AN INVESTIGATION OF THE REHABILITATION POTENTIAL OF THE BAAKENS RIVER, GQEBERHA

PART 5: REHABILITATION POTENTIAL OF THE BAAKENS RIVER, GQEBERHA. SUMMARY REPORT.

Amanda Uys, James MacKenzie, Anton Bok, Patsy Scherman, Micah Moynihan, Jackie Crafford, Bernice Macquela and Nonopha Kanise

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TT 910/5/23

An Investigation of the Rehabilitation Potential of the Baakens River, Gqeberha

Part 5: Rehabilitation potential of the Baakens River, Gqeberha. Summary Report.

Report to the
Water Research Commission

by

A Uys, J MacKenzie, A Bok, P Scherman, M Moynihan, J Crafford, B Macquela & N Kanise
Laughing Waters & Associates

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This report forms part of a set of five reports emanating from WRC project no. C2022/2023-01121. The other reports are:

An investigation of the rehabilitation potential of the Baakens River, Gqeberha. Part 1: Current state of the river. (WRC Report No. TT 910/1/23)
An investigation of the rehabilitation potential of the Baakens River, Gqeberha. Part 2: River rehabilitation scenarios. (WRC Report No. TT 910/2/23)
An Investigation of the rehabilitation potential of the Baakens River. Part 3: Cost benefit analysis. (WRC Report No. TT 910/3/23)
Rehabilitation Potential of the Baakens River, Gqeberha. Part 4: Recommendations. (WRC Report No. TT 910/4/23))

Cover Design: Anja van der Merwe, WRC

Cover page photographs:
View of the Baakens River through Settlers Valley. Source: Dean McCleland

One of the penalties of an ecological education is that one lives alone in a world of wounds. Much of the damage inflicted on land is quite invisible to laymen. An ecologist must either harden his shell and make believe that the consequences of science are none of his business, or he must be the doctor who sees the marks of death in a community that believes itself well and does not want to be told otherwise.
The government tells us we need flood control and comes to straighten the creek in our pasture. The engineer on the job tells us the creek is now able to carry off more flood water, but in the process, we lost our old willows where the cows switched flies in the noon shade, and where the owl hooted on a winter night. We lost the little marshy spot where our fringed gentians bloomed. Some engineers are beginning to have a feeling in their bones that the meanderings of a creek not only improve the landscape but are a necessary part of the hydrologic functioning. The ecologist sees clearly that for similar reasons we can get along with less channel improvement on Round River.

Aldo Leopold: Round River, 1993.

"The time has come for science to busy itself with the earth itself. The first step is to reconstruct a sample of what we had to start with."

Aldo Leopold: The Arboretum and the University, The River of the Mother of God.

NOTE TO THE READER

This summary is not a requirement of the Study, but has been prepared to assist the reader in getting the gist of this project without having to read all four deliverables (Parts 1-4). Where there is interest in further detail, please consult the report in question. As this summary is essentially a copy of the Executive Summaries of each part of the series, with additional graphics, there will be repetition!

ACKNOWLEDGMENTS

The Project Team would like to thank the Mandela Bay Development Agency (MBDA) for the funding for this project, and hold the sincere hope that the Baakens River rehabilitation work continues under their good guidance. Mr Bonani Madikizela of the WRC is appreciated for the integral part he played in this project, and for accompanying the team on the field survey. Mr Madikizela is also acknowledged for the role he continues to play in leading South Africa into an active river restoration future. Ms Singathwa Posma, Ms Tamlynn David and Ms Pumza Tshebe of the MBDA are thanked for their support and assistance during the project.

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Historian and writer extraordinaire Mr Dean McCleland gave the Project Leader material to mull over and read, providing deep insights into the history of the Baakens River and the city. A broad historic perspective is what makes for sound rehabilitation goals. That input was valuable and greatly appreciated.

The Project Leader thanks the A-Team, James MacKenzie, Anton Bok, Patsy Scherman, Micah Moynihan and Nonopha Kanise, who worked willingly and for long hours to get the work, planning and thinking done. Healthy rivers really are our Life Mission, it's a privilege to work with you all.

Mr Renzo Driussi and members of the Nelson Mandela Bay Business Chamber are thanked for their time, their interest in the project, and their ongoing work and endeavours to keep their City well maintained, functional, attractive, and clean.

A few members of the community and from civic organisations stepped forward to assist with information and context on this project and are gratefully acknowledged: Ms Ellen Paasche, founder of the Community Crime Awareness group in the valley (we wish all South Africans understood community and ecology the way she does); Mr Gary Koekemoer who wears many hats, including the Chairmanship of the Wildlife and Environment Society, Algoa Bay Branch, and who inspires us with his relentless commitment to reversing degradation in the Metro; Mr Johan Gerryts and Ms Candy Boonzaaier, the first to meet us on site, who are thanked for their time, insights, information and enthusiastic trail-guiding.

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ACRONYMS, ABBREVIATIONS, NOMENCLATURE

approx.	Approximately
ASPT	Average Score Per Taxon
BGIS	Biodiversity GIS
DHSWS	Department of Human Settlements, Water and Sanitation (historic name)
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry (historic name)
DWS	Department of Water and Sanitation (current name)
EA	Environmental Authorisation
EC	Ecological Category
EIS	Ecological Importance & Sensitivity
FRAI	Fish Response Assessment Index
GIS	Geographical Information System
ha	hectares (10 000 m^2 or 0.01 km^2)
IHAS	Integrated Habitat Assessment System
IHI	Index of Habitat Integrity
IZ	Integration Zone
km^2	square kilometres
mamsl	metres above mean sea level
MBDA	Mandela Bay Development Agency
mcm	Million cubic metres
MIRAI	Macroinvertebrate Response Assessment Index
mm	Millimetres
m^3/s	cubic metres per second
m^3/a	cubic metres per annum
na	not applicable
NEMA	National Environmental Management Act
NMBBC	Nelson Mandela Bay Business Chamber
NMBM	Nelson Mandela Bay Metro
NWA	National Water Act
PAI	Physico-chemical Assessment Index
PES	Present Ecological State
REC	Recommended Ecological Category
SASS5	South African Scoring System version 5 (invertebrate biomonitoring method)
spp.	several species
VEGRAI	Vegetation Response Assessment Index
WRC	Water Research Commission
WR2012	Water Resources of South Africa, 2012
WWTW	Waste Water Treatment Works

PROJECT SUMMARY

1 PART 1: CURRENT STATE OF THE BAAKENS RIVER

1.1 INTRODUCTION

The Mandela Bay Development Agency (MBDA) is tasked with the conceptualisation and implementation of projects on behalf of the Nelson Mandela Bay Metropolitan Municipality ('the Metro') in the Eastern Cape city of Gqeberha. The MBDA has entered into an agreement with the country's primary water research funding organisation, the Water Research Commission (WRC), to facilitate water-related studies in areas in which information is needed for development decision-making by the MBDA.

In the case of this project, the MBDA sought a study which would provide information on the Baakens River, which occupies a central locality in the city and is a critical component of the city's future development plans. Over the 200 years since the arrival of settlers in the area, the river has been subjected to a suite of impacts including development of its floodplain, clearing of its riparian zone, flow impoundment, water quality impairment, and dense urbanisation, and as a result the river is degraded. Nonetheless, it occupies a central position in the life and heart of the city, provides a safe green space for the people of Gqeberha, and has significant biodiversity and natural-capital value which requires regeneration and protection.

As 'current state' overview of the system is required as a starting point and as a base from which decisions regarding the possible rehabilitation of the river can be made. A cost-benefit analysis of a river rehabilitation exercise is also a necessity for the Metro. These requirements serve as the rationale for this project.

A Memorandum of Understanding (MOU) was signed between the WRC and the MBDA to facilitate this and other research. The WRC Research Manager for this study is Mr Bonani Madikizela, and the study coordinator for the MBDA is Research, Innovation and Sustainability Manager Ms Singathwa Poswa.

The project team, led by Laughing Water & Associates, comprises four senior aquatic scientists and a senior resource economist, each with over 20 years in their respective fields, and an MSc level GIS/RS student.

The study aims are:

a. To determine, using accepted current South African methods, the Present Ecological State (PES) of the Baakens River, with respect to its water quality, fauna and flora.
b. To develop a rehabilitation vision and broad strategy for the Baakens catchment and apply these in 3 or 4 different rehabilitation scenarios, in consultation with key stakeholders.
c. To do a cost-effectiveness analysis on the rehabilitation scenarios.
d. To present the results and to engage with the stakeholder forum to prioritise scenarios.
e. To provide more detail on the prioritised scenario.
f. To make recommendations to the MBDA regarding the feasibility of rehabilitation for the Baakens River, and the most cost-effective starting point.

This report represents the first project deliverable and provides the preliminary information on the current state of the Baakens River, based on findings to date.

1.2 BACKGROUND: THE BAAKENS RIVER

The Baakens River is a small, urbanised river, about 23 km in length and with a catchment size of 85 km^2. The river flows from west to east, bisecting the city of Gqeberha, and providing the catchment community with a green corridor and a literal breathe of fresh air. The catchment is situated in Ecoregion II 20.01 (South Eastern Coastal Belt) and in quaternary catchment M20A. The estuary flows into the ocean at the Port of Gqeberha.

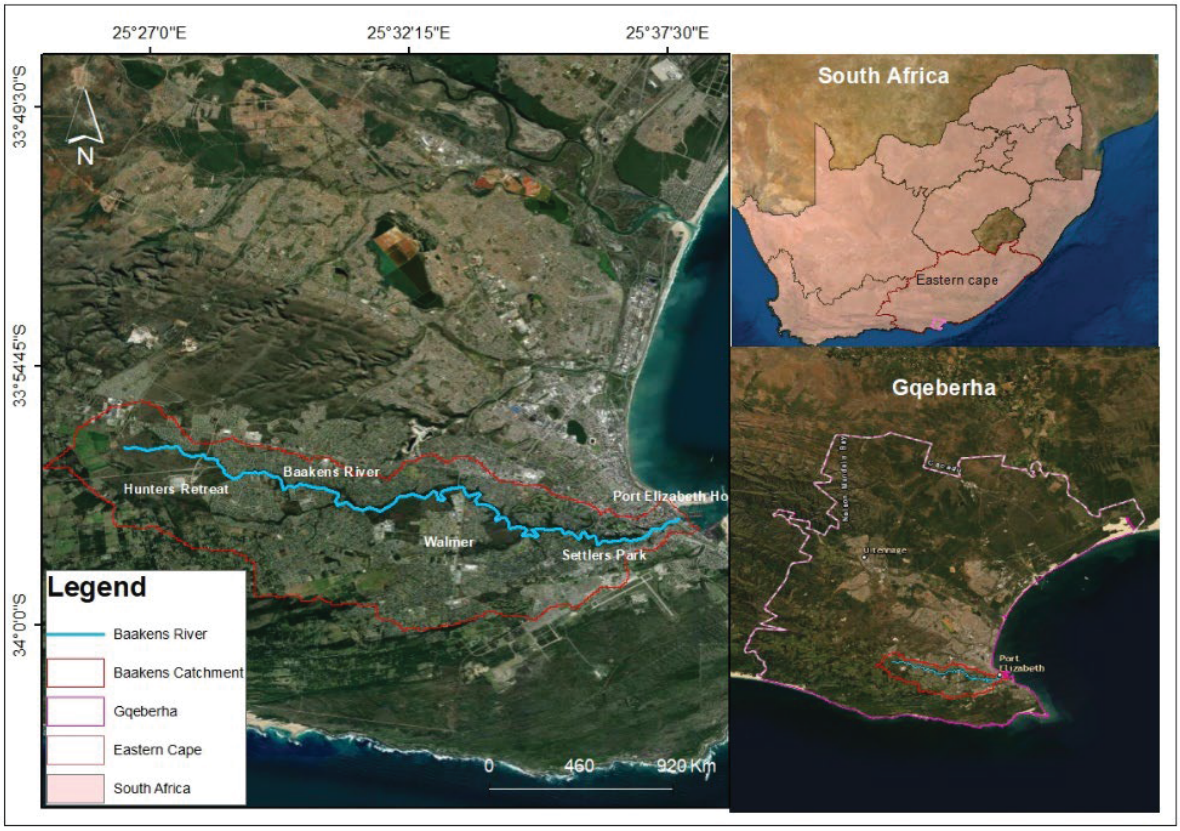


Figure 1.1 Locality of the Baakens River, Gqeberha

Climatically, the area is transitional between a subtropical and a temperate climate, with bimodal (spring and autumn) peaks in rainfall, and runoff with a high coefficient of variability. The naturalised Mean Annual Runoff (MAR) from the Baakens River (1920-2009) was 5.3 million cubic metres (approximately 0.17 m^3/s or 170 litres per second), with baseflows comprising approximately 15.4% of total flows. Under natural conditions and on average, the months with the lowest flows were January and February. The 'Water Resources of South Africa' study (WR2012) estimates that under natural conditions, the river would have been intermittent, ceasing to flow for approximately one-quarter of the time in the two lowest-flow months (viz. January and February).

The Baakens catchment is underlain largely by weather-resistant Peninsula Formation sandstones and quartzites of the Table Mountain Series (TMS) of the Cape Supergroup. The geology is responsible for the acidity of the Baakens River and its poor, shallow and stony soils, which also provide the ideal conditions for fynbos and thicket vegetation. Due to its marine origins, it is also thought to be the cause of the relatively high electrical conductivity (EC) of the river water.

The vegetation of the catchment is fynbos dominated, with thicket and forest elements in the steeper forested areas. The river occupies an important locality from a biodiversity perspective, at the confluence between two vegetation biodiversity hotspots, the Cape Floristic Region and the Pondoland-Maputaland-Albany Biome. Numerous Critical Biodiversity Areas (CBAs) have been identified in the Baakens Valley. The catchment is categorized as a Freshwater Ecosystem Protected Area (FEPA), a Fish Sanctuary area (as it supports two threatened fish species) and a Fish Support Area (FSA). It is also home to a wide array of plant Species of Special Concern, including endemic and critically endangered species.
Important seep wetlands are located in the source area of the river, in the Hunters Retreat area to the west of the city. Aside from their intrinsic ecosystem value, these wetlands offer the services of water purification, flood protection, groundwater recharge and baseflow maintenance. They are also home to the seep-dependant plant *Cyclopia pubescens* (Honeybush), which is critically endangered. The valley is home to several other plant species of special concern (SSCs), which have been at the core of certain of the Systematic Conservation Planning initiatives for the Metro.

The estuary has been built into, onto and over since the 1860s, and its remnant channel is now confined to a narrow concrete canal up to its confluence with the ocean in the Port of Gqeberha. Nonetheless, the system still retains some functionality as a link between the freshwater and marine environments and serves as a corridor for the movement of indigenous migratory fish and eel species.

The 75Ha Settlers Reserve in the lower section of the valley catchment is the only formally protected element of this catchment. Dodd's Farm area and Robert Searle Reserve are two other areas with Public or Private Open Space Zoning. Both areas are popular with walkers and mountain bikers.

1.3 HISTORY OF THE RIVER

Note: This section is a summary of the Baakens History as variously told by McClenan (2017, 2018), and with his permission.

The Baakens has played a central role in the city's history and development. Prior to European visitors to these shores, Khoisan hunter-gatherers roamed this valley, which provided a plentiful source of water, fruit, and small animals to hunt. Of the many words inherited from the Khoisan, those still in relation to the river are Kragga Kamma, which probably means 'sweet' or 'fresh' water, and 'Kabega' (abundance of reeds) – the name of the rivers which form the Baakens at Frame Park.

Portuguese ships docking in Algoa Bay in the 1690s used a small spring near the mouth of the river, 'Baatjes Fonteyn', as a source of fresh water. The British took control of Algoa Bay in the late 18th century, and the development of Port Elizabeth commenced, north and south of the Baakens River. During those days, the estuary was a wide shallow lagoon, with a bedrock sill across the mouth that served to back-up incoming tidal water while allowing the river to flow to the ocean. For decades the lagoon was used as a recreational area, as small boats could also access it, however as development progressed, factories were built along the left (northern) bank of the lower river, and the system was slowly degraded to the point that it became unusable for recreation.

In the 1860s it was the site of several factories and wool washing operations on its bank. In 1864 the city was granted the right to fill a portion of the lagoon with rock from a nearby area which had been quarried for development. Over time the lagoon was gradually 'reclaimed' and declined in size and condition until eventually there was no hint that it had ever been there. The lower sections of the river were eventually confined to a canal to make space for more development. This canal still carries the water of the Baakens River to the ocean, via the city's Port.

In the 1950s the City formally protected the area, which is now known as Settlers Valley, upstream of the upper limit of the estuary. An area of approximately 75Ha was cleared and fenced to create Settlers Park. A network of walking trails was created and Settlers Park became a well-loved recreational area. It is only in the past decade that this area has become overgrown and is now considered unsafe to walk alone in.

1.4 STUDY APPROACH AND METHODS

Local and international river rehabilitation guidelines informed the approach and methodology of this study. The main method applied the 12-step Australian Stream Rehabilitation method, with which the Project Leader was most familiar. Only a few of the 12 steps were possible within the Scope and duration of the study, and the method was adapted accordingly, as shown in the graphic below.

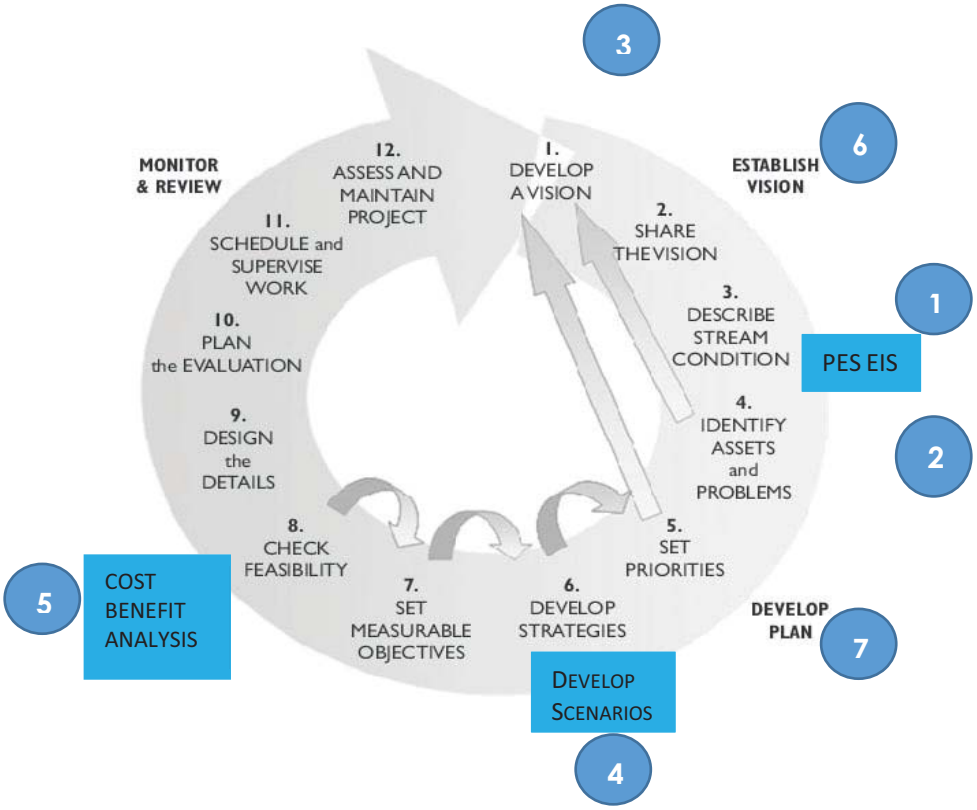


Figure 1.2 A graphic summary of the 12-step river rehabilitation process of Rutherfurd et al. 2000. Numbers in blue circles represent the altered sequence of steps in this study, and blue text boxes indicate the slightly different approach taken.

This study had four main tasks, which are reported as Parts 1-4:

1. **Description of current state:** Determination of the Present Ecological State (PES) of the river, in terms of its water quality, flora and fauna, using the method of Ecoclassification.
2. **Rehabilitation scenarios:** The formulation of an overall vision and broad strategy for the catchment, and a series of rehabilitation actions in the form of options or scenarios.
3. **Cost-benefit analysis:** The analysis of the cost-effectiveness and cost-benefit of these options.
4. **Recommendations:** A series of recommendations regarding prioritisation of these scenarios and other means of rehabilitating the Baakens River.

Consultation was a key element of the project and involved the interaction with key stakeholders in the determination of issues, scenarios, future vision, and priorities.

Part 1 deals with the first of these tasks, the determination of current state. The approach followed is the standard South African stepwise method of Ecoclassification, somewhat tailored to the resources and time available in the project. The following are the steps taken to determine Present Ecological State (PES) for the four components (water quality, riparian vegetation, fish and aquatic macroinvertebrates) and the overall Ecostatus per site:

- Divide the river into manageable units for analysis (reaches), and select one site within each of four reaches.
- Determine reference or pre-impact conditions for each component
- Do a field survey (May 2022) at four sites to collect data on each component
- Analyse the data and use the component-specific Excel spreadsheet-based models (PAI, VEGRAI, FRAI, MIRAI) to calculate the extent of deviation of condition of that component from reference condition (i.e. the PES)
- Use the component PES to determine the Ecostatus for the site.
- Determine the trajectory (i.e. is the site improving or deteriorating) for each component as well as for the Ecostatus.
- Determine the Ecological Importance and Sensitivity (EIS) of the site.
- Based on the Ecostatus and EIS, determine the Recommended Ecological Category (REC) for the site.

Note: The PES and Ecostatus are expressed as a category, ranging from A to F (unimpacted to critically degraded). Each subsequent category represents 10-20% greater deviation from reference (pre-impact) condition, which is set at 100%. Thus, a C category would represent a deviation of 30-50% from reference.

1.5 DIVISION OF THE CATCHMENT INTO REACHES

For the purposes of assessment and analysis, the Baakens River mainstem was divided into six relatively homogenous reaches (units) on the basis of a range of considerations: ecosystem type (wetland, river or estuary) and morphology, geology and topography, land-use zoning, protected area status, linkage to previous studies' river divisions, extent of degradation, urban features, and accessibility.

A single river site for survey/sampling was selected within each of the four lower reaches. Where possible these sites corresponded with existing or historic sites (water quality, fish sampling) so that historic data could be consulted.

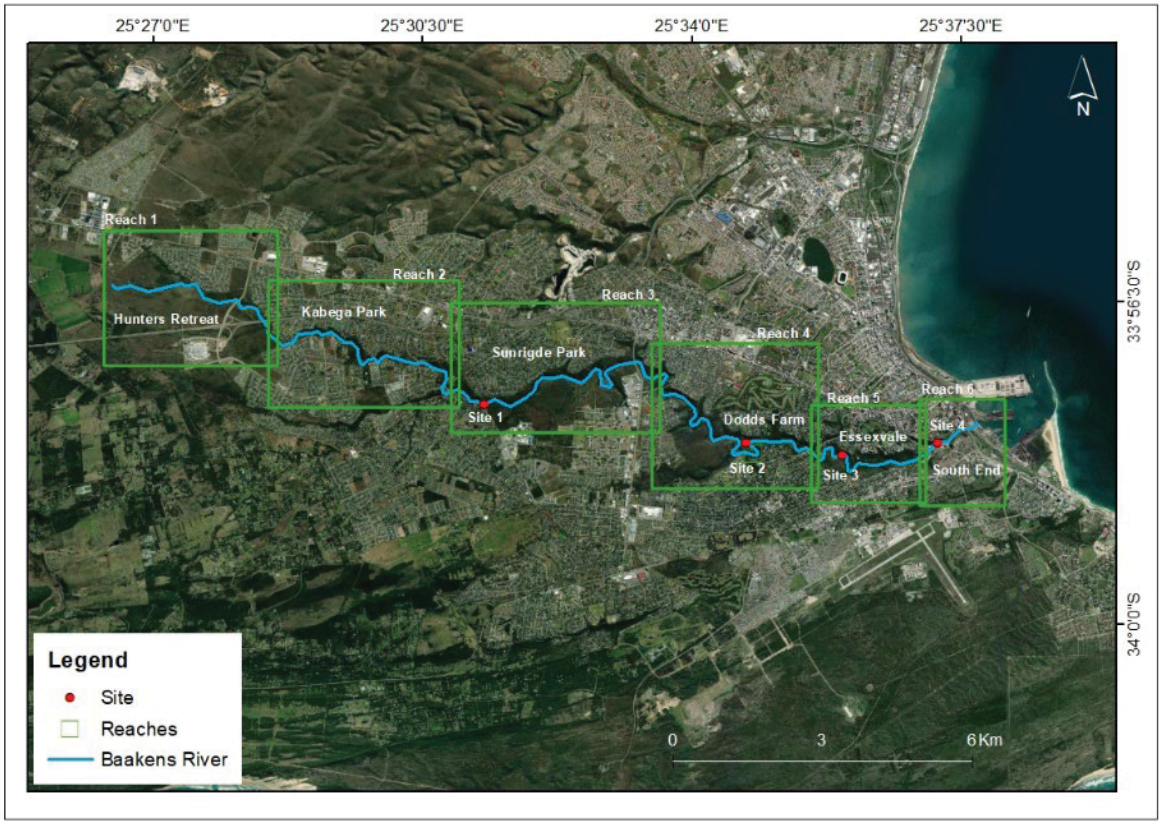


Figure 1.3 Map of the Baakens showing the 6 river reaches and 4 sites for PES determination.

Figure 1.4 Photographs of each of the four sampling sites (Clockwise from Left Top: Sites 1-4)

1.6 REFERENCE CONDITIONS

Water Quality

The Reference Condition or natural state would be described by slightly salty water with high dissolved oxygen levels, low nutrients and low toxins. It is assumed that instream temperatures would be low due to overhanging vegetation.

The natural geology of Peninsula Formation shales underlying the catchment is expected to be the reason for the somewhat 'salty' (high electrical conductivity) character of the overlying waters. It is assumed that although there has been an anthropogenic increase in salinity levels, the natural or reference state would still be higher than 30 mS/m. The baseline condition was therefore recalibrated to 55 mS/m to account for these 'natural' salts. Note that this is an assumption, as no data exists for unimpacted systems.

Riparian Vegetation

Within the Baakens River catchment the two dominant Vegetation Units are Algoa Sandstone Fynbos and Bethelsdorp Bontveld which belongs to the Albany Thicket Bioregion and follows the contours of the Baakens River along its incised valley.

Under Reference Condition, sites in the Fynbos are expected to not be dominated by tall woody species, with lower to small shrubs at most and characterised by a marginal zone dominated by non-woody riparian obligates such as sedges, grasses and hydrophilic herbaceous forbs. Algoa Sandstone Fynbos is described as "flat to slightly undulating plains supporting grassy shrubland (mainly graminoid fynbos). Grasses become dominant especially in wet habitats".

Sites within the Albany Thicket on the other hand are expected to have a well-defined and tall woody component, but one that does not dominate to the extent of exclusion of marginal zone non-woody specialists. Bethelsdorp Bontveld is described as "a mosaic of low thicket (2-3 m) consisting of bush clumps in a matrix of low, succulent-rich shrubland comprising renosterveld and succulent karroid elements, e.g. *Smelophyllum capense*."

Fish

The indigenous fish species expected under natural or reference condition in the Baakens River are presented in

Table 1.1. The fish species expected in the Baakens River under Reference conditions

FISH SPECIES			
SCIENTIFIC NAME	**COMMON NAME**	**SCIENTIFIC NAME**	**COMMON NAME**
Pseudobarbus afer	Eastern Cape redfin	*Monodactylus falciformis*	Cape moony
Sandelia capensis	Cape kurper	*Anguilla mossambica*	Longfin eel
Enteromius pallidus	Goldie barb	*Eleotris fusca*	Dusky sleeper
Myxus capensis	Freshwater mullet	*Awaous aeneofuscus*	Freshwater goby
Mugil cephalus	Flathead mullet	Stenogobius ?polyzona	Banded goby

Invertebrates

The invertebrate taxa expected to be present in the middle and lower reaches of the Baakens River under natural conditions are tabulated below. Note that to account for the naturally high Electrical Conductivity (EC) or 'saltiness' of the water, taxa scoring over 10/15 (higher sensitivity to water quality) have been removed from the derived reference condition.

TAXON	Family	Common name	TAXON	Family	Common name
PORIFERA		Sponges	MEGALOPTERA	Corydalidae	Dobsonflies
COELENTERATA		Freshwater polyp	TRICHOPTERA	Ecnomidae	Caseless caddisfly
TURBELLARIA		Flatworms		Hydropschychidae	Net-spinning caddisfly
ANNELIDA	Oligochaeta	Aquatic worms	COLEOPTERA	Hydroptilidae	Purse-case caddisflies
HIRUDINEA		Leeches		Leptoceridae	Micro-caddis
CRUSTACEA	Potamonautidae	Crabs		Dytiscidae	Predaceous diving beetles
	Palaeomonidae	Freshwater prawns		Elmidae	Riffle beetles
HYDRACARINA		Water mites		Gyrinidae	Whirligig beetles
EPHEMEROPTERA	Baetidae 2 sp	Small minnow mayflies		Haliplidae	Crawling water beetles
	Caenidae	Cainflies (mayflies)		Hydraenidae	Minute moss beetles
	Leptophlebiidae	Prongills (mayflies)		Hydrophilidae	Water scavenger beetles
ODONATA	Synlestidae	Malachite dragonfly	DIPTERA	Ceratopogonidae	Biting midges
	Coenagriidae	Narrow-winged damsel		Chironomidae	Midges
	Lestidae	Spreadwing damselfly		Culicidae	Mosquito larva
	Protoneuridae	Hawker dragonflies		Dixidae	Meniscus midges
	Aeshnidae	Darner dragonflies		Empididae	Dagger flies
	Gomphidae	Skimmers		Muscidae	House fly larvae
	Libellulidae	Common skimmers		Psychodidae	Moth fly larvae
HEMIPTERA	Belostomatidae	Giant water bugs		Simuliidae	Blackfly larvae
	Corixidae	Water boatmen		Syrphidae	Rat tailed maggot larvae
	Gerridae	Pond skaters		Tabanidae	Horsefly larvae
	Hydrometridae	Marsh treaders		Tipulidae	Cranefly larvae
	Naucoridae	Creeping water bugs	GASTROPODA	Ancylidae	Freshwater limpets
	Nepidae	Water scorpions		Lymnaeidae	Pond snails
	Notonectidae	Backswimmers		Physidae	Pouch snails
	Pleidae	Pygmy backswimmers		Planorbinae	Orb snails
	Veliidae	Riffle bugs			

1.7 SURVEY RESULTS

Site 1: Hawthorne Ave, Upper River

WATER QUALITY (WQ)
The river at Site 1 is significantly transformed from natural. There was a risk of high turbidity levels if the fine sediment were to be mobilized during high flows, for example. Hawthorne Sewage Pump Station located directly below the sampling point at Site 1 Is reportedly non-compliant with discharge standards and dysfunctional at times. Load-shedding will exacerbate this situation, and backup, temporary storage, or bypass protocols may be inconsistently applied according to reports. E. *coli* levels were very high at this site, indicating sewage pollution.
RIPARIAN VEGETATION
Most of the reach has been invaded by perennial alien species which has resulted in the exclusion of indigenous flora. Portions of the reach have been cleared and landscaped by river front and replanted banksand constructed some in-channel pools and habitats. These in-channel areas support some in-channel marginal zone vegetation.
FISH
Five individuals of the indigenous goldie barb *Enteromiu*s (ex *Barbus) pallidus* were captured within the upper section among marginal vegetation and under the rocks on the substrate.
AQUATIC INVERTEBRATES
The invertebrate fauna was a resilient, low diversity one, comprising mostly taxa scoring ≤8 out of 15 on the sensitivity score, except for the Baetid mayflies (>2 species present, scoring 12). The South African Scoring System 5 (SASS5) score was 76, with 19 taxa, giving an Average Score Per Taxon (ASPT) of 4.

Site 2: Dodd's Farm, Middle River:

WATER QUALITY (WQ)
Despite the aesthetics of the surrounding area, the odour and visible water quality clues at the weir on Dodd's Farm indicated poor water quality. A pipe built into the weir was discharging raw effluent, possibly from the Mangold Park sewage pump station upstream. Dissolved oxygen at this point was extremely low but increased with distance downstream. DWS results indicate that on average, E.coli levels are extremely high (exceed limits) in this section.
RIPARIAN VEGETATION
Marginal Zone Riparian and aquatic vegetation associated with pools at this site is mostly indigenous, but the alien *Myriphyllum* (Parrots Feather) has started encroaching in some areas and may invade. Indigenous riparian species occur in pools. Most of the marginal zone is not in the backup areas however and comprises runs with overhanging vegetation and less aquatic representation. Here *Phragmites australis* are present. **Non-marginal zone** This zone is characterised by high aerial cover and dense vegetation, both woody and non-woody and the patchiness of this appears to be maintained by mowing and clearing of certain areas for public access. Open areas are dominated by grasses while woody areas range from bush clumps with dense shrubs to more open understorey areas dominated by tall trees to shrub and succulent-dominated Fynbos as one leaves the valley. Perennial alien species comprising dense shrub and tall trees exist at moderate levels and pose a threat to longer-term integrity of natural vegetation.

Site 2: Dodd's Farm, Cont…

FISH
No indigenous fish species were found during the present survey at Site 2, with only low numbers of alien banded tilapia and southern mouthbrooder captured.
AQUATIC INVERTEBRATES
The SASS5 score was 68, with 15 taxa, giving an ASPT of 4.5. The highest scoring taxon was the single Platycnemid damselfly larva (scoring 10/15). The stones-in-current fauna was dominated by Baetid mayflies and Simuliid (blackfly) larvae, and the marginal vegetation by Simuliid larvae and Physid snails. Notably absent were a variety of Hemiptera (bugs) and Coleoptera (beetles).

Site 3: Essexvale (in Settlers Park), Lower River:

WATER QUALITY (WQ)
Discharges from Essexvale Pump Station are reported to overflow directly into the river in this reach. At the time of the site survey a significant rupture in the rising main off Lloyd Road was responsible for the impacts seen at Site 3, e.g. low oxygen levels (3.36 mg/L) even in fast-flowing water. *E. coli* levels were very high and serve as an indicator of pollution by sewage discharges.
RIPARIAN VEGETATION
Marginal zone Essexvale is very similar to Dodd's Farm: The two main habitat forms in the marginal zone are pools or backup zones and natural channel forms, mostly runs with a linear nature. Riparian and aquatic vegetation associated with pools is mostly indigenous, but Parrots Feather has started encroaching in some areas and may invade. **Non-marginal zone** The non-marginal zone is characterised by high aerial cover and dense vegetation, both woody and non-woody. The patchiness of woody to non-woody appears to be maintained by mowing and clearing. Open areas are dominated by grasses, while woody areas range from bush clumps with dense shrubs to more open understorey areas dominated by tall to shrub and succulent dominated Fynbos as one leaves the valley. Perennial alien species comprising dense shrub and tall trees exist at moderate levels and pose a threat to longer-term integrity of natural vegetation.
FISH
In addition to the alien banded tilapia and southern mouthbrooder captured at this site, four endangered Eastern Cape redfin and one large (ca. 45 cm long) longfin eel were captured. It is important to note that Site 3 is located in the same river reach and approximately 800 m upstream from the only site in the Baakens River where this endangered Eastern Cape redfin was captured by Strydom in 2014.
AQUATIC INVERTEBRATES
Despite increasing sample effort, the SASS5 total sample was extremely poor, with only four taxa collected. This is attributed to the water quality impacts related to the upstream raw sewage overflow, and the associated low oxygen conditions. The SASS5 score was 9, with 4 taxa, giving an ASPT of 2.25. The only taxa collected were river crabs, Notonectids, Hemipterans, and Chironomid and Culicid dipteran larvae.

Site 4: Alchemy, Lower river (estuarine influence)

WATER QUALITY (WQ)
The river water appears clear in this section of the river, although *E. coli* levels are very high and serve as an indicator of pollution by sewage discharges. This would be expected as the site is at the bottom of an urban catchment. It is clear that poor water quality, primarily linked to sewage discharges rather than industrial waste, is of primary concern in the mid and lower catchment. Any recreational use in the lower catchment would be severely constrained by the high *E. coli* levels in the water.
RIPARIAN VEGETATION
Left Bank The marginal zone comprises a linear bank along a concrete canal, broken in places, with seeps into the zone from the upland areas. Aerial cover is 100%, dense vegetation that is mostly non-woody with overhang from woody shrubs, mostly the alien *Cestrum laevigatum* (Inkberry). The canal has some snags and a pulse of sediment moving through the system. Indigenous species dominate but aliens present include *Ricinus communis* and *Arundo donax* . The non-marginal zone is characterised by high aerial cover and dense vegetation, both woody and non-woody, and comprises a linear bank along a cliff or urban area. **Right Bank** The right bank is landscaped for public use and comprises mown lawns with some scattered plantings of Fig trees, although there is some recruitment of the invasive alien *Sesbanea punicea* nearer the channel. The right bank has little ecological value, with negligible ability to function as a corridor or for flood attenuation and virtually no contribution to biodiversity.
FISH
The only fish species captured during the present survey (freshwater mullet, *Myxus capensis*) was a secondary freshwater species with a catadromous life history. The absence of preferred slow-deep habitats favoured by this species indicates that the fish captured were using Site 4 as a migration corridor.
AQUATIC INVERTEBRATES
The river in this section of Reach 5 is considered estuarine interface, although the EC did not suggest highly salty water at this site (possibly due to dilution by rain). The river was canalised here, however there were habitat elements that could be sampled. The SASS5 score was 66, with 14 taxa and an ASPT of 4.7. Taxa present in the SASS5 sample were nonetheless the less sensitive, lower-scoring ones. The lack of more sensitive taxa is attributed to the overall paucity of good habitat in this section of the river, and to the chronic upstream deterioration in water quality.

1.8 PRESENT ECOLOGICAL STATE, ECOSTATUS AND EIS

The PES results are presented as a summary of Present Ecological State (PES) percentages, Ecological Categories (ECs) and confidence values out of 5 (Conf) for each of the four sites, for water quality (PAI results), riparian vegetation (VEGRAI), fish (FRAI) and macroinvertebrates (MIRAI).

REACH	SITE	WQual	EC	Con	RipVeg	EC	Con	Fish	EC	Con	Invert	EC	Con
3	**1**	64.1%	C	3	13.7%	F	3	44.2%	D	2	48.9%	D	2
4	**2**	66.5%	C	3	66.7%	C	4	45.3%	D	2	43.5%	D	2
5	**3**	26.5%	E	4	62.0%	C	4	59.0%	C/D	2	14.5%	F	2
6	**4**	68.8%	C	3.5	35.9%	E	3	46.3%	D	2	40.9%	D/E	2

The final integrated results per site are presented below. These are the Ecostatus percentages (Eco %) and associated Ecological Categories (EC) together with the Ecological Importance and Sensitivity values (EIS), site Trajectory (Traj; Neg – negative), and Recommended Ecological Category (REC). In the case of an Ecostatus of E or lower, remediation is considered a requirement.

REACH.	SITE	Eco %	EC	EIS	Traj	REC
1	**-**	-	-	HIGH	-	-
3	**1**	29.2%	E	HIGH	Neg	Remediation
4	**2**	57.8%	C/D	VERY HIGH	Neg	C
5	**3**	53.8%	D	VERY HIGH	Neg	C/D
6	**4**	39.8%	D/E	VERY HIGH	Neg	D

Where:

- A: near natural (>89% to 100%)
- B: largely natural (> 80% to 89%)
- C: moderately modified (> 60% to 79%)
- D: largely modified (>40% to 59%)
- E: seriously modified (>20% to 39%)
- F: critically modified (<20%)

The PES/Ecostatus category descriptions are as follows:

CATEGORY	BIOTIC INTEGRITY	DESCRIPTION OF GENERALLY EXPECTED CONDITIONS
A	Excellent	Unmodified, or approximates natural conditions closely. The biotic assemblages compares to that expected under natural, unperturbed conditions.
B	Good	Largely natural with few modifications. A change in community characteristics may have taken place but species richness and presence of intolerant species indicate little modifications. Most aspects of the biotic assemblage as expected under natural unperturbed conditions.
C	Fair	Moderately modified. A lower than expected species richness and presence of most intolerant species. Most of the characteristics of the biotic assemblages have been moderately modified from its naturally expected condition. Some impairment of health may be evident at the lower end of this class.
D	Poor	Largely modified. A clearly lower than expected species richness and absence or much lowered presence of intolerant and moderately intolerant species. Most characteristics of the biotic assemblages have been largely modified from its naturally expected condition. Impairment of health may become evident at the lower end of this class.
E	Very Poor	Seriously modified. A strikingly lower than expected species richness and general absence of intolerant and moderately tolerant species. Most of the characteristics of the biotic assemblages have been seriously modified from its naturally expected condition. Impairment of health may become very evident.
F	Critical	Critically modified. Extremely lowered species richness and an absence of intolerant and moderately tolerant species. Only tolerant species may be present with complete loss of species at the lower end of the class. Most of the characteristics of the biotic assemblages have been critically modified from its naturally expected conditions. Impairment of health generally very evident.

And the EIS descriptions are as follows:

EIS CATEGORIES	GENERAL DESCRIPTION
VERY HIGH	Quaternaries/delineations that are unique on a national or even international level based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use.
HIGH	Quaternaries/delineations that are unique on a national scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) may be sensitive to flow modifications but in some cases, may have a substantial capacity for use.
MODERATE	Quaternaries/delineations that are unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually not very sensitive to flow modifications and often have a substantial capacity for use.
LOW/MARGINAL	Quaternaries/delineations that are not unique at any scale. These rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have a substantial capacity for use.

2 PART 2: DEVELOPMENT OF REHABILITATION SCENARIOS

2.1 INTRODUCTION

This study was commissioned and funded by the Mandela Bay Development Agency (MBDA) through a Memorandum of Understanding with the Water Research Commission (WRC).

The study aims are: 1) to determine the present ecological state (PES) of the Baakens River, to consultatively develop a rehabilitation vision and scenarios for the river, to do a cost-effectiveness analysis on the rehabilitation scenarios, and to make recommendations regarding the feasibility of rehabilitation for the Baakens River.

This report represents the second phase of the project and is focussed on providing different rehabilitation scenarios for the river.

The rehabilitation process followed is informed by the Australian method, with reference also to the South African and British river rehabilitation methods.

The first step was to determine both the natural, pre-impact (reference) condition, and the current state of the Baakens River. For the Present Ecological State (PES) study, the river was divided into six reaches numbered from upstream to downstream. Four survey sites were selected in four of the reaches, and numbered in the same way. Based on these results the integrated Ecostatus (EC) per site was determined. The EC varied from an E category (29% of natural state) at the uppermost Site 1 to a C/D (58%) at Site 2, a D (54%) at Site 3 and a D/E (39%) at Site 4. In contrast, the Ecological Importance and Sensitivity (EIS) scores for the sites were High for Site 1 and Very High for Sites 2 to 4. The Recommended Ecological Categories (REC) were set as a D, C, C/D and D category for Sites 1 to 4 respectively.

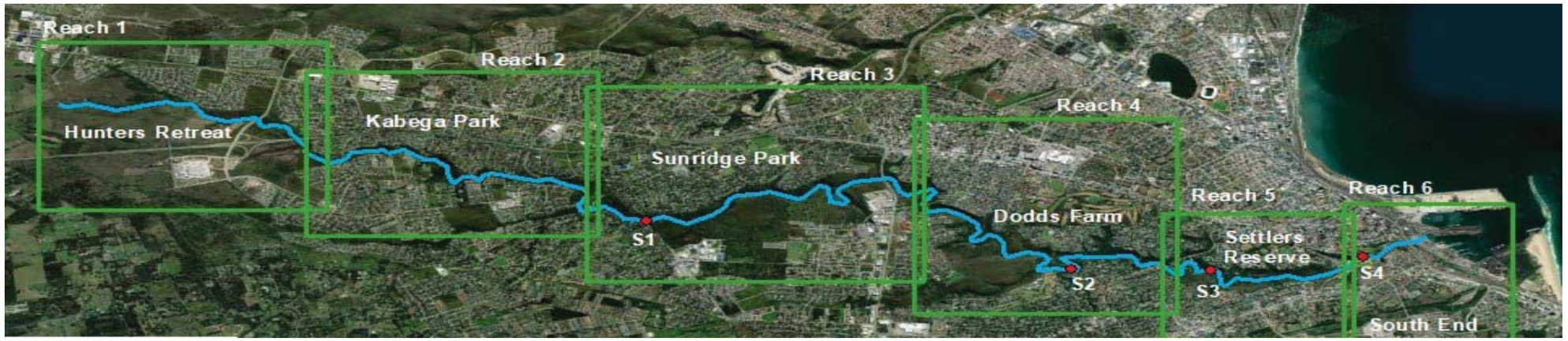
The next step in the process was to describe the 'assets and problems' of each reach. These are based on the PES findings and a review of available documentation. The 'assets' are described for the reference state. Upper catchment healthy seep and depressional wetlands (Reach 1) provide water storage during dry periods, groundwater recharge, flood attenuation and detention, erosion prevention and control, and supply of habitat for a range of plants and animals, including endemic plant species. The natural river (Reaches 2 to 5) would deliver habitat for fauna, biomass production, biodiversity, nutrient cycling, oxygen production, carbon sequestration, water filtration, flow regulation, flood attenuation, a movement corridor, and a venue for recreational and educational activities. The estuary (Reach 6C) would deliver ecosystem services including food supply, oxygen production, carbon sequestration, water filtration, flow regulation, disturbance regulation, climate regulation, waste treatment, and scientific and recreational interest.

The 'problems' in the river provide the basis for the development of the rehabilitation scenarios. In the upper catchment (Reach 1), the seep and depressional wetlands are partly degraded due to clearing for agriculture and grazing to their edges. The area is heavily invaded with the alien Port Jackson willow. In Reaches 2 to 6, the most critical and urgent issue is water quality deterioration due to inflows of raw sewage from pump stations or surcharging sewers. The diversity and abundance of fish and invertebrate biota are low, reflecting this poor water quality. The middle reaches of the river (Reaches 2 and 3) are highly urbanised, with development close to or onto the floodplain. The riparian zone in this section is cleared in places and highly invaded in others.

Table 2.1 A brief description of the river assets under natural conditions

	REACH 1	REACH 2	REACH 3	REACH 4	REACH 5	REACH 6
	HUNTERS RETREAT	KABEGA PARK	SUNRIDGE PARK	DODD'S FARM	SETTLERS PARK	VALLEY ROAD
	WETLANDS, ENDEMIC PLANTS	RIVER	RIVER	RIVER, DODD'S FARM	RIVER, SETTLERS PARK	ESTUARY
NATURAL STATE: ASSETS	In this upper catchment there are numerous seep and depressional wetlands. Under natural conditions, and when functioning optimally, these wetlands provide a range of ecosystem services: water storage during dry periods, groundwater recharge, flood attenuation and detention, erosion prevention and control, supply of habitat for a range of plants and animals. The fynbos plant species of special concern (SSC), the Honeybush (*Cyclopia pubescens*) occurs in association with the seep wetlands and rocky outcrops in the area. This, together with numerous other plant SSCs, as well as the wetlands and rocky outcrops, provide this reach with high biodiversity, high ecological importance and sensitivity, and high protection value.	The river in these reaches represents a natural corridor and green lung. The water quality is unimpacted. The instream habitat is chiefly bedrock, boulder and cobble, and the river has a riffle-run-pool morphology. The riparian zone and floodplain are well connected to the channel. The riparian vegetation varies from Bethelsdorp bontveld (Albany thicket bioregion) in the lower reaches to Algoa Sandstone Fynbos in the middle and upper reaches. The ecosystem services supplied by the healthy river, riparian zone and floodplain would include: habitat for a diverse fauna (including rare fish species, invertebrates, birds, reptiles and amphibians), biomass production, biodiversity provision, nutrient cycling, oxygen production, carbon sequestration, water filtration, flow regulation, flood attenuation, a movement corridor, and healthy open space for recreation, adventure sport, outdoor and scientific research and education, spiritual gatherings, and events (e.g. concerts, markets).				The lower river, estuarine interface and estuary would under natural conditions be a dynamic system, with a healthy fauna and well vegetated floodplain. It would provide the following ecosystem services: food supply, oxygen production, carbon sequestration, water filtration, flow regulation, disturbance regulation, climate regulation, waste treatment, and scientific and recreational interest.

Table 2.2 Degraded Present-Day Assets per Reach, Baakens River



	REACH 1	REACH 2	REACH 3	REACH 4	REACH 5	REACH 6
	HUNTERS RETREAT	KABEGA PARK	SUNRIDGE PARK	DODDS FARM	SETTLERS PARK	VALLEY ROAD
	SEEPS, DEPRESSIONAL WETLANDS	RIVER	RIVER	RIVER	RIVER	RIVER, ESTUARY
PROBLEMS: PRESENT DAY DEGRADED ASSETS	Seep and depressional wetlands in this upper catchment area are degraded due to clearing, grazing, and recent large-scale development (Bay West Mall). There is the threat of further development, particularly in the form of large residential complexes. As a result of the farming and development in the catchment, and the loss of wetland functionality, there is reduced NFM capability. There is extensive litter, likely from stormwater inputs and pedestrian traffic. Numerous people appeared to be making their homes in the bush (Site visit May 2022). Trajectory with no interventions: Negative	The major issues here are extensive urbanisation of the catchment, substantial increase in hardened surface, development into the floodplain, severe water quality deterioration as a result of sewage spills directly into the river from Hawthorne Ave pump station (inter alia), large-scale invasion of riparian vegetation by AIVs, loss of riparian zone and floodplain integrity, and the presence of instream barriers. Trajectory with no interventions: Negative	The right bank, riparian zone and floodplain have historically been cleared for small-scale farming. There is extensive encroachment of invasive alien vegetation (juvenile and well established Eucalypts, Port Jackson willow, Pines). Development continues in this reach, coupled with an increase in hardened surface, a decrease in infiltration and an increase in storm runoff. Natural flood management (NFM) capability is reduced. Water quality is reportedly consistently poor due to regular inflows or raw sewage from the Woodlands and Mangold Park sewage pump stations. Trajectory with no interventions: Negative	As much of the land in Reach 6, Dodd's Farm, is protected from development and naturally vegetated, the riparian and floodplain vegetation in this reach is relatively intact, and incidence of alien invasive vegetation is relatively low. The vegetation is however very overgrown and needs clearing. Major threats in this reach are water quality deterioration as a result of sewage spillage (at the weir), threats to human health, declining biodiversity, loss of amenity and infrastructure value (due to disuse and lack of maintenance and management of structures), and safety and security for visitors. The continual presence of members of community groups such as the Community Crime Awareness (CCA) group and Fat Tracks mountain bike club, and the monitored high-level security camera, assist greatly in addressing security. Trajectory with no interventions: Negative	The major threats in this section are severe water quality deterioration (representing sewage inputs from upstream Mangold Park and Essexvale pump stations) representing a health threat to human users and to biota. Indigenous vegetation is overgrown and poses a security hazard to recreational users. There are vagrants living in the overgrowth. The numerous river crossings and the major weir in this reach represent barriers to fish migration. Reserve infrastructure has been vandalised and represents a safety hazard. Trajectory with no interventions: Negative	Reach 6A. Major issue is water quality, alien invasives and overgrown indigenous riparian vegetation. Reach 6B: Channel gabion-lined, lacking natural instream habitat, right bank riparian and floodplain vegetation cleared. NFM capability severely reduced. Reach 6C: Estuarine wetland floodplain cleared and largely developed. Estuarine channel filled in (1860s) and partially developed. Remains of the channel have been narrowed and constrained in a concrete canal. Loss of flood conveyance capacity. Loss of all instream habitat, marginal and riparian vegetation and floodplain functionality. Loss of connectivity to ocean, river and floodplain. Loss of estuarine functionality. Trajectory with no interventions: Negative

In Reaches 4 (Dodd's Farm) and 5 (Settlers Valley) the water quality problem persists. The river channel and riparian zone vegetation remain relatively intact, with good functionality. However, even the indigenous vegetation is overgrown and poses a security hazard to recreational users. The numerous river crossings and the major weirs represent barriers to upstream fish migration. While the biota generally scored extremely low particularly in the latter reach, the endangered fish *Pseudobarbus after* (Eastern Cape redfin) was found here.

At the top of Reach 6 (6A) the major issues are water quality, alien invasives and overgrowth of indigenous riparian vegetation. In the middle section of Reach 6 (6B), the channel is gabion-lined, and lacking natural instream habitat. The right bank riparian and floodplain vegetation has been cleared, and natural flood management capability is impaired. In the lowest section of Reach 6 (6C), the estuary has been partially filled in (1860s) and built over. The remains of the channel have been narrowed and constrained into a concrete canal, with no instream or marginal habitat, and no lateral connectivity to the floodplain. These modifications have resulted in a significant reduction in flood conveyance capacity and of estuarine functionality.

Having described the assets and problems, a preliminary vision was set for the Baakens River. This vision begins as an ideal, and is then reworked in consultation with other stakeholders to a more practical and attainable statement. The initial vision is as follows:

The Baakens River and estuary that we envision will be a natural icon of Gqeberha. It will serve as a natural green belt and a lung for the city, offering its communities a safe and healthy escape from urban life, a reconnection to the natural world, and a place to enhance fitness and outdoor adventure skills. A network of safe walking, hiking and cycling tracks will criss-cross the Reserve areas.

The highly sensitive indigenous and endemic plant and fish species of the river will be formally protected. At the source of the river, the seep wetlands will function in good health and be protected for their habitat, biodiversity value and ability to retain water and assist in natural flood management. In the river's upper, middle and lower reaches, the river will flow clean with the largely-indigenous riparian zone and floodplain serving as a corridor for the movement of birds and small animals.

The lower river and estuary will be naturalised and reconnected to the upper reaches. It will be fringed with indigenous plants in a more functional riparian zone. The estuary will again function as a nursery area for larval fish and provide passage for migratory fish species to move from the ocean all the way up the river. It will be a clean and safe environment for recreational activity.

2.2 EXISTING BAAKENS RIVER REHABILITATION INITIATIVES

A number of studies on the rehabilitation of the Baakens River pre-date this one and bear sharing. There is a great deal of commonality between these, but also innovative concepts which are exclusive to each. Consideration should be given to drawing on all of this work in the final rehabilitation planning exercise.

The GAPP Consortium was appointed by the MBDA in August 2014 to develop a plan for the redevelopment of the Baakens Valley Precinct. The plan sets out the vision for the study area as a vibrant, attractive and usable precinct, orientated around a dominant open space system. The intention is also to develop numerous facilities for recreation and tourism and to revitalise and provide linkages to historic buildings and venues. There are four focus areas: the Heart of the Bay, Baakens River Valley, St Georges Park and the Waterfront.

In the GAPP Consortium Plan, the **Baakens River Parkway** plan concerns the section of the river and its floodplain from the Brickmakers Street Bridge to the Port. The aim here is to provide or upgrade facilities within the existing river park area and the open space area along the banks of the river. The work will include landscaping and beautification, upgrading of parking and addition of recreational facilities.

Part of the proposal is to clear the river banks of dense alien vegetation and to implement rehabilitation measures on the canalised sections of the river and estuary. Recreational facilities include open space facilities for recreational activities including a climbing wall, bicycle path, trails, and gardens.

In terms of environmental permissions required, the final Basic Assessment Report for the Baakens Valley Precinct plan was done by Engineering Advice and Services PE in 2019, and authorised in October 2019. A renewed environmental authorisation was granted in March 2022. The conditions of approval included the requirement for the submission of a Layout Plan and Construction and Operational Environmental Management Plan covering the various aspects of the plan. As the BAR included a commitment to rehabilitation of aspects of the Baakens River, this requirement is reflected in the Environmental Authorisation.

The **Green Lung Report: Restoration of the Baakens River Valley** (2022) was commissioned by the NMB Business Chamber in collaboration with a number of partners. The Mantis Eco Group developed the plan. The report focusses on the 'redevelopment' of the Baakens Valley, and on leveraging the natural asset value of the system. It provides a series of solutions for the Baakens River in its present state. These are based on existing research, knowledge, experience and on historic studies done in the Baakens River Valley.

Three major issues are highlighted: invasive alien vegetation, sewage, and safety and security. The three themes for the initiative are: Remove, Replant, Reignite. Each is associated with a number of tasks. Under Remove, the tasks are alien vegetation removal; and addressing the sewage problem and the security threat. Under Replant, the tasks are restoration of soil health, indigenous vegetation, the river and the hydrology; nurserying of indigenous vegetation; the establishment of 3 zones; and a focus on community participation. The tasks under Reignite include the creation of a recreational zone focussed on concerts, markets, guided tours and sporting events; the conservation of natural areas (through protection); the long term goal of establishing a botanical garden; and the opportunity to use the valley for teaching and for research.

The three zones are Zone 1 (Recreational), with the pilot area being Dodd's Farm; Zone 2 (Natural/Protected) which would focus on the formal protection and conservation of natural vegetation in a series of natural areas through the valley and the establishment of a Botanical Garden, and Zone 3 (Educational), a series of educational areas to be used for formal education, research, skills development, and as nurseries for indigenous vegetation. The estimated cost of all interventions phased over a 20 year period, is R50 million.

The **Baakens River Revival Plan** (2013) is a detailed and forward-thinking landscape architecture plan focussed on the Lower Baakens River Valley. The report was authored by Rosemary Anne Buchanan (RB) and submitted in fulfilment of Degree of Masters, Landscape Architecture, University of Cape Town.

Buchanan makes effective use of graphic imagery (GIS map layers and CAD images) to present and analyse information on the upper, middle and lower catchment areas: geology and topography,

hydrology and stormwater, vegetation, critical biodiversity areas, terrestrial and aquatic fauna, and natural processes.

This leads to a series of conclusions. Firstly, that habitat loss is a critical factor, and the Valley needs to have greater protection status. Development encroachment needs to be carefully monitored and pollution of the river needs to be curbed. Secondly, that floods are a real threat and a holistic approach to water run-off and bridges needs to be implemented, following principles such as Sustainable Drainage Systems (SuDS). Thirdly, that causeways and weirs should also be removed where possible as these create barriers for fish and environmental flow; alternatively, fishways should be constructed. Lastly, that river rehabilitation of the mouth needs to be implemented as part of a landscape plan for the Lower Baakens.

Professor Nadine Strydom, in her 2014 report on the fish of the Baakens River, made recommendations regarding **remedial actions for the Baakens Ecosystem**. She argued that rivers should be managed as whole ecosystems and not partitioned in piece-meal rehabilitation efforts. The problems currently facing the future of fish health in the Baakens (at the time) include alien fish, pollution and siltation. Reference was made to the fact that in terms of the National Environmental Management: Biodiversity Act 10 of 2004, threats to endangered species and threats to ecosystem health should be mitigated. Strydom recommended that the lower section of the Baakens River be rehabilitated to its natural small estuary status. This meant widening and deepening the existing channel, along with the additional creation of small embayments along the margins of the area, preferably with suitable submerged aquatic vegetation to serve as shallow refugia for lower-river, estuarine and marine-dependent non migratory fishes. Other recommendations included the immediate eradication of alien fish, the prevention of sewage spills into the river, clearing of the channel from excess vegetation, and the installation of appropriate fish ladders along the river course.

2.3 OFFICIAL PLANNING DOCUMENTS

There are a number of important NMB Metro and MBDA planning documents which guide development and planning decisions. They generally have a lifespan of 3-5 years.

The Integrated Development Plan (IDP) is a strategic plan for development that provides guidance on the budgeting and decision-making processes of the municipality. The executive committee of the local municipality manages the IDP process alongside the Executive Mayor. The current IDP is the fifth edition, valid 2017/18 through to 2021/22.

The Climate Change and Green Economy Action Plan (CC&GEAP) of 2015 is an official document that guides the strategic vision for the city, and is included in the IDP. It includes the identification of climate risks and vulnerabilities of the city to these risks, and proposes interventions to build adaptive capacity, climate responsiveness, and resilience to cope with these risks. While the Baakens River is not specifically mentioned in the report, the issue of flooding (which is problematic in the Baakens) is raised for specific management intervention, and catchment restoration is included in the suite of proposed interventions.

The NMB Built Environment Performance Plan (BEPP) is a planning tool to align, consolidate and focus the existing strategic planning instruments into a spatially targeted investment and implementation plan. In terms of the BEPP, the Baakens Area development planning falls within the focus on the Urban Network Strategy (UNS), Integration Zones (IZ) and Economic/ Growth nodes. Within these nodes, the CBD is seen as a Primary Hub, in which the focus of catalytic projects is on interventions including

development within the defined Integration Zone (Zone 1) and assisting with private and public sector initiatives with respect to developments.

The Bioregional Plan is a spatial plan providing information on terrestrial and aquatic features critical for conserving biodiversity and maintaining ecosystem function (Critical Biodiversity Areas or CBAs and Ecological Support Areas or ESAs). It is based on the 2010 Conservation and Assessment Plan produced for the Metro.

The Spatial Development Framework (SDF) of 2015 deals with future spatial planning of the Metro at a detailed level. The intention to develop the Waterfront (Port) and Lower Baakens River is included here, and the development of the Baakens Valley Precinct is identified as one of the Catalytic Projects, shown to be viable (by 2015). The Baakens Valley is noted for its importance the Metro's most extensive corridor through fynbos habitats, and of critical importance for the continuation of ecological processes that sustain biodiversity. It is also recognised that the area provides numerous ecosystem services, playing an important role in flood attenuation, storm water management, environmental education and nature-based recreation.

The MBDA Five Year Development Plan (2018) is in alignment with all the planning documents already presented. The Baakens Area Report included in this plan deals exclusively with development planning for this area. In terms of the Inner-city Local Spatial Development Framework (not accessed as yet), the Baakens River Precinct has the following development vision: to provide an area for higher density residential development; to link the inner core to the Baakens Conservation Zone and Harbour Development; and to do careful conservation of the Baakens River and its floodplain. The proposed interventions presented in the plan include 'Environmental rehabilitation of the north and south banks (of the Baakens), including removal of alien vegetation'. The assumptions include 'Partnerships with key land and property owners and other stakeholders in the Inner-city'. One example of this being currently implemented is in the working relationship between NMBDA and the NMB BC.

The stakeholders identified for the implementation of projects in the area include youth, organised business, Nelson Mandela Metro University, environmental lobby groups, NMB Tourism and its members, South End Museum and members, Wildlife and Environment Society of SA and its members, NMB Heritage Trust, sporting bodies, adventure groups, and private sector owners.

2.4 REHABILITATION SCENARIO PLANNING

The next step in rehabilitation planning process for this project is to consider, on the basis of the most identified issues in the river, a number of options or scenarios to rehabilitate the river towards improved ecological health.

The scenarios presented in the following chapters arise from a process that has been underway since April 2022. This has included: gaining a broad understanding of the spatial planning context for the Metro and of MBDA's plans for the revitalisation of the South End, Baakens Valley Precinct and Baakens Parkway; a review of the available literature on the Baakens river, estuary, and catchment; a review of all other known rehabilitation plans for the Baakens; three visits to the river to walk sections of it; two days of river surveying; a visit to the South End Museum to get context; and meetings/discussions with numerous stakeholders and officials and members of the catchment community.

On the basis of what is now known of the Baakens River catchment, the main issues of concern to the ecological health of the river and its biota are considered to be: water quality deterioration, unnatural

water quantity (particularly floods and base-flows); system connectivity, channel form, and habitat availability. The deterioration in presence, abundance and condition of river biota is related to the first and last of these issues. From a social perspective the key concerns are human health, safe access and recreation, and security.

The assumption is that the MBDA's Baakens River Parkway plan, and the Green Lung Project's Baakens River Restoration Plan, will both be initiated and will address the major social concerns. For this reason, three rehabilitation scenarios have been developed to address the key ecological issues.

2.5 REHABILITATION SCENARIO 1: ADDRESS WATER QUALITY

The current state of water quality in the Baakens is consistently poor. The water quality results presented during Phase 1 of this project reported Present Ecological State (PES) values, for Sites 1 to 4, of 64% (Category C), 67% (C), 27% (E) and 69% (C). From day to day, it may vary from these values, but Is unlikely to be better than this.

The problems arise in the main from sewage inflows into the river. These are reported on a regular basis by members of the community. The sewage is typically either direct overflow from pump stations, surcharge from manholes, or runoff from damaged or blocked sewer lines.

There are a number of organisations working to get a clearer picture of the situation and the details of the problems. At present however, the problems reported here are generic issues that apply to all pump stations (there are at least 8 in the catchment) and the catchment sewerage network.

These include the following: loss of power to pumps at pump stations (during loadshedding more severe than Stage 4); lack of backup generators and/or fuel for these; failure of pumps; vandalism to buildings – or theft of pump station pumps, and cables; lack of backup or emergency pumps; lack of screening of influent sewage at most pump stations; jamming of pump rotors by rags thrown into the system; lack of emergency sumps to accommodate sewage overflows; absence of emergency procedures; lack of adequate security; problems with procurement (for parts, etc.); non-payment of repairs (and thus repaired goods are retained and maintenance cannot proceed); inadequate staffing of pump stations; and too few inspectors of sewerage lines. According to the Executive Mayor Retief Odendaal, the budgets for maintenance and repairs of the sewerage system have hardly been spent in recent years.

There is no warning system or verification of water quality state from water quality data, as water quality data have not been uploaded to the DWS national water quality data management system (WMS) since 2019. According to local DWS, their own data have not yet been uploaded to the system.

There are also a number of areas where foreign items (e.g. glass, cement, paint, rags, packets) make their way into the sewerage system or are thrown into open manhole covers. Litter is another problem, typically flowing directly into the river from the stormwater system.

The Objectives for water quality rehabilitation are: to improve the water quality along the entire length to a sustained C category in the short term and to a B/C in the longer term; to improve Green Drop KPA status for Cape Recife Waste Water Treatment Works to 80% by 2023; to implement water quality monitoring at the existing Baakens River sites, and reporting of data in public media; to reduce the health risk to visitors to the river.

The rehabilitation interventions for water quality are as follows: 1. Commission an updated Sewerage System Master Plan for the catchment, with public participation. 2. Implement the actions as recommended in the intervention plan. 3. Employ additional staff members for line functions such as inspection of the sewerage lines. 4. Appoint trained staff to manage pump stations. 7. Ensure regular water quality and biological monitoring at key (existing monitoring) points along the river 8. Involve DWS in ensuring that compliance is achieved. Monitoring results should be published in popular media. 9. Install litter traps at key stormwater runoff points in the catchment. Employ unskilled labour to clear stormwater drains daily. 10. Institute a city-wide anti-litter campaign (should be aired on television). 11. Partner with community groups to drive clean-up actions and citizen science 12. Institute a training programme for all sanitation technical staff and management, particularly those working at pump stations.

2.6 REHABILITATION SCENARIO 2. IMPROVE WATER QUANTITY (FLOW) MANAGEMENT

The water quantity issue of immediate concern in the Baakens River is the flood flows. Floods in the catchment have historically caused deaths and major infrastructural damage, and with climate change this threat is increased. Improved management of floods and flood preparedness in the catchment are considered an urgent need. In addition, the current hydrology of the catchment (and how this differs from natural) is not well understood. Base flows are impacted by alien invasive vegetation and likely also by the increasing number of boreholes in the catchments during the drought. Real-time flow monitoring is considered necessary.

The water quantity related problems that can be addressed by the rehabilitation interventions are: flood risk and loss of the river's Natural Flood Management (NFM) capabilities; Alien Invasive Vegetation (AIV) particularly in the upper catchment; degradation of the upper catchment seep wetlands; climate change threats; and the poor understanding of the river's current hydrology.

The objectives for the rehabilitation of water quantity aspects of the river are: to reinstate some of the river's natural flood management (NFM) capabilities; to gain a better understanding of the river's current-day hydrology through real-time flow measurement; to manage the river system for worst-case scenario in terms of climate change; and to ensure that all (but particularly, vulnerable) human communities are adequately prepared for and protected against the effects of climate change, which include the increased threat of floods.

The interventions proposed are: 1. The commissioning of a 10-20 year Stormwater Master Plan for the Baakens catchment with an emphasis on Water Sensitive Urban Design (WSUD); 2. The augmenting of the river's NFM capability through the further introduction of SuDS (e.g. rainwater tanks; swales, bioretention/biodetention ponds); 3. The clearing and ongoing management of upper catchment AIV; 4. The rehabilitation of the seep and depressional wetlands in the upper catchment; 5. The proposal that no further development be permitted in the upper catchment area and that formal protection of this area be applied for; 6. The clearing of AIV in the lower river and estuarine reach (Reach 6); 7. The restoration of floodplain function in the lower river; 8. The initiation of real-time flow gauging at minimum of one site in the middle Baakens.

2.7 REHABILITATION SCENARIO 3: IMPROVE CONNECTIVITY, CHANNEL FORM AND HABITAT

This intervention is focussed on the lower portion of the river from the Brickmakerskloof Bridge to the mouth of the river at the Port. This section, Reach 6, is further divided into Reaches 6A (upper), B (middle) and C (lower), representing river, river-estuarine interface, and estuary respectively.

In this section of river, longitudinal (ocean-estuary-river-wetland) and lateral connectivity (river-floodplain) and habitat availability have been reduced or lost due to the alteration of channel form (canalisation of the lower section) and the clearing of instream, marginal and riparian habitat. Longitudinal connectivity in the river has been further reduced by the presence of several instream barriers across the river in the form of low-level crossings and weirs, particularly upstream in Settlers Park and Dodd's Farm areas.

The results of this have been a loss of estuarine functionality (particularly the larval fish nursery), a decrease in instream and riparian biodiversity; loss of the migration corridor for catadromous fish and for and a significant reduction in NFM capability in this reach.

The proposed interventions include: 1. The installation of fishways on man-made barriers to upstream fish migration; 2. The clearing of AIV and thinning of all indigenous vegetation as required in Reaches 6A and B; 3. The naturalisation of channel morphology, increase in channel cross-sectional area, and reinstatement of instream, marginal and riparian habitat in Reaches 6B and 6C; and 4. The possible introduction of floodplain features such as flood channels in Reaches 6B and C.

The Table on the following page summarizes the 3 Rehabilitation Scenarios, and the interventions that apply to each.

2.8 STAKEHOLDER ENGAGEMENT

The proposed stakeholder engagement for this project was limited to a single meeting with identified stakeholders, to present and discuss project outcomes and rehabilitation options, actions and costings, and to engage with the Metro and community regarding the best ways in which to initiate the shift of the selected sites/areas in the direction of ecological functionality, more natural conditions, and best recreational opportunities.

However, as the project unfolded it became clear that a single meeting with stakeholders would not provide adequate interaction, particularly regarding perceived issues, and it was agreed that the approach should rather be a sequence of engagements throughout the project. While this approach is superior it has been extremely time consuming and not all stakeholders have been contacted as wished, as yet. This is considered ongoing work.

The stakeholders who were identified and contacted or engaged with during the course of the project (via email, telephone, or online/real-time meetings) include: NMB Metro (Infrastructure and Engineering, Public Health); local Department of Water and Sanitation; Nelson Mandela Bay University (Prof. Nadine Strydom, Mr Adrian Grobler), Private Enterprise (NMB Business Chamber, Engineering Advice and Services PE, Urban Dynamix, Hive Ecosystems, Mantis Group, Rose Buchanan Landscape Design), Organisations (WESSA, Algoa Bay Ocean Stewards, Community Crime Awareness, Civil Society Coalition), Historian and Author Dean McCleland, and Community members (Ms Candy

Boonzaaier, Mr Johan Gerryts, Ms Ellen Paasche, Mr Gary Koekemoer). There is ongoing communication and discussion with a number of these groups and individuals.

The value of this approach is that it has provided a platform for communicating with individuals and organisations who are actively and continuously committed to the City and to the future of their natural environment, and the Baakens River system in particular. Some have been helpful in assisting with ground-truthing the river, providing local context, assisting with historical background and present day information, and being willing to discuss the practicalities of proposed rehabilitation interventions. The work is considered ongoing, as this is the nature of river rehabilitation.

	SUMMARY TABLE: ISSUES, REHABILITATION SCENARIOS, COST BENEFIT ANALYSIS OUTCOMES		
	BAAKENS RIVER VALLEY: ECO-PHYSICAL ISSUES, CAUSES AND IMPACTS		
ECOPHYSICAL ISSUE	**WATER QUALITY DETERIORATION**	**LOSS OF NATURAL FLOW / FLOOD MANAGEMENT CAPABILITY**	**LOSS OF CONNECTIVITY, NATURAL CHANNEL FORM & HABITAT**
MAJOR CAUSES	Deterioration due to regular inflows of undiluted sewage; litter washoff into stream via stormwater system (Ecostatus Categories C to D/E).	Increased flood risk due to high levels of development, increase in hardened surfaces, increase in runoff, numerous river crossings, choked channel, canalisation at lower end	Loss of width and depth in lower river and estuary due to canalisation; loss of connectivity due barriers. Loss of instream habitat in lower reaches due to canalisation, poor marginal vegetation and loss of riparian vegetation and corridor in lower river (right bank).
SOCIAL IMPACT	Human Health Risks	Risk to human life and catchment infrastructure	Loss of recreational value and human security in the lower catchment particularly.
ECOPHYSICAL IMPACT	Loss of biodiversity and reduction in species of special concern	Loss of wetland water storage and flood attenuation functionality, uncertainty about baseflows and groundwater status, loss of floodplain functionality	Loss of diversity and abundance of natural biota. Increase in alien invasive species.
	REHABILITATION SCENARIOS (PART 2)		
SCENARIO	**SCENARIO 1**	**SCENARIO 2**	**SCENARIO 3**
OVERARCHING REHABILITATION REQUIREMENT	**ADDRESS WATER QUALITY**	**ADRESS WATER QUANTITY**	**ADDRESS CONNECTIVITY, CHANNEL FORM AND HABITAT**
REHABILITATION OBJECTIVE/S	Address current sewage issues in the catchment (pump stations, sewage lines, manholes), augment systems for future predicted loads, maintain and manage water to a state acceptable for a healthy aquatic ecosystem (Category C to B/C), monitor regularly.	Improve understanding of current and possible stormwater flows in the catchment. Maintain baseflows, reinstate and augment Natural Flood Management (NFM) capability of the river. Mitigate flood and climate change threats.	In the lower 1 km of river and estuary: Naturalise channel geometry (shape) and improve connectivity between ocean, estuary, river and wetlands. Naturalise instream, marginal and riparian habitat. Create refugia. Increase abundance, diversity and species richness of expected indigenous fauna and flora. Eliminate alien fish species if possible.

	PROPOSED INTERVENTIONS PER SCENARIO		
	SCENARIO 1	**SCENARIO 2**	**SCENARIO 3**
	ADDRESS WATER QUALITY	**ADRESS WATER QUANTITY**	**ADDRESS CONNECTIVITY, CHANNEL FORM AND HABITAT**
1	Commission a 10-20 year Sewerage Situation Analysis and Management Plan, with programme and budget. NMB METRO/NMBBC	Commission an updated Stormwater Management Plan for the Baakens catchment, focussing on Sustainable Drainage Systems (SuDS). NB. The revised floodline study should be done prior to this plan, and should inform it. NMB METRO	Based on existing concepts design, engineer and construct fishways for all structures that represent barriers to indigenous fish migration. At least 8 of these structures (river crossings) in Reach 5 Settlers Park MBDA/METRO/NMU/CONSULTANTS
2	Implement required actions identified and prioritised in Sewerage Situation Assessment: pump stations, sewer line, collector sewer and WWTW. Refurbish and upgrade where necessary and aim to improve Green Drop status from 66% to 75% by 2024. and to 80% by 2026 NMB METRO/NMBBC	Put a moratorium on further development in the upper catchment (Reach 1). Clear and manage AIV in priority areas of the upper and lower catchment initially (Reaches 1 and 6). In the upper catchment (Reach 1), delineate wetland areas. Restore seep and depressional wetlands. Apply for Protected Area status for Reach 1 or the identified areas thereof. SANBI/Working for Wetlands/NMB Metro/NMBBC	Clear AIV along left and right channel and bank along river from Brickmakerskloof Bridge to mouth. Thin marginal vegetation throughout catchment on an ongoing basis – this will also assist with security and safety of recreational users Replant cleared (AIV) areas with appropriate indigenous marginal and riparian species. Plant low-level, flood tolerant marginal zone species at the toe of the newly-formed bank slope/terrace. MBDA/METRO
3	Appoint and train sanitation team including more sewerage line inspectors. Incentivise performance using Green Drop as a meter of performance. Develop a public reporting system for sewage and wastewater treatment status. Publish results weekly in local media. NMB METRO/NMBBC	Improve Sustainable Urban Drainage Systems (SuDS) in the catchment. Install 2-3 hybrid bioretention-wetland facilities at key points of stormwater concentration. Investigate all options for increasing infiltration in the catchment. Improve flood conveyance in the lower river by widening the channel and developing high-flow activated wetlands on the floodplain (see Scenario 3). NMB METRO	Under Engineering and Ecohydraulic planning, design and guidance, remove gabion-lined canal and concrete canal in lower river and estuary (ca. 1 km). See detailed interventions in report. Widen exposed channel and possibly excavate at lower end. Slope or terrace exposed banks. Armour banks and bed with gabions/boulders, and plant appropriate indigenous marginal and riparian plants into interstices. Protect existing infrastructure. Create fish refugia and areas of cover or overhang for larval fish at intervals up the channel. Install appropriate-sized instream rock and cobble habitat in the lower area of the river, as advised by hydraulic and sediment studies MBDA/METRO
4	Monitor water quality monthly (Metro) and Biomonitoring of biota 2-4 times annually (DWS). Report results in local popular media NMB METRO/NMBBC/Department of Water and Sanitation (DWS)	Improve stormwater system flood conveyance. Appoint and train staff to clear the network catchment stormwater drains of litter and sand. Clear AIV and thin out indigenous vegetation 500 m upstream and downstream of all major crossings and bridges. NMB METRO/ WORKING FOR WATER	
5		Incentivise rainwater harvesting in catchment. Launch a public awareness campaign using radio, TV, social media to inform public on the benefit of rainwater harvesting, and about illegal stormwater to sewer connections. NMB METRO/MEDIA & COMMS SPECIALISTS	
6		Monitor discharge real-time at 2 points in the catchment (minimum) to gain a better understanding of the current day hydrology of the river. NMB METRO /NMBBC	

3 COST BENEFIT ANALYSIS

By: Prime Africa

In its current state, the delivery of ecosystem services by the Baakens River Catchment to the residents and municipality of Nelson Mandela Bay is severely impaired. This report provides an economic justification for undertaking a range of interventions identified in the broader study, proposed to address aspects of this situation.

The three sets of interventions, structured as three scenarios, proposed in Part 3 of this study, are evaluated to assess their relative costs and benefits. This assessment finds scenario one to be the most cost effective, and imperative for the effective implementation of scenarios two and three. Scenario three is found to be the next most compelling, aligning with the development and climate change objectives of the NMB Metro.

A description of the process of ecosystem service valuation is outlined to provide the reader with sufficient background information to interpret the methodology employed and the findings of the report.

A benefit transfer method is applied to arrive at reference values for the range of ecosystem services identified as being delivered by the Baakens River Catchment. These values are applied at a detailed level according to the observed level of ecosystem functioning at each site, as assessed by the project team, to provide an indication of the value of the services currently being enjoyed.
The recommended ecological conditions derived for each site are used to calculate the expected change in benefits that can be expected from implementing the scenarios developed to arrive at these conditions.

Costs associated with each scenario are estimated through a review of relevant literature and the inputs of the project team.

The findings of this analysis show that it makes economic sense to undertake a rehabilitation programme for the Baakens River Catchment, as this will result in an increase in the delivery of ecosystem services to the municipality and its residents that exceeds the costs associated with such a programme, at a ratio greater than 1-to-1, and up to 3-to-1 specifically for interventions aimed at improving the water quality of the Baakens River.

The Table below summarizes some of the key findings per Rehabilitation Scenario.

	ESTIMATED COSTS, BENEFITS and BENEFIT:COST RATIO OF EACH SCENARIO (PART 3)		
ECOPHYSICAL ISSUE	**WATER QUALITY**	**WATER QUANTITY**	**CONNECTIVITY, CHANNEL FORM, HABITAT**
SCENARIO	**SCENARIO 1**	**SCENARIO 2**	**SCENARIO 3**
OVERARCHING REHABILITATION REQUIREMENT	**ADDRESS WATER QUALITY**	**ADRESS WATER QUANTITY**	**ADDRESS CONNECTIVITY, CHANNEL FORM AND HABITAT**
MAJOR ACTION	1. ADDRESS WATER QUALITY DETERIORATION	2. RESTORE NATURAL FLOOD MANAGEMENT (NFM) CAPABILITY, UNDERSTAND HYDROLOGY AND BASEFLOWS, MONITOR FLOWS	3. RESTORE LONGITUDINAL & LATERAL CONNECTIVITY, NATURALISE CHANNEL & FLOODPLAIN IN LOWER RIVER and ESTUARY
ESTIMATED TOTAL CAPEX (OPEX)	ZAR 30 500 000 (ZAR 350,000)	ZAR 44 400 000 (ZAR 440,000)	ZAR 45 600 000 (ZAR 0)
BENEFIT:BENEFIT RATIO (20y)	Range 2.6-3.4	Range 1.1-1.6	Range 1.6-2.3
MARGINAL BENEFITS**	R9 million to R12 million per annum	R5 million-R7.5 million per annum (by 6th year)	R7 million-R10 million per annum
IMPLEMENTING AGENCIES	NMB METRO IN COLLABORATION WITH NMB BC	NMB METRO, NMB BC, WORKING FOR WATER, WORKING FOR WETLANDS	MBDA, NMB BC, NELSON MANDELA UNIVERSITY

4 PART 4: RECOMMENDATIONS

4.1 BACKGROUND

This report represents the final part of a study funded by the Mandela Bay Development Agency and managed by the Water Research Commission. The main objective of the study was to determine the feasibility and cost-benefit of rehabilitating the Baakens River in the city of Gqeberha, Eastern Cape. The four study phases were: 1) Assessment of current state of the river at four sites; 2) Development of river rehabilitation scenarios; 3) Cost benefit analysis of scenarios; and 4) Prioritisation of rehabilitation scenarios and actions, and recommendations. The method adapted for use was the 12-step Australian Stream Rehabilitation method, and only those steps which were accommodated within the project brief were included.

4.2 RECOMMENDATIONS REGARDING REHABILITATION PRIORITIES

The prioritisation process is based largely on the Australian method, and contextualised for the local situation. Account has been taken both of matters for which there is assurance in the current political milieu, as well as of those for which there is not. For instance, there is some assurance that the intention of the Development Agency is to develop the South End Precinct, which commits them to fulfilling certain environmental authorisation conditions including the production of a rehabilitation plan for the lower river and estuary. There is however a lack of assurance regarding the stability of the local political leadership in Nelson Mandela Bay, and this leadership has been threatened in recent months, despite the vast strides made in service delivery. This could result in delays in decision-making and implementation of plans.

The 3 rehabilitation scenarios to be prioritised were each associated with numerous interventions. These were developed on the basis of what was known of the river reaches in terms of their current state, ecological importance and sensitivity, natural assets under threat, and the trajectory of these assets. The cost-benefit analysis was a separate exercise in which the scenarios were assessed. The ranking of the 3 scenarios in terms of the benefit:cost ratio of each is also a key factor in the prioritisation.

The process is based on a number of principles. It takes account of how much natural biodiversity will be returned for expenditure or rehabilitation effort, usually in the shortest time. It is usually preferable to protect reaches of stream that remain in good condition than rehabilitating damaged reaches. It is also more efficient to stop a stream deteriorating than to address problems later. It is necessary to identify any fatal and limiting problems and to treat these first. Once stream assets have been protected, improvement through rehabilitation is possible.

Ten prioritisation categories are recognised, and each reach of the river together with its scenario/s and interventions is tested against these categories and assigned to one. The categories have had to be slightly adapted to accommodate the specific context of this project, and the first two categories are additions from this project team.

Category 0. Implement actions required in terms of existing plans or environmental authorisation conditions. 1. Address critical ecological and urban threats. 2. Protect reaches with regional conservation value. 3. Protect reaches with local conservation value. 4. Protect and improve deteriorating reaches. 5. Expand good reaches. 6. Improve impeded-recovery reaches. 7. Improve moderately damaged reaches. 8. Improve basket case reaches. 9. Improve basket case reaches with

hope. Each category represents the ranking of the priority. Category 0 represents activities that are not considered optional, and Category 1 represents the next highest priority.

Category 0: covers for those aspects of scenarios/interventions which are strictly not optional as they are requirements of the environmental authorisation for the Development Agency's South End Precinct Development. These actions are excluded from the prioritisation process and hence numbered '0'.

The requirements are for a river rehabilitation plan and implementation for the lower river and estuary; detailed designs for any implementations which could be seen as having rehabilitation function; design and construction of two fishways on existing barriers (road crossings) located on the river in Settlers Park nature reserve; and development of a stormwater plan for the South End Precinct Development. The proposed interventions included in Scenario 3 address many of these requirements. These largely focus on returning a more natural connectivity, channel form, habitat and biodiversity to the river and estuary. The estimated cost of implementing this scenario are R45,6 million, and the benefit:cost ratio over a 20 year period following implementation is in the range of 1.6 to 2.3 (second highest ratio of the three scenarios). The marginal benefits (or estimated change in value of ecoservice benefits) are estimated as R7 to R10 million per annum.

Outside of these requirements are those scenarios and interventions which are prioritised for action in the various reaches of the river.

Category/Priority 1: Address critical ecological and urban threats. In terms of both the prioritisation method, and the benefit:cost ratios, the top rehabilitation priority is to address water quality. This is the focus of Rehabilitation Scenario 1.

The most urgent intervention is the commissioning of an updated Sewerage Situation Analysis and Master Plan for the Baakens Valley. This plan should focus on the identification of issues affecting the sewerage infrastructure through the valley, the Driftsands Collector Sewer and the Cape Recife wastewater treatment works, and all related infrastructure, staffing and maintenance. Issues should be prioritised, solutions budgeted, and an implementation plan with schedules and targets produced. Implementation of this plan should be expedited. The responsible authority is the NMB Metro. The NMB Business Chamber has partnered with the Metro to assist in this regard.

The estimated costs of addressing Scenario 1 adequately are estimated at R30,500 million. The benefit:cost ratio over a 20 year period following implementation is in the range of 2.6 to 3.4, the highest of the three scenarios. The marginal benefits (or estimated change in value of ecoservice benefits) are estimated as R9 to R12 million per annum.

The next most critical urban and ecological threat to address is that of flooding in the valley, which falls under Scenario 2: Address water quantity. Catastrophic flooding could occur at any time in the Baakens Valley, costing lives and significant infrastructure, as has happened historically. The most urgent intervention is the commissioning of an updated Stormwater Situation Analysis and Management plan for the catchment, which should be drafted with reference to an updated (anticipated) catchment floodline analysis, and the recommended Scenario 2 interventions presented in Part 2 of this report series. These interventions are a function of the NMB Metro.

Linking to the second intervention, and considered urgent, is the initiation of a campaign for the installation of rainwater tanks catchment-wide, and the drafting of policy requiring that new developments are equipped with the same. This will somewhat ease the domestic demand for water in the current drought, and may to a lesser extent assist with the elevated runoff and thus with

stormwater management in the catchment. In addition, the Green Lung project recommends the drafting of local policy to control and measure water usage via boreholes in the catchment. This too is within Scenario 2. Note that none of these interventions were included in the original costing.

Scenario 2 includes numerous other more ecologically-focussed interventions. The total cost of implementing these is estimated at R44,4 million. The benefit:cost ratio over a 20 year period following implementation is in the range of 1.1 to 1.6, the lowest of the three scenarios. The marginal benefits are estimated as R5 to R7.5 million per annum, also the lowest of the three. While these values do not suggest that Scenario 2 should be a high priority, there is no question that water is the central focus of the city at present, and that urgent interventions in this regard are required.

Category/Priority 2. Protect Regional Conservation Value. The remainder of the interventions in Scenario 2 are focussed on more ecological means of managing water quantity in the catchment, and for this reason fit the description of Priority 2, despite not being associated with the second highest benefit:cost ratio.

Actions expected to have the greatest value in returning a more natural flood management capability to the system are focussed in the upper source area which remains largely undeveloped. There are large critical biodiversity areas here. Numerous seep and depressional wetlands occur, and it is home to a number of plant species of special concern, including the endemic, critically endangered honeybush plant which is associated with seep wetlands. Irreplaceable rocky outcrops occur in association with certain plant species.

The proposed interventions include the declaration of a moratorium on further development in this area, the clearing of all alien invasive vegetation from this area, the rehabilitation of the seep and depressional wetlands, and the application for formal protection of the area (reserve status). These actions would assist greatly in protecting regional (global) conservation value, and reinstating wetland functionality which includes 'sponge' behaviour, stormwater retention and gradual release of baseflows to the river, and flood attenuation.

Most of these interventions are Metro functions, but it is recommended that Working for Water is partnered with in regard to alien clearing, and that Working for Wetlands and the SA National Biodiversity Institute are consulted in regard to the urgent assessment of the wetlands and assistance in the process of acquiring formal protection for the area.

Category/Priority 3. Protect local conservation value. This category description is fulfilled by Scenario 3: Improve connectivity, channel form and habitat in the lower river and estuary.

This takes into account the fact that some / all of the Scenario 3 interventions may already have been implemented as part of Priority 0, as they were required to be in terms of the Environmental Authorisation conditions. This is unlikely however, and it is recommended that any remaining activities are scheduled in at this level of prioritisation.

Furthermore, the authorisation requirement was for construction of only two fishways in Settlers Park, whereas numerous additional fishways were recommended and costed as part of Scenario 3. This is in order to reinstate longitudinal connectivity between the ocean, estuary and lower river. A fishway is required for every road-crossing representing a barrier to upstream fish or eel migration (there are a minimum of 8 in Settlers Park alone). The reinstatement of fish passage through the lower system would have a substantial effect on the system's local conservation value, as migratory fish and eels previously precluded from this reach will now move up-river and into this habitat.

Once fishways have been installed, it has been recommended that investigations are made into the possibility of removing alien fish from this reach. This would likely be an intensive physical process (electro-shocking or netting) and, according to the project team specialist, would most likely need to be repeated on a yearly basis to give the sensitive endangered and other indigenous fish species a chance to recover in to more natural abundances in this section of the river.

However, as the estuarine rehabilitation is a far more complex intervention than is the upstream river channel (Bridge St. to Lower Valley Road circle), it is possible that the estuarine rehabilitation may be delayed until after the upstream works are complete and the various documents providing guidance on floodlines and stormwater flows have been prepared, as these will be important inputs to the estuary rehabilitation plan.

Category/Priority 4: Protect and improve deteriorating reaches, and **Priority 5: Expand good reaches.** The best fits for these priorities are the proposals made by the Green Lung Project report on the Baakens River Valley Restoration. These are highlighted as actions to be pursued once the priority concerns of invasive alien vegetation, sewage contamination of the river, and safety and security have been addressed. The proposal is for the revival of recreational facilities, natural areas and educational opportunities within the valley. Three zones are recognised as having the potential to be developed: Recreational (zone 1), Natural/protected (zone 2) and Educational (zone 3). While these zones are considered fluid throughout the valley, they do have focus areas: Dodd's Farm (zone 1), Settlers Valley (zone 2) and the upper catchment (zone 3). As Settlers Valley is in a deteriorating reach (study Reach 5) requiring improvement; and Dodd's farm is in relatively good condition (study Reach 4), both befit these prioritisation categories. Settler's valley is already protected but requires a number of improvements (water quality, river longitudinal connectivity, vegetation clearing, improved security). The recreational aspects of Dodd's Farm have largely fallen into disuse and need to be revived and expanded upon. The development and improvement of sport, recreational and educational assets along the river and Guinea Fowl Trail are considered instrumental in the long-term maintenance of river and catchment health.

The Prioritisation and Cost Benefit Analysis are summarised in the following Table.

The Table below provides a comparison between the ranking of the three scenarios based on Benefit:Cost ratios and that based on the adapted prioritisation method.

BENEFIT:COST RATIO RANKINGS As per Moynihan et al. (2023)			PRIORITY DETERMINED ACCORDING TO CATEGORY As per Rutherfurd et al.(2000, adapted)			
PRIORITY RANK	BENEFIT: COST	SCENARIO	PRIORITY RANK	DESCRIPTION	SCENARIO	REACH
			0	REACHES WITH GUARANTEED PLANS, FUNDS OR EA CONDITIONS	SC3	**CONNECTIVITY AND CHANNEL FORM** REACHES 5, 6 LOWER RIVER Env. Authorisation conditions require a river rehabilitation plan and construction of two fishways
1	HIGHEST B:C RATIO (2.6-3.4)	**Scenario 1** Address Water quality	**1**	ADDRESS CRITICAL ECOLOGICAL AND URBAN THREATS*	SC1	**ADDRESS WATER QUALITY: ALL REACHES** Commission Sewerage Assessment and Management Plan. Implement.
					SC2	**ADDRESS WATER QUANTITY (Floods)** Commission a Stormwater Management Plan. Implement. Launch campaign for rainwater harvesting.
2	SECOND HIGHEST B:C (1.6-2.3)	**Scenario 3** Reinstate connectivity and naturalise lower river	**2**	PROTECT REGIONAL CONSERVATION VALUE	SC 2	**ADDRESS WATER QUANTITY: UPPER CATCHMENT ACTIONS** Clear AIV and rehabilitate wetlands to restore some natural flood management capability. Apply for formal protection.
3	THIRD HIGHEST B:C RATIO (1.1-1.6)	**Scenario 2** Manage water quantity	**3**	PROTECT LOCAL CONSERVATION VALUE	SC 3	**NATURALISE CONNECTIVITY, FORM, FUNCTION and HABITAT in LOWER RIVER.** Stepwise implementation of remaining SC3 interventions
			4	PROTECT AND IMPROVE DETERIORATING REACHES	Green Lung Prj	**SETTLERS VALLEY REACH 5** Create conservancy pockets, safe trails, bird hides, amphitheatre (Mantis 2021)
			5	EXPAND GOOD REACHES	Green Lung Prj	**REVITALISE DODD'S FARM REACH 4** Revive Dodd's Farm as safe recreational and sporting venue (Mantis 2021, Pilot Phase)
			6	IMPROVE IMPEDED-RECOVERY REACHES	Green Lung Prj	**CLEAR AIV** REACH 2,3 Clear AIV, improve security, extend trails (Mantis 2021 Plan)

Abbreviations: B:C Ratio: Benefit cost ratio (range); CBA: Critical Biodiversity Areas Green Lung Prj: Green Lung Project (Mantis 2021) Sc – Scenario; SC1 – Water Quality, SC2 – Water Quantity, SC3 – Connectivity, channel form, habitat

4.3 RECOMMENDATIONS REGARDING THE ONGOING REHABILITATION PROCESS

These recommendations are based on the findings of the study and the ongoing interactions with the Mandela Bay Development Agency and identified stakeholders.

At this stage it is important for the Development Agency to enter into open discussion with other agencies, organisations and stakeholders regarding the rehabilitation of the river. Those parties who have already initiated studies and made recommendations in this regard, and those involved in or affected by the rehabilitation measures, should participate in these deliberations. As will be clear from the previous chapters, a successful rehabilitation effort will require the commitment and input of a number of agencies and authorities. Coordination and cooperative management of this extensive effort will be fundamental to effective implementation, and to realising the rehabilitation benefits.

It is unclear to what extent there are open lines of communication between the Development Agency and the various departments of the Metro. Be that as it may, this initiative provides the opportunity to strengthen existing, relevant partnerships and to create new ones. The existing ones include those between the Mandela Bay Development Agency and the Metro; and between the Development Agency and the Nelson Mandela Bay Business Chamber. The MB Business Chamber, and the Civil Society Coalition of which they are a member, are active and effective in working with businesses to assist with important and practical local issues in their own sphere of influence. They are also one of the parties involved in the Green Lung Project, which aims to create three green lung corridors as protected areas for the city (Baakens, Van der Kemps Kloof and Swartkops Rivers). A report on the restoration of the Baakens River has been produced under the auspices of this project, and interest has been shown by business in partnering with this initiative. This represents a major opportunity for collaboration, as there is common vision and also possible access to funds which are not administratively or politically tethered.

In addition, engagement with organisations that will play a critical role in implementation of scenarios is vital at an early stage. These include Working for Water (clearing of alien invasives), Working for Wetlands (wetland assessment, delineation and rehabilitation), South African National Biodiversity Institute (protection of the upper catchment), and Nelson Mandela Bay University, who have already produced a number of studies focussed on the conservation value of the Baakens River and Estuary.

It is recommended that a Management Committee is established once the role players are known. This committee could either be along the lines recommended in the Green Lung report on the Baakens restoration (which is headed by a Steering Committee, overseeing numerous Task Teams and reporting to stakeholder representatives), a Catchment Management Forum as advocated by Department of Water and Sanitation, or another structure.

Consider including on this committee relevant representatives of the Development Agency, the Metro, the Business Chamber, the Department of Water and Sanitation, Department of Forestry, Fisheries and Environment (or local department of Economic Affairs, Environment and Tourism), Wildlife and Environment Society of SA, the Civil Society Coalition, Nelson Mandela University, the Community Crime Awareness group, one or more sporting bodies such as Fat Traxx, a representative of Traditional Healers, an Engineering Consultancy, Environmental Consultancy, and a Rehabilitation Specialist.

The committee should comprise a number of Task Teams covering more specialised areas of intervention, such as water quality, security, stormwater management, sport and recreation, and natural resources.

Stakeholder representatives should meet with the Management Committee regularly to get and give feedback. These organisations may also have representatives on the Steering Committee or Task Teams. Stakeholders could include representatives of environmental organisations, community groups, religious or spiritual groups, and traditional healers.

The committee would ideally draft a constitution or charter. Guidelines for a charter for a Catchment Management Forum are available.

The Management Committee would assist in making final decisions regarding the priority interventions for the river, the role each party should play, what further studies would be required to commence detailed planning, the allocation of funds, and the programme of action. These decisions should be well supported by the options presented in this series of reports, and the proposals presented in the Green Lung: Baakens Valley restoration report.

The Management Committee will be in the position to oversee the remainder of the rehabilitation process. This would typically involve the completion of the remaining Steps and Taks in the Australian method, including (in brief) the setting of measurable objectives, planning and designing the details of the implementation, planning the evaluation, scheduling and supervising the works, and assessing and maintaining the project.

Ongoing open discussion with role-players and other stakeholders is very important during this process.

The setting of measurable objectives is detailed process which will apply to individual interventions rather than scenarios, and will probably require specialist inputs. These objectives should be a precise, clear, measurable statement of the intended outcomes of prioritised interventions. They form the basis for the evaluation of the project at a future stage. The process involves defining the amount of change expected, spatial scope, time frame, how success will be measured, and the feasibility of the objective.
In the context of Nelson Mandela Bay, with its current infrastructural challenges, it is important that the objectives take into account the possibility of failure due to circumstances beyond the implementer's control.

In terms of further studies identified as urgent, the following would assist in informing detailed planning of the rehabilitation exercise: a sewerage situation analysis and management plan; a stormwater situation analysis and management plan; an updated floodline report for the catchment; and a detailed rehabilitation plan and design drawings for the lower river and estuary.

The project options that are selected in the pre-design phase will then be subjected to detailed description and design. The final report and drawings for one or more interventions will be submitted to the controlling authorities together with applications for authorisation as and where required. Final design would require the input of various specialists, the project initiator, and the Management Committee.

Depending on which interventions are selected for implementation, any or all of the following studies could be required for the detailed planning phase: a wetland delineation and current state assessment hydraulic computations for the naturalisation of channel form in the lower river and estuary; geotechnical studies of the lower river and estuary; engineering studies and design for the fishways, with specialist input from a fish biologist; engineering studies and design for biodetention or bioretention ponds, with specialist input from a wetland specialist.

The final design documents per major intervention would likely include a written report, a set of maps, a set of drawings, hydraulic computations, relevant engineering designs and stability analysis of hydraulic structures, a full costing, and specialist reports as necessary. Further information or studies may be required for the purposes of environmental or water use authorisations.

Based on this documentation, the various authorisations required would be applied for. Rehabilitation activities may trigger numerous approvals or permits, including water use licenses or general authorisations, environmental authorisation, heritage permits, waste management licenses, permits in terms of biodiversity, and other approvals. The Construction and Operational Environmental Management Programmes as required must be drafted in consultation with the relevant ecological specialists, as these are likely to differ significantly from standard construction programmes.

Once the authorisations are acquired, or during the authorisation process, tender documents can be prepared. These will include timing schedules for the various activities, specific materials to be used, specific environmental conditions to be met during the construction and operational phases, and the quality the finished work is to achieve.

The remainder of the rehabilitation process essentially involves the implementation process, the evaluation of the effectiveness of the measures over time, and the ongoing maintenance of these over the next decades. These phases are well beyond the scope of this report, however information is available in the various rehabilitation guideline documents available online to the public.