PROPOSED RIVERBANK MAINTENANCE ON REMAINDER 1 of FARM 305 HANGLIP, PLETTENBERG BAY.

Estuarine and Plant Species – Specialist Assessment

Prepared For: Eco Route

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- I consider myself bound to the rules and ethics of the South African Council for Natural Scientific Professions (SACNASP);
- At the time of conducting the study and compiling this report I did not have any interest, hidden or otherwise, in the proposed development that this study has reference to, except for financial compensation for work done in a professional capacity;
- Work performed for this study was done in an objective manner. Even if this study results in views and findings that are not favourable to the client/applicant, I will not be affected in any manner by the outcome of any environmental process of which this report may form a part, other than being members of the general public;
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- I confirm that this report contains all the necessary information required by GN 9 of 10 January 2020 and GN 320 of 20 March 2020 (Procedures for the Assessment and Minimum Criteria for Reporting on Identified Environmental Themes in Terms of Sections 24(5)(A) and (H) and 44 of the National Environmental Management Act, 1998, when Applying for Environmental Authorisation).
- All the particulars furnished by me in this document are true and correct.

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DISCLAIMER

Reporting requirements for the plant species and aquatic biodiversity theme have been combined in this single report. This is because the plant species that was confirmed to be of a High sensitivity (*Zostera capensis*) is estuarine and occurs in the sub-tidal zone of the estuary. The plant species is therefore not terrestrial and given the overlap in impacts between the themes it was decided to combine the reporting requirements for both themes in one single report. The report has therefore been jointly authored by a specialist in Aquatic Biodiversity (James Dabrowski) and a specialist in Botany (Bianke Fouche). Reporting requirements for protocols for both themes have been included in this report.

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1. INTRODUCTION

1.1 Background

Confluent Environmental (Pty) Ltd was requested by the Plettenberg Bay Angling Club (PBAC) to conduct a specialist estuarine impact assessment for the proposed stabilisation of the banks of a section of the Keurbooms Estuary on the Remainder 1 of Farm 305 Hanglip, Plettenberg Bay. The bank is currently eroding and is placing existing infrastructure at risk.

1.2 Key Legislative Requirements

According to the protocols specified in GN 9 of 10 January 2020 and GN 320 of 20 March 2020 (Procedures for the Assessment and Minimum Criteria for Reporting on Identified Environmental Themes in Terms of Sections 24(5)(A) and (H) and 44 of the National Environmental Management Act, 1998, when Applying for Environmental Authorisation), assessment and reporting requirements for plant species and aquatic biodiversity are associated with a level of environmental sensitivity identified by the national web-based environmental screening tool (screening tool).

1.2.1 Aquatic Biodiversity Theme

An applicant intending to undertake an activity identified in the scope of this protocol on a site identified by the screening tool as being of:

- **Very High** sensitivity for aquatic biodiversity, must submit an Aquatic Biodiversity Specialist Assessment; or
- **Low** sensitivity for aquatic biodiversity, must submit an Aquatic Biodiversity Compliance Statement.

The screening tool identified the site as being of **Very High** aquatic biodiversity as the proposed works will take place within:

a) An estuary that has been categorised as a Critical Biodiversity Area (CBA); and

b) A quinary catchment that has been categorised as a Freshwater Ecosystem Priority Area (FEPA).

A detailed site verification visit was therefore undertaken to confirm the site sensitivity and report accordingly.

1.2.2 Plant Species Theme

The screening tool identified the site as **Medium** sensitivity based on the possible presence of several plant species of conservation concern (SCC) (*Table 1*). An area designated as being of **Medium** sensitivity is considered to have suspected habitat for SCC based either on there being records for this species collected in the past prior to 2002 or being a natural area included in a habitat suitability model. According to the protocols, an applicant intending to undertake an activity identified in the scope of this protocol on a site identified by the screening tool as being of **Medium** sensitivity must undertake a site visit to verify the sensitivity of the site:

- Site confirmed as being of **Very High** or **High** (confirmed habitat for species of conservation concern) sensitivity for plant terrestrial species must submit a Specialist Assessment; or
- Site confirmed as being of **Low** sensitivity (i.e. no suspected occurrence of SCC) for terrestrial plant species must submit a Compliance Statement.

Table 1: List of plant species

Sensitivity	Species
Medium	*Faurea macnaughtonii*
Medium	*Ocotea bullata*
Medium	*Ruschia duthiae*
Medium	*Amauropelta knysnaensis*
Medium	*Leucospermum glabrum*
Medium	*Selago burchellii*
Medium	*Cotula myriophylloides*
Medium	*Acmadenia alternifolia*
Medium	*Sensitive species 763*
Medium	*Zostera capensis*

1.3 Terms of Reference

Assess the direct and indirect positive and negative implications of each phase of the proposed bank stabilisation on plant species and aquatic biodiversity associated with the affected section of the Keurbooms Estuary. This includes an assessment of the following potential impacts:

- Evaluate the potential impact of the proposed development on aquatic biodiversity and plant species (as per the Screening Tool Report).
- Assess the positive and negative environmental impacts of the proposed development on the receiving environment.
- Provide recommendations and, if necessary, a rehabilitation plan.

1.4 Study Area

The PBAC is situated on the western bank of the Keurbooms Estuary (Figure 1). The proposed stabilisation will take place along an approximately 55 m stretch of the riverbank and associated intertidal zone. Boats are moored to poles anchored into the bank of the river. The Keurbooms Estuary is prone to episodic flooding that has significant consequences for landowners and infrastructure. Floodwaters cause extensive erosion, particularly in the lower reaches of the estuary where extensive urbanisation and surface hardening has taken place and natural vegetation and riparian zones have been cleared to make way for residential developments and resorts (CAPE Estuaries Programme, 2010). In particular, the removal of riparian vegetation destabilises the bank, resulting in undercutting and ultimately collapse into the estuary. As such, various bank stabilisation interventions have been implemented along the banks of the estuary over time. These range from vertical retaining walls to sloping banks constructed from a reno mattress over lying a stepped sandbag foundation.

Figure 1: Map indicating the extent of the proposed bank stabilisation.

1.5 Bank Stabilisation: Alternative Options

Three alternative options have been proposed and will be assessed in this report. All three options require the construction of a 3 m reno mattress that will be placed approximately 1 m below the existing bed profile of the estuary and will extend approximately 3 m into the estuary. This will prevent undermining of the embankment.

- Option 1: Construction of stepped gabions over a geotextile layer (*Figure 2*).
- Option 2: Reprofiling the bank (1.3 m horizontal to 1 m vertical) using sandbags (800 mm x 500 mm x 170 mm).and covering these with a 0.3 m x 3.0 m reno mattress (*Figure 3*).
- Option 3: Reprofiling the bank (1.3 m horizontal to 1 m vertical) using larger, heavy duty geotextile sandbags (2 m x 1.9 m x 0.65m) which will remain uncovered (*Figure 4*).

For all options, the stabilisation will be restricted to the steeply eroded section of the embankment and will stop at the point where the gradient of the embankment flattens out and is not actively eroding (*Figure 1* and *Figure 5*).

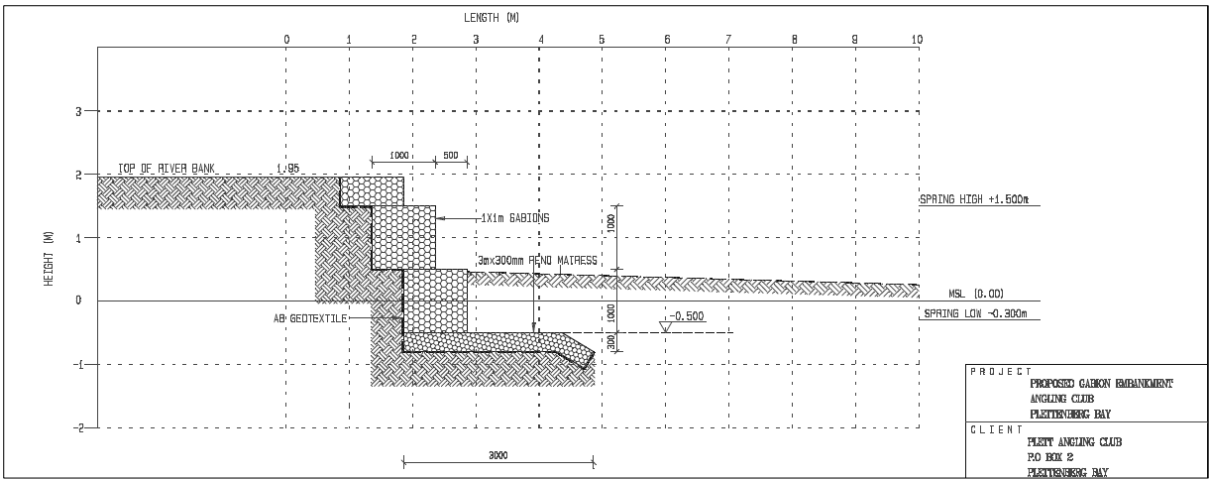

Figure 2: Section for Option 1.

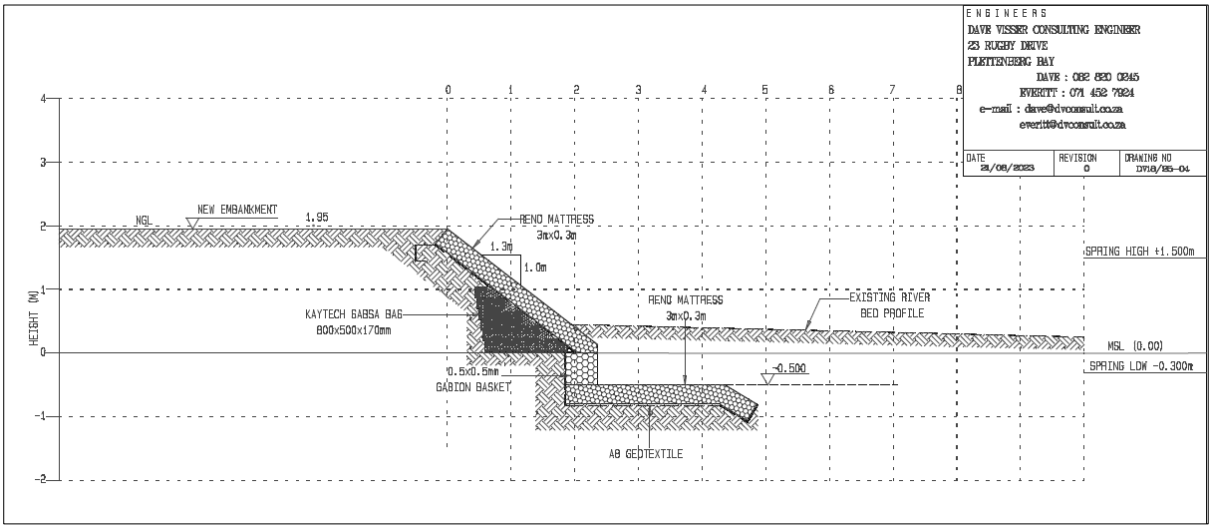

Figure 3: Section for Option 2.

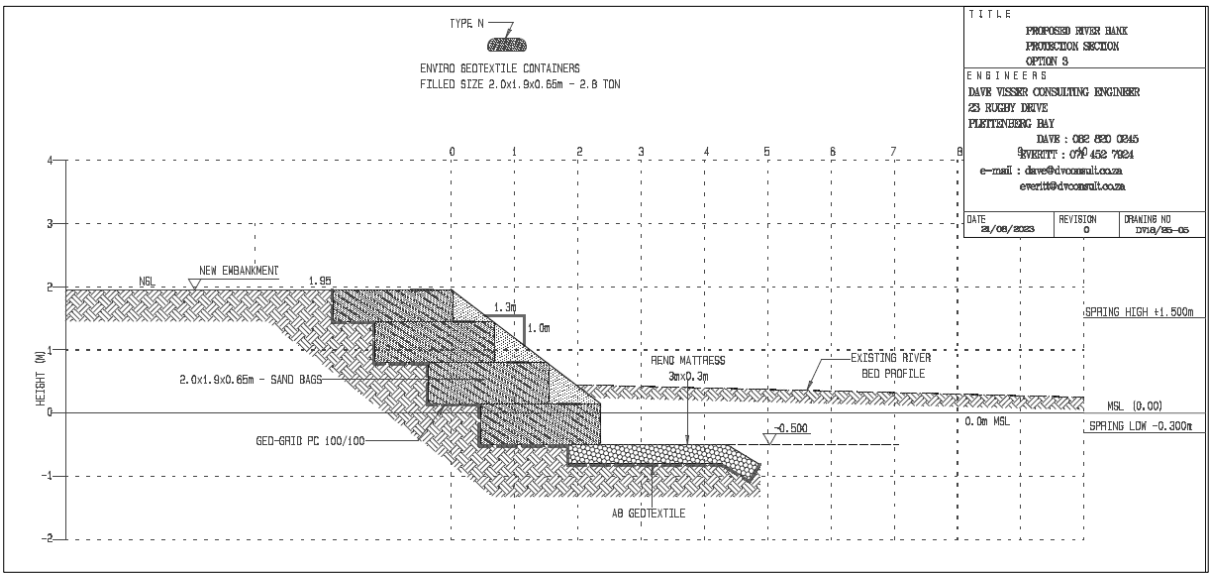

Figure 4: Section for Option 3.

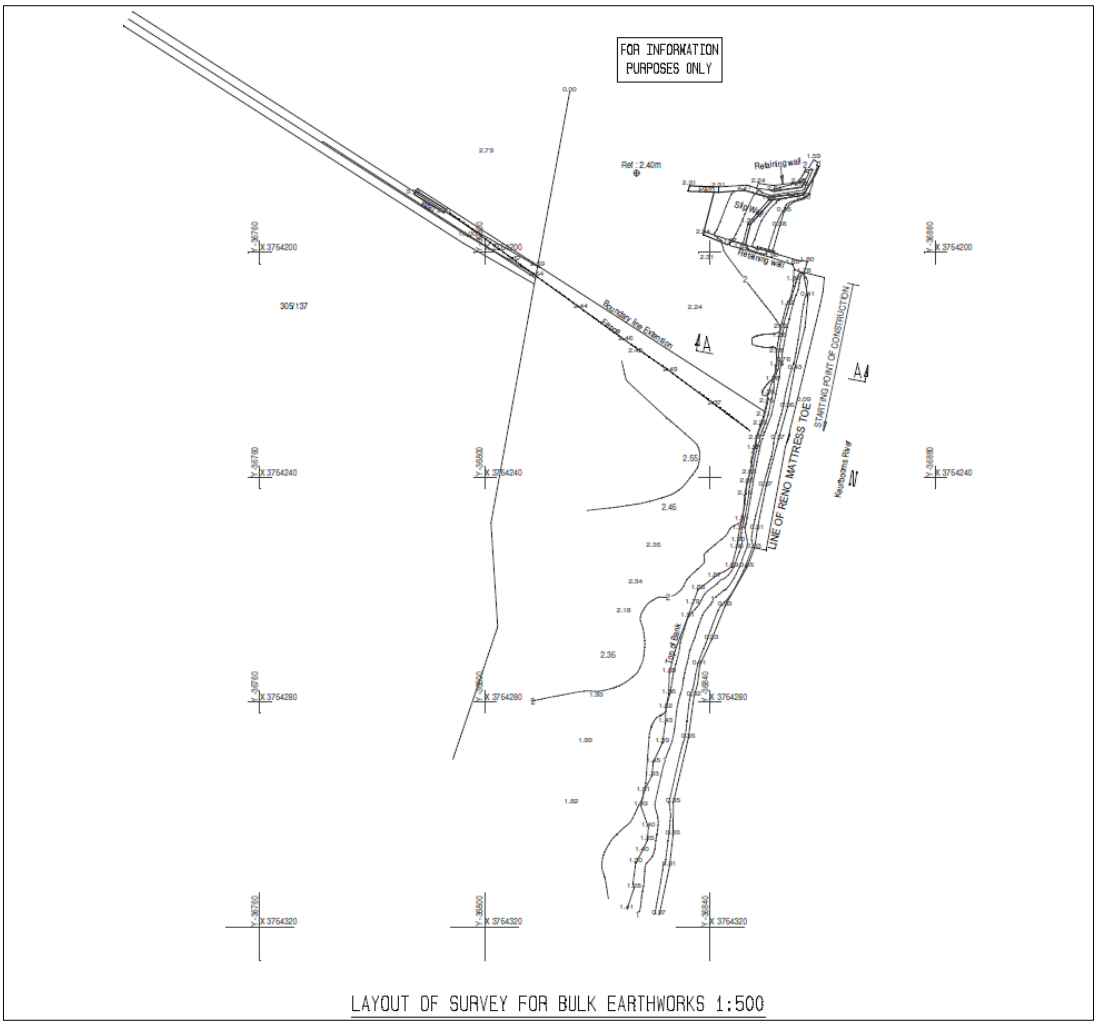

Figure 5: Proposed bank stabilisation layout.

2. ASSUMPTIONS AND LIMITATIONS

2.1 Estuarine Assessment

- Estuaries are complex, dynamic systems influenced by multiple environmental and anthropogenic variables. A comprehensive assessment that considers all of these variables did not form part of the scope of work. Assessments of the ecological state of the estuary were therefore derived using appropriate desktop resources.
- The dynamic nature of estuaries means that the structure of physical habitat and associated estuarine fauna and flora can change rapidly in response to tidal and hydrological (e.g. flooding events) influences. This assessment is based on a single site visit that took place in July 2023 and represents a 'snapshot' in time.
- No sampling of biota was undertaken (e.g. fish, invertebrates, microphytes, etc.) and all biotic data was derived from desktop sources.

2.2 Plant Species Assessment

This assessment is subject to a few assumptions, uncertainties, and limitations, as listed below:

- Two surveys took place during March and April 2024, which includes one survey on the 05th of April undertaken with the botanical specialist present. Seasonal and time constrains always somewhat limit the findings of any ecological report.
- It is assumed that this study is limited to the proposed extent of the bank stabilisation which impacts mostly on estuarine (as opposed to terrestrial) vegetation.
- Environmental factors and nearby species distribution heterogeneity may have impacted the visibility of estuarine plant SCC (e.g., flowers may not have been visible, for example *Cotula myriophylloides* (Critically Endangered, CR), however this species is still relatively obvious to identify when not flowering given its diagnostic floating stems in shallow coastal lagoons). However, one description from Powell et al. (2014)of *Cotula myriophylloides* is "A single collection of this species at Piesangs River near Knysna suggests that additional possibly overlooked populations between Agulhas and Knysna may still remain…" .

3. METHODS

3.1 Estuarine Assessment

3.1.1 Present Ecological State of the Keurbooms Estuary

The 2018 National Biodiversity Assessment (NBA) evaluated the ecological health of all estuaries in South Africa (Van Niekerk et al., 2019a). This assessment considered both abiotic and biotic components, namely hydrology, hydrodynamics and mouth condition, water chemistry, sediment processes, microalgae, macrophytes, invertebrates, fish and birds. Each estuary was assigned a condition score based on the similarity to natural for these various abiotic and biotic components. For each of the components, a panel of experts estimated the change in health as a percentage (0 – 100 %) of the natural state. Scores were weighted (25 % for each abiotic and 20 % for each biotic component) and aggregated (to provide an overall score that reflects the present health of the system as a percentage of that under natural conditions.

Table 2: Estuary health scoring system indicating the relationship between the six Ecological Categories and the loss of ecosystem condition and functionality.

Category	Description
A	**Natural:** The natural biotic processes should not be modified. The characteristics of the resource should be determined by unmodified natural disturbance regimes. There should be no human induced risks to the abiotic and biotic processes and function.
B	**Largely Natural:** A small change in natural habitats and biota may have taken place, but the ecosystem functions are essentially unchanged.
C	**Moderately Modified:** A loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged
D	**Largely Modified:** A large loss of natural habitat, biota, and basic ecosystem function has occurred.
E	**Seriously Modified:** The loss of natural habitat, biota and basic ecosystem function is extensive.
F	**Critically Modified:** Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural abiotic processes and associated biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

Van Niekerk et al. (2019a) assessed the overall ecological importance and sensitivity of estuaries based on several criteria including the size (i.e. surface area), habitat importance, zonal rarity type and biodiversity importance. These criteria were each rated (out of a score of 100) and the average of all criteria was used as the final EIS Score (Table 3).

Table 3: Description of EIS Scores for estuaries derived by Van Niekerk et al. (2019a).

EIS Score	Description
0 – 60	Average Importance
61 – 80	Important
80 – 100	High Importance

3.2 Plant Species Assessment

Field work was undertaken on the 22nd of March 2024. The method for identifying species was similar to a BioBlitz, also described as a "timed meander", where the specialist especially keeps an eye out for rarer and threatened species. Some Red Listed Plant species are found more easily during a site survey than other species. This survey method is an attempt to account for the short and single survey period. Observations of individual species and environmental characteristics were documented using a Nikon Coolpix camera.

4. ATTRIBUTES OF THE AFFECTED SYSTEM

4.1 Catchment

The affected portion of the Keurbooms Estuary falls in quaternary catchment K60E (*Figure 6*). The main river flowing through the catchment area is the Keurbooms River. The estuary falls within level 22.02 of the Southern Coastal Belt ecoregion, which is characterised by moderately undulating plains of moderate relief with altitude ranging from 0 to 500 m above mean sea level. Mean annual precipitation for the catchment area is relatively high (between 300 and 700 mm per annum), and occurs year-round, with peaks in late winter and early spring (August to October).

The Keurbooms and Bitou estuaries (collectively referred to as the Keurbooms) are located close to Plettenberg Bay and both feed into what is known as the Keurbooms Lagoon, which is separated from the sea by a prominent berm, prior to it flowing out to sea. The confluence of the Bitou and Keurbooms estuaries is approximately 3.5 km from the mouth. The Bitou River is 23 km long, with its source at Buffelsnek, and is tidal for 7.2 km from the confluence to the causeway at Wittedrift. The Keurbooms River is approximately 85 km long, with its source at Spitskop in the Outeniqua Mountains, and is tidal for approximately 8.5 km from the confluence (CAPE Estuaries Programme, 2010).

In South Africa, the Estuarine Functional Zone (EFZ) is defined as the area that not only delineates the boundaries of the estuarine waterbody, but also the supporting physical and biological processes and adjacent habitats necessary for estuarine function and health (Van Niekerk et al., 2019b). It includes all dynamic areas influenced by long-term estuarine sedimentary processes, multiple ecotones of floodplain and estuarine vegetation that contribute organic material and provide refuge from strong currents during high flow events. EFZs are currently delineated by the 5 m contour line and therefore include large areas of land (much of which has been developed) that border the actual water body. The EFZ is now commonly used to delineate the spatial extent of the entire estuary. In this respect large

sections of the Keurbooms EFZ have been developed into residential and agricultural properties (*Figure 7*).

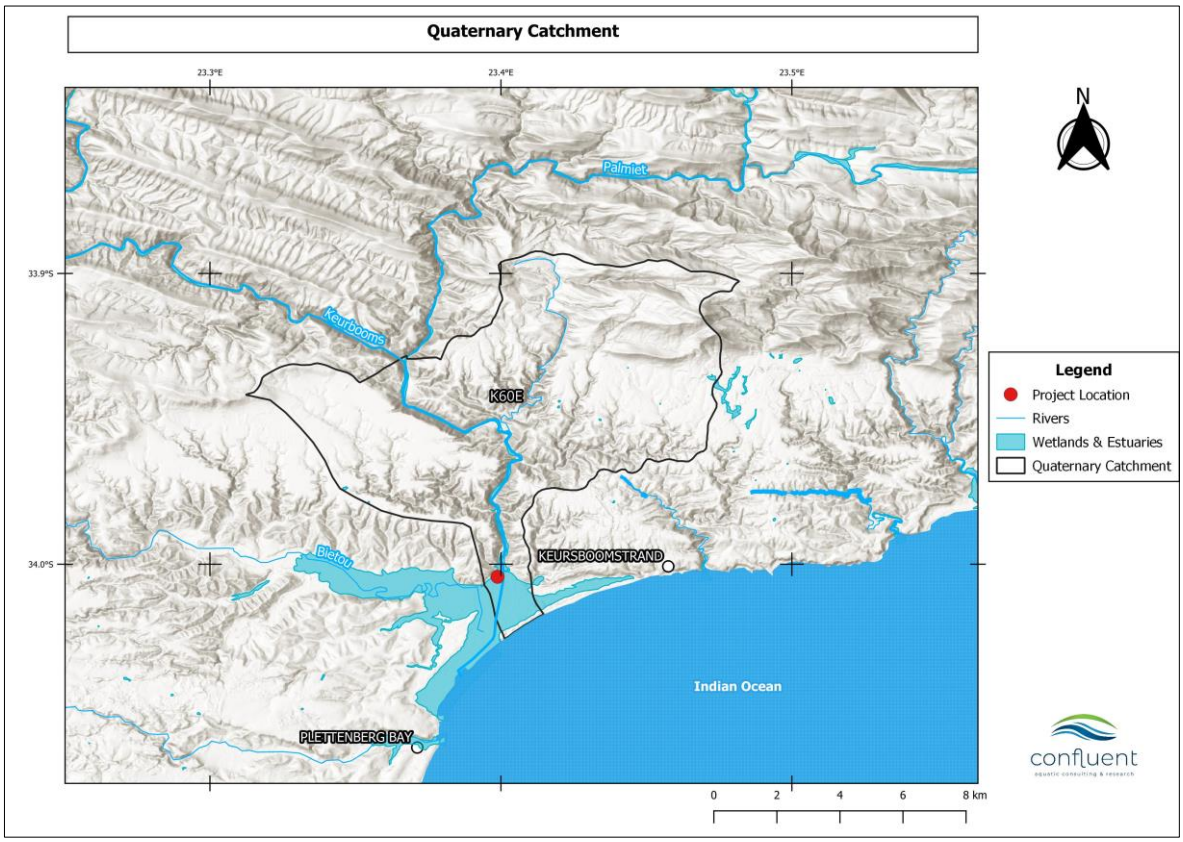

Figure 6: Figure illustrating the location of the project area in relation to quaternary catchment K60E.

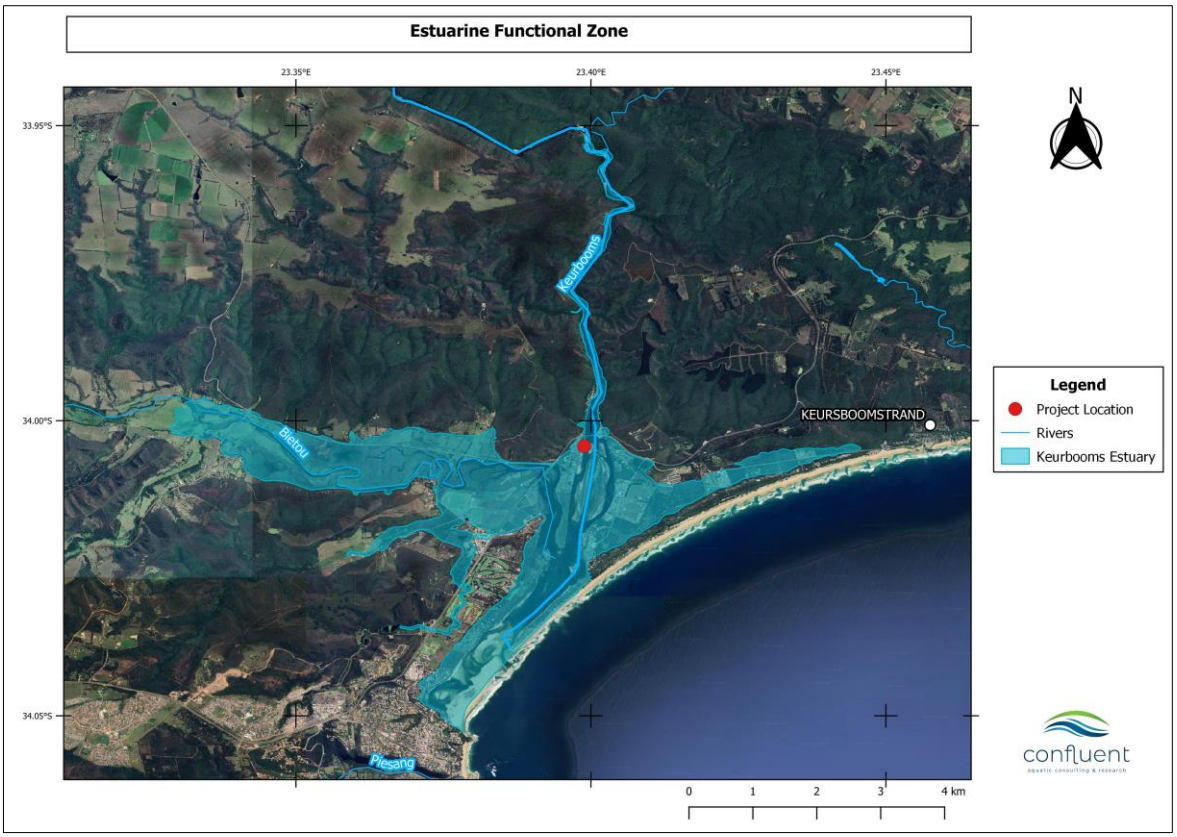

Figure 7: Map indicating the EFZ of the Keurbooms Estuary.

4.2 Estuary Classification

The Keurbooms Estuary is classified as a Predominantly Open estuary which is characterised by the following (Van Niekerk et al., 2019c):

- They are open to the sea for more than 90 % of the time.
- They are linear systems in which mixing processes are dominated by both fluvial inputs and tidal action creating vertical and horizontal salinity gradients.
- They usually support wetlands, salt marshes, macrophyte beds and marine and estuarine fauna.
- They vary in size from as little as 10 ha to as much as 7 500 ha.

4.3 Conservation & Biodiversity Planning

4.3.1 National Freshwater Ecosystem Priority Areas

The property falls within sub-quaternary catchment (SQC) 9097, which, according to the National Freshwater Ecosystem Priority Atlas (NFEPA, Nel et al., 2011), has been classified as a Freshwater Ecosystem Priority Area (FEPA) (*Figure 8*). River FEPAs achieve biodiversity targets for river ecosystems and threatened/near-threatened fish species and were identified in rivers that are currently in a good condition (A or B ecological category). Their FEPA status indicated that they should remain in a good condition in order to contribute to national biodiversity goals and support sustainable use of water resources (Nel et al., 2011).

For river FEPAs, the whole SQC is identified as a FEPA, although the FEPA status applies to the actual river reach within such a sub-quaternary catchment. The shading of the whole sub-quaternary catchment indicates that the surrounding land and catchment area needs to be managed in a way that maintains the good ecological condition of the river reach, which in this case, is the Keurbooms River. It is therefore important that development does not result in any deterioration of the river or its catchment area. Similarly, the Keurbooms Estuary and adjacent wetland areas have been identified as an estuary FEPA, which is also indicative of the good ecological condition of the estuary. The larger drainage network and surrounding land use should therefore be managed to ensure the estuarine system remains in a good ecological condition.

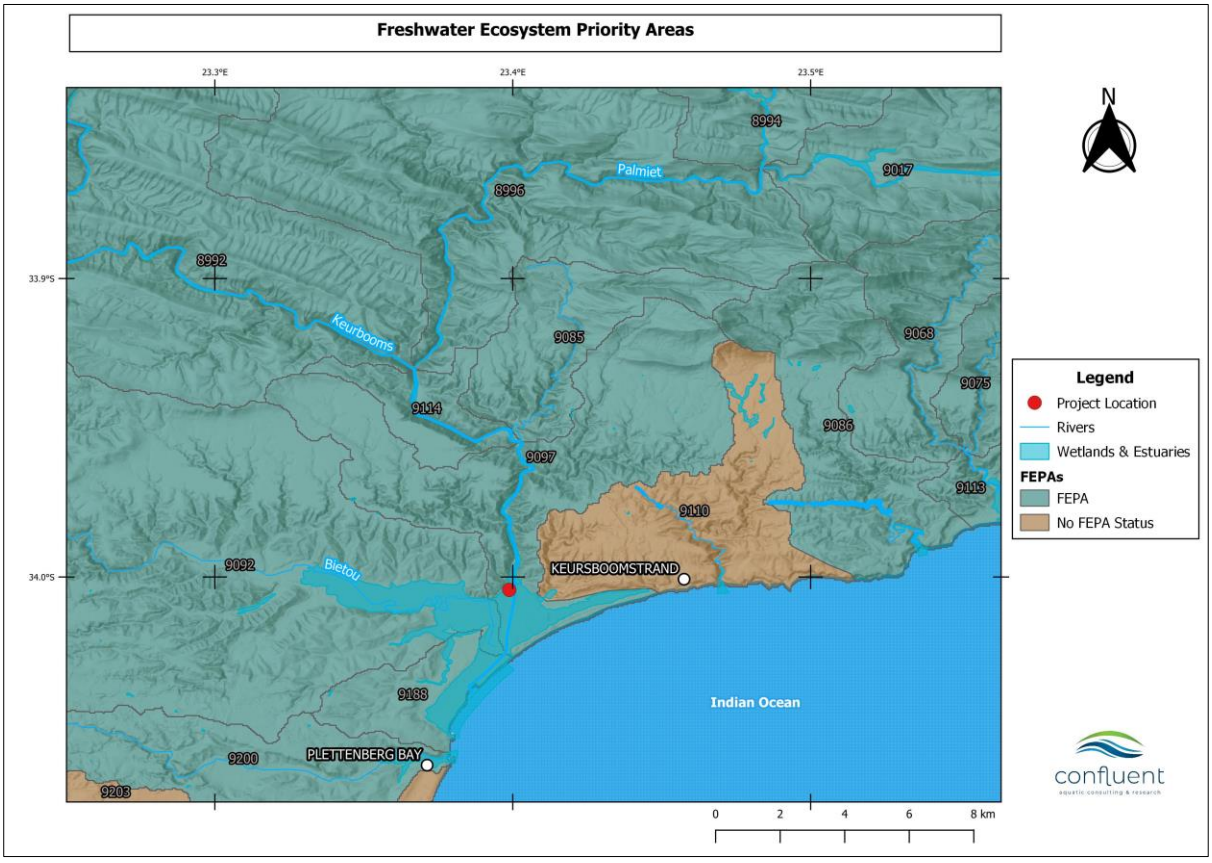

Figure 8: Map illustrating the loaction of the project area in relation to FEPA sub-quaternary catchments.

4.3.2 Western Cape Biodiversity Spatial Plan

According to the Western Cape Spatial Biodiversity Plan, the Keurbooms Estuary falls within a Critical Biodiversity Area 1 (CBA1), under the sub-category for estuarine habitats (Figure 9). Management objectives associated with CBAs are provided in *Table 4* and stipulate that degraded areas should be rehabilitated and that only low impact activities are appropriate.

Table 4: Definitions and management objectives of the Western Cape Biodiversity Spatial Plan.

Category	Description	Management Objective
CBA 1 (Estuaries)	Areas in a natural condition that are required to meet biodiversity targets, for	Maintain in a natural or near-natural state, with no further loss of natural habitat. Degraded areas should be

	species, ecosystems or ecological processes and infrastructure.	rehabilitated. Only low-impact, biodiversity-sensitive land uses are appropriate.

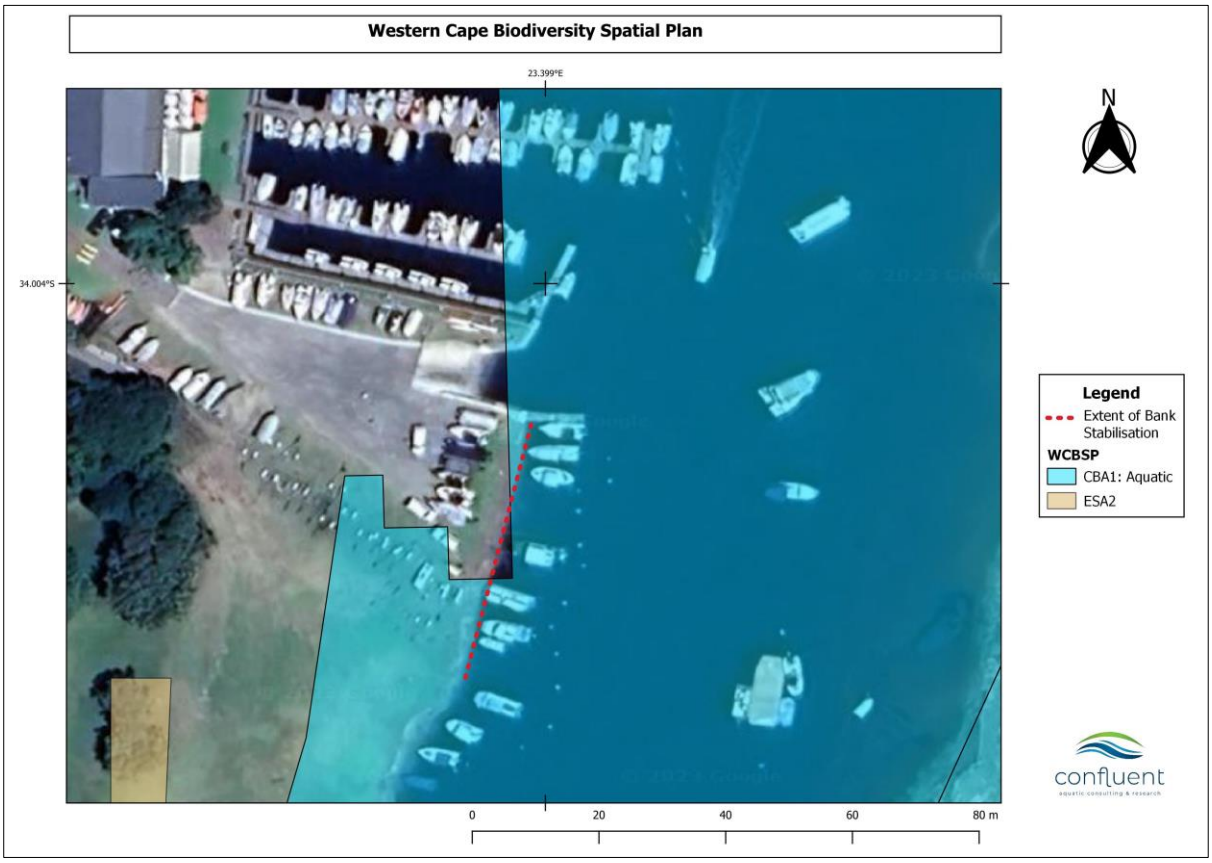

Figure 9: Map indicating the area of development in relation to the Western Cape Spatial Biodiversity Plan (WCBSP).

4.4 National Biodiversity Assessment

According to 2018 National Biodiversity Assessment (NBA) (Van Niekerk et al., 2019a), the PES of the Keurbooms Estuary is A/B (**Near Natural**), indicating that it is relatively good ecological condition and has not been significantly modified from its natural state (*Table 5*). Most of the abiotic indices used to derive the overall PES are in fact in a natural condition (A). Modifications to fish assemblages and bird populations are the most important drivers of change from the natural state. The ecological importance is therefore regarded as being high and Turpie (2004) ranked the Keurbooms estuary as the 18th most important system in South Africa in terms of conservation importance. According to Van Niekerk et al. (2019d) the ecosystem threat status of the Keurbooms Estuary, is **Vulnerable**. These systems are poorly protected in South Africa.

Table 5: Summary of the Present Ecological Status (PES) and Ecological Importance of the Keurbooms Estuary (Van Niekerk et al., 2019a).

Index	Category
Hydrology	*A*
Hydro-dynamics	*A*
Physical Habitat	*B*
Water Quality	*A*
Microalgae	*B*
Macrophytes	*C*
Invertebrates	*A*
Fish	*C*
Birds	*B*
Overall PES	**A/B**
Ecological Importance	**High**

4.5 Resource Quality Objectives

The classification of water resources and development of Resource Quality Objectives (RQOs) for the Breede-Gouritz Catchment Management Area was finalised in 2018. Quaternary catchment K60F, falls within the G15 Coastal Integrated Unit of Analysis (IUA). The Water Resource Class for this IUA is II, indicating moderate protection and moderate utilisation. The Target Ecological Category (TEC) for the Keurbooms Estuary has been set as an A (Natural), which indicates that the estuary must be managed to achieve a pristine state. Specific RQOs have been produced for the estuary in alignment with the TEC. These include specific limits at which indicators of water quantity and quality, habitat and biota must be maintained (*Table 6*).

Table 6: Numeric RQOs for the Keurbooms Estuary

Component	Sub-component	Indicator	RQO Narrative	RQO Numeric
Quantity	Flow	MMR/MAR (% Nat)	Maintain flow regime as close to natural as possible	
Quality	Nutrients	DIN	Inorganic nutrient concentrations not to exceed TPCs for macrophytes and microalgae	DIN not >100 µg/L once-off.
		DIP		DIP not >20 µg/L once-off.
	Salinity	Salinity	Salinity distribution not to exceed TPCs for fish, invertebrates, macrophytes and microalgae	Average salinity >10 at the top of the estuary in the Keurbooms and/or Bitou Arm, average salinity >20 along the length of the system
	System variables	Turbidity	System variables not to exceed TPCs for biota	>10 NTU in low flow
		Dissolved oxygen		>5 mg/L in estuary.
		Enterococci	Concentrations of waterborne pathogens should be maintained in an Acceptable category for full contact recreation	≤185 Enterococci/100 ml) (90th percentile)
		Escherichia coli		≤500 E. coli/100 ml (90th percentile)
Habitat	Hydrodynamics	Mouth state	Maintain connectivity with marine environment at a level that ensures water quality and habitat remains suitable for biota typically found in the estuary	Estuary mouth permanently open
		Tidal variation	Flood regime is sufficient to maintain natural Bathymetry and sediment characteristics	Average tidal amplitude near the mouth during low flows (summer) must not change by >10% from established baseline.

Component	Sub-component	Indicator	RQO Narrative	RQO Numeric
	Sediment	Sediment characteristics, Channel shape/size	Flood regime to maintain natural bathymetry and the sediment characteristics	Channel shape/size, sediment grain size and organic matter must not change by >30% from established baseline
Biota	Microalgae	Biomass and community composition of phytoplankton and benthic microalgae community	Maintain the composition and richness of phytoplankton and benthic microalgae groups and medium-low biomass	Maintain low/median phytoplankton/benthic microalgae biomass: phytoplankton not to exceed 3.5 µg/ℓ (median), phytoplankton not to exceed 20 µg/ℓ and/or cell density not to exceed 10 000 cells/ml (once-off); benthic microalgae not to exceed 23 mg/m2 (median); prevent formation of phytoplankton blooms
	Macrophytes	Extent, distribution and richness of macrophytes	Maintain extent, distribution and richness of macrophyte groups, limit colonisation/spread of the EFZ by alien species	Maintain the distribution of sensitive macrophyte habitats (e.g. salt marsh, submerged macrophytes, reeds and sedges) (of special importance are the submerged macrophytes in the Bitou Arms as habitat for the endangered seahorses *H. capensis*); rehabilitate the Bitou wetlands by removing weirs, berms, old bridges; limit the spread of invasive plants; maintain the integrity of the riparian zone
	Invertebrates	Macrofauna Community composition, abundance and richness	Maintain composition, richness and abundance of different groups of benthic macrofauna and zooplankton	Maintain high biomass and diversity of benthic invertebrates in the lagoon area in the lower estuary; maintain rich invertebrate communities associated with the REI zone in the upper estuary (zooplankton and benthos).
	Fish	Fish community composition, abundance and richness	Maintain composition, richness and abundance of different groups of fish, prevent colonisation/increase of alien species	Fish assemblage should comprise the 5 estuarine association categories in similar proportions (diversity and abundance) to that under the reference (see 2015 EWR report); numerically assemblage should comprise: Ia estuarine residents (50-80% of total abundance), Ib marine and estuarine breeders (10-20%), IIa obligate estuarine dependent (10-20%), IIb estuarine associated species (5-15%), IIc marine opportunists (20-80%), III marine vagrants (not more than 5%), IV indigenous fish (1-5%), V catadromous species (1-5%); Category Ia species should contain viable populations of at least 4 species ; Category IIa obligate dependents should be well represented by large exploited species
	Birds	Avifauna Community composition, abundance and richness	Maintain composition, richness and abundance of different avifauna groups	Maintain population of original groups of birds present on the estuary; number of birds in any group, other than species that are increasing regionally such as Egyptian geese, should not drop below the baseline median (determined by past data and or initial surveys) number of species and/or birds counted for three consecutive summer or winter counts

4.6 Keurbooms-Bitou Estuary Management Plan

Estuaries are recognised as particularly sensitive and dynamic ecosystems and the National Environmental Management: Integrated Coastal Management Act (No. 24 of 2008, as amended by Act 36 of 2014) (ICMA), via the prescriptions of the South African National Estuarine Management Protocol (the Protocol), require Estuary Management Plans (EMPs) to be prepared for estuaries in order to create informed platforms for efficient and coordinated estuarine management. To this end, the Keurbooms EMP was compiled in 2017 (DEADP, 2018) and provides a detailed situation assessment of the estuary as well as management objects aimed at achieving an agreed upon vision for the estuary which is as follows:

"From catchment to coast, the Keurbooms and Bitou systems will be harmoniously managed through active participation to maintain their biodiversity in order to attract visitors, promote education, create awareness, and preserve the cultural, natural and recreational heritage for (the benefit of) all (South Africans)."

A specific management objective highlighted in the EMP that is relevant to the proposed development structures and privately owned and developed land should be managed in such a way as to prevent further bank erosion during flood events.

4.7 Species of Conservation Concern

4.7.1 Knysna Seahorse (Hippocampus capensis)

The Knysna seahorse (*Hippocampus capensis*) occurs only in the Keurbooms, Knysna and Swartvlei estuaries (Lockyear et al., 2006) and is listed as an endangered species on the IUCN Red List due to its fragmented distribution, small area of occupancy, the vulnerability of its habitat and susceptibility to high mortality due to freshwater flooding (Pollom, 2017). *Hippocampus capensis* is restricted to sub-tidal areas (Teske, 2003) and is usually found at depths between 0.5-20 m in association with submerged aquatic plants (Bell et al. 2003). Bell (2003) and Teske (2007) found the species to associate with *Zostera capensis*, *Caulerpa filiformis*, *Codium extricatum*, *Halophila ovalis* and *Ruppia cirrhosa.* While Teske (2007) did not report on any preference for a specific species of macrophyte, Bell (2003) did indicate a preference for *Z. capensis.* Both studies showed contrasting preference for percentage of cover ranging from dense (> 75 %; Teske, 2007) to sparse (< 20 % cover). More recent studies indicate that the species also use artificial habitats (including reno mattress) extensively (Claassens, 2017) and that constructed artificial habitats such as marinas and boat harbours using reno mattresses within the estuaries have increased population numbers and increased the range of the species. *Hippocampus capensis* can also tolerate a wide range of environmental conditions (Lockyear et al. 2006). Increased boat activity and associated noise has been show to significantly decrease activity within suitable habitats (Claassens and Hodgson, 2018).

4.7.2 Eelgrass (Zostera capensis)

This CR species is confirmed to be present on the site, and is represented elsewhere in the estuary (therefore it has a low irreplaceability rating at the site location). The proposed activity will also not have an irreversible effect on this species, which is important given the Red List status of this plant.

Globally, seagrasses provide important ecological services in estuaries, including stabilizing sediment, preventing erosion, reducing water flow, trapping nutrients and organic materials and providing sheltered habitat for fish and invertebrates. Because of these ecological services they provide to coastal zones they are ranked among the most productive and valuable ecosystems on Earth (Adams, 2016). As a result of coastal development, habitat destruction and its continued decline, *Z. capensis* is listed as vulnerable in the Red Data List of Species (Short et al., 2010). Studies in South Africa have shown that *Z. capensis* beds support a more diverse and abundant invertebrate and fish community than unvegetated benthic habitats (Whitfield et al., 1989). Furthermore *Z. capensis* provides critical habitat for *H. capensis* (Lockyear et al., 2006). *Zostera capensis* is the dominant submerged aquatic macrophyte in the Keurbooms estuary (CAPE Estuaries Programme, 2010). Although in South

Africa abundant, *Z. capensis* is considered an endangered (EN) species and has the following description on SANBI's Red List website:

> *"The species experiences extreme fluctuations in population size due to dynamic changes in cover abundance in response to floods, droughts, sedimentation, and freshwater abstraction (Adams, 2016; Adams & Talbot, 1992; Cyrus et al., 2008; Pillay et al., 2010; Talbot et al., 1990; Talbot & Bate, 1987). The number of known subpopulations have been reduced, as two subpopulations have been lost from Durban Bay and the St Lucia system. The subpopulation in the uMhlathuze system is variable due to partial protection by Ezemvelo KwaZulu-Natal Wildlife, and the threat of increased turbidity and silt smothering from dredging. It is a concern that the next largest eelgrass subpopulation occurs approximately 850 km south of uMhlathuze at the Keiskamma Estuary, making recolonization difficult, if a subpopulation is lost, however propagules could still come from the Kosi system. Of the 62 subpopulations of eelgrass, there are only thirteen large subpopulations (Kosi, uMhlathuze, Qora, Keiskamma, Kariega, Bushmans, Swartkops, Kromme, Keurbooms, Knysna, Langebaan, Berg and Olifants) and these have shown varying changes in extent over time, with increases and decreases caused by similar activities such as disturbance from boats, bait digging and trampling. Further investigation is necessary to understand the dynamic responses of this species to environmental changes and habitat disturbance, to improve predictions of future distribution and status (Adams, 2016)."*

4.7.3 Floating buttons (Cotula myriophylloides)

This species is a highly specialised floating halophyte that has been severely impacted by urban expansion. It is restricted to shallow margins of some saline estuary edges (a habitat that was not present at this site due to the state of the estuary bank). Despite the habitat not currently existing, it is possible that this species may occur on the site when the banks have been stabilised and improved, if there are unknown populations that occur outside of, or somewhere localised within the project area of influence. For this reason, the likelihood of occurrence for this species is assumed to be high, following the precautionary principle, despite no evidence of its presence during the site assessments. This species is unique due to the stems and leaves that float on the surface of the water (Powell et al. 2014). It is known from only two localities, namely around the Cape Peninsula and a single collection near the Piesangs River near Knysna. This suggests that unknown populations of this CR species may still persist in estuaries nearby Knysna.

5. FIELD ASSESSMENT

5.1 Project Area of Interest

The expectation of broader impacts occurring outside of the footprint of the streambank stabilisation structure is expected to be very low. Consequently, the PAOI is limited to an approximately 50 m length of the eroded bank of the estuary (where the bank stabilisation structure will be constructed) and, a distance of approximately 10 m inland from the banks and 5 m into the inter-tidal zone of the estuary (where habitat may be disturbed due to the construction activities and vehicles). The total surface area of the footprint of the PAOI is less than 1 000 m^2 (Figure 10).

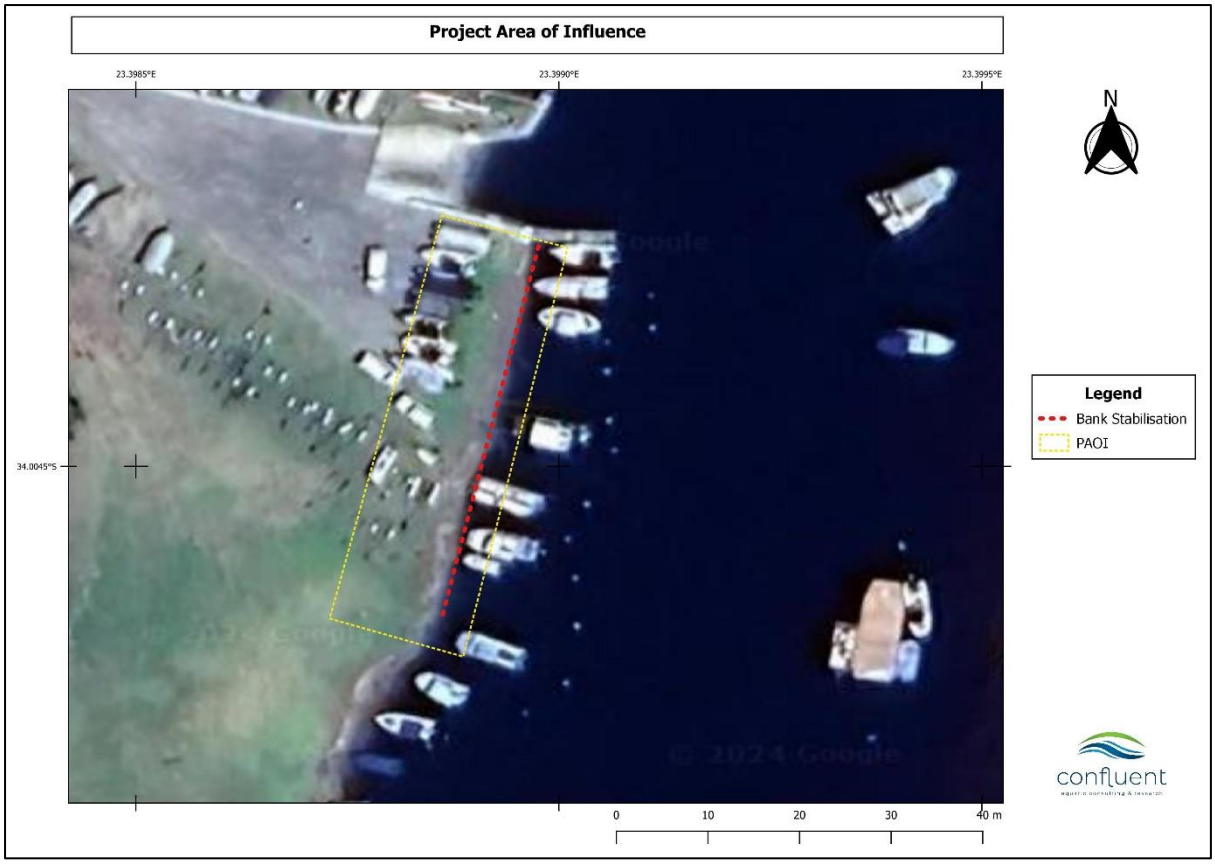

Figure 10: Map illustrating the extent of the streambank stabilisation and the associated PAOI.

5.2 Estuarine Habitat

The PBAC consists of a small marina, slipway and wooden floating jetties to which numerous boats are moored. Almost the entire shoreline of the area comprising the marina has been stabilised with gabion basket structures (*Figure 11*). The site visit confirmed the presence of an approximate 55 m stretch of the estuary bank that is vertically incised (approx. 1.5 m high) and eroded and is actively slumping into the estuary. The most northern stretch is approximately 3 m from the edge a tarred parking area. The entire bank is devoid of any indigenous riparian vegetation and is covered by kikuyu lawn (*Cenchrus clandestinus*).

Figure 11: Photographs illustrating existing gabions and jetties at the PBAC (A); boats mooring along the eroded bank (B); actively eroding banks (C to E); and the estuary banks further downstream where erosion is not as severe (F).

The inter-tidal zone consists of a narrow section mud flat/sand bank and the deeper sub-tidal zone is dominated by *Zostera capensis* on the bed of the estuary. This can clearly be seen in recent aerial images of the site (*Figure 12*). Numerous boats were moored along the banks (within the inter- and subtidal zone of the estuary) and are tied to wooden poles driven into the bank of the estuary. The stretch of the eroded bank therefore experiences frequent boat traffic and while *Z. capensis* is abundant, is unlikely to provide suitable conditions for abundant numbers of *H. capensis* (Claassens and Hodgson, 2017) and other estuarine vertebrates (e.g. fish).

Figure 12: Google Earth image (2022) indicating the extent of Z. capensis in the vicinity of the PBAC.

5.3 Plant Species

The terrestrial component of the PAOI consists of a large, open grass lawn comprised predominantly of a mixture of low growing grass species (invasive *Clandestinus cenchrus* and indigenous *Cynodon dactylon*). No trees or shrubs were present within or close proximity to the PAOI. The inter-tidal zone habitat is very narrow (exposed sand banks at low tide are less than 3 m in width) and is used to moor boats along the shoreline. Vegetation is limited, consisting of *Z. capensis* within the inundated subtidal zone of the estuary and isolated patches of salt marsh species along the outer edge of the inter-tidal zone (Figure 3). Other terrestrial/ estuarine species observed are illustrated in *Figure 13*. Apart from *Z. capensis* no other SCC were observed within the PAOI and are also deemed to have a very low probability of occurrence due to the complete transformation in natural terrestrial habitat that has occurred.

Figure 13: Plant species observed at the site, including Z. capensis (A) Plantago carnosa (B) Salicornia sp. (C) Tetragonia fruiticosa (D) Carpobrotus sp. (E) Chenolea diffusa (F) and transformed terrestrial habitat adjacent to the bank of the estuary (G).

5.4 Historical Perspective

It is worth noting that similar bank stabilisation structures have been implemented at other locations along the estuary bank. This author has had experience with the San Marino Estate and the Silverstreams River Estate, both of which occur along the eastern bank of the estuary. In both these cases, a sloped reno mattress stabilisation structure, similar to Option 2 was implemented - in combination with the construction of floating jetties. In both cases, the reno mattress replaced a pre-existing vertical wooden bank stabilisation structure. The Silverstreams River Estate bank stabilisation commenced in the beginning of 2019 and was

completed in the same year. The bank stabilisation (and jetty construction) has not had a serious impact on *Z. capensis* beds which are still present post construction (*Figure 14*).

Figure 14: Google Earth images showing Z. capensis beds pre (left) and post (right) construction of bank stabilisation and floating jetties along the eastern bank of the Keurbooms Estuary.

6. IMPACTS ASSOCIATED WITH THE DEVELOPMENT

Impacts are discussed according to the three options described in Section 1.5 and the No-Go option. The No-Go alternative also provides a baseline against which the impacts of the preferred options are compared. The proposed activities will not result in modifications to surface flows into the estuary and will not result in the construction of infrastructure across the estuary. The development will therefore in no way impact on the base flows or hydrological regime (i.e. timing and magnitude of surface flows) of the estuary or cause fragmentation or loss of ecological connectivity. Furthermore, the activities are of such a scale that will in no way impact on the frequency of estuary mouth closure.

6.1 Construction Phase Impacts

Assessment of impacts associated with the construction phase consider all three options and the No Go option. A summary of ratings for each impact associated with the construction phase can be viewed in the impact tables below.

Impact 1 – Disturbance of estuarine habitat and biota caused by placement of sandbags and reno mattresses.

The eroded embankment will be replaced by either of the three alternative options. The reno mattress will extend into the bed of the estuary and construction will therefore result in initial disturbance of inter- and subtidal habitat, including loss of *Z. capensis*. Based on experience from similar structures, the bed is however expected to re-establish over most of the reno mattress over time and it is likely that *Z. capensis* will also re-establish.

Impacts associated with the No-Go option are minor due to continued active erosion of the bank which can affect the quality of supra- and intertidal habitat.

Impact	Option 1		Option 2		Option 3		No-Go
	Without Mitigation	With Mitigation	Without Mitigation	With Mitigation	Without Mitigation	With Mitigation	
Intensity	High	Moderate	High	Moderate	High	Moderate	Low
Duration	Short term	Short term	Short term	Short term	Short term	Short term	Ongoing
Extent	Very limited	Very limited	Very limited	Very limited	Very limited	Very limited	Very Limited
Probability	Certain	Certain	Certain	Certain	Certain	Certain	Probably
Significance	**-63: Minor**	**-56: Minor**	**-63: Minor**	**-56: Minor**	**-63: Minor**	**-56: Minor**	**-40: Minor**
Reversibility	High	High	High	High	High	High	High
Irreplaceability	Low	Low	Low	Low	Low	Low	Low
Confidence	High	High	High	High	High	High	High

Mitigation:

- A comprehensive method statement must be drawn up which provides a clear step by step plan of the sequence of construction activities that will be undertaken.
- The method statement should follow a phased approach with the aim of minimising the length of time that excavated bed or banks are exposed to fluctuating tide levels.
- Working areas must be clearly demarcated and disturbance (i.e. trampling, smothering etc.) of estuarine habitat outside of these demarcated areas must be minimised as far as is possible.
- *Zostera capensis* and occurring within the construction footprint must be rescued and kept on the site to be planted in any disturbance buffer (no wider than 2m) later during the phase

Impact 2 – Sedimentation of estuary caused by the excavation of the bed and banks of the estuary.

The eroded embankment requires the excavation of a level platform to 1 m below the existing estuary bed profile. This excavation will need to extend approximately 3 m into the estuary. Excavation of the estuary bed is likely to result in the mobilisation of sand and sediment which can potentially smother in-stream habitats. Active erosion of the bank leads to a minor sedimentation impact under the No-Go option.

Impact	Option 1		Option 2		Option 3		No-Go
	Without Mitigation	With Mitigation	Without Mitigation	With Mitigation	Without Mitigation	With Mitigation	
Intensity	High	Low	High	Low	High	Low	Very low
Duration	Brief	Brief	Brief	Brief	Brief	Brief	Ongoing
Extent	Very limited	Very limited	Very limited	Very limited	Very limited	Very limited	Very limited
Probability	Certain	Probably	Certain	Probably	Certain	Probably	Likely
Significance	-56: Minor	-24: Negligible	-56: Minor	-24: Negligible	-56: Minor	-24: Negligible	-45: Minor
Reversibility	High	High	High	High	High	High	High

Irreplaceability	Low	Low	Low	Low	Low	Low	Low
Confidence	High	High	High	High	High	High	High

Mitigation:

- Excavations should take place during low tide to minimise the mobilisation and transport of high volumes of sediment into the estuary.
- Excavation of the estuary bed and placement of sandbags and reno mattress should take place systematically (i.e. one section at a time) to avoid exposing sections of excavated bed or banks to fluctuating tide levels. The excavation of a section of the bed and placement of stabilising materials should ideally be completed within a single low tide cycle, before moving onto the next section. Excavation of the bank and placement of sandbags therefore needs to be planned according to the time provided by the low tide cycle.
- Construction activities should be timed to avoid periods of high rainfall and should be avoided during wet weather conditions.
- Construction activities should also be timed in relation to potential rainfall occurring higher up in the Keurbooms river catchment to mitigate against the effects of flooding in the estuary.
- Silt barriers must be placed around the working area to limit the migration of sediment from the construction area.

Impact 3 – Impairment of water quality caused by the operation of heavy machinery operating within the bed and banks of the estuary.

Vehicles and heavy machinery will be required to construct the bank stabilisation structure and will need to be refuelled and maintained at regular intervals. Leaks of hydrocarbon contaminants (i.e. fuel, oil, grease etc.) may occur which could pollute the estuary.

Impact	Option 1		Option 2		Option 3		No-Go
	Without Mitigation	With Mitigation	Without Mitigation	With Mitigation	Without Mitigation	With Mitigation	
Intensity	Moderate	Very low	Moderate	Very low	Moderate	Very low	No Impact
Duration	Short term	Brief	Short term	Brief	Short term	Brief	
Extent	Limited	Limited	Limited	Limited	Limited	Limited	
Probability	Likely	Unlikely	Likely	Unlikely	Likely	Unlikely	
Significance	-45: Minor	-18: Negligible	-45: Minor	-18: Negligible	-45: Minor	-18: Negligible	
Reversibility	High	High	High	High	High	High	
Irreplaceability	Low	Low	Low	Low	Low	Low	
Confidence	High	High	High	High	High	High	

Mitigation:

- All vehicles/machinery should be readily serviced and inspected for leaks. Vehicles/Machinery needing repairs should not be used for construction at the site until repaired and fully operational.
- Any work or maintenance on the vehicles/machinery should be done far away from the watercourse, preferably in a work yard or on a concrete surface.
- Refuelling of vehicles/machinery must take place away from the estuary and on a paved surface to prevent seepage in the event of a spill.
- All vehicles/machinery should be parked off-site, and away from the edge of the watercourse when not in use.

6.2 Operational Phase Impacts

A summary of ratings for each impact associated with the operational phase can be viewed in the impact tables below.

Impact 4 –Impact of bank stabilization structure on downstream bank erosion

Due to the frequency of flooding events the Keurbooms/Bitou Estuary Management Plan (DEADP, 2017) recommended that structures and privately owned and developed land be managed in such a way as to prevent further bank erosion during flood events. It also recommends that a standardised methodology be adopted for the purposes of bank stabilization. In this respect the method proposed for this development is consistent with that adopted in neighbouring estates.

Hydrological armouring of stream banks (e.g. wooden retaining wall, rip rap or reno mattress constructions) is a common technique used to stabilise banks for erosion protection. They can cause problems further downstream in that these hardened structures tend to increase the speed of water flow along an armoured reach, as the water has no points of friction to come up against and nothing to slow it down. This additional strength of flow can cause problems further downstream, as water is deflected off the hardened surface and directed at other points of the riverbank. The increased strength and speed of the water can increase erosive forces at these new locations, the result of which is the necessity of installing additional armouring, which merely moves the problem further down the stream.

The sloping profile of Option 2 and the porous nature of the reno mattress revetment will improve the ability of the bank to absorb and dissipate the energy associated with large flooding events in comparison to the vertical profile of Option 1 and the less porous Option 3. Furthermore, this construction provides a longer-term solution to stabilizing the bank against flooding events and persistent tidal flow, due to a reduced risk of structural failure.

There have been a number of incidents of serious bank erosion related to flooding events in the past and the risk of bank erosion associated with the No-Go option therefore represents a similar impact.

Impact	Option 1		Option 2		Option 3		No-Go
	With Mitigation	Without Mitigation	With Mitigation	Without Mitigation	With Mitigation	Without Mitigation	
Intensity	High	Moderate	High	Moderate	High	Moderate	High
Duration	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing
Extent	Local	Local	Local	Local	Local	Local	Limited
Probability	Likely	Likely	Likely	Likely	Likely	Likely	Likely
Significance	-70: Minor	-65: Minor	-70: Minor	-65: Minor	-70: Minor	-65: Minor	-65: Minor
Reversibility	High	High	High	High	High	High	High
Irreplaceability	Low	Low	Low	Low	Low	Low	Low
Confidence	High	High	High	High	High	High	High

Mitigation:

- The transition from the bank stabilisation structure to the remaining natural channel bank must be smooth so that no nick point develops along the channel bank which could lead to unanticipated erosion downstream of the structure. In other words, the southern end of the bank stabilisation structure must “tie-in” to the natural contour of the remaining unprotected channel bank.
- The structure must be routinely inspected to ensure that the integrity of the structure is sound and that it is not causing erosion of the channel further downstream. Any obvious signs of erosion must be immediately attended to.

Impact 5 –Impact of structure on stabilising the estuary bank

All proposed options are likely to be effective in stabilising the estuary bank. There is a higher risk of failure for Option 3 (i.e. geotextile bags may become weathered or physically punctured/torn over time) resulting in a slightly lower positive impact rating. The No-Go option represents a continued minor negative impact.

Impact	Option 1		Option 2		Option 3		No-Go
	With Mitigation	Without Mitigation	With Mitigation	Without Mitigation	With Mitigation	Without Mitigation	
Intensity	High	High	High	High	High	High	High
Duration	Permanent	Permanent	Permanent	Permanent	Ongoing	Ongoing	Ongoing
Extent	Very limited	Very limited	Very limited	Very limited	Very limited	Very limited	Limited
Probability	Likely	Likely	Likely	Likely	Probably	Probably	Likely
Significance	+65: Minor	+65: Minor	+65: Minor	+65: Minor	+48: Minor	+48: Minor	-65: Minor
Reversibility	High	High	High	High	High	High	High
Irreplaceability	Low	Low	Low	Low	Low	Low	Low
Confidence	High	High	High	High	High	High	High

Mitigation:

- The bank stabilisation structure must be routinely inspected and maintained (particularly after flood events) to ensure that the structure does not fail.

Impact 6 –Impact of artificial habitat (reno mattress) on estuarine fauna

Reno mattress will essentially replace the existing eroded estuary bank and a thin section of inter-tidal mud/sand bank. This will alter habitat for burrowing benthic macroinvertebrates. The modification to habitat should however not have any negative impact on the potential occurrence of *H. capensis* given its known utilisation of artificial reno mattress habitat. This section of the estuary is however unlikely to be heavily utilised by larger vertebrate estuarine fauna due to the pre-existing high frequency of boat traffic. Impacts for all three options are minor although Option 2 has slightly lower impacts due to it more natural profile (compared to Option 1) and because spaces in between the rocks packed in the reno mattress offers better potential habitat options for macroinvertebrates (compared to Option 3). Impacts for the No-Go option are also minor given that ongoing erosion of the bank will result in sub-optimal habitat.

Impact	Option 1		Option 2		Option 3		No-Go
	Without Mitigation	Without Mitigation	Without Mitigation	Without Mitigation	Without Mitigation	Without Mitigation	
Intensity	Moderate	Moderate	Low	Low	Moderate	Moderate	Very low
Duration	Permanent	Permanent	Permanent	Permanent	Permanent	Permanent	Ongoing
Extent	Very limited	Very limited	Very limited	Very limited	Very limited	Very limited	Very limited
Probability	Almost certain	Almost certain	Almost certain	Almost certain	Almost certain	Almost certain	Almost certain
Significance	-72	-72	-66	-66	-72	-72	-54
Reversibility	High	High	High	High	High	High	High
Irreplaceability	Low	Low	Low	Low	Low	Low	Low
Confidence	High	High	High	High	High	High	High

Mitigation:

- Preference should be given to the option that has the least impact on estuarine fauna (i.e. Option 2).
- Revegetation of substrates using rescued plant material in areas of temporary disturbance following the construction phase is an essential part of concluding the construction phase of the project. The following is a description of transplanting methods that could be used:

- Bundles of shoots with an attached rhizome segment can be tied together and anchored into the sediment (using a metal anchor); or
- Shoots and associated rhizome structures can be bound to elongated stones using biodegradable thread (e.g. cotton or hemp), which are then buried in the sediment."

6.3 Cumulative Impacts

While the impacts associated with the bank stabilisation structure are considered negligible to minor, the structure does represent an increase (although very small) in the total length of the estuary bank that will be stabilised by a hard, engineered structure. Historical residential and recreational development along the banks of the estuary has resulted in the removal of natural indigenous estuarine and riparian vegetation from the banks, which makes them far more susceptible to erosion. Furthermore, development within the floodline of the estuary has also imposed artificial boundaries along the estuary resulting in a concentration of flows to a narrower channel, which also contributes to erosion of the embankment. Bank stabilisation interventions are therefore inevitably required to protect the bank and properties and have been implemented along numerous properties bordering the estuary. Increased bank stabilisation results in further confinement of the channel and concentration of flows which may then lead to erosion along remaining unprotected banks. Stabilisation of the banks is therefore expected to be an ongoing requirement in the future. Future residential/urban development along the banks must be set back an appropriate distance from the banks and must maintain natural riparian and estuarine vegetation wherever possible.

7. CONCLUSION

Given the high conservation status and ecological importance of the Keurbooms Estuary (as indicated by NFEPA, the Western Cape Spatial Biodiversity Plan and the desktop eco-classification of estuaries of South Africa) and the confirmed presence (i.e.,. *Z. capensis and H. capensis*) and likely habitat suitability (i.e., *Cotula myriophylloides*) for and of IUCN Red Listed species it is important that any development is planned and conducted in a sensitive manner.

While the construction phase will result in an initial minor disturbance to estuarine habitat, this is unlikely to be permanent and there is strong evidence to suggest that recovery will occur in the short term (1 to 5 years) and that estuarine fauna utilise artificial habitat. The fact that identical activities have been approved and implemented successfully at other properties along the estuary – all of which are associated with abundant eelgrass and associated faunal communities - provides further support to this view. Overall, the ecological condition of the estuary is unlikely to be negatively impacted and the proposed bank stabilisation and associated activities are aligned to the various management objectives stipulated in estuarine management and national and provincial conservation plans, which are summarised as follows:

- The structure is intended to rehabilitate an eroded section of the channel and will result in negligible to minor impacts to the estuary. The proposal is therefore aligned to CBA management objectives.

- While a temporary disturbance to biota will occur, the scale of this disturbance is negligible and is expected to recover after a relatively short time-period. The structure will not affect RQOs for water quality, quantity, habitat and biota.

In summary, the impacts associated with all three options are considered acceptable. Of the three proposed alternatives, Option 2 is most recommended as it is consistent with other bank stabilisation structures that have been implemented at other locations in the estuary.

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APPENDIX

This section was prepared according to guidelines for specialists published by DEADP (Brownlie, 2005). Individual impacts for the construction and operational phase were identified and rated according to criteria which include their intensity, duration and extent. The ratings were then used to calculate the consequence of the impact which can be either negative or positive as follows:

Consequence = *type x (intensity + duration + extent)*

where type is either negative (i.e. -1) or positive (i.e. 1). The significance of the impact was then calculated by applying the probability of occurrence to the consequence as follows:

Significance = *consequence x probability*

The criteria and their associated ratings are shown in Table 7.

Table 7: Categorical descriptions for impacts and their associated ratings

Rating	Intensity	Duration	Extent	Probability
1	Negligible	Immediate	Very limited	Highly unlikely
2	Very low	Brief	Limited	Rare
3	Low	Short term	Local	Unlikely
4	Moderate	Medium term	Municipal area	Probably
5	High	Long term	Regional	Likely
6	Very high	Ongoing	National	Almost certain
7	Extremely high	Permanent	International	Certain

Categories assigned to the calculated significance ratings are presented in Table 8.

Table 8: Value ranges for significance ratings, where (-) indicates a negative impact and (+) indicates a positive impact.

Significance Rating	Range	
Major (-)	-147	-109
Moderate (-)	-108	-73
Minor (-)	-72	-36
Negligible (-)	-35	-1
Neutral	0	0
Negligible (+)	1	35
Minor (+)	36	72
Moderate (+)	73	108
Major (+)	109	147

Each impact was considered from the perspective of whether losses or gains would be irreversible or result in the irreplaceable loss of biodiversity of ecosystem services. The level of confidence was also determined and rated as low, medium or high (Table 9).

Table 9: Definition of reversibility, irreplaceability and confidence ratings.

Rating	Reversibility	Irreplaceability	Confidence
Low	Permanent modification, no recovery possible.	No irreparable damage and the resource isn't scarce.	Judgement based on intuition.
Medium	Recovery possible with significant intervention.	Irreparable damage but is represented elsewhere.	Based on common sense and general knowledge
High	Recovery likely.	Irreparable damage and is not represented elsewhere.	Substantial data supports the assessment