MARINE & ESTUARINE RESEARCH

AMAHLONGWA ESTUARY MANAGEMENT PLAN
SITUATION ASSESSMENT

JULY 2022 | FINAL REPORT

Prepared by

MER

For

Triplo 4

and

Department of Economic Development, Tourism and Environmental Affairs, Province of Kwazulu-Natal

KWAZULU-NATAL PROVINCE
ECONOMIC DEVELOPMENT, TOURISM AND ENVIRONMENTAL AFFAIRS
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EXECUTIVE SUMMARY

Introduction

Estuaries along the South African coast are complex because they are subjected to dynamic drivers arising from marine, riverine and terrestrial ecosystems. They form a connection between marine and freshwater systems and are part of regional, national and global ecosystems either directly via water flows or indirectly through the movement of fauna. Along the sub-tropical KwaZulu-Natal coastline these systems are important assets providing and supporting important goods and services to the area and acting as attractive nodes for tourism and development.

The aMahlongwa estuary is situated at 30°16'06" S; 30°45'54" E approximately 65 km south of Durban. It lies on the boundary between the eThekwini and Ugu District Municipalities. The river is *ca.* 23 km long and the catchment has an area of between 90 and 100 km^2. The Mean Annual Runoff (MAR) has been estimated at 14.7 x 10^6 m^3. There are no dams on the river above the estuary, but it could be expected that there would be some usage by the expanding rural populations in the upper reaches of the catchment although not enough to significantly affect the MAR. There is little evidence of the extensive sugar cane fields typical of coastal KZN until the area immediately to the west of the N2 is reached. Also of high significance is the adjacent Aliwal Shoal Marine Protected Area. The most recent classification describes the estuary as a "Small Temporarily Closed Estuary", the most numerous estuary type in the sub-tropical geographic zone. This classification level is defined as an estuary smaller than 15 ha and open to the sea less than 50% of the time (van Niekerk, Skowno *et al.* 2019). The estuary has also been recently delineated as part of this same National Biodiversity Assessment (van Niekerk, Skowno *et al.* 2019). The original estimates placed the head of the estuary at or slightly above the N2, which is 1.8 km from the mouth, resulting in an estuarine area of ca. 5.9 km^2. More recent delineation, based on the gazetted

use of the estuarine functional zone (EFZ) boundary, raised these figures to 2.8 km from the head of the estuary to the mouth and 14 ha in area for the EFZ.

Purpose and structure of this Situation Assessment Report

The objective or target of a Situation Assessment Report, in this case for the aMahlongwa estuary, is to provide and utilize available, relevant background information in order ultimately to construct a defensible Estuary Management Plan (EMP). Such a report is a requirement under the National Environmental Management: Integrated Coastal Management Act 2008 (as amended in Act No 36 of 2014) (ICMA Act). Implicit in the use of the term "management" in the present context is the realization that South African rivers and estuaries now have a legal *persona,* that historical estuarine management was aimed at the modification of these systems in order to benefit people and that management in the present context refers to the control of human activities impinging on natural estuarine function and the maintenance or restoration of such functioning.

Catchment characteristics

The river is located in the tertiary catchment U80 and contained within a single quaternary catchment, U80L. The natural biomes surrounding the estuary include predominantly KwaZulu-Natal Coastal Belt Grassland, interspersed with Northern Coastal Forest, and bounded on the coastal strip with azonal Subtropical Seashore Vegetation. A more detailed look at these biomes reveals that some existing coastal forest has remained largely intact but large areas of what was determined to be KZN Coastal grassland have been transformed through sugarcane cultivation, while abandoned cane fields have resulted in the appearance of secondary scrub or bushveld. Some areas have been disturbed by quarrying while sandmining in the river and riparian edges occurs immediately above the head of the estuary. Urban developments have transformed significant areas, specifically the township of Freeland Park on the south bank of the estuary between the R102 coastal road and the N2 freeway.

Existing or potential modifiers of estuary condition

Physical anthropogenic impacts which would modify flow patterns and sediment transport include the road (R102) and rail bridges, both within 200 m of the mouth, and the N2 bridge *ca*. 1.8 km upstream. A stone revetment, presumably to prevent erosion, lines the interface between the estuary and its closest approach to the R102 upstream of the coastal bridges. Unstable causeways at the head of the estuary and also on a tributary are particularly vulnerable to high flows or floods, resulting in the deposition and accumulation of concrete and rock debris below both structures. The estuary has however to a large degree escaped the habitat losses incurred by many southern KZN estuaries where extensive cost saving causeways have been used in bridge construction, resulting in major habitat loss as well as drastic effects on scouring and sedimentation patterns.

Ecological function and State of the Estuary

The earliest comparative ratings, which arguably qualify as health status assessments, were produced on a national scale by Harrison, Cooper & Ramm (2000) on the basis of the fish community structure, the water quality and the aesthetics, each on a scale of poor, moderate or good. On this basis the system was rated at that time as respectively, good, moderate and moderate. Subsequently as part of a survey of the 16 estuaries within or bordering the eThekwini municipality the aMahlongwa was rated, based on physico-chemical and biotic surveys in 2007/2008 (Forbes & Demetriades 2010) as in "fair" condition on a scale of near pristine, good, fair, poor or highly degraded."

The most recent assessment of the Present Ecological State, albeit conducted at a desktop level of assessment, is a "C" on a scale of A to F which describes an estuary in Moderate or Fair condition. The estuary is rated as a 2, *i.e.* of "some importance" on a national conservation scale of 1-5 where 5 represents an extreme level of importance (DWS 2013).

Ecosystem services

Ecosystem services ultimately permit the survival of humanity on this planet. The water cycle, whereby evaporation from the surface of the sea becomes the source of fresh water via rainfall may be the most obvious example. Broadly speaking, ecosystem services "cover the benefits that people obtain from ecosystems, including provisioning services, such as food and water, regulating services such as flood control, cultural services such as recreational benefits and supporting services such as nutrient cycling and carbon storage". The ecosystem services provided by the aMahlongwa Estuary are varied and range from nursery function for estuary dependent marine species, both vertebrate and invertebrate, raw materials, tourism and recreation, carbon sequestration, water treatment and the export of organisms and nutrients to the marine environment.

Impacts or potential impacts to the Estuary

The principal threats rated in 2008 as "Medium" on a scale of low to high were habitat loss, water quality changes, with eutrophication high on the alert list, and alien invasive plant species. The following should also be added from recent observations, *viz*. insensitive development, freshwater abstraction, chemical contamination, solid waste litter/debris, and sea level rise.

Legislation

This section in the report is not repeated here but provides an overview of legislation and policy applicable to the management of estuaries in South Africa and specifically to the aMahlongwa estuary. South Africa has an extensive legal framework for governing the protection and sustainable use of the coastal marine environment including estuaries. A summary table of the relevant legislation is provided, as well as a description of provincial legislation and local policies and strategies that relate to the estuary. Two key pieces of legislation, namely the National Water Act (Act 36 of 1998) and National Environmental Management: Integrated Coastal Management Act (Act 24 of 2008) (ICMA) are relevant.

Opportunities and constraints for consideration in an EMP

The aMahlongwa estuary lies at the border of the jurisdiction between the two municipalities referred to above, while the EMP falls under the overall direction of the KZN Department of Economic Development, Tourism and Environmental Affairs. The management actions and strategies will need to be agreed upon while the implementation will require substantial co-operative governance. A SWOT analysis was conducted and numerous Strengths, Weaknesses, Opportunities and Threats have been teased out. These will be used to formulate implementation plans and actions in the next phase.

Recommendation to address information gaps

Knowledge and understanding of the aMahlongwa estuary have been gathered sporadically since 1937 when the first aerial surveys were done.

A list of information requirements identified as needed to update historical data and facilitate and enhance future management actions has been included. This information would identify drivers of impacts on the estuary needing more management as well as identify additional opportunities for stakeholder learning, training and employment.

Going Forward…

Conditions in and health status of the estuary summarized as a Situation Assessment Report based on a site inspection and desktop survey have been collated in this document. This information will then be used in conjunction with inputs from Interested and Affected Parties, including local municipal and conservation authorities, in order to generate the Estuarine Management Plan in the next phase.

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GLOSSARY

Abiotic	Non-living characteristics of a habitat or ecosystem that affect organisms' life processes.
Aerobic	Using oxygen.
Algae	Chlorophyll containing non-vascular organisms, plant or plant-like.
Alien	A species that occurs outside of its natural range and dispersal potential.
Biotic	Referring to living things
Benthic	Describing the substrate or bottom of a water body.
Benthos	Bottom-dwelling plants and animals from bacteria to the highly visible macrobenthos such as mussels, crabs and worms.
Biodiversity	The variety of plant and animal life in a particular habitat.
Catchment area	The area from which rainfall flows/drains into the estuary.
Community	An association of interacting populations of one or more species of animals or plants
Estuary	A semi-enclosed body of water at the coast where land derived freshwater drainage at times meets the sea and within which seawater is measurably diluted by fresh water derived from land drainage.
Eutrophication	Process by which additions of nutrients (phosphates and/or nitrates) causes imbalances in algal and/or emergent plant growth.
Floodplain	Broad and relatively flat area on either side of a stream, river or estuary inundated by water during floods.
Head (of estuary)	The upstream part of the system where freshwater enters.
Indigenous	Species within the limits of their native range (Synonyms: native).

Invasive alien species	Species whose natural range occurs outside the area being considered which were transported to their current location by artificial means allowing them to reproduce, spread and typically cause negative ecological impact.
Impact	A change to the existing environment, either adverse or beneficial, that is directly or indirectly due to the development of the project and its associated activities.
Invertebrate	An animal that does not have a backbone (*e.g*. a prawn, crab, or worm).
Legislation	Laws, legal requirements or the process of making or enacting laws.
Macrophytes	Aquatic plants large enough to be seen by the naked eye.
Microalgae	Microscopic algae, typically found in freshwater and marine systems, living in both the water column and sediment. They are unicellular species which exist individually, or in chains or groups.
Migration	Movement of living organisms from one ecosystem or biome to another, commonly with changing seasons
Nursery	Term used colloquially to refer to estuaries – particularly in relation to their role on the coast – important 'nursery grounds'. Many invertebrate and fish species are dependent on estuaries for part of their life cycles and hence 'nursery' in these habitats. Estuaries are often referred to erroneously as 'breeding grounds'
pH	Unit of measurement used to indicate how acidic or alkaline a water-based solution is.
Phytoplankton	Microscopic organisms that live in aquatic systems that are able to photosynthesize to feed themselves.
Residence time	The period of time during which a body of water remains within a specific region of the system.
Zooplankton	Refers to small usually floating animal plankton which derives nutrition from other sources of organic carbon, mainly by eating plant or animal matter.

LIST OF ABBREVIATIONS

CMP	Coastal Management Programme
DEDTEA	Department of Economic Development, Tourism and Environmental Affairs KZN
EC	Ecological Category
EFZ	Estuarine Functional Zone
EA	Environmental Authorisation
EIA	Environmental Impact Assessment
EMP	Estuarine Management Plan
EWR	Ecological Water Requirement
DFFE	Department of Forestry, Fisheries and the Environment
DWA	Department of Water Affairs (Changed after 2008)

DWAF	Department of Water Affairs and Forestry
DWS	Department of Water Affairs and Sanitation (Changed after May 2014)
IAAP	Invasive Alien Aquatic Plants
ICMA	National Environmental Management: Integrated Coastal Management Act (Act No. 24 of 2008), as amended by National Environmental Management: Integrated Coastal Management Amendment Act (Act No. 36 of 2014)
IDP	Integrated Development Plan
KZN	KwaZulu-Natal
MAR	Mean Annual Runoff
MER	Marine and Estuarine Research
MLRA	Marine Living Resources Act (Act No. 18 of 1998, amended 2000)
MPA	Marine Protected Area
MSL	Mean Sea Level
NBA	National Biodiversity Assessment
NCMP	National Coastal Management Programme
NEMA	National Environmental Management Act (Act No. 107 of 1998)
NWRS	National Water Resource Strategy
nMAR	Natural Mean Annual Runoff
PES	Present Ecological State
Protocol	National Estuarine Management Protocol
REC	Recommended Ecological Category
SAR	Situation Assessment Report

aMahlongwa Estuary Management Plan

Situation Assessment Report



1 INTRODUCTION

1.1 Relevant Background

Estuaries along the South African coast are complex environments because they are subjected to dynamic processes arising from adjoining marine, riverine and terrestrial ecosystems. They form a connection between marine and freshwater systems and are part of regional, national and global ecosystems linked either directly via water flows or indirectly through the movement of fauna. Along the sub-tropical KwaZulu-Natal coastline these systems are important assets supporting and providing important goods and services to the area and acting as attractive nodes for tourism and development.

Disturbances in one estuary can influence a wide variety of ecological processes and affect socio-economic benefits. To ensure the sustainable use of these systems and to address the cycle of degradation which has occurred along the

coast, it is important to be proactive before the wreaking of irreversible damage occurs. Therefore, to facilitate better understanding of ecological processes and the impact of human activities on these systems, a Situation Assessment Report (SAR) typically precedes an Estuarine Management Plan (EMP) which in combination forms a sound platform to provide action plans and guidance on the best management practices.

The development of an EMP is required in terms of Chapter 4, Section 34 of the National Environmental Management: Integrated Coastal Management Act, 2008 (Act 24 of 2008) ("Act") and the National Estuarine Management Protocol of 2013 ("the Protocol"). These serve as the guiding documents for the development and implementation of EMPs. In addition, the EMP must be consistent with the National, Provincial and Municipal Coastal Management Programmes (CMP) requiring that these be taken into account as part of the process. In addition the Department of Environmental Affairs has developed holistic and inclusive "Guidelines for the development and implementation of Estuarine Management Plans" to supplement the Protocol in providing clear procedures and guidance to the responsible management authority who develop and coordinate the implementation of EMPs (DEA 2015). Under the Provincial CMP, it is a requirement that strategies be developed for the effective and co-operative management of the coastal zone. It is implicit in this requirement that a measure of control of human activities be exerted in order to maintain the natural functioning of coastal ecosystems, specifically including estuaries. At this point the prime anthropogenic activities impacting on or degrading estuarine function are well-known.

In the case of estuaries situated at the boundary between municipalities, in this instance between eThekwini and Ugu District Municipalities, the responsibility for the development of an EMP falls to the KwaZulu-Natal Department of Economic Development, Tourism and Environmental Affairs (DEDTEA). This is the case for the aMahlongwa Estuary.

The aMahlongwa Estuary is situated at 30°16'06" S; 30°45'54" E approximately 65km south of Durban (

Figure 1-1). The river is *ca.* 23 km long and the catchment has an area of between 90 and 100 km^2. The Mean Annual Runoff (MAR) has been estimated at 14.7 x 10^6 m^3. There are no dams on the river above the estuary, but it could be expected that there would be some usage by the expanding rural populations in the upper reaches of the catchment, although not enough to significantly affect the MAR. There is little evidence of the extensive sugar cane fields typical of coastal KZN until the area immediately to the west of the N2 is reached. Also of high significance is the adjacent coastal Marine Protected Area (MPA). In October 2018, 20 new MPAs were approved and then implemented on 1 August 2019 increasing protection of South Africa's mainland waters from 0.4% to 5%. One of these is the expanded Aliwal Shoal MPA which has two zones (restricted and controlled) within the 678 km^2 area (Figure 1-1) and lies adjacent to the coast spanning the area well to the north and south of the aMahlongwa estuary.

The recent National Biodiversity Assessment (NBA) (2018) which focussed on the Marine Environment indicated that this MPA's level of protection had been downgraded as a result of poor water quality inputs and thus any improvements to the estuaries linked to this MPA would assist in increasing the level of protection of this MPA.

The most recent classification describes the aMahlongwa as a "**Small Temporarily Closed Estuary**", the most numerous estuary type in the sub-tropical geographic zone. This classification is defined as an estuary smaller than 15 ha and open to the sea less than 50% of the time (van Niekerk, Skowno *et al.* 2019). The estuary has also been recently delineated (Figure 1-2) as part of this same NBA. The original estimates placed the head of the estuary at or slightly above the N2, which is 1.8 km from the mouth, resulting in an estuarine area of *ca.* 5.9 km^2. The more recent delineation based on the gazetted use of the Estuarine Functional Zone (EFZ) boundary, raised these figures to 2.8 km from the head of the estuary to the mouth and 14 ha in area for the EFZ (Figure 1-2).

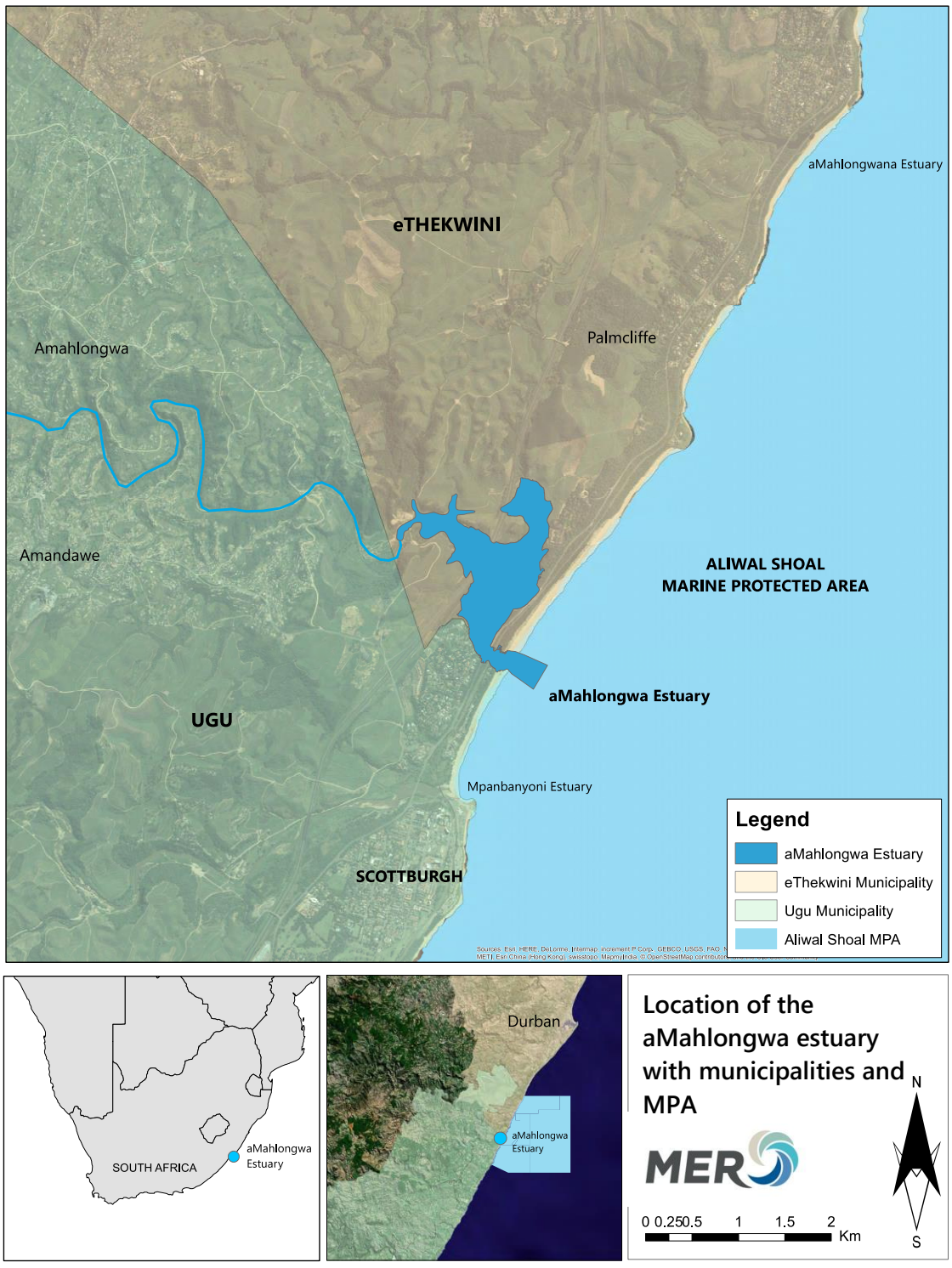


Figure 1-1 Position of the aMahlongwa estuary on the KwaZulu-Natal coast relative to Durban. The District Municipalities and the Marine Protected Area are indicated.

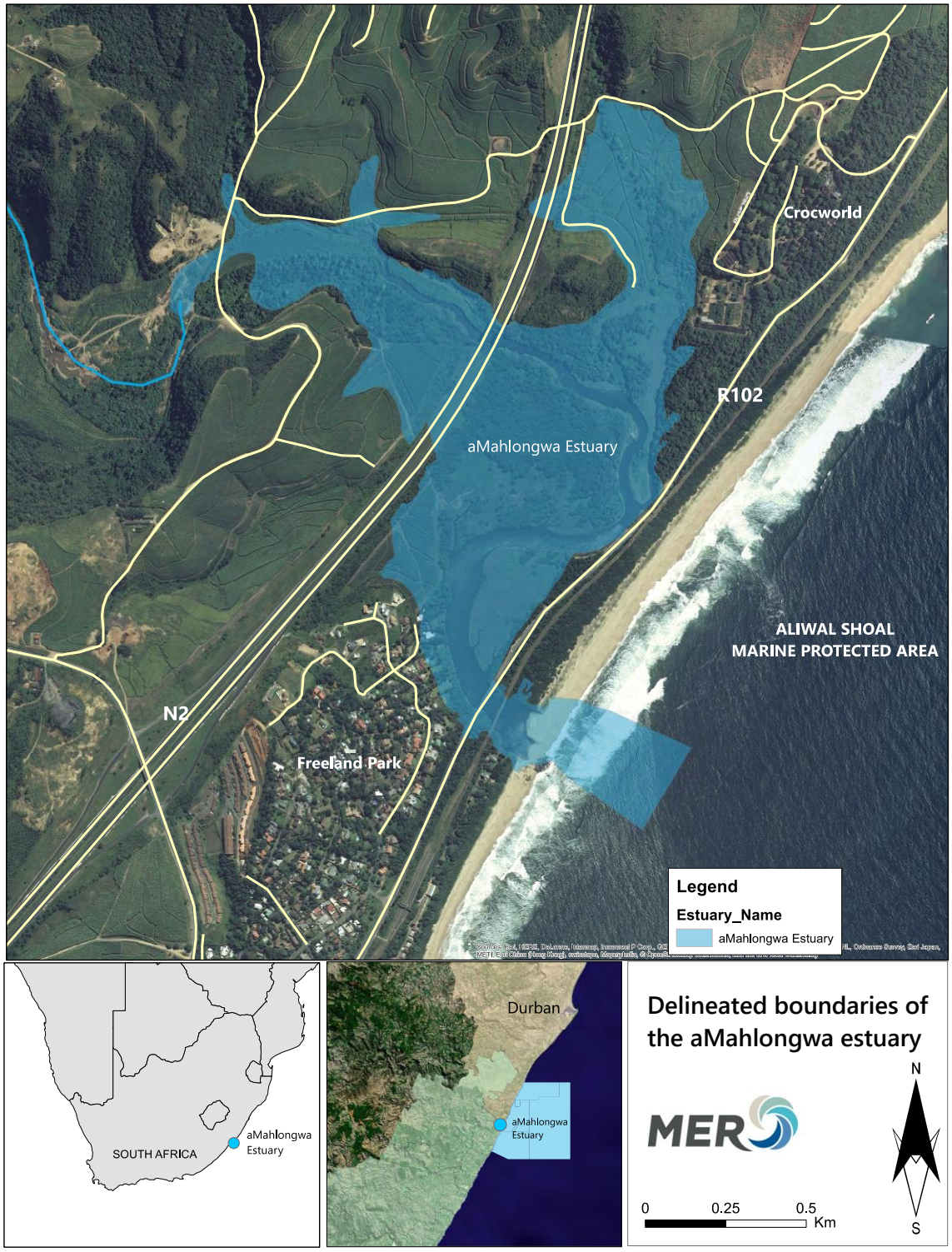


Figure 1-2 The EFZ of the aMahlongwa Estuary with the road network and other key features and areas discussed in the text

In the NBA 2011 the 5m amsl contour was used as a first desktop delineation informed by topography and vegetation. Following a more inclusive approach in 2018, extensive efforts went into addressing subsequent identified deficiencies in the estuary delineation process of the NBA 2011. Over the last five years, important supporting datasets became readily available in digital format such as the 5m and 10m topographical contours and these were combined with LIDAR to determine the most recent delineation. For small estuaries (i.e. 0 m, 5m and 10m contour in close proximity to each other) with relatively high river flow, the 10 m contour or a combination of the 5m and 10m contour, were used as the default to accommodate mapping uncertainty, and flood processes.

The relevance of the EFZ is as follows. The promotion of wise use of estuarine resources and the protection and conservation of estuarine biodiversity requires not only the protection of estuarine habitat and biota, but also the protection of the physical processes/functions that sustain ecological and evolutionary processes. Therefore, to ensure the present and future health of estuaries, it is necessary to define the 'space' within which estuaries function over longer time scales – these areas are referred to as the EFZ. The NBA (Van Niekerk *et al*. 2019) defines the EFZ as "*the area that not only encapsulates the estuary waterbody, but also the supporting physical and biological processes and habitats necessary for estuarine function and health. It includes all dynamic areas influenced by long-term estuarine sedimentary processes, i.e. sediment stored or eroded during floods, changes in channel configuration, aeolian transport processes, and changes due to coastal storms. It also encompasses all the multiple ecotones of floodplain and estuarine vegetation that contribute detritus (food source) and provide refuge from strong currents during high flow events*".

Importantly, the NEMA EIA Regulations (2010) identify the estuarine functional zone as a sensitive area that requires environmental authorisation before a development may proceed. It is important that this consideration is also taken up by the ICM Act and the National Water Act, both of which need to recognise the value of the estuarine floodplain and the threat of (back) flooding within this zone.

1.2 Purpose and Structure of the Situation Assessment Report

The objective or target of a Situation Assessment Report (SAR), in this case for the aMahlongwa Estuary, is to provide and utilize available, relevant background information in order to construct a defensible EMP. Such a report is a requirement under the National Environmental Management: Integrated Coastal Management Act 2008 (as amended in Act No 36 of 2014) (ICMA Act). Implicit in the use of the term "management" in the present context is the realization that South African rivers and estuaries now have a legal *persona*, that historical estuarine management was aimed at the modification of these systems in order to benefit people and that management in the present context refers more aptly to the control of human activities impinging on natural estuarine function in order to minimize these anthropogenic effects.

2 CATCHMENT CHARACTER

2.1 Geology and Geomorphology

An appreciation of relevant geological principles is fundamental to understanding the unique environmental aspects of the coastal zone (Rust 1991), mainly because the environmental character of a zone is controlled to a significant extent by its geological features, geo-environmental processes, and geomorphology. Estuaries with their position on the coast and the significant processes at play between land and sea conclusively make this a relevant factor in the understanding of estuaries as dynamic coastal environments.

The coastal zone of the eThekwini and Ugu municipalities has, in places, been extensively modified. For a variety of reasons several activities have been undertaken or structures built including harbour walls, groynes, tidal-pool complexes, beach-nourishment schemes, shoreline protection and reclamation schemes, promenades, sea walls, beach parking lots, beach-side timeshare condominiums, marinas, pipelines for sewage outfall and industrial waste-disposal and small-boat harbours. All these structures interfere with the dynamic

balance of the coastal zone and thereby affect the natural response of the coastline at a geomorphological level.

The instantaneous effect of a natural storm on the morphology of the coastal zone is usually impressive, but natural long-term changes in conditions can result in changes that may eventually be even more impressive. In sandy beaches, where response to environmental changes takes place quickly, the dynamic nature of the shoreline is seen clearly. Natural seasonal shifts in beach profile go largely unnoticed except when man-made structures suddenly appear as fixed beacons on a dynamic shoreline. Users of such facilities tend to become increasingly intolerant of the shoreline's natural actions, and counteractions to "reclaim", "restore", "nourish" or "stabilize" the affected area usually follow. However, a word of caution is critically important here as modifications and restraints in one sector of the coastal zone frequently result in feedback reactions elsewhere, a so-called "environmental cascade-effect", for which the time scale can range from minutes to centuries.

The comparatively straight coastline of the KZN coast makes it even more vulnerable to these incremental slow processes and large 'acute' events which contrast with that of the western and southern coasts. The KZN coast is strongly influenced by the narrow continental shelf which mirrors the coast's straight edge and shelves steeply close in shore with the direct result of the presence of deep open water close to the shoreline. This adds to the marine influence on this part of the coastline.

The southern section of the coast where Ugu and eThekwini Municipalities meet is made up of bedrock, with a thin cover of soft sediments. This part of the coast consists of a series of rocky headlands with intervening sandy beaches, often across the mouths of estuaries. The hinterland rises steeply to the Drakensberg escarpment, incised by dozens of river courses which flow to the sea expressing as numerous and often small estuaries. Begg (1978) refers to the underlying geology of the aMahlongwa catchment as Dwyka tillite outcrops inland, followed by Ecca shales near the estuary which are overlain by Berea red sands. More

recent detail is provided by Cooper & Smith (2014) which describes the oldest rocks on the KZN coast as the exposed granites of the Natal Metamorphic Province on the coast south of Durban, dating to about 1 200 million years BP. These granites create distinctive rounded, pinkish outcrops, particularly noticeable around Port Edward and overlying these are the distinctive sandstones of the Natal Group Sandstone. The solid rocks are overlain by the much younger sediments of the Quaternary (or Pleistocene) period.

2.2 Climate and runoff

KwaZulu-Natal has a sub-tropical climate characterized by summer rainfall accompanied by high humidity conditions on the coast and cooler, drier winters. Average annual rainfall on the coast is *ca.* 1 000 mm. The significance of this for the aMahlongwa estuary is the seasonality of flow which characterises these smaller, intermittently open estuaries. This means that relatively higher inflows occur during summer (*ca.* 0.2 $m^3.sec^{-1}$) and lower inflows (*ca.* 0.03 $m^3.sec^{-1}$) during winter. This is the level of flow and distribution of flows established by the recent NBA (2018) but this could be altered by climate crisis influences.

The river is *ca.* 23 km long with a catchment area of 80-100 km^2. It is located in the tertiary catchment U80 and contained within a single quaternary catchment, U80L (Figure 2-1). The natural Mean Annual Runoff (MAR) has been estimated at 13.8 x 10^6 m^3 and a recent desktop study estimated the current MAR to be similar at 13.2 x 10^6 m^3 constituting a decrease of 4% in the overall annual volume. The estimates to changes in baseflow are more concerning and have been estimated to have decreased by 14%. This is related to direct use and abstraction. There are no major impoundments, but it could be expected that there has been increased use by the expanding populations in the catchment although not necessarily enough to significantly affect the MAR. Unlike many small estuaries on the KZN coast there is no added inflow from wastewater treatment works. Apart from a mention of a water level just below the coastal road bridge and the flood plain being under water in 1976 (Forbes & Demetriades 2010) there do not appear to be long term historical flood records.

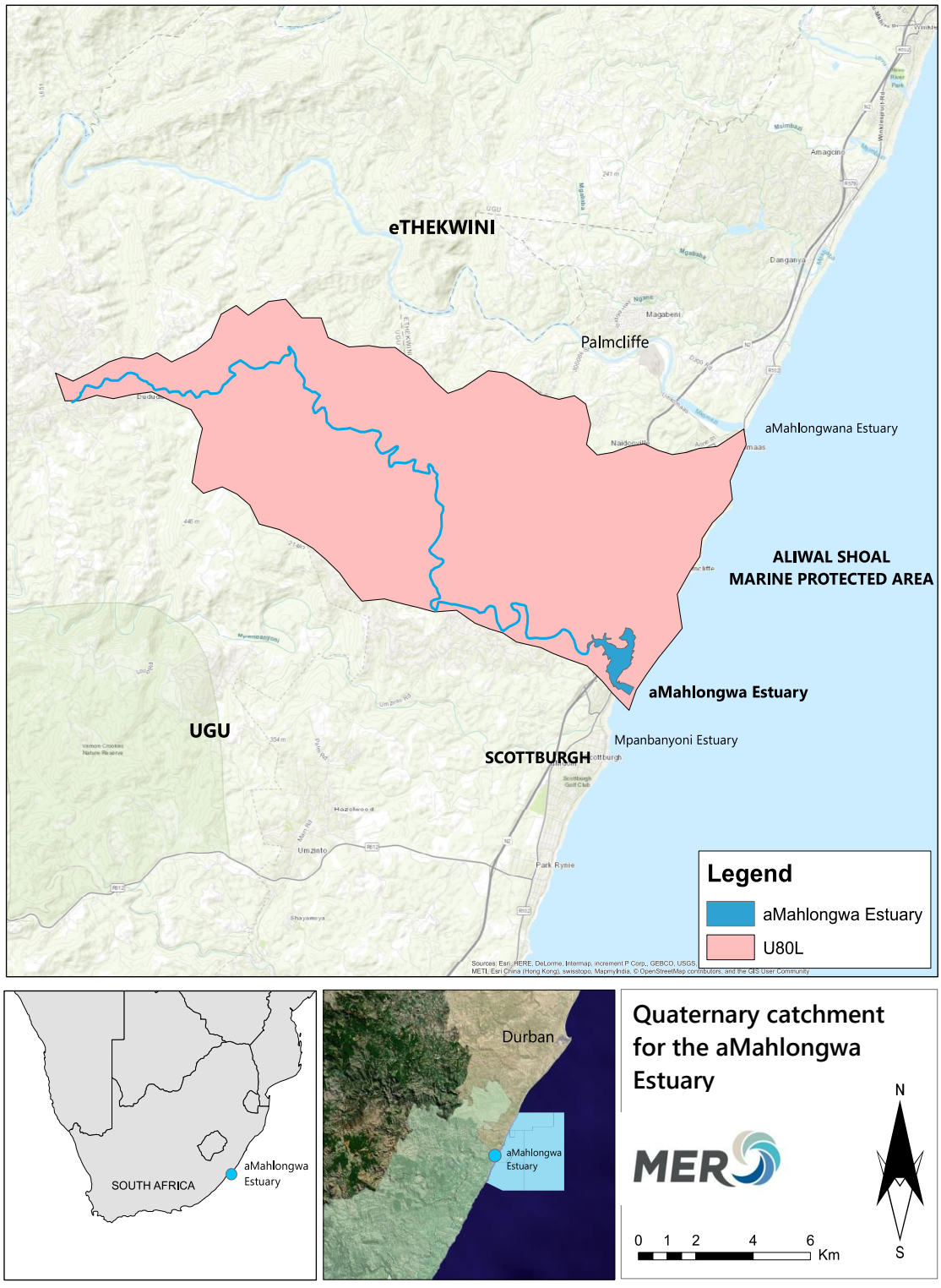


Figure 2-1 Quaternary Catchment of the aMahlongwa Estuary

2.3 Land Use

The natural biomes surrounding the estuary comprise predominantly KwaZulu-Natal Coastal Belt Grassland, interspersed with Northern Coastal Forest, and bounded on the coastal strip by azonal Subtropical Seashore Vegetation (SANBI 2019). A more detailed look at these biomes reveals that some coastal forest has remained largely intact but large areas of what was determined to be KZN Coastal grassland has been transformed by sugarcane cultivation, while disturbed areas revert to a secondary scrub or bushveld. There have been localised significant areas disturbed by quarrying for stone and sand as well as sandmining in the river and riparian fringe immediately above the head of the estuary. Urban developments have also transformed larger areas through the development of the township of Freeland Park on the south bank of the estuary between the R102 coastal road and the N2 freeway. The north shore between the R102 and the N2 is under cane as is the area immediately to the west of the N2. Further to the west the topography becomes more hilly with pockets of indigenous coastal forest and increasing levels of rural settlement.

The historical set of photos available from the South African Department of Mapping and Land Survey provides a graphic history of changing land use around the estuary since the original surveys in 1937. A selection of these is presented in Plate 2-1, Plate 2-2 and Plate 2-3. It also provides an indication of the stability of different habitats such as the estuary water surface, sandbanks, and marginal shallow areas. The only slightly different configuration is shown in 2003 with what seems to be a period of extended mouth closure and shows extensive backflooding into the EFZ.

Plate 2-1 aMahlongwa estuary in 1937 and 1953 (from Coast KZN)

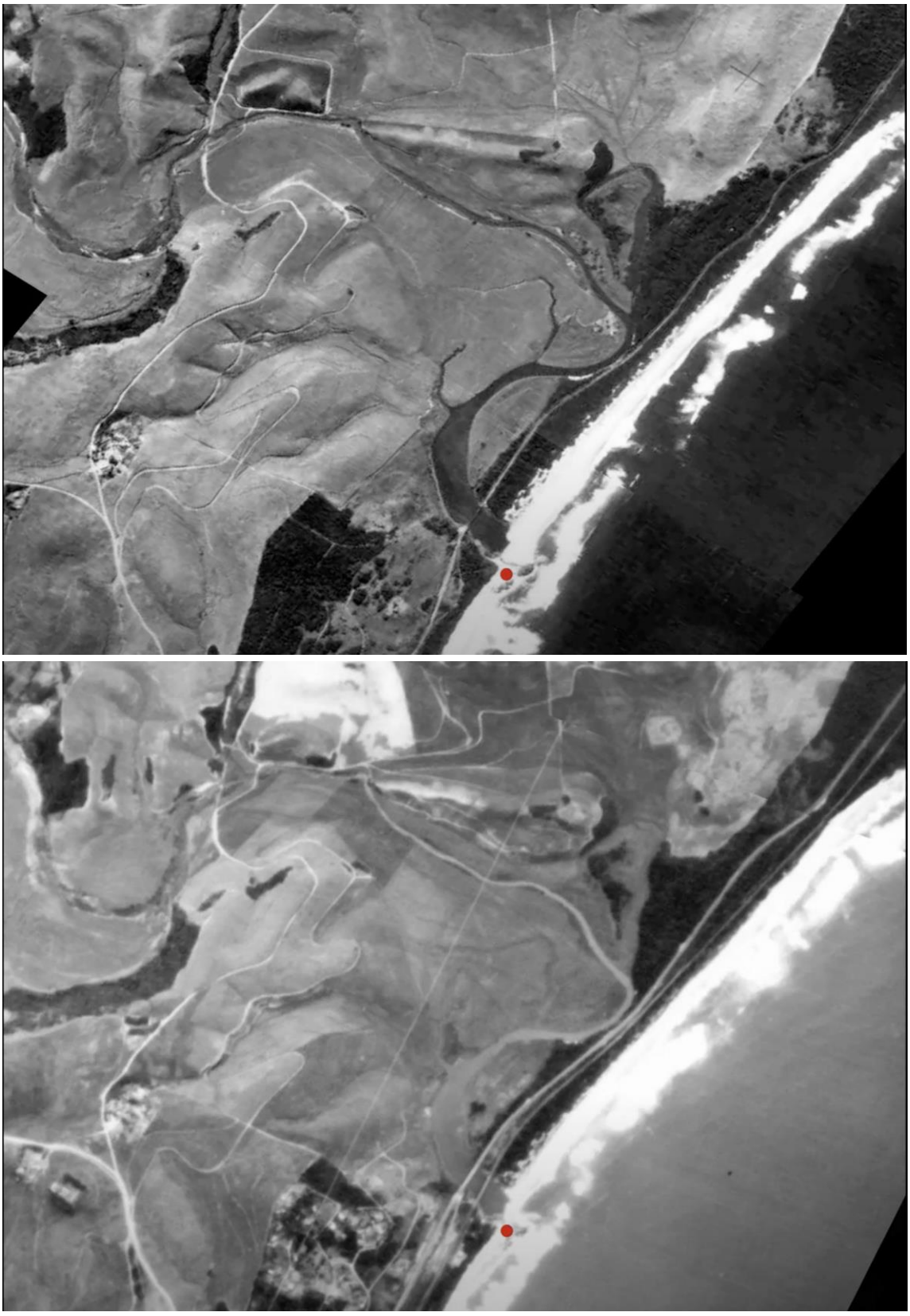


Plate 2-2 aMahlongwa estuary in 1973 and 1993 (from Coast KZN)

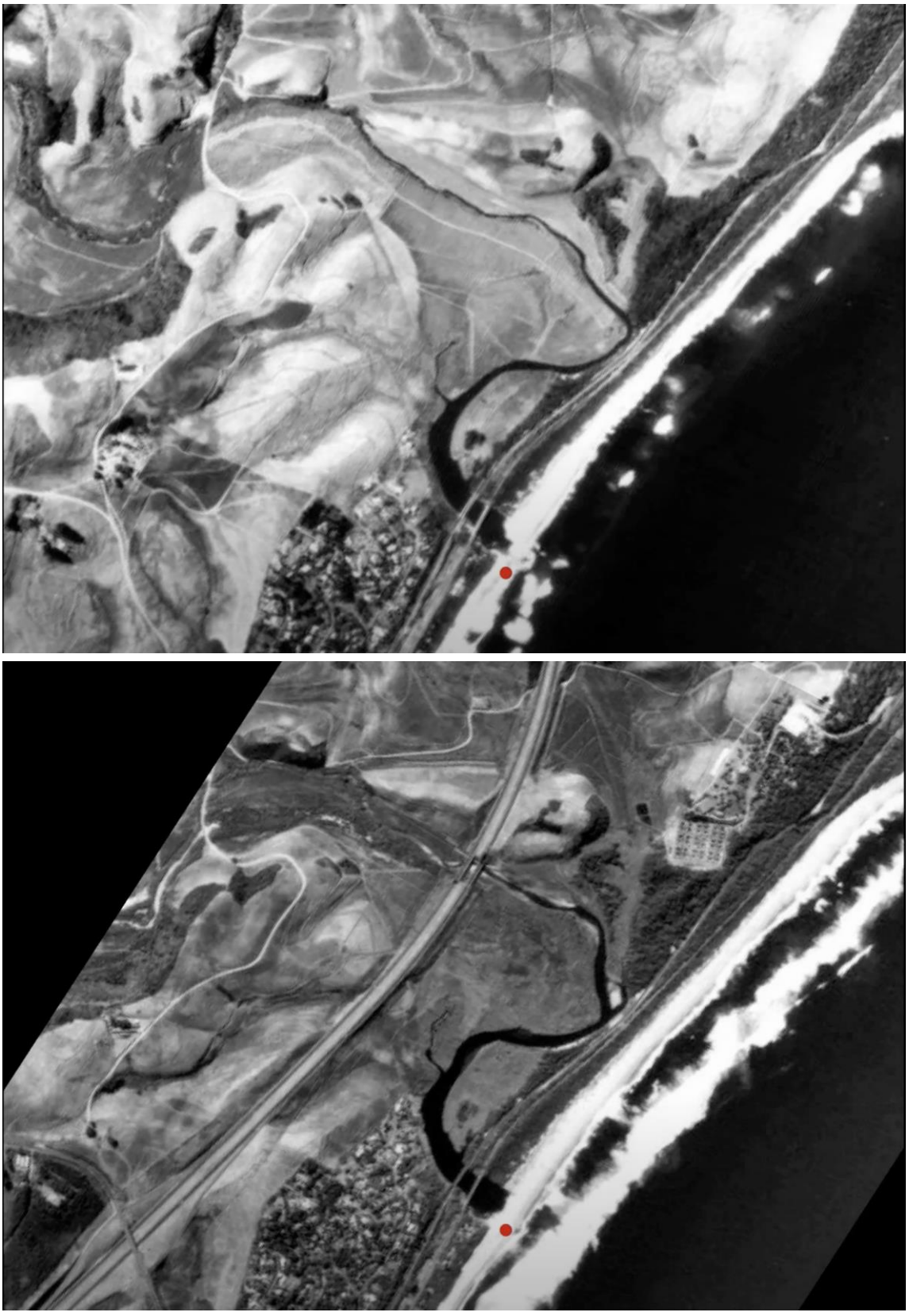


Plate 2-3 aMahlongwa estuary in 2003 and 2013 (from Coast KZN)



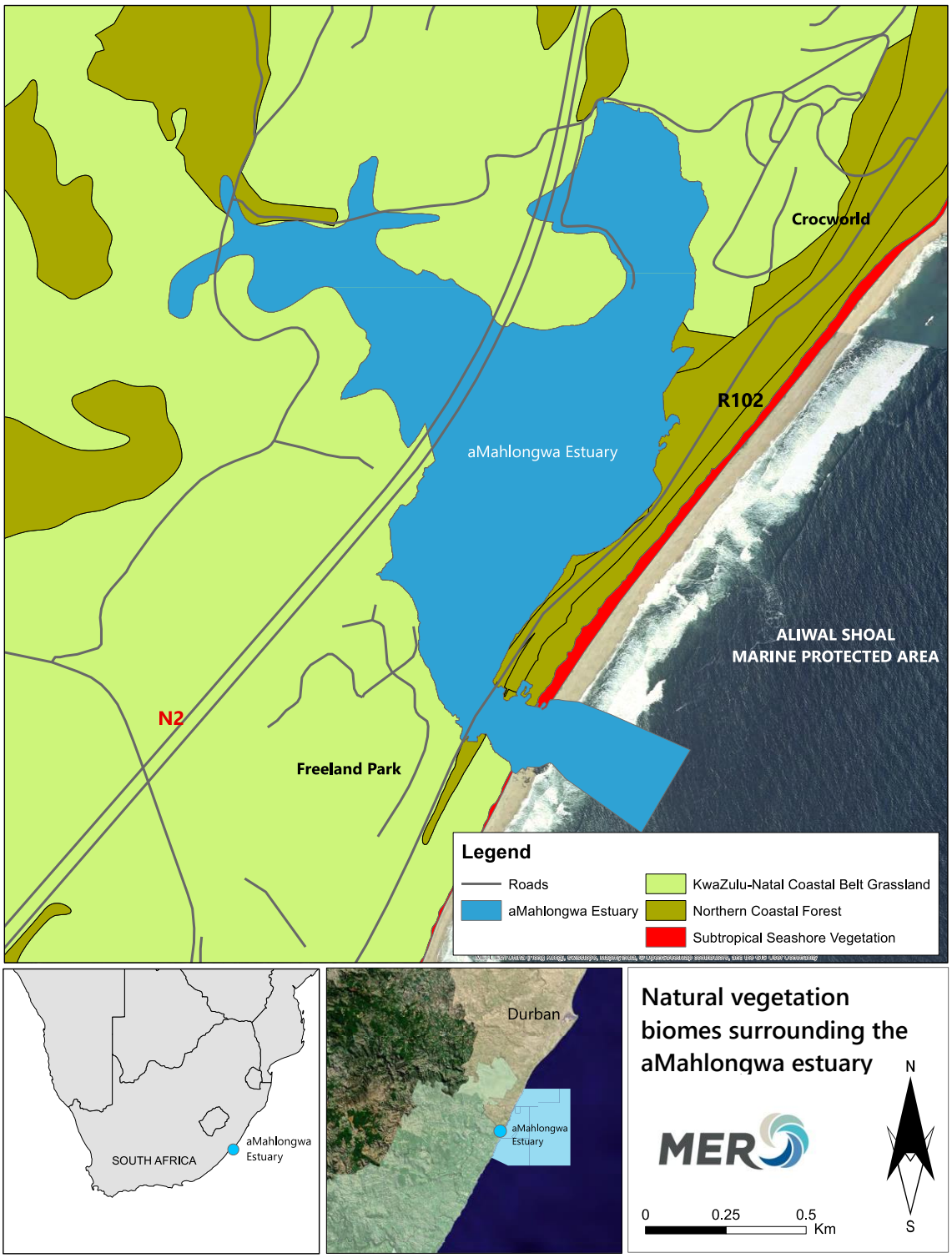


Figure 2-2 Natural Vegetation Biomes in the areas adjacent to the aMahlongwa estuary

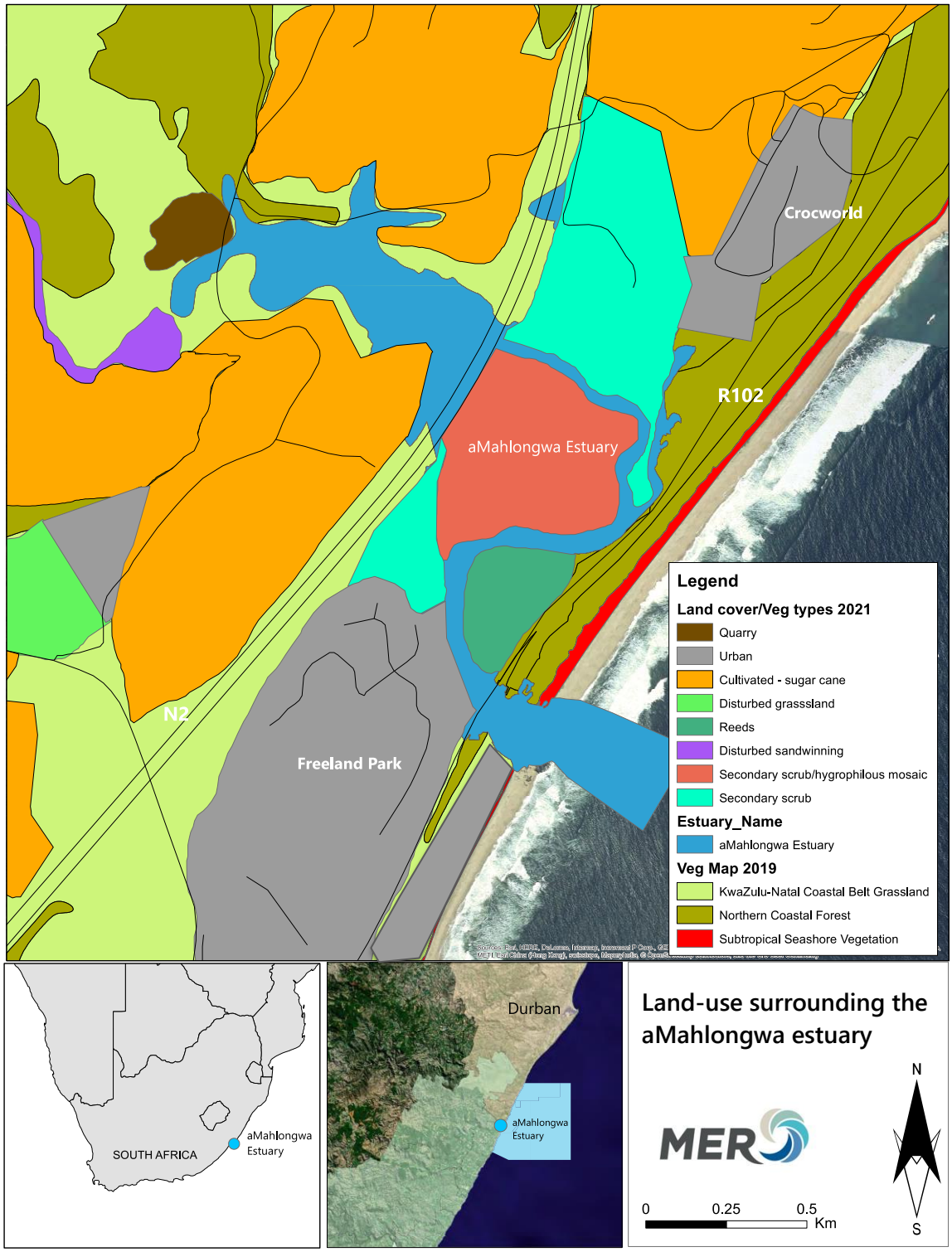


Figure 2-3 Primary landcover in the areas adjacent to the aMahlongwa estuary in 2021.

3 OVERVIEW OF THE STATE AND FUNCTIONING OF THE ESTUARY

3.1 Ecological health status

The earliest estuarine comparative ratings, which arguably qualify as health status assessments, were produced on a national scale by Harrison, Cooper & Ramm (2000) on the basis of the fish community structure, the water quality and the aesthetics, each on a scale of poor, moderate or good. On this basis the system was rated at that time as respectively, good, moderate, and moderate.

Subsequently as part of a survey of the 16 estuaries within or bordering the eThekwini municipality, the aMahlongwa was rated, based on physico-chemical and biotic surveys in 2007/2008 (Forbes & Demetriades 2010) as in "fair" condition on a scale of near pristine, good, fair, poor or highly degraded.

More recently there has been the development of an Estuarine Health Index (EHI) which provides an indication of the level of functionality of an estuary. This level is determined by the status or degree of change of abiotic factors such as the hydrology, hydrodynamics, and habitats, and equally the condition of the fauna and flora. These would ideally range from the smallest microalgae to the largest fish, reptile, bird, and mammalian species all of which may reflect, but will also influence the functionality of the estuary.

More recently the rating system has been modified slightly from the original (Table 3-1) and the health quality of an estuary is described by its 'Ecological Category' or State on a scale of A to F with a description of the features of the different states.

Table 3-1 Ecological categories applied to South African estuaries

Condition (% of pristine)	Present Ecological State	Description
≥91%	A	Unmodified, approximates natural condition: The natural abiotic processes should not be modified. The characteristic of the resources should be determined by unmodified natural disturbance regimes. There should be no human induced risks to the abiotic and biotic processes and function.
76--90	B	Near natural with few modifications: A small change in the natural habitats and biota may have taken place, but the ecosystem functions are essentially unchanged
61-75	C	Moderately modified: A loss and change of the natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.
41-61	D	Heavily modified: A large shift in natural processes and ecosystem functions and/or loss of habitat and biota have occurred.
21-41	E	Severely modified: The loss of natural habitat, biota and basic ecosystem functions are extensive.
≤20	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.

The percentage scores in Table 3-1 are then incorporated into Table 3-2 as a measure of estuarine functionality and health category.

Table 3-2: Relationships between condition score, health description, state and functionality.

Condition	**>91%**	**90-75%**	**75-61%**	**60-41%**	**40-21%**	**<20%**
Health Category	**A Natural**	**B Largely natural with few changes**	**C Moderately Modified**	**D Largely modified**	**E Highly degraded**	**F Extremely degraded**
State	Excellent	Good	Fair		Poor	
Functionality	Retains process and pattern		Loss of process and pattern		No process and pattern	

In June 2013, an Intermediate level Ecological Reserve Determination or Ecological Water Requirement (EWR) was prepared for the uMvoti to uMzimkulu water management area classification study for the 2018 National Biodiversity Assessment (NBA) (Van Niekerk, Turpie *et al.* 2012, van Niekerk, Taljaard, Adams *et al.* 2019)

The Estuarine Health Index (EHI) applied in Ecological Water Requirement (EWR) studies for the aMahlongwa estuary included several abiotic and biotic variables/categories as laid out in Table 3-1**.** For each category, the conditions were estimated as a percentage (0 – 100%) of the pristine health. Scores were then weighted and aggregated so that the final score reflects the present, *i.e.* most recent holistic health assessment of the estuary as a percentage of the pristine state (DWS 2015a) and the ecological category (A-F) is applied.

Table 3-1 Ecological categories associated with individual components of the estuary health index for the aMahlongwa estuary on a desktop basis.

NBA 2018 Condition			
ABIOTIC		**BIOTIC**	
Hydrology	**B**	Microalgae	**C**
Hydrodynamics	**A**	Macrophytes	**C**
Water Quality	**C**	Invertebrates	**C**
Physical habitat	**D**	Fish	**D**
		Birds	**C**
Overall Health Score C			

Based on the categories (Table 3-1, Table 3-2) and the ratings of the individual components (Table 3-1) the Present Ecological State (PES) at a desktop level of assessment as of 2018 is a "C", *i.e.* an estuary in Moderate or Fair condition. The estuary is rated as a 2 for importance on an increasing scale of 1-5 which implies 'some' level of importance (van Niekerk, Turpie *et al.* 2019). This importance score considers the estuary size, rarity of its type within its biogeographic zone, habitat, and functional importance. In addition, the aMahlongwa, although not on the National priority list for conservation, is on the KZN priority estuaries conservation

planning list but does not have specific protected area status. The listing for KZN however places the conservation importance of this estuary at a Level 5 (the highest ranking) which marks it as requiring more effective conservation and protection, particularly given its association with the Aliwal Shoal MPA. This has resulted in the estuary's Target Ecological Category (TEC) for the aMahlongwa Estuary being gazetted as a "B" (Government Gazette 41306, Notice No. 1386 of 8 December 2017). This TEC requires that the aMahlongwa estuary health is lifted from its current C category, with a score between 61 – 75% of natural, to a B category with a health score falling between 76 – 90%.

Recommendations for a particular category are based on a suite of assessment categories which also allow for an option for a "Recommended Ecological Category" (REC), which might or might not differ from the *status quo*. A decision in this latter regard is based on ecological, social, and economic criteria in a participative process called the National Water Resource Classification System's Classification Process (Dollar *et al*. 2010; gazetted in 2010). Ultimately the Department of Water Affairs (DWA) now Department of Human Settlement, Water and Sanitation (DHSWS)} will be responsible for the process of classification of all significant water resources in the country, including estuaries, and these decisions will be re-evaluated at intervals (Turpie *et al*. 2012).

Associated with this gazetted TEC are specific Resource Quality Objectives (RQOs). The National Water Resource Strategy (NWRS) therefore stipulates that "Resource Quality Objectives" describe, among other things, the quantity, pattern and timing of flow, water quality, the character and condition of habitat, and the characteristics and condition of the aquatic biota" (DWS 2015a). These are numerical as well as descriptive and provide requirements for the range of biological, chemical, and physical attributes that will help to achieve the health status of the aMahlongwa estuary at this level of protection as defined by its Classification.

The RQOs for the aMahlongwa (DWS 2015b) are included as Appendix A.

3.2 Abiotic function

3.2.1 Hydrodynamics and sediment

Three bridges presently cross the estuary (Figure 1-2), *viz*. the railway bridge at the mouth built in 1940, the road bridge on the R102 built in 1942 (Plate 3-1) and the N2 freeway bridge completed in 1984. The southern approaches to the latter were constructed in 1980. The remains of the original railway bridge are still present immediately downstream of the present rail bridge. These all represent impacts on flow patterns, scouring effects and consequent sediment dispersal and distribution.

Plate 3-1 The railway bridge and R102 cross the aMahlongwa estuary at the mouth. The N2 crossing is further upstream out of view of this picture.



The river/estuary channel is therefore now pinned in three places, which will affect any channel movement, although such restrictions affect erosion patterns and can accelerate channel movement away from the fixed positions. The coastal

vegetated dune north of the present mouth appears to present a natural feature although the erosion that is presently occurring (Plate 3-2) suggests that in the past the mouth might have been well north of its present position.

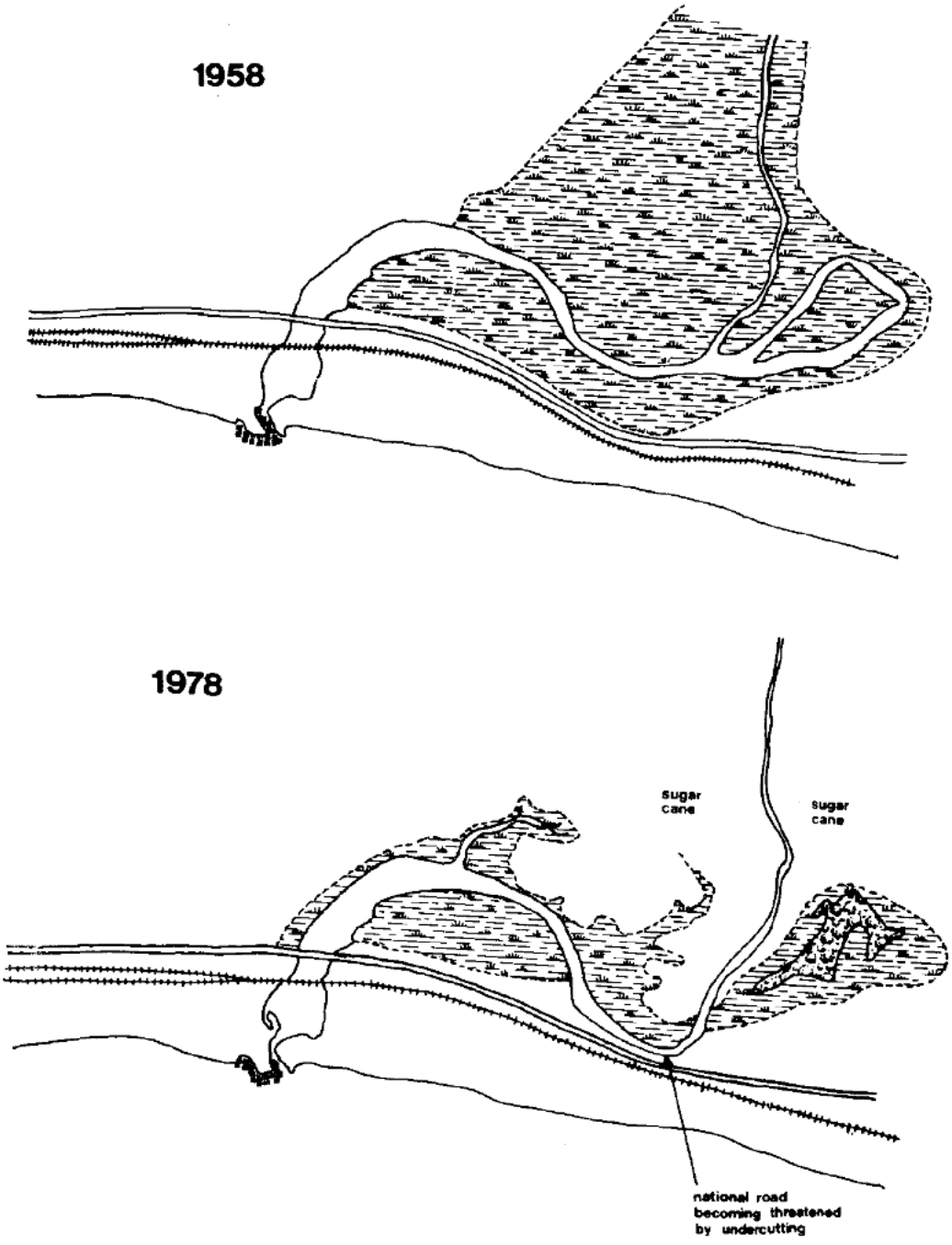
Begg (1978) described seaward channel movement in the area downstream of the present N2 freeway whereby the 1958 channel position was well away from the dune/causeway supporting the R102 coastal road but by 1978 was beginning to undercut this bank (Plate 3-3). This required bank stabilization which has had the effect of moving the erosion focus further downstream. Boulders had been placed along the eastern (left) bank "to prevent undercutting of the national road (R102)", a problem which has now existed for at least 40 and possibly 80 years.

It can be assumed that historically any southward movement of the mouth would have been limited by the rocky reef on the southern bank. Southward mouth migration is unusual in the KZN context but is known in systems such as the uMhlali (Forbes & Demetriades 2010).

Plate 3-2 Erosion on the left bank upstream of the R102 with significant gabion basket stabilisation.



Plate 3-3: Changing channel positions in the lower estuary (Begg 1984).



Forty years prior to the present description Begg (1978) described major drainage of reedbeds and establishment of sugar cane fields as well as changes in the shape of the "lagoon" (his terminology) between 1937 and 1976 manifested as "increased sinuosity, narrowing of the river channel and a loss of open water". Floods, such as that which occurred in 1976, could well have totally changed that situation.

Begg (1984) described bottom sediments as muddy sand grading into mud in the upper reaches with silt in backwater areas. The mangrove lined channel on the north bank differed in having "black, anaerobic deposits of silt and sludge. These sediment descriptions were not quantified, unlike the data gathered during the 2007/2008 surveys (Forbes & Demetriades 2010). Sediment samples taken in the mouth area were poorly sorted, *i. e*. they contained a mix of very fine (0.063 mm) to coarse (1 mm) sand with sub-sieve (<0.063 mm) components generally less than 15% of the total. Sediments were better sorted, *i.e*. more uniform, upstream becoming coarser (1 mm) in the middle reaches and very coarse (up to 2 mm) in the upper reaches. Sub-sieve components made up less than 5% in the mid reaches and less than 1% in the upper reaches. Only one of the 2007/2008 samples had an organic content exceeding 1%. This was a muddy sample taken in the mouth area which had an organic content of 6.6% and a sub-sieve of 50%.

Mouth behaviour is reflected in river or wave driven sediment dynamics which in turn, in a broad sense, respectively drive open or closed mouth conditions. Between 1979 and 1982 (Begg 1984) the average annual mouth closure time was 71% ranging from 62% in 1979 to 88% in 1982. The mouth did however open "relatively frequently" but for "short periods" and was subject to "being breached artificially", presumably by Crookes Brothers agents, to prevent back flooding of cultivated sugar cane fields.

A longer data set generated by daily mouth observations between January 1980 and June 2020 is described by MER in

Figure 3-1, Figure 3-2 and Figure 3-3. Such long-term data sets are unique in KZN but interestingly generated similar conclusions to those in the previous paragraph in terms of annual closure (78%) and open time (22%) while adding significantly more detail in terms of monthly patterns and breaching history.

Open times by month peaked at 40% in December and January declining to less than 5% in June and July. Artificial breaching occurred in every year between 1980 and 1983, again in 1987, 1990 and 1991 and lastly in 1998 but with no further records over the following 18 years up to 2020. There was no distinct monthly pattern with artificial breaching records from every month except January and June. The decline in artificial breaching activity reflects the decline in cane cultivation on the south bank of the estuary east of the N2 freeway.

Annual breaching data indicates that mouth breaching patterns vary with rainfall fluctuations with open mouth conditions increasing through times of higher rainfall and declining during periods of lower rainfall. There is no indication from this data that the periods of closure have increased since the first decade that is documented by the dataset.

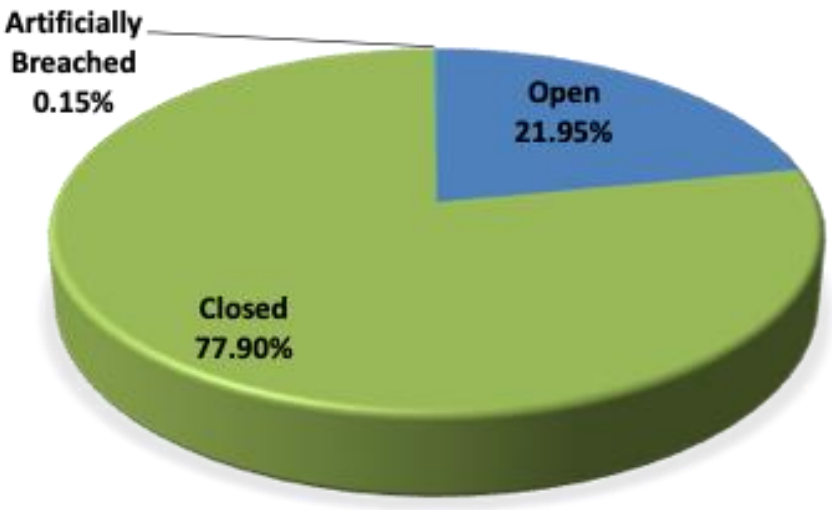


Figure 3-1 Summary of 40 years of daily mouth observations 1980 – 2021

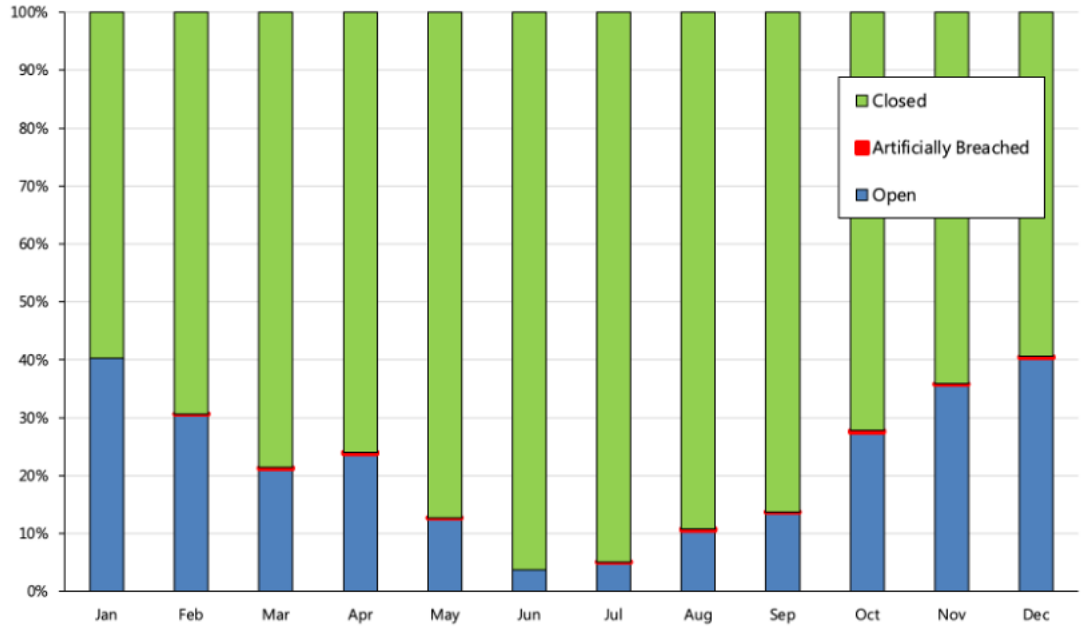


Figure 3-2 Monthly summary of daily mouth observations 1980 – 2020

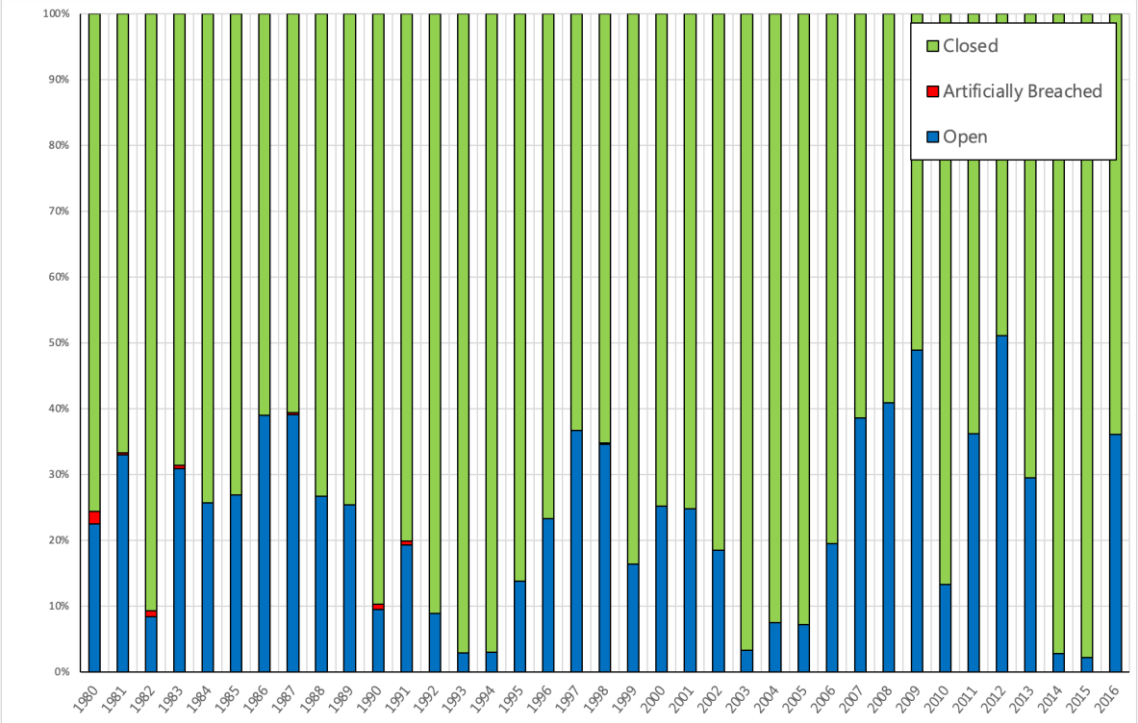


Figure 3-3 Annual summary of daily mouth observations 1980 – 2016

An aerial photograph taken in 2003 (Plate 3-4) show much of this latter area under water due to backflooding. Cessation of cane planting in this area would have removed an incentive to artificially breach.

Plate 3-4 Inundated areas between the N2 freeway and the R102 in 2003.



A further corollary of sediment dynamics combined with mouth behaviour would be variations in water depth and channel morphology. There are no pre-1937 data so the condition prior to the establishment of sugar cane fields, which were already ubiquitous in the catchment surrounding the estuary at that time, is unknown. It is arguable nevertheless that cane cultivation in the catchment would have accelerated erosion to at least some degree and shallowing of the estuary would have occurred. Begg (1984) found a maximum depth of 2.8 m in the vicinity of the R102 and the rail bridge during closed mouth conditions, but this dropped to 1.1 m when the mouth was open. During the 2007/2008 survey (Forbes &

Demetriades 2010), nearly 30 years later, a depth of 2.15 m was recorded in the same area when the mouth was open and minimal depths would have been expected. There are no data, apart from the aerial photographs, which could be used to describe sedimentary conditions in the estuary during the intervening 30 years. While it could be intuitively argued that human influences have accelerated catchment sediment mobilisation, erosion and estuary sedimentation, accurate long-term quantification without real data is not possible and the frequent perception of permanent net shallowing and sedimentation of KZN estuaries requires consideration. The available aerial imagery indicates that the water surface area of the estuary has remained very similar since 1937 with variations related to floods or mouth status. Additional support for this interpretation is provided by the large *Phragmites australis* supporting sandbank in the lower estuary. The historical sequence of photographs indicates a remarkably stable area covered by this sandbank which suggests that no additional sedimentation has occurred. This is also supported by the few measurements of depth which exist. The EHI Hydrodynamics score in the desktop assessment (van Niekerk *et al*. 2019) which includes mouth status, sediment and salinity fluxes was judged to be an 'A'.

3.2.2 Water Quality

Salinity is a major determinant of conditions in any estuary, influencing both biotic diversity and distribution patterns. Salinity at any particular point in an estuary will depend on the extent and pattern of mixing of fresh river water and sea water at that point. In the case of tidal systems, variable mixes can result in substantial changes at a fixed point over a tidal cycle. The morphology of the estuary bed is a contributory factor in that a system where the bottom is below mean sea level will tend to retain sea water and have a higher salinity than a system where the bottom is closer to or even above mean sea level and consequently tends to drain to a greater degree during open mouth periods.

Begg (1984) recorded relatively high salinities of 20-30 (sea water 35) during mid-year in 1980. During a closed phase in August 2007 a maximum of three was

recorded in the mouth area and less than one at the uppermost site. These low levels would have been a consequence of a sustained riverine input. During an open mouth period in February 2008, full sea water was present on the bottom near the lower bridges, declining to 10 on the surface at the mid site, the upper site being inaccessible by boat because of very shallow conditions (Forbes & Demetriades 2010).

During 1979-1981 (Begg 1984) oxygen levels generally remained "at satisfactory levels" which presumably meant there was no biological threat. Oxygen saturation levels, which make allowance for the effects of temperature and salinity on oxygen solubility, measured in August 2007 and February 2008 (Forbes & Demetriades 2010), varied between 75 and 82% in summer and 70 to 108% in winter. The lower levels did not represent any biological threat while the upper levels were not indicative of any eutrophication which is characterized by levels well above saturation during daytime.

Bacterial levels, especially in the case of *Escherichia coli* in November 1979 and June 1981 in the river above the estuary were indicative of "faecal contamination" (Begg 1984). This situation appeared to have improved over the following years as Harrison *et al.* (2000) rated the water quality as "fair" on a scale of "good, fair or poor". This was however in the estuary and not in the river and the Golden Mile principle could be invoked here. Levels were generally low at the three sampling sites (Forbes & Demetriades 2010) in winter 2007 but markedly higher at the accessible lower and mid sites in February 2008 in terms of nitrates, *E. coli* and total coliform levels. A stream of foul-smelling water was observed during the 2008 survey flowing through a servitude on the south bank leading to the then boat launching ramp. Phosphate levels were five times and nitrate 20 times higher than in the adjacent estuary. During a site visit in January 2021, it was noted that the drainage channel was now nearly 1 m deep and had been formalised with concrete blocks although at the time there was no indication of discharge. It has been indicated that this carries stormwater flows directly from

Freeland Park into the estuary with no retention or filtration to improve flow velocity or quality

The EHI Water Quality score in the desktop assessment (van Niekerk *et al.* 2019) was determined to be an '**C'**.

3.3 Biotic function

3.3.1 Microalgae

These are unicellular (single celled) plants that occur either suspended in the water column or benthically, *i.e*. attached to rocks or on bottom sediments. The former is referred to as phytoplankton and the latter as microphytobenthos. Both are important as sources of primary production to the estuary but also as potential indicators of pollution effects, particularly the import of nitrates and phosphates from sewage works or run-off of agricultural fertilisers.

At this point there are no data relating to the microphytobenthos but measurements of chlorophyll-a, a proxy for the phytoplankton biomass, indicated a slightly raised level (6.9 $mg.m^{-3}$) in the mouth area during a closed phase in winter 2007 (Forbes & Demetriades 2010). The EHI Microphyte score from the desktop assessment (van Niekerk *et al* 2019) is currently a '**C'**.

3.3.2 Vegetation

The earliest published description of estuarine and flood plain vegetation was based on surveys carried out in the late 1970s and early 1980s (Begg 1978, 1984). These included comments on the "impressive clumps of palm trees" (*Phoenix reclinata)* and the "healthy patch of black mangroves" (*Brugueira gymnorrhiza)* on the north bank of the estuary. The mangrove presence would have been unusual and reflective of some past condition(s) which allowed colonization and survival of this species in an intermittently open estuary. Also, and relatively unusual in a KZN estuary context, was the presence of the submerged macrophyte *Ruppia spiralis* below the railway bridge.

Based on aerial photographs dating from the earliest available, viz. 1937, and Google earth images incorporating the EFZ, it appears that the extent of sugar cane cultivation, within the EFZ, particularly to the east of the N2 freeway and on the south bank has declined over the last 70 years. Recovery of the natural vegetation has however been reduced by the development of Freeland Park. Structures on properties fringing the estuary on the south bank, except for one, are situated above the EFZ limit (Plate 3-5) although it appears to be common practice to clear the vegetation between the houses and the water's edge, presumably to improve the view). In some cases, jetty-like structures have been established in the reed beds although they do not extend beyond the reed fringe (Plate 3-6)

The EHI Macrophyte score in the desktop assessment (van Niekerk et al. 2019) was judged to be a 'C'.

Plate 3-5 Properties situated within the EFZ (blue line). Everything to the right of the line is within the estuary boundary.



Plate 3-6 Clearing of vegetation and jetty construction at the estuary





3.3.3 Invertebrates

The invertebrate fauna of an estuary is often sub-divided into groups depending on their specific habitat. Zooplankton are present in the water column, the benthos on bottom sediments and hyper-benthic species just above the bottom. Benthic species can be further separated into intertidal species, which clearly depend on open estuaries where tidal effects result in regular exposure of sand or mudbanks, and sub-tidal species living below the low water mark or in closed systems where there are no tidal effects.

Ninety samples collected using a small beam trawl (Begg 1984), a technique not used again in this system, between Oct 1979 and June 1981 produced 10 prawn species, five of which were of the family Penaeidae, although the catch was dominated by the freshwater/brackish water caridean species *Macrobrachium equidens*. The penaeid catch was indicative of the system's use as a nursery ground by these marine migrants. The crab catch was dominated by *Hymenosoma projectum* (formerly *H.orbiculare)* (Dawson & Griffiths 2012) followed by *Rhynchoplax bovis* and the less common migrants *Varuna litterata* and *Scylla serrata*. The beam trawl also produced the bivalve *Brachidontes virgiliae,* the gastropods *Thiara marula (vouamica)* and the normally freshwater *Melanoides tuberculata* and *Neritina pulligera*. A feature of the system was the abundance of the burrowing prawn *Kraussichirus (formerly Callianassa and Callichirus) kraussi* in the mid-reaches (Begg 1984). This species list is indicative of an estuary with a diversity of habitats and in good condition at the time.

Observations and benthic grab sampling during 2007/2008 indicated *K. kraussi* beds still present and a total of 23 other taxa including a variety of polychaete worms as well as amphipod, cumacean, isopod and tanaid crustaceans, all species to be expected in a relatively healthy, intermittently open, small KZN estuary. The frequently closed nature of the mouth precludes the development of any inter-tidal specialists such as fiddler crabs, *Uca* spp. The EHI Invertebrate score from the desktop assessment (van Niekerk *et al.* 2019) is currently a C.

3.3.4 Fish

The earliest recorded beam trawl sampling was carried out between 1979 and 1981 (Begg 1984) and produced 23 species dominated by the long spined glassy *Ambassis ambassis* (47%) and the tank goby *Glossogobius giuris* (40%). The sampling technique would however have under-estimated fast swimming species like mullet which were major components in later surveys. These early surveys did produce the rare burrowing goby *Croilia mossambica,* small scale purse mouth *Gerres acinaces* and spotted grunter *Pomadasys commersonnii*. This reference also referred to angling records of tarpon *Megalops cyprinoides*, barracuda *Sphyraena jello* and river snapper *Lutjanus argentimaculatus*, none of which appeared in subsequent surveys.

A small collection (51 specimens, nine species) in March 1986 (Ramm, Cerff & Harrison 1986) was dominated by three species of mullet (62%), which were in turn dominated by the long arm *Moolgarda cunnesius*. Nationwide surveys (Unpublished) of South African estuarine fish in the late 1990s using seine and gill nets produced 19 species, including eight species of mullet making up 48% of the total catch. The mullet species were dominated by the freshwater *Pseudomyxus capensis* (23%) and the robust *Moolgarda robusta* (22%). Following the 1990s surveys the fish faunal status was rated as "good" on a scale of good, fair, or poor (Harrison et al. 2000)

Sampling in 2007/2008 (Forbes & Demetriades 2010) produced 65 individuals comprising nine species including five species of mullet which made up 61% of the catch, a result broadly similar to the results of the 1986 survey. The mullet catch was dominated by the robust *Moolgarda robusta* (25%) and diamond *Planiliza alata* (20%). Tilapia *Oreochromis mossambicus* contributed 15% of the catch, a figure very similar to that recorded during the national surveys.

The EHI Fish score from the desktop assessment (van Niekerk *et al.* 2019) is currently a **'D'**.

3.3.5 Birds

The criteria for what species qualify as estuarine associated or dependent are not always clearly defined. Broadly speaking, the species that would be expected in a generalized estuarine habitat would include large waterbirds (ducks, kingfishers, rallids), smaller, often migratory waders (scolopacids, jacanas and plovers), larger waders (herons, hamerkop and ibises), gulls and terns, aquatic raptors, grebes, darters and cormorants, wagtails, plus other wetland-associated species mainly small passerines*, i.e*. swallows and martins, warblers and cisticolas, weavers and bishops, and waxbills, but also coucals.

Begg (1984) recorded the following species between October 1979 and June 1981: Spur-winged *Goose Plectopterus gambensis,* Egyptian Goose *Alopochen aegyptiacus,* African Black Duck *Anas sparsa,* Water Thick-k*nee Burhinus vermiculatus,* Giant Kingfisher *Megaceryle maxima* and Pied Kingfisher *Ceryle rudis*.

Surveys in winter 2007 and summer 2007/2008 produced 59 individuals of 16 species followed by 93 individuals of 17 species and a total species count of 27. The winter counts were dominated by 16 Kelp Gulls *Larus dominicanus* and, unusually, 13 Black-crowned Night Herons *Nycticorax nycticorax*. The latter were not recorded in the summer count which was dominated by 57 Sacred Ibis *Threskiornis aethiopicus*. The addition of only one species in the summer list reflects the absence of migratory waders which are largely invertebrate feeders in intertidal zones. Under closed mouth conditions there would not be any tidal effects, no suitable foraging habitat and the major consumers in the system would be the 11 piscivorous species recorded in 2007/2008. The EHI Bird score from the desktop assessment (van Niekerk *et al.* 2019) is currently a '**C**'.

4 ECOSYSTEM SERVICES

4.1 What are ecosystem services?

Ecosystem services ultimately permit the survival of humanity on this planet. The water cycle, whereby evaporation from the surface of the sea becomes the source of fresh water via rainfall may be the most obvious example. Broadly speaking, ecosystem services "cover the benefits that people obtain from ecosystems, including provisioning services, such as food and water, regulating services such as flood control, cultural services such as recreational benefits and supporting services such as nutrient cycling and carbon storage".

Ecosystems have been described as "natural capital" which contributes to economic production. The Millennium Ecosystem Assessment (2003) categorized the services obtained from ecosystems as follows:

- Provisioning services such as food, water and harvested natural products.
- Regulating services such as flood and disease control.
- Cultural services such as spiritual, recreational, and cultural benefits; and
- Supporting services, such as nutrient cycling, that maintain the conditions for life on Earth.

4.2 Estuaries and their importance

Estuaries have been afforded specific protection and management attention in South Africa's legal and regulatory framework due to:

- the high levels of degradation of estuarine habitat globally (Millennium Assessment Report, 2005) and in South Africa where over 50% of the country's estuarine habitat is considered to be in poor condition, and less than 1% in excellent condition (van Niekerk & Turpie, 2012). This situation is particularly acute in KwaZulu-Natal, where the majority of

estuaries are significantly impacted and considered to be in poor, or very poor condition (Whitfield & Baliwe, 2013);

- limited formal protection afforded by the national network of protected areas;
- high levels of productivity (Forbes & Demetriades 2010; Savage, Thrush, Lohrer & Hewitt 2012) and the contribution of these ecosystems to the South African economy (van Niekerk & Turpie 2012).
- the management conflicts that often arise between high levels of consumptive and non-consumptive human use (cumulative anthropogenic impacts) and the conservation of natural resources and ecosystem services for current and future generations.
- Given the role that estuaries play in the broader coastal environment, and their sensitivity to human impacts (Harrison, Cooper & Ramm 2000), a focused and coordinated approach to sustainable use of these ecosystems is essential to the continued delivery of ecosystem services.

4.3 Ecological services provided by the aMahlongwa estuary

4.3.1 Raw materials

There was no evidence of ongoing harvesting of reeds or any other plant material. The estuary does not support the highly sought-after salt rush *Juncus kraussi* (incema grass) which is harvested extensively in estuaries where it still occurs in KZN. It can be expected that a level of fishing would occur but there are no data. A level of fishing pressure has been estimated at a 'medium level' and this is an aspect along with poor water quality and habitat destruction which has been highlighted in DWS (2013) for restoration/rehabilitation action. It can be further expected that illegal gill netting would occur as this activity is now expanding rapidly in South African estuaries (Whitfield, Lamberth, Cowley & Mann 2019).

4.3.2 Carbon sequestration

Carbon sequestration is an important ecosystem service particularly considered as an important mitigation service against the climate crisis. Marine systems, including estuaries are considered just as important and possibly even more so than forests. Estuary sediments, if undisturbed can store carbon 10 times as quickly as soils in forests. As carbon dioxide accumulates in our atmosphere and as temperatures increase, sea-levels rise, and water pushes inland, the choices we make about the health of these habitats will be vital. Building resilient shorelines that are not only beautiful but important for the fish, crabs and carbon storage is going to be key to our survival.

4.3.3 Waste treatment

Even though estuaries appear to be narrow strips of habitat along the KZN coastline they serve a vital filtration service for water brought down to the coast by the surrounding catchments. This includes herbicides, pesticides, heavy metals and excess nutrients. There are, fortunately, no industrial developments nor wastewater treatment works in the catchment or in proximity to the estuary at present, but the surrounding cultivated land, quarry and possible urban developments are potential sources of these pollutants to the estuary and the coast.

4.3.4 Refugia and nursery areas

The aMahlongwa Estuary, by biological and environmental standards, is arguably contributing to the viability of the total estuarine environment in KZN where the eThekwini situation serves as an illustration of the parlous state of estuaries in the rest of the province. None of the 16 eThekwini estuaries between the uThongathi and the aMahlongwa was rated in "excellent or pristine" condition on a scale of excellent, good, fair, poor or highly degraded. Three were rated as good while the aMahlongwa was one of four in the "fair" category implying a retention of significant estuarine function. In this case it would provide a link between and local estuaries and a potential source of recruits for impacted estuaries.

4.3.5 Export of materials and nutrients

Estuaries serve a dual role as conduits for materials, inorganic and organic, derived from the catchment, and to a different degree for materials generated within the estuary EFZ and exported through water movement to the sea or by migrant organisms, aquatic and terrestrial, including birds. Migrant species using estuaries for feeding purposes will clearly act as export mechanisms. Nutrients *sensu stricto* will be derived from the catchment, rather than the estuary itself, used by plants in the EFZ and ultimately exported as detritus if not consumed in the estuary, or flushed out to sea depending on river flows and mouth condition.

4.3.6 Tourism and recreational value

Depending on their size South African estuaries and their surrounds are often popular holiday destinations as they provide multiple attractions that are often associated with the developed area such as beaches, villages, and other natural areas. Revenue is created through restaurants, retail stores and accommodation. Activities such as swimming, boating and fishing that can be conducted in and around the estuary attract tourists to the area. To a certain extent the tourism value of an estuary can be linked to the development of the area surrounding the estuary.

The aMahlongwa is not a large system and consequently cannot provide all the above services or opportunities but the estuary can be assumed to have recreational, aesthetic and financial benefits to residents of Freeland Park in particular and less obvious more general regional benefits such as nursery sites for marine migrant fish and invertebrates.

5 IMPACTS OR POTENTIAL IMPACTS TO THE ESTUARY

5.1 Bridges and Causeways

Characteristic features of KZN south coast estuaries are the rail and road bridges of which the former in each case is virtually always the oldest. As indicated earlier in this report in many cases the original rail bridges were subsequently replaced but the remains of the original are often present as concrete pillars in the mouth area. This is the case in the aMahlongwa where in common with other such estuaries these concrete structures modify flow patterns and sediment distribution. The second feature of bridge construction relates to the extensive causeways across flood plains which irreversibly cause major losses of floodplain habitat as well as intrude into the EFZ. This approach reduces the costs of bridge construction but has the result of significantly altering flow and sedimentation rates and patterns.

Plate 5-1 Road support causeways intrude across the EFZ to carry a smaller, cheaper bridge span.



A causeway in the upper reaches of the estuary as well as on a tributary stream constitutes a significant constriction to flow and a source of rocky debris due to instability of the material used for construction of the causeway under high flow conditions The remains of a previous causeway and the flow obstruction effects downstream of the then existing structure are clearly visible in the lower picture (Plate 5-2).

Plate 5-2 Causeway crossing on the upper reaches of the estuary (top), flow from right to left, and tributary causeway (bottom). (December 2020).





Stakeholder input suggests that between December 2020 (Plate 5-2) and May 2021 (Plate 5-3) the causeways have washed away three times. It is not known if these crossings have been authorised by the relevant authorities and whether the rebuild of these crossings has been permitted.

Plate 5-3 The re-engineered causeway 5 May 2021 (Photograph provided by T. Petterson)



5.2 Sedimentation

Sediment transport by water movement is an intrinsic component of KZN estuaries. Catchment erosion and transport of sediments into estuaries or through estuaries into the marine environment is a natural component of coastal dynamics. This erosion and transport process is variable depending on the magnitude of river flow. Major flood events frequently result in deepening of an estuary. Sediment dynamics in the mouth area are driven by the opposing effects of river flow and wave action coupled with longshore drift.

Water depths in the estuary are described elsewhere in this document and give the impression of a generally shallow system, in keeping with other KZN estuaries. Detailed historical data of bathymetry is not available, but Begg (1978) hypothesises that the general degradation of KZN estuaries dates from the introduction of sugar cane cultivation into their respective catchments. However, sugar cultivation pre-dates any available information with photographic records which could be used to infer condition, with land survey aerial images initiated in 1937. Conditions prior to this in the aMahlongwa estuary catchment are unknown. It is noticeable in the case of the aMahlongwa that there appears to have been a withdrawal of sugar cane from the EFZ particularly on the south bank between the R102 and the N2 after the late 1980s or early 1990s. This is obviously a positive change resulting in less physical disturbance within the EFZ, less nutrient inputs and less pressure for artificial breaching to the ultimate benefit to the estuary and its supporting habitats.

5.3 Sand mining

No sand mining appears to have taken place within the EFZ but there has been reported activity in the downstream river reaches just before the head of the estuary. These activities would need to be carefully examined to establish the level of activity actually taking place and the existence of permits and conditions imposed on these operations. The removal of sand is an activity that can be expected to increase with the proliferation of developments within the area resulting in suitable building sand in the catchment area ultimately being exploited.

5.4 Quarry

Other potential sources of sediment would be the quarry on the north bank where exposed areas represent a risk of accelerated runoff and erosion due to the lack of any vegetation cover.

5.5 Water Quality

Run-off from the R102 and the N2 freeway, both of which pass over the estuary, represents long term, permanent sources of pollutants which can only increase with increases in traffic on these roads. These pollutants include aluminium, copper, lead, manganese, nitrogen, phosphorus, zinc, oils and grease (Robertson, Armitage & Zuidgeest 2019).

Runoff from Freeland Park includes the above types of pollutants from roads and traffic as well as potential seepage from any septic tanks. It appears however that the houses closest to the estuary have waterborne sewage systems which would reduce the risk of contamination of the estuary.

Fertiliser and biocide runoff from cane fields is likely but no water quality data on these pollutants could be sourced. It can also be expected that the expanding rural developments further up the catchment will contribute to water quality impacts via solid waste and sewage.

5.6 Flood plain alterations

The flood plain in the lower catchment around the estuary can broadly be equated with the EFZ. Habitat in this area has been lost through freeway and causeway construction. This is unlikely however to extend into further losses. Overall the EFZ area has been liberated from historical transformations, particularly as regards the substantial withdrawal of cane from the area east of the N2. These areas need to have some management of invasive species to improve their ecological value and service to estuary health. Freeland Park development along the estuary fringe would need to be constrained going forward if development towards the N2 proceeds as these could potentially infringe further into the EFZ.

5.7 Invasive/alien species

It was suggested (Forbes & Demetriades 2010) that alien plants were becoming established on the south bank area between the N2 and R102. This has increased

since then with widespread terrestrial species such as red pepper *Schinus terebinthifolius* and other species covering significant portions of the EFZ.

No aquatic alien plants were noted at the time of writing although there have apparently been past records. Invasive aquatic species, such as Nile cabbage *Pistia stratiotes* and water hyacinth *Eichhornia crassipes,* are common in many south coast KZN estuaries, and the possibility always exists that colonization could occur. Press reports have referred to invasive aquatics in the aMahlongwa estuary, but these articles were actually reporting on the adjacent aMahlongwana estuary situation. Apparently, an infestation which previously occurred was washed out of the estuary during a high flow event and has not re-appeared (Lamble *pers comm*[1]). The proximity of the aMahlongwana Estuary makes dispersal of these species to the aMahlongwa Estuary a possibility meriting a degree of monitoring and possible action.

5.8 Coastal Access

Access to the estuary for the public is limited as is the case for many of KZNs smaller estuaries where the steep terrain and surrounding developments serve to isolate the estuary. Freeland Park houses effectively limit access between the R102 and the N2 except for one area (Plate 5-4) which appears to be a servitude and had a partially constructed jetty noted during the December 2020 site visit. Access to the mouth is limited by the railway line, private developments south of the mouth or layby areas to the north and would require an approximately 1 km walk from the north or 1.5 km from the south.

[1] Neil Lamble – aMahlongwa estuary neighbour resident in Freeland Park.

Plate 5-4 Cleared servitude on the south bank of the aMahlongwa estuary



6 OVERVIEW OF SOCIO-ECONOMIC CONTEXT

6.1 Demographics

This information is only available at a broad scale/high-level municipality wide basis and as such extends far beyond the bounds of the estuary or its catchment. The information below is therefore taken from the documentation available for Ugu and Umdoni (Umdoni 2017) in particular, and eThekwini reports on Integrated Development or Strategic Environmental analysis.

In 2019 Ugu District Municipality's population of 749 000 comprised 89.85% African (710 000), 5.80% White (45 800), 0.94% Coloured (7 460) and 3.40% Asian (26 800) people. The uMdoni Local municipality is dominated by formal housing and has the highest population density (313 people/km^2) within the Ugu district and this is mostly focussed on the coastal belt with some traditional rural areas governed by tribal authorities further west in the catchment. The most significant of these settlements for the estuary is the development of the coastal urban nodes in both the uMdoni and eThekwini areas adjacent to the estuary boundaries.

On the eThekwini side some focussed information comes from the uMkhomazi Local Area Plan regarding demographics which estimates the population of this area at just under 19 000 in 2015. While Amahlongwa appears to have the second highest population in Umkhomazi, it is a combination of two subplaces which included Crowder in this calculation. The population distribution is not uniform, with the highest density in Craigieburn, while the lowest is found in Clansthal. The highest density is found in Naidooville at 2 181 people/per km^2. The lowest densities are found in Umzinto and Umkhomazi which are largely under commercial agriculture at present.

6.2 Economic profile

The area on this boundary of two municipalities is located between the rapidly developing tourist and upmarket residential node of Scottburgh to the south, and KZN‟s primary business, economic and infrastructure node of Durban to the

north. These nodes are joined by the national and regional roads, the N2 and the R102. The local area has nine significant sub-areas (2001 census demarcations) with Umkhomazi, Widenham, Sappi Saiccor, Clansthal, Umzinto, Naidooville, Mkhomanzi Drift, Craigieburn, and Ezembeni and the southwestern subplace of Amahlongwa.

This southern uMkhomazi area is currently identified as being rural but will gradually become more urban (EM 2010). Significant economic growth throughout the area will be initiated by residential developments some of which already have environmental authorisation. The residential development industry is identified as being at the core of the economic growth of the area however this is only sustainable with commercial and facility development. Residential developments will inject demand into the area. Residential development and growth of the area is however not possible without facility development, *e.g*. schools and clinics so it can be expected that this will follow. Ethekwini Muncipality's planning documents suggest that this area is anticipated as being distinctly quieter than the north node of Durban and the south node of Scottburgh and because of this anticipates that the area will not become heavily urban or heavily industrialised but it is not expected to remain rural. They do state that urban agriculture is required in the areas of Amahlongwa and Crowder to leverage land availability and light agriprocessing to strengthen small scale agriculture. This is considered to ultimately create value chains and increase employment and value added within the catchment area. Interestingly, the Local Area Plan highlights the aMahlongwa estuary along with the uMkhomazi and aMahlongwana with their major valley system as representing important local natural resources which are sensitive and need to be appropriately protected and managed.

6.3 Social considerations

The area around the aMahlongwa estuary, although between two economic hubs, is at present not significantly developed although potential exists for developments and improved linkages. In particular an urgent need has been

identified for additional, appropriate local economic development and upgrading of the existing traditional settlement area to ensure better integration into the wider municipal areas and identification of opportunities for the development of amenities and local activities.

Besides the agricultural activities in the area, tourism appears as one of the major economic development opportunities. While coastal tourism needs to be appropriately supported, taking into account the sensitive natural environment, more emphasis needs to also be put onto the inland tourism opportunities.

Other considerations from a social perspective include the migration of people to development nodes in search of employment, better schooling and health care which create challenges for municipalities who have often not planned for these movement patterns. The uMdoni municipality along with the Ugu district municipality should put short term interventions in place as well as deal with unauthorised water and electricity connections.

Plate 6-1. A view over the lower aMahlongwa Estuary



7 LEGISLATIVE INSTRUMENTS AND RELATED STRATEGIES/PROGRAMMES

The laws that govern activities in and around estuaries are numerous and complex and a mutifaceted approach when tackling any issues surrounding an estuary impacting activity is required. Without a doubt there are enough laws to ensure the sustainable development and protection of estuaries and their surrounds. The complexity arises in knowing which combination of laws to use and how to use them. Legal action is expensive and tends to polarize people in opposing camps and therefore it is recommended that this route should only be followed when all other avenues explored have been unsuccessful.

7.1 Legal framework applicable to estuarine management

The overarching legislation which is pertinent to estuaries stipulates the following.

- The Constitution including the Environmental Bill of Rights ensures that, amongst other things, everyone has the right to an environment that is not harmful to their health or well-being, and to have the environment protected for current and future generations.
- The Integrated Coastal Management Act recognizes that estuaries are key coastal resources and that they require active management and conservation to maintain their integrity.
- The Environmental Conservation Act (ECA) requires, through the Environmental Impact Assessment (EIA) Regulations, that an environmental report is required for almost any development in or adjacent to an estuary and permission for development is required from the relevant authority (usually the provincial environmental department). Many activities in the catchment including the cultivation of virgin land, the building of dams and weirs, and the construction of other infrastructure also require an environmental report and permission to be obtained prior to development.

- The National Environmental Management Act contains over-arching environmental legislation. Included in this is the provision that allows members of the public to take legal action in the public interest or the interest of protecting the environment. This includes taking legal action against government departments to force them to implement laws.
- The Marine Living Resources Act (MLRA) regulates all activities related to the use of living resources in estuaries. This includes bait collection; commercial, recreational and subsistence fishing, and the harvesting of estuarine plant species.
- The Conservation of Agricultural Resources Act (CARA) requires that, when farming, steps are taken to ensure particularly the conservation of soil and water.
- The National Water Act (NWA) recognizes that an estuary is a water user and that provision needs to be made so that an estuary has sufficient freshwater inflow to sustain its ecological functions.
- The National Forest Act (NFA) regulates the use of indigenous forest resources in and around estuaries and, importantly, covers the protection of mangrove forests.
- The Minerals Act (MA) requires that mining, quarrying or sand-winning are subject to an environmental report (including rehabilitation measures and dedicated fund to pay for this) prior to commencement and that the activity is permitted by the Department of Minerals and Energy (DME).
- The Municipal Systems Act (MSA) requires that municipalities establish Integrated Development Plans (IDPs). These plans need to include spatial development frameworks, land-use management systems, and environmental management plans. These all require that potential environmental impacts of development/land-use options be considered.

Table 7-1 summarises the national policies which are pertinent for estuaries

Table 7-1 Summary of national policies which affect water quality and quantity in estuaries in general, land use, development and resource use in the estuarine environment (directly from Dawson, Sedick and Clark 2020).

		Component	Key Legislation	Authority
Estuarine resources	**Planning, Protection & quantity**	Water Resource Protection	National Water Act (1998)	Water
		Biodiversity	Biodiversity Act (2004)	Environment
		Protected areas	Protected Areas Act (2003)	Environment
		Fisheries	Marine Living Resources Act (MLRA) (1998)	Fisheries
		Heritage areas	World Heritage Convention Act (1999)	Environment
			National Heritage Resources Act (1999)	
Management of Activities or Uses in and around estuaries	**Water quality & quantity**	Water (abstraction)	National Water Act (1998)	Water
		Effluent disposal	National Water Act (1998)	Water
			Integrated Coastal Management Act (ICMA) (2008)	Environment
		Pollution (spillage)	National Water Act (1998)	Water
		Dredging (e.g. harbours)	ICMA (2008)	Environmental
		Solid waste management	Waste Act (2008)	Environment
		Recreation (water quality)	National Health Act (2003)	Municipalities
		Shipping (e.g. harbours)	Prevention of Pollution from Ships Act (1983)	Transport
		Coastal access	ICMA (2008)	Municipalities
		Off road vehicles & boat launching	ICMA (2008)	Environment Provincial lead agents
	Land-use and Infrastructure Development	Ports	National Ports Act	National Ports Authority
		Mining	Mineral & Petroleum Resources Development Act (2002)	Mineral Resources
		Infrastructure & Land-use	Municipal Systems Act (2002)	Cooperative Governance Municipalities
			Spatial Planning and Land-use Management Act (SPLUMA) (2013)	Provincial departments Municipalities
			National Building Regulation and Building Standards Act (1977)	Trade and Industry
		State assets	Government Immovable Asset Management Act (2007)	Public Works (National/provincial)
		New/upgrading/approval of activities/development	National Environmental Management Act (1998) (EIA regulations)	Environment
	Exploitation of Living Resources	Fishing (catch limits etc.)	Marine Living Resources Act (1998)	Fisheries
		Bait collection		
		Marine aquaculture		
		Seaweed (e.g. kelp)		
		Mangroves	National Forest Act	Forestry
		Use of terrestrial plants (in the EFZ)	Conservation of Agricultural Resources Act (1983)	Agriculture
Integration	**Estuary Management**	National Estuary Management Protocol (2013)	Integrated Coastal Management Act (ICMA) (2008)	Environment Provincial lead agents
		Development/integration of Estuary Management Plans		
		Guidelines for EMPs (2014)		

7.1.1 National Biodiversity Assessment

The South African National Biodiversity Institute (SANBI) has delineated the countries estuaries in the planning and assessment of the biodiversity resources of South Africa. SANBI manages the Biodiversity Geographic Information System that supplies the regulated boundaries of the country's estuaries and has used these desktop boundaries in the estuary component of the National Biodiversity Assessment (van Niekerk *et al.* 2019).

7.1.2 Provincial guidelines

At a provincial level Ezemvelo KZN Wildlife as the KwaZulu-Natal (KZN) biodiversity authority requires the delineation of Predominantly Open Estuaries and Intermittently Open Estuaries (or Temporarily Open/Closed Estuaries) by the 5 m contour for the purposes of biodiversity specialist studies in KZN. It should be noted that delineation and assessment of estuarine bays, estuarine lakes and river mouths require additional biophysical considerations that often require a larger area to be included in the assessment of the core estuarine area (Forbes & Demetriades 2010).

7.2 Management strategies/plans relevant to the estuary

7.2.1 eThekwini Municipality Strategic Environmental Assessment

A Strategic Environmental Assessment (SEA) is a widely used tool for proactively integrating environmental sustainability issues into the formulation of policies, plans and programmes. A SEA is a legislated requirement in terms of the Spatial Planning and Land-use Management Act, 2013 (SPLUMA) and the Local Government: Municipal Planning and Performance Management Regulations (2001) and is intended to be a key informant of a municipality's Spatial Development Framework (SDF).

A phased approach is being adopted for eThekwini Municipality's SEA, with the first phase focusing on understanding the 'state of the environment' that has resulted from existing development patterns in Durban. The eThekwini

Municipality has completed this first phase, and an Environmental *status quo* Report on Durban has been completed. The second phase of the SEA is developing an equivalent understanding of the 'state of the social and economic systems' that have produced the current environmental state and use the knowledge to explore the implications of possible future socio-economic pathways linked to the SDF. It is important that the estuary status, services and function are considered in this assessment.

7.2.2 eThekwini Municipality Biodiversity Report 2019/2020

The intention of State of Biodiversity reporting is to present qualitative and quantitative information that describes the status of the biodiversity and ecosystem services in Durban to highlight key threats and to record actions aimed at protecting and managing biodiversity. These reports are produced annually, and this is the eThekwini Municipality's (EM) 12th State of Biodiversity Report. It collates data relevant to the 2019/2020 municipal financial year1.

7.2.3 eThekwini Municipality Integrated Development Plan

This report includes visions and goals for biodiversity as well as actions to implement this. It details current status of estuaries and other biodiversity areas within the municipality with a list of current threats that include pollution. The relevant findings of this report should be included in any management plans of the aMahlongwa Estuary.

7.2.4 eThekwini Biodiversity Stewardship Programme Policy

As part of the strategy for promoting responsible management of eThekwini Municipality's (EM) biodiversity, the Environmental Planning and Climate Protection Department (EPCPD) has taken a strategic decision to include biodiversity stewardship as a principal tool for achieving biodiversity protection, environmental management and climate change adaptation. There is a real opportunity to have estuaries become part of this programme.

7.2.5 Durban Metropolitan Open Space System (D'Moss)

D'Moss, currently 94 000 hectares in extent, is a spatial layer of interconnecting open spaces in public, private and traditional authority ownership that seeks to protect the biodiversity and associated ecosystem services of Durban for future generations. From a natural resource perspective, D'MOSS comprises approximately 2 400 ha of estuarine environment, including sand and mudbanks, mangrove and swamp forests; and therefore, all estuaries within the eThekwini Municipality fall into this plan, including the aMahlongwa. D'MOSS thus provides a unique opportunity to conserve many of South Africa's threatened ecosystems and species including the endangered KZN Sandstone Sourveld grasslands, the critically endangered *Brachystelma natalense* (a small herbaceous plant) and the endangered Oribi, Spotted Ground Thrush and Pickersgill's Reed Frog. If protected and managed, D'MOSS will assist the province and the country in meeting biodiversity conservation targets.

7.2.6 Ugu Strategic Environmental Management Plan

Ugu Municipality's Strategic Environmental Management Plan serves to direct the way forward for attaining the desired environmental state. The Strategic Environmental Management Plan bridges the divide between the current state of the environment in the district and the desired state. To achieve this Environmental Management zones have been defined and to facilitate the attainment of the desired state for these zones, guidelines will be compiled that stipulate compatible activities and specific management requirements and objectives to ensure development proceeds in accordance with the overall plan.

7.2.7 Ugu Municipality Integrated Development Plan (IDP 2020/2021)

The Ugu District Council adopted a five-year Integrated Development Plan in June 2019. This plan is meant to provide a basis for both public and private sector investment in the district and is reviewed on an annual basis. It is important that this plan is taken into account for any planning and implementation regarding the estuary management plan for the aMahlongwa Estuary.

7.2.8 uMdoni LUMS/SEA and SDF

It was brought to the team's attention that these documents are in prep or draft form. To date copies of these have not been acquired by the team.

7.3 Existing monitoring programmes

7.3.1 National Estuarine Monitoring Programme

The National Estuarine Monitoring Programme (NESMP) for South Africa, is intended to ensure that the mandate of the Department of Water and Sanitation (DWS) as custodian of South African water resources, and as entrenched in the National Water Act is achieved and is in support of integrated co-operative coastal governance as per the ICM Act. Monitoring is undertaken by the DWS for the protection of water resources especially those in estuarine environments. This programme has three tiers that focus on the collection of basic data, determination of the inflow requirements of estuaries and seeks to resolve key issues related to each estuary such as fish kills and sewage inflow. Initiated in 2012, the programme continues annually (as long as funding is successful) in collaboration with relevant role players.

8 OPPORTUNITIES AND CONSTRAINTS FOR CONSIDERATION IN THE EMP PHASE

The values of a SWOT analysis are that it provides a useful overview of current and future practices which have a bearing on estuary health. Each of the components of the analysis (Strengths, Weaknesses, Opportunities and Threats) is dealt with individually below. Stakeholders may very well be able to add to this list from personal knowledge of the estuary.

8.1 Strengths

The strengths for the aMahlongwa estuary are cross-cutting and lie both with the cooperative governance frameworks which exist as well as the physical and other characteristics of this particular estuary. Each of these is listed below:

- Although the Estuary lies on the border between the eThekwini Metropolitan Municipality, and the Umdoni Local Municipality within the larger Ugu District Municipality there is a strong sense that the provincial authority by commissioning this Estuary Management Plan is committed to the improvement of estuary health and the effective control of impacting activities on the estuary.

- There is a commitment from the district municipalities and the provincial authorities to address historical decisions, which have impacted the estuary, and move forward with a plan to guide future decision making.

- Strong link to the Aliwal Shoal MPA makes the estuary part of a biodiversity mosaic that is worthy of protection.

- The small size of the catchment makes the estuary a very realistic candidate for improvement.

- Lack of high population density and pollution by commercial enterprises in the catchment area and the reversible nature of some land-uses allows for restoration/rehabilitation of EFZ areas.

- The identification of the estuary as a sensitive, important environment worthy of future tourism investment by the uMkhomazi Local Area Plan

- Estuary identified provincially as an important estuary for protection

- High aesthetic value

- High restoration potential

8.2 Weaknesses

The weaknesses for the aMahlongwa estuary are listed below:

- No environmental data have been collected for over 15 years. The lack of recent in-depth survey data is a weakness that removes confidence in the assessment of estuary health scores and to some extent may hamper efforts to measure improvement in response to actions unless this is addressed.
- Irreversible changes to estuary habitat within the EFZ as a result of the bridges and predominantly their supporting causeways mean a permanent loss and change of function which will always influence the health score of the estuary.
- Non-point sources of pollution, which occur within the catchment area. This has practical impacts on the implementation of the estuarine management plan, where implementation responsibilities may fall outside the mandate of the responsible agents.
- There is a lack of coordination between public, private and government entities with regards to management of the estuary.
- Ineffective implementation of legislative instruments to control impacting activities which to some extent arises because of the point above.
- Environmental authorisation(s) have been issued for a significant mixed-use development surrounding the estuary (Renishaw Estate) without due regard for impacts to the estuary or with buffers in place to protect the estuary.
- Land-uses poorly synchronised

Close proximity of quarry and sand mining operations

8.3 Opportunities

Opportunities for the management of the aMahlongwa Estuary include the following:

- The improvement of water quality is something which can easily be addressed by a detailed forensic audit of the water quality entering the estuary. This would also need to take account of residence times in the estuary.
- Monitoring of a number of key parameters would provide a significant learning, training and motivating opportunity for stakeholders.
- Establishment of an estuary management committee/forum which would be able to provide report back to the broader stakeholder group and also engage with other groups such as the Catchment Management Forums and authorities.
- Eco-tourism linked enterprises, cottage industry and other employment opportunities linked to monitoring and implementation should be explored for the management plan and visioning phase.
- Education for local schools possible using the estuary at all socio-cultural levels and even through artistic means.
- Potential for formal protection for the estuary, especially with linkage to the MPA.
- Waste disposal and sanitation awareness raising opportunities especially if partnering with the adjacent aMahlongwana estuary with which this estuary provides a contrast.
- Joining the eThekwini Land Stewardship programme
- Estuary could increase its contribution to the Climate Crisis through increased carbon sequestration
- High potential as a birding and outdoor experience venue.

8.4 Threats

Threats to the maintenance, functioning and long-term survival of the aMahlongwa estuary are listed and these include the following:

- ❖ Rising sea level and sea temperature through climate change
- ❖ Increases in poor water quality pose a threat to the health status of the estuary.
- ❖ New developments already authorised in the immediate vicinity of the estuary pose a significant challenge and innovative ways to address these are needed to avoid the threats. These include the authorisation for one of the nodes of the Renishaw Application and specifically around this estuary, the Croc World Development (Figure 8-1) to be read in conjunction with the EA amendment of 28/7/2020 which dealt with some specific changes to the layouts within the blocks indicated below.

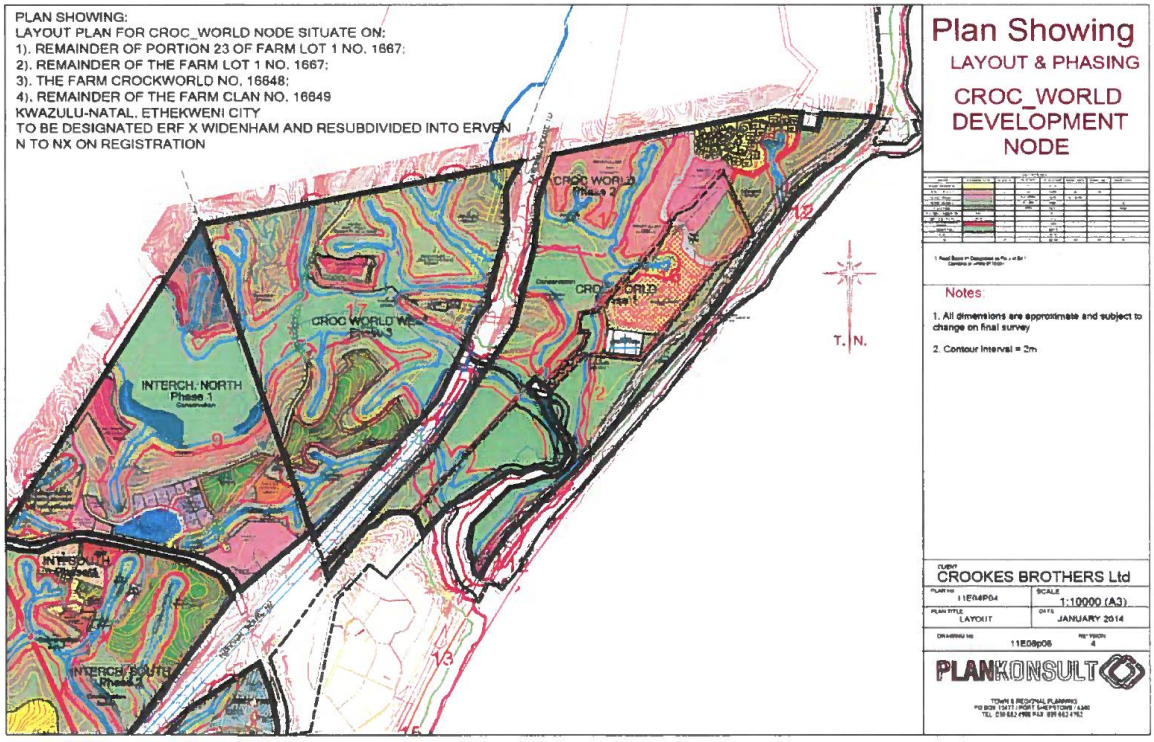


Figure 8-1 Layout included in Environmental Authorisation for the mixed use development Renishaw Estate dated 28/3/2014

- The lack of recent information on this estuary poses a threat in that it is difficult to respond to and address 'unknown' threats.
- Lack of funding, lack of interest or a feeling of helplessness to address the large threats facing our water resources.
- Lack of funding or political will to make a significant change.
- Poorly controlled and illegal garbage and waste dumping.
- Non-compatible business interests/land-uses overriding environmental concerns.
- Quarry activities and proximity of sand mining operations to the EFZ

9 RECOMMENDATIONS TO ADDRESS MAJOR INFORMATION GAPS

The standard problem in the development of estuarine management plans is the frequent absence of recent data, the last survey data in this particular case being now approximately 15 years old.

The following is a list of information requirements identified as being needed to improve on future studies for the aMahlongwa Estuary. This information would enhance the identification of drivers of impacts on the estuary needing more management as well as identify additional opportunities for stakeholder learning, training and employment:

- Monitoring of water quality, *i.e.* sources of contamination, concentrations, seasonal fluctuations, potential for remedial actions to improve water quality.
- Improved quantification of water use in and around the catchment which is small and therefore extremely possible.
- Maintain the current level of mouth state observations. This could be easily accomplished by installation of a water level recorder near the mouth.

- Information on the accumulation of toxic substances in sediments
- Detailed and regular data on the composition of invertebrate, fish and bird communities. These can be done at different levels and timescales to address costs and practicality.

10 GOING FORWARD…

The aMahlongwa estuary is one of 16 that were surveyed in 2007/2008 (Forbes & Demetriades 2010) under a contract with the eThekwini Municipality. It was rated as being in "Fair" condition on a scale of five categories ranging from "Excellent" to "Good", "Fair", "Poor" and finally "Highly Degraded". None was in Excellent condition. Only three were rated "Good" and four as "Fair", the latter class including the aMahlongwa. Estuaries in a "Fair" condition have their core estuarine function intact, retain some support habitats, show some water quality impacts and loss of biodiversity but have key estuarine processes largely in place. The significance of these features is that the impacts do not reflect the effectively irreversible structural impacts as do the highly urbanized areas in systems like the aManzimtoti or eZimbokodweni. Adherence to the restrictions imposed by the adoption of the 2018 estuarine boundary in conjunction with an adequate buffer and attention to factors influencing water quality should have every likelihood of raising the system to a higher classification level.

The Situation Assessment was arrived at on the basis of desktop information and useful satellite photography, the former dating back to 1937. There was a collation of existing information (Begg 1978) followed by field work (Begg 1984, Ramm, Cerff & Harrison 1986, Harrison *et al.* 2000) and surveys in 2007/2008 (Forbes & Demetriades 2010) when the estuary was given a status/health classification as described under Section 8 above. Prior to the preparation of this report an observational site visit was carried out by the MER team of estuarine ecologists during December 2020 and July 2021, the end result of all the above being the accumulation of a substantial body of knowledge which it is anticipated will be presented to the local authorities and all interested and affected parties.

This will then form the basis for the development of a Vision and Objective Setting, which will guide the development of an Estuarine Management Plan incorporating the caveats outlined in the first paragraph of this report.

The assumption here is that anthropogenic problems could or would be identified during this follow-up phase, policies and actions drafted and a suitable monitoring programme developed which would allow assessment of progress made and the recognition of the attainment of a REC.

11 REFERENCES

Begg G.W. 1978 The Estuaries of Natal. *Natal Town and Regional Planning Report* 41:1 -657.

Begg G.W. 1984 The estuaries of Natal. Part 2. *Natal Town and Regional Planning Report* 55: 631 pp

Cooper A. & Smith A. 2014. Geology and Geomorphology . Ugu Lwethu – Our Coast. A profile of coastal KwaZulu-Natal. KwaZulu-Natal Department of Agriculture and Environmental Affairs and the Oceanographic Research Institute, Cedara, 17-19.

Dawson J. & Griffiths C.L. 2012 Revision of the crown crabs, genus *Hymenosoma* (Crustacea: Hymenosomatidae), of South Africa. *African Natural History* 8:16-29.

Dawson J, Sedick S and Clark BM. 2020. uThongathi Estuary Management Plan Situation Assessment Draft Report no. 1905/2 prepared by Anchor Research & Monitoring (Pty) Ltd for the KwaZulu Natal Department of Economic Development, Tourism and Environmental Affairs (EDTEA).

Department of Environmental Affairs (DEA). 2014. The National Coastal Management Programme of South Africa. (Cape Town, South Africa).

Dollar E.S.J., Nicolson C.R., Brown C.A., Turpie J.K., Joubert A.R., Turton A.R., Grobler D.F., Pienaar H.H., Ewart-Smith J. & Manyaka S.M. 2010. Development of the South African Water Resource Classification System (WRCS): a tool towards the sustainable, equitable and efficient use of water resources in a developing country. *Water Policy* 12: 479–499.

Department of Environmental Affairs (DEA). 2015. Guidelines for the Development and Implementation of Estuarine Management Plans in terms of the National Estuarine Management Protocol. Cape Town.

Department of Water Affairs (DWS). 2013. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu WMA: Desktop Estuary EcoClassification and Ecological Water Requirement. Report Number: RDM/WMA11/00/CON/CLA/0313. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd.

Department of Water and Sanitation (DWS), South Africa., September 2015a. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu WMA: Volume 2d: Supporting Information on the Determination of Water Resource Classes Ecological Consequences on Estuaries in T4, U2, U3, U5, U6, U7 and U8 of operational scenarios. Prepared by: CSIR for Rivers for Africa eFlows Consulting PTY Ltd.

Department of Water and Sanitation (DWS), South Africa., September 2015b. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Volume 4: Estuary Resource Quality Objectives. Prepared by: Van Niekerk L., Adams J., Taljaard S. & Weerts S.

EM 2010 Umkhomazi Local Area Plan. August 2010. RCR Collaborative Project Team.

Forbes A.T. & Demetriades N.T. 2010. Estuaries of Durban, KwaZulu-Natal, South Africa. Report for the Environmental Management Department, eThekwini Municipality. Second Edition.

Harrison T.D., Cooper J.A.G. & Ramm A.E.L. 2000 State of South African estuaries. Geomorphology, Ichthyofauna, Water Quality and Aesthetics. State of the Environment Series Report No: 2. Department of Environmental Affairs and Tourism, South Africa. 127 pp.

Ramm A.E.L., Cerff E. C. & Harrison T.D. 1986 The Mahlongwa Estuary. Natal Estuary Status Report No. 46. Estuaries and Coastal Processes, National Institute for Water Research, CSIR Durban. No pagination.

Robertson A., Armitage N. & Zuidgeest M.H.P. 2019 Stormwater runoff quality on an urban highway in South Africa. *Journal of the South African Institution of Civil Engineering* 61(2)

Rust I.C. 1991 Environmental geology of the coastal zone: a South African perspective. *South African Journal of Marine Science* 10:1, 397-405,

Savage C., Thrush S.F., Lohrer A.M. & Hewitt J.E. Ecosystem services transcend boundaries: estuaries provide resource subsidies and influence functional diversity in coastal benthic communities. PLoS One. 2012;7(8):e42708. doi: 10.1371/journal.pone.0042708. Epub 2012 Aug

Turpie J.K., Taljaard S., van Niekerk L., Adams J., Wooldridge T., Cyrus D., Clark B. & Forbes N. 2012. The Estuary Health Index a standardised metric for use in estuary management and the determination of ecological water requirements. WRC Report No. 1930/1/12.

Umdoni 2017 Integrated Development Plan 2016/2017 Umdoni Municipality.

Van Niekerk L., Adams J.B., Bate G.C., Forbes A.T., Forbes N.T., Huizinga P., Lamberth S.J. , MacKay C.F., Petersen C., Taljaard S., Weerts S.P., Whitfield A.K. & Wooldridge T.H. 2013. Country- wide assessment of estuary health: An approach for integrating pressures and ecosystem response in a data limited environment. *Estuarine, Coastal and Shelf Science*. 130: 239-251

Van Niekerk L., Adams J.B, Lamberth S.J., Taljaard S., MaKay F., Bashoo S., Parak O. & Weerts S. 2019. Chapter 6: Pressures on the Estuarine Realm. South African National Biodiversity Assessment 2018: Technical Report. Volume 3: Estuarine Realm. South African National Biodiversity Institute, Pretoria. Report Number: SANBI/NAT/NBA2018/2019/Vol3/A.

Van Niekerk L., Skowno A., Adams J.B., Lamberth S.J., Turpie J., MacKay C.F. & Sink K. 2019. Chapter 8. Ecosystem Threat Status and Protection levels', South African National Biodiversity Assessment 2018: Technical Report. Volume 3: Estuarine Realm, South African National Biodiversity Institute, Pretoria. Report Number: SANBI/NAT/NBA2018/2019/Vol3/A.

Van Niekerk L. & Taljaard S. 2002. Recommendations on a framework for effective cooperative governance of South African estuaries. CSIR Environmentek Draft report 8 July 2002, Eastern Cape Estuaries Management Programme, Co-operative governance sub-project

Van Niekerk L., Taljaard S., Adams J.B., Clark B., Lamberth S.J., MacKay C.F., Weerts S.P. & Whitfield A.K. 2019. 'Chapter 7: Condition of South Africa's estuarine ecosystems' in South African National Biodiversity Assessment 2018: Technical Report. Volume 3: Estuarine Realm. South African National Biodiversity Institute, Pretoria. Report Number: SANBI/NAT/NBA2018/2019/Vol3/A.

Van Niekerk L. & Turpie J.K. (eds.). 2012. South African National Biodiversity Assessment 2011: Technical Report. Volume 3: Estuary Component. CSIR Report Number CSIR/ NRE/ECOS/ER/2011/0045/B. Council for Scientific and Industrial Research, Stellenbosch.

Van Niekerk L., Turpie J.K, & Lamberth S.J. 2019. Estuary Biodiversity Importance. South African National Biodiversity Assessment 2018: Technical Report. Volume 3: Estuarine Realm, South African National Biodiversity Institute, Pretoria. Report Number: SANBI/NAT/NBA2018/2019/Vol3/A.

Whitfield, A.K. & Baliwe, N.G. 2013. A century of science in South African estuaries: Bibliography and review of research trends. SANCOR Occasional Report No. 7: 289 pp.

Whitfield A.K., Lamberth S., Cowley P. & Mann B. 2019. Fisheries in South African estuaries – are we on the right road?. *The Water Wheel* Nov/Dec: 12-15.

12 APPENDIX A

aMahlongwa Estuary RQOs (DWS 2015b)

PES:	C	REC:	B	TEC:	B

Components that require interventions to achieve the TEC:
- Protect baseflows to estuary to maintain mouth state and salinity profile.
- Improve water quality.
- Partial restoration estuarine riparian habitat.
- Control and reduce fishing pressure.

Flow:

PES	nMAR (MCM)	pMAR (MCM)
B	13.76	13.18
	Flows should not exceed natural and seasonal distribution should not be compromised. Current baseflows should be upheld into estuary to maintain present mouth state and salinity regime. The distribution patterns of the flood components differ by no more than 10% (in terms of magnitude, timing and variability) from that of the Present (2015).	

Sediment processes:

D↑	▪ The flood regime maintains the sediment distribution patterns and aquatic habitat (instream physical habitat). The suspended sediment concentration from river inflow does not deviate by more than 20% of the present sediment load-discharge relationship (to be determined). The sedimentation and erosion patterns in the estuary do not differ significantly from present (± 0.5 m) (to be determined). ▪ Changes in tidal amplitude of less than 20% from present (to be determined). ▪ Changes in sediment grain size distribution patterns similar to present. The median bed sediment diameter deviates by less than a factor of two from present levels (to be determined). The sand/mud distributions in middle and upper reaches do not change by more than 20% from Present State over a five year average.

Mouth state:

A	Mouth open conditions should be maintained within the current range: 22% (± 5%).

Water quality: Salinity

B	The system needs variability in salinity regime, with a measurable increase in salinity in the lower and middle reaches during the low flow season. Mid-waters in the lower reaches should exceed 10 (to be confirmed).

Water quality: Other

	Ecosystem health:	Recreational use:	Yes
D↑	Water quality poses risk to REC/TEC, sufficiently reduced if: ▪ DIN: Freshwater inflow, 50%ile < 0.2 mg/l (high risk). ▪ DIP: Freshwater inflow, 50%ile < 0.015 mg/l (high risk). ▪ DO: Entire estuary, average ≥ 6 mg/l (high risk). ▪ Turbidity: Estuary, clear (<10 NTU) accept during high inflow events. Toxic substances: ▪ Substance concentrations in estuarine waters not to exceed targets as per SA Water Quality Guidelines for coastal marine waters (DWAF, 1995). ▪ Substance concentrations in estuarine sediment not to exceed targets as per WIO Region guidelines (UNEP/Nairobi Convention Secretariat and CSIR, 2009).	Microbiology: Sufficient levels (DEA, 2012).	

Macrophytes (plants)

C↑	▪ Maintain the distribution of current macrophyte habitats (< 20% change in the area covered by different macrophyte habitats which accounts for natural changes due to the dynamic nature of estuaries). ▪ Maintain the integrity of the riparian zone. No bare patches or unvegetated, cleared areas along the banks. Prevent further disturbance and development of the floodplain habitat. ▪ No invasive floating aquatic species present in the estuary e.g. water hyacinth. ▪ Control the spread of invasive plants in the riparian zone. Invasive plants (e.g. syringa berry, Casuarina, Spanish reed, black wattle, Brazilian pepper tree) cover < 5% of total macrophyte area. ▪ Maintain present salinity regime to maintain reed and sedge habitats (< 50% loss of reed and sedge habitats in non-flood year). ▪ Improve salinity regime to encourage the reestablishment of mangrove habitat.

Inverts

C↑	As sampled by plankton net, grab and dip nets/traps (as appropriate):

PES:	C	REC:	B	TEC:	B
	▪ Population abundances of plankton and benthic assemblages (baselines to be set) should not deviate by more than 30%. ▪ Zooplankton should be dominated by estuarine copepods *A. natalensis* and *P. hessei*. ▪ Macrobenthos should be abundant and dominated by amphipods, but should include isopods, tanaids, polychaetes, the crab *H. projectum* and insect taxa. ▪ Chironomid larvae and oligochaetes should not occur in abundance and should not dominate the benthos. ▪ Penaeid and carid (Caridina and Macrobrachium) prawns should occur. ▪ Sandprawn *C. kraussi* should occur in sandy areas in the systems lower reaches (to be confirmed). ▪ Large brachyuran crabs (macrocrustacea) are dominated by *V. litterata*. ▪ Molluscan assemblage should include bivalves and gastropods (including *Melanoides tuberculata*). ▪ Invasive alien species should not occur in abundance.				
Fish					
C↑	As sampled by seine and gill net in open waters: ▪ 15 species should occur to include freshwater, estuarine resident and estuarine dependant marine fishes. ▪ Estuarine resident species should comprise a minimum of four species. ▪ Estuarine resident and estuarine dependant marine fishes should dominate catches by abundance. ▪ *G. callidus, M. capensis* and *R. holubi* should occur with 100% frequency of occurrence (every sampling trip). ▪ *P. commersonni* should be sampled with 70% frequency of occurrence. ▪ Pelagic piscivores should occur. ▪ No alien fish species should occur. ▪ Fish should be free of lesions and other anomalies related to water quality. ▪ No fish kills should occur.				