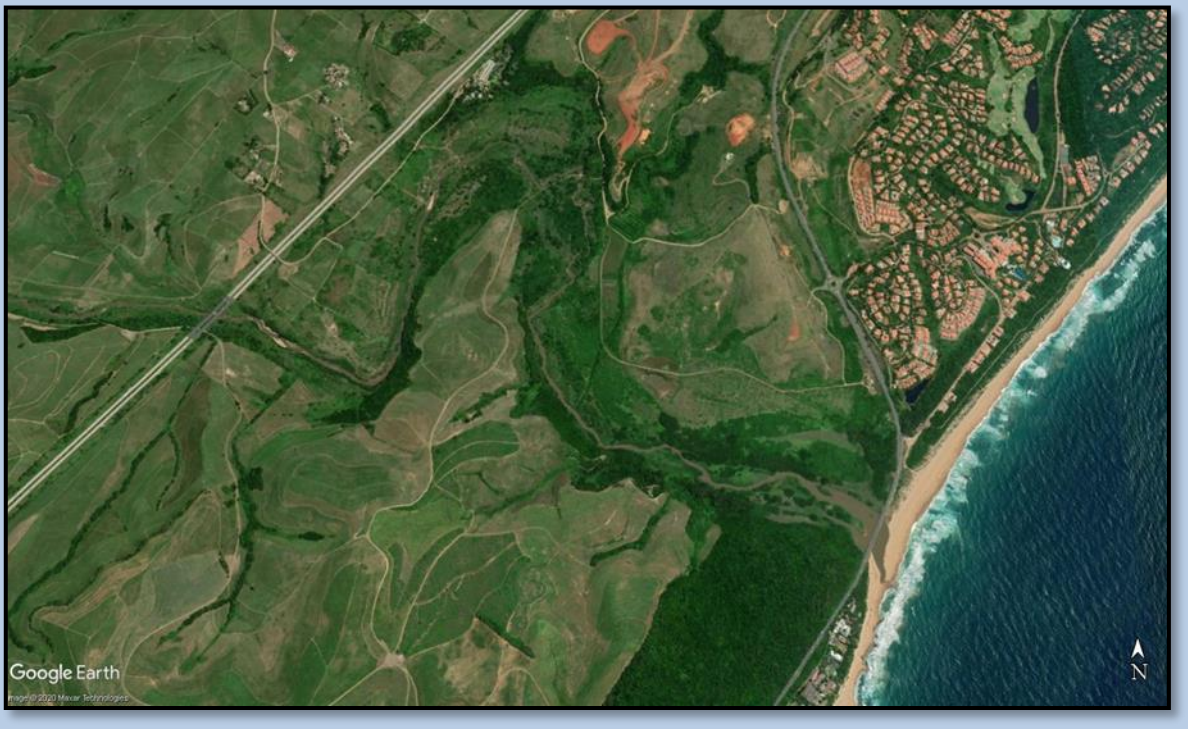
KWAZULU-NATAL PROVINCE
ECONOMIC DEVELOPMENT, TOURISM
AND ENVIRONMENTAL AFFAIRS
REPUBLIC OF SOUTH AFRICA

UTHONGATHI ESTUARY MANAGEMENT PLAN

SITUATION ASSESSMENT

FINAL REPORT



July 2021

ANCHOR
research & monitoring

Anchor Research and Monitoring Report No. 1905/6

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Report prepared for:
Province of Kwazulu-Natal
Department of Economic Development,
Tourism and Environmental Affairs

KWAZULU-NATAL PROVINCE
ECONOMIC DEVELOPMENT, TOURISM
AND ENVIRONMENTAL AFFAIRS
REPUBLIC OF SOUTH AFRICA

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EXECUTIVE SUMMARY

Introduction

This Situation Assessment report for the uThongathi Estuary provides a framework of relevant and available information that enables the development of the Estuary Management Plan, as stipulated under the National Environmental Management: Integrated Coastal Management Act 2008 (As amended in Act No 36 of 2014) (ICMA Act). The report provides an overview of the spatial and physical characteristics of the uThongathi Estuary, describes the current state of the estuary and provides a review of the legal framework relevant to the system; a summary of the social and economic context including land-use patterns; a description of the estuaries biophysical characteristics; assessments undertaken in relation to ecological water quality and quantity, flow rates and ecosystems goods and services and related management recommendations; management opportunities and constraints; and information gaps currently faced in the system.

Catchment characteristics

The uThongathi Estuary is located approximately 35 km north of Durban in the vicinity of the King Shaka International Airport and falls on the boundary between the eThekwini Metropolitan and iLembe District Municipalities. The estuary is just under 6km long from mouth to head, with an estimated estuarine area of 37 ha. Anthropogenic impacts acting on the estuary include commercial sugar cane farming; residential development; two bridges (the M4 bridge located ±100 m from the mouth and N2 Bridge just short of 5 km upstream of the mouth), a causeway 2.5 km from the mouth and the discharge of wastewater into the river just upstream of the estuary head. Being a small estuary that experiences strong wave action from the adjacent sea, as well as high levels of sedimentation has resulted in the development of a perched estuary (a system with a raised berm and a resulting water level that is higher than that of the adjacent sea level) and a constricted mouth which limits the extend of tidal intrusion.

Located within a summer rainfall region, the system consists of two quaternary catchment areas totalling 423 km^2 in size. Water flow that is diverted to the two dams located on a small tributary just off the main river system, is supplemented by the addition of wastewater into the river from the Tongaat Central Wastewater Treatment works. The systems Natural Mean Annual runoff (nMAR) is approximated at 70.79 million m^3 per year, however, the present Mean Annual Runoff (pMAR) is estimated to be 79.2 million m^3 per year. The majority of the land surrounding the uThongathi Estuary is under cultivation in the form of sugarcane farming. Additionally, low-density and rural settlements, the Tongaat town and industrial area, and residential developments are present in the lower catchment and alongside the estuary. There is a significant area of coastal forest on either side of the estuary mouth which is important from a biodiversity perspective and also provides an aesthetically pleasing component to the estuary and its surrounds. Aside from sugarcane cultivation and built up areas, the land cover includes three types of vegetation cover, degraded land and a small portion of invasive plant species.

Ecological function and State of the Estuary

The uThongathi Estuary's present ecological state (PES) is listed as "D" (Poor/Heavily modified) with a recommended ecological category (REC) of "C". Described as being small with a low assimilative capacity, the estuary is sensitive to pollution, therefore, a significant impact within the estuary causing a reduction in the ecological category is poor water quality, which in turn influences biotic components of the system. The main sources of pollution include wastewater treatment works that discharge into the system, discharge from industry, agricultural return flows, as well as urban runoff in the river catchment which results in poor water quality for the inflowing water that reaches the head of the estuary. It has been gazetted that the Target Ecological Category (TEC) for the uThongathi Estuary should be a "B/C". Achieving this mandated Ecological category (EC) will require the improvement of several of the individual components within the system, i.e. water quality and flow, birds, fish, invertebrates. Similarly, the specific Resource Quality Objectives laid out for the estuary must be upheld to ensure that the health of the estuary does not deteriorate and will need to be improved upon, in order for the mandated category to be achieved.

Like many of the estuaries along the KwaZulu Natal coastline, the uThongathi is a perched system, with water levels higher than mean sea level. Under natural conditions, powerful wave action and increased sediment movement along the coastline cause the mouth to become restricted, reducing the tidal influence on the system and resulting in the development of a sandbar closing the estuary mouth for varying periods of time, which increases the estuary's overall water surface area. However, anthropogenic impacts have contributed to the decline of the overall shape and size of the estuary relative to its historical extent. These impacts include the increased, nutrient enriched, freshwater inflows causing the mouth to remain open for more extended periods of time, as well as changes in the sediment input to the estuary due to agricultural runoff, development and ad hoc sand mining operations in the system. The estuary is classed as a "Large Temporarily Closed estuary" with the mouth reported as open 84-87% of the time.

Due to its small size the uThongathi estuary has little resilience to changes in freshwater quantity and nutrient loading. Water quality declines dramatically during periods of low flow (reduced freshwater inputs) and closed mouth conditions when the water residence time is increased. This is primarily attributed to the accumulation of nutrients present in the effluent discharges from wastewater treatment works, as well as toxins from urban, agricultural, and industrial runoff/discharges. Water quality in the estuary has been described as "poor" as far back as 1978, although conditions improved slightly with the upgrade of the wastewater treatment works. However, the overall water quality is still considered poor with the system experiencing a build-up of nutrients and pathogens and a decline in oxygen concentrations during periods of low water flow. In addition, several nutrient parameters have been found in concentrations known to be toxic to aquatic life and fish kills have been recorded to occur within the system.

The nutrient rich waters of the uThongathi Estuary support high levels of primary production and microalgal growth and while Phytoplankton biomass within the estuary is generally below 5 ugCha/l, episodic/isolated events can result in biomass ranging from 1-120 µg Chla/l, varying with the volume of freshwater inflow, the state of the mouth and the level of nutrients being introduced by the Wastewater Treatment Works. The microalgal community within the Estuary has been classed as having an ecological status of "E" or "Severely modified".

An estimated 55% of the estuarine area has been lost to habitat transformation, with the majority of the floodplain being altered by commercial and subsistence sugarcane farming. The remaining area can generally be divided into four different vegetation types, namely (1) KwaZulu Natal coastal belt grassland, (2) Northern Coastal Forest and bushveld, (3) reeds and sedges and (4) invasive plant species. Smaller estuaries, like the uThongathi Estuary, which experience high nutrient pollution pressure and flow modification are vulnerable to the spread of invasive alien plant species and the diversity and abundance of invasive alien plants within the uThongathi Estuary has increased over time with four freshwater species of aquatic invasive species recorded. Additionally, four species of terrestrial invasive species are present on the banks of the estuary. The macrophyte community within the Estuary has been classed as having an ecological status of "D" or "Heavily modified".

The uThongathi Estuary's invertebrate and fish communities both have an ecological status of "E" or "Severely modified". Studies show that the estuary has a reduced diversity and abundance of invertebrates and that this is an indication of a community exposed to moderate to heavy pollution, along with low salinities and low oxygen levels. Similarly, the fish communities within the system have been known to vary greatly from year to year, amongst seasons and even from month to month, depending on the state of the mouth and water quality. It appears that the species diversity and abundance of fish has decreased relative to community composition in the early 1980's. This is likely the result of loss of estuarine habitat, linked to the reduced saline intrusion (mouth condition and the obstruction created by the causeway) and declines in the water quality within the system. Three species of alien fish species are recorded as present in the estuary.

The uThongathi Estuary is considered to be of regional importance to the waterbird community of Durban's estuaries as well as being species rich and having high abundance relative to its size. However, the recent assessment of the Estuary conducted for the 2018 NBA assigned the lowest estuarine health score, "F" or "Critically modified" to the bird population. It is likely that the loss of suitable fringing habitat (in which to roost and nest); changes to in-stream vegetation and the associated loss in open sand and intertidal wading areas; as well as the low abundance and diversity of invertebrates (a food source for birds) has resulted in the change in community composition and the overall decline in bird abundances.

Ecosystem services

Defined as "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, carbon storage) that maintain the conditions for life on Earth." The list of ecosystem services provided by the uThongathi Estuary is short, as the system is small and has already been subjected to anthropogenic impacts in the past. Services provided include the provision of raw materials, the breakdown of waste and detoxifying of pollutants, as well as very limited provision of refugia and nursery area, material and nutrient export as well as limited tourism and recreational value.

Impacts or potential impacts to the Estuary

The estuary has been significantly modified and the ecological functioning and provision of ecosystem services has declined. The 2018 National Biodiversity Assessment rates the cumulative pressure level of the uThongathi Estuary as high, with pressures listed for the estuary including: pollution (very high);

habitat loss and alien fish (high); flow modification and invasive plant species (medium); low fishing pressure, the presence of sand mining and the occurrence of unauthorised artificial breaching of the mouth. Additionally, the physical impacts acting on the system include several main categories; (1) the construction of a causeway across the upper reaches of the estuary; (2) high rates of sediment accumulation in the estuary during the last 30 years as a result of high erosion rates; (3) sand mining impacts; (4) the proliferation of sugar cultivation and invasive alien plants in the estuary, riparian zone and floodplain ; and (5) most significantly - the poor water quality within the estuary and impacts of wastewater discharges. Other identified management issues include: (1) coastal access: the poor accessibility to the estuary for those who do not live in the direct vicinity; (2) a need to increase public awareness and education regarding the estuary; and (3) the lack of adequate warning signs regarding the presence of crocodiles in the system.

Socio-economic context

The uThongathi Estuary falls within three municipalities, the eThekwini Metropolitan Municipality and the KwaDukuza Local Municipality within the larger iLembe District Municipality. The majority of the land surrounding the estuary consists of agricultural land (sugarcane cultivation), and to a lesser extent industrial, commercial, residential areas and informal settlements (located to the northwest of the estuary) as well as some built up residential land on either side of the mouth. The majority of economic activity is sugarcane farming and processing as well as a small proportion of sand mining. The population is growing and consists largely of people under the age of 35 years.

The cumulative population, of the six main communities surrounding the estuary, is approximately 70 612 people, from 23 548 households, which generally include three or less family member. Although households in all except one community (Greylands), are predominantly living in formal dwellings, just under 4000 households live in informal dwellings and as much as 3011 households in the region are reported to have no form of income. The families from these households are likely to be dependent on subsistence farming and harvesting/gathering natural resources from the surrounding environment. This includes utilising the uThongathi Estuary for subsistence fishing and the collection/harvesting of plants such as wild spinach i.e. uMfino, for consumption.

Legislation

This section provides an overview of legislation and policy applicable to the management of estuaries in South Africa and specifically to the uThongathi estuary. South Africa has an extensive legal framework for governing the protection and sustainable use of the coastal marine environment, 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 uThongathi Estuary. Government's response in mitigating deterioration of South African estuaries is manifested in two pieces of key legislation, namely the National Water Act (Act 36 of 1998) and National Environmental Management: Integrated Coastal Management Act (Act 24 of 2008) (ICMA). Policy and legislation which affects estuaries directly can be roughly divided into that affecting (1) estuarine resources planning and protection, (2) enabling integration for estuarine management and (3) management of activities or uses in and around the estuaries.

Opportunities and constraints for consideration in EMP

Given that the estuary lies on the border of three municipalities, the management of the system will need to be appropriately divided between authorities within these municipalities, based on the area in which management strategies need to be applied, or else be co-ordinated amongst all authorities where strategies overlap, therefore requiring a fair amount of cooperative governance.

The poor water quality within the estuary, the occurrence of sewage spills and malfunctioning infrastructure at the WWTW poses the most significant and severe risk to the uThongathi Estuary. Unless the flow modification and level of enrichment within the system is reduced all other attempts to improve the condition of the estuary are likely to have minimal to no positive effect, simply allowing the estuary to retain the current ecological state.

A comprehensive Environmental Management Programme (EMPr) has been developed for the Zimbali Lakes and Golf Course Residential Development (construction for which began in 2020) which falls along, and within, a substantial portion of the northern border of the Estuarine Functional Zone, between the mouth and the N2 roadway. This programme includes an estuarine rehabilitation, monitoring and management plan; a stormwater management plan, and a wetland management and rehabilitation plan; which together address and will improve a number of the issues and threats impacting the estuary. While the development does not encompass the entire estuarine area, it does account for roughly half of the total functional zone therefore substantially reducing the management workload of the local authorities and creating a valuable opportunity to reduce the responsibility while increasing the overall impact of the Estuarine Management Plan. In addition, an Environmental Control Office (ECO) was appointed to monitor activities for compliance with the provisions set out in the EMPr.

Recommendation to address information gaps

With the exception of a recently published paper on the invasive aquatic plant species in the estuary (Nunes *et al.* 2020), intermittent water quality monitoring as part of the National Estuarine Monitoring programme (NEsMP) and Ezemvelo KwaZulu-Natal Wildlife's mouth monitoring programme, there has been very little research or data collection conducted in the system over the last 10 years. Spatial and temporal replication of information is valuable for enabling researchers to map the changes that occur within a system over time and how the system is responding to human activities. A list of information identified as being needed to improve on future Ecological Water Reserves studies for the uThongathi Estuary is provided.

What's next

This Situation Assessment (as determined during a desktop study and stakeholder consultation) provides the background to the current state and condition of the uThongathi Estuary and its biota, as well as highlighting the deficiencies and necessities in terms of management that must be addressed, in order to maintain a functional estuarine system. Next, the local authorities and general public from the surrounding communities will be consulted in a stakeholder meeting to gain their input and perspective on the draft Estuary Management Plan for uThongathi Estuary. The Draft EMP will then be published for a 30-day comments period before it is finalised.

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GLOSSARY

Abiotic	Physical rather than biological; not derived from living organisms.
Aeolian	Relating to or arising from the action of the wind.
Alien	A species that occurs outside of its natural range and dispersal potential.
Biotic	Relating to living organisms.
Benthic	Pertaining to the environment inhabited by organisms living on or in the bottom of a water body.
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	In ecology, a community is a group or association of populations of two or more different species occupying the same geographical area and in a particular time.
Eutrophication	A process by which a body of water becomes overly enriched with minerals and nutrients which induce excessive growth of algae. This process may result in oxygen depletion of the water body after the bacterial degradation of the algae
Extralimital	Situated, occurring, or originating from outside a particular region/estuary.
Floodplain	Broad and relatively flat area on either side of a stream, river or estuary that are 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 of South Africa and which were transported to their current location by humans; where they are able 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 without a backbone (e.g. a prawn, crab, or worm).
Legislation	Laws, legal requirements or the process of making or enacting laws.
Macrofauna	Animals larger than 0.5 mm.
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 group.
pH	A measure or scale used to quantify how acidic or basic (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 stationary or trapped within a specific region of the system.
River Estuary Interface	Productive zone within an estuary where marine and freshwater meets, salinity is less than that of sea water and organic deposition due to reduced current speeds and flocculation occurs and is retained.
Zooplankton	Heterotrophic plankton i.e. plankton that cannot manufacture its own food by carbon fixation and therefore derives its intake of nutrition from other sources of organic carbon, mainly plant or animal matter.

LIST OF ABBREVIATIONS

Anchor	Anchor Environmental Consultants
CFU	Colony Forming Units
CMP	Coastal Management Programme
D'MOSS	Durban Metropolitan Open Space System
DEADP	Department of Environmental Affairs and Development Planning
DEAT	Department of Environmental Affairs and Tourism
DMR	Department of Mineral Resources
DoT	Department of Transport
DPLG	Department of Provincial and Local Government
DWA	Department of Water Affairs (Change after 2008)
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water Affairs and Sanitation (Change after May 2014)
EC	Ecological Category
ECO	Environmental Control Officer
EDTEA	Economic Development, Tourism and Environmental Affairs
EFZ	Estuarine Functional Zone
EIA	Environmental Impact Assessment
EMP	Estuarine Management Plan Environmental Management Plan
EMPr	The Environmental Management Programme
EWR	Ecological Water Requirement
FPL	Food poverty line
IAAP	Invasive Alien Aquatic Plants
ICLEI SA	International Council for Local Environmental Initiatives African Secretariat
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
LAB	Local Action for Biodiversity
LBPL	Lower-bound poverty line
MAR	Mean Annual Runoff
MCM	Marine and Coastal Management
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)
NEsMP	National Estuarine Monitoring Programme
nMAR	Natural Mean Annual Runoff
NWRS	National Water Resource Strategy

PES	Present Ecological State
pMAR	Present Mean Annual Runoff
Protocol	National Estuarine Management Protocol
REC	Recommended Ecological Category
REI	River-Estuary Interface
ROD	Record of Decision
RQO	Resource Quality Objective
SPLUMA	Spatial Planning and Land-use Management Act
TEC	Target Ecological Category
UBPL	Upper-bound poverty line
WMA	Water Management Area
WSAP	Wetlands South Africa Programme
WWTW	Wastewater Treatment Works

1 INTRODUCTION

1.1 Background

With the implementation of the Provincial Coastal Management Programme (adopted by the MEC in September 2019) that includes strategies and plans for the effective and co-operative management of the coastal zone, the KwaZulu-Natal (KZN) Department of Economic Development, Tourism and Environmental Affairs has prioritised the better management of estuaries in the province. With the aim to mitigate the deterioration of KZN regional estuaries, an estuary prioritisation process was undertaken and the uThongathi Estuary was prioritised for the development of an Estuary Management Plan (EMP).

Located within the province of KwaZulu Natal on the east coast of South Africa, the uThongathi Estuary is approximately 35 km north of Durban in the vicinity of the King Shaka International Airport and lies on the boundary between the eThekwini Metropolitan Municipality and iLembe District Municipalities (Figure 1.1) (Forbes & Demetriades 2009). The estuary is just under 6 km in length from the mouth, which leads into the Indian Ocean, to its head, and the total estuarine area is approximately 37 ha (Adams and Van Niekerk 2020). The newly revised estuarine classifications for South Africa, define a "Large Temporarily Closed estuary" as one in which the mouth of the system is open to the sea more the 50% of the time (Van Niekerk *et al.* 2019a, 2020). The uThongathi Estuary mouth has been reported to be open between 84-87% of the time (DWA 2013, Nunes *et al*. 2020).

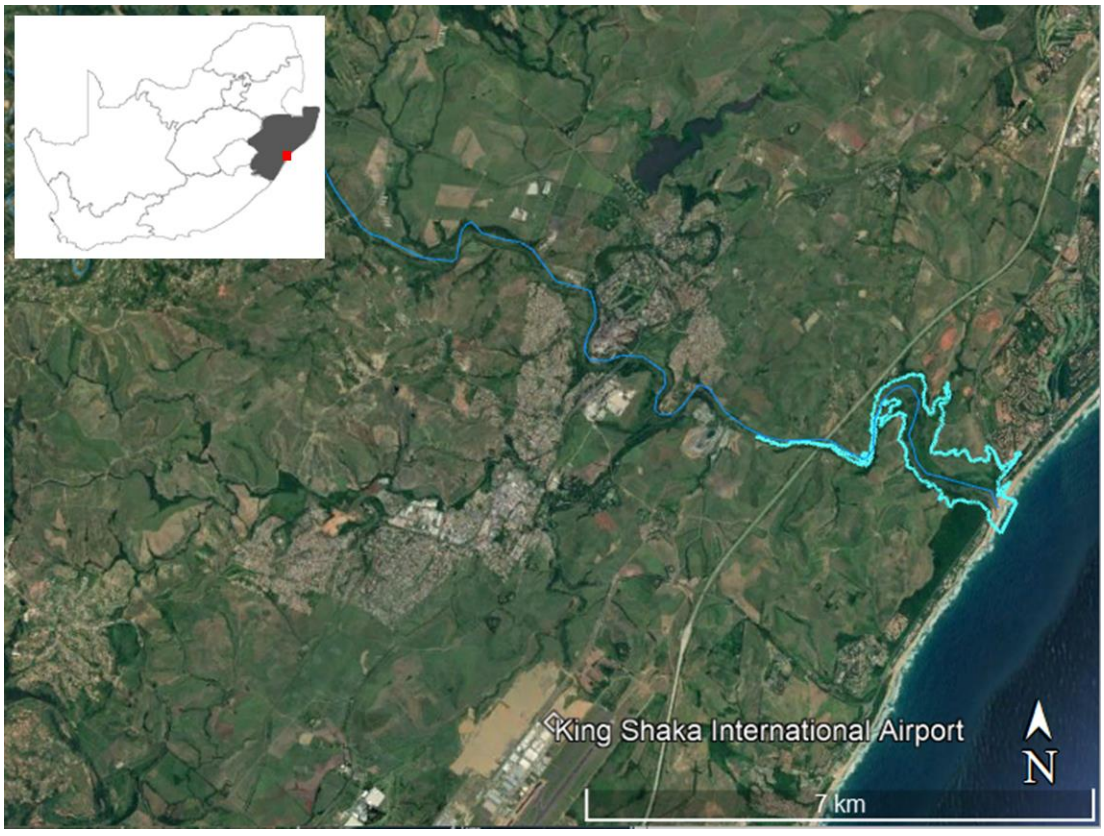


Figure 1.1. Location of the Tongati River and the uThongathi Estuary and estuarine area within the province of KwaZulu Natal, South Africa.

The uThongathi town and industries lie to the west/north west of the system with urban areas starting less than one kilometre from the head of the estuary. Additionally, there are residential areas to the north and south of the estuary mouth and the construction of a new residential development and golf estate has begun along the northern banks of the middle to lower reaches of the system. The vast majority of land surrounding the estuary is under agricultural development in the form of sugarcane, although there is a significant area of coastal forest on either side of the estuary mouth which is important from a biodiversity perspective and also provides an aesthetically pleasing component to the estuary and its surrounds (Forbes & Demetriades 2009).

Described as being small with a low assimilative capacity, the estuary is sensitive to pollution and has a long history of anthropogenic change. The main sources of pollution are listed as including wastewater treatment works that discharge into the system, as well as urban and agricultural discharge and runoff in the river catchment which results in poor water quality for the inflowing water that reaches the head of the estuary (Forbes & Forbes 2012). Other threats to the system include alien invasive species (fish and vegetation), sand mining, bait collection, fish kills from oxygen depletion associated with low water quality within the estuary, and habitat loss (Van Niekerk *et al.* 2019e).

The estuary has been classified as an endangered system of high biodiversity importance in the recent National Biodiversity assessment, however, it has no specific formal protection status and the present ecological state (PES) is listed as D - "Poor" or "Heavily modified" (DWS 2015a,b, Van Niekerk *et al.* 2019b,c,d). Numerous restoration measures, designed to improve the estuary's ecological condition and mitigate anthropogenic pressures, were put forward in the most recent national biodiversity assessment and include the removal of alien vegetation and rehabilitation of the riparian vegetation and wetland; the eradication of alien fish; protection from mining impact and the reduction and monitoring of wastewater (Van Niekerk *et al*. 2019f) and highlight the need for a management plan which assigns the responsibility of these and other activities to the appropriate parties.

1.2 Purpose and structure of the Situation Assessment

The purpose of Estuary Management Plans (EMP), as stated in the National Estuarine Management Protocol (NEMP 2013) and development guidelines "is to provide the mechanism that will enable coordination and alignment of management activities across sectors, underpinned by a shared vision – that is integrative estuarine management." (DEA 2015).

The purpose of the Situation Assessment is to reflect on the current condition of the system and status of estuarine management for the specific estuary. The document therefore provides a framework of relevant and available information that enables the development of the Estuarine Management Plan as well as highlighting any knowledge gaps that may impact the effective implementation of the EMP.

The following components are included in the Situation Assessment Report:

- A biogeographical description of the uThongathi Estuary and comprehensive assessment of the structure (abiotic and biotic), functioning and state of the estuary.
- The reserve determination for the uThongathi Estuary is available in the form of an intermediate level Ecological Water Reserve study (DWAF 2007), as well as in the National Biodiversity

Assessments and ecological reserve studies for the greater water management area. These are summarized in Section 3.1.

- Identification of the goods and services and/or human use activities and their impacts or potential impacts on the present ecological state.
- The geographic and socio-economic context of the estuary, including dependence of local communities on the estuary. Opportunities and Constraints within the ecological system considering the current and recommended ecological state and limits of acceptable change where possible.
- The legislative instruments currently applicable to the effective management of the uThongathi Estuary – including existing and planned management strategies or plans (catchment management strategies, Integrated Development Plans, Spatial Development Frameworks, Coastal Management Programmes, Disaster Management Plans, Contingency Plans and Mouth Management Plans are examples).
- Identification of information gaps pertaining to the estuary.

2 CATCHMENT CHARACTERISTICS

2.1 Geology and geomorphology

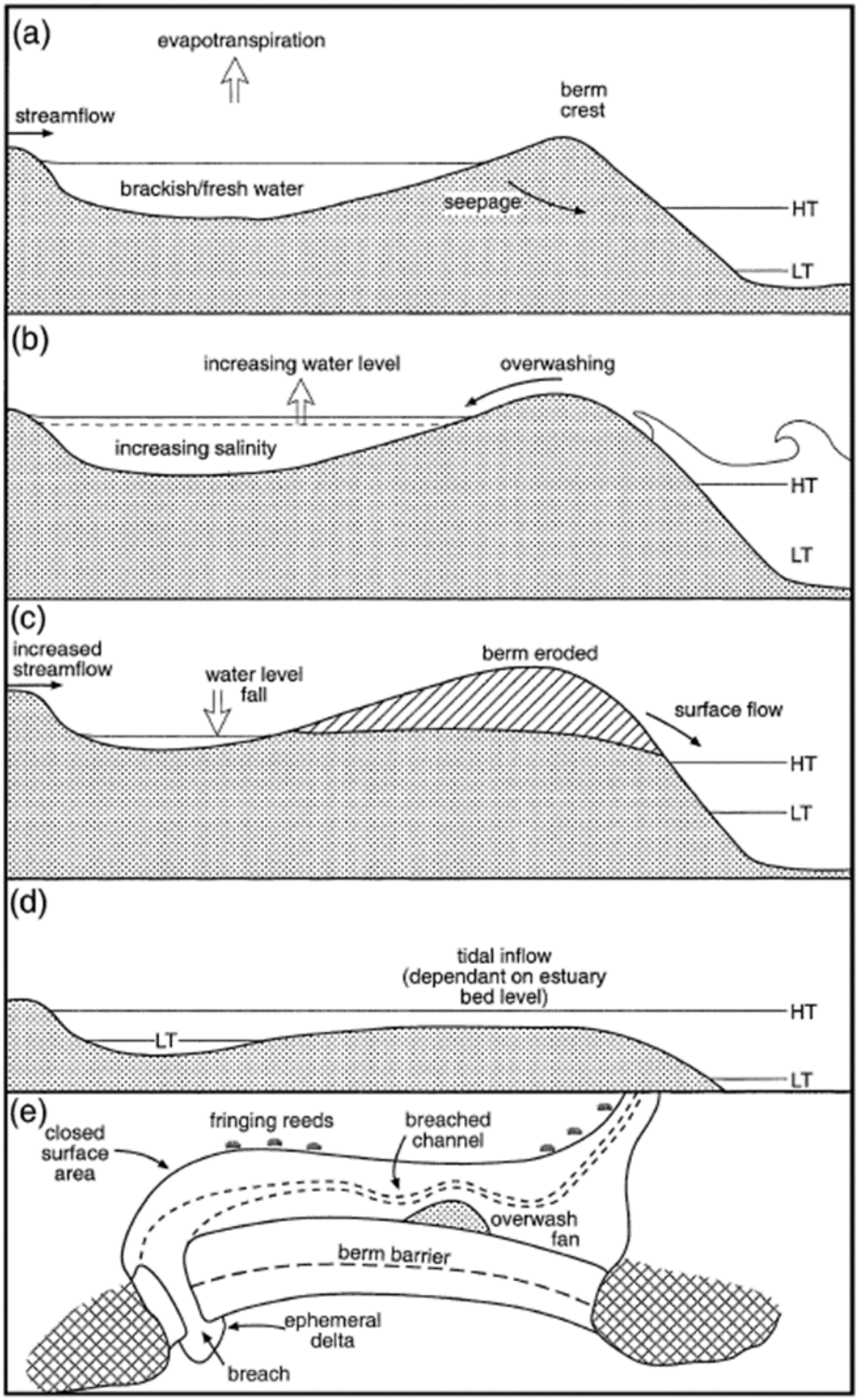
The uThongathi Estuary and its surrounds are located on several different geology types including Alluvium along the watercourse, Berea Formation and leached Berea, Karoo dolerite, and Vryheid shale (GroundTruth 2018). The latter is common along the edges of the watercourse and due to its greater clay content, areas underlain by this formation commonly contain more wetland than the other formations mentioned (GroundTruth 2018). Anthropogenic impacts acting on the estuary include commercial sugar cane farming since 1848; residential development since 1945; the construction of two bridges; (1) the M4 bridge located ±100 m from the mouth of the estuary (constructed in 1960) and (2) the N2 Bridge just short of 5 km upstream of the mouth; as well as the construction of a causeway 2.5 km from the mouth (constructed in 1989, Forbes & Demetriades 2009, Nunes *et al.* 2020).

In order to facilitate the cultivation of sugarcane, which prefers drier earth than wetland areas, much of the landscape surrounding the estuary was altered to include a number of ridge-and-furrow networks, the construction of which has altered the functionality of the floodplain. This disrupted the water table, preventing diffuse waterflow and ultimately led to a reduction in the provision of important goods and serves provided by the floodplain for the estuary (MER 2008). Similarly, the construction of the bridges and causeway altered flow within the estuary.

The "Large Temporarily Closed estuary" is open to the sea 75-99% of the time (Taljaard *et al.* 2017, Adams & Van Niekerk 2020). Like most of the estuaries along the KZN coastline, strong wave action, as well as high levels of sediment availability has resulted in the development of a perched system i.e. a system with a raised berm and a resulting water level that is higher than that of the adjacent sea level (Box 1).

Box 1. Generalised model of a perched estuary.

A generalised model showing the behaviour and characteristics of a perched estuary as seen through a series of cross-sections (a–d) and a plan (e) based on work by Cooper (2001) is presented below. Under balanced conditions (a), the stream inflow is matched by evapotranspiration and seepage. Overwashing (b) may elevate water levels and salinity while increased streamflow (c) may promote breaching. When breached (d), the water levels are lowered, and tidal flow may take place if bed levels are sufficiently low. In the plan view (e), the difference in water area during open and closed conditions is evident.



Mouth size is dependent on volumes of freshwater flow i.e. the width of the mouth increases during flood events and very high flow rates, but generally, the estuary has a small, constricted mouth which only allows for reduced tidal intrusion (Figure 2.1). The presence of a causeway across the estuary, located 2.5 km from mouth, creates a barrier which further limits the penetration of saline water beyond this point.



Figure 2.1. **Photo taken in December 2020 showing the small, restricted mouth of the uThongathi estuary as well as the perched nature of the system (water level in the estuary higher than that of the adjacent sea).**

2.2 Climate and runoff

The KwaZulu Natal region experiences a summer rainfall season, predominantly receiving rainfall between October and April, with high rainfall events typical in the months of December and February. Associated with this seasonal rainfall the estuary experiences low river inflow during winter (approximately 1.2 $m^3.s^{-1}$) and high river inflow during summer (approximately 2.2 $m^3.s^{-1}$). The Tongati River catchment consists of two quaternary catchments (U30C and U30D) with a total catchment area of 423 km^2 and an estimated Natural Mean Annual runoff (nMAR) of 70.79 million m^3 (Figure 2.2). By contrast, the present Mean Annual Runoff is estimated at 79.2 million m^3 due to additional wastewater inputs (DWS 2015a, b). Two dams (Figure 2.3), the Dudley Pringle (2.31 $x10^6$ m^3) and the smaller Syphon dam (0.35 x 10^6 m^3) are located in the Wewe tributary which meets the Tongati River approximately 5 km above the upper limit of the estuary (Begg 1978, Forbes & Demetriades 2009). Any reduction in MAR as a result of water diverted to these dams is compensated for by the addition of water from the Tongaat Central Wastewater Treatment Works (WWTW), Frasers WWTW and the Hulett Maidstone Sugar Mill, which are located downstream of the tributary leading to the dams (Figure 2.3) (Nunes *et al.* 2020).

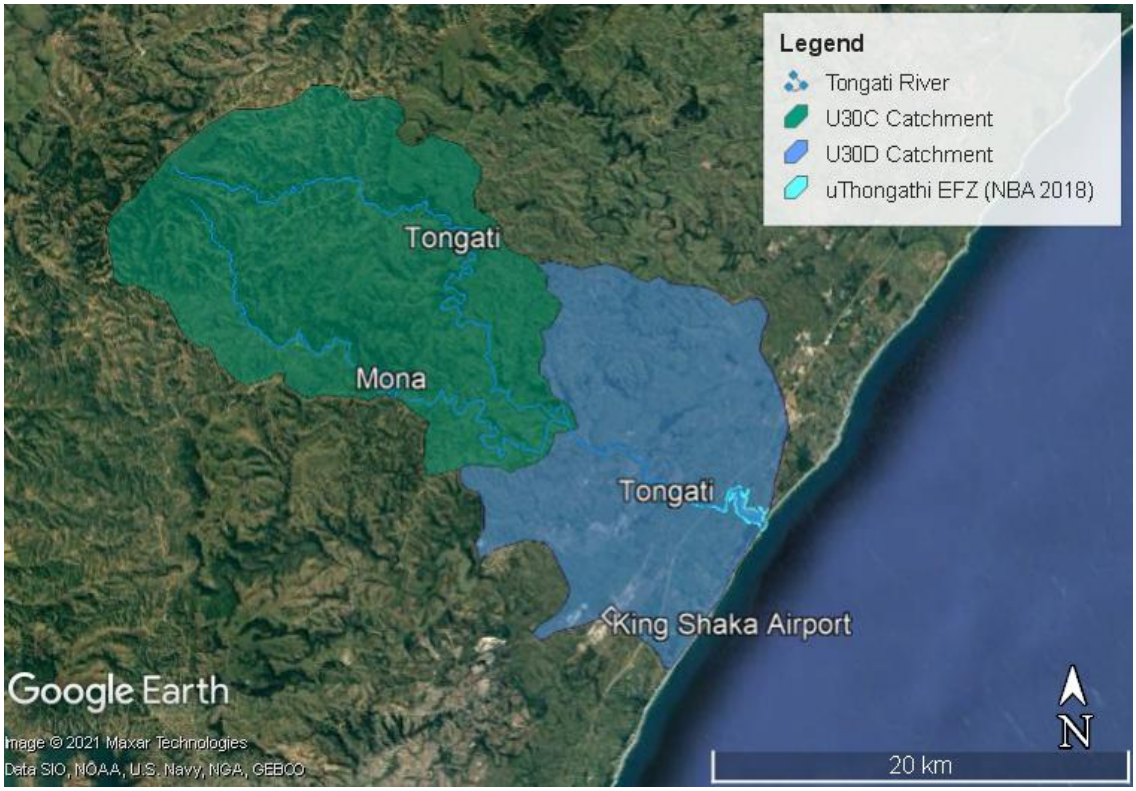


Figure 2.2. Tongati River Catchment and Estuary Functional Zone (EFZ).

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 known as the 'Estuarine Functional Zone' (EFZ, Van Niekerk *et al*. 2012, 2013).

The National biodiversity Assessment (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*." The extent of the uThongathi Estuary's EFZ as delineated in the recent NBA can be seen in Figure 2.3 and Figure 3.1. Although in most estuaries the 5m contour was still used to define the functional zone, for some small, incised estuaries (i.e. 0 m, 5 m and 10 m contour in close proximity to each other such as uThongathi Estuary) with relatively high river flow, a combination of the 5m and 10m contour, were used as the default to accommodate mapping uncertainty (Van Niekerk *et al*. 2019).

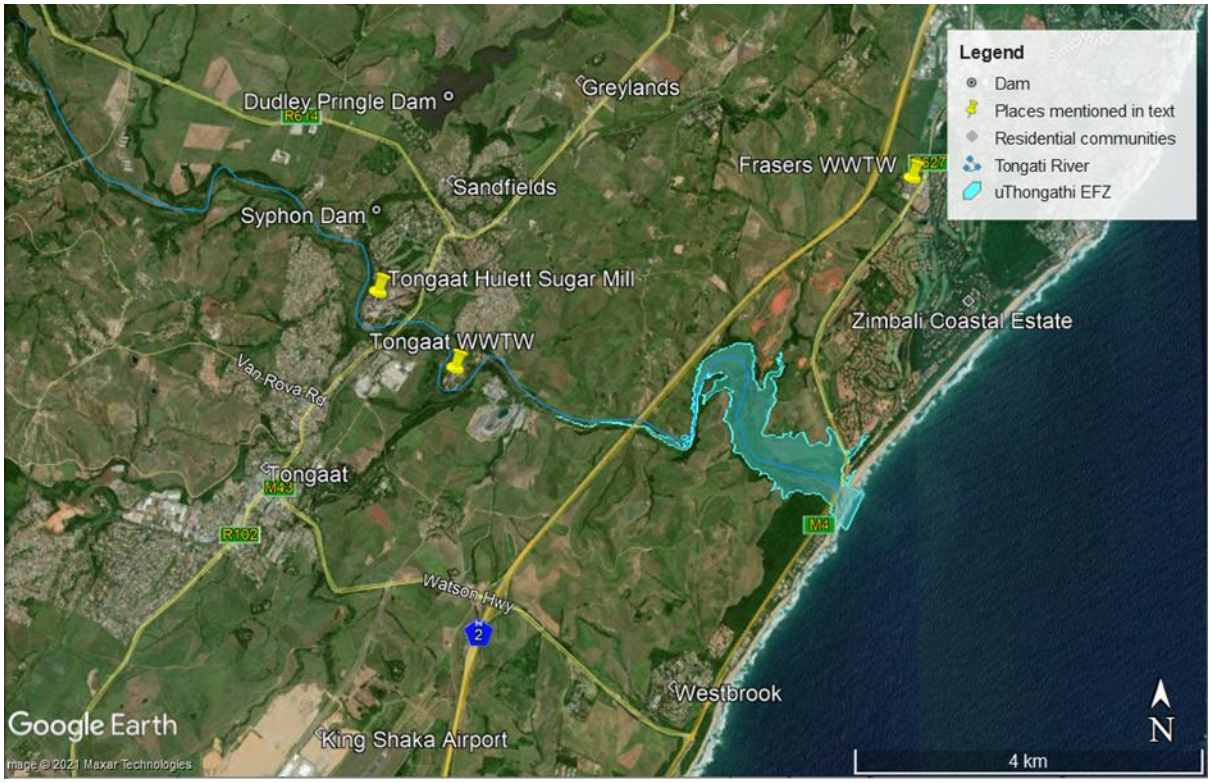


Figure 2.3. **uThongathi Estuary with local roads, associated dams, residential communities, places mentioned in text and the extent of the Estuarine Functional Zone (EFZ) as defined in the latest National Biodiversity Assessment (Van Niekerk *et al*. 2019).**

2.3 Land-use

The river section in the upper quaternary catchment (U30C) is 36 km in extent (Figure 2.2). The upper reaches (27%) of the river, as well as along the remaining extent of the southern side of the river are rural and nearly exclusively comprised of scattered households with evidence of informal agriculture in the form of farming and live-stock grazing. Between the scattered households and the remaining area, the dominant land-use is open terrain or natural vegetation (DWS 2015c).

The lower quaternary catchment (U30D) is characterised by low-density settlements and rural settlements as well as the uThongathi town and industries. The area is predominantly a sugar cane farming area with most of the landscape covered with dry land sugar cane plantations (DWS 2015c). In built up areas there is some commercial, community, industrial and mining activity.

The majority of the land surrounding the uThongathi Estuary as well as within the EFZ is under cultivation in the form of sugarcane farming, which was first started in 1848. Additional anthropogenic impacts acting on the estuary include residential development since 1945, the construction of two bridges (1) the M4 bridge located ±100 m from the mouth of the estuary and (2) the N2 Bridge just short of 5 km upstream of the mouth, and the construction of a causeway 2.5 km from the mouth (Forbes & Demetriades 2009, Nunes *et al.* 2020). Major land-use changes that occurred within the catchment over time can be seen in Figure 2.4, which include the development of Wastewater Treatment Works (WWTW) that discharge effluent into the system.

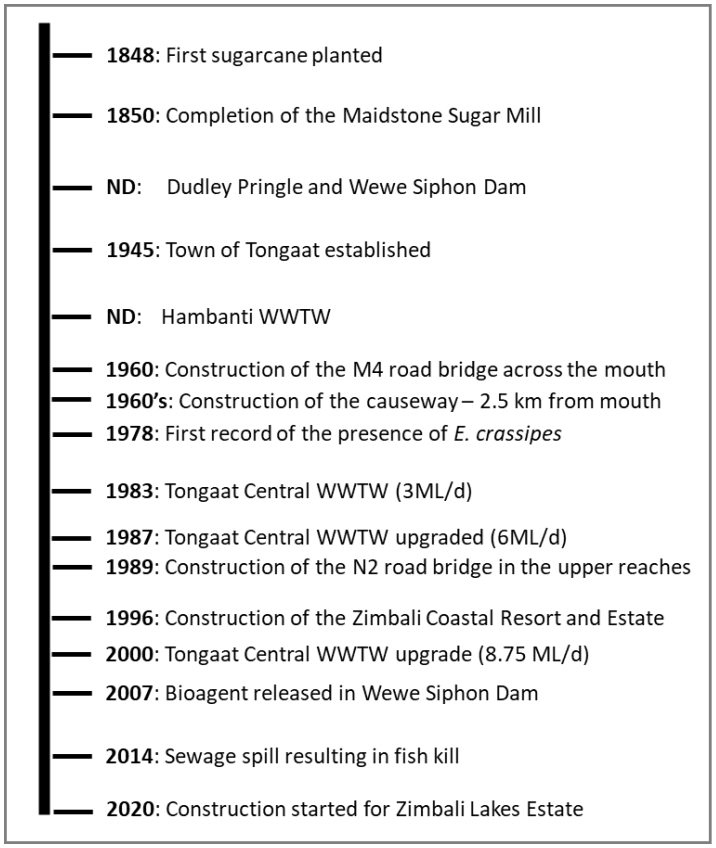


Figure 2.4. Timeline showing the major catchment land-use changes within the Tongati River Catchment (amended from DWAF 2007 and Nunes *et al.* 2020).

Land use categories based on GIS data maps provided on the CoastKZN website[1] indicate that the majority of the surrounding land is under sugarcane cultivation, with some built up urban residential areas to the north and south of the estuary mouth and a number of small holdings north of the upper reaches of the estuary (Figure 2.5). The land surrounding the estuary includes two main vegetation types, which include Indigenous coastal swamp forest, specifically on the lower southern bank, and Thicket/Dense Bush along the water course. The coastal forest and much of the land on southern banks of the estuary have been included in the Durban Metropolitan Open Space System, '*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*' (Figure 2.6). There are also small portions of reeds and sedges located close to the estuary mouth as well as stands of Invasive Alien Aquatic Plants (IAAPs) within the water (Forbes and Forbes 2012, Nunes *et al*. 2020).

[1] Operated by the Oceanographic Research Institute, in partnership with the KZN Department of Economic Development, Tourism and Environmental Affairs.

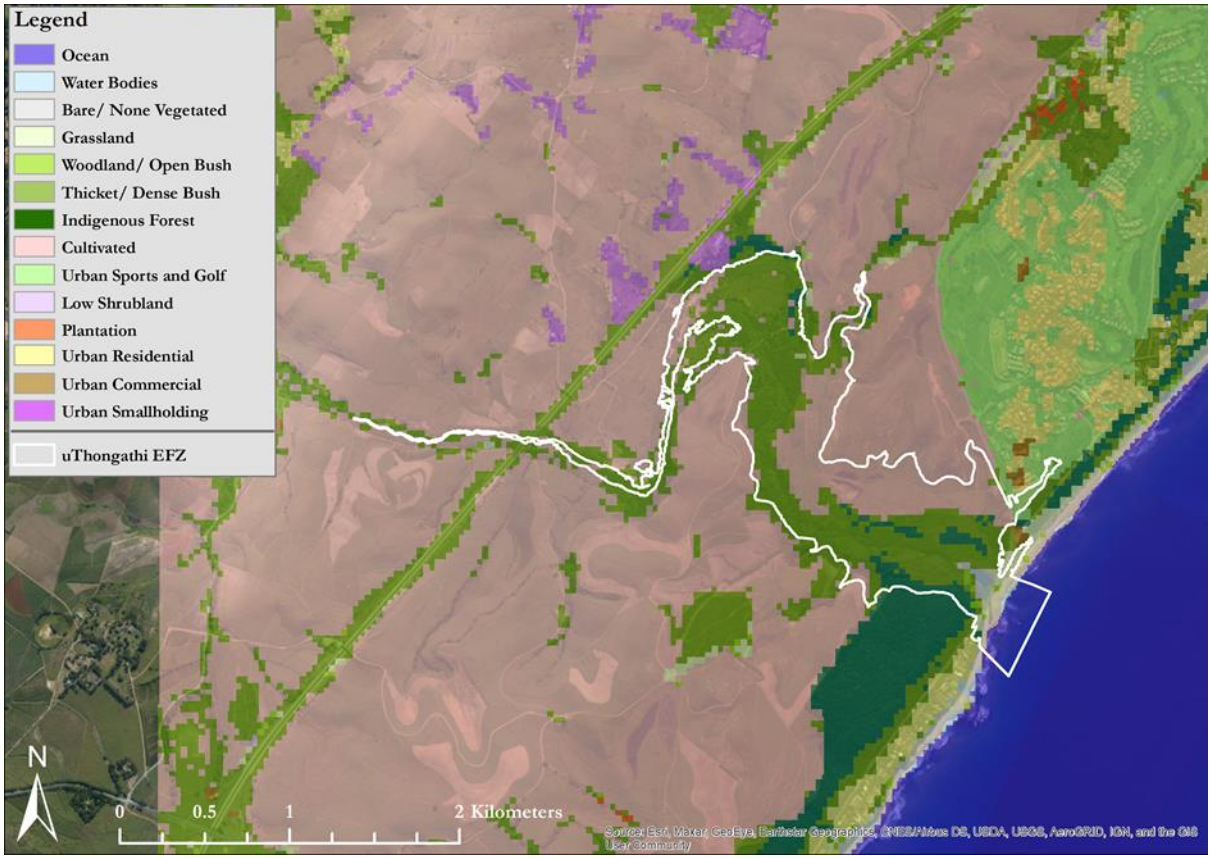


Figure 2.5. **Primary landcover types surrounding the uThongathi Estuarine Functional Zone (EFZ) based on online GIS data maps providing DEA land use categories (Source: https://maps.coastkzn.co.za/CoastKZN/).**

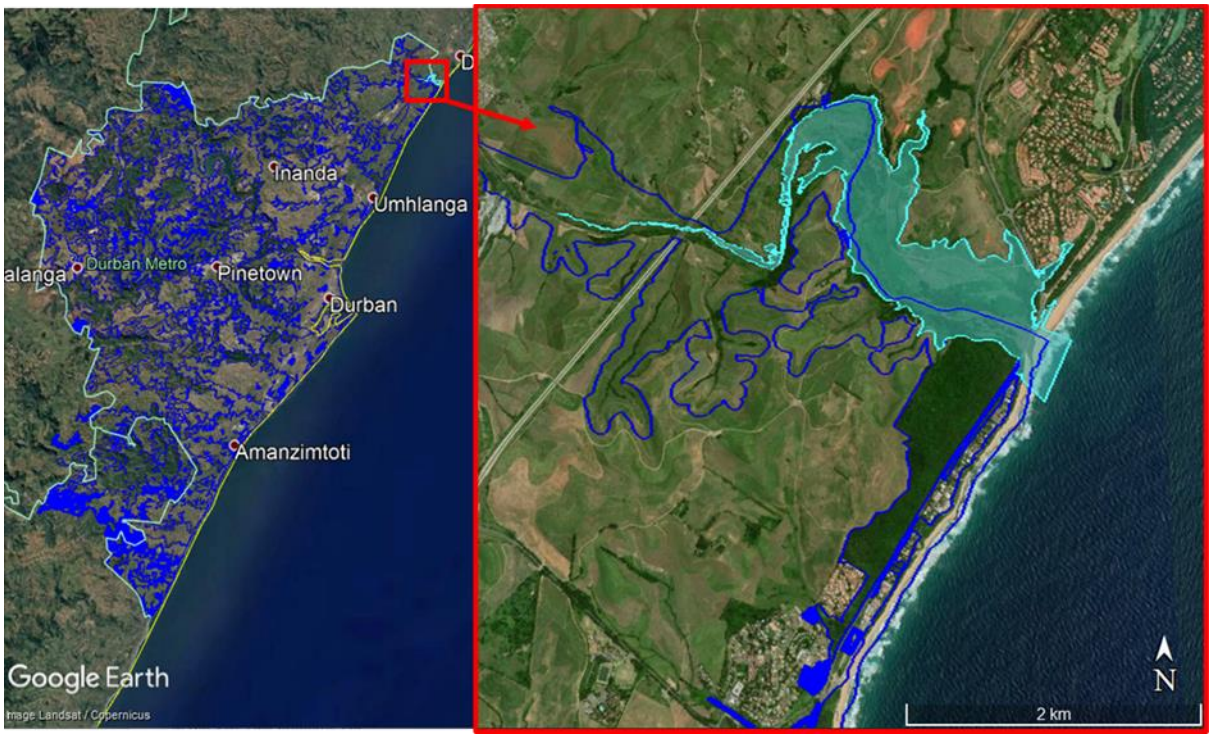


Figure 2.6. **The complete Durban Metropolitan Open Space System (D'MOSS 2018) areas for all of eThekwini (left) and a close up of the uThongathi estuary's D'MOSS areas (right). Sources: http://gis.durban.gov.za/.**

It is noteworthy that ground was broken in 2020 for the Zimbali Lakes and Golf Course Residential Development, this property is located along and within a substantial portion of the northern borders of the EFZ, between the mouth and the N2 roadway. This development will result in the demolishment of a large portion of sugarcane, to be replaced by a golf course and housing estate. The south-western portion of this development, specifically the two lakes, will fall within the EFZ, however, the development has a comprehensive Environmental Management Programme (EMPr) which aims to protect and minimise impacts on the estuarine environment. This includes the removal of alien vegetation and the rehabilitation of degraded wetland areas (see section 8.2).

3 OVERVIEW OF ECOLOGICAL FUNCTION AND STATE OF ESTUARY

3.1 Ecological health status

The National Water Act of 1998 requires the implementation of 'Resource Directed Measures' (RDM) for the optimal use of our country's water resources while minimising ecological damage. The main focus of a RDM is the determination of the 'Reserve', which is the water quality and quantity required for the protection of both basic human needs and the needs of aquatic systems. The 'Ecological Reserve' is the quality and quantity of water required for a specific aquatic system (e.g. river reach, wetland, estuary) to maintain a desired level of structure and function, or quality. The desired quality of the water resource is defined by its 'Ecological Category' which is assigned a letter on a health scale of A to F (Table 3.1). While scientists can make recommendations for this category the "Recommended Ecological Category" (REC), the final decision will be 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 {now Department of Human Settlement, Water and Sanitation (DHSWS)} will be responsible for the Classification of all significant water resources in the country, including estuaries, and these decisions will be re-evaluated at intervals (Turpie *et al*. 2012).

Table 3.1. Ecological categories for South African estuaries, the uThongathi Estuary has been classified as a D status. (DWA 2012, Van Niekerk *et al*. 2019).

Condition (% of pristine)	Present ecological state	General 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, biota have occurred.
21-41	E	**Severely modified:** The loss of natural habitat, biota and basic ecosystem functions is 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.

In June 2007, an Intermediate level Ecological Reserve Determination or Ecological Water Requirement (EWR) was prepared for the uThongathi Estuary (DWAF 2007). The estuary has since additionally been assessed during a classification of Water Resources and Resource Quality Objectives (RQO) study for the Mvoti to Umzimkulu Water Management Area (DWS 2015a,b,c), as well as for the 2011 and 2018 National Biodiversity Assessment (NBA) (Van Niekerk *et al.* 2012, 2019).

The Estuarine Health Index (EHI) applied in Ecological Water Requirement (EWR) studies include a number of variables/categories laid out in DWA (2008) (Table 3.2). For each category, the conditions are estimated as a percentage (0 – 100%) of pristine health. Scores are then weighted and aggregated so that the final score reflects the present holistic health of the estuary as a percentage of the pristine state (DWS 2015a).

The uThongathi Estuary's present ecological state (PES) is listed as "D" (Poor/Heavily modified) with a recommended ecological category (REC) of "C" (DWS 2015a, b, Van Niekerk *et al.* 2019d). A breakdown of the individual components assessed, and the scores given to each within the uThongathi Estuary is provided below and shows that despite the overall ecological category being a "D" several of the individual components have lower scores and are "severely" or "critically modified" (Table 3.2).

Table 3.2. Ecological categories associated with individual components of the estuary.

NBA 2018 Condition Status			
Present Ecological State (2018)	D	Microalgae	E
Hydrology	C	Macrophytes	D
Hydrodynamics	B	Invertebrates	E
Water Quality	E	Fish	E
Physical habitat	D	Birds	F

Described as being small with a low assimilative capacity, the estuary is sensitive to pollution, therefore, a significant impact within the estuary causing a reduction in the ecological category is poor water quality, which in turn influences biotic components of the system. The main sources of pollution include wastewater treatment works that discharge into the system, as well as urban runoff in the river catchment which results in poor water quality for the inflowing water that reaches the head of the estuary (Van Niekerk *et al.* 2019e).

The estuary has been classified as an endangered system with a high biodiversity importance rating in the recent National Biodiversity assessment, however, the estuary has no specific formal protection status (Van Niekerk *et al.* 2019b,c,d). In addition, it has been gazetted that the Target Ecological Category (TEC) for the uThongathi Estuary should be a "B/C" (Government Gazette 41306, Notice No. 1386 of 8 December 2017). This category represents an overall health score that ranges between roughly 67-83% of pristine estuarine health when the current state is between 40-60%. Achieving this mandated Ecological category (EC) will require the improvement of a several of the individual components.

Associated with the EC of the estuary are specific Resource Quality Objectives (RQOs), these are numerical as well as descriptive statements regarding the biological, chemical and physical attributes that characterise a resource (estuary in this case) for the level of protection defined by its Class. The National Water Resource Strategy (NWRS) therefore stipulates that "Resource Quality Objectives might 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). Although not officially gazetted, more in depth RQOs have been developed for the uThongathi Estuary and are shown in section 12.1 – Appendix 2. These RQOs must be upheld to ensure that the

health of the estuary does not deteriorate and will need to be improved upon, in order for the mandated REC to be achieved.

3.2 Abiotic function

3.2.1 Hydrodynamics and sediment

The overall shape and size of the estuary has declined relative to its historical extent (Begg 1984) likely due to the increased freshwater inflows promoting open mouth conditions and changes in the sediment input to the estuary due to agricultural runoff, development and ad hoc sand mining operations (Forbes and Demetriades, 2009; Forbes and Forbes, 2012, Adams & Van Niekerk 2020). In addition, the placement of an illegal causeway 2.5 km from the mouth (constructed in 1989 to service sugarcane plantations), creates an artificial estuary head as saline water cannot penetrate beyond this obstacle and sediment accumulates above this point (Figure 3.1). These anthropogenic impacts have resulted in the overall estuary area being reduced from approximately 150 ha under reference (historical natural) to 20 ha when assessed in 2008 (MER 2008, Forbes & Demetriades 2009). More recently, the system's estuarine area is estimated to be 37 ha (Adams and Van Niekerk 2020) and the EFZ, as defined in the 2018 NBA, reaches beyond the causeway, stretching to 6 km from the mouth, thus including important vegetation and floodplain areas that fall beyond the reach of saline water (Figure 3.1).

Begg (1984) described the uThongathi Estuary sandbar as 150 m in length, 30-70 m wide and reaching a height of 5 m above mean sea level (MSL), however, by 2007 the width of the sandbar increased substantially due to a large sea storm in March of that year, which deposited large volumes of sand in the mouth (Forbes and Demetriades 2009).

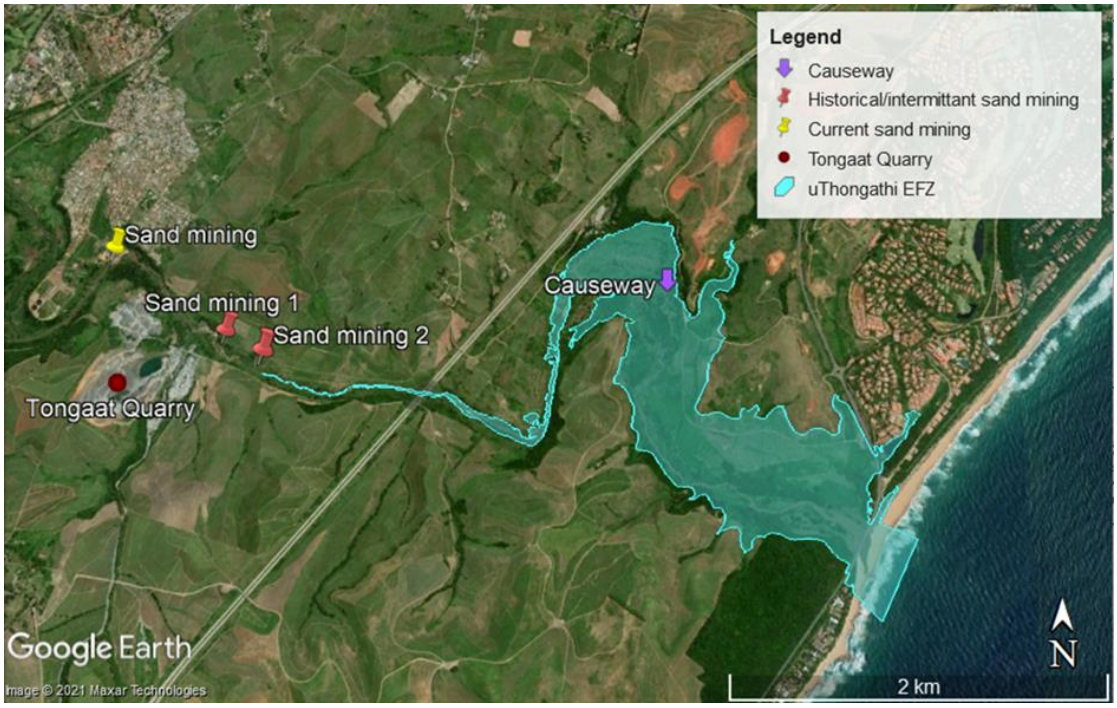


Figure 3.1. Location of the causeway, sand mining activity, Tongaat Quarry and the Estuarine Functional Zone (EFZ) of the uThongathi Estuary as defined in the latest National Biodiversity Assessment (Van Niekerk *et al*. 2019). Source: Google Earth and CSIR 2018.

Four different mouth states have been identified for Estuaries in South Africa (Table 3.3). According to the new estuary classification developed by Van Niekerk *et al*. (2019a, 2020) the estuary is classed as a "Large Temporarily Closed estuary" (an estuary in which the mouth is open to the sea >50% of the time). Specifically, the uThongathi Estuary mouth has been reported as open between 75-99% of the time (Taljaard *et al.* 2017, Adams & Van Niekerk 2020). Based on data from the Ezemvelo KZN Wildlife mouth monitoring programme for the uThongathi Estuary during the period 2005-2013, open mouth conditions dominated 46% of the time, semi-closed 41%, closed but overtopping 10% and closed conditions only 3% of the time (Nunes *et al.* 2020). Examples of different mouth conditions in the uThongathi Estuary are shown in Figure 3.2.

Surveys conducted in 1980/1981 found that the mouth and lower reaches of the estuary were dominated by medium sand (~55%), the middle reaches by medium (~35%) to fine sand (~45%) and the sediment particle size in the upper reaches was more well sorted with coarse (~15%), medium (~35%) and fine sand (~45%, Blaber *et al.* 1984). In contrast, sediment samples taken in 2007/2008 showed medium to fine sand at the mouth, and well sorted medium to coarse sand in the middle and upper reaches of the estuary which suggests that the conditions have changed from those historically report (Forbes and Demetriades 2009). This is likely the result of changes in the sediment input to the estuary due to agricultural development and ad hoc sand mining operations (Figure 3.1) (Forbes and Demetriades, 2009; Forbes and Forbes, 2012).

Table 3.3. The mouth state classification for temporarily closed estuaries as defined by DWAF (2007) and Snow and Taljaard (2007).

Mouth state	Definition
Open	Open mouth is maintained by high river inflow to estuary. Seawater intrusion occurs during high tides.
Semi-closed	Low river inflow and an increase in berm height is evident. Freshwater outflow is still permitted. Seawater intrusion is limited to spring tides.
Closed but overtopping	Very low to no river inflow. Berm height prevents freshwater outflow and seawater intrusion. Sporadic freshwater outflow to ocean depending on berm height and river inflow.
Closed	Very low to no river inflow. Berm height prevents freshwater outflow and seawater intrusion.

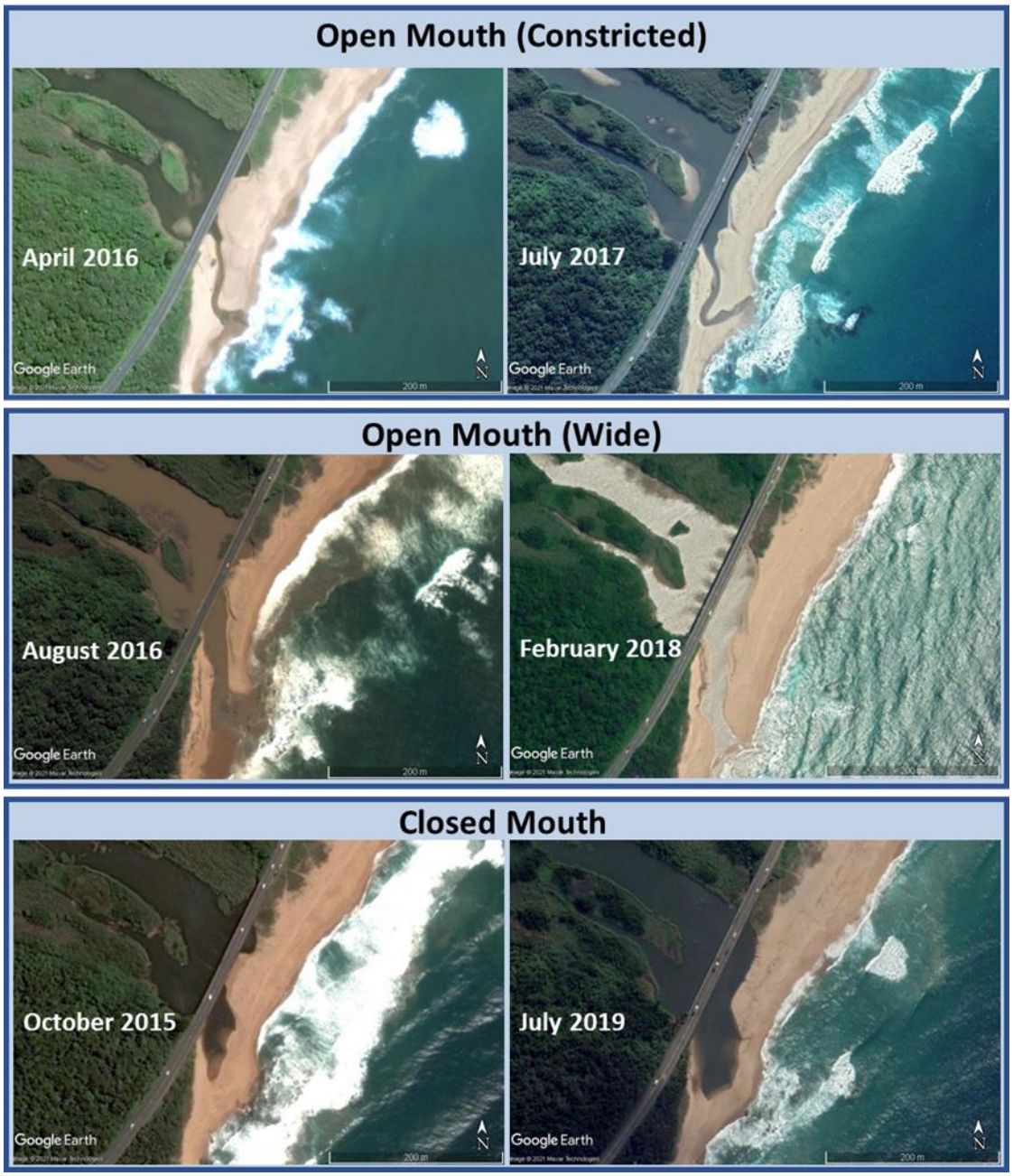


Figure 3.2. Mouth states for the uThongathi Estuary. Source: Google Earth.

3.2.2 Water quality

The distribution of saline water in an estuary (the longitudinal salinity distribution) is of fundamental importance as it affects the distribution of all biota in the system due to their differing salinity tolerances. River inflow and sea level together determine the penetration of seawater into the system, thereby determining the salinity profile of the estuary. The extent of saltwater penetration for any given freshwater inflow depends on tidal phase (spring vs. neap and ebb vs. flood tides) as well as the dynamics of the mouth and the volume of freshwater inflow.

Similar to a number of other estuaries within the greater Durban region (Mvoti to uMzimkulu Water Management Area), due to its small size the uThongathi Estuary has little resilience to changes in freshwater quantity and nutrient loading (Van Niekerk *et al*. 2019g). Water quality declines dramatically during periods of low flow (reduced freshwater inputs) and closed mouth conditions. This is primarily attributed to the accumulation of nutrients present in the effluent discharges from wastewater treatment works, as well as toxins from urban, agricultural, and industrial runoff/discharges (MER 2008).

Strong wave action and high levels of sediment availability in the uThongathi Estuary have resulted in the development of a perched system i.e. a system with a raised berm and a resulting water level that is higher than that of the adjacent sea level (Copper 2001, Appendix 1). Additionally, the estuary has a small, constricted mouth which only allows for reduced tidal intrusion. The system has previously been reported as being highly stratified with virtually fresh surface waters and salinities greater than 20 recorded at the estuary bottom (Begg 1984, Blaber *et al*. 1984). A description of the estuary's salinity profiles during varying mouth states in provided in Table 3.4.

Table 3.4. Description of the salinity within the estuary during the various mouth states and based on descriptions of salinity profiles in DWAF (2007).

Mouth state	Salinity during this state
Open	There will be no saline water in the estuary, except for short periods over higher tides.
Semi-closed	The estuary will be predominantly fresh at low tide with salinity concentrations of 5 ppt at the mouth and 0 ppt round the first small bend. At high tide some marine influence will elevate the salinity to 15 ppt at the mouth, but increases are not expected beyond the first bend
Closed but overtopping	The estuary is assumed to be homogeneously fresh throughout with salinity predominantly less than 5 ppt. Shortly after closure overwash can contribute to an increase in salinities, about 20-15 ppt at mouth. These salinities are presumed to decrease after a few weeks due to seepage losses and dilution
Closed	The estuary is assumed to be homogeneously fresh throughout with salinity predominantly less than 5 ppt.

Numerous studies have described the water quality of the uThongathi Estuary as "poor" (Begg 1978, 1984, Harrison *et al*. 2000). Begg (1978) described the estuary as having foul, malodorous water, characterised by low oxygen levels and high oxygen demand (a measure of the oxygen required by organisms within the system to survive), as well as heavy levels of pollution. Begg (1984) reported high levels of stratification within the system with average salinity values ranging from 5-15 and a maximum bottom salinity of 29, temperatures within the estuary ranged from 20.3 to 24.0°C and dissolved oxygen from 0 to 7.3mg/l, with bottom oxygen levels of zero often recorded. Similarly, Blabler *et al*. (1984) found the system stratified and subject to low oxygen levels particularly in the bottom waters of the upper estuary, however, temperature generally remained fairly constant within the water column, changing only slightly with the seasons.

It appears that the estuary experienced improved water quality in 2007/2008 relative to the early 1980's which can be attributed to the upgrading of the Tongaat Wastewater Treatment Works in 2000 (Forbes and Demetriades 2009). However, the overall water quality was still considered poor with the

system experiencing a build-up of nutrients and pathogens and a decline in oxygen concentrations during periods of low water flow and several of the parameters measured were found in concentrations known to be toxic to aquatic life. In addition, sampling conducted for the determination of the intermediate ecological water reserve for the estuary revealed high levels of ammonia, polyaromatic hydrocarbons (PAHs) and certain pesticides (DWAF 2007).

The uThongathi Estuary has been subjected to flow modifications (as a result of abstraction within the catchment and diversion into dams) and nutrient enrichment, originating from agricultural runoff and wastewater effluent discharge (Blaber et al. 1984; Forbes and Demetriades 2009; Forbes and Forbes 2012; Van Niekerk et al. 2019g). The mean monthly flow rate ($m^3.s^{-1}$) of the Tongati River measured at a gauging station managed by DWS and located approximately 14.5 km upstream of the mouth are shown in Figure 3.3. Missing data from this long-term record at the gauging station was supplemented by simulated monthly runoff (including irrigation) calculated in the Reserve Determination study (DWAF 2007). It is noteworthy that although the Reserve Determination Study suggested a mean monthly flow rate of less than 1 $m^3.s^{-1}$ (specifically 0.59 $m^3.s^{-1}$) the flow rate within the system is often significantly higher than the suggested value).

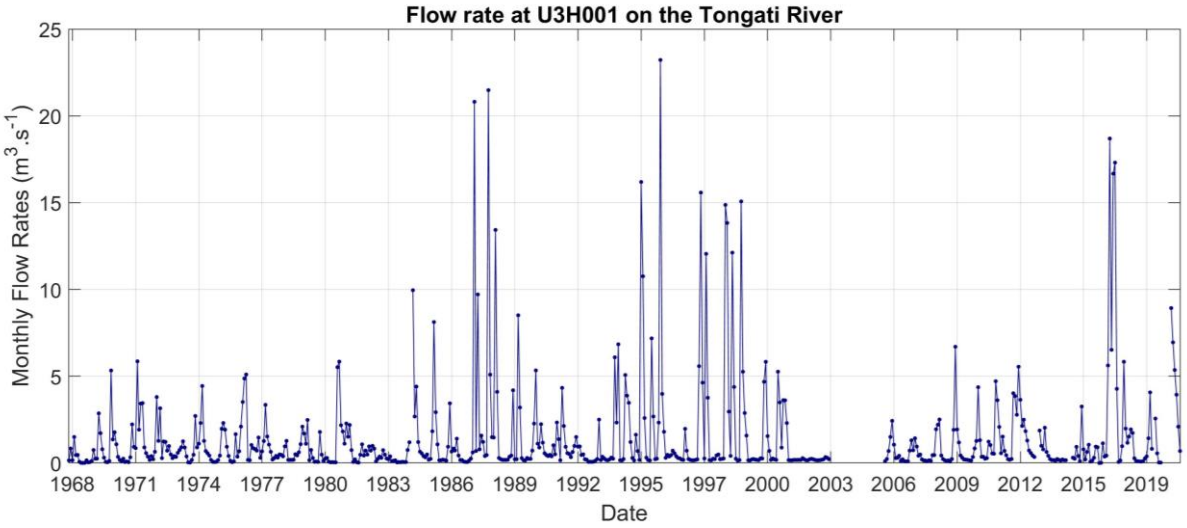


Figure 3.3. Graphical representation of the mean monthly flow rate ($m^3.s^{-1}$) of the Tongati River collected at gauging station U3H1 (Figure 2.2) approximately 14.5 km from the estuary mouth. Supplemented with simulated monthly runoff data from the Reserve determination study (DWAF 2007).

A recent study, which used the water quality data collected as part of National Estuarine Monitoring Programme (NEsMP), showed that salinity was highest at the mouth (5 ± 9.3 SD) and significantly lower in the middle and upper reaches of the estuary (0.25 ± 0.1 SD and 0.26 ± 0.1 SD, respectively, also see Figure 12.3). In contrast, temperature, dissolved oxygen (DO) and pH were not spatially different across the length of the estuary (Nunes *et al*. 2020). Preliminary results from a seasonal survey conducted between 2019-2020, showed that saltwater intrusion was limited to the mouth, with mesohaline to polyhaline conditions occasionally recorded in the bottom water (≥1 m) during the low rainfall season, due to the combination of the perched mouth, the shallow water depth and the increased freshwater inflow from the WWTW. (*Pers*. *Comm*. Monique Nunes).

The Tongaat Central Wastewater Treatment Works (WWTW) discharges 3.06 x 10^6 m^3 per year, with nutrient concentrations reported to be below the accepted WWTW chemical compliance limits, however however the median dissolved inorganic phosphate (DIP) concentrations from the WWTW exceed the eutrophic threshold set for estuaries (Nunes *et al.* 2020). The total volume of wastewater entering the estuary daily is 12.4 Ml/day, which originates from the Tongaat Central and the Frasers Wastewater Treatment Works (DWS 2015c, Van Niekerk et al. 2019e).

Water Quality data gleaned from the DWS RQIS website are shown in section 12.2 Appendix 3. However, while there are eight sampling stations (Figure 12.1) with samples ranging from May 2014 to May 2018, the data are very limited (maximum of 22 samples per site) and not all sites have data for each variable (Figure 12.2 & Figure 12.3). Three of the estuary sampling station data sets only have records for salinity (conductivity), water temperature and pH with no information regarding vital nutrient parameters. In addition, the single estuary sampling station that does provide more comparative data to compare to the WWTW effluent discharge data is outdated with most of the samples collected in or prior to 2017.

It is concerning that several of the limits for effluent specifications for discharging waste based on special standards contained in the General Authorisation (Notice No 665 dated 6 September 2013) under Section 21(f) of The National Water Act (Act 36 of 1998) are frequently exceeded for the WWTW discharges as well as within the estuary itself (Figure 12.2). In addition, *E. coli* count data (a microbial indicator of poor water quality) at all stations frequently exceeds the recommended limit for healthy recreational use (500 CFU/100ml), with nine readings during the sampling period being higher than 10 000 CFU/100ml. Salinity data for the estuarine monitoring stations show that salinity within the estuary rarely exceeds 5, even at the M4 bridge which is approximately 150 m from the sea/estuary mouth. The pH data also suggests that the system is largely dominated by fresh water as the pH ranges between 5.3 and 7.8 implying very little seawater intrusion as the pH of seawater is typically 8.1.

3.3 Biotic function

3.3.1 Microalgae

Microalgae in estuaries comprise unicellular algae that either live suspended in the water column (termed phytoplankton) or benthically on rock or sediments in the estuary (termed microphytobenthos or benthic microalgae). These microalgae i.e. phytoplankton and microphytobenthos are very important in estuarine systems as they are generally the main source of primary production in the estuary. Examples of benthic microalgal taxa (specifically diatoms) found in estuarine sediments are provided in Figure 3.4.

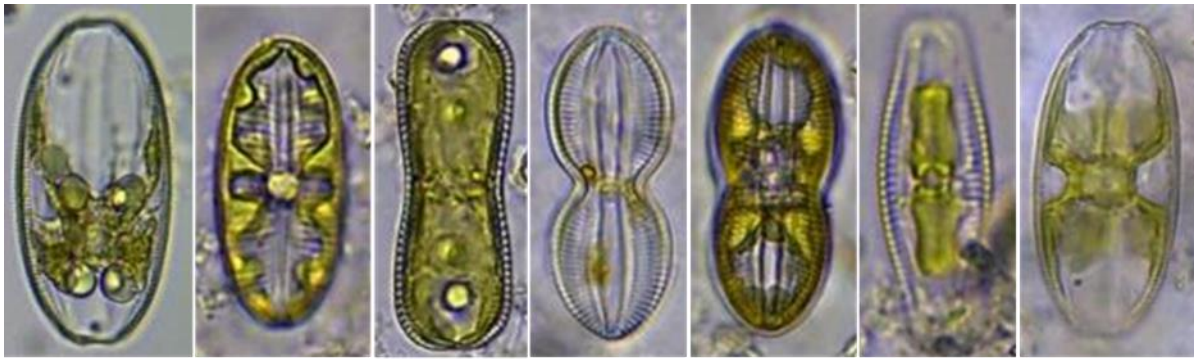


Figure 3.4. Examples of benthic microalgal species found in estuarine sediments.

Phytoplankton communities in estuaries are influenced by salinity and therefore by freshwater inflow, generally dominated by flagellates where river flow dominates and by diatoms in marine dominated situations. Diatoms are commonly dominant in the area of the estuary where the salinity is in the region of 10-15 ppt, often referred to as the River-Estuary Interface (REI) zone. Phytoplankton biomass in an estuary is also generally at its maximum in this region. Biomass of phytoplankton in estuaries varies very widely and may range from 0-210 µgChla/l (Adams *et al.* 1999). If nutrient concentrations in an estuary are high (particularly in the case of nitrogen) then phytoplankton biomass in the estuary is generally high too. Under extreme conditions, when nutrient levels are very high, certain toxic dinoflagellate species may form dense blooms known as harmful algal blooms. Excessive nutrient loading within a system can lead to a shift from a macrophyte dominated system to one dominated by phytoplankton and/or macroalgae (Adams *et al.* 2020).

The distribution and biomass of benthic microalgae are dependent on exposure (desiccation), light availability (turbidity) and salinity (Adams *et al.* 1999) and can be subdivided into two groups, i.e. intertidal (on the banks of a system where they are exposed to air intermittently as tides change) and subtidal (permanently submerged). The biomass of benthic microalgae in estuaries can range from 0-297 µgChla/l depending on conditions within the system (Adams *et al.* 1999).

The uThongathi Estuary is known to be a eutrophic system, meaning it is nutrient rich and therefore supports high primary production biomass. Phytoplankton biomass within the estuary is generally below 5 ugCha/l, however, episodic/isolated events can result in biomass ranging from 1-120 µg Chla/l (Forbes & Demetriades 2009). Phytoplankton biomass varies with the volume of freshwater inflow, the state of the mouth and the level of nutrients being introduced by the Wastewater Treatment Works, which has been shown to pose a risk to the resilience and health of South African estuaries that experience little tidal range (<2 m, Adams *et al.* 2020). Should high levels on nutrient loading coincide with periods of closed mouth conditions, which prevent the flushing of the system and increase the water residence time, the water quality deteriorates, and algal blooms may develop. These can lead to reduced or depleted oxygen levels within the system which are harmful to other aquatic species (Forbes and Demetriades 2009).

During a survey conducted in the uThongathi Estuary between 1980-1981 Blaber *et al.* (1984) reported that the intertidal areas of the lower reaches of the estuary were rich in algae. Seven species were recorded in the lower reaches and seven in the middle reaches of the estuary (two of which differed from those at the mouth). Additionally, euglenoid flagellates, species predominantly associated with

shallow, fresh, eutrophic habitats, were recorded in the estuary, supporting reports of low levels of salinity (Blaber *et al.* 1984, Wehr *et al.* 2015). More recently the microalgal community within the Estuary has been classed as having an ecological status of "E" or "Severely modified" (Van Niekerk *et al.* 2019e).

3.3.2 Vegetation

The floodplain can generally be divided into five different vegetation types, namely (1) Sugarcane cultivation, (2) KwaZulu Natal coastal belt grassland, (3) Northern Coastal Forest and bushveld, (4) reeds and sedges and (5) Invasive plant species. Forbes and Forbes (2012) estimated that approximately 55% of the estuarine area has been lost to habitat transformation, with the majority of the floodplain being altered by commercial and subsistence sugarcane farming, interspersed by reeds and grasses and small sections of indigenous swamp forest (Nunes *et al*. 2020). The largest area of swamp forest, consisting of species *Barringtonia racemosa* and *Hibiscus tiliaceus*, is located on the southern bank adjacent to the mouth, this belt of coastal forest also includes *Chrysanthemoides monilifera, Brachylaena discolor*, *Strelitzia Nicolai* and *Carissa macrocarpa*. *Hibiscus tiliaceus*, hygrophilous grasses and Phragmites reeds grow close to the edge of the estuary where water is more readily available. The floodplain has also been described as having patches of reedswamp *Phragmites* which are located largely on the northern bank of the lower reaches with a few small patches on the southern banks and on islands within the open water of the system (Begg 1978, Pillay and Webster 1997). The increased growth of the reeds, sedges and rafting grasses can be attributed to reduced water quality within the system and increased nutrients (DWAF 2007). Pillay and Webster (1997) also emphasised the importance of maintaining the natural riverine vegetation located further upstream stating that it provides some protection of the water quality lower down the system. It is important to note that habitat degradation or lost as a result of sugarcane farming is not irreversible and the land can be rehabilitated to increase the availability of natural habitat within the estuarine functional zone (Forbes and Forbes 2012).

Smaller estuaries, like the uThongathi Estuary, which experience high nutrient pollution pressure and flow modification are vulnerable to the spread of invasive alien plant species and the diversity and abundance of invasive alien plants within the uThongathi Estuary has increased over time (Adams *et al.* 2020, Nunes *et al.* 2020). The water hyacinth *Pontederia crassipes* was reported as present in the estuary by both Begg (1978) and Blaber *et al.* (1984) with the number of invasive species increasing to three in 2007; namely *Pontederia crassipes*, *Salvinia molesta* and *Pistia stratioides* (DWAF 2007). Additionally, *Myriophyllum aquaticum* has been reported in 2013, 2017 and 2020 (Adams *et al.* 2020, Nunes *et al.* 2020). These plants are classified under the Conservation of Agricultural Resources Act 1983 (Act 43 of 1983) as Category 1 prohibited aquatic weeds and therefore require immediate eradication (Zengeya & Wilson 2019, Van Wilgen *et al.* 2020). Terrestrial invasive species reported to occur along the banks of the estuary include the Caster Oil plant *Ricinus communis*, the Brazilian pepper tree *Schinus terebinthifolius,* wild-sage *Lantana camara* and the Beefwood tree *Casuarina* sp. (Forbes and Demetriades 2009, Adams *et al.* 2019). Additional invasive species, reported as being present in the swamp forest, include the woody cactus *Pereskia aculeata* and a species from the daisy family *Chromolaena* sp (*Pers*. *Comm*. Don McCulloch).

3.3.3 Invertebrates

Invertebrates inhabiting estuaries can be divided into a number of sub-groups based on where they reside in the estuary. Zooplankton live mostly in the water column, benthic organisms live in the sediments on the bottom and sides of the estuary channel, and hyperbenthic organisms live just above the sediment surface. Benthic organisms are frequently further subdivided into estuarine intertidal (those living between the high and low water marks on the banks of the estuary) and subtidal groups (those living below the low water mark).

Early studies suggest that the uThongathi Estuary had a reduced diversity and abundance of invertebrates and that this was an indication of a community exposed to moderate to heavy pollution, along with low salinities and low oxygen levels (Begg 1978). Similarly, studies have shown that zooplankton populations are "impoverished" with no single species dominating the estuary throughout the year with various species present or dominating during different periods of the year or mouth state, such as chironomid larvae, polychaete *Prionospio* sp, copepod *Pseudodiaptomus hessei*, Ostracoda, or the bivalve *Musculus virgiliae* (Blaber *et al.* 1984). Begg (1984) recorded the presence of four species of prawns and three species of crabs. Surveys conducted in 1999 recorded that copepod species *Acartia natalensis* and *P. hessei* dominated the water column, while a survey conducted in 2007 found that *P. hessei* dominated the water column (Forbes and Demetriades 2009). The estuary has the ability to produce a good standing stock (number of individuals at a given time) of zooplankton, specifically copepods species as mentioned above, however, this stock is damped by high volumes of discharge from the Wastewater Treatment Works and the high frequency of mouth open conditions (DWAF 2007).

Historically the Zoobenthos (also known as benthic macrofauna) within the estuary was also depauperate with few species present and the community being dominated by a single species of polychaete worm *Prionospio* sp. (Blaber *et al.* 1984, DWAF 2007). Although in significantly lower numbers, the polychaete *Owenia* sp., oligochaetes and chironomid larvae were also recorded in the estuary, along with two species of prawns and three species of crabs. Generally, the communities present belonged to the freshwater and estuarine groups with very few marine species. This can be attributed to the generally low salinities, the high frequency of mouth open state (reducing the water residence time) and sediment instability associated with the reasonably consistent strong outflow during mouth open periods (Blaber *et al.* 1984, Forbes and Demetriades 2009). In contrast to samples collected from the estuary bottom, the roots of the floating water hyacinth were host to a large variety of species, including amphipods and tanaid crustaceans, crabs, gastropods, insects, oligochaetes and polychaetes, while the stems of the reed *Phragmites* were generally uncolonized (Blaber *et al.* 1984, Forbes and Demetriades 2009).

Survey data collected in 2004 recorded a population dominated by five polychaete species as well as records of two amphipod species not previously recorded in the estuary (*Grandidierella lignorum* and *G. lutosa*) however, the abundance of all species recorded showed strong declines the following year as a result of increased river flow (Forbes and Demetriades 2009). More recent data collected in 2007/2008 showed similarly depauperate communities with the diversity ranging from 2-7 species, of which polychaetes dominated in the lower and middle reaches of the system while freshwater insects dominated in the upper reaches (Forbes and Demetriades 2009).

The Resource Quality Objectives (RQOs) recommend that "Macrobenthos should be abundant and dominated by polychaetes but should include amphipods, isopods, tanaids, polychaetes and the crab *Hymenosoma projectum* (Figure 3.5). Insect taxa should occur in the far upper reaches only" (DWS 2015b).



Figure 3.5. **Photo of the Crown crab *Hymenosoma projectum,* a species which according to the RQOs proposed by DWS (2015b) should be present in the uThongathi Estuary. Source Dawson and Griffiths 2012.**

3.3.4 Fish

It has been reported that low-income households in KwaZulu-Natal regularly depend on fish and estuarine invertebrates as these harvested resources are consumed as food, sold to provide income, or used as bait for capturing fish (Branch *et al.* 2002). Although the standard of fishing within the estuary was historically reported as very high, poor water quality has had a negative impact on the fish community and fishing conditions within the system have been reported as poor as far back as 1978 (Begg 1978, Adams *et al.* 2020). This is supported by reports that indicate that the estuary was classed as having a "low" fishing effort in 2011 and 2018 (categories: Very High, High, Medium and Low) with a total estimate of one tonne of fish reported as caught in both years (Van Niekerk *et al.* 2019e). The recent assessment of the Estuary conducted for the 2018 NBA reported that the Fish had an ecological status of "E" or "Severely modified", as well as noting that three "alien or extralimital" fish species are present within the system (Van Niekerk *et al.* 2019d,e).

Fish communities within the system have been known to vary greatly for year to year, amongst seasons and even from month to month, depending on the state of the mouth as well as the condition of the estuary as water quality strongly influences fish communities. In 1980, prior to a flood event that scoured the estuary bottom and removed the oxygen depleted bottom sediment layer of the system, 11 species of fish were recorded during trawl catches, with some monthly trawls capturing five species and several months recording no fish what-so-ever (Begg 1984). Subsequent to the flood, 17 species of fish were recorded, several of which were marine migrants that had since moved into the system. Begg's (1984) total species count was 21 with fish abundance dominated by five species of Mugilidae, contributing to 72% of the total catch, of these, the flathead mullet *Mugil cephalus* (76%) and the bluetail *Valamugil buchanani* (14%) were most abundant. Also recorded, were the

Mozambique tilapia *Oreochromis mossambicus* (14% of catch) and although in generally low abundance, the seabreams *Acanthopagrus berda* and Cape stumpnose *Rhabdosargus holubi*, and the spotted grunter *Pomadasys commersonnii* (Figure 3.6).



Figure 3.6. Examples of fish species found in the uThongathi estuary, Mullet (Top left), Spotted grunter (bottom left) and Tilapia (right).

Blaber *et al.* (1984) similarly reported a fish community dominated by Mullet and Tilapia, with monthly species counts ranging from three to 14 species, as well as reporting a lack of any catch at certain sites within the estuary during months with low oxygen concentrations and a fish kill event (consisting mainly of Tilapia) in November 1981. A total of 32 species were recorded, however, of these 15 species were only present once during the 12-month sampling period and others were caught infrequently. Species occurring in more than half the months sampled (6 months) included the mullet *Mugil cephalus*, Pseudo*myxus capensis* and *Osteomugil cunnesius,* tilapia *Oreochromis mossambicus* and *Tilapia rendalli,* the grunter *Terapon jarbua* and the catfish *Clarias gariepinus*.

More recent fish surveys conducted between 2002 and 2007 found reduced numbers of species and abundance with species counts reported as 14 and 18 species. The community was still dominated by estuary dependant species such as mullet, however the presence of alien species was also recorded. These included the Nile tilapia *Oreochromis niloticus* and a guppy *Poecilia reticulata* (Forbes and Demetriades 2009). Despite the acknowledgement that the latest data was collected during discrete sampling trips as opposed to repetitive monthly sampling, it appears that the species diversity and abundance has decreased relative to the fish communities surveyed in the early 1980's (Forbes and Demetriades 2009). The likely cause of these declines can be attributed to loss of estuarine habitat as well as a decline in the water quality within the system.

It is important to note that the pressures listed in the recent National Biodiversity Assessment as affecting the system include the occurrence of fish kills from 2000 to 2016, linked to pollution within the system (Van Niekerk *et al.* 2019e). Further fish kill events have been observed in August/September of 2018 and 2020 (*Pers. Comm.* Don McCulloch, Dec 2020)

3.3.5 Birds

The uThongathi Estuary is considered to be of regional importance to the waterbird community of Durban's estuaries as well as being species rich and having high abundance relative to its size (DWAF 2007, Forbes and Demetriades 2009). However, the recent assessment of the Estuary conducted for the 2018 NBA reported that the birds had an ecological status of "F" or "Critically modified" (Van Niekerk *et al.* 2019e).

Monthly bird counts conducted by Blaber *et al.* (1984) recorded a total of 27 species, with diversity ranging from as low as three species in April to 15 species in November. The most common/abundant species recorded were the common sandpiper *Tringa hypoleucos,* the yellow-billed duck *Anas undulata* and the pied kingfisher *Ceryie rudis*. Piscivorous (fish-eating) species (Figure 3.7) were commonly seen throughout the year, while invertebrate-feeding Palaearctic waders were most abundant when the mouth was open allowing for the exposure of sand flats.



Figure 3.7. Examples of piscivorous bird species found in the uThongathi Estuary. The Giant *Megaceryle maxima* (Left) and Pied *Ceryie rudis* Kingfisher (Right).

During the EWR conducted in 2007 a total of 42 species were recorded, these included large waterbirds (ducks, kingfishers, rallids), smaller waders (scolopacid waders, jacanas and plovers), larger waders (herons, hamerkop and ibises), gulls and terns, aquatic raptors, grebes, darters and cormorants, wagtails, and an additional 11 of the small wetland-associated species (mainly small passerines, i.e. swallows and martins, warblers and cisticolas, weavers and bishops, and waxbills, but also coucals) (DWAF 2007). The study suggested that there did not appear to be a significant change in the waterbird diversity and abundance within the uThongathi Estuary between 1980 and 2007 (DWAF 2007).

Bird counts conducted in 2007/2008 showed a similar diversity to counts done in 1980 (30 and 27 species respectively), however, only 12 species were common to both surveys (Table 3.5). Generally, common species that used the estuary as a roosting area were recorded in 2007/2008 (Forbes and Demetriades 2009). Larger birds characteristic of open water conditions (including swimming species, as well as perch and aerial hunters) dominated, accounting for >75% of the total abundance, followed

by smaller-bodied waders, while species associated with emergent and floating vegetation contributed least to the abundance and diversity.

Table 3.5. Bird species recorded in the uThongathi Estuary between December 1980 and November 1981 (Blaber *et al.* 1984) and in 2007/2008 (Forbes and Demetriades 2009).

Scientific name	Common name	Blaber *et al.* 1984	Forbes & Demetriades 2009
Actitis hypoleucos	Common Sandpiper	✓	✓
Acrocephalus gracilirostris	Lesser Swamp Warbler		✓
Actophilornis africanus	African Jacana	✓	
Alcedo (Corythornis) cristata	Malachite Kingfisher	✓	
Alopochen aegyptiacus	Egyptian Goose	✓	✓
Amaurornis flavirostra	Black Crake	✓	✓
Anas sparsa	Black Duck	✓	
Anas undulata	Yellow-billed Duck	✓	
Anhinga rufa	African Darter	✓	
Ardea cinerea	Grey Heron	✓	
Ardea goliath	Goliath Heron	✓	
Bostrychia hagedash	Hadeda Ibis		✓
Bradypterus baboecala	Little Rush Warbler		✓
Burhinus vermiculatus	Water Thick-knee		✓
Calidris minuta	Little Stint	✓	
Ceryle rudis	Pied Kingfisher	✓	✓
Charadrius hiaticula	Common Ringed Plover	✓	✓
Charadrius marginatus	White-fronted Plover	✓	✓
Charadrius tricollaris	Three Banded Plover	✓	
Ciconia episcopus	Woolly-necked Stork		✓
Cisticola galactotes	Rufous Winged Cisticola		✓
Dendrocygna viduata	White-faced Whistling Duck	✓	
Egretta (Casmerodius) alba	Great White Egret	✓	
Egretta garzetta	Little Egret	✓	
Gallinula chloropus	Common Moorhen	✓	
Haliaeetus vocifer	African Fish-Eagle	✓	✓
Heron Butorides striatus	Green-backed		✓
Hirundo albigularis	White-throated Swallow		✓
Larus dominicanus	Kelp Gull		✓
Megaceryle maxima	Giant Kingfisher	✓	✓
Motacilla aguimp	African Pied Wagtail		✓
Motacilla capensis	Cape Wagtail		✓
Nycticorax nycticorax	Black-crowned Night Heron	✓	
Phalacrocorax africanus	Reed Cormorant	✓	✓
Platysteira peltata	Black-throated Wattle-eye		✓
Plectropterus gambensis	Spur-winged Goose	✓	✓

Scientific name	Common name	Blaber *et al.* 1984	Forbes & Demetriades 2009
Riparia paludicola	Brown-throated Martin		✓
Scopus umbretta	Hamerkop	✓	✓
Sterna albifrons	Little Tern		✓
Sterna bergii	Swift Tern		✓
Sterna paradisaea	Arctic Tern		✓
Sterna sandvicensis	Sandwich Tern		✓
Tringa glareola	Wood Sandpiper	✓	
Tringa nebularia	Common Greenshank	✓	✓
Vanellus armatus	Blacksmith Lapwing		✓
Total		**27**	**30**

4 ECOSYSTEM SERVICES

4.1 What are ecosystem services?

The NBA 2018 describes ecosystem services as "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, carbon storage) that maintain the conditions for life on Earth." These ecosystem services add value to human society as a result of a healthy stock of ecological infrastructure. Therefore, if this ecological infrastructure is degraded or lost, the flow of ecosystem services will diminish.

Ecosystems can be viewed as natural capital which contributes to economic production. They provide goods, services and attributes, collectively known as ecosystem services, which contribute to human welfare (Barbier 1994):

- Goods are harvested resources, such as fish.
- Services are processes that contribute to economic production or save costs, such as water purification.
- Attributes relate to the structure and organisation of biodiversity, such as beauty, rarity or diversity, and generate less tangible values such as spiritual, educational, cultural and recreational value.

The Millennium Ecosystem Assessment (2003) recategorized the services obtained from ecosystems as follows:

- Provisioning services such as food and water;
- 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.

The first three align well with the definitions of goods, services and attributes described above, while the fourth underlies these and need only be considered in as much as changes in these affect the values of the first three (Turpie 2007).

4.2 Goods and services provided by the uThongathi Estuary

The main types of ecosystem services that are associated with Subtropical South African estuaries are listed in Table 4.1. Not all of these are provided by the uThongathi Estuary as the system is small and has already been subjected to anthropogenic impacts in the past. The goods and services provided by the uThongathi Estuary are discussed in more detail below.

Table 4.1. Ecosystem services based on definitions by Costanza *et al.* (1997) that are likely to be provided by a subtropical South African estuary (Turpie 2007)

Category	Goods and services	Examples
Ecological	Biological Control	Maintaining the balance/diversity of plants/ animals
	Refugia/Migratory Corridors	Fish and crustacean nurseries and roost for migratory birds
	Sediment supply	Creation and maintenance of beaches, sand bars and sand banks
	Erosion control	Prevention of soil loss by estuary vegetation, and by capturing soil in reed beds and mangroves
	Soil formation	Accumulation of sediment and organic material on floodplains and in mangroves
	Nutrient supply and cycling	Nutrient supply, nitrogen fixation and nutrient cycling through food chains
	Genetic Resources	Genes for mariculture, ornamental species and fibre
	Disturbance regulation	Flood control, drought recovery and refuges from natural and human induced catastrophic events (e.g. oil spills)
Subsistence	Collection of living resources for food	Line fishing, inter-tidal collecting, beach and seine netting
	Raw material for subsistence use (e.g. building material)	Harvesting of craftwork and house-building materials
Recreational & Tourism	Nature appreciation	Providing access to estuaries and associated wildlife for viewing and walking.
	Scenic views	Resort, residential houses, housing complexes and offices with scenic views, increasing turnover of properties with seaview
	Culture	Aesthetic, educational, research, spiritual, intrinsic, and scientific values of estuary ecosystems
	Sports fishing	Estuary flyfishing, estuary and inshore conventional fishing
	Water sports	Water sports: swimming, sailing, canoeing, skiing, and kayaking
Commercial and Industrial	Waste treatment	Breaking down of waste and detoxifying pollution
	Water supply and regulation	Water supply to marine environment and water for mariculture
	Mariculture (e.g. oysters, bait, etc.)	Production (natural and cultivated) of fish, crustaceans, and worms
	Commercial food production	Fishing
	Raw material for commercial use	Diamond and titanium mining
	Transport services	Ports, harbours, marinas and skiboat launching sites

4.2.1 Raw materials

Other than direct human consumption estuaries produce many other useful materials such as vegetation that may be used as fertilizer and grazing for livestock. In the lower portion of the river system, particularly in the area around the town of Tongaat, utilisation of goods and services (fish, wood for fuel, building and handicrafts, medicinal plants, and riparian grazing) is of high importance to a significant proportion of the population. However, there is no recorded use of building materials

(e.g. reeds, sand) gathered from within the estuarine area for subsistence or commercial purposes, the only exception being that sand is mined just upstream of the estuary head. Additionally, residents from the surrounding rural community utilises the estuary for subsistence fishing and harvest 'uMfino' (Wild Spinach) from the banks in the upper reaches to below the N2 bridge (*Pers*. *Comm*. Monique Nunes). The limited subsistence use is unsurprising because of the lack of traditional dwellings close to the estuary.

4.2.2 Carbon sequestration

Carbon sequestration is an important ecosystem service that mitigates an increasingly changing climate and is measured in terms of the net storage or loss of carbon that takes place because of a long-term increase or decrease in biomass. The contribution made by estuaries to carbon sequestration is unknown but is unlikely to be significant apart from in mangrove systems.

4.2.3 Waste treatment

Water filtering into ecosystems such as estuaries naturally transport some nutrients added through processes such as geological weathering and the transporting of detritus and plant material washed into the system from the drainage basin, however they can also transport pollutants as well as anthropogenically enriched water. Estuaries and associated wetlands are known to act as a natural filtering system or buffer zone that stabilizes the shoreline and protects coastal areas.

The uThongathi Estuary is particularly vulnerable to pollution via discharge from local wastewater treatment works (WWTW) that discharge into the estuary and from sand mining works to the North of the estuary head. Other contributions of wastewater include agricultural and urban run-off that usually results in poor water quality and leads to high levels of contaminants in the system that are eventually flushed out into the sea during open mouth conditions.

4.2.4 Refugia and nursery areas

Refuge areas are protected areas that help to maintain populations in a broader area. For example, wetlands within relatively arid areas may play an important seasonal role in the maintenance of wild herbivores that are utilised in tourism operations well beyond the wetland. Estuaries usually provide refuge to small animals such as fish and benthic organisms from unfavourable conditions that may prevail on the open coast such as large waves, low water temperatures, large predators etc. This is usually limited to estuarine dependant species (Lamberth *et al.* 2010). However, the uThongathi Estuary in its current state appears to have limited value as a fish nursery or refugia. Fish species diversity and abundance in the estuary are generally low with eight (354 individuals) and 11 (33 individuals) species recorded in the 2007 winter and 2007/2008 summer, respectively (Forbes and Demetriades 2009). This may be a result of the hypoxic conditions experienced in the estuary, caused by the industrial pollution, which has led to fish kills and a change in habitat structure. Additionally, the water levels and the morphology of the mouth of estuary make it difficult for organisms to move between the marine and estuarine waters (poor connectivity).

Nursery areas are breeding habitat for populations that reside elsewhere. Estuaries provide critical nursery areas for a large number of marine fish species that use the warm, productive sheltered waters to enhance growth and survival of young fish. Estuaries are known to provide nursery areas and habitat for numerous species of fish that are exploited by recreational and commercial harvesting in the inshore marine environment. Different species are dependent on estuaries to different degrees for stages of their development and growth such that the population is adversely affected if the estuary is in poor condition. Little information is available regarding the ability of the estuary to function as a nursery area, however, it is likely that the system has a very low nursery value as a result of poor water quality and resultant hypoxic conditions, the mouth morphology of the estuary which make it hard for species to move between water bodies and the overall low diversity and abundance of available invertebrate species (food source) within the estuary.

Bird populations may also be dependent on the estuary and include many species that move into the area to breed, moving to other areas for much of the remainder of the year. The presence of the birds may contribute both to the ecological (biodiversity) and aesthetic value of the system. A total of 125 individual birds across 27 species were recorded in a 2007/2008 survey of the uThongathi Estuary where birds who were characteristic of open water conditions were abundant (>75%) and comprised species that generally use the estuary as a roosting area. The uThongathi is thus considered important for the health of waterbird communities.

4.2.5 Export of materials and nutrients

The export of sediments and nutrients to the marine zone is an important function of some river systems. For example, the prawn fisheries of KwaZulu-Natal depend on such exports (DWAF 2004). Over the last few decades, the uThongathi Estuary has become shorter and shallower. This is most likely due to the removal of vegetation in favour of crops or because of grazing ultimately leading to erosion and mud deposition. The sediment accumulation reduces habitats and changes the water flow thereby affecting the rate at which materials and nutrients are exported and providing favourable conditions for alien species to establish. Further low flow rates result in onshore sediment deposits at the mouth of the estuary thereby restricting mouth conditions and flow exchange between the estuary and marine environment (Nunes *et al.* 2020). This therefore increases the amount of time that water resides within the estuary and if sustained, leads to salinity regime shifts, low oxygen concentrations and increased decomposition processes (Nunes *et al.* 2020). During flood events, enough disturbance is created that the high nutrient, low oxygen water is flushed out of the estuary and water quality is improved.

4.2.6 Tourism and recreational value

South African estuaries are generally deemed to be popular holiday destinations as they provide multiple attractions that are often associated with the developed area surrounding the estuary such as beaches, villages, and other natural areas. Thus, 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 are what attracts tourist to the area and therefore to a certain extent the

tourism value of an estuary can be closely linked to the development of the area surrounding the estuary.

Water quality of the uThongathi Estuary is heavily impacted by elevated nutrients and fertilizers, industrial and agricultural pollution as has been reported as poor as far back as 1978 (Begg 1978, DWS 2015c). This has resulted in low oxygen conditions that are further exacerbated by the biological demands of the estuary. This is particularly problematic during low flow and closed mouth conditions when the water has been described as “odorous” and a “public nuisance” (Begg 1978). Consequently, tourism in the area appears to be very low. Additionally, the incised nature of the estuary, dense forest vegetation and the development of much of the surrounding land for sugar cane has limited direct access to the estuary, as well as altering the appearance and sense of being surrounded by nature that would otherwise be found in a system like this.

5 THREATS, IMPACTS OR POTENTIAL IMPACTS TO ESTUARY

As seen in the review of available data relating to the ecological functioning and state of the estuary it is evident that the system has been significantly altered and the ecological functioning and provision of ecosystem services has declined. In the Estuarine rehabilitation and management plan for the Zimbali Lakes and Golf Course Residential Development, Marine & Estuarine Research (MER 2008) allocated these physical impacts into four main categories; (1) the construction of a causeway across the upper reaches of the estuary; (2) high rates of sediment accumulation in the estuary during the last 30 odd years as a result of high erosion rates; (3) declines in water quality and (4) the proliferation in the estuary, riparian zone and floodplain by sugar cultivation and invasive alien plants. These and other issues identified more recently as posing a threat to the health and functioning of the estuary are listed below.

5.1 Causeway

The removal of the causeway will improve flows through the estuary and prevent further build-up of sediment above this structure. This will additionally potentially enable smaller flood events to scour and move sediment within the system (Mer 2008). In addition, the removal of this structure may allow saline water from the mouth to penetrate further upstream thus increasing the available habitat for estuarine species. MER (2008) recommended that the removal of the causeway be prioritised "*thus allowing the reversion of the river to its natural flow path over time*". The authors acknowledged that this could lead to some erosion upstream and at the causeway resulting in re-deposition of sediments downstream, however, they concluded that the removal of the causeway was considered "*the best long-term solution for restoring the former upper estuarine habitat*." The report suggested that the width of the floodplain at the causeway, up to the 5 m contour should be completely cleared of all artificial obstructions to flow and that the process would "*require a specific operational procedure, and which will need to be developed by an engineer, sedimentologist and estuarine scientist*."

5.2 Sedimentation within the estuary

Sediment input to the estuary has and is being increased by agricultural development and sand mining operations (Blaber *et al.* 1984, Forbes and Demetriades 2009, Forbes and Forbes 2012). This build-up of sediment can smother benthic organisms and may provide an explanation for the low invertebrate score for the estuary's ecological health status (Table 3.2). The removal of the causeway, restoration of flow and removal of the built-up sediment may improve the condition of the invertebrate communities which in turn provide a food source for the fish and birds thereby potentially improving the condition of these community groups as well.

5.3 Public awareness and education

Effective management of the uThongathi Estuary will be dependent on the involvement and interest of the local stakeholders and to a lesser extent on the visitor's appreciation of the management

regulations as the estuary has a low tourism and recreational value. Therefore, education is an important tool which can be used to enhance the awareness of the local community and highlight the advantages gained when the condition of the estuary and its ability to provide goods and services is improved.

5.4 Coastal access

Due to their smaller size and the fact that they are typically deeply incised, estuaries in KwaZulu-Natal often have limited accessibility. The highly dynamic nature of the KwaZulu Natal coastline and surrounding area presents a significant challenge for accessing the estuary and the ecosystem services they offer. A large number of the users of the uThongathi Estuary do not live in the direct vicinity of the estuary or the mouth. In addition, there is limited access to the system in terms of roads or parking facility and the condition of the safety railing on M4 bridge at the mouth of the estuary where one may view the estuary has been steadily declining over the years (Figure 5.1).



Figure 5.1. Image showing the deteriorating state of the railings of the M4 road bridge across the uThongathi Estuary mouth.

5.5 Sand mining

Small-scale mining including (sand, diamonds, and heavy minerals) is causing permanent habitat destruction in up to 12% of South African estuaries (Van Niekerk *et al.* 2019). Specifically, low-value sand mining has been identified as having impacts on critical estuarine habitats, water flow, the grain size of sediment and depleting sediment reservoirs that are vital to replenish physical habitat after flood events cause scouring. In KwaZulu Natal, 37 out of 74 estuaries have sand mining in, or upstream

of, the system, with 17 estuaries directly impacted by mining in the Estuarine Functional Zone (Van Niekerk *et al*. 2019). It was reported in 2007 that sand mining was occurring at two locations along the Tongati river just upstream of the head of the estuary (Demetriades 2007). More recently, based on google earth imagery these operations have ceased, but a larger sand mining area is present of on the northern banks of the river just downstream of the Tongaat WWTWs. Despite the fact that sand mining can have numerous negative effects on estuaries (Figure 5.2), the frameworks governing small-scale sand mining in South Africa lack the necessary capacity to support better environmental compliance, and the enforcement mechanisms to successfully deter illegal activities are weak (Chevallier 2014). High sand mining pressure (in terms of the number, frequency and size of mining operations) is reported within the uThongathi Estuary and it has been recommended that future research and monitoring of the impacts and sustainability of local sand mining within this system and many others along the KZN coastline should be prioritised (CoastKZN 2021).

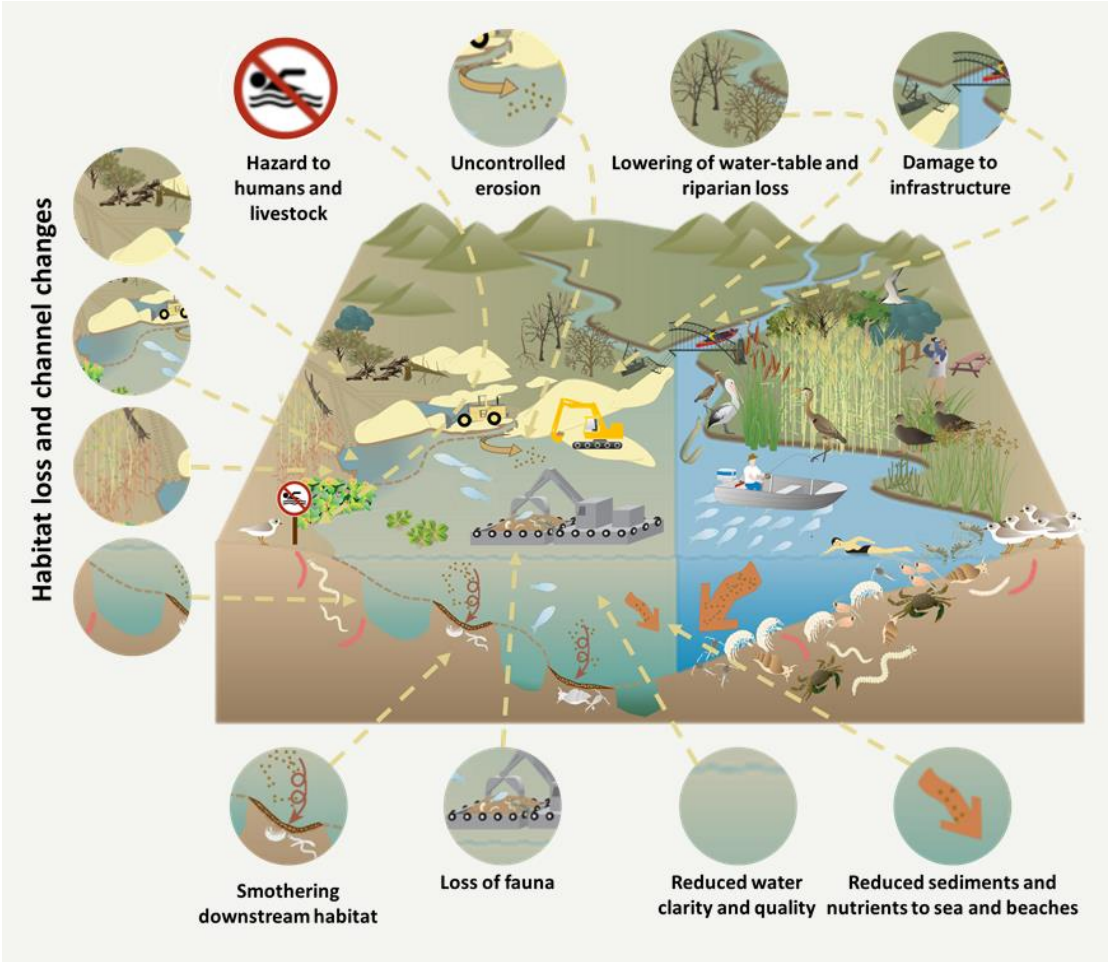


Figure 5.2 **Impacts of sand mining on estuaries as reported by CoastKZN (source: http://www.coastkzn.co.za/)**

5.6 Alterations to floodplain and Invasive/Alien species

Increased nutrient levels associated with the wastewater discharge and agricultural run-off and persistent freshwater conditions can cause the stimulation of indigenous reeds such as *Phragmites australis* and rafting grasses such as *Eichinochloa colona,* as well as enhancing the growth of alien plants (MER 2008, Nunes 2020). The proliferation of these species can restrict/obstruct the water channel thereby causing reduced flow rates; and when they die and decay can result in reduced dissolved oxygen concentrations within the water column. The number of recorded aquatic invasive plant species in 2007 was three i.e. *Pontederia crassipes*, *Salvinia molesta* and *Pistia stratioides* (DWAF 2007) and more recent records include the presence of *Myriophyllum aquaticum* (Adams *et al.* 2020, Nunes *et al.* 2020). The removal of these floating macrophytes will increase light penetration to the benthos and improve flow and water quality.

5.7 Presence of crocodiles within the estuary

Researchers, visitors, and locals have spotted and reported the presence of a number of crocodiles in the estuary. These crocodiles have been seen in the water, while conducting boat-based research, as well as sunning themselves on the sand banks near the mouth. The uThongathi estuary is located south of the reported South African distribution of Nile crocodiles *Crocodylus niloticus* (Isberg *et al.* 2019, Figure 5.3). It is possible that the uThongathi population has grown from individuals that escaped or were washed out of the Crocodile Creek facility located just below the N2 roadway. This poses a potential risk to anyone using the estuary as there are no sign boards warning users of the presence of Crocodiles.



Figure 5.3. Reported population distribution of Nile Crocodile *Crocodylus niloticus* within South Africa and the location of the uThongathi estuary. (Adapted from IUCN Red List Isberg *et al.* 2019)

5.8 Water quality and wastewater discharges

Estuarine species are known to be resilient and generally well adapted to withstand the natural fluctuations of physico-chemical conditions inherent in estuarine ecosystems (MER 2008). However, few species are likely to survive or thrive within the system given the extent of the nutrient enrichment within the uThongathi by wastewater effluent and industrial and urban runoff, and the associated lowered oxygen levels. Figure 5.4 shows the degraded sediment conditions only 1 m from the water's edge where anoxic/deoxygenated conditions prevail within an inch of the surface. In addition, fish kills have been reported to occur within the system, the most recent of which were August/September of 2018 and 2020 (*Pers*. *Comm*. Don McCulloch, Dec 2020). This suggests that water quality and oxygen concentrations dropped significantly low to cause fish mobility.



Figure 5.4 **A footprint in the sediment at the water's edge of the uThongathi Estuary mouth showing the presence of severely anoxic/deoxygenated (black) sediment.**

The occurrence of repeated raw sewage spills, malfunctioning pumpstations, broken sewer lines and blocked or overflowing manholes has been raises as a vital issue within the uThongathi Estuary. Numerous stakeholders have concerns over the poor water quality and the highly enriched condition within the system. Locals from the Zimbali Coastal Estate reported a sewage spill in September 2020 which caused water conditions on the adjacent beach to drop so low that a planned beach clean-up event was postponed (*Pers*. *Comm*. Brendan Smith, ZEMA, Dec 2020). It has also been reported that a significant amount of domestic waste/litter flows downstream and out the mouth of the estuary to collect on the adjacent beaches north and south of the estuary mouth (*Pers*. *Comm*. Brendan Smith and Careen Tait). It is important to note that water quality data collected upstream of the sugar mill occasionally show non-compliant levels of water quality parameters suggesting that pollutants are also being introduced higher in the catchment area.

5.9 Current and future development

Concerns have been raised about the impacts of current and future developments, such as the Zimbali Lakes Resort which is currently under construction on the Northern bank of the estuary. The Environmental Impact Assessment (EIA) regulations of the National Environmental Management Act No. 107 of 1998 (as amended) (NEMA), specify that any development undertaken within the defined coastal management line around the estuary (if defined, or within a distance of 100 m inland of the high water mark of the estuary) requires environmental authorization, through the completion of a full EIA. Authorisation for the Zimbali Lakes development, following the final EIA published in 2007, was granted on the 27th of February 2008. As part of the authorisation an Environmental Management Programme ("EMPr") had to be developed and approved by the then, KZN Department of Agriculture and Environmental Affairs prior to the commencement of any construction-related activity on site, including bulk earthworks. Failure to do so would have resulted in the authorisation lapsing and it would no longer be valid. The complete EMPr has been developed and approved, and an Environmental Control Officer from Kinvig and Associates Environmental Consulting was appointed to ensure that this programme is suitably carried out. Provided the programme is strictly adhered to, the overall impact of the development on the estuary will be positive. This is a good example of how considered economic development that complies with the NEMA EIA process, and estuarine rehabilitation can both be achieved.

5.10 NBA pressure status and restoration measures

The 2018 NBA rates the cumulative pressure level of the uThongathi Estuary as high, with pressures listed for the estuary including: pollution (very high) in the form of WWTW discharge, urban runoff and stormwater plastics; habitat loss and alien fish (high); flow modification and invasive plant species (medium); low fishing pressure, the presence of sand mining and the occurrence of unauthorised artificial breaching of the mouth (Van Niekerk *et al*. 2019e). Together these identify a number of management actions for restoration of the estuary and floodplain.

The restoration measures recommended in the most recent NBA for the improvement of the uThongathi Estuary are listed below:

- The restoration or protection of freshwater base flows reaching the estuary.
- Improved management or reduction of stormwater and drainage from flood plain.
- Improved water quality.
- Monitoring, reduction or re-use of wastewater discharges.
- Improved mouth management (prevent unauthorised breaching).
- Rehabilitate riparian areas/wetlands.
- Remove alien vegetation.
- Investigate the eradication of alien fish.
- Restore and/or protect against the impact of mining.

6 OVERVIEW OF SOCIO-ECONOMIC CONTEXT

6.1 Demographics

The information provided below is predominately taken from each municipality's Integrated Development Plan (IDPs).

The uThongathi Estuary falls within three municipalities: iLembe District Municipality, KwaDukuza Local Municipality and eThekwini Metro. The KwaDukuza Local Municipality is mostly urban in nature with tribal areas on the outskirts of the municipality. This region is made up of higher intensity developments (i.e. predominantly retail centres), suburban settlements (i.e. established urban centres such as KwaDukuza town), lower income residential areas (i.e. townships generally dislocated from main urban centres), agricultural settlement (i.e. very low residential densities mainly around main roads and service centres), higher density suburbia (i.e. cluster or townhouse types of development), informal settlements (generally. close to areas of employment and or activity), lifestyle residential development (i.e. Zimbali estates) and traditional rural area (governed by tribal authorities and with a strong subsistence base). The majority of the land is privately owned with very few properties that are publicly owned. Since 2011 the population has increased by about 40% to a population of about 260 000 people with a large number of them being youth; (29% children under 14 years and 40.35% between the ages of 15-34 years). The most spoken language within this municipality is IsiZulu with 67.50% of the population being fluent in the language.

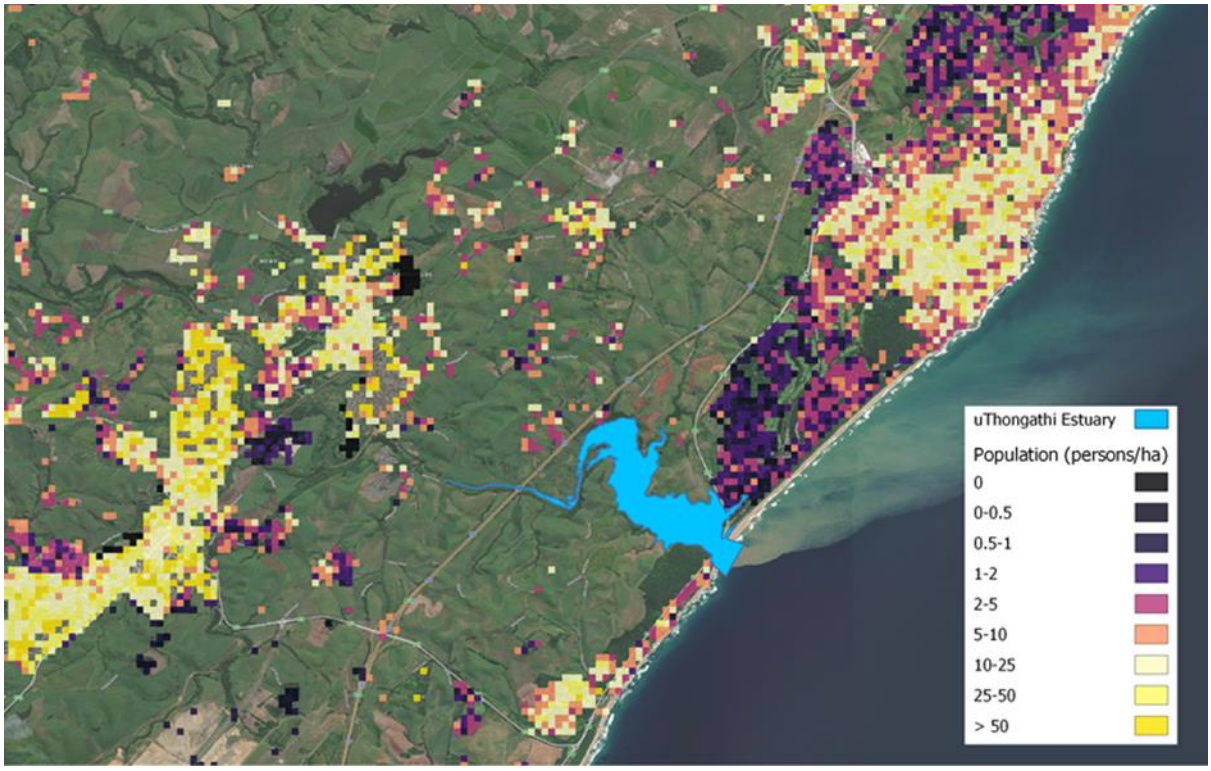


Figure 6.1 **Population densities (persons/ha) for the area surrounding the uThongathi Estuarine Functional Zone based on Census 2011 data (Bondarenko *et al.* 2020)**

The eThekwini municipality is largely metropolitan in nature with a wide range of formal and in formal use. Rural areas (i.e. traditional structures and communal land with dispersed settlement patterns) form the majority (68%) of the municipality, about 10% of which comprise commercial farms and metropolitan open space. There are also a large number of informal settlements distributed throughout the municipality and on the periphery (i.e. on steep lands or flood plains) which makes them a vulnerable and at-risk community. The remainder of the municipal areas are urban in nature with residential, commercial and industrial land use. With a growing population, the eThekwini municipality has > 3 million people with the majority of the population under the age of 35 years (57%) with relatively low employment rates. The main languages spoken here are isiZulu and English.

6.2 Social considerations

Within the KwaDukuza municipality 6.8% of the population are without any schooling, only 1.5% has an education higher than secondary school, while approximately 14% have completed secondary school. In terms of amenities, about 28,5% of the population has municipal water flowing through a tap inside the house, 39.2% with a workable toilet and 17,3% with metered electricity. Two national roads (the N2 and R102) run through the municipality and provide the main access routes with levels of accessibility which favour connection to these roads (such as in areas like Ballito). However, levels of accessibility diminish greatly with a change in topography and less developed infrastructure, especially toward the outskirts of the municipal area.

A larger portion (26%) of the eThekwini municipality has some form of secondary education, 25% have a primary school education and 7% with no schooling. Given that most people within the municipality live below the poverty line, there is still a struggle with access to basic household and community services especially within the informal settlements. Many people are unable to afford basic services, resulting in illegal connections to water and electricity.

6.3 Economic profile

The local economy in the KwaDukuza municipality has a heavy reliance on agriculture which comprises 54% of the local economy and contributes 8% towards employment in the iLembe district. The majority of economic activity is sugarcane farming and processing as well as light industry contributions such as engineering, manufacturing (which contributes 17% to the municipal economy) of paper and packaging and, tourism. However, unemployment rate is noticeably high (46%), and most households (81.4%) depend on a monthly income of about R6 300 or less.

The majority of the GDP produced in the eThekwini municipality is from the following sectors: community services (21%), finance (21%), transport (14%) and trade (17%) with remaining sectors being manufacturing (19%), construction (5%), mining (~ 1 %) and agriculture (~1%). The unemployment rate is high (21%) although the number of people looking for employment has decreased over recent years. However, it should also be noted that most people are living below the poverty line within the municipality.

Poverty is described as a state or condition in which a person or community lacks the financial resources and essentials for a minimum standard of living. Much of the South African population still live below the international poverty line, although conditions within the country have generally improved with the proportion of the population living below the international USD 1.9 per day standard having decreased from 25.4% in 2006 to 18.8% in 2015.

Statistics South Africa (Stats SA) defines absolute poverty as a '*condition characterised by severe deprivation of basic human needs, including food, safe drinking water, sanitation facilities, health, shelter, education and information*'. Internationally recognised measures of poverty used in South Africa include the food poverty line (FPL), the lower-bound poverty line (LBPL), and the upper-bound poverty line (UBPL). The FPL is defined as '*the rand value below which individuals are not in a position to purchase or consume enough food to meet their minimum per-capita-per-day energy requirement for adequate health'*. In April 2018, based on prices at the time, the FPL was standing at R547 per person per month. The LBPL is defined as a line where an individual does not have enough resources to acquire both food and non-food items and is therefore forced to choose between food and important non-food items. The LBPL was reported as R785 (in April 2018 prices) per person per month. Individuals who can afford to purchase both adequate food and non-food items but cannot afford the minimum lifestyle desired are considered to live below the UBPL (R1 183 in 2018) (Stats SA 2019). Statistics for the South African Population are shown in Figure 6.2.

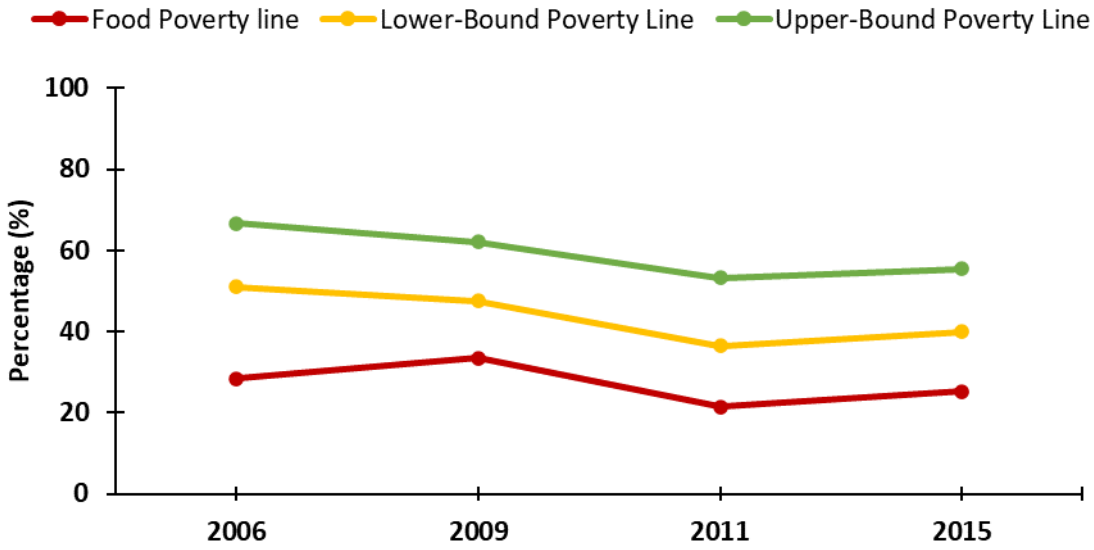


Figure 6.2 **Percentages of the South African population living blow the three poverty lines (2006 – 2015). Data source: Stats SA.**

More detailed data for the communities surrounding the uThongathi Estuary (Figure 6.3) sourced from the national census data (Stats SA) are provided in Table 6.1. Most of the local population (87.5%) live in Tongaat and Ballito, with the remaining population located in the five smaller towns, namely Salt Rock and Greylands located to the north and northwest of the estuary, respectively, and Westbrook, Genazzano and Tongaat Beach south of the estuary along the coastline.



Figure 6.3 **Communities surrounding the estuary for which census 2011 data is available.**

The cumulative population is approximately 70 612 people, from 23 548 households, which generally include three or fewer family members. Although households in all except one community (Greylands), are predominantly living in formal dwellings, just under 4 000 households live in informal dwellings and as many as 3 011 households in the region are reported to have no form of income. The families from these households are likely to be dependent on subsistence farming and harvesting/gathering natural resources from the surrounding environment. This includes utilising the uThongathi Estuary for subsistence fishing and the collection/harvesting of plants such as wild spinach i.e. uMfino, for consumption.

Table 6.1 **Select population statistics for communities surrounding the uThongathi Estuary. Source: Stats SA.**

	Total Population count	Number of households	Average household size	Formal dwellings	Households with no income
Tongaat	42554	12375	3.3	80.7%	1634
Tongaat Beach	722	236	2.7	91.5%	14
Genazzano	2585	760	2.8	69.2%	125
Westbrook	1526	617	2.2	83.5%	70
Greylands	2185	1039	2.1	42.9%	240
Ballito	19234	7866	2.4	91.7%	865
Salt Rock	1806	655	2.7	96.5%	64

7 LEGISLATIVE INSTRUMENTS AND RELATED STRATEGIES/PROGRAMMES

7.1 Legal framework applicable to estuarine management

This section provides an overview of legislation and policy applicable to the management of estuaries in South Africa and specifically to the uThongathi Estuary. More detailed discussion on legislative framework for estuary management, including international and regional treaties and obligations, national policies and laws, provincial and local policies and legislation is provided in Taljaard (2007) and Taljaard *et al.* 2019.

South Africa's legal framework has a hierarchical structure with the Constitution (108 of 1996) first and foremost. After which there are three levels (1) national, including national policy and national acts; (2) Provincial (Acts such as Land-use planning and conservation) and (3) local, consisting of municipal by-laws such as land-use planning and coastal development.

The South African Constitution is the supreme law of the land and provides the legal framework for legislation regulating environmental management in general. Section 24 of the Constitution states that:

"Everyone has the right:

- *to an environment that is not harmful to their health or well-being; and*
- *to have the environment protected, for the benefit of present and future generations through reasonable legislative and other measures that –*
- *prevent pollution and ecological degradation;*
- *promote conservation; and*
- *secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.*

This lays the basis for environmental law in South Africa (Breen & McKenzie 2001) and is a very important justification for the wise use of estuarine biodiversity.

Since they do not fall within the broader categories of freshwater, terrestrial or marine environments, estuaries have tended to be neglected in past legislation. However, the fact that estuaries contain freshwater, terrestrial and marine components, and are heavily influenced by activities in a much broader catchment and adjacent marine area, means that they are affected by a large number of policies and laws. The situation has improved with newer policies and legislation, however, despite the significant increase in number and size of South Africa's Marine Protected Areas (MPAs) in 2019, there is still no specific provision for Estuarine Protected Areas.

Government's response in mitigating deterioration of South African estuaries is manifested in two pieces of key legislation, namely the National Water Act (Act 36 of 1998) and National Environmental Management: Integrated Coastal Management Act (Act 24 of 2008) (ICMA), among others.

The ICMA set out specific requirements for the development of a National Estuarine Management Protocol (NEMP) (Government Gazette 36432. No 341 of 10 May 2013).

Specifically, the purpose of the Protocol (as set out in the ICMA) is to:

- Determine a strategic vision and objectives for achieving effective integrated management of estuaries.
- Set standards for management of estuaries.
- Establish procedures or provide guidance regarding how estuaries must be managed and how the management responsibilities are to be exercised by different organs of state and other parties.
- Establish minimum requirements for estuarine management plans.
- Identify who must prepare estuarine management plans and the process to be followed in doing so.
- Specify the process for reviewing estuarine management plans (EMPs) to ensure that they comply with the requirements of the ICMA.

The ICMA requires the establishment of Coastal committees which facilitated the establishment of the National Coastal Committee known as "Working group 8" under which are Provincial coastal committees, within these are a number of Municipal coastal committees. Each level has a specific Estuary sub-committee, and the ultimate goal is for each individual estuary to have its on local advisory body e.g. Estuary Forums.

Estuary management falls mainly under two national government departments: Department of Human Settlement, Water and Sanitation (DHSWS) which is responsible for water resources, and the Department of Environmental Affairs, Forestry and Fisheries (DEFF) which is responsible for all other environmental matters e.g. land use and living resources. Environmental management in most instances is devolved to provincial level through whichever provincial department is responsible for environmental matters, which in this case is the KwaZulu Natal Department of Economic Development, Tourism and Environmental Affairs (EDTEA). Management and conservation of marine living resources is an exception in this respect, in that this is retained as a national competency, responsibility residing with the Department of Environment, Forestry and Fisheries. In instances where provincial or local legislation are in conflict with national legislation, national legislation prevails. At a local (municipality) level, municipal councils pass municipal by-laws, which in turn, cannot conflict with provincial and national laws (McKenzie 2001).

South Africa has an extensive legal framework for governing the protection and sustainable use of the coastal marine environment including at least 19 international obligations and agreements to which the country is signatory and approximately 46 national acts (Taljaard 2011, DEA 2014 and Taljaard *et al*. 2019). A summary of the most relevant estuarine legislation is provided in Table 7.1. Policy and legislation which affects estuaries directly can be roughly divided into that affecting (1) estuarine resources planning and protection, (2) enabling integration for estuarine management and (3) management of activities or uses in and around the estuaries. The latter can be further divided into (a) water quality and quantity, (b) land-use and infrastructure, and (c) exploitation of living resources (Van Niekerk & Taljaard 2002, Taljaard 2007).

Most South African estuarine systems fall within the boundaries of a single municipality, and some occur totally or partly within areas that are currently protected or are likely to be protected in future. It is the local people that usually benefit most from the goods and services that estuaries provide and who are most familiar with general conditions relating to the system. Additionally, local government generally has closer involvement with activities happening within and around estuaries than the other spheres of government (NEMP 2013).

The authorities responsible for developing and implementing an Estuary Management Plan therefore depends on the location of the estuary. In the case of the uThongathi Estuary, which falls on the boundary of three municipalities, the authority falls to the provincial environmental department (EDTEA) and the affected municipalities or local government. It is important to note that Local government has three types of Municipalities: Category A (Metro), category B (District municipalities) and category C (Local municipalities) (Reference Constitution clause 155). The local government involved in uThongathi includes one of each of these: the eThekwini Metro, the iLembe District municipality and the KwaDukuza Local Municipality.

Specific provincial and local government legislation and policies relevant to the uThongathi Estuary are given in Table 7.2.

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.

		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
	Land-use and Infrastructure Development	Coastal access	ICMA (2008)	Municipalities
		Off road vehicles & boat launching	ICMA (2008)	Environment Provincial lead agents
		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)		

Table 7.2. Provincial and local government legislation applicable to the uThongathi Estuary

Legislation	Short description
KZN Provisional Coastal Management Programme (CMP) (Provincial Gazette PN 48 of 2020)	Aimed at promoting sustainable coastal development and long-term benefits for the sustainability of coastal resources. CMPs are aimed at aggregating and combining environmental, economic, social and political factors that influence the sustainable utilisation of coastal environments and their resources into plan/s that provide a coordinated approach for coastal managers, practitioners, users and other interested parties (DEA, 2012).
eThekwini Environmental Management Policy	The eThekwini Environmental Policy guides effective municipal implementation of the Integrated Development Plan and promotes environmental sustainability, as well as economic efficiency and social equity.

7.2 Management strategies/plans relevant to the estuary

The eThekwini Municipality Biodiversity Report 2007

This report includes visions and goals for biodiversity as well as actions to implement this. It details the 2007 status of estuaries and other biodiversity areas within the municipality with a list of threats such as include pollution. At the time, the uThongathi Estuary was considered to be in fair health, with 89% of the catchment area being transformed and comprising five fish species, 40 invertebrate families and 80 diatom species.

The eThekwini Municipality Integrated Development Plan (IDP 2020-2021)

The IDP focuses on future development within the municipality with a main focus on prioritization planning, management and monitoring within given timeframes and budgets thereby creating an actionable plan. While it does not mention the uThongathi estuary specifically, it identifies and recognizes that estuaries are an important natural resource which require effective management.

eThekwini Strategic Development Framework (SDF 2017/2018 – 2021/2022)

The aim of this SDF is to guide 'the desirable spatial distribution of land uses within a Municipality in order to give effect not only to the spatial vision, goals and objectives of the Municipality but by directing where the city should intervene in space to achieve its transformational objective.' The SDF notes that estuaries within the eThekwini Municipality are generally in poor condition and that eutrophication as a result of nutrient enrichment is having a detrimental impact on these systems. Suggesting that the reduction of nutrient loading, particularly at wastewater treatment works, could significantly reduce the impact of this threat. The municipality aims to protect specific natural environments, including estuaries, in order to secure a sustained supply of ecosystem services (ES). The economic value of the coastline (estuaries and beaches) was valued at R5 Billion in 2008, and the completion of Estuarine Management Plans was proposed to aid in the protection of these systems.

Durban's Systematic Conservation Assessment (2016)

Durban's Systematic Conservation Assessment (Mclean *et al.* 2016) was designed to provide the necessary information to promote the protection of conservation worthy areas against alternative,

competing land-uses (such as development) and to identify priority areas in which to undertake conservation actions, for the protection of biodiversity and the ecosystem services, before they are transformed or degraded.

Durban Metropolitan Open Space System (D'MOSS 2018)

The Durban Metropolitan Open Space System (D'MOSS) is a conservation plan produced for the eThekwini Metro municipality, which identifies areas of open space important for biodiversity and the provisioning of ecosystem services, that require protection and management, i.e. rivers, wetlands, estuaries, grasslands, forests and coastal zone resources. D'MOSS forms part of Durban's Integrated Development Plan (IDP), Strategic Development Framework (SDF) and the regional Spatial Development Plans (SDP).

Durban's Strategic Environmental Assessment (In progress)

The eThekwini Municipality SEA will seek to proactively inform development plans and programmes of the Municipality, specifically the SDF and the associated Spatial Development Plans (SDPs) by: 1) providing initial information on the sustainability of eThekwini Municipality's proposed development path, as outlined in its SDF and 2) identifying opportunities and constraints which the natural environment places on development. The key outputs of the SEA will include a spatial representation that indicates key areas of risk and opportunity with regard to the biophysical environment in relation to the development path outlined in the SDF and supporting SDPs.

50-year Durban Aerotropolis master plan. Final Draft 2018

This provides a development framework for the next 50 years of growth in the region's premier airport precinct. By anticipating and responding to the region's potential trends and challenges, the master plan creates a favourable physical environment for investment through integrated and coordinated spatial planning, integrated multimodal transport networks, place marketing, infrastructure and engineering services, and environmental sustainability. The uThongathi Estuary is identified as a conservation management zone and future offset area should development happen in sensitive areas.

Dube Tradeport State of the environment report 2015/2016

The state of environment report acts as an important tool that can be used by decision-makers to determine how best to utilise natural resources and ecological goods and services, and to determine the best management and monitoring necessary to improve or maintain the current environmental state. This report recognizes that the current location of Dube Tradeport may indirectly impact areas close to the coastal zone such as the uMdloti and uThongathi Estuaries through reduced water quality. Plans to potentially mitigate this include the implementation of a conservation strategy that incorporates an integrated wastewater management works, reverse osmosis desalination plant and the use of groundwater resources amongst many others.

Ohlanga-Tongati Local Area Plan and Coastal Management Plan (2007)

The Ohlanga-Tongati Local Area contains a section of the national coastal corridor. It also forms the receiving environment for three major river systems in the eThekwini Municipal Area (the Ohlanga,

Umdloti and Tongati), and several smaller catchments draining land near to the coast. It was identified as an area for future growth in terms of local residential tourism and commercial land use. To protect and prioritise the environment, this management plan creates the foundation for managing the natural environment and any land use activities, such as transportation and infrastructure development, within the Ohlanga-Tongati Local Area Plan and Coastal Management Plan.

Northern Spatial Development Plan (NSDP) and Northern Urban Development Corridor (NUDC)

The NSDP provides an update to the land use intentions contained in the Ohlanga Tongati Local Area Plan and Coastal Management Plan. Specifically, it provides broad based land use directives to guide local area planning, land use management, environmental, bulk infrastructure and transportation planning on a smaller scale than the municipal SDF and IDP. Dividing eThekwini into four regions (Central, South, Outer West and North), these plans focus on managing land use and development in the municipal area north of Durban. The Northern Urban Development Corridor Study addresses the long-term planning (to the year 2030) for the area consisting of Phoenix, Verulam and Tongaat, in which the uThongathi Estuary lies, taking into account the provision of engineering services such as transportation, electricity, water supply and sewerage. The NSDP (2013/2014 review) indicated that the proposed development plans would increase the quantity of wastewater disposal into the uThongathi Estuary to a point that will closely mimic its natural state, however, the system currently receives approximately 12% more flow than its Natural Mean annual runoff (see section 2.2)

iLembe Integrated Development Management Plan (Draft 2020/2021 review)

The iLembe District comprises four local municipalities: Mandeni, KwaDukuza, Ndwewe and Maphumulo. The iLembe IDP is a strategic five-year plan with specific objectives with a view to creating a sustainable region which includes adequate management and conservation of the natural resources and also seeks to align the IDP's of the respective local Municipalities. While the uThongathi Estuary is not specifically mentioned nor listed in the IDP, the development of Estuary Management Plans (EMP) is recognized to better manage natural resources and is listed as an objective at the district and local municipality level. The uThukela River and Nyoni/ AmaTigulu River have been identified for the development of an EMP in the Mandeni Municipality while the KwaDukuza Municipality has identified critical estuaries for development of EMPs and whose budget still need to be approved.

The iLembe Environmental Management Framework (EMF)

The iLembe District Municipality is situated along a stretch of KwaZulu Natal coastline that is rich in natural resources such as natural coastal flats vegetation, river valleys and dune areas making it a tourist hotspot and a preferred area for infrastructure development. This places immense pressure on the environment and an environmental management plan is thus needed to preserve the natural environment. This plan aims to mitigate any negative impacts on the natural environment and provides decision making criteria and guidance on any development and or management activities within the district. More specific to estuaries, the management framework aims to improve ecosystem functioning and protection of biodiversity, increase ecosystem goods and services benefits for local communities and provide opportunities to improve tourism and economic development. This includes the designation of sensitive, degraded and under-threat areas; implementation and development of management plans; promoting education and awareness as well as promoting co-

operative governance through the establishment of estuary advisory forums, amongst many other specifications.

iLembe Coastal Management Programme (Draft)

Within the context of an environmental management framework, the coastal management programme seeks to identify and better manage natural resources within the district. Strategies for conservation are developed with an aim of achieving sustainable coastal development through a coastal working group.

iLembe District Municipality Wetland Strategy and Action Plan (2017- 2030)

iLembe District Municipality is implementing the Local Action for Biodiversity: Wetlands South Africa (LAB: Wetlands SA) programme with support from ICLEI Africa Secretariat (ICLEI AS). The LAB: Wetlands SA project aims to ensure the protection of priority natural wetland resources, thus enabling the supply of ecosystem services, and promoting resilient communities and sustainable local economies under a changing climate within South African local governments. Through the development of this WSAP, ICLEI AS will assist iLembe District Municipality in identifying the gaps in management and assist with devising new and better wetlands management strategies going forward.

The KwaDukuza Municipality Integrated Development Plan (IDP 2019-2020)

The IDP details a strategic five-year plan that includes the sustainable development plans and growth within the municipality. It identifies the need for a climate change response strategy to be implemented and recognizes the need for estuary management plans to help conserve their natural corridors and for the protection of resources. Here, the uThongathi Estuary is listed as having a present ecological category of 'E', considered to be in poor to highly degraded condition and recognized as having no management plan. Through the implementation of the Expanded Public Works Programme (EPWP), the cleaning of estuaries is listed as a project to be funded under the EPWP grant. Though the uThongathi Estuary is not listed under the programme specifically, this project would still greatly benefit the overall health of the estuary.

KwaDukuza Strategic Development Framework (SDF 2017)

The role of this framework is to provide strategic guidance for future physical and spatial development of KwaDukuza Municipal area, as well as create a management tool and standardised structure to guide future developments. This framework proposes the development of EMPs for all seven estuaries located within the KwaDukuza Municipality. The framework lists estuaries as 'high value environmental resources' that must be protected, as well as being one of the key driving factors for the tourism sector. It is suggested that rivers and estuaries should be protected from development to create Distinct Open Space/Environmental Systems.

KwaDukuza Biodiversity and Open Space Management Plan

With many of the areas in the municipality being transformed from their natural state especially through the cultivation of sugar cane, a large focus has been placed on identifying priority biodiversity areas. Estuaries have been identified as important priority areas for which formal management plans

should be developed and as priority conservation areas to be considered in any and all future development plans.

KwaDukuza Coastal Management (2016)

In accordance with legislation this CMP was developed for the sustainable use of KwaDukuza's coast, it contains detailed strategies that may be actioned to achieve coastal management objectives. This includes the conservation and rehabilitation of natural resources, appropriate development and redevelopment along the coast and equal access to the coast and its social, economic and environmental benefits. The uThongathi Estuary is listed as having a present ecological category of 'E' and recognized as being in poor condition with poor water quality and a critically endangered threat status. The general objectives of this programme state that coastal resources such as estuarine functional zones need to be protected from degradation and/or damage and recommends that land use zoning provisions as they apply to estuaries be reviewed in order to protect estuaries in terms of the NEM Act and ICM Act, respectively.

7.3 Existing By-laws

eThekwini Metropolitan Municipality Nuisance and Behaviour in Public Places By-law (2015)

To provide for measures preventing, minimising or managing public nuisances; to prohibit certain activities or conduct in public places; to provide for the repeal of laws and savings; and to provide for matters incidental thereto.

eThekwini Metropolitan Municipality Beaches By-law (2015)

To provide for measures to manage, control and regulate public access and behaviour at beaches and beach areas; to provide for the real of laws and savings; and to provide for matters incidental thereto.

eThekwini Metropolitan Municipality Coastal Management By-law (2018)

To provide for measures for managing and protecting the coastal zone; to provide for measures for aligning development within the coastal zone with the objects of the National Environmental Management: Integrated Coastal Management Act; to provide for measures for protecting the natural environment of the coastal zone; to provide for measures for managing public access to the coastal zone; to establish the Municipal Coastal Committee; to give effect to the Municipal Coastal Management Programme; and to provide for matters connected therewith.

7.4 Existing monitoring programmes

National Estuarine Monitoring Programme

Monitoring is undertaken by the Department of Water and Sanitation 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.

Ezemvelo KwaZulu-Natal Wildlife's mouth monitoring programme

Ezemvelo conduct monitoring programmes with the objective of facilitating adaptive management through the assessment of management intervention and the provision of information for achieving the objectives of the Park.

Zimbali lakes and golf course estate: EIA/ 4708 Environmental Monitoring Programme

The development of a resort, golf course, office park and hotel on a large section of land adjacent to the uThongathi Estuary triggered a number of listed activities within NEMA: EIA Regulations and resulted in the need for an Environmental Impact Assessment. This process included the development and implementation of an environmental management programme (EMPr). This involves the management and rehabilitation of the developed wetland and lakes, landscaping and vegetation, waste and stormwater.

8 OPPORTUNITIES AND CONSTRAINTS FOR CONSIDERATION IN EMP

8.1 Constraints

The legal landscape, which encompasses estuaries and governs activities and developments potentially impacting on the coastal marine environment, is managed across a range of sector-based government departments. Taljaard *et al.* (2019) acknowledge that although important for effective governance of the diverse range of issues encountered in the coastal & marine environment, this structural framework can result in confusion, fragmentation, and conflicts that often arise as a result of a lack of understanding of this complexity.

The uThongathi Estuary lies on the border between the eThekwini Metropolitan Municipality, and the KwaDukuza Local Municipality within the larger iLembe District Municipality. Therefore, the management of the system will need to be appropriately divided between authorities within these municipalities, based on the area in which management strategies need to be applied, or else be co-ordinated amongst all three authorities where strategies overlap, therefore requiring a fair amount of cooperative governance. Additionally, the majority of the land adjacent to the estuary, except the unalienated river bed (state owned), is owned by private landowners. Thus, any plan or management of the estuary must be co-ordinated with landowners and municipal authorities together to ensure estuarine management is achievable.

The estuary has been classified as an endangered system of high biodiversity importance in the recent National Biodiversity assessment, however, it has no specific formal protection status and little provision for the formal protection of the estuary.

The poor water quality within the system and the occurrence of sewage spills, malfunctioning infrastructure at the WWTW, pump stations and manholes, poses the most significant and severe risk to the uThongathi Estuary. Nunes *et al*. (2020) reported that the Tongaat Central Wastewater Treatment Works (WWTW) discharges 3.06 x 10^6 m^3 per year, and that nutrient concentrations were reportedly below the accepted WWTW chemical compliance limits in provided in Lemley *et al.* (2014). However, data from the DWS show that compliance has dropped, and sampled values are periodically above the limit (See section 12.2). In addition, the estuary is frequently enriched due to the reduced volumes of freshwater flows from the catchment, increased volumes of wastewater discharge and a loss of wetland habitat that can act as a nutrient sink. The eutrophication of the system as a result of the high nutrient loads causes the invasive aquatic plant species to proliferate and restricts or prevents the growth of natural aquatic primary producers. The total volume of wastewater presently entering the estuary daily from the Tongaat Central and the Frasers Wastewater Treatment Works is 12.4 Ml/day (DWS 2015c, Van Niekerk et al. 2019e). This has resulted in the increase of the present Mean Annual Runoff (MAR) to 112% (79.2 x 10^{-6} m^3/year) of the recorded Natural MAR (70.8 x 10^{-6} m^3/year) (DWS 2015a, Van Niekerk *et al.* 2019)).

Section 19 of the National Water Act, 1998 (Act 36 of 1998) (NWA) states that " An owner of land, a person in control of land or a person who occupies or uses the land on which any activity or process is or was performed or undertaken; or any other situation exists, which causes, has caused or is likely to cause pollution of water resource, must take all reasonable measures to prevent any such pollution from occurring or recurring". Therefore, users up-steam which may be effecting the quality of the

freshwater inflow into the estuary must be held accountable for impacts upon the estuary and the persons or authorities responsible for managing such must be identified.

The estuary is classed as heavily modified with a number of specific ecological categories being severely and even critically modified (See section 3.1). Additionally, fish kills have been recorded in the estuary emphasising that it is already threatened by nutrient and organic loading. However, due to increased current and future developments within the Tongaat town and the Aerotropolis (area surrounding the King Shaka airport that is scheduled to be heavily developed) there are plans to upgrade the Tongaat Central WWTW and increase the volume of effluent discharged into the estuary. While the original Reserve Determination Study for the uThongathi suggested that it was possible to improve the ecological state of the estuary under a scenario in which the volume of wastewater discharge increased to 30 Ml/day, this was contingent on the reversal of human induced influences including the removal of the causeway and nutrients from wastewater discharge, as well as removal of sediment from the catchment (i.e. deepening of the estuary to more natural levels through dredging) (DWAF 2007).

A more recent assessment of possible future scenarios showed that the condition of the estuary could only be retained at its present state if wastewater volumes to a maximum limit of 18 Ml/day were discharged and only after an **improved treatment level** was applied to increase the quality of the effluent. All other scenarios, except the complete cessation of all wastewater discharges, were predicted to cause the condition of the estuary to deteriorate. In addition, it was reported that "*the removal of the weir midway up the uThongathi Estuary will restore some intertidal and water column habitat, but if the water quality conditions do not improve this is effectively "environmental accounting" in which habitat is made available, but is not viable for use*." (DWS 2015a). Therefore, it is imperative that the water quality within the system be improved and that the condition of the effluent discharged into the estuary similarly be improved. The poor ecological condition of the estuary's biotic components (invertebrates, fish and birds, as well as vegetation) will likely only become better with the improvement of water quality within the estuary. Without this intervention, it is likely that any other steps taken to restore the system will only maintain the current ecological state of the estuary or prevent future degradation, with minimal to no net positive effect. It has been suggested that the quality of water flowing into the estuary and within the system can be improved by the restoration of wetlands which are knowns to act as nutrient sinks and sediment traps, as well as contributing to sediment stability (Forbes and Forbes 2012, Robinson 2017).

8.2 Opportunities

Ground was broken, in 2020, for the Zimbali Lakes and Golf Course Residential Development, which falls along, and within, a substantial portion of the northern border of the EFZ, between the estuary mouth and the N2 roadway (Figure 8.1). As part of the conditions of the authorisation of the Environmental Impact Assessment (EIA) stipulated in the Record of Decision (ROD), it was mandated that an Environmental Management Plan be created and approved prior to the commencement of any construction. The Environmental Management Programme (EMPr) was required to include a number of plans/strategic reports that will be highly beneficial to the portions of the EFZ which fall within the property owned by Tongaat Hulett Developments and the estuary itself. These include an estuarine rehabilitation, monitoring and management plan, a stormwater management plan, and a

wetland management and rehabilitation plan. In addition, an Environmental Control Office (ECO) was appointed to monitor activities for compliance with the provisions set out in the EMPr.

Priority management actions brought forward in the Estuary rehabilitation and management plan (MER 2008) for the Zimbali Lakes Estate include:

- The removal of the causeway within the estuary.
- The reinstatement of the floodplain hydrological regime by the removal of drainage networks created to facilitate sugarcane agriculture.
- Clearing of alien vegetation in the riparian zone and on the floodplain.
- The removal of sediment from the estuary to restore estuarine habitat.

Thereby addressing several of the pressures reported to impact the estuary, as well as the recommendations for the improvement of the estuary's ecological status put forward in the NBA. The monitoring plans required within the development will also provide valuable data that has previously been scarce.

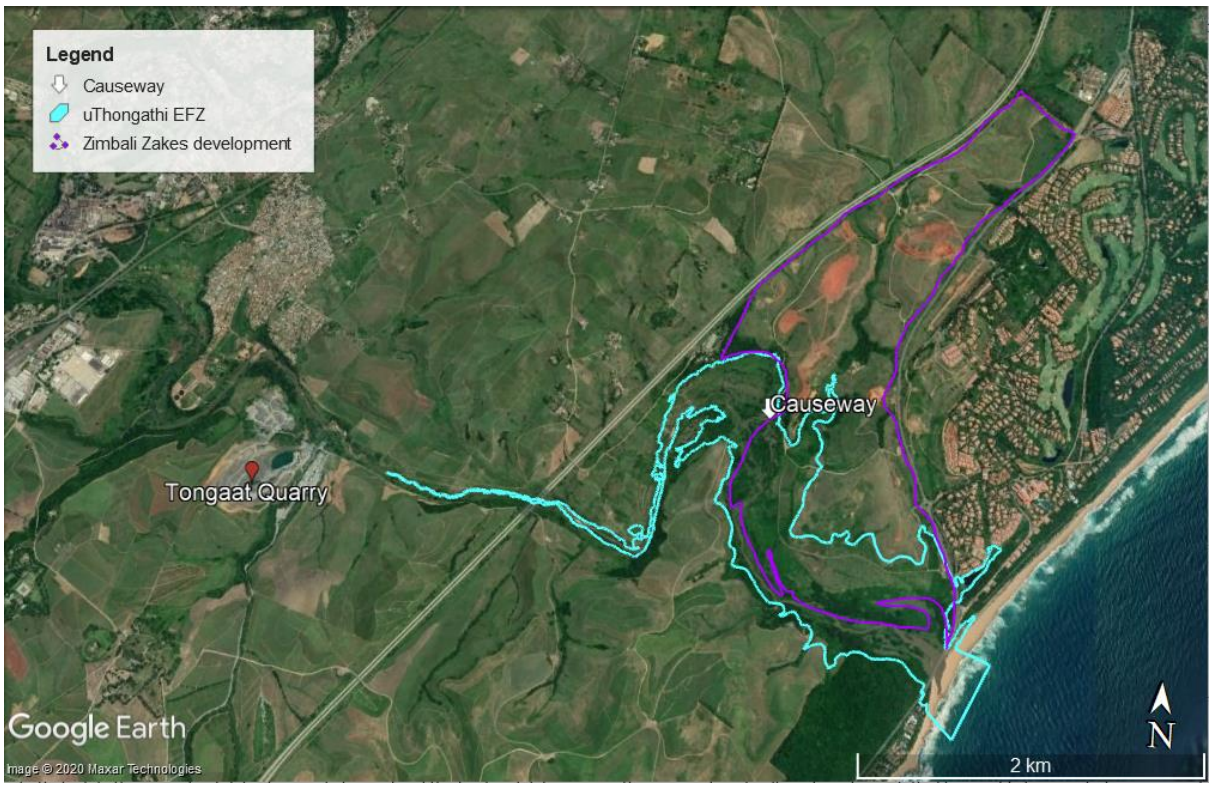


Figure 8.1. **The area of land on which the Zimbali Lakes development will be constructed in relation to the estuarine functional zone.**

The lakes from which the name of the development is derived, will be constructed upon the floodplain on the north bank between the M4 and N2 bridges on an area currently cultivated with sugar cane. The rehabilitation of transformations made to the floodplain for sugarcane cultivation (the removal of riparian/wetland vegetation and reedbed), will in turn involve the levelling out of artificial drainage structures, the eradication of alien plants and the stabilization of surrounding sediments by active

planting programmes. Natural recolonization of the area will likely occur, and it is anticipated that reedswamp and hygrophilous grassland will ultimately be the predominant vegetation type. The removal of sugar cane farming from the floodplain could reduce the perceived need for the artificial breaching of the estuary, as the return of a more natural cycle of flooding/inundation of the floodplain will no longer destroy valuable crops (Mer 2008). The return of the system to a more natural flow regime as well as the linkage of the estuary to the lakes and surrounding wetlands will likely improve water quality. Collectively, these factors will likely have a positive impact on the biotic components of the estuary.

While this development does not encompass the entire estuarine area, it does account for roughly half of the total EFZ therefore substantially reducing the management workload of the local authorities and creating a valuable opportunity to reduce the responsibility while increasing the overall impact of the EMP. However, it will be necessary for the local authorities' estuarine management strategies to be conducted concurrently with those of the the private landowners' efforts, to prevent the latter from becoming redundant.

Additionally, the Tongaat Hulett Maidstone Sugar Mill is not currently discharging any effluent into the Tongati River. Instead, the effluent is being used to irrigate sugarcane fields at Tongaat Hulett's Inyanga Estate. In line with their Water Use License requirements, Tongaat Hulett is planning to install an effluent treatment plant that will allow the Maidstone Sugar Mill to recycle and reuse a portion of its treated effluent, thereby limiting the volume to be discharged to the river in the future (*Pers. Comm*. Sinthi Naidoo, Production manager at Tongaat Hulett, Feb 2021).

9 RECOMMENDATIONS TO ADDRESS MAJOR INFORMATION GAPS

With the exception of a recently published paper on the invasive aquatic plant species in the estuary (Nunes *et al.* 2020), intermittent water quality monitoring as part of the National Estuarine Monitoring programme (NEsMP) and Ezemvelo KwaZulu-Natal Wildlife's mouth monitoring programme, there has been very little research or data collection conducted in the system over the last 10 years. Spatial and temporal replication of information is valuable for enabling researchers to map the changes that occur within a system over time and how the system is responding to human activities.

The following is a list of information identified as being needed to improve on future EWR studies for the uThongathi Estuary (DWS 2015a) this information will also better help provide information as to which aspects of the estuary need more management.

- An improved understanding of the catchment water quality, i.e. sources of contamination, concentrations, seasonal fluctuations, potential for remedial actions to improve water quality.
- Better quantification of inflows to the estuary (river and WWTW) that drive the mouth condition including the mode of delivery. Ideally, river inflow to these small systems needs to be resolved at daily or hourly time scales. It is not sufficient to evaluate these on monthly time steps as required by EWR process. Current flow data is obtained from a flow gauge located approximately 14.5 km from the estuary mouth. A portion of which is diverted to the two dams located off the main river channel between this gauging station and the head of the estuary. Additionally, wastewater is discharged into the system below the gauging station and therefore the actual flow rate entering the head of the system in not known.
- Continuous mouth state data are lacking and need to be acquired (i.e. water level recorder near the mouth).
- Information on the accumulation of toxic substances (e.g. metal, herbicides and pesticides), and the current impact associated with such accumulation needs investigation, especially in the urban systems or those receiving extensive runoff from agricultural areas.
- Improved understanding on the responses of microalgae and macrophytes to various nutrient loading and assimilative capacities is required, as well as the effect on dissolved oxygen processes.
- Long-term data on the composition and functioning of invertebrates, fish and birds are also lacking and need to be improved.

With the upcoming development of the Zimbali lakes in the EFZ and the extensive rehabilitation activities set out in the Environmental Management Programme for the development, there will be a greater opportunity for bird watching and possibly greater access to the estuary itself. It may be worth facilitating the creation of a local birding group that could conduct citizen science bird counts which will provide more regular and on-going bird data for the estuary.

Additionally, there is a lack of clarity around the prescribed roles and responsibilities of various authorities and therefore, confusion with regards to who should be contacted or informed in the event of an emergency or pollution incident. Additionally, there is inadequate capacity in local government institutions and agencies for the enforcement of environmental legislation.

10 WHAT'S NEXT

This Situation Assessment (as determined during a desktop study and stakeholder consultation) provides the background to the current state and condition of the uThongathi Estuary and its biota, as well as highlighting the deficiencies and necessities in terms of management that must be addressed, in order to maintain a functional estuarine system. Next, the local authorities and general public from the surrounding communities will be consulted in a stakeholder meeting to gain their input and perspective on the draft Estuary Management Plan for uThongathi Estuary. The Draft EMP will then be published for a 30-day comments period before it is finalised.

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12 APPENDICES

12.1 Appendix 1 – uThongathi RQOS (DWS 2015b)

PES:	D	REC:	C	TEC:	D*

Key components that require protection to maintain the TEC:
- Baseflows to estuary to maintain mouth state and salinity profile.
- Maintain water quality; and
- Maintain of estuarine riparian habitat.

Components that require interventions to achieve the REC include:
- Restore baseflows to estuary to improve mouth state and salinity profile.
- A significant improvement in water quality needed; and
- Partial restoration of estuarine habitat.
- Remove weir/causeway in upper reaches.
- Prevent low oxygen events that results in fish kills.

Flow:

PES	nMAR (MCM)	pMAR (MCM)
C	70.79	79.21

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).

Present flows poses a risk to the REC.

Sediment processes:

D

- The flood regime maintain the sediment distribution patterns and aquatic habitat (instream physical habitat). The suspended sediment concentration from river inflow do not deviates 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:

B Mouth open conditions should be maintained within the current range: 84% (± 10%).

Water quality: Salinity

C 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 be between 5 and 10 (to be confirmed).

Water quality: Other

F

Ecosystem health:	**Recreational use:** N/A
Water quality poses risk to REC/TEC, sufficiently reduced if: DIN: Freshwater inflow, 50%ile <0.5 mg/l (high risk) DIP: Freshwater inflow, 50%ile <0.125 mg/l (high risk) DO: Lower estuary, average ≥4 mg/l (high risk) Turbidity: Estuary, clear (<15 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)	Not identified as recreational area in stakeholder meeting

Macrophytes (plants)	
D	• 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 further bare patches or unvegetated, cleared areas along the banks. Prevent further disturbance and development of the floodplain habitat. In particular by sugarcane cultivation in the EFZ. • 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 & sedge habitats (< 50 % loss of reed & sedge habitats in non-flood year).
Inverts	
E	As sampled by plankton net, grab and dip nets/traps (as appropriate): • Population abundances of plankton and benthic assemblages (baselines to be set) should not deviate by more than 50%. • Zooplankton should be dominated by estuarine copepods *Acartia natalensis* and *Pseudodiaptomus hessei*, but include other groups such as mysids. Meroplankton occur frequently. • Macrobenthos should be abundant and dominated by polychaetes but should include amphipods, isopods, tanaids, polychaetes and the crab *Hymenosoma projectum.* Insect taxa should occur in the far upper reaches only. • Chironomid larvae and oligochaetes should not occur in abundance and should not dominate the benthos. • Penaeid and carid prawns should occur. • Sandprawn *Callichirus kraussi* should occur in sandy areas in the systems lower reaches (to be confirmed). • Molluscan assemblage should include bivalves and gastropods. • Large brachyuran crabs (macrocrustacea) should include *Scylla serrata*, *Varuna litterata, Macrophthalmus sp.,* Sesarmidae and *Uca sp,* • Invasive alien species do not dominate macrobenthos in lower reaches.
Fish	
E	As sampled by seine and gill net in open waters: • 10 species should occur to include freshwater, estuarine resident and estuarine dependant marine fishes. • Estuarine resident species should comprise a minimum of 3 species. • *Glossogobius callidus, Myxus capensis* and *Rhabdosargus holubi* should occur with 100% frequency of occurrence (every sampling trip). • *Pomadasys commersonni* should be sampled with 30% frequency of occurrence. • Pelagic piscivores should occur (including *Caranx* spp.). • No alien fish species should occur. • Fish should be free of lesions and other anomalies related to water quality. No fish kills should occur.

12.2 Appendix 2 – Water quality data

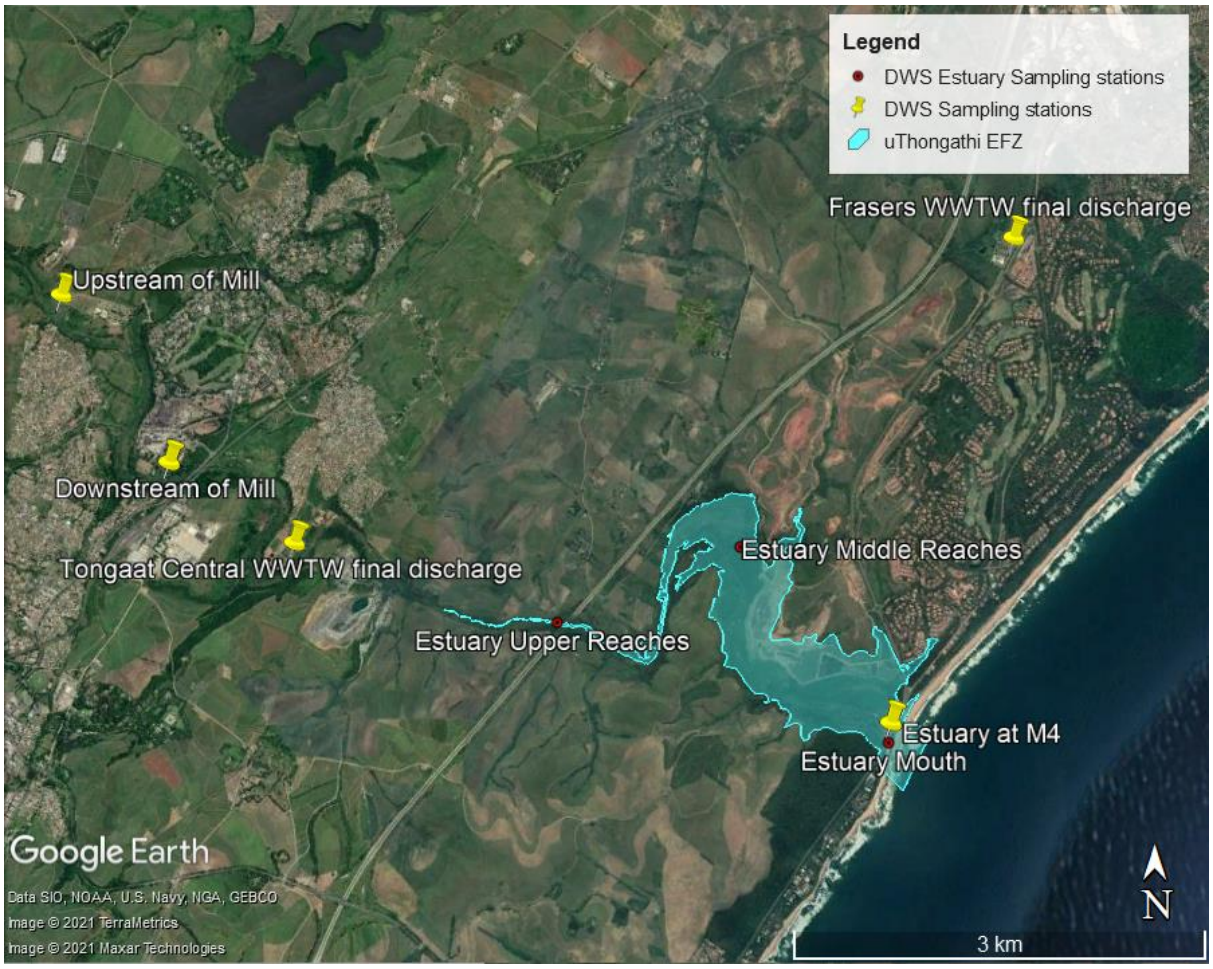


Figure 12.1 **Map showing the location of the DWS water quality sampling stations for the river, Wastewater Treatment Works (WWTW) and Estuarine sampling stations.**

According to the General Authorisation (Notice No 665 dated 6 September 2013) under Section 21(f) of The National Water Act (Act 36 of 1998) Act for Discharging waste or water containing waste into a water resource through a pipe, canal, sewer, sea outfall or other conduit, volumes of up to 2Ml/Day may be discharge into a water course provided it meets the general wastewater limit values, volumes greater than 2Ml/Day must adhere to special limits. Effluent specifications have been summarised below in Table 12.1.

Table 12.1 **Effluent specification showing the upper limit of permissible nutrient levels for wastewater discharges.**

Contaminant	Unit	General Limits	Special limits
COD (Chemical Oxygen Demand)	mg/l	75	30
Ammonia Nitrogen	mg – N/l	6	2
Nitrate Nitrogen	mg – N/l	15	1.5
Total Phosphorous	mg – P/l	10	1 (median) & 2.5 (maximum)

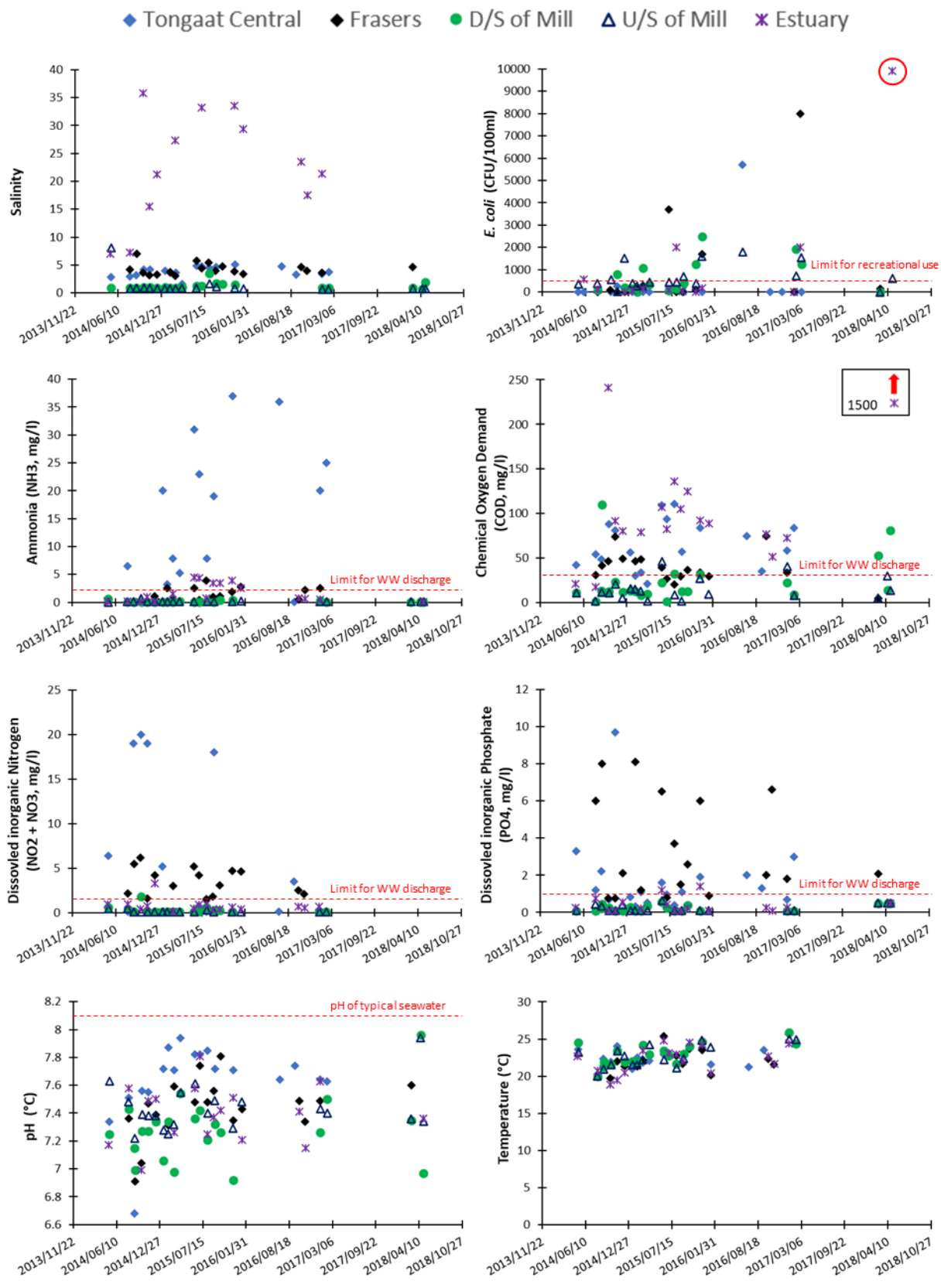


Figure 12.2 **Water quality data for the five DWS sampling stations shown in Figure 12.1: Wastewater Treatment works - Tongaat Central and Frasers; River stations - Upstream of the Sugar Mill and Downstream of the Sugar Mill; and a single Estuary site at the mouth. Red lines represent the upper limit of permissible nutrient levels for wastewater discharges, recreational use, or values typical of seawater.**

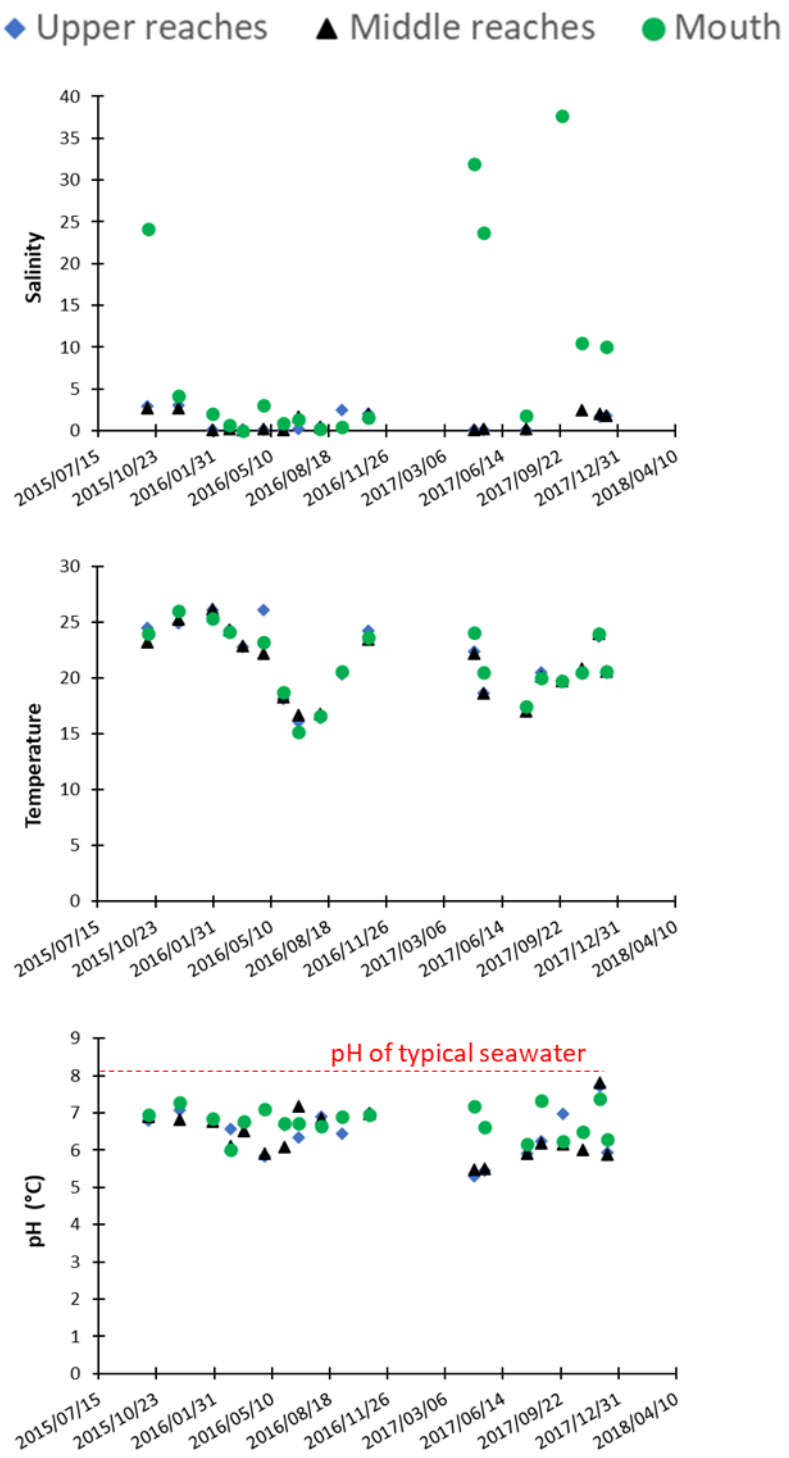


Figure 12.3. **Water quality data for the three DWS Estuarine sampling stations shown in Figure 12.1: Upper Reaches, Middle reaches and at the Estuary Mouth. Parameters include Salinity (Top), Temperature (°C, Middle) and pH (Bottom).**



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