Environmental Impact Assessment (EIA) for the Proposed Construction, Operation and Decommissioning of a Sea Water Reverse Osmosis Plant and Associated Infrastructure Proposed at Lovu on the KwaZulu-Natal South Coast

FINAL EIA REPORT

CHAPTER 7: ESTUARINE ECOLOGY

ABBREVIATIONS, UNITS & GLOSSARY

KZN	KwaZulu-Natal
BIR	Botanical Importance Rating
EIA	Environmental Impact Assessment
TOCE	Temporarily open/closed estuary
LC50	Lethal Concentration 50: The concentration of contaminant that results in 50% mortality of test organisms

EXECUTIVE SUMMARY

The purpose of this assessment was to determine the potential impacts of Umgeni Water's proposed desalination plant to be located on the upper south side of the Lovu Estuary. A literature review of the estuaries biophysical characteristics and a field study of the system's physicochemistry, estuarine vegetation and the fish community was undertaken to determine the current state and functional integrity of the system as an estuary. The Lovu Estuary, although small in national terms, is an important functional estuary and contributes significantly to the estuarine resources on this section of the KwaZulu-Natal coastline. Estuarine resources are under threat from development pressure, overexploitation and pollution at provincial, bioregional, national and international levels. These environments are therefore conservation worthy and any further impacts on these systems must be critically assessed.

Having established that the estuary is worthy of protection an Environmental Impact Assessment (EIA) of envisaged potential impacts arising from the proposed development was completed for the proposed desalination plant and associated infrastructure. This assessment of potential impacts did not indicate any fatal flaws for any individual impact and most were assessed with a high degree of confidence. The following impacts were identified and assessed in this Estuarine Ecological Impact Assessment:

<u>Construction Phase</u>

- Loss of vegetation during the construction of the proposed plant and installation of pipelines. For the most part, vegetation that will be most affected is of little conservation significance (and indeed a significant proportion of it is cultivated sugar cane). This impact was therefore regarded as being of low significance.
- Impacts on the ecological corridor between the proposed plant and the estuarine channel.
- Noise during proposed construction, installation of pipelines and decommissioning of the plant will disturb fauna. The assessment concluded that noise had the potential to impact on local fauna but that the temporary nature mostly resulted in this impact having a medium significance score. However, the impacts on fish from vibrations due to tunneling beneath the estuary are largely unknown and hence the assessment for this is made with a low degree of confidence.
- Potential for increased estuarine turbidity with consequent impacts on aquatic fauna during excavation for the proposed plant construction and installation of pipelines. The probability of this impact occurring is dependent on frequency, duration and intensity of rainfall events. Good site hygiene and stormwater management should be standard practice and the overall significance was rated as low.
- Possible release of contaminants from the old dumpsite during excavation for pipeline installation. Due to the unknown nature of the contaminants that may be present in the dumpsite effects could not be predicted with a high level of confidence. It is thus recommended that a toxicity study be conducted on sediment leachates from the

dumpsite. This will inform developers of how excavated material could be stored, used as fill material, or should be disposed of.

Operational Phase

- Impacts on the ecological corridor between the proposed plant and the channel.
- Possible entrainment of brine into the surf zone that could potentially impact on recruitment of juvenile fish into the estuary. The frequency and duration and intensity of these conditions were predicted to be very low and the impact scored an overall low significance rating.
- Noise during plant operation. It is expected that with the measures to dampen noise in the plant design, impacts will be of low significance.

The following key mitigation measures are recommended:

- A setback distance of 25 m for the Preferred site to increase the ecological corridor between the development and the estuarine channel.
- Re-vegetate as soon as possible with appropriate species such as fast growing indigenous grasses following excavation and installation of pipelines. Further restoration should involve planting and successfully re-vegetating the disturbed area with indigenous shrubs and trees.
- Reduce vehicle speed limits to reduce noise (during construction and operational phases).
- Measures must be taken to prevent runoff from disturbed construction areas carrying silts, clays, muds or other sediments, excavated materials, building sands and other potential contaminants into the estuary These measures may include the use of sediment traps and geotextile blankets to prevent discharge of sediments into the estuary during rainfall events during and after construction. A monitoring programme will need to be implemented in the event of inflows into the estuary from construction areas resulting in noticeable elevation in turbidity. Ideally however, such inflows should not occur, and every effort must be made to prevent them.
- Limit construction footprint and undertake awareness training for all staff (flora and fauna).

Assessment of the potential impact associated with release of contaminants from the old dumpsite could not be made with a high degree of confidence since the nature, concentrations and hence possible effects on biota are unknown. As the contaminants, if present, are unknown it is difficult to determine what parameters should be analysed chemically to assess potential effects on biota. The specialists thus strongly recommend that sediment leachates from the dumpsite be tested for toxicity prior to installation of the pipelines. This will inform the developer about appropriate handling, storage, use and disposal of excavated material from the dumpsite.

The construction of the proposed desalination plant at the Preferred site or at the Alternative site is anticipated to result is estuarine impacts of similar significance, providing that the recommended management actions are effectively implemented, in particular a setback distance of 25 m for the Preferred site to increase the ecological corridor between the development and the estuarine channel. Note that the Alternative site has slightly lower risk of being impacted by major floods. In the event of a major rainfall and flood event this would entail less risk in terms of damage to the facility and this in turn will reduce the risk of any chemicals that are used and stored in the facility being washed into the estuary with the storm flows.

The alternatives proposed for the seawater and brine pipeline routing between the seawater intake and desalination plant scored similarly in terms of vegetation impacts as there is no substantial loss of indigenous vegetation. While impacts of noise levels on fauna also scored similarly, it is uncertain if noise levels and vibrations due to the use of tunnelling equipment for Alternative 2 will have greater impact than the Preferred route or Alternative 1. The assessment in this case was made with a low degree of confidence.

In conclusion, from a perspective of potential estuarine impacts, the specialists recommend:

- A setback distance of 25 m for the Preferred site of the desalination plant to increase the ecological corridor between the development and the estuarine channel.
- While there is no strong indication for selection of any of the various seawater and brine pipeline routes in terms of vegetation impacts, there is some uncertainty regarding potential impacts on groundwater (although anticipated to be unlikely) and impacts of vibrations and noise from tunnelling activities incurred in Alternative 2. This will cross, and potentially impacts a sensitive area of estuary. Given this, selection of the options that involve north bank routing (Preferred and Alternatives 1 and 3) are recommended over alternative 2.
- For Alternative 2, the reception pit for tunnelling on the south bank should be moved by at least 100 to 130 m further west.
- If any of the tunnelling options are selected for pipeline routing (Alternatives 2 and 3), it is imperative that there is **no disposal** of excavated material, slurry (including bentonite mixes) wastewater (including waters treated with flocculants) within the floodplain of the estuary or the waterbody. All wastes should be appropriately disposed of (at registered dumpsites or recycled if appropriate). While the only toxicity reference to bentonite was an LC50 of 19 g.l-1 (for rainbow trout), the author (SP) has previously tested a range of drilling fluids which indicated potential toxicity to sensitive species or more especially to early life stages such as gametes, larvae and juveniles.

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7. LOVU ESTUARINE IMPACT SPECIALIST STUDY

This chapter presents the estuarine ecology specialist study undertaken by Mr Steven Weerts and Mrs Shamilla Pillay from CSIR as part of the Environmental Impact Assessment for the proposed 150 Ml Seawater Reverse Osmosis Plant and associated infrastructure in Lovu, KwaZulu Natal. An independent review of this report was undertaken by Prof Tris Wooldridge from Nelson Mandela Metropolitan University (refer to Appendix A).

7.1 INTRODUCTION

The Coastal systems group of the CSIR was appointed to undertake an Estuarine Ecological Impact study as part of the Environmental Impact Assessment (EIA) for the Umgeni Water's proposed desalination plant and associated infrastructure located at the Lovu Estuary, south of central Durban.

7.1.1 Scope of Work

The scope of work of this assessment includes:

- A general description of the local environment;
- A literature review of environmental information;
- A field survey to ground truth estuarine vegetation and identify sensitive species/ communities. Mapping of the vegetation communities to determine botanical importance;
- A once off field study of estuarine fish species for comparison with existing data;
- Impact assessment with and without mitigation of the proposed development on the estuarine resources; and
- If the proposed project is not found to be fatally flawed and if applicable, additional relevant recommendations on possible rehabilitation procedures/ management guidelines are to be proposed.

7.1.2 Study Approach

7.1.2.1 Desktop Study

A review of available environmental information was undertaken to describe the Lovu Estuary (including floodplain) in terms of the estuarine functioning. This included biotic composition, physicochemical conditions, current status, relative conservation importance etc. These data were compared to the data collected during the field survey undertaken as part of this assessment.

7.1.2.2 Estuarine Surveys

A field survey of the Lovu estuary was undertaken on 30th April 2015 to conduct fish and vegetation surveys for the purpose of accessing current state and for comparison with historical information where available. The following methods were employed:

- Land coverage was verified and designated on orthophotographs and aerial views (Google Earth) of the estuary. These data were later digitized using Google Earth and coverage of estuarine vegetation was determined for calculation of the botanical importance of the Lovu Estuary;
- Fish surveys were conducted at 6 sites from the lagoon to the upper section of the Lovu Estuary using gill and seine nets. At each site a YSI multiparameter sonde was deployed through the water column to measure a range of physicochemical water quality parameters of relevance to the health of estuarine biota.

7.1.2.3 Impact Assessment/mitigation and management recommendations

The impact assessment, without and with recommended mitigation measures, was conducted according to the standard protocol described in Chapter 4 of the Draft EIA Report. Based on this, recommendations on the preferred options are made. Where relevant, additional management actions to avoid or reduce the significance of negative impacts are also recommended.

7.1.3 Information Sources

Mapping of land cover was done using orthophotographs and Google Earth images. All other information was obtained from published papers or reports which are appropriately referenced within this report. A field survey was conducted to provide additional data on estuarine status.

7.1.4 Assumptions and Limitations

The following assumptions and limitations apply:

- Potential impacts associated with a proposed pilot plant were not included in the scope of this EIA and are not assessed as part of this work. Should the layout, processes, intakes and outlets of the pilot plant differ from those described for the development assessed here, different impacts might be expected.
- It is assumed that the construction methodologies will not entail any artificial manipulation of the mouth of the estuary. Essentially this means that water will not be abstracted from the estuary or river, that would lead to flow reductions and possible increases in mouth closure. Similarly, if the system does close during construction or operation of the plant and its associated infrastrucute, there will be no need to artificially breach the estuary mouth. In the unlikely event that mouth breaching is required permission to do so will need to be sought from the relevant authorities including *Ezemvelo* KZN Wildlife and the provincial Department Economic Development, Tourism and Environmental Affairs. Advice from suitably qualified and experience estuarine ecologists should be sought on the authorization, timing, duration, nature and location of the breach.
- Only one baseline monitoring study was undertaken for the fish resources as part of this assessment. As such seasonal variations cannot be accounted for but data from previous studies have been included in the review of the estuarine components to provide a more comprehensive assessment of fish communities.

- No estuarine water or sediment quality assessment was undertaken for this study, with the exception of physicochemical water quality measurements taken during fish sampling as these are of relevance to biological health. However the turbidity measurements will be of relevance should there be a need for monitoring this parameter during construction.
- The release of contaminants from the old dumpsite has not been specifically addressed in terms of measurement of particular parameters. This is due to the unknown nature of the contaminants and thus difficulty in determining what parameters should be measured. However mitigation will be proposed regarding this potential impact.
- Assessment of the impacts of tunneling is based on the assumption that all waste materials including excavated materials, bentonite slurry and any wastewater will be removed and disposed of appropriately (e.g. registered dumpsite or recycled where possible) i.e. no disposal within the estuarine floodplain or waterbody.
- It is assumed that mitigation measures inherent to the project design, as detailed in the project description, will be implemented regardless of additional mitigation measures recommended in this study (i.e. ratings for impact significance 'without additional mitigation' is assumed to already include mitigation measures inherent to the design). Mitigation measures pertaining to this specific field of study and that are assumed to be inherent to the project design include engineering design of the proposed plant to incorporate noise reduction measures that will efficiently damp down noise during operation of the plant.
- The authors are not aware of any additional proposed developments that may impact on the Lovu Estuary. In addition, there are no permanent (irreversible) impacts envisaged in terms of estuarine ecological functioning due to the current proposed development if the recommended alternatives are selected. Based on this no cumulative effects are envisaged. However, it must be noted that estuaries along the coast have been variously impacted with some being in poor state (e.g. the Isipingo). It is thus assumed that recommended mitigation measures will be implemented to prevent additional stresses on the estuarine resources locally and nationally.

7.2 PROJECT DESCRIPTION: ESTUARINE ECOLOGICAL IMPACT STUDY

Development along the coastline of South Africa has in many instances resulted in impacts and stresses on the limited estuarine resources of the county. Estuaries are amongst the most productive ecosystems on earth, far more so than their inflowing riverine and adjacent marine ecosystems (e.g. Costanza *et al*., 1997; Kimmerer 2002; Simenstad *et al*., 2000; Kennish 2004; Robins *et al*., 2006). They are critical migration links between marine spawning grounds and freshwater habitats for several species (such as anguillid eels). They support diverse resident fauna and flora, but importantly also provide critical nursery habitat for marine fish and shellfish, and therefore have ecological roles affecting resources at wider coastal scales. Many South Africans are directly or indirectly reliant on coastal ecosystems for their livelihoods, while others use these ecosystems for recreational purposes. The importance of estuaries and the goods and services they provide to humans is now widely recognised. With a decline of these systems at all scales (worldwide, regional, national and local), both in terms of direct losses due to coastal development and indirect losses due to flow modifications and pollution, increasing obligation and public pressure is placed on relevant authorities, managers and users to manage these resources wisely for wider and greater societal benefit. Thus any proposed developments that could affect estuarine resources must be adequately assessed for potential impacts.

This study provides an Estuarine Ecological Impact Assessment of Umgeni Water's proposed desalination plant and associated infrastructure, the details of which are described in Chapter 2 of the Draft EIA Report. In this study the status of the various estuarine components is firstly described based on review of information and data from previous studies of the Lovu Estuary. Further data to validate and update existing information were collected through a once off field survey of the fish community and determination of coverage by estuarine plant communities to characterize the estuary and floodplain components. These data are used to describe the health and importance of this system in terms of estuarine resources and functioning.

Several aspects of the proposed development, such as noise and excavation and construction activities on or near the flood plain for construction and operation of the desalination plant and intake and effluent pipelines, are expected to have some impact on estuarine resources. These are identified and assessed in this study to determine if there are fatal flaws that would result in rejection of the project or parts thereof. For identified impacts which are not considered to present flaws to the project, mitigation measures to remove or reduce severity of such impacts are recommended. Additional management recommendations to protect estuarine resources are also indicated as necessary.

A detailed description of the engineering works entailed in the proposed development is given is Chapter 2 of this EIA assessment report. The detailed (estuarine) impact assessment is dealt with later in this report (section 7.4-). However, at the outset, and for the benefit of the reader, it is useful to draw on some of the key infrastructural developments and operations that have the most direct potential impacts and are of immediate relevance to the estuary, and also to point out some of the characteristics of proposed activity that will result in little, or at least less impact to the estuary than otherwise have been the case if other design options were being considered.

Intake water will be marine and the proposed intake will occur at sea north of the estuary in approximately 20 m of water, 1000 m offshore. This is approximately 1400 m from the 'normal' mouth breach position. Similarly, brine discharge will be to sea, via a marine outfall running parallel to the intake pipe, but in shallower water and at least 650 m offshore. In many cases in other parts of the world estuaries are used, both as water sources (estuarine intakes) and as wastewater receptors (brine outfalls). This results in various estuarine impacts which are often significant. These are clearly not of pertinence here. That said it is possible that brine discharge to sea in the vicinity of the estuary mouth may result in impacts associated with disruption of salinity cues for species that recruit into the estuary from the sea (notably larval and juvenile fishes and crustaceans).

Options for siting the proposed reverse osmosis plant are both located outside of the river 1:100 year flood plain on land that is presently under sugar cane cultivation, and therefore has limited ecological value. Similarly the intake pump station is located outside of the river 1:100 year flood plain at a distance far enough from the estuary to have negligible impact.

In most layouts being considered, with little exception, all permanent infrastructure (including planned terrestrial seawater and brine pipelines) will be developed outside of the estuarine functional zone which is defined as the 5 m topographical contour (5 m above mean sea level). The exception is an area of back-flooding at the estuary mouth which develops along the beach as a northward extension of the estuary during extended periods of mouth closure Proposed marine intake and outfall pipes will cut across this section of the system. Of note is that these pipes will be tunnelled well below the substrate level and long term impacts on (even this localised section of) the estuary are expected to be negligible. Planned crossing of pipelines at the head of the estuary (Pipeline Alternatives 1 and 3, Figure 2.3) will be by specially constructed pipe bridge which is unlikely to have any significant impact within the estuary functional zone. One layout option (Pipeline Alternative 2, Figure 2.3) involves the routing of seawater and brine pipelines beneath the estuary, and this clearly traverses a significant section of the estuarine functional zone (albeit buried well below a depth that can be expected to result in significant long term impacts). In all cases product water will be pumped away from the plant by use of existing nearby bulk water pipeline.

From the above it is apparent that seawater and brine pipelines between the intake pump station and desalination plant are the most likely sources of potential impact arising from the proposed development. While these pipelines are located, for the most part, outside of the estuarine functional zone, they do, at points come close to the estuary, and also cross the system (either by bridging or tunnelling). They occur within the 1:100 year flood line, and, in a natural (unimpacted) system vegetation here would be riparian or have estuary associations, effectively forming part of an estuarine-terrestrial continuum. Assessment of this was one of the focuses of the estuarine ecology impact assessment study.

7.3 DESCRIPTION OF THE AFFECTED ENVIRONMENT

The Lovu Estuary (30° 06' 34.87''S : 30° 51' 01.33''E) is located some 37 km south of central Durban and is one of 16 estuaries located in the eThekwini Municipality. The Lovu River is a small to medium sized system being approximately 135 km in length (Begg, 1978) and delivering a mean annual flow of 6.2 $m^{3}\cdot sec^{-1}$. The estuary closes periodically under conditions of low flow and marine sediments building up at the mouth. It is therefore classified as a temporarily open/closed estuary or TOCE (Whitfield, 1992). The major part of the estuarine water body varies in depth from < 0.5 to 2.3 m (Begg, 1984) depending on rainfall, river flow and mouth and tidal conditions. However for most part the water level is about 1 m and large areas of exposed sand/mud banks are present. Both vertical and horizontal salinity gradients are apparent in the system (CSIR unpublished; Forbes and Demetriades, 2008).

Surrounding urban and/or agricultural development has impacted the Lovu Estuary reduced the ecological goods and services that the system could provide. This is true of the vast majority of estuaries in KwaZulu-Natal, South Africa (and indeed worldwide). Major impacts on the system included causeways, road and rail bridges that impact both the floodplain and channel characteristics. Other impacts have also occurred historically, and continue in the present day. These include physical alteration and destruction of habitat, as well as pollution. Evidence of sand mining along the northern bank was observed in 2012 during a site visit by Aurecon (Figure 7.1a & b) and has also been reported by Forbes and Demetriades (2008). A dumpsite for solid waste was created within the wetland on the north bank in the early days when authorities were less sensitive to the value of estuarine resources. Historically the system was subject to pollution from the adjacent sugar mill. Currently there is still a carpark and sports field on the north bank. With the exception of the lowermost reaches, the floodplain of the estuary has been cleared for sugar cane cultivation, which has occurred at least since the early 1900s. In spite of these changes the determination of the estuarine health index for KwaZulu-Natal (KZN) estuaries (Cooper *et al*., 1994) resulted in an aesthetic value (which makes up part of the health index) of 7.5 out of maximum of 10.

Figure 7.1a Disturbance from sand mining operations along the northern bank of the Lovu River

Figure 7.1b Evidence of sand mining along the northern bank of the Lovu River

7.3.1 Review of previous studies of the Lovu Estuary

7.3.1.1 Mouth dynamics

As indicated above the Lovu is a temporarily open/closed system estuary (i.e. it periodically closes to the sea). Mouth state (open vs. closed) is governed primarily by freshwater flows and marine sediment dynamics. Both of these drivers fluctuate seasonally. Freshwater flows closely follow rainfall patterns, being lowest in the winter and highest in the summer months. The accumulation of marine sediments at the mouth is generally greatest during the winter months when wave height and energy is greatest on the KZN coast. Mouth closure is therefore most frequent during the winter months.

Frequency and duration of mouth closure has significant impacts upon the physicochemical and biological character of temporarily open/closed estuaries and is therefore an important determinant of these systems' ecologies (Whitfield *et al.*, 2008; 2012). The Lovu is a system which is more open than closed. Begg (1984) reported the system to remain open for 75% of the time. His study was based on mouth observations from May 1978 to December 1982. Over this period there were considerable differences in mouth state in different years, ranging from being open 95% of the time in 1979 to 45% in 1980. These differences were attributable to drought (Forbes and Demetriades, 2008). Begg's (1984) data indicate mouth closure typically occurs during the months from April to August, are generally months of lower rainfall on the KZN coastal belt. In more recent years *Ezemvelo* KZN Wildlife have begun to keep a record of mouth observations on the system, and although not complete this record suggest that the system remains open for 80% of the time, and that closures typically occur during the months from May to August.

7.3.1.2 Water Quality

As indicated above the open mouth condition (which is these systems predominant state) results in a tidal prism and salinity penetration into the estuary. Recent measurements (Forbes and Demetriades, 2008) indicated salinity intrusion some 3.6 km upstream from the mouth. Surface waters in the upper reaches are usually fresh but salinity stratification occurs even in waters below a metre in depth (Begg, 1984). Historically water quality was often impaired in the system due to leachate from the dumpsite, accidental discharges from the sugar mill and possibly sewage from septic tanks since very high faecal coliforms have been recorded. Low dissolved oxygen in bottom waters was also a common feature of the system and still occurs in backwater areas. More recently it would appear that there has been substantial improvement in water quality in that relatively low levels of nutrients and oxygen impairment were measured (Forbes and Demetriades, 2008). This is probably due lower levels of contamination from the dumpsite leachates and fewer accidental spillages into the system. However, there was indication of algal blooms at the time (i.e. 2007/2008) so the low nutrient levels could have been a result of these being bound in algal biomass. This study confirmed the findings of surveys made in 1992 (CSIR, unpublished) where relatively low levels of nutrients were present, but some chlorophyll records were higher than 15 $\mu g.l^{-1}$ indicating elevated algal productivity. There are no records for organic contaminants such as herbicides and pesticides or heavy metals for the system. In the estuarine health index score for KZN estuaries (Cooper *et al*., 1994) the water quality component for the Lovu scored 6.8 out of maximum of 10.

7.3.1.3 Floodplain Vegetation

Estuarine vegetation has been previously assessed by the current author (SP, unpublished). As indicated above the floodplain of Lovu has been severely impacted. Bank alteration and encroachment of sugar cane cultivation onto the floodplain is evident in even the earliest available (1937) aerial photographs. Other interventions (use of the northern bank as a dumpsite, sports field, recreational and parking area) further degraded the floodplain by the infilling of wetland area. A *Phragmites* reedswamp community occurs along the north bank of the estuary and along the south bank west of the N2 freeway. A very narrow fringe of reeds is present along the waters’ edge at the south bank of lower estuary and along the north bank up to the mid estuary. A stand of *Hibiscus tiliaceus* occurs along the south bank of the lower estuary but its distribution is limited by the steep rise in terrain on the landward side. Upstream a fringe of riverine vegetation occurs along the banks of the river and the coastal vegetation surrounding this on both the north and south sides are disturbed and alien infested. Dune thicket occurs along the coast on either side of the estuary. Further upstream the area is characterized by agricultural development.

Estuarine vegetation in terms of community composition/habitat type at the Lovu is considered less important than some of the other local (eThekwini area) systems as the most significant habitat in the system in terms of coverage is reed swamp which is common to most estuaries. Nonetheless the ecological services (nutrient and contaminant assimilation, filtering capacity, detritus supply) contributed by floodplain vegetation i.e. its functional importance in terms of overall estuarine ecology and functioning, must not be under estimated.

7.3.1.4 Algal Communities

No studies on phytoplankton species or algal community composition for the Lovu could be found, but the author (SP) noted during several visits to the estuary in the early 1990s that both phytoplankton blooms and blue green algae scums were present on exposed sand/mud banks. Nutrient enrichment from runoff from the adjacent sugar cane fields, sewage contaminated stormwater and seepage and previously accidental discharges from the mill are likely to have been sources of nutrient enrichment into the system.

7.3.1.5 Invertebrates

Begg (1984) conducted several trawl surveys (essentially sampling larger epibenthic fauna) and found that the fauna was dominated by the prawn *Metapenaeus monoceros* but that the three migratory penaeid prawn species were also present. Three estuarine crab species (which included *Paratylodiplax blephariskios* and *Scylla serrata* which have an obligatory marine breeding phase) and one intertidal species were noted. During visits to the estuary in the early 1990s the author (SP) of this report noted the presence of an abundance of amphipods and sandprawn *Callichirus kraussi* on the central intertidal sandbank.

Benthic analyses of grab samples taken at the mouth, mid and upper estuary in August 2007 and January 2008 (Forbes and Demetriades, 2008) indicated highest diversity in the more marine influenced areas of the estuary. Highest diversity occurred amongst the polychaetes (5 species) followed by amphipods (4 species) and high abundance of the tanaid *Halmyrapseudes digitalis* was recorded at the mouth and mid reaches of the estuary in winter, and at the mouth in summer. The invasive alien gastropod *Tarebia granifera* was also present at the Lovu Estuary. The authors of these surveys rated the estuary as being fair in terms of the benthic invertebrate community as higher diversity was expected given the frequency of open mouth conditions.

Dr Allan Connell (pers. comm. – unpublished data) conducted zooplankton surveys of all the estuaries from the Mtamvuna to the Mhlathuze in September 1999 and found that the Lovu was one of the richest estuaries with settled zooplankton volume from a standard 50 m haul being 20 cm^3. This high volume was largely due to a high density of the mysid *Mesopodopsis africana* and the two estuarine copepods *Psudeodiaptomus hessei* and *Acartia natalensis*. Repeat surveys in October 2000 showed slightly lower settled volumes due largely to an almost complete absence of the mysid.

7.3.1.6 Fish

Several fish surveys have been conducted at the Lovu Estuary. Begg (1984) sampled 27 species by beam trawling over seven months in 1980 and 1981. Overall, the fish assemblage was dominated by small estuarine species, including most notable the goby *Oligolepis acutipennis* and estuarine roundherring *Gilchristella aestuaria*. Sampling gear undoubtedly had an impact on the actual and relative abundances of fishes sampled, and larger, more mobile marine species were under sampled during these surveys. Harrison and co-workers (CSIR unpublished data) used seine and gill nets to sample the estuary in 1998 and recorded a much wider variety of species (32) with overall fish abundance dominated by marine dependant estuarine species (mullet). *Gilchristella aestuaria* nevertheless remained a significant component of the fish assemblage. Based on these results, and comparing them with data from other estuaries sampled in the subtropical bioregions, Harrison *et al*. (2000) categorised the Lovu estuarine fish assemblage as being in a moderate condition.

More recently the system was sampled as part of a post graduate research at the University of KwaZulu-Natal (winter and summer surveys in 2006). Twenty-two taxa were recorded, with mullet dominating fish abundance (Mclean *et al*., 2006, cited in Forbes and Detmetriades, 2008). Surveys that followed in winter 2007 and summer 2008 (Forbes and Detmetriades, 2008) yielded 16 taxa, again dominated by mullet.

Dr Allan Connell (pers. comm. - unpublished data) conducted larval recruitment studies at the estuary over incoming spring tides from October 2005 to February 2006 and April 2007 to January 2008). Large numbers of several species were found to recruit into the system from the marine environment. These included springer *Elops machnata* and tarpon *Megalops cyprinoides* in summer months and glassies *Ambassis* spp. in autumn months. Moonies *Monodactylus* spp. and Cape stumpnose *Rhabdosargus holubi* recruited throughout the year, along with several species of mullet. Goby larvae were also abundant at times. Most larvae were approximately thirty days old and the predominance of species with strong estuarine associations indicated that recruitment was not passive. This is supported by research conducted elsewhere which has shown that estuarine dependent marine spawning species actively follow fresh- and estuarine water cues to locate and recruit into estuarine nurseries (Boehlert and Mundy, 1988; James *et al*., 2008). The predominance of open mouth conditions in the Lovu Estuary and its relatively large size render it important as a fish nursery area on the eThekwini and KwaZulu-Natal coast, where small temporary open/closed estuaries numerically dominate the wider estuarine resource.

7.3.1.7 Birds

In an exercise to prioritize estuaries for conservation using bird populations as an indicator (Turpie, 1995) the Lovu Estuary was ranked 41 out of 42 estuaries based on a species richness score of 20. By way of comparison the highest ranking estuary was the Mhlathuze with a score of 68. In more recent surveys conducted in the winter of 2007 and summer of 2008 (Forbes and Demetriades, 2008) 14 species (total count 69) and 28 species (total count 195) were recorded respectively. The highest abundances were for the sanderling and common ringed plover in summer and the swift tern in both surveys.

7.3.2 Results of the Vegetation and Fish Surveys

7.3.2.1 Vegetation Community Survey

As indicated in the review above the author (SP) has previously surveyed the floodplain for estuarine vegetation and mapped these communities onto orthophotographs. During this study the land cover along the estuary was categorized and digitized using Google Earth (Figure 7.2). No significant qualitative or quantitative changes in estuarine vegetation cover were noted during this survey and hence the reader is referred to section 7.3.1.2 for a general account of these communities. It would, however, appear that alien infestation of the riparian/dune communities along the estuary has increased. Invasive species include both shrubs (e.g. *Chromolaena odorata*, *Lantana camara*, *Riccinus communis*) and trees (e.g. *Melia azedarach*, *Syzygium cumini, Litsea sebifera*). The most invasive tree species, however, was the Brazilian pepper tree *Schinus terebinthifolius*, with severe infestation throughout the estuarine floodplain.

Figure 7.3 indicates the planned siting of infrastructure for the proposed desalination project overlayed onto the landcover map for clarity regarding vegetation communities that may be impacted.

As illustrated in Figure 7.2 the only communities of relevance for determination of estuarine botanical importance of the Lovu Estuary are reeds, small stands of hibiscus (lagoon swamp forest), intertidal sandbanks (benthic algae) and the water body (phytoplankton). When determining the botanical importance of a particular estuary the scores obtained are compared to the highest scoring estuary regionally or nationally whichever is appropriate for the purpose. The development and use of botanical importance ratings have undergone various developments over the years (Coetzee *et al*., 1997; Colloty *et al*., 2000) to incorporate habitat degradation, community rarity etc. For the purpose of this study, the Lovu was compared to the uMgeni, the highest scoring and one of the larger estuaries within the eThekwini Municipality. This provided an importance rating in the context of the local region. Comparison with much larger estuaries such as the St Lucia and Kosi Bay systems (for reasons of the large size of these systems) would have resulted in a misleadingly low functional importance evaluation of smaller systems along this section of the coast.

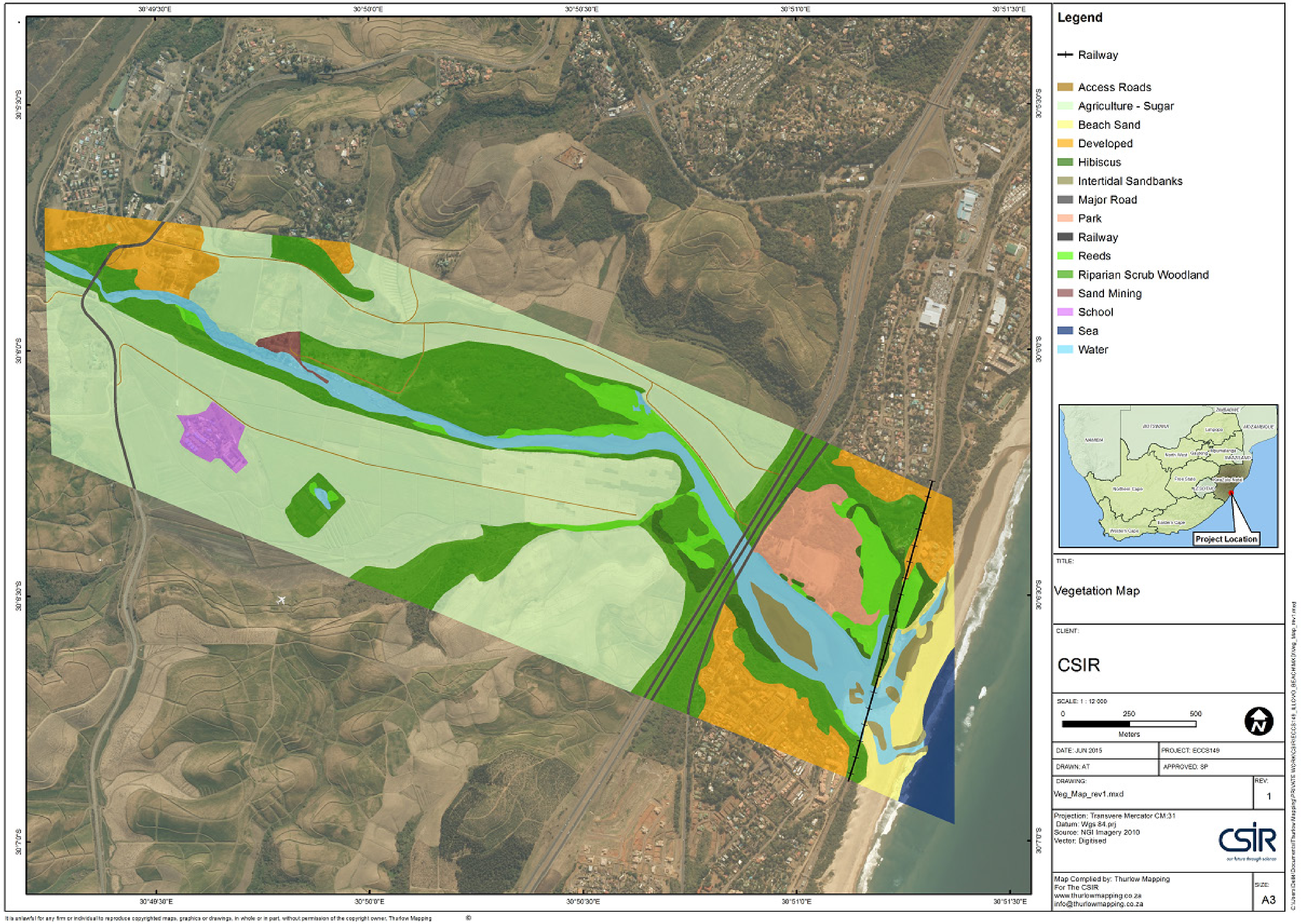

Figure 7.2 Land cover along the Lovu Estuary digitized in Google Earth to indicate distribution of estuarine vegetation along the floodplain

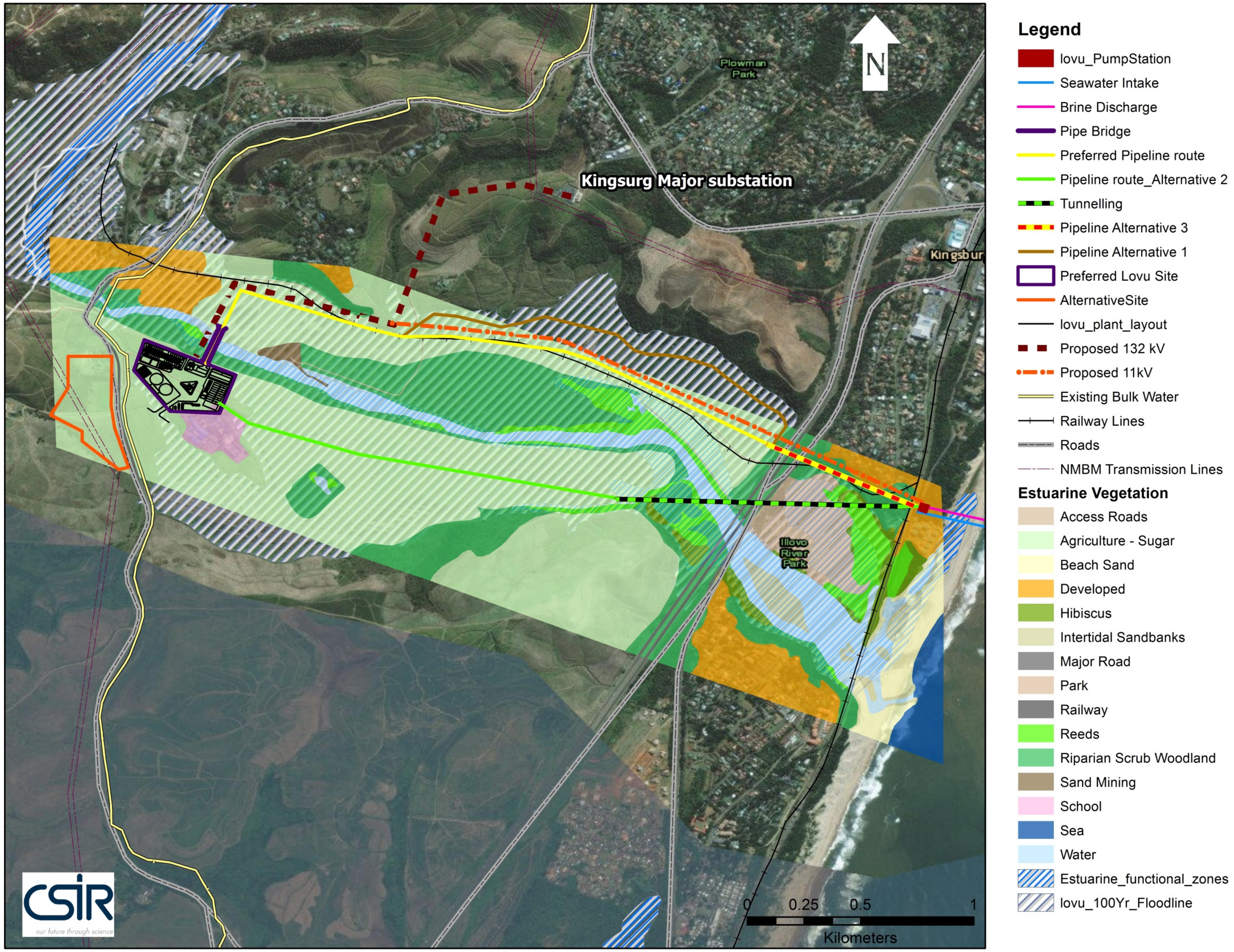

Figure 7.3 Planned infrastructure overlaid onto land cover map

A simplified botanical index using coverage (areas), the standard productivity factor for each community type and the weighted community importance of each community type was used to compare the two systems. Usually botanical importance includes a degradation index but comparison of the uMgeni with the Lovu indicates that both these systems have been significantly degraded due to floodplain land use, the existence and bridges, water quality impacts, other anthropogenic effects such as littering and footpaths, and in case of the former, large dams in the catchment. The degradation index has thus been excluded. The coverage in hectares of each community type and the productivity score {community importance factor x coverage (area in hectares) x community productivity factor} is given in Table 7.1. The botanical importance Rating represents the sum of these according to the formula:

$$BIR = 1.5(area_{RS}X1384) + 1.5(area_{IS}X\ 124) + 1.75(area_{LSF}\ X\ 1890) + 1(area_{w}\ X\ 163) + 2(area_{M}\ X\ 1835)$$

[*Where: RS = Reed Swamp; IS = Intertidal Sandbanks; LSF = Lagoon Swamp Forest; W = Water; M = Mangroves*]

Table 7.1 Coverage by community type and productivity scores for estuarine communities

Community Type	**A. Community Importance Factor**	**B. Coverage** (hectares)	**C. Productivity Factor**	**Productivity score (AxBxC)**
Lovu Estuary				
Reed Swamp (reeds and sedges)	1.5	16.415	1 384	34 077.54
Intertidal Sandbanks (benthic algae)	1.5	5.483	124	1 019.84
Lagoon Swamp Forest (hibiscus)	1.75	6.224	1 890	20 585.88
Water (phytoplankton)	1	30.452	163	4 963.68
Botanical Importance Rating (=Total Productivity Score)				**60 646.94**
uMgeni Estuary				
Reed Swamp (reeds and sedges)	1.5	9.841	1 384	20 429.91
Intertidal Sandbanks (benthic algae)	1.5	4.142	124	770.42
Lagoon Swamp Forest (hibiscus)	1.75	5.679	1 890	18 783.29
Water (phytoplankton)	1	36.993	163	6 029.86
Mangroves	2	20.284	1 835	74 442.28
Botanical Importance Rating (=Total Productivity Score)				**120 455.76**

The calculated botanical importance score for the Lovu Estuary is thus 60 646.94 and that of the uMgeni is 120 455.76. When comparing estuaries these large numbers are converted to percentages of the highest scoring estuary. The practice is thus to produce a normalised botanical importance score by reducing the score of the highest ranking estuary to 100 so that all other estuaries are ranked as a percentage of 100. Therefore in this instance if the uMgeni is given a score of 100 then the Lovu would achieve a botanical importance score of 50. The difference is due to the presence and extent of a mangrove stand in the uMgeni, which is a permanently open system. This scoring provides some context of value in terms of the larger estuaries situated within this local region of the coastline. Thus although the Lovu would score relatively low if compared on a national basis due to relatively small size and low community diversity, it is clear that it is of significant value in a local context where the overwhelming majority of estuaries are small temporarily open/closed systems. These small estuaries collectively make important contributions to provincial estuarine habitat and the provisioning of estuarine goods and services along the wider reach of the KZN coastline. All these estuaries have furthermore been subjected to development impacts and are currently in various states of degradation making it imperative that estuarine resources in this area are appropriately protected against further trajectory of negative environmental change.

7.3.2.2 Physicochemical Water Quality Parameters

Physicochemical water quality parameters of significance to estuarine biota were measured *in situ* at sites where seine nets were deployed for the fish assessment (S1-S7, Figure 7.3). The results obtained for surface and bottom waters (with the exception of site S4 which was very shallow) are presented in Table 7.2. As seine netting was conducted along the shoreline, depths sampled were generally shallow and bottom readings were typically taken at ~1 m.

Table 7.2 Results for physicochemical parameters measured along the Lovu Estuary

Site	Temperature (°C)	Salinity	pH	Turbidity (NTU)	Chlorophyll-*a* (µg/L)	Dissolved Oxygen Saturation (%)	Dissolved Oxygen (mg/L)
S1 surface	22.37	15.12	8.21	4.60	7.97	107.18	8.53
S1 bottom	23.06	18.99	8.21	4.82	13.72	108.94	8.37
S2 surface	23.45	16.48	8.21	4.52	10.34	116.83	9.04
S2 bottom	23.51	16.64	8.17	5.81	13.35	117.92	9.10
S3 surface	24.17	16.79	7.32	5.34	8.15	115.09	8.77
S3 bottom	24.84	23.94	7.34	8.36	31.84	124.87	9.03
S4 surface	25.92	13.75	8.21	10.24	3.20	130.55	9.82
S5 surface	24.42	13.06	7.84	6.11	9.43	111.44	8.64
S5 bottom	26.04	21.96	7.80	9.58	19.04	104.24	7.47
S6 surface	25.08	13.18	8.13	5.91	11.00	120.21	9.20
S6 bottom	27.25	21.86	7.83	10.55	24.63	110.60	7.77
S7 surface	26.04	11.19	7.96	8.31	13.64	117.04	8.91
S7 bottom	27.12	15.65	7.80	15.30	22.41	110.61	8.06

Despite being closed at the time of sampling salinity measurements indicated a marked marine influence throughout the sampling area which extended to approximately 4 km upstream from the mouth. Although the multi parameter probe was deployed in relatively shallow areas there was evidence of vertical salinity gradient with greater salinity recorded in bottom waters at each site. The highest salinity (>23) was measured in bottom water at the site S3 in the lower reaches of the estuary.

Turbidity measurements were relatively throughout the estuary, typically <10NTU. Turbidities in KwaZulu-Natal estuaries are generally higher than those in open marine water. The highest turbidity measure in the Lovu in April 2015 was 15.3 NTU in bottom waters at the uppermost sampling site (S7). The generally low turbidity measurements in the system were the result of sampling being conducted during a relative dry period with little preceding rainfall and riverine sediments being delivered into the estuary. Forbes and Demetriades (2008) similarly reported low turbidity (range 4.7 – 15.1 NTU) in August 2007 (low flow period) compared to February 2008 (range 16 – 29 NTU, high flow period).

Chlorophyll-*a* measurements indicated nutrient enrichment in the system with the highest levels being recorded in the more saline bottom waters. Algal productivity resulted in the supersaturated oxygen concentrations measured in the system. The highest oxygen saturation level was measured at Site s4 (surface waters) where intertidal and shallow subtidal benthic algae probably contributed to oxygen levels in the water.

One water sample from the lower estuary was examined qualitatively to determine the dominant phytoplankton present in the system. The algal community was essentially composed of diatoms with a single species of *Navicula* being numerically dominant. Two unknown species of dinoflagellates and three species of euglenoids were also present in the sample. The absence of cyanophytes (blue green algae) such as *Osillatoria* indicated that the system was not severely eutrophic.

During this survey none of the measured physicochemical parameters were expected to impact adversely on the biota in the system.

Figure 7.4 Physicochemical water quality and fish sampling sites (Google Earth, 2015)

7.3.2.3 Fish community survey

Twenty-one species were sampled in the Lovu Estuary in April 2015 (Table 7.3). Estuarine dependent marine species dominated seine net catches numerically, either in the form of Cape stumpnose *Rhabdosargus holubi*, Natal stumpnose *Rhabdosargus sarba*, or groovy head mullet *Liza dumerilii*. These species are typical of KwaZulu-Natal temporary open/closed estuaries, but the relative abundance of *L. dumerilii*, together with the presence of several marine species such the slimy *Leiognathus equula* and blacktail *Diplodus sargus* is indicative of a system which is subject to frequent penetration by marine (saline) water and which has a mouth which is frequently open to the marine environment.

Surprisingly few estuarine resident fishes were recorded in April 2015, and those that did occur were sampled in relatively low abundances. This suggests possible system degradation and with the high algal productivity noted during fish sampling is a source of some concern, although more frequent sampling would be needed to make a more confident assessment of the system's state. Based on the data at hand there is little to suggest that the system has changed from being in a "Fair" condition as assigned by Forbes and Demetriades (2008) based on their field work in 2007 and 2008.

Although impacted, the estuary has considerable more value as an estuarine resource than indicated by Begg (1978). Turpie *et al*. (2002) ranked the Lovu 80th of ~ 250 South African estuaries in terms of its conservation status. On a more localised scale, given the estuary's relative large size and the degradation of nearby systems, the Lovu must be regarded as an important system. Several of the fishes reported from the estuary are important in estuarine- and shore fisheries. These included the stumpnoses *Rhabdosargus* spp., river bream *Acanthopagrus vegas*, spotted grunter *Pomadasys commersonnii*, kingfishes *Carynx* spp. and barracuda *Sphyraena* spp. All of these species have populations which are declining, in part because of overexploitation, but also because of habitat losses and particularly because of loss of estuarine nursery area. At least one species listed under the National Environmental Management: Biodiversity Act 10 of 2004: Amendment R1187 of 2007 occurs in the estuary (*Myxus capensis*, vulnerable). Conservation importance and vulnerability of estuarine fishes in South Africa is better reflected in the IUCN Red List of Threatened Species (IUCN 2015), which includes several fish species which have been sampled in the Lovu Estuary. These include fishery species (such as *A. vegas*) but are more commonly small estuarine fishes with a high degree of habitat specificity (e.g. *Oligolepis acutipennis*). Fish surveys of the Lovu are generally limited to fish sampling gears that are historically used in South African systems, and which target fishes in open habitats. Despite being in a highly modified state, and having undergone significant habitat alteration and destruction over the years, there is still a good deal of structured reed habitat in the Lovu Estuary which undoubtedly supports fish species which have not yet been reported in the system. These will be small cryptic estuarine residents and are likely to include several Red Listed species not currently reported from the estuary, such as checked goby *Redigobius dewaali*, dusky sleeper *Eleotris fusca*, and barbelly pipefine *Hippichthys spicifer*.

Table 7.3 Relative abundance (%) of different fishes sampled (% abundance) by seine net at sites (Figure 7.3) on the Lovu Estuary (April 2015). (IUCN 2015 Red List category (version 3.1) indicated, LC = Least Concern, DD = Data Deficient)

Species	S1	S2	S3	S4	S5	S6	S7
Estuarine resident species							
Ambassis ambassis (LC)					3.8		
Ambassis natalensis				32.0			
Oligolepis acutipennis (DD)						3.1	
Estuarine dependant marine species							
Myxus capensis			14.3		7.7	1.6	
Liza macrolepis			1.3	1.6		16.3	
Mugil cephalus			1.3	0.8			
Pomadasys commersonnii						2.3	
Rhabdosargus holubi	44.4	71.1	33.8	3.1	34.6	50.4	58.3
Terapon jarbua (LC)			23.4	3.9		0.8	
Valamugil cunnesius				7.0	3.8	17.1	
Gerres filamentosus (LC)			6.5				
Gerres methueni			1.3			0.8	
Leiognathus equula					3.8	1.6	8.3
Liza dumerilii	50.0	7.9	6.5	50.0			8.3
Rhabdosargus sarba	2.8	18.4	6.5	1.6	42.3		8.3
Carynx sp.			1.3			3.1	16.7
Diplodus sargus	2.8						
Sphyraena sp.		2.6					
Valamugil buchanani			3.9				
Freshwater species							
Glossogobius giuris						2.3	
Oreochromis mossambicus					3.8	0.8	

7.4 IDENTIFICATION OF KEY ISSUES AND POTENTIAL IMPACTS

7.4.1 Key Issues Identified During the Scoping Phase

Phase 1 (Construction phase):

1. Destruction and disturbance of floodplain vegetation especially significant for Alternative 2 of the pipeline route.
2. Permanent destruction of on-site vegetation and disturbance of adjacent floodplain vegetation during construction of the proposed desalination plant.
3. Increased turbidity in the estuary during excavation and construction activities. Resultant effects on fauna and possible increased siltation and smothering of benthic fauna.
4. Potential release of contaminants from old dumpsite into the estuary during excavation for pipelines on the north bank.

5. Disturbance to bird populations (noise, movement of machinery and workers).

Phase 2 (Operational phase): Discharge of wastewater (brine) to the nearshore environment

1. Possible entrainment of brine into the nearshore environment at the mouth of estuary. If salinities are increased at the mouth then there are potential impacts on recruitment into the estuary due to loss of cues such as reduced salinity.

Phase 2 (Operational Phase): Noise from operation of the desalination plant

1. Noise can result in disturbance to fauna especially birds.

It is important to note that the impact of noise on sensitive areas and receptors (such as residential areas, construction personnel etc.) is the subject of a separate Noise Impact Assessment specialist study (Chapter 9 of this Draft EIA Report).

The following key issues were identified during the public consultation period on the scoping report:

eThekwini's Environmental Planning and Climate Protection Department made the following comments:

- This Department is concerned as to the proximity of the northern edge of the proposed plant to the Ilovu Estuary. Further comment will be provided once a detailed site layout is provided. However on principle all structures must be located as far from the river as possible.
- Impacts associated with the proposed crossing of the Ilovu Estuary must be addressed as part of the EIR.

7.4.2 Identification of Potential Impacts

Phase 1 (Construction phase): Construction of the proposed desalination plant and associated infrastructures

1. Destruction and disturbance of floodplain vegetation as a result of the construction of the seawater intake and brine discharge pipelines.

2. Permanent destruction of on-site vegetation and disturbance of adjacent floodplain vegetation during construction of the proposed desalination plant.

3. Increased turbidity in the estuary during excavation and construction of the pipelines and desalination plant, resulting in effects on fauna and possible increased siltation and smothering of benthic fauna.

4. Potential release of contaminants from old dumpsite into the estuary as a result of the construction of the seawater intake and brine discharge pipelines.

5. Disturbance to bird populations and other fauna (noise, movement of machinery and workers).

Phase 2 (Operational phase): Discharge of wastewater (brine) to the nearshore environment

1. Possible entrainment of brine into the nearshore environment at the mouth of estuary. If salinities are increased at the mouth then there are potential impacts on recruitment into the estuary due to loss of cues such as reduced salinity.

2. Possible contamination in the region of mouth of the estuary from chemicals used in the treatment process that may still be present in residual concentrations in the discharged brine.

Phase 2 (Operational phase): Stormwater

1. Increased hard surfaces at the proposed plant will cause an increased runoff coefficient and the discharge point into the estuary could be subject to erosion.

Phase 2 (Operational phase): Noise during plant operation

1. Mitigation is provided by the engineering design of the plant but there is uncertainty about the actual noise level that would occur during operation.

Phase 3 (Decommissioning phase): Noise during decommissioning of plant

1. Noise during removal of equipment etc. from the plant and increased traffic.

7.5 PERMIT REQUIREMENTS

No permit applications have been submitted as part of this specialist study. Potential development and consequent impacts on the estuary may be subject to the following legislative requirements:

The legislative context is provided by two conventions of which South Africa is signatory:

1. The Convention on Biological Diversity (1992) ensures that every effort is made to conserve all species; and
2. The Action Plan of the Environmental Initiative of the New Partnership for Africa's Development (NEPAD of 2003) promotes sustainable development and implies the need to conserve biodiversity while advocating wise use of our natural resources.

South African legislation applicable to estuarine fauna and flora are:

1. The National Environmental Management: Biodiversity Act 10 of 2004: Amendment R1187 of 2007 ensures the protection of all species and prohibits any destruction of or damage to any threatened or keystone species and ecosystems. (Threatened fish species, including species listed under the National Environmental Management Biodiversity Act, have been recorded in the Lovu Estuary –see fish report section 7.3.2.3).
2. The National Environmental Management: Integrated Coastal Management Act 24 of 2008; Section 33- The Estuarine Management Protocol. The protocol provides guidance for the management of estuaries through the development of individual estuarine management plans (Note that the local authority is responsible to develop such plan together with stakeholder contributions).

3. KZN Provincial Nature Conservation Ordinance (1974): Protected indigenous plants are controlled under the relevant provincial Ordinances or Acts. In terms of this Ordinance, a permit must be obtained from *Ezemvelo* KZN Wildlife to remove or destroy any plants listed in the Ordinance (*Hibiscus tiliaceus* is of relevance in this study).

7.6 ASSESSMENT OF IMPACTS AND IDENTIFICATION OF MANAGEMENT ACTIONS

7.6.1 Construction Phase

7.6.1.1 Potential Impact 1: Increased estuarine turbidity due to the construction of the proposed desalination plant (direct impact).

Construction activities for the proposed desalination plant for both site alternatives will entail excavation for foundations as well as transport and storage of building sand. Rainfall events during construction may result in discharge of sediments into the estuary. The resultant effect would be increased turbidity and potential for increased sedimentation in the estuary should large volumes enter the estuary. This would lead to impacts on biota in the system including:

- Loss of visual cues affecting feeding in predatory fish;
- In the case of a severe event there is potential for clogging of fish gills and filter feeding structure in invertebrates;
- High sediment inputs will result in smothering of benthic fauna; and
- Aesthetic quality will be reduced.

While these effects are expected to be largely temporary, large inputs of sediments, should they occur, will impact benthic fauna which may require greater than two years to recover. Without mitigation increased turbidity in the estuary is likely to occur especially if intense rainfall events occur during the construction period. The intensity of the impact will depend, inter alia, on the severity and frequency of rainfall events. Impact intensity is assessed to be medium as the area covered by the development is low in relation to the remaining floodplain and the current land use i.e. sugar cane farming is likely to be currently causing similar impacts. The overall significance of this negative impact is rated as **low** with a high level of confidence, without the implementation of key mitigation measures.

Key mitigation measures proposed include:

- Measures must be taken to prevent runoff from disturbed construction areas carrying sediments (and other contaminants) into the estuary. These measures may include the use of sediment traps and geotextile blankets to prevent discharge of sediments into the estuary during construction. If construction operations unavoidably result in increased turbidity in the river or estuary, then a monitoring programme should be implemented. Turbidity impacts must be restricted in severity, area and duration. Tentative action levels are given here, which can be modified based on the development of a monitoring programme by a suitable qualified and experienced estuarine ecologist and informed by more measured data on turbidity in the Lovu Estuary than presently exists. If operations cause turbidity to increase over an area of more than 20 m (axial length) by more 20 NTU from ambient levels (taken as an average of readings in unaffected upstream and downstream waters) during mouth open conditions, operations should cease and/or immediate remedial measures must be taken. If operations cause turbidity to increase over an area of more than 20 m (axial length) by more 10 NTU from ambient levels (taken as an average of readings in unaffected upstream and downstream waters) during mouth closed conditions, operations should cease and/or immediate remedial measures must be taken.

Additionally mitigation measures recommended by specialist to manage this impact include:

- If possible, excavation and trenching should be planned to occur during the low rainfall period (winter).

The effective implementation of the above key mitigation measures is likely to reduce the significance of this potential impact to **very low**.

7.6.1.2 Potential Impact 2: Increased estuarine turbidity during installation of seawater intake and brine discharge pipelines (direct impact).

Preferred pipeline route and Alternatives 1 and 3- North bank routing and bridging over upper estuary with and without tunnelling

Excavation for installation of the proposed seawater intake and brine discharge pipelines along a current service line and bridging of these across the upper estuary, indicated as the Preferred Pipeline route (in yellow) in Figure 7.3, will cause similar risk of increased turbidity as described in section 7.6.1.1 above. The routing of Pipeline Alternative 1 (shown in brown in Figure 7.3) slightly north of the preferred option is not expected to have any significant reduction in impacts and for the purposes of this estuarine assessment hereafter both options are simply treated similarly in terms of envisaged impacts. Effects of increased turbidity on water quality and biota will be the same as described in section 7.6.1.1 above. The impact assessment is thus also the same and is predicted to have an overall **low** significance without the implementation of key mitigation measures. The level of confidence in the assessment is high.

Key mitigation measures proposed include:

- Measures must be taken to prevent runoff from disturbed construction areas carrying sediments (and other contaminants) into the estuary. These measures may include the use of sediment traps and geotextile blankets to prevent discharge of sediments into the estuary during construction. A turbidity monitoring programme (as described above in section 7.6.1.1) may be required in the event of inflows into the estuary from construction areas resulting in noticeable elevation in turbidity. Ideally however, such inflows should not occur, and every effort must be made to prevent them.
- Revegetate excavated areas with appropriate species (see section 7.6.1.3).

Additionally mitigation measures proposed by specialists include:

- If possible, excavation and trenching should be planned to occur during the low rainfall period (winter).

With the effective Implementation of the above key mitigation measures will slightly reduce the significance of the impact to **very low** through reduced severity and probability of occurrence.

Alternative 2 - Tunnelling beneath the estuary and routing across the lower estuary

For Pipeline Alternative 2, the installation of the proposed seawater and brine pipelines across the lower estuary is also expected to result in turbidity impacts during excavation activities for the non-tunnelled section and during the establishment of temporary work areas at the proposed entry and exit sites on either side of the estuary for the tunnelled section. The effects on the water quality and biota may be similar to those described for Alternative 1 but proximity to the mouth of the estuary could also result in a risk of turbidity effects in the nearshore environment. Furthermore, for this alternative the proximity of construction activities to the estuarine water's edge increases the probability, and possibly severity, of turbidity impacts on the estuary. Given the above, impacts associated with increased estuarine turbidity during the construction of Alternative 2 pipeline route are predicted to be of **medium** significance without the implementation of key mitigation measures.

A concern associated with drilling is the possibility of frac-outs, which are generally defined as an inadvertent return of drilling fluids to the surface or into the adjacent soil or rock. Frac-outs generally occur in very coarse-grained sands containing material in the size range of pebbles to cobbles. Given the anticipated geology along the proposed route (i.e. mostly consolidated materials/bedrock), it is very unlikely that this type of material could be encountered in the course of the drilling operations. Umgeni is planning to use water based drilling muds which are biodegradable and typically consist of a mixture of water and bentonite. It might, however, contain small quantities of trace metals. Bentonite is an inert clay material and is considered essentially non-toxic to aquatic organisms, although it can have adverse physical effects on organisms that become coated with the clay. Drilling mud losses could cause temporary and localised increases in turbidity and suspended solids concentrations in surface water and also promote siltation in underlying shallow alluvial aquifers. Although the occurrence of frac-outs associated with drilling is possible, the potential related impact on surface and groundwater quality, and knock-on effects on aquatic fauna and flora, is anticipated to be of low-medium intensity, spatially localized and persistent in the short-term only. Overall, the significance of the potential impacts associated with frac-outs is therefore anticipated to be **low**.

Key mitigation measures proposed include:

- Measures must be taken to prevent runoff from disturbed construction areas carrying sediments (and other contaminants) into the estuary. These measures may include the use of sediment traps and geotextile blankets to prevent discharge of sediments into the estuary during construction. A turbidity monitoring programme (as described above in section 7.6.1.1) may be required in the event of inflows into the estuary from construction areas resulting in noticeable elevation in turbidity. Ideally however, such inflows should not occur, and every effort must be made to prevent them.
- Re-vegetate impacted areas as soon as possible (see section 7.6.1.3).

- Monitor estuarine water quality prior to, during and after drilling operations. This should include *in situ* monitoring of physicochemical parameters (pH, salinity, turbidity, dissolved oxygen) as well as grab samples taken for laboratory analysis (metals, hydrocarbons). Monitoring should be conducted during tunnelling operations on a weekly basis at least. This frequency may be amended based on ongoing review of results and assessment of risks.

Additionally mitigation measures proposed by specialist include:

- If possible excavation and trenching should be conducted during the low rainfall period (winter).

Implementation of key mitigation measures will reduce the overall significance of this negative impact to **low**.

7.6.1.3 Potential Impact 3: Removal of indigenous vegetation for construction of the proposed desalination plant

Both site alternatives (Figure 7.3) have similar impacts regarding removal/disturbance of vegetation at, and adjacent to, the proposed desalination plant and thus the impact assessment is the same for both sites. Both sites are currently under sugar cane cultivation which has no value in terms of conservation. However, the preferred option is very closer to the main estuarine channel and therefore potentials limits space for terrestrial and semi-aquatic vertebrates and invertebrates to move up and down the system. There may therefore be some restriction of an ecological corridor between the proposed plant and the channel. Loss of any indigenous species and impact on the ecological corridor for the Preferred site and adjacent areas is considered probable, resulting in an overall significance assessment of **Medium**. For the Alternative site, this impact is predicted to be of **very low** significance.

Key mitigation measure is limited to:

- For the Preferred site move the development back to create at least a 25 metre extension between the development and the channel.
- Endeavour to control the footprint of the development.

The overall rating with mitigation is expected to be **very low** and the confidence level in the assessment is high.

7.6.1.4 Potential Impact 4: Removal/disturbance of indigenous vegetation during pipeline installation

Preferred pipeline route and alternatives 1 and 3 – North Bank Routing

These alternatives essentially route the pipelines along a current service line and thus, impacts on surrounding vegetation are expected to be minimal. Furthermore, with the exception of some riparian vegetation (which is severely alien infested) in the vicinity of the proposed bridge (i.e. where the pipeline is proposed to cross the estuary) and similar communities between the proposed pump station and the N2 freeway, the proposed route is located within sugar cultivation areas which are of little conservation significance. The loss of some indigenous species is, however, considered probable and this results in an overall **very low** significance.

Key mitigation measures proposed include:

- Rehabilitate the riparian vegetation community in the region of the proposed bridge as soon as construction activities are completed. Use indigenous groundcover such as the grass *Stenotaphrum secundatum* and trees such as *Brachylaena discolor*, *Acacia karoo* etc.
- Following the installation of the proposed pipelines, re-vegetate the surface with a fast growing coastal grass such as *S. secundatum*. This is mainly to protect against erosion and inputs of sediment into the estuary. Further restoration should involve planting and successfully re-vegetating the disturbed area with indigenous shrubs and trees.

With the effective implementation of the above key mitigation measures, the overall significance of this impact remains **very low**. The confidence level for this impact assessment is high.

Alternative 2 - Tunnelling beneath the estuary and routing across the lower estuary

Ecologically the most important estuarine habitats are located at the lower sections of the estuary. Habitat diversity is thus generally greatest in this area. The proposed routing of pipelines in this alternative traverses ecologically significant reed swamp and swamp forest along both the south and north banks and crosses the channel of the estuary (see Figures 7.2 and 7.3). However, since it is proposed that this section of the route will be tunnelled beneath these sensitive habitats no major impacts are envisaged and the vegetation loss would be low significance for most of the route. However, the reception pit for tunnelling on the south bank is currently located at the edge of the sensitive area and almost within a drainage line. Given the threat to this sensitive environment, the significance in terms of vegetation loss without additional mitigation is **medium**.

Key mitigation measure proposed includes:

- The reception pit for tunnelling on the south bank should be moved by at least 100 – 130 m further west.
- Following the installation of the proposed trenched section of the pipeline re-vegetate the surface with a fast growing coastal grass such as *S. secundatum*. This is mainly to protect against erosion and inputs of sediment into the estuary. Further restoration should involve planting and successfully re-vegetating the disturbed area with indigenous shrubs and trees.

The overall significance assessment remains **low** with the implementation of the key mitigation measure.

7.6.1.5 Potential Impact 5: Noise and removal of vegetation during construction of the proposed desalination plant resulting in disturbance to fauna

Increased noise from construction activities, machinery and vehicles during the construction of the desalination plant (preferred and alternative sites) and removal of vegetation is a certainty. This will impact on bird populations, as well as small reptiles and mammals currently inhabiting the cane fields. The mere presence of a large work force in the area will be a source of disturbance. The impact is temporary and animals that move away from the source are expected to return to the area on cessation of these activities. The intensity has been assessed as medium-low and the overall significance is rated as **low** (without the implementation of key mitigation measures). This assumes exploitation of resources (e.g. fish) by worker is prohibited, as is standard good practice.

There can be little done to reduce expected noise levels during construction. The only key mitigation measure proposed is:

- Limit vehicle speed in and around the construction site.
- Endeavour to control the footprint of the development.
- Awareness training of all staff regarding fauna disturbance.
- Prevent extractive exploitation of natural resources by construction workers. Notably, fishing in the estuary should be prohibited.

Mitigation is not expected to have substantial reduction in noise levels and the assessment with key mitigation is **low** and is made with a high degree of confidence.

7.6.1.6 Potential Impact 6: Noise and removal of vegetation during installation of the proposed pipelines resulting in disturbance to fauna

The impacts on fauna associated with noise and removal of vegetation during the construction activities for the Preferred route and Alternatives 1 and 3 (north bank routing) are similar to those associated with the construction of the desalination plant (section 7.6.1.5 above) and are anticipated to be of **low** significance without the implementation of key mitigation measures. The slight increase in spatial extent of the impact compared to that of noise during construction of the desalination plant is due to a wider area of impact which includes the lower estuary where the ecologically important habitats occur.

For Alternative 2 (south bank routing and tunnelling beneath lower estuary), these impacts are similar to those associated with the construction of the preferred route. However, there is some uncertainty regarding impacts from vibrations that may be produced by tunnelling equipment. Effects of likely vibrations on biota (fish and invertebrates in particular) are not known. Impacts of underground tunnelling on aquatic organisms was assessed as part of an impact assessment of the Corrib Gas Pipeline on the northwest coast of Ireland. In the systems considered, this assessment regarded potential temporary impacts on behaviour of benthic organisms and fish as likely to be to be "imperceptible and temporary" (based on low levels of vibrations) (RPS, 2009). It is however noted that this assessment was not based on any actual observations or data. Due to these uncertainties the present assessment must remain conservative (**medium** significance) and of low confidence level.

There can be little done to reduce expected noise levels during the proposed installation of the pipelines. The following key mitigation measures are proposed:

- Limit vehicle speed in and around the pipeline route.
- Endeavour to control the footprint of the development.
- Awareness training of all staff regarding fauna disturbance.
- Prevent extractive exploitation of natural resources by construction workers. Notably, fishing in the estuary should be prohibited.

Mitigation is not expected to have substantial reduction in noise levels and the significance of these impacts with the implementation of key mitigation remains **low** for the preferred route and for all the alternative routes.

7.6.1.7 Potential Impact 7: Release of potential contaminants from the old dumpsite during proposed pipeline installation

This potential impact is limited to the preferred route and Alternatives 1 and 3 pipeline routes only as the dumpsite is located on the north bank. During excavation for installation of the proposed pipelines high rainfall events could wash sediments containing contaminants into the estuary and these could have effects on estuarine biota. However, there has been no study undertaken concerning the type or concentration of contaminants potentially present in sediments at the dumpsite. The significance assessment of this impact can thus only be made with a low level of confidence and is thus largely based on probability of occurrence which would be due to frequency and intensity of rainfall events. This potential negative impact is predicted as short term with a medium intensity and the overall significance is assessed as **low** without the implementation of key mitigation measures.

Proposed key mitigation measures include:

- Use sandtraps and geotextile blankets to prevent excavated material from entering the adjacent water body. However if contaminants are highly soluble the efficacy of this mitigation will be reduced. A turbidity monitoring programme (as described above in section 7.6.1.1) may be required in the event of inflows into the estuary from construction areas resulting in noticeable elevation in turbidity. However, such inflows should not occur, especially in this section of the estuary and involving sediments that may be contaminated. Sediment toxicity testing must inform the need and extent of prevention measures to be adopted.

Given that the solubility of contaminants that may potentially be released from the old dumpsite is unknown, the potential impacts associated with those release in the estuarine environment during construction activities are anticipated to remain of **low** significance with the effective implementation of the above key mitigations. Given this uncertainty it is further recommended that:

- A sediment toxicity assay should be conducted prior to the proposed pipeline installation. Toxicity is recommended as it serves as a risk assessment tool to determine potential biological availability of any contaminants that may be present. Chemical analyses cannot be recommended as the types of the contaminants are unknown and therefore it is not possible to determine which parameters should be analysed. Toxicity should be conducted on sediments leachates from at least two random sites within the dumpsite using the sea urchin toxicity test. It is recommended that samples be collected from surface, mid depth and bottom (bottom being the depth at which the pipeline is to be buried) at each site along the proposed pipeline route where it traverses the dumpsite. Samples from each of these depths may be collected through digging of a pit or coring at each site.

With the implementation of the above additional mitigation measures, the significance of this negative impact is still anticipated to be **very low**.

7.6.2 Operational Phase

No significant impact from increased runoff due to increased hard surfaces at the proposed desalination plant is expected as this forms a very small footprint (area) in relation to the surrounding catchment. No further assessment of this impact is therefore considered necessary.

7.6.2.1 Potential Impact 8: Impacts on the ecological corridor between the plant and the estuarine channel

The preferred option is very close to the channel allowing very limited space for semi-aquatic and terrestrial fauna to move along the channel, or migrate laterally into adjacent terrestrial areas during floods, therefore impacting on the ecological corridor between the proposed plant and the channel. Moreover, the proximity of the development to the channel means that there is little room for ecological adaptation to impacts such as climate change, thus potentially affecting long-term ecological resilience. Impact on the ecological corridor for the Preferred site and adjacent areas is considered probable, resulting in an overall significance assessment of **Medium**. For the Alternative site, this impact is predicted to be of **very low** significance.

Key mitigation measure is limited to:

- For the preferred site, the development footprint should be set back / moved to create at least a 25 metre buffer area between the development and the channel, with the channel measured from the top of the bank or the indigenous riparian fringe, whichever is the greater.

The overall rating with mitigation is expected to be **low** to **very low** and the confidence level in the assessment is high.

7.6.2.2 Potential Impact 9: Noise during plant operation

This assessment is applicable to both alternatives for siting of the Desalination Plant. The design of the buildings of the desalination plant has inherent noise reduction measures. Noise will have the same effect on biota as described for the construction phase but the intensity of this impact is expected to much lower during plant operation. The duration is however long term, i.e. the lifespan of the project. The overall significance of this impact without additional mitigation measures has been assessed as **Low**. The confidence level however remains medium as it is difficult to predict the actual intensity of the noise and consequent impacts on the biota.

It is recommended that supply and waste removal vehicles are subjected to speed limits in and around the site. Additional mitigation measures to reduce noise due to plant operation are presented in the noise specialist study (refer to Chapter 9).

7.6.2.3 Potential Impact 10: Possible entrainment of brine into the surf zone

Estuarine environments are important nursery areas for several estuarine dependent fishes and crustaceans. Most of these species breed at sea and recruit into the estuaries as larvae and juveniles. Reduced salinity in the surf zone around estuary mouths is an important factor for these species to successfully locate estuaries and recruit into them. Increased salinity due to brine discharge has thus been identified as having the potential to negatively impact on fish recruitment. Assessment of this potential impact is based on the brine dispersion modelling report (WSP, 2013) from which the modelled worst case scenario (discharge of 3 040 $l.sec^{-1}$; salinity 57.57 ppt) was used to complete the impact assessment. The hydrodynamic model indicates that salinity above ambient conditions occurred in the surf zone during the both summer and winter modelling periods (90 day) for 1% of the time which amounts to <1 day. The salinity exceedance was between 0.05 and 0.10 ppt above ambient. Ambient salinity was assumed to be 35 ppt and no compensation for naturally occurring reduced salinity around estuary mouths were made. In addition, the diffuser is designed and placed at sufficient distance from the intake structure such as to prevent re-circulation of the brine stream. Dispersion modelling results indicate that the risk of entrainment of brine in the surf-zone is negligible (Aurecon, 2015). Given the low frequency of occurrence and low intensity of the predicted salinity increases, impact of entrainment of brine into the surf zone is assessed as being of **low** significance without the implementation of key mitigation measures. In addition, any other residual contaminants in the brine are also expected to undergo significant dilution and this aspect has thus not been further assessed. Confidence in the assessment is medium as actual conditions may differ from modelled conditions.

No additional mitigation measures are recommended for this potential impact.

7.6.3 Decommissioning Phase

The facility will most probably be refurbished and will continue to operate beyond its predicted 25 year lifespan. The timing of final decommissioning is thus unknown. Nonetheless, it is assumed that all final disposal of waste materials (including chemicals) and redundant equipment and machinery will be handled according to best practices and legal requirements during decommissioning. These aspects will thus not be further assessed.

7.6.3.1 Potential Impact 10: Noise during decommissioning of the facility

The impacts of noise during decommissioning are similar to those described for the construction phase above except that the intensity is expected to be lower. This impact is assessed as being of **low** significance without the implementation of key mitigation measures.

Key mitigation is limited to:

- Imposing speed limits on vehicles.

Mitigation is not expected to reduce substantially noise levels and the overall assessment of significance remains **low**.

7.6.4 Cumulative Impacts

The proposed development has the potential to cause further impact on the already highly modified estuary. These impacts will be on select elements of the remaining estuarine vegetation above the estuary's waterline. The brunt of this area is already highly modified and under sugar cane cultivation, or put to alternative use (e.g. carpark and recreational field area). The proposed development footprint is therefore largely over highly modified terrain. The plant itself will be located in what is in reality sugar cane field at present. Agricultural, rural and peri-urban development has already impacted the estuary's physical habitats as well as its water quality in the estuary. The proposed developed poses no persistent and significant long term threats that will change, or accelerate these impacts. During construction of pipeline routes there is some potential for water quality impacts to manifest, but good construction practise, stormwater management and mitigation measures can be adopted to alleviate this impact (in terms of likelihood and severity). There is opportunity to re-vegetate disturbed area with indigenous vegetation which actually has the potential to impact positively the system in the long term, even if only in a small way. This opportunity should be pursued.

7.7 IMPACT ASSESSMENT SUMMARY

The summary of the impact assessment is shown in Table 7.4 below:

Table 7.4 Impact assessment summary for the Construction Phase

Construction Phase										
Impact Description	**Status**	**Spatial Extent**	**Duration**	**Reversibility**	**Potential Intensity**	**Probability**	**Significance (Without Mitigation)**	**Key Management actions (i.e. actions that are not negotiable and have to be implemented to ensure that the significance of the associated impact is acceptable)**	**Significance (With Mitigation)**	**Confidence**
Preferred Desalination plant site, Preferred pipeline route & Alternatives 1 & 3 and powerline										
Impact 1 (Direct): Increased estuarine turbidity due to the proposed desalination plant construction	Negative	Local 2	Temporary 1	Highly Reversible	Medium 4	Probable 0.5	**Low 3.5**	Measures to prevent runoff from disturbed construction areas carrying sediments (and other contaminants) into the estuary. These may include the use of sediment traps and geotextile blankets to prevent discharge of sediments into the estuary during construction. Turbidity monitoring, as described in this report, may be required.	**Very Low 1.25**	High
Impact 2 (Direct) : Increased estuarine turbidity during pipeline installation	Negative	Local 2	Temporary 1	Highly Reversible	Medium 4	Probable 0.5	**Low 3.5**	Measures to prevent runoff from disturbed construction areas carrying sediments (and other contaminants) into the estuary. These may include the use of sediment traps and geotextile blankets to prevent discharge of sediments into the estuary during construction. Turbidity monitoring, as described in this report, may be required.	**Very Low 1.25**	High
Impact 3 (Direct) : Removal of indigenous vegetation and disturbance to the ecological corridor between the site and the channel during construction activities for the desalination plant	Negative	Site Specific 1	Long Term 4	Low Reversibility	Medium 4	Probable 0.5	**Low 4.5**	Minimise construction footprint Setback distance of 25m to increase the ecological corridor between the plant and the channel	**Low 3.5**	High

Impact 4 (Direct) : Removal/disturbance of Indigenous vegetation during pipeline installation and bridging	Negative	Local 2	Short term 2	Moderate Reversibility	Medium-Low 2	Probable 0.5	**Low** **3**	Rehabilitate riparian vegetation at bridge using indigenous species Re-vegetate pipeline route with grasses once installation is complete. Further restoration should involve planting and successfully re-vegetating the disturbed area with indigenous shrubs and trees.	**Low** **3**	High
Impact 5 (Direct): Impact on fauna due to noise and removal of vegetation during construction of desalination plant-	Negative	Site Specific 1	Temporary 1	Highly Reversible	Medium-Low 2	Definite 1	**Low** **4**	Implement vehicle speed limits and limit construction footprint. Endeavour to control the footprint of the development Awareness training of all staff regarding fauna disturbance	**Low** **3**	High
Impact 6 (Direct) : Impact on fauna due to noise and removal of vegetation during installation of pipelines	Negative	Local 2	Temporary 1	Highly Reversible	Low 1	Definite 1	**Low** **4**	Limit vehicle speeds and limit construction footprint. Endeavour to control the footprint of the development Awareness training of all staff regarding fauna disturbance	**Low** **3**	High
Impact 7(Direct): Impact on estuarine biota associated with the potential release of contaminants from the old dumpsite	Negative	Local 2	Short term 2	Moderate Reversibility	Medium 4	Probable 0.5	**Low** **4**	Measures (e.g. use sandtraps and geotextile blanket) to prevent sediment entry into estuary. Conduct toxicity testing If contaminated remove excess excavated material.	**Very Low** **1.5**	Low
Alternative Desalination plant site and Alternative 2 pipeline route										
Impact 1(Direct) : Increased estuarine turbidity due to desalination plant construction	Negative	Local 2	Temporary 1	Highly Reversible	Medium 4	Probable 0.5	**Low** **3.5**	Measures to prevent runoff from disturbed construction areas carrying sediments (and other contaminants) into the estuary. These may include the use of sediment traps and geotextile blankets to prevent discharge of sediments into the estuary during construction. Turbidity monitoring, as described in this report, may be required.	**Very low** **1.25**	High

Impact 2 (Direct): Increased estuarine turbidity during pipeline installation	Negative	Local 2	Temporary 1	Highly Reversible	Medium 4	Highly Probable 0.75	**Medium 5.25**	Measures to prevent runoff from disturbed construction areas carrying sediments (and other contaminants) into the estuary. These may include the use of sediment traps and geotextile blankets to prevent discharge of sediments into the estuary during construction. Turbidity monitoring, as described in this report, may be required. Re-vegetate impacted areas as soon as possible.	**Low 2.5**	High
Impact 3(Direct) : Removal of indigenous vegetation for plant construction and impact on the ecological corridor	Negative	Site Specific 1	Long Term 4	Moderate Reversibility	Low 1	Improbable 0.1	**Very Low 0.6**	Minimise construction footprint.	**Very Low 0.6**	High
Impact 4(Direct) : Removal/disturbance of indigenous vegetation during pipeline installation	Negative	Local 2	Long Term 4	Low Reversibility	Medium 4	Probable 0.5	**Medium 5**	Re-vegetate with indigenous grasses. Further restoration should involve planting and successfully re-vegetating the disturbed area with indigenous shrubs and trees. Locate reception pit 100-130 m further west(away from drainage line)	**Very Low 1**	High
Impact 5 (Direct): Impact on fauna due to noise and removal of vegetation during construction of desalination plant	Negative	Site Specific 1	Temporary 1	Highly Reversible	Medium-Low 2	Definite 1	**Low 4**	Implement vehicle speed limits. Prevent extractive exploitation of natural resources by construction workers. Notably, fishing in the estuary should be prohibited.	**Low 3**	High
Impact 6 (Direct): Impact on fauna due to noise, vibrations (tunnelling) and removal of vegetation during installation of pipelines	Negative	Local 2	Temporary 1	Highly Reversible	Medium-Low 2	Definite 1	**Medium 5**	Implement vehicle speed limits. This will not reduce potential impacts of tunnelling however. Prevent extractive exploitation of natural resources by construction workers. Notably, fishing in the estuary should be prohibited.	**Medium 5**	Low

Table 7.5 Impact assessment summary for the Operational Phase

Operational Phase										
Impact Description	**Status**	**Spatial Extent**	**Duration**	**Reversibility**	**Potential Intensity**	**Probability**	**Significance (Without Mitigation)**	**Key Management actions (i.e. actions that are not negotiable and have to be implemented to ensure that the significance of the associated impact is acceptable)**	**Significance (With Mitigation)**	**Confidence**
Preferred Site for the Desalination Plant (Eastern site)										
Impact 8 (Direct) : Decrease of the ecological corridor and associated impacts between the site and the channel	Negative	Local 2	Long Term 4	Low Reversibility	Medium 4	Probable 0.5	**Medium 5**	Remain within development footprint Setback distance of 25 m to increase the ecological corridor between the plant and the channel	**Low 3**	High
Impact 9(Direct): Noise during plant operation (with inherent measures in building design)	negative	Site Specific 1	Long Term 4	Highly Reversible	Low 1	Probable 0.5	**3 Low**	Implement speed limits for supply and waste removal vehicles	**3 Low**	Medium
Impact 10 (Direct): Entrainment of Brine into the surf zone	Negative	Local 2	Long Term 4	Highly Reversible	Low 1	Low Probability 0.25	**1.75 Very Low**	Recommend limiting maximum discharge volumes if possible	**1.75 Very Low**	Medium
Alternative Site for the Desalination Plant (Western site)										
Impact 8 (Direct) : Decrease of the ecological corridor and associated impacts between the site and the channel	Negative	Local 2	Long Term 4	High Reversibility	Low 1	Improbable 0.1	**Very Low 0.7**	Remain within development footprint	**Very Low 0.7**	High
Impact 9(Direct): Noise during plant operation (with inherent measures in building design)	negative	Site Specific 1	Long Term 4	Highly Reversible	Low 1	Probable 0.5	**3 Low**	Implement speed limits for supply and waste removal vehicles	**3 Low**	Medium
Impact 10(Direct) : Entrainment of Brine into the surf zone	Negative	Local 2	Long Term 4	Highly Reversible	Low 1	Low Probability 0.25	**1.75 Very Low**	Recommend limiting maximum discharge volumes if possible	**1.75 Very Low**	Medium

Table 7.6 Impact assessment summary for the Decommissioning Phase

Decommissioning Phase										
Impact Description[1]	**Status**	**Spatial Extent**	**Duration**	**Reversibility**	**Potential Intensity**	**Probability**	**Significance (Without Mitigation)**	**Key Management actions (i.e. actions that are not negotiable and have to be implemented to ensure that the significance of the associated impact is acceptable)**	**Significance (With Mitigation)**	**Confidence**
Preferred Site for the Desalination Plant (Eastern site)										
Impact 10 (Direct): Noise during plant decommissioning	Negative	Local 2	Temporary 1	Highly Reversible	Medium-Low 2	Highly Probable 0.75	**3.75 Low**	Implement vehicle speed limits	**Low 2**	High
Alternative Site for the Desalination Plant (Western Site)										
Impact 10 (Direct): Noise during plant decommissioning	Negative	Local 2	Temporary 1	Highly Reversible	Medium-Low 2	Highly Probable 0.75	**3.75 Low**	Implement vehicle speed limits	**Low 2**	High

[1] Please specify in this column whether the impact is direct or indirect.

7.8 CONCLUSION AND RECOMMENDATION

It is clear from the review and findings of the field survey conducted during this study that the Lovu Estuary, which although small in national terms, is an important functional estuary that contributes significantly to the estuarine resources in this section of the coastline. As estuarine resources are under threat, nationally and internationally through development pressure, these environments are identified as conservation worthy and any further impacts on these systems must be critically assessed.

The proposed desalination plant and associated infrastructure, like all developments, will have environmental impacts which may or may not be reduced by the implementation of mitigation measures. This assessment of potential impacts on the estuarine environment did not indicate any fatal flaws for any individual impact and most were assessed with a high degree of confidence. The key impacts (medium significance prior to the implementation of recommended mitigation measures) identified in this Estuarine Ecological Impact Assessment are associated with the construction phase of the proposed project:

- Impacts on the ecological corridor between the proposed plant and the channel.
- Potential for increased estuarine turbidity with consequent impacts on aquatic fauna during the installation of the Alternative 2 pipeline route.
- Loss of indigenous vegetation and disturbance of fauna due to noise and removal of vegetation during the construction of the proposed Alternative 2 Pipeline route.

The following key mitigation measures are recommended:

- A setback distance of 25 m for the Preferred site to increase the ecological corridor between the development and the channel
- Measures to prevent runoff from disturbed construction areas carrying sediments (and other contaminants) into the estuary. These may include the use of sediment traps and geotextile blankets to prevent discharge of sediments into the estuary during construction. A turbidity monitoring programme (as described above in section 7.6.1.1) may be required in the event of inflows into the estuary from construction areas resulting in noticeable elevation in turbidity
- Re-vegetate with appropriate indigenous species following excavation and installation of pipelines. This should include re-vegetating with fast growing indigenous grasses as soon as possible following completion of any earthworks and further restoration involving planting and successfully re-vegetating the disturbed area with indigenous shrubs and trees.
- Limit construction footprint and undertake awareness training for all staff (flora and fauna).
- Reduce vehicle speed limits during the construction phase of the proposed project to reduce noise.
- For Alternative 2, the reception pit for tunneling on the south bank should be moved by at

Assessment of the potential impact associated with release of contaminants from the old dumpsite could not be made with a high degree of confidence since the nature, concentrations and hence possible effects on biota are unknown. As the contaminants, if present, are unknown, it is difficult to determine what parameters should be analysed chemically to assess potential effects on biota. The specialists thus strongly recommend that sediment leachates from the dumpsite be tested for toxicity prior to installation of the pipelines. This will inform the developer about correct handling of excavated material from the dumpsite.

The construction of the proposed desalination plant at the Preferred site or at the Alternative site is anticipated to result is estuarine impacts of similar significance, providing that the recommended management actions are effectively implemented, in particular a setback distance of 25 m for the Preferred site to increase the ecological corridor between the development and the channel. Note that the Alternative site has slightly lower risk of being impacted by major floods.

The alternatives proposed for the seawater pipeline routing scored similarly in terms of impacts on vegetation as there is no substantial loss of indigenous vegetation. While impacts of noise levels on fauna also scored similarly, it is uncertain if noise levels and vibrations due to the use of tunnelling equipment for Alternative 2 are expected to have greater impact than the Preferred route or Alternative 1. The assessment in this case was made with a medium degree of confidence.

In conclusion, from a perspective of potential estuarine impacts, the specialists recommend:

- A setback distance of 25 m for the Preferred site to increase the ecological corridor between the development and the channel.
- While there is no strong indication for selection of any of the various pipeline routes in terms of vegetation impacts, there is some uncertainty regarding potential impacts on groundwater (although anticipated to be unlikely) and impacts of vibrations and noise from tunnelling especially for Alternative 2 which crosses sensitive area of estuary. Given this, selection of the options that involve north bank routing (Preferred and Alternatives 1 and 3) are recommended over alternative 2.
  - If any of the tunnelling options are selected for pipeline routing (Alternatives 2 and 3), it is imperative that there is **no disposal** of excavated material, slurry (including bentonite mixes) wastewater (including waters treated with flocculants) within the floodplain of the estuary or the waterbody. All wastes should be appropriately disposed of (at registered landfill site or recycled if appropriate). While the only toxicity reference to bentonite gave an LC_{50} of 19 $g.l^{-1}$ (for rainbow trout; Kegley S.E., Hill B.R., Orme S., Choi A.H., PAN Pesticide Database, Pesticide Action Network, North America (Oakland, CA, 2014), http:www.pesticideinfo.org.), the author (SP) has previously tested a range of drilling fluids which indicated potential toxicity to sensitive species or more especially to early life stages such as gametes, larvae and juveniles.

7.9 REFERENCES

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

Begg, G., 1978. The Estuaries of Natal. Natal Town and Regional Planning Commission.

Boehlert G.W. and Mundy B.C., 1988. Roles of behavioral and physical factors in larval and juvenile fish recruitment to estuarine nursery areas. In: Larval Fish and Shellfish Transport through Inlets. (Ed. Weinstein M.P.). American Fisheries Society Symposium 3: 51-67.

Coetzee, J.C., Adams, J.B. and Bate, G.C., 1997. A botanical importance rating of selected Cape estuaries.*Water SA* **23** 81-93.

Colloty, B.M., Adams, J.B. and Bate, G.C., 2000. The use of a botanical importance rating to assess changes in the flora of the Swartkops Estuary over time. *Water SA* 26 (4) 161-170.

Cooper, J.A.G., Ramm, A.E.L. and Harrison, T.D., 1994. The estuarine health index: A new approach to scientific information transfer, Ocean and Coastal Management 25: 103-141.

Costanza R., D'Arge R., de Groot R., Farber S., Grasso M., Hannon B., Limburg K., Naeem S., O'Neill R.V., Paruelo J., Raskin R.G., Sutton P. & Van den Belt M. (1997). The value of the world's ecosystem services and natural capital. *Nature*: 387: 253-260.

Forbes A.T. & Demetriades N.T. ,2008. Estuaries of Durban, KwaZulu-Natal, South Africa. Report for the Environmental Management Department, eThekwini Municipality.

Harrison, T.D., Cooper, J.A.G. & Ramm., 2000. State of South African estuaries: Geomorphology, ichthyofauna, water quality and aesthetics. Department of Environmental Affairs and Tourism. Pretoria. 127 pp.

IUCN, 2015. The IUCN Red List of Threatened Species. Version 2015.1. <www.iucnredlist.org>. Downloaded on 22 June 2015.

James N.C., Cowley P.D., Whitfield A.K. and Kaiser H., 2008. Choice chamber experiments to test the attraction of postflexion Rhabdosargus holubi larvae to water of estuarine and riverine origin. *Estuarine, Coastal and Shelf Science* 77: 143-149.

Kennish M.J., 2004. Estuarine Research Monitoring, and Resource Protection. CRC Press.

Kimmerer W.J., 2002. Effects of freshwater flow on abundance of estuarine organisms: physical effects or trophic linkages? *Marine Ecology Progress Series* 243: 39-55.

McLean C.T., Forbes A.T. & Demetriades N.T. 2006 The fish fauna of four estuaries in the Thekwini municipal area: Indicators of system functioning. Honours degree thesis, University of KwaZulu-Natal.

McLean C.T., Forbes A.T. and Demetriades N.T., 2006 The fish fauna of four estuaries in the Thekwini municipal area: Indicators of system functioning. Honours degree thesis, University of KwaZulu-Natal.

Ramm, A.E.L., Cerff, E.C. and Harrison, T.D., 1986. The Lovu Estuary, Natal Estuary Status Report No. 64, Estuaries and Coastal Processes Division, National Institute for Water Research, CSIR, Durban.

RPS, 2009. Corrib Onshore Pipeline Impact Statement. Chapter 14 – Marine Environment. Environment Impact Statement Report undertaken for Shell E&P Ireland Ltd. (SEPIL).

Robins J., Mayer D., Staunton-Smith J., Halliday I., Sawynok B. and Sellin M., 2006. Variable growth rates of the tropical estuarine fish barramundi *Lates calcarifer* (Bloch) under different freshwater flow conditions. Journal of Fish Biology 69: 379-391.

Simenstad C.A., Brandt S.B., Chalmers A., Dame R., Deegan L.A., Hodson R. and Houde E.D., 2000. Habitat-Biotic Interactions. In: Hobbie J.E. (ed) Estuarine Science: A Synthetic Approach to Research and Practice. Island Press, Washington, D.C.

Turpie J.K., 1995. Prioritizing South African Estuaries for Consevation. A Practical Example using Waterbirds. Biological Consevation, 74: 175-185.

Turpie J.K., Adams J.B., Joubert A., Harrison T.D., Colloty B.M., Maree R.C., Whitfield A.K., Wooldridge T.H. , Lamberth S.J., Taljaard S. and van Niekerk L., 2002. An Assessment of the Conservation Priority Status of South African Estuaries for use in Management and Water Allocation. Water SA, 28 (2): 191-206.

Whitfield A.K., 1992. A characterization of southern African estuarine systems. Southern African Journal of Aquatic Science 18: 89-103.

Whitfield A.K., Adams J.B., Bate G.C., Bezuidenhout K., Bornman T.G., Cowley P.D., Froneman P.W., Gama P.T., James N.C., Mackenzie B., Riddin T., Snow G.C., Strydom N.A., Taljaard S., Terörde A.L., Theron A.K., Turpie J.K., van Niekerk L., Vorwerk P.D. and Wooldridge T.H. 2008. A multidisciplinary study of a small, temporarily open/closed South African estuary, with particular emphasis on the influence of mouth state on the ecology of the system. African Journal of Marine Science 30: 453-473.

Whitfield A.K., Bate G.C., Adams J.B., Cowley P.D., Froneman P.W., Gama P.T., Strydom N.A., Taljaard S., Theron A.K., Turpie J.K. and Van Niekerk L., 2012. A review of the ecology and management of temporarily open/closed estuaries in South Africa, with particular emphasis on river flow and mouth state as primary drivers of these systems. African Journal of Marine Science, 34(2), pp.163-180.

WSP, 2013. KZN east coast desalination plants detailed feasibility study: Lovu and Tongaat hydrodynamic and plume dispersion modelling.

7.10 APPENDIX A

Comments on the Lovu Estuary – Chapter 7 of the draft EIA report

The report focuses on potential impacts of a proposed desalination plant in the middle-upper reaches of the Lovu Estuary located south of Durban. The report draws information mostly from a literature review, with additional information provided from a single field visit that focused on the estuarine vegetation and the fish community. While no fatal flaws were identified, issues of concern were raised and these were addressed in the document. The current review focused on the merits of the report in terms of its relevance to the EIA process.

Although the Chapter stresses the Importance Rating of the estuary on a national scale (information mostly extracted from Turpie *et al*. 2002), I feel insufficient attention is directed towards its regional status. Many of the estuaries along the KZN South Coast are severely impacted by man, but what is the status of the Lovu Estuary on a more local scale? As a suggestion, consider the estuaries 25 kms north and south of the Lovu. Most of these systems are TOCEs of variable size that open to the sea for varying lengths of time. Given the fact that the mouth remains open for much of the time (linked to relatively strong freshwater inflow), the Lovu may rank very highly as a functional estuary on a local scale. In turn, this may influence the decision making process (including terms and conditions imposed during the various phases of construction and decommissioning of the plant). I also suggest that this Importance Rating discussion fall under a separate sub-section of the draft EIA report.

In Section 7.3.1.4, the statement is made that the estuary is not particularly rich with respect to species richness. This statement could lead to a misinterpretation by a non-biologist wrt the functional value of the estuary. The emphasis should be on a biomass assessment; typically high in freshwater-rich systems experiencing euryhaline conditions throughout (even near the mouth – refer to Fig.7.4). In these systems, species richness is naturally on the low side. Also note that the area was going through a relatively dry phase at the time of the field survey (leading to higher salinity values along the estuary). A clue to high biomass is shown by Allan Connell's work on the estuarine zooplankton – among the highest recorded along his section of the coast. High zooplankton biomass also promotes the nursery function of the system that may be highly significant on a regional scale. This aspect needs greater emphasis. Also note that two of the inverts listed have undergone a name change – *Callianassa* and *Apseudes.*

Given the apparent high biomass of the zooplankton community (that is naturally variable), is there any information that could be extracted from earlier work done by George Begg, Ticky Forbes and Nicky Demetriades (among others) to supplement a biomass assessment of the macrozoobenthos?

Within the zooplankton community, three species dominated - *Mesopodopsis africana, Pseudodiaptomus hessei* and *Acartia natalensis*. No information is provided on the response of any of these species to high turbidity (identified as an issue of concern). Suggest the author refers to work done by Nicky Carrasco and Renzo Perissinotto on turbidity effects on these species. Turbidity has the potential to impact the food web and therefore the nursery function of the estuary in a negative way. Determine thresholds of concern for the Lovu, recommend a monitoring strategy and potential response measures needed to deal with this issue. The strong tidal exchange may be a benefit wrt turbidity issues.

Information suggests that the Lovu is an important nursery system. This aspect is covered in the report, but local South African references are not covered sufficiently. The surfzone itself may be an important nursery habitat, also providing a corridor along which small fish enter the estuary (following concentration cues originating from the estuary). Need to refer to work done by Nadine Strydom and others on this issue.

In conclusion, Chapter 7 of the draft EIA report adequately covers key issues that may impact the biota and functional aspects of the Lovu Estuary. However, sections of the report can be strengthened, providing more information that will assist the decision-making process as well as terms and conditions imposed.

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