of erosion (Top, upper, lower bank)	T U (L)	
Channel geometry (inside bend, outside bend, straight, basin)	I O S (B)	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C (NC) U	
Immediate landward constraint to treatment?	(Y) N Basin walking track.	
Any offshore constraint?	Y (N)	
Public access to foreshore required?	(Y) N	
High value asset at risk?	(Y) N Sewer infrastructure	
Riparian vegetation community? (none, low, moderate, high)	N L M (H)	
Width of riparian vegetation	<2 <5 (<10) <20 >20m Casuarinas	
Are weeds contributing to instability?	Y (N)	
Wind waves undercutting bank, large casuarinas falling over and taking root ball with them causing erosion. Basin walking track under construction Existing erosion control method?	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	(N) C PC PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name St Georges Basin 28/11 12.30pm		
Location ID (mark on map) McLeans Pt MP02		
Environmental Impact of erosion (negl., low, mod, high)	(N) L M H	
Infrastructure/Commercial impact	(N) L M H	
Amenity/Safety Impact	(N) L M H	
Future Trajectory	(Not occurring, not likely) Not occurring but likely Occurring and continuous Occurring and accelerating	
Current Erosion severity	(N) L M H E	
Contributing Cause (circle all that apply)	(Wind waves) Ocean waves Vessel waves River/tidal flow Sediment extraction Stock access Public access	
Upper, mid or lower estuary	(U) M L	
Location of erosion (Top, upper, lower bank)	T U (L)	
Channel geometry (inside bend, outside bend, straight, basin)	I O S (B)	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C (NC) U	
Immediate landward constraint to treatment?	(Y) N Basin walk	
Any offshore constraint?	Y (N)	
Public access to foreshore required?	(Y) N	
High value asset at risk?	(Y) N Sewer? Basin walk	
Riparian vegetation community? (none, low, moderate, high)	N L (M) H	
Width of riparian vegetation	<2 (<5) <10 <20 >20m Saltmarsh casuarina	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method?	None Rock Revetment (Rock Fillets) Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	N (C) PC (PD) I R	

Rock fillets working well to control erosion + prevent loss of casuarinas

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name St Georges Basin 28/11 1pm		
Location ID (mark on map) 1P01 Island Pt.		
Environmental Impact of erosion (negl., low, mod, high)	N (L) M H	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N (L) M H	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	
Current Erosion severity	N (L) M H E	
Contributing Cause (circle all that apply)	(Wind waves) Ocean waves (Vessel waves) River/tidal flow Sediment extraction Stock access Public access	
Upper, mid or lower estuary	(U) M L	
Location of erosion (Top, upper, lower bank)	T U (L)	
Channel geometry (inside bend, outside bend, straight, basin)	I O S (B)	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C (NC) U	
Immediate landward constraint to treatment?	(Y) N Reserve, Sewer infrastructure	
Any offshore constraint?	Y (N)	
Public access to foreshore required?	(Y) N Public Reserve	
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N (L) M H Casuarina	
Width of riparian vegetation	(<2) <5 <10 <20 >20m	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method?	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	(N) C PC PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name St Georges Basin 28/11 Paradise Bch Sth & Nth		
Location ID (mark on map) PB01-02 2.00pm		
Environmental Impact of erosion (negl., low, mod, high)	N (L) M H	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N (L) M H	
Future Trajectory	~~Not occurring, not likely~~ (Not occurring but likely) ~~Occurring and continuous~~ Occurring and accelerating	
Current Erosion severity	N (L) M H E	
Contributing Cause (circle all that apply)	(Wind waves) ~~Ocean waves~~ Vessel waves River/tidal flow Sediment extraction Stock access Public access	
Upper, mid or lower estuary	(U) M L	
Location of erosion (Top, upper, lower bank)	T U (L)	
Channel geometry (inside bend, outside bend, straight, basin)	I O S (B)	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C (NC) U	
Immediate landward constraint to treatment?	(Y) N Basin Track	
Any offshore constraint?	Y (N)	
Public access to foreshore required?	(Y) N	
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N L (M) H	
Width of riparian vegetation	<2 <5 (<10) <20 >20m	
Are weeds contributing to instability?	(Y) N	
Existing erosion control method?	None Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large ~~woody debris~~ (Revegetation) Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	N C (PC) (PD) I R	

Patches have been revegetated and this has been successful; where this hasn't occurred erosion has continued

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name St Georges Basin		
Location ID (mark on map) Loralyn Ave East	LAW01	
Environmental Impact of erosion (negl., low, mod, high)	N (L) M H	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N (L) M H	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	
Current Erosion severity	N L (M) H E	
Contributing Cause (circle all that apply)	(Wind waves) Ocean waves Vessel waves River/tidal flow Sediment extraction Stock access Public access	
Upper, mid or lower estuary	(U) M L	
Location of erosion (Top, upper, lower bank)	T (U) L Erosion in places on upper bank	
Channel geometry (inside bend, outside bend, straight, basin)	I O S (B)	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B (C) NC U clay	
Immediate landward constraint to treatment?	(Y) N Basin Track	
Any offshore constraint?	Y (N)	
Public access to foreshore required?	(Y) N	
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N L (M) H	
Width of riparian vegetation	<2 (<5) <10 <20 >20m Patches	
Are weeds contributing to instability?	(Y) N in some places	
Existing erosion control method?	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment (Large woody debris) Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	N C (PC) PD I R	

Areas where riparian veg is still in tact have fared better. Weeds + stormwater affecting bank stability in places

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name St Georges Basin Aloha Caravan Park		
Location ID (mark on map) STB01 Blacket Park		
Environmental Impact of erosion (negl., low, mod, high)	N (L) (M) H → Mangroves affected	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N (L) M H	
Future Trajectory	Not occurring, not likely ~~Not occurring but likely~~ (Occurring and continuous) Occurring and accelerating	
Current Erosion severity	N (L) M H E	
Contributing Cause (circle all that apply)	(Wind waves) Ocean waves (Vessel waves) ~~River/tidal flow~~ Sediment extraction Stock access Public access	
Upper, mid or lower estuary	(U) M L	
Location of erosion (Top, upper, lower bank)	T U (L)	
Channel geometry (inside bend, outside bend, straight, basin)	I O S (B)	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B C (NC) U Sandy	
Immediate landward constraint to treatment?	(Y) N Sewer	
Any offshore constraint?	(Y) N jetties in some areas	
Public access to foreshore required?	(Y) N Public reserve	
High value asset at risk?	(Y) N Sewer	
Riparian vegetation community? (none, low, moderate, high)	N (L) M H Casuarinas, Sparse	
Width of riparian vegetation	(<2) <5 <10 <20 >20m	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method?	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches (Seawall) rock seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	N C PC (PD) I R	

Where no structures, erosion affecting shoreline,

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name St Georges Basin	28/11 3.50pm	
Location ID (mark on map) Basin View BV02		
Environmental Impact of erosion (negl., low, mod, high)	N (L) M H	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N L (M) H	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	
Current Erosion severity	N L (M) H E	
Contributing Cause (circle all that apply)	(Wind waves) Ocean waves (Vessel waves) River/tidal flow Sediment extraction Stock access Public access	
Upper, mid or lower estuary	(U) M L	
Location of erosion (Top, upper, lower bank)	T U (L)	
Channel geometry (inside bend, outside bend, straight, basin)	I O S (B)	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	(S) M D	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B (C) NC U	Clay
Immediate landward constraint to treatment?	Y (N)	
Any offshore constraint?	Y (N)	
Public access to foreshore required?	(Y) N	Public Reserve
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	(N) L M H	
Width of riparian vegetation	(<2) <5 <10 <20 >20m	
Are weeds contributing to instability?	(Y) N	No riparian vegetation, only lawn grass.
Existing erosion control method?	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	(N) C PC PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name Wandandian Ck 16/2.		
Location ID (mark on map) WOD1 Upper creek		
Environmental Impact of erosion (negl., low, mod, high)	N L M (H)	
Infrastructure/Commercial impact	N (L) M H	
Amenity/Safety Impact	N (L) M H	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	
Current Erosion severity	N L M (H) E	
Contributing Cause (circle all that apply)	Wind waves Ocean waves (Vessel waves) (River/tidal flow) Sediment extraction (Stock access) Public access	
Upper, mid or lower estuary	(U) M L	
Location of erosion (Top, upper, lower bank)	T (U) (L)	
Channel geometry (inside bend, outside bend, straight, basin)	I (O) S B	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	S M (D)	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B (C) NC U	
Immediate landward constraint to treatment?	Y (N)	
Any offshore constraint?	(Y) N channel	
Public access to foreshore required?	Y (N)	
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N (L) M H	
Width of riparian vegetation	(<2) <5 <10 <20 >20m	
Are weeds contributing to instability?	(Y) N	
Existing erosion control method?	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	(N) C PC PD I R	

Proforma for Bank Erosion

	Response (circle)	Comment
Estuary name Wandandia Ck W002		
Location ID (mark on map) d/s. 16/2		
Environmental Impact of erosion (negl., low, mod, high)	N L (M) H	
Infrastructure/Commercial impact	(N) L M H	
Amenity/Safety Impact	(N) L M H	
Future Trajectory	Not occurring, not likely Not occurring but likely (Occurring and continuous) Occurring and accelerating	
Current Erosion severity	N L (M) H E	
Contributing Cause (circle all that apply)	Wind waves Ocean waves (Vessel waves) River/tidal flow Sediment extraction Stock access Public access	
Upper, mid or lower estuary	(U) M L	
Location of erosion (Top, upper, lower bank)	T U (L)	
Channel geometry (inside bend, outside bend, straight, basin)	I O (S) B	
Depth (shallow <0.8m, moderate 0.8-1.5m, deep >1.5m)	S M (D)	
Substrate (bedrock, cohesive, non-cohesive, unknown)	B (C) NC U	
Immediate landward constraint to treatment?	Y (N)	
Any offshore constraint?	(Y) N	
Public access to foreshore required?	Y (N)	
High value asset at risk?	Y (N)	
Riparian vegetation community? (none, low, moderate, high)	N L M (H)	
Width of riparian vegetation	<2 <5 <10 <20 (>20m)	
Are weeds contributing to instability?	Y (N)	
Existing erosion control method?	(None) Rock Revetment Rock Fillets Geotextile sand containers Timber walling Log/timber revetment Large woody debris Revegetation Bed control structures Groynes Cobble Beaches Seawall Concrete Other (acceptable) Building rubble Tyres Unacceptable (other)	
Effectiveness of control (none, complete, partial (condition), partial (design), ineffective, redundant	(N) C PC PD I R	

Appendix B
Decision Support Tool Results

Bank segment ID	Risk Rating Inputs: Impact Ratings – Environmental	Infrastructure / commercial	Amenity / safety	Estimated future trajectory	Current erosion severity	Contributing causes: Wind waves	Ocean waves	Vessel waves	River/tidal flow	Sediment extraction	Stock access	Public access
WB01 (Wrights Beach)	Low	Negligible	Negligible	Not occurring but likely	Low	Yes	No	No	No	No	No	Yes
EB01 (Erowal Bay east)	Low	Medium	Low	Occurring and continuing	Low	Yes	No	No	No	No	No	No
EB02 (Erowal Bay west)	Negligible	Negligible	Negligible	Not occurring but likely	Low	Yes	No	No	No	No	No	No
OEB01 (Old Erowal Bay Prentice Av)	Medium	Low	Low	Occurring and continuing	Moderate	Yes	No	No	No	No	No	No
MP01 (Mcleans Point east)	Medium	Low	Low	Occurring and continuing	Moderate	Yes	No	No	No	No	No	No
PB01 and PB02 (Paradise Beach)	Low	Low	Low	Not occurring but likely	Low	Yes	No	No	No	No	No	No
LAW01 (Loaralyn Ave East)	Low	Low	Low	Occurring and continuing	Moderate	Yes	No	No	No	No	No	No
IP01 (Island Point)	Low	Low	Low	Occurring and continuing	Low	Yes	No	Yes	No	No	No	No
STB01 (Blackett Park)	Medium	Low	Low	Occurring and continuing	Low	Yes	No	No	No	No	No	No
BV02 (Basin View west of boat ramp)	Low	Low	Medium	Occurring and continuing	Moderate	Yes	No	Yes	No	No	No	No
BV03 (Mathie Street)	Medium	High	High	Occurring and continuing	Moderate	Yes	No	No	No	No	No	No
W001 (Wandandian Ck upstream)	High	Low	Low	Occurring and continuing	High	No	No	Yes	Yes	No	Yes	No
W002 (Wandandian Ck downstream)	Medium	Negligible	Negligible	Occurring and continuing	Moderate	No	No	Yes	No	No	No	No
Tullarwalla Lagoon	Low	Negligible	Negligible	Not occurring but likely	Low	No	No	Yes	Yes	No	No	Yes
Tullarwalla Creek	Low	Negligible	Negligible	Occurring and continuing	Low	No	No	Yes	Yes	No	No	No
Tallyan Point	Negligible	Negligible	Negligible	Occurring and continuing	Low	Yes	No	Yes	No	No	No	No

Bank segment ID		Top of bank	Upper bank	Lo Bank												
WB01 (Wrights Beach)	Upper estuary	No	Yes	No	Basin or Broadwater	Shallow	Non-cohesive									
EB01 (Erowal Bay east)	Upper estuary	No	Yes	No	Basin or Broadwater	Shallow	Cohesive	Yes	No	Yes						
EB02 (Erowal Bay west)	Upper estuary	No	No	Yes	Basin or Broadwater	Shallow	Cohesive	No	Yes	Yes	No	Low	<2	No		
OEB01 (Old Erowal Bay Prentice Av)	Upper estuary	No	No	Yes	Basin or Broadwater	Shallow	Cohesive	No	No	Yes	No	Moderate	<20	No	No existing control	No existing con
MP01 (Mcleans Point east)	Upper estuary	No	No	Yes	Basin or Broadwater	Shallow	Non-cohesive	Yes	No	Yes	Yes	High	<10	No	No existing control	No existing control
PB01 and PB02 (Paradise Beach)	Upper estuary	No	No	Yes	Basin or Broadwater	Shallow	Non-cohesive	Yes	No	Yes	No	Moderate	<10	Yes	Revegetation	Partially (condition)
LAW01 (Loaralyn Ave East)	Upper estuary	No	Yes	No	Basin or Broadwater	Shallow	Cohesive	Yes	No	Yes	No	Moderate	<5	Yes	Large woody debris	Partially (condition)
IP01 (Island Point)	Upper estuary	No	No	Yes	Basin or Broadwater	Shallow	Non-cohesive	Yes	No	Yes	Yes	Low	<2	No	No existing control	No existing control
STB01 (Blackett Park)	Upper estuary	No	No	Yes	Basin or Broadwater	Shallow	Non-cohesive	Yes	Yes	Yes	Yes	Low	<2	No	No existing control	No existing control
BV02 (Basin View west of boat ramp)	Upper estuary	No	No	Yes	Basin or Broadwater	Shallow	Cohesive	No	No	Yes	No	Negligible	<2	Yes	No existing control	No existing control
BV03 (Mathie Street)	Upper estuary	No	Yes	Yes	Basin or Broadwater	Shallow	Cohesive	Yes	No	Yes	Yes	Negligible	<2	Yes	Rock revetment	Partially (condition)
W001 (Wandandian Ck upstream)	Upper estuary	No	Yes	Yes	Outside Bend	Deep	Cohesive	No	Yes	No	No	Low	<2	Yes	No existing control	No existing control
W002 (Wandandian Ck downstream)	Upper estuary	No	No	Yes	Straight	Deep	Cohesive	No	Yes	No	No	High	>20	No	No existing control	No existing control
Tullarwalla Lagoon	Upper estuary	No	No	Yes	Basin or Broadwater	Shallow	Cohesive	No	No	No	No	High	>20	No	No existing control	No existing control
Tullarwalla Creek	Upper estuary	No	No	Yes	Straight	Shallow	Cohesive	No	No	No	No	High	>20	No	No existing control	No existing control
Tallyan Point	Mid estuary	No	Yes	Yes	Basin or Broadwater	Moderate	Cohesive	No	No	No	No	High	>20	No	No existing control	No existing control

Bank segment ID	Risk Ratings					Bank Stabilisation Techniques											Applicable Treatment Recommendations		Other Treatment						Threshold score for shortlisted options
WB01 (Wrights Beach)																									
EB01 (Erowal Bay east)																									16.5
EB02 (Erowal Bay west)																									
OEB01 (Old Erowal Bay Prentice Av)																									18.0
MP01 (Mcleans Point east)	Medium	Low																							19.5
PB01 and PB02 (Paradise Beach)	Low	Low	Low	N																					
LAW01 (Loaralyn Ave East)	Low	Low	Low	No	No																	Riparian vegetation management + M/ment Controls			
IP01 (Island Point)	Low	Low	Low	No	No																				
STB01 (Blackett Park)	Medium	Low	Low	Yes	No					26.0															19.5
BV02 (Basin View west of boat ramp)	Low	Low	Medium	Yes	No					24.0															18.0
BV03 (Mathie Street)	Medium	High	High	Yes	No					25.5			18.5	23.0											19.1
W001 (Wandandian Ck upstream)	High	Low	Low	Yes	No		25.0							14.3	19.3		LargeWoo								18.8
W002 (Wandandian Ck downstream)	Medium	None	None	Yes	No		26.0							14.0	17.0		LargeWoodyDebris								19.5
Tullarwalla Lagoon	Low	None	None	No	No												Fencing	None							
Tullarwalla Creek	Low	None	None	No	No												Do Nothing	None				Do Nothing + M/ment Controls			
Tallyan Point	None	None	None	No	No												Do Nothing	None				Do Nothing + M/ment Controls			

DST Inputs

Bank segment ID	Impact Ratings: Environmental	Infrastructure / commercial	Amenity / safety	tra		Wind waves	Ocean waves	Vessel waves	River/tidal flow	Sediment extraction	access	access					
H01 (The Haven u/s)	Medium	Low	Medium	Occurring and continuing	High	No	No	Yes	Yes	No	No	Yes	Lower estuary	Yes	Yes	Yes	Outside bend
H02 (Haven central)	Low	Low	Low	Not occurring but likely	Low	No	No	Yes	Yes	No	No	No	Lower estuary	No	Yes	No	Outside bend
H03 (Haven d/s)	Medium	Low	Medium	Occurring and continuing	High	No	No	Yes	Yes	No	No	Yes	Lower estuary	Yes	Yes	No	Outside bend
H04 (Haven u/s croppers)	Low	Low	Low	Occurring and continuing	Low	No	Yes	No	No	No	No	No	Lower estuary	No	Yes	No	Inside bend
H05 (Croppers)	Low	Low	Medium	Occurring and continuing	Moderate	No	Yes	No	Yes	No	No	No	Lower estuary	Yes	Yes	No	Outside bend
S001 (Fairview Cres)	Low	Low	Low	Occurring and continuing	Low	Yes	No	No	Yes	No	No	No	Upper estuary	No	No	Yes	Straight
S002 (Badgee Lagoon)	Low	Negligible	Negligible	Occurring and continuing	Low	Yes	No	Yes	No	No	No	No	Upper estuary	No	Yes	Yes	Basin or Broadwater
S003 (Badgee d/s bridge)	Low	Low	Low	Occurring and continuing	Low	Yes	No	Yes	No	No	No	No	Upper estuary	No	No	Yes	Inside bend
S004 (u/s Nielson L)	Medium	Low	Medium	Occurring and continuing	Moderate	Yes	No	Yes	No	No	No	Yes	Mid estuary	No	No	Yes	Straight
S005 (d/s Nielson L)	Low	Low	Low	Occurring and continuing	Moderate	No	No	Yes	No	No	No	No	Mid estuary	No	No	Yes	Straight
S006 (u/s Christians Minde)	Medium	Negligible	Negligible	Occurring and continuing	High	No	No	Yes	Yes	No	No	No	Mid estuary	No	No	Yes	Outside bend
S007 (RSL foreshore)	Negligible	Low	Low	Not occurring not likely	Low	No	No	Yes	No	No	No	No	Mid estuary	No	No	Yes	Straight
S008 (River Rd)	Low	Low	Low	Occurring and continuing	Low	No	No	Yes	No	No	No	No	Mid estuary	No	No	Yes	Straight
S009 (island in Quays)	Low	Low	Low	Not occurring but likely	Low	No	No	Yes	No	No	No	No	Mid estuary	No	Yes	No	Inside bend
S010 (Chris Creek)	Medium	Low	Low	Occurring and continuing	Moderate	No	No	Yes	No	No	No	No	Mid estuary	No	No	Yes	Straight
S011 (Little Manly)	High	Low	Medium	Occurring and continuing	High	No	No	Yes	Yes	No	No	No	Mid estuary	No	Yes	Yes	Outside bend
S012 (Alamein)	High	Medium	Medium	Occurring and continuing	Moderate	No	No	Yes	No	No	No	Yes	Lower estuary	No	Yes	Yes	Straight

Bank segment ID												Risk Ratings				
H01 (The Haven u/s)																
H02 (Haven central)	Moderate	Non-cohesive	Yes	Yes	Ye											
H03 (Haven d/s)	Moderate	Non-cohesive	Yes	Yes	Yes	No	Moderate	>20	No	No existing						
H04 (Haven u/s croppers)	Shallow	Non-cohesive	Yes	No	Yes	No	Negligible	<2	No	Concrete	Ineffective	Low	Low			
H05 (Croppers)	Shallow	Non-cohesive	Yes	No	Yes	No	Low	<10	Yes	Timber walling	Partially (design)	Low	Low	Medium	Yes	
S001 (Fairview Cres)	Shallow	Non-cohesive	No	Yes	Yes	No	Low	<10	Yes	Log/timber revetment	Partially (condition)	Low	Low	Low	No	Yes
S002 (Badgee Lagoon)	Deep	Unknown	No	No	No	No	High	>20	No	No existing control	No existing control	Low	None	None	No	No
S003 (Badgee d/s bridge)	Shallow	Non-cohesive	No	No	Yes	No	Low	<2	No	Groynes	Partially (design)	Low	Low	Low	No	Yes
S004 (u/s Nielson L)	Shallow	Non-cohesive	No	Yes	Yes	No	Low	<2	No	Log/timber revetment	Partially (design)	Medium	Low	Medium	Yes	Yes
S005 (d/s Nielson L)	Moderate	Non-cohesive	No	Yes	Yes	No	Low	<2	No	Revegetation	Partially (condition)	Low	Low	Low	No	Yes
S006 (u/s Christians Minde)	Deep	Non-cohesive	No	Yes	No	No	High	>20	No	No existing control	No existing control	Medium	None	None	Yes	No
S007 (RSL foreshore)	Shallow	Non-cohesive	No	Yes	Yes	No	Moderate	<5	No	Log/timber revetment	Partially (condition)	None	None	None	No	Yes
S008 (River Rd)	Moderate	Non-cohesive	Yes	Yes	Yes	No	Low	<2	No	No existing control	No existing control	Low	Low	Low	No	No
S009 (island in Quays)	Shallow	Non-cohesive	No	No	Yes	No	Low	<2	No	Rock revetment	Partially (design)	Low	Low	Low	No	No
S010 (Chris Creek)	Moderate	Non-cohesive	No	No	No	No	High	>20	No	No existing control	No existing control	Medium	Low	Low	Yes	No
S011 (Little Manly)	Moderate	Non-cohesive	No	No	No	No	High	>20	No	No existing control	No existing control	High	Low	Medium	Yes	No
S012 (Alamein)	Moderate	Non-cohesive	Yes	Yes	Yes	Yes	Negligible	<2	Yes	Building rubble	Ineffective	High	Medium	Medium	Yes	No

DST Outputs

Bank segment ID	Bank Stabilisation Techniques											Applicable Treatment Recommendations		Other Treatment						Threshold score for shortlisted options
H01 (The Haven u/s)																				16.2
H02 (Haven central)																				
H03 (Haven d/s)																				18.4
H04 (Haven u/s croppers)																				
H05 (Croppers)																				16.9
S001 (Fairview Cres)																		Restore riparian vegetation		
S002 (Badgee Lagoon)																	Do Nothing + M/ment Controls			
S003 (Badgee d/s bridge)																	ion m/ment +			
S004 (u/s Nielson L)					27.0			14.7	21.0	17.3		Maintenance on exi								20.3
S005 (d/s Nielson L)												Maintenance on existing control	None							
S006 (u/s Christians Minde)		24.0							17.0	22.0		LargeWoodyDebris	RockRevetment							18.0
S007 (RSL foreshore)												Maintenance on existing control	None	Yes		Yes	Main M/ment Controls			
S008 (River Rd)												Do Nothing	None			Yes				
S009 (island in Quays)												Riparian vegetation management	None	Yes		Yes	Riparian vegetation management + M/ment Controls			
S010 (Chris Creek)		22.0	21.0	15.0	18.0		15.0	10.0	14.0	16.0		LargeWoodyDebris	RockFillets, CobbleBeach			Yes	LargeWoodyDebris + M/ment Controls			16.5
S011 (Little Manly)		21.0	19.5	11.5	12.5		16.0	11.0	15.0	19.0		LargeWoodyDebris	RockFillets, RockRevetment, Groynes			Yes	LargeWoodyDebris + M/ment Controls			15.8
S012 (Alamein)					27.5			20.0	28.0	25.0		GeotextileSandContainers	CobbleBeach, RockRevetment	Yes	Yes	Yes	GeotextileSandContainers + Riparian vegetation m/ment+ Fencing + M/ment Controls			21.0

DST Inputs

Bank segment ID	Impact Ratings: Environmental	Impact Ratings: Infrastructure / commercial	Impact Ratings: Amenity / safety	Estimated future trajectory	Current erosion severity	Contributin: Wind waves	Contributin: Ocean waves	Contributin: Vessel waves	Contributin: River/tidal flow	Contributin: Sediment extraction	Contributin: Stock access	Contributin: Public access
SW01 (lower entrance channel)	Low	Negligible	Negligible	Not occurring but likely	Moderate	No	No	No	Yes	No	No	No
SW02 (upper entrance channel)	Low	Low	Low	Not occurring but likely	Low	No	No	No	Yes	No	No	No

Bank segment ID		Top of bank	Upper bank	Lower Bank				Immediate landward constraint	Offshore constraint	Public access required?	High value asset at risk?	vegetation continuity	vegetation width (m)	instability		
SW01 (lower entrance channel)	Lower estuary	No	Yes	Yes	Outside bend	Shallow	Cohesive	Yes	Yes	No	No	Moderate	<5	No	No existing control	No existing control
SW02 (upper entrance channel)	Lower estuary	No	Yes	No	Straight	Moderate	Cohesive	Yes	Yes	No	Yes	Moderate	<5	No	No existing control	No existing control

DST Outputs

Bank segment ID	Risk Ratings					Bank Stabilisation Techniques											Applicable Treatment Recommendations		Other Treatment						Threshold score for shortlisted options
SW01 (lower entrance channel)	Low	None	None	No	No																				
SW02 (upper entrance channel)	Low	Low	Low	No	No												Do Nothing	Non				Do Nothing			

DST Inputs

Bank segment ID	Impact Ratings: Environmental	Impact Ratings: Infrastructure / commercial	Impact Ratings: Amenity / safety	Estimated future trajectory	Curren erosion severity	Wind waves	Ocean waves	Vessel waves	River/tidal flow	Sediment extraction	Stock access	Public access		Top of bank	Upper bank	Lower Bank
BC01 (just upstream entrance)	Low	Low	Medium	Occurring and continuing	Low	No	Yes	No	Yes	No	No	Yes	Lower estuary	No	Yes	Yes
BC02 (upstream beach access)	Low	Low	Low	Occurring and continuing	Low	No	No	No	Yes	No	No	No	Lower estuary	No	No	Yes
BC03 (Berrara Beach Holiday Chalets)	Medium	Low	Low	Occurring and continuing	Moderate	No	No	No	Yes	No	No	No	Lower estuary	No	Yes	No
BC04 (Berrara Waters)	Low	Low	Low	Occurring and continuing	Low	No	No	No	Yes	No	No	No	Lower estuary	No	No	Yes
BC05 (Lakeland Avenue)	Low	Low	Low	Occurring and continuing	Low	Yes	No	No	No	No	No	Yes	Lower estuary	No	Yes	Yes
BC06 (Southern bank opposite Lakeland Avenue)	Low	Negligible	Negligible	Occurring and continuing	Low	Yes	No	No	Yes	No	No	No	Lower estuary	No	Yes	Yes
BC07 (opposite Fishermans Rock)	Medium	Medium	Low	Occurring and continuing	Moderate	No	No	No	Yes	No	No	No	Mid estuary	Yes	Yes	No

Bank segment ID				landward constraint	constraint	required?						
BC01 (just upstream entrance)	Inside bend	Shallow	Non-cohesive	No	No	Yes	No	Low	<5	Yes	No existing control	No existing control
BC02 (upstream beach access)	Straight	Shallow	Bed rock	Yes	No	No	No	Low	<2	No	No existing control	No existing control
BC03 (Berrara Beach Holiday Chalets)	Straight	Shallow	Bed rock	Yes	No	No	Yes	Low	<2	Yes	Building rubble	Ineffective
BC04 (Berrara Waters)	Outside bend	Shallow	Non-cohesive	No	No	Yes	No	Low	<2	No	No existing control	No existing control
BC05 (Lakeland Avenue)	Outside bend	Shallow	Non-cohesive	No	No	Yes	No	Low	<5	No	No existing control	No existing control
BC06 (Southern bank opposite Lakeland Avenue)	Inside bend	Shallow	Non-cohesive	No	No	No	No	High	>20	No	No existing control	No existing control
BC07 (opposite Fishermans Rock)	Straight	Shallow	Cohesive	Yes	No	Yes	Yes	Low	<2	No	No existing control	No existing control

DST Outputs

Bank segment ID	Risk Ratings					Bank Stabilisation Techniques											Applicable Treatment Recommendations		Other Treatment						Threshold score for shortlisted options
BC01 (just upstream entrance)	Low																								17.6
BC02 (upstream beach access)	Low	Low	Low	No	No																				
BC03 (Berrara Beach Holiday Chalets)	Medium	Low	Low	Yes	No		17.0	21.0		17.0					22.0		RockRevetment	Ro							16.5
BC04 (Berrara Waters)	Low	Low	Low	No	No												Riparian vegetation management	None	Yes		Yes	Riparian veg			
BC05 (Lakeland Avenue)	Low	Low	Low	No	No												Riparian vegetation management	None	Yes	Yes	Yes	Riparian vegetation management+ Fencing + M/ment Controls		Management of Kayak Storage	
BC06 (Southern bank opposite Lakeland Avenue)	Low	None	None	No	No												Do Nothing	None				Do Nothing			
BC07 (opposite Fishermans Rock)	Medium	Medium	Low	Yes	No					21.0			17.0	25.5	22.5		GeotextileSandContainers	RockRevetment, CobbleBeach			Yes	GeotextileSandContainers + M/ment Controls			19.1

Appendix C Site Photos

St Georges Basin – Wandandian Creek

Upper Wandandian Creek, Bewong Site Ref W001

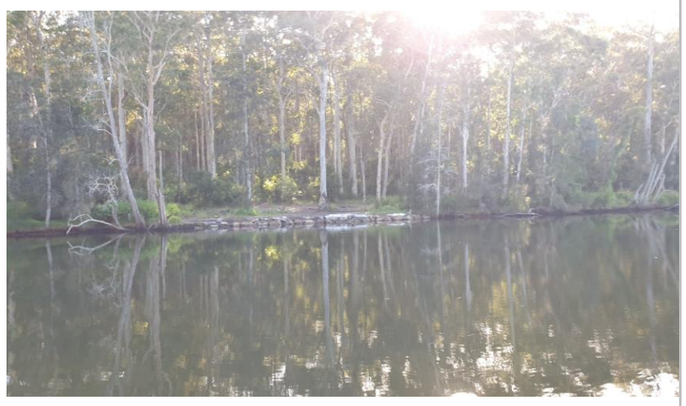
Upper Wandandian Creek, Bewong Site Ref W001

Upper Wandandian Creek, Bewong Site Ref W001

Upper Wandandian Creek Site Ref W001

Upper Wandandian Creek Site Ref W001

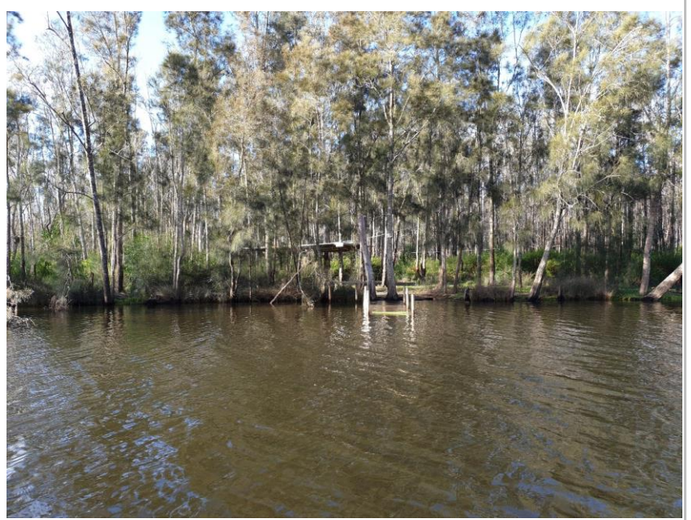
Lower Wandandian Creek Site Ref W02



Lower Wandandian Creek Site Ref W02

Lower Wandandian Creek Site Ref W02

Lower Wandandian Creek Site Ref W02

St Georges Basin – Tullarwalla Lagoon & Inlet		
		
Tullawwalla Inlet on approach to lagoon Site Ref TW03	Tullarwalla Lagoon, southern foreshore showing vehicle access Site Ref TW01	Tullarwalla Lagoon, northern foreshore showing vehicle access controls Site Ref TW02
		
Tullarwalla Inlet, near entrance to lagoon, inundated informal jetty Site Ref TW03	Tullarwalla Inlet, undermined trees along bank Site Ref TW03	Tullarwalla Lagoon, general view Site Ref TW02

St Georges Basin – Basin View

Foreshore east of boat ramp Site Ref BV03

Rock revetment protecting sewer infrastructure at Mathie St Site Ref BV03

Building rubble on upper section of bank at Mathie St Site Ref BV03

Foreshore at Basin View, eastern end of Basin View Parade Site Ref BV03

Basin View foreshore west of boat ramp Site Ref BV02

Basin View foreshore west of boat ramp Site Ref BV02

Basin View foreshore west of boat ramp Site Ref BV02

Tallyan Point, Basin View Site Ref BV01

Tallyan Point, Basin View Site Ref BV01

St Georges Basin – Blackett Reserve, Pelican Point, Home Bay		
		
Pelican Point Site Ref PP01	Basin Road, near Basin Road Jetty Site Ref STB02	Looking west from Basin Road Jetty Site Ref STB02
		
Basin Road Jetty Site Ref STB02	Blackett Reserve, showing area where sewer infrastructure located on an eroding foreshore Site Ref STB01	Blackett Reserve near Aloha caravan park, showing rock protection at eroding foreshore Site Ref STB01
		
Mangrove being undermined, Blackett Reserve Site Ref STB01	Erosion near stormwater outlet at Blackett Reserve. [redacted] Site Ref STB01	Concrete-lined foreshore with seating at Blackett Reserve. Note undermining of slab by erosion Site Ref STB01

St Georges Basin – Island Point

Erosion of foreshore and undermining of trees at Island Point, looking east, near jetty Site Ref IP01

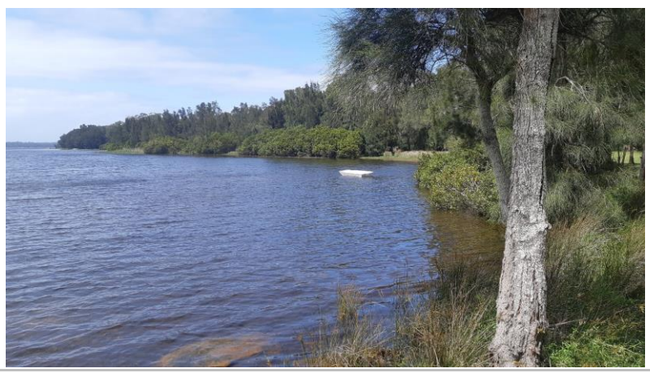
Erosion of foreshore at Island Point, looking west Site Ref IP01

Eroding foreshore at Island Point looking north over privately owned foreshore. Note lack of riparian vegetation here, [redacted] Site Ref IP01

Looking west from Island Point, note erosion of foreshore in root zone of casuarinas Site Ref IP01

St Georges Basin – Loralyn Avenue		
		
Loralyn Avenue near the Wool Lane, looking west Site Ref LAW01	Note exposure to south fetch at Loralyn Avenue foreshore and breaking wind waves Site Ref LAW01	Undermining of mature casuarinas at Loralyn Avenue Site Ref LAW01
		
Ad-hoc storage of small craft at Loralyn Avenue Site Ref LAW01	Undermining of large trees, Loralyn Avenue Site Ref LAW01	Loralyn Avenue – eroding foreshore in foreground where no riparian vegetation, less erosion in no-mow zone with casuarinas in background Site Ref LAW01
		
Effect of seagrass wrack in reducing foreshore erosion, near Walmer Avenue Site Ref PB01	Erosion at remnant clay feature on upper section of bank near intersection of Walmer and Loralyn Avenue Site Ref PB01	

St Georges Basin – Paradise Beach		
		
Undermining of foreshore vegetation at Paradise Beach Site Ref PB01	Mowing of vegetation up to the water's edge, Paradise Beach Site Ref PB01	Successful implementation of no-mow zone at Paradise Beach in background Site Ref PB01
		
Inundation of Paradise Beach reserve at high water levels, no-mow zone in background Site Ref PB02	Dedicated kayak-launching ramp at Paradise Beach, can prevent erosion due to launching of kayaks at random locations Site Ref PB02	Erosion due to undermining of trees at Paradise Beach Site Ref PB02
		
Successful use of rock fillets to prevent undermining of large trees, Macleans Point Site Ref MP02	Incorporation of raised boardwalk feature along The Basin Walk at Macleans Point Site Ref MP02	Foreshore erosion at The Basin Walk, Macleans Point Site Ref MP01

St Georges Basin – Sanctuary Point		
		
Undermining of foreshore vegetation at Palm Beach Site Ref MP01	Groyne providing protection from wind waves at Sanctuary Point Site Ref SP01	Semi-permeable groyne incorporating intertidal habitat at Sanctuary Point Site Ref SP01
		
Successful implementation of saltmarsh no-mow zone and succession of riparian vegetation at Sanctuary Point Site Ref SP01	No-mow zone at Sanctuary Point Site Ref SP01	Healthy riparian zone at Boobook Reserve, Sanctuary Point Site Ref SP01
		
Successful use of groyne field combined with riparian vegetation to protect foreshore from erosion at Sanctuary Point Site Ref SP01	Established mangroves in front of casuarina woodland provides protection from wind waves and undermining Site Ref SP01	Private moorings along foreshore at Sanctuary Point Site Ref SP01

St Georges Basin – Old Erowal Bay

Prentice Avenue Reserve, Old Erowal bay Site Ref OEB01

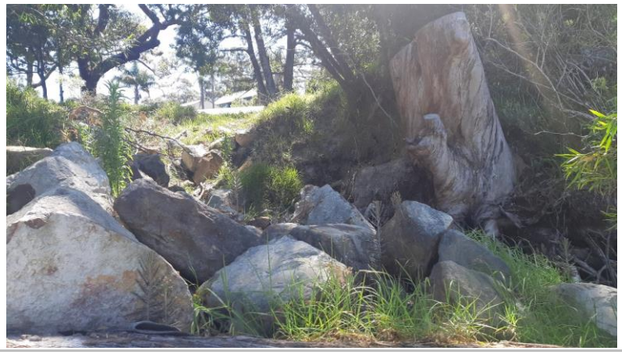
Undermined vegetation at Prentice Avenue Reserve, Old Erowal Bay Site Ref OEB01

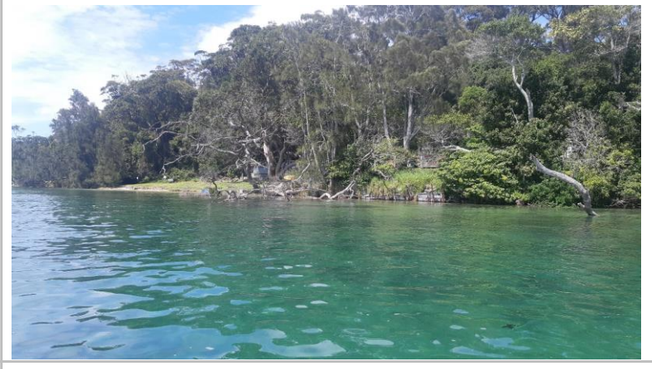
Erosion escarpment at Prentice Avenue Reserve, Old Erowal Bay Site Ref OEB01

Undermined vegetation at Prentice Avenue Reserve, Old Erowal Bay Site Ref OEB01

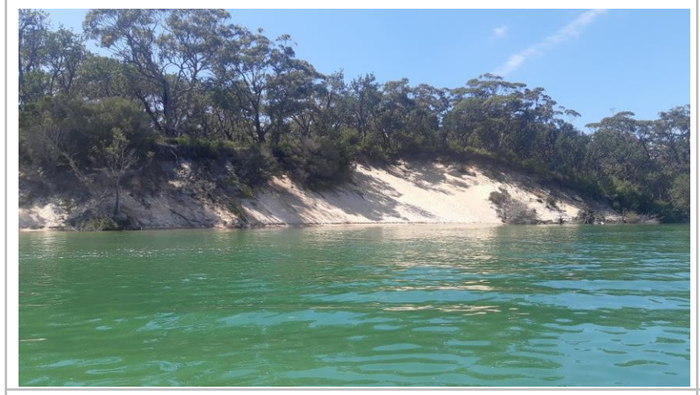
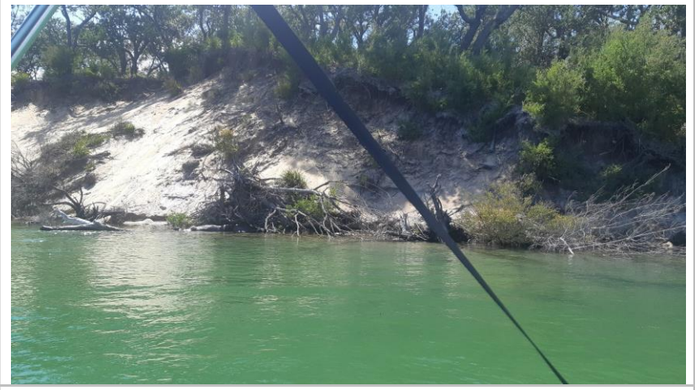
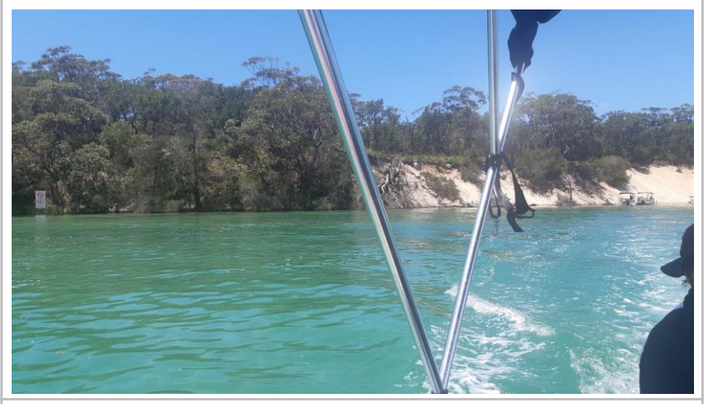
St Georges Basin – Erowal Bay and Wrights Beach		
		
Foreshore erosion threatening sewer infrastructure at Wharf Road, Erowal Bay Site Ref EB01	Private foreshores at Erowal Bay, looking east from Wharf Road Reaerve Site Ref EB01	Bank being held together by casuarina roots at King George St. Erowal Bay Site Ref EB02
		
Undermined tree at Wrights Beach Site Ref WB01	Undermined trees at Wrights Beach Site Ref WB01	Minor erosion at Wrights Beach Site Ref WB01

Sussex Inlet – The Big "S" and Croppers Cabins		
		
Overturning failure and missing boards from existing timber toe protection wall Site Ref H05	Collapsed sand dune smothering vegetation over underlying clay slope, with toe erosion caused by ocean waves Site Ref H05	Existing timber toe protection wall showing rock boulders behind wall and additional erosion adjacent to wall Site Ref H05
		
Large tree toppled over April 2022 Site Ref H05	Evidence of slip-circle geotechnical failure on upper slope Site Ref H05	Toe erosion at slope caused by ocean waves Site Ref H04
		
View of toe protection wall and relatively successful stabilisation area, looking south Site Ref H05	Outflanking of old concrete seawall at the Big "S" Site Ref H04	Area behind old concrete seawall with exposed boulders and erosion at toe of bank Site Ref H04

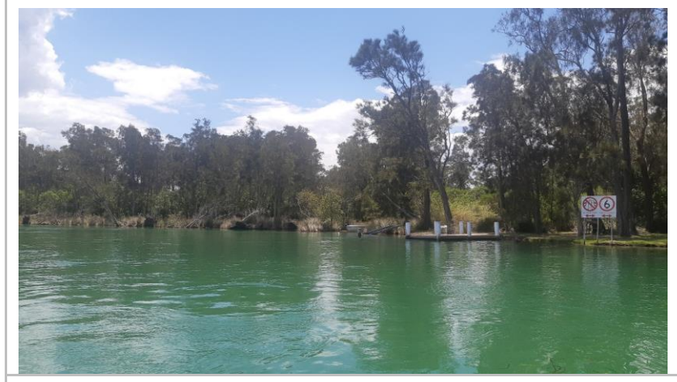
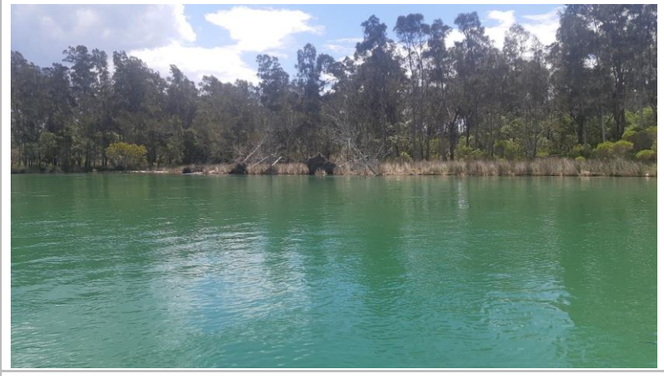
Sussex Inlet – The Haven Holiday Resort		
		
Undermined large trees at The Haven Site Ref H03	Collapsed tree at The Haven, holding sand together at the toe of the slope Site Ref H03	Undermined footings for signage for power lines and boating safety notice Site Ref H03
		
Geotextile groyne field and beach nourishment undertaken in 2017 providing protection to central area of The Haven Site Ref H02	Rock outlet structure for stormwater at The Haven Site Ref H02	Hinged landing for beach accessway to accommodate erosion at The Haven Site Ref H02
		
Collapsed trees due to unstable slope, northern end of The Haven Site Ref H01	Bare unstable sand dune area at The Haven Site Ref H01	Looking across The Haven toward The Cove, east side of channel Site Ref H01

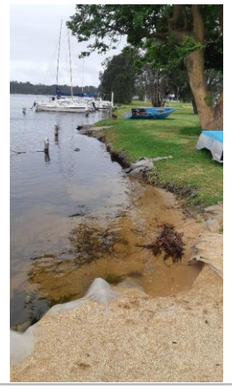
Sussex Inlet – Alamein		
		
Concrete rubble foreshore protection at Alamein Site Ref S012	Rubble foreshore protection Site Ref S012	Stand of mangroves at Alamein Site Ref S012
		
Informal infrastructure and undermined trees, Alamein Site Ref S012	Erosion escarpment at sandy foreshore, Alamein Site Ref S012	Private mooring structures, Alamein Site Ref S012
		
Looking west along Alamein Road into canal Site Ref S012	Looking across canal to Edgewater Avenue with eroded vertical clay embankment Site Ref S012	Alamein foreshore with undermined trees and informal bank protection at high tide Site Ref S012

Sussex Inlet – Lions Park and Marine Rescue area		
		
Erosion damage from March 2022 East Coast Low near Lions Park boat ramp fish cleaning table Site Ref S013	Looking north from Lions Park boat ramp, with groyne field and sandy foreshore in background Site Ref S013	Rock-lined foreshore on south side of Marine Rescue building Site Ref S013
		
Foreshore adjacent to boat ramp near Pelican Shores Site Ref S013	Collapsing concrete-lined foreshore between Pelican Shores and Marine Rescue Site Ref S013	Kyowa bags at foreshore adjacent to Pelican Shores boat ramp Site Ref S013

Sussex Inlet – Little Manly		
		
Exposed unstable dune at Little Manly Site Ref S011	Collapse of vegetation on unstable slope, Little Manly Site Ref S011	Continuing erosion of sandy foreshore, downstream Little Manly Site Ref S011
		
Loss of mature trees and continuing erosion, Little Manly Site Ref S011	Sand boarding/sliding on unstable slope, Little Manly Site Ref S011	Relatively stable bank on upstream side of unstable sand slope, Little Manly Site Ref S011

Sussex Inlet – Jacob Elimoos Reserve		
		
Damaged mooring structures mear Sussex Inlet RSL	Timber log foreshore protection with erosion behind, near Sussex Inlet RSL	Eroded foreshore at Jacon Elimoos Reserve
		
Eroded foreshore, Jacob Elimoos Reserve Site Ref S007	Eroded foreshore, Jacob Elimoos Reserve Site Ref S007	Informal launching area, Jacob Elimoos Reserve Site Ref S007
		
Established riparian zone with mangroves, saltmarsh and casuarina, Jacob Elimoos Reserve Site Ref S007	Rock foreshore protection near Sussex Inlet RSL Site Ref S007	Looking south from Sussex Inlet Marine Centre along rock-lined foreshore Site Ref S007

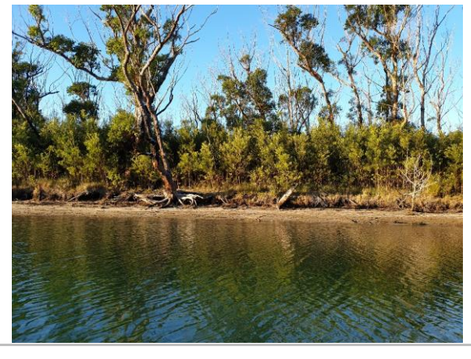
Sussex Inlet – Christians Minde		
		
Undermined trees at Christian's Minde Site Ref S006	Undermined trees, Christian's Minde Site Ref S006	Undermined trees, Christians Minde Site Ref S006
		
Undermined trees, Christians Minde Site Ref S006	Eroded foreshore, Christian's Minde Site Ref S006	Undermined trees, Christian's Minde Site Ref S006

Sussex Inlet – near Nielsons Lane		
		
Minor erosion upstream from Sussex Marine Centre Site Ref S005	Sandy foreshore for public access with adjacent saltmarsh vegetation Site Ref S004	Sandy foreshore with rock fillets Site Ref S004
		
Rock fillets and moorings catering to holiday accommodation Site Ref S004	Rocky foreshore with some undermined casuarinas Site Ref S004	Sinkholes forming behind timber seawall Site Ref S004
		
Sinkholes behind timber seawall, treated by filling with gravel Site Ref S004	Sandy foreshore with imported sand and geotextile Site Ref S004	Eroded foreshore behind moored boats, upstream from Nielson Lane Boat Ramp Site Ref S004

Sussex Inlet – Badgee Lagoon, Ralph Lucas Waterway and The Quays		
		
Erosion at entrance to Badgee Lagoon, downstream River Road Bridge Site Ref S003	Badgee Lagoon undermining of trees Site Ref S002	Badgee Lagoon undermining of trees Site Ref S002
		
Ralph Lucas Waterway undermining of trees Site Ref S010	Ralph Lucas Waterway undermining of trees Site Ref S010	Damaged seawall at The Quays Site Ref S010
		
Ralph Lucas Waterway undermining of trees Site Ref S010	Duck Island sandy foreshore with rock groynes Site Ref S009	Fallen trees near River Road boat ramp Site Ref S008

Sussex Inlet – Channel between Badgee Lagoon and St Georges Basin	
	
Tyres holding bank together, near Fairview Cres Site Ref S001	Timber log foreshore protection behind private mooring jetty, near Fairview Cres Site Ref S001
	
Undermining of trees, eastern side of channel between Badgee Lagoon and St Georges Basin entrance Site Ref S001	Minor undermining of trees near Fairview Cres Site Ref S001

Swan Lake		
		
Erosion of back dune and wave overtopping of berm at The Gap Site Ref SW03	Erosion of back dune due to ongoing meandering of Swan Lake channel Site Ref SW03	Back dune erosion and remnant dune blowout at The Gap Site Ref SW03
		
Ongoing erosion along inside of bend, Swan Lake inlet channel Site Ref SW01	Erosion at inside of bend, Swan Lake inlet channel Site Ref SW01	Minor erosion at upper bank, Ski Beach Site Ref SW05
		
Undermining of speed limit sign by erosion, northern lake foreshore Site Ref SW07	Dead tree being undermined and in danger of collapsing, southern lake foreshore Site Ref SW04	Storage of unpowered craft on banks, eastern side of inlet on lake side Site Ref SW05

Berrara Creek		
		
Erosion at base of beach access track, near Berrara Creek entrance Site Ref BC01	Erosion upstream of entrance access track Site Ref BC01	Erosion along eastern foreshore of Berrara Creek, note building rubble in banks Site Ref BC02
		
Erosion below cabins at Berrara Site Ref BC03	Steep slope being undermined by erosion below cabins Site Ref BC03	Undercutting of trees at Lakeland Avenue reserve Site Ref BC05
		
Ad-hoc storage of kayaks, Lakeland Avenue Reserve Site Ref BC05	Undermining of trees at foreshore, opposite Lakeland Avenue Site Ref BC06	Erosion of foreshore at powerlines opposite Fishermans Rock Site Ref BC07

Appendix D
General Erosion Management Techniques

D.1 Large Woody Debris

The purpose of large woody debris is to divert/alter and/or dissipate flows from a river bank, to allow sediment to deposit and riparian vegetation to become established. An example of the application of this technique is shown in Figure 10-1. In conjunction with the use of large woody debris along the outside of the bend, maintenance of fencing to exclude stock from the riverbank and establishment of a riparian vegetation zone along the bank may be used to reduce the erosion.

Figure 10-1 – Application of large woody debris at Hunter River, NSW. (Hydrosphere Consulting, 2020).

D.2 Cobble Beaches

Cobble beaches use rock in the form of cobblestones for bank protection against moderate to high waves (Hydrosphere Consulting, 2020). The cobbles dissipate wave energy and are suitable for situations with low tidal range (<300mm), shallow depths, and where the cause of the erosion is wind waves or vessel waves (i.e. typical of the foreshores along the northern side of St Georges Basin). They also allow continued public access to the foreshore, and provide for a riparian zone for the planting of saltmarsh and fringing vegetation.

The suggested technique is illustrated in Figure 10-2, with an example of its application at Lake Macquarie in Figure 10-3. Establishment of a crest at the top of the slope may help prevent undermining of the slope due to wave overtopping.

Establishment of riparian vegetation is often recommended in conjunction with this technique.

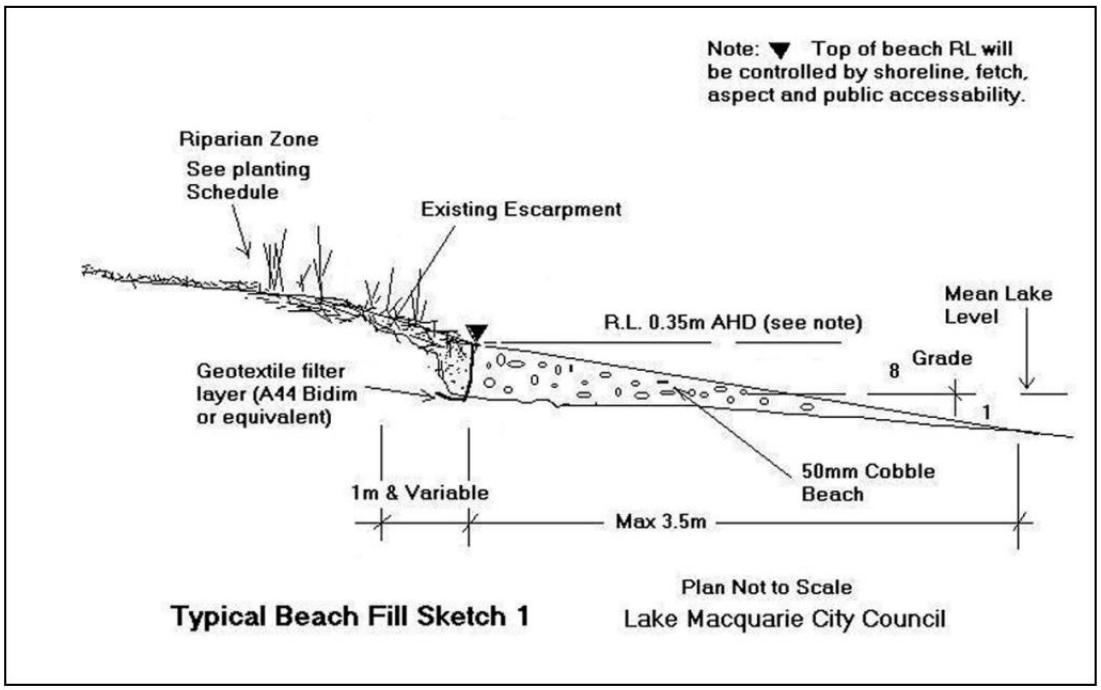


Figure 10-2 – Typical application of cobble beaches suggested to address erosion at Basin View (Walpole et al, 2009)

Figure 10-3 – Example application of cobble beach, Lake Macquarie NSW. Left – prior to treatment, right – post treatment (Walpole et al 2009).

In areas where there is critical infrastructure in the erosion zone, a cobble beach could be combined with rock erosion protection, as shown in the example in Figure 10-4. The elements of the protection would need to be designed to withstand the wave action expected at the site. An option may comprise the incorporation of a salt-marsh berm as per the Environmentally Friendly Seawalls Guide (NSW Office of Environment and Heritage, 2012) and use logs from fallen trees to dissipate wave energy.

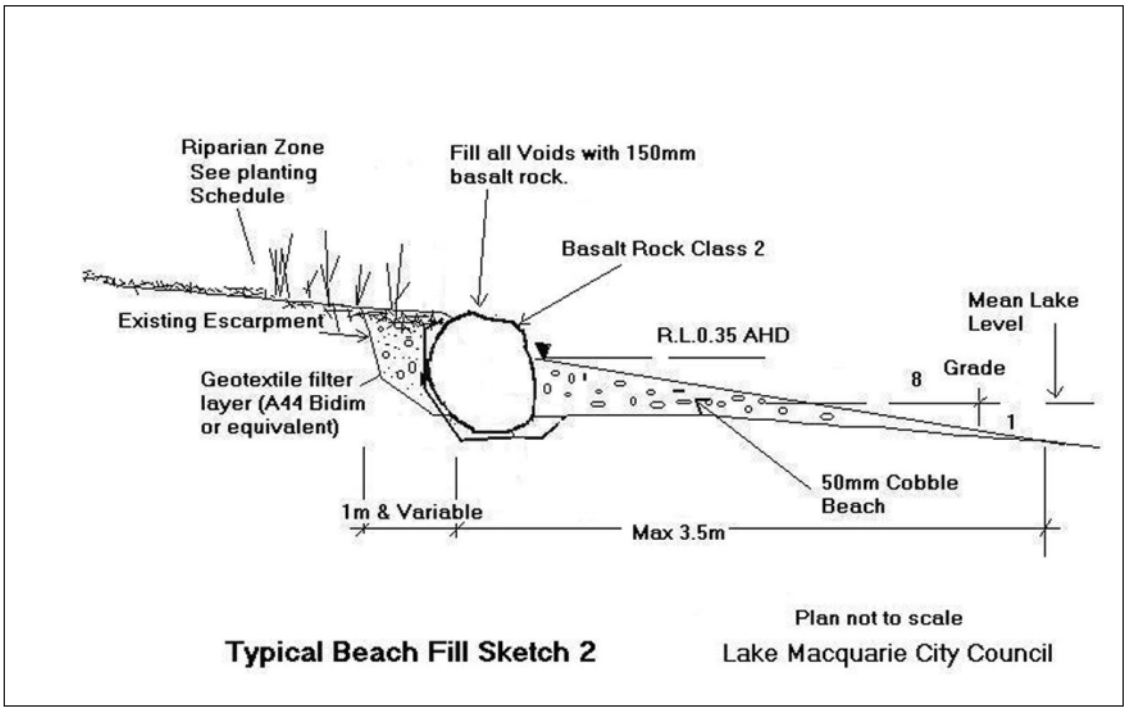


Figure 10-4 – Example of combining rock protection with cobble beach

D.3 Riparian Vegetation Management

Riparian vegetation management refers to the practice of maintaining native vegetation along the banks of an estuary to reduce the risk of erosion. The roots from native vegetation can be effective in holding together the banks, and mangroves, saltmarsh and seagrass wrack can dissipate wave energy and prevent erosion in areas where public access is not required. Techniques for establishing riparisan vegetation that have proven successful within St Georges Basin and Sussex Inlet include no-mow zones. Note that in the areas where public access is not required, fallen trees can also be effective in dissipating wave energy reaching the bank.

Figure 10-5 – Sanctuary Point foreshore, south of boat ramp. Note gentle slope, well-established foreshore vegetation and no-mow zone (28 November 2021). Site reference SP01.

D.4 Timber Toe Protection Wall

This management technique involves the installation of a barrier at the toe of a steep estuary bank, to prevent the bank from being undermined by toe erosion due to factors such as channel meandering, vessel waves or wind waves. This technique has been applied at The Haven in Sussex Inlet and has proven to be successful (Figure 10-6).

D.5 Brush Matting and Dune Stabilisation

On the upper parts of steep embankments subject to geotechnical slope instability, without reducing the gradient of the slope, slope stabilisation would likely be difficult to achieve. The use of dune fencing combined with brush matting and planting of dune vegetation in upper sections of the slope may allow vegetation to become established on the dune by creating terraced areas on the slope where the gradient is reduced and slope stability is improved.

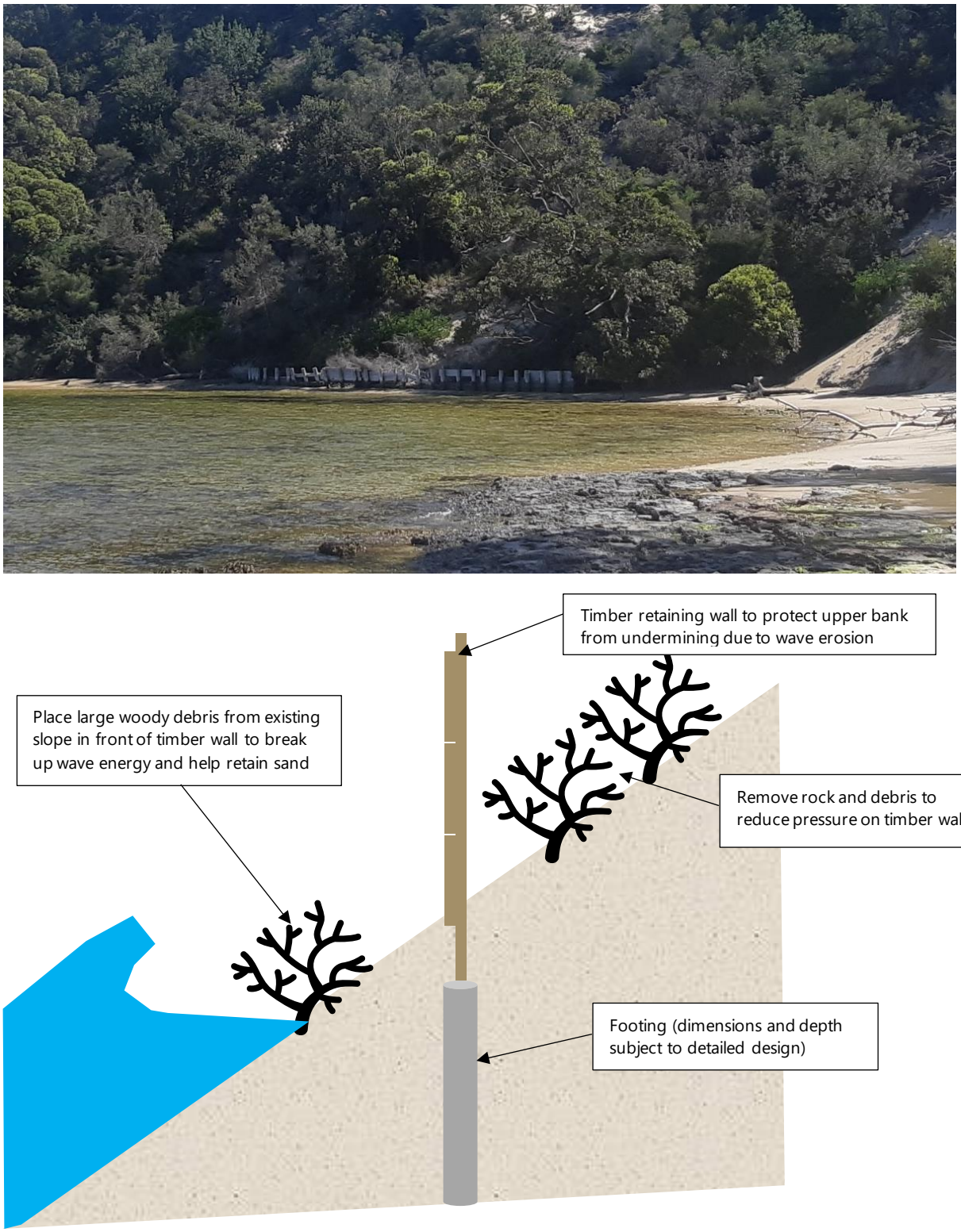


Figure 10-6 – Concept of timber toe protection wall

D.6 Groynes

Groynes refer to one or more shore-normal structures which could be constructed of rock, geotextile containers or timber, designed to trap sediment that is being transported along the shoreline. In an estuarine setting, groynes can be used to push the channel alignment away from the toe of a slope and prevent further erosive pressure on the slope. This concept is illustrated in Figure 10-7.

In conjunction with the use of groynes, renourishment of the groyne field could be used to provide toe protection to the eroding slope with sand won from future maintenance dredging activities elsewhere in the navigation channel, or the use of large woody debris or brush matting sourced from collapsing vegetation at the site could be used to provide protection to the toe of the slope.

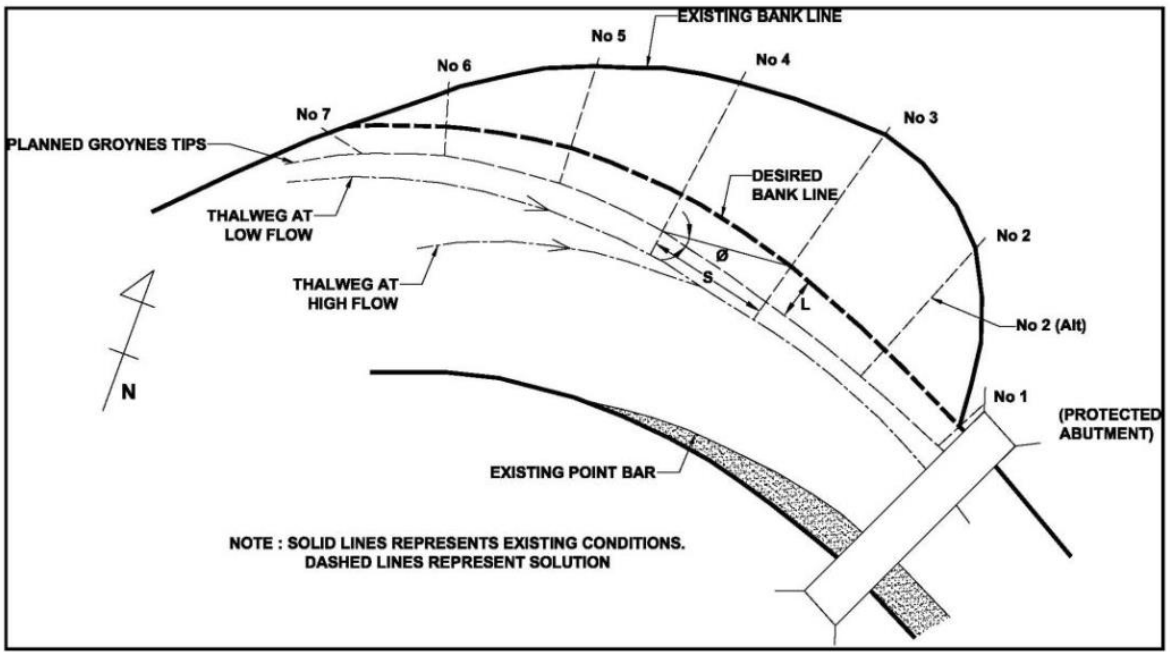


Figure 10-7 – Use of groynes to deflect flows away from the eroding bank on the outside of the bend (Lila et al 2009)

Figure 10-8 – Use of rock fillet/groyne at western end of foreshore, creating a foreshore access area and improving amenity (27 November 2021). Site reference S004.

D.7 Rock Fillets

Rock fillets involve the use of rock strategically placed along an eroding bank to protect existing riparian vegetation, such as mangroves. Rock is placed around the vegetation root zones so as to not smother existing bank vegetation but to protect it from undermining due to wave action. An example of this technique is shown in Figure 10-9.

Figure 10-9 – Use of rock fillets to protect casuarina roots from undermining and provide erosion protection to Basin Track (northern end of Macleans Point, 28 November 2021). Site reference MP02.