RED HOUSE CHELSEA ARTERIAL

AQUATIC IMPACT ASSESSMENT

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ACRONYMS

CARA	Conservation of Agricultural Resources Act
CBD	Central Business District
DWA	Department of Water Affairs
EIS	Ecological Importance and Sensitivity
GIS	Geographic Information System
PES	Present Ecological State
SABIF	South African Biodiversity Information Facility, a SANBI database that contains both faunal and floral species records
SANBI	South African National Biodiversity Institute
WUL	Water Use License
WULA	Water Use License Application

1 INTRODUCTION

Terratest appointed Scherman Colloty & Associates (SC&A) assisted by Anton Bok & Associates to assess the potential impact of the proposed Redhouse Chelsea arterial water course crossings on the Baakens River and its drainage lines (Figure 1). The objective of the study was to assess the current ecological state of the riparian or riverbank vegetation as potential fish habitats against the proposed project impacts. This assessment would also form part of the required documentation for the required Water Use License Applications being submitted to the department of Water Affairs.

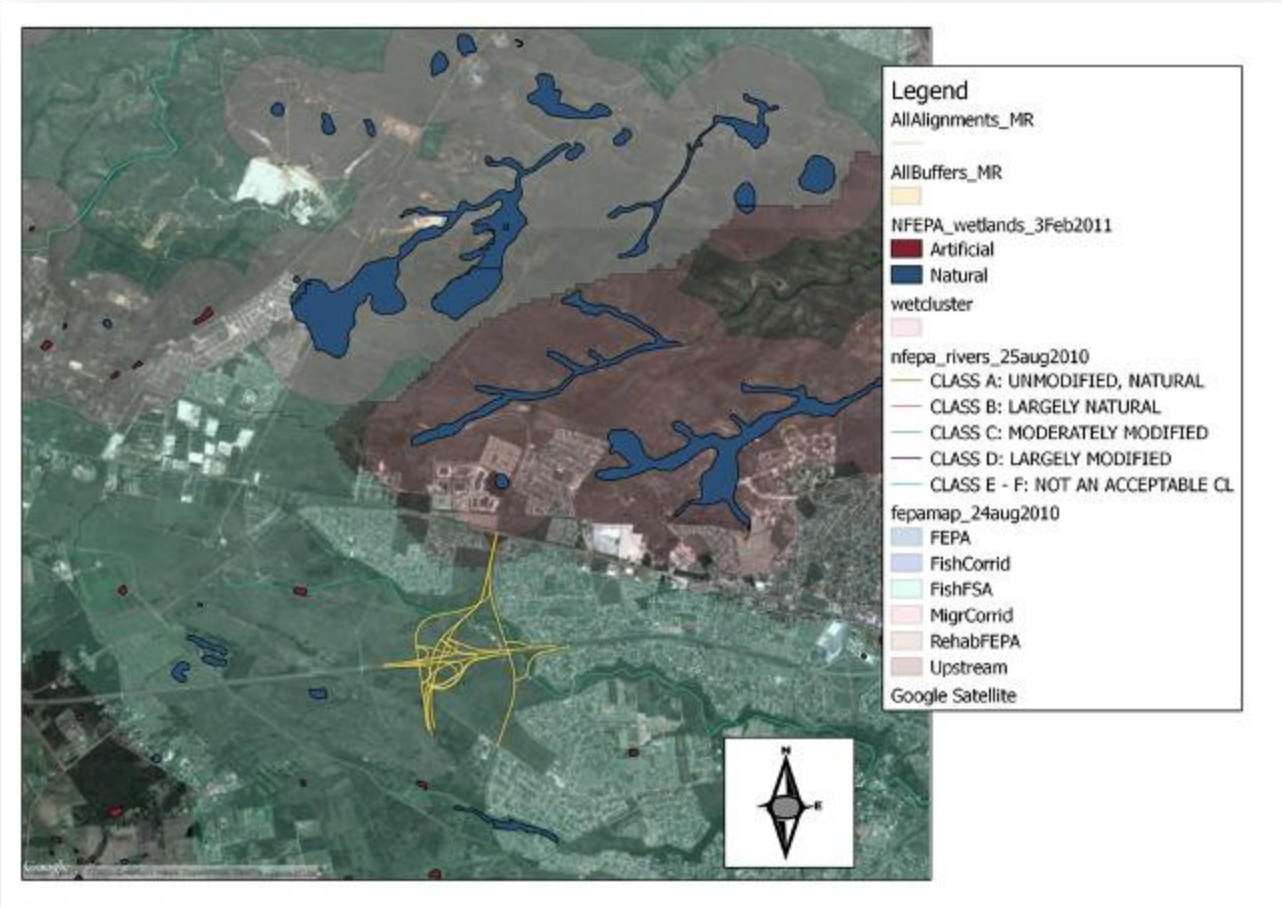

Figure 1: Locality map indicating the project route alignment alternatives and various aquatic features known in the area

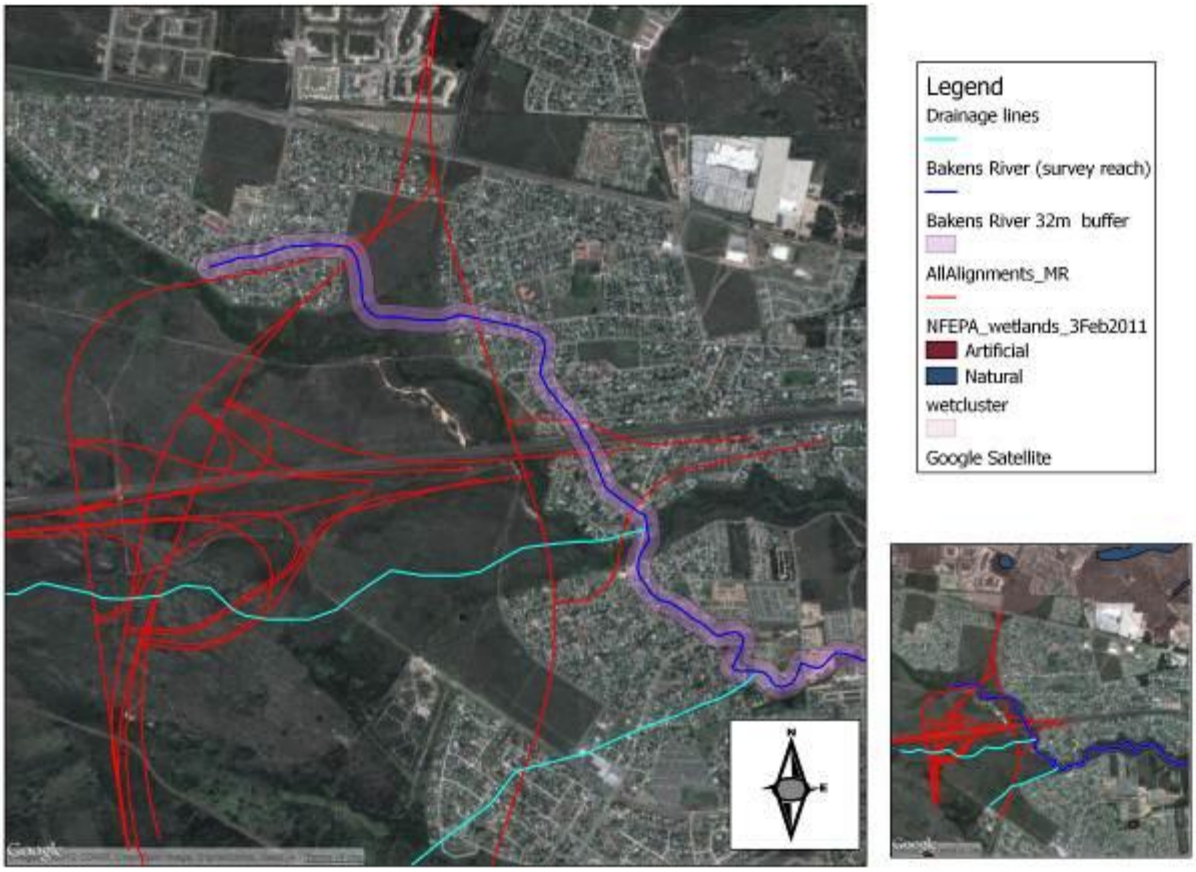

Figure 2: The aquatic water bodies investigated in relation to all the potential river crossings posed by the various alternatives

Several terms and definitions are used in this report and the reader is referred to the box below for additional detail.

Definition Box

Present Ecological State is a term for the current ecological condition of the resource. This is assessed relative to the deviation from the Reference State. Reference State/Condition is the natural or pre-impacted condition of the system. The reference state is not a static condition, but refers to the natural dynamics (range and rates of change or flux) prior to development. The PES is determined per component - for rivers and wetlands this would be for the drivers: flow, water quality and geomorphology; and the biotic response indicators: fish, macroinvertebrates, riparian vegetation and diatoms. PES categories for every component would be integrated into an overall PES for the river reach or wetland being investigated. This integrated PES is called the EcoStatus of the reach or wetland.

Ecoregions are geographic regions that have been delineated in a top-down manner on the basis of physical/abiotic factors. • NOTE: For purposes of the classification system, the 'Level I Ecoregions' for South Africa, Lesotho and Swaziland (Kleynhans *et al.* 2005), which have been specifically developed by the Department of Water Affairs (DWA) for rivers but are used for the management of inland aquatic ecosystems more generally, are applied at Level 2A of the classification system. These Ecoregions are based on physiography, climate, geology, soils and potential natural vegetation.

1.1 Relevant legislation and policy

Locally the South African Constitution, seven (7) Acts and one (1) international treaty allow for the protection of rivers and water courses. These systems are thus protected from the destruction or pollution by the following:

- Section 24 of The Constitution of the Republic of South Africa;
- Agenda 21 – Action plan for sustainable development of the Department of Environmental Affairs and Tourism (DEAT) 1998;
- National Environmental Management Act (NEMA), 1998 (Act No. 107 of 1998) inclusive of all amendments, as well as the NEM: Biodiversity Act, 2004 (Act 10 of 2004);
- National Water Act, 1998 (Act No. 36 of 1998);
- Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983);
- Minerals and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002);
- Nature and Environmental Conservation Ordinance (No. 19 of 1974);
- National Forest Act (No. 84 of 1998); and
- National Heritage Resources Act (No. 25 of 1999).

Apart from NEMA, the Conservation of Agricultural Resources Act (CARA), 1983 (Act No. 43 of 1983) will also apply to this project. The CARA has categorised a large number of invasive plants together with associated obligations of the land owner. A number of Category 1 & 3 plants were found on the site investigated, thus any land owner and contractors must take extreme care to limit further spread of these plants.

This report will be used as per the relevant submissions to the Department of Water Affairs in terms the required licenses.

Provincial legislation and policy

Various guidelines on aquatic buffers have been issued in a number of the provinces, including the Eastern Cape Province and those stated in this report are based on accepted provincial guidelines as stated in the Eastern Cape Biodiversity Conservation Plan or ECBCP (Table 1). These are stated below so that the engineers and contractors are aware of these buffers during the planning phase. Although construction **would** have to take place within the water courses, the associated batch plants, stockpiles, lay down areas and construction camps should avoid these buffer areas.

With regard protected flora, which includes wetland / riparian associates, the Eastern Cape Provincial Nature Conservation Ordinance (PNCO) includes a list of protected flora. Any plants found within the sites will be described in this report. Should any species that are listed in the ordinance be found, the relevant permits should be obtained by the proponent from either for their relocation or destruction, as required.

Table 1: Recommended buffers for rivers highlighted in blue from Berliner & Desmet (2007).

River criterion used	Buffer width (m)	Rationale
Mountain streams and upper foothills of all 1:500 000 rivers	50	These longitudinal zones generally have more confined riparian zones than lower foothills and lowland rivers and are generally less threatened by agricultural practices.
Lower foothills and lowland rivers of all 1:500 000 rivers	100	These longitudinal zones generally have less confined riparian zones than mountain streams and upper foothills and are generally more threatened by development practices.
All remaining 1:50 000 streams	32	Generally smaller upland streams corresponding to mountain streams and upper foothills, smaller than those designated in the 1:500 000 rivers layer. They are assigned the riparian buffer required under South African legislation.

2 STUDY AREA DESCRIPTION

The proposed project is located along the Baakens River, east of the Port Elizabeth CBD in the Eastern Cape (Figure 1). The project proposes to construct a link road between Rowallan Park in the North and Sherwood (Walker Drive) in the South. These two areas are currently separated by the N2 and the project will also see the construction of various on / off ramps, that would also provide access to the N2 for the residents of the western suburbs.

Regardless of the alternative chosen, three new crossings would be required across the Baakens River and possibly several culverts where the embankments of the on/off ramps cross the various drainage lines / seep areas, what has been termed the *Cyclopia* crossings (refer to vegetation report) and the South on / off ramps

2.1 Hydrology

The study area hydrology was characterised mostly ephemeral flows within the Baakens River and one of its small tributaries / drainage lines found within the South Eastern Coastal Belt Ecoregion of the M20A quaternary catchment (Figure 2). The steep river banks within the survey reach are formed through a combination of the softer sediments contained in the regional geology and localised flooding events (Plate

1). The rivers are thus scoured and become incised over time and thus limit the development of wide floodplain areas, with the associated broad riparian zones. Thus wide riparian zones are not a natural phenomenon of these types of systems.

Plate 1: The area downstream of the project area colonised by invasive tree and reed species. Note the flood debris 1-1.5 m above the current river levels

3 METHODS

3.1 Study terms of reference

SC&A based this study on the following scope of work:

- Identify and delineate aquatic systems and associated biota, including fish species and instream aquatic habitats, that may be impacted upon by the proposed road alignments over existing water courses;
- Identify and rate potential environmental risks (including sewer realignments) with regard to the aquatic zone;
- Provide a significance rating of surface water impacts which includes a rating of the ecological sensitivity of the site, and the effect of the development on the riparian ecology of the site;
- Identify mitigations for negative impacts.

- Evaluate the impacts between bridge or culverts being utilised as water course crossings, at the following localities (this was however done for a greater area see Figure 1 & 2 due to the potential cumulative impacts of these types of projects):
    - Baakens River
    - Cyclopia
    - South On- & Off- Ramps

Based on our understanding of these requirements, SC&A would produce the following:

- Riparian and /or wetland area delineation supplied together with an analysis of the potential riparian aquatic sensitivity (including any wetlands should they occur).
- Instream Present Ecological State (PES) based on the fish species and instream aquatic habitats present in the affected river reach,
- Riparian Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) assessment after a short site visit has been conducted; in line with the Department of Water Affairs requirements with regard to the necessary licenses.

3.2 Study methods

This assessment was initiated with a survey of the pertinent literature, past reports that exist for the study region. Maps and Geographical Information Systems (GIS) were then employed to ascertain, which portions of the proposed development, could have the greatest impact on the water courses and associated habitats.

A site visit was then conducted to ground-truth the above findings, thus allowing critical comment of the proposed project. Information was also collected to determine the PES and Ecological Importance and Sensitivity (EIS) of the site. These analyses were based on the models developed by the Department of Water Affairs, with the results producing a ratings (A – F), summarised in Table 2. The importance of the study area was also assessed against local and provincial conservation plans such as the Draft NMBM Bioregional Plan and the Eastern Cape Biodiversity and Conservation Plan.

Aquatic vegetation (Figure 2) were assessed on the following basis:

- Vegetation type – verification of type and its state or condition based, supported by species identification using Germishuizen and Meyer (2003), Vegmap (Mucina and Rutherford, 2006 as amended) and the South African Biodiversity Information Facility (SABIF) database. The SABIF database contains older species records for areas, thus allowing a comparison of present versus past states. This data was also compared to past and present aerial images, although these are limited to the scale at which the narrow band of riparian vegetation could be observed due to image resolution.
- Plant species were further categorised as follows:
    - Terrestrial: species are not directly related to any surface or groundwater base-flows and persist solely on rainfall
    - Facultative: species usually found in wetlands (inclusive of riparian systems) (67 – 99% of occurrences), but occasionally found in terrestrial systems (DWAF, 2005)

- Obligate: species that are only found within rivers and wetlands (>99% of occurrences) (DWAF, 2005)

- Mitigation measures or recommendations required

Table 2: Description of A – F ecological categories based on Kleynhans *et al*., (1999).

ECOLOGICAL CATEGORY	ECOLOGICAL DESCRIPTION	MANAGEMENT PERSPECTIVE
A	Unmodified, natural.	Protected systems; relatively untouched by human hands; no discharges or impoundments allowed
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	Some human-related disturbance, but mostly of low impact potential
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	**Multiple disturbances associated with need for socio-economic development, e.g. impoundment, habitat modification and water quality degradation**
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	**Often characterized by high human densities or extensive resource exploitation. Management intervention is needed to improve health, e.g. to restore flow patterns, river habitats or water quality**
F	Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	

The Fish Response Assessment Index (FRAI) methodology was used to assess the present ecological state in terms of the fish and aquatic habitats in the vicinity of the proposed arterial road crossing sites using standard procedures as recommended by Kleynhans (2007) and accepted by DWA. This procedure compares the fish assemblage and aquatic habitat condition expected under reference (undisturbed or near-pristine) conditions for the river reach under consideration with the existing assemblage and aquatic habitats found under current conditions. Historical fish distribution data from past fish surveys were used to ascertain the reference fish assemblage in this section of the Baakens River.

The response of the fish assemblage to changing environmental conditions is assessed by undertaking fish surveys and/or is inferred from the observed changes to the instream habitat and knowledge of species' ecological requirements. In this study, the assessment of the instream habitat present played an important role in assessing the FRAI due to the apparent absence of fish in the areas sampled (see below).

A 160 m length of the Baakens River both upstream and downstream of the Riverstone Road causeway crossing located below the N2 was sampled for fish using an Electro-fisher (Samus 725G) on 11 September 2012. Electro-fishing is a highly effective method to sample fish in clear, shallow streams such as the Baakens River, which has abundant instream snags or cover in the form of rocks, branches, root wads undercut banks and marginal vegetation. This river reach was surveyed for fish in 1981 (Heard & King 1981), in 1984 (King and Bok 1984) and in 1994 (Bok 1994) using electro-fishing techniques. These previous surveys thus allowed fish population trends in this river reach over the last 30 years to be determined.

4 RESULTS

4.1 Riparian vegetation

A site survey was conducted along the reach, approximately 500 m upstream and 2 km downstream of the road crossing points shown in Figure 3.

As mentioned broad aquatic and riparian zones were not evident, with little or no permanent riparian / obligate riparian species found within this reach. This was due to the steep nature of the river banks, that precludes the development of wide riparian floodplains and the degree of degradation already mentioned in this report.

Forb and woody species were thus limited to invasive or encroaching species such as *Acacia cyclops, Acacia longifolia*, *Acacia saligna*, Kikuyu (*Pennisetum clandestinum*), *Sesbania punicea*, Opuntia spp, and *Rubus* spp. Three facultative hydrophytic plants species were evident within greater study area, namely *Phragmites australis* (Common Reed), *Cyperus latifolius* and *Typha capensis* (Bulrushes).

It was also noted that the clearing of the alien vegetation by the Working for Water programme, had resulted in the increase in natural vegetation along the riverbanks. However, the felled alien trees are not removed from the catchment and with floods; this debris then accumulates in the rivers, forming blockages (dams) when trapped by other alien vegetation or culvert road crossings. Additional impacts also include back-flooding of upstream areas, scour and sedimentation in downstream areas. Finally these alien trees dams also prevent the movement of aquatic fauna (fish) during low flow periods.

4.2 Fish and instream aquatic habitats

The fish survey did not reveal any fish in the river reach downstream of the Redhouse-Chelsea Arterial in the vicinity of the Rivertone Road causeway, although tadpoles, frogs and crabs were observed and aquatic habitats appeared capable of supporting fish life. The FRAI assessment, largely based on the condition of the instream aquatic habitats in the Study Area, gave the present ecological status (PES) in terms of fish as a **D Class**, due to the large loss of aquatic biota and natural aquatic habitat. The main impacts are related to destruction of indigenous riparian and marginal vegetation, increased sediment input and pollution from contaminated run-off from the catchment.

Historical data from fish surveys conducted at this site in the Baakens in 1981 (Heard & King 1981 and in 1984 (King & Bok 1984) captured both the endangered Eastern Cape Redfin *Pseudobarbus afer*, and the Goldie barb *Barbus pallidus.* However, follow-up surveys in this river each in 1994, after large-scale bulldozing and clearing of the riparian habitat had taken place in this area, found only small numbers of Barbus pallidus and no *Psuedobarbus afer* (Bok 1994).

4.3 General

No protected plant or plants species of special concern were observed within or adjacent to the water courses due to the degree of past disturbance. However the surrounding catchment is still considered important (Critical Biodiversity Area) due to the potential presence of the endangered fish species (*Pseudobarbus afer*) that probably still occurs within the catchment, as well the important terrestrial plant species found in the region and dealt with in a separate report.

The overall condition or Present Ecological State (PES) of the riparian vegetation and the fish for this reach was assessed using accepted methodologies. The Department of Water Affairs did present a desktop analysis of the region in 1999 (Kleynhans, *et al*. 1999), in which the overall PES for the river reach within the study area (Figure 2) and was rated as C (Moderately modified – Table 3). The PES system, using an updated DWA method is presently being revised by SC&A and Anton Bok & Associates on a province wide scale. Due to the overall degradation of the site, the current riparian vegetation PES would be lower i.e. **D** when compared to the 1999 rating. This is due to the lack of riparian zone continuity due to the lack of natural vegetation cover. This is further supported by the PES rating for the fish, which was **D** for the survey reach.

4.4 Conservation importance

Rivers and the associated riparian zones are protected by several sections of national legislation. This together with the associated flood risk associated with "flashy ephemeral" systems should preclude any development along these rivers, regardless of their conservation value. The Environmental Importance and Sensitivity or EIS is a measure of the conservation value. Due to the current disturbances within the study area the EIS would be rated as **LOW**, due to the lack of any important riparian vegetation or sensitive plant and fish species associated with the river.

Of interest is the National Freshwater Ecosystems Priority Areas project (CSIR, 2011), several important catchments (sub-quaternaries or SQ) have been earmarked, based either on the presence of important biota (e.g. rare or endemic fish species i.e. historical records of *Pseudobarbus afer*) or the degree of riverine degradation, i.e. the greater the catchment degradation the lower the priority to conserve the catchment. The important catchments areas are then classified as Freshwater Ecosystems Priority Areas or FEPAs.

The survey reach does fall within one of these identified by NEFPA (Figure 1) and as a consequence their River Conservation rating was C (moderate need for conservation), as this catchment historically contained the Eastern Cape Redfin (*Pseudobarbus afer*). This rating is not related to PES or EIS, but a separate scoring system to determine the conservation priority of the river on a national basis.

Recent genetic research has shown that all populations of endangered Eastern Cape Redfin (*Pseudobarbus afer)* are restricted to the Baakens, Swartkops and Sundays River systems, with populations west of the Baakens River System belonging to different taxa (Swartz and Impson 2007). It is important to note that recommendations to prevent the extinction of *Pseudobarbus afer* in the Baakens River System include the rehabilitation of areas where this species was found previously and then restocking with fish found in other less impacted reaches within the catchment. The river reach within the area potentially impacted by the Chelsea-Redhouse Arterial Road should thus be seen as having potential conservation value.

4.5 Recommended buffers

According to national policies and DWA accepted best practices, these rivers should receive a buffer of 50 m (Table 1). Based on this assessment and the proposed designs, this project would have little **physical** impact on the conservation importance and functioning on the riparian systems, should the project proceed. It is recommended that no stockpiles or laydown areas, construction camps or other works associated with the upgrade are located within the 32 m buffer. The rationale being, that due to the channel form, i.e. steep river banks, with no floodplain areas, buffering the river by 50 m would aid little in the form of conserving any additional riverine associated habitat that would already be protected within the 32 m buffer.

5 IMPACT ASSESSMENT

The impact assessment was derived from the methodology provided by Terratest, the proposed project description and the conceptual design layout, which was the measured against the current state of the observed water courses. Several impacts have been highlighted and have been rated based on the project actions / impacts, as well as any potential cumulative impacts during the construction and operational phases of the project. These were also assessed with and without mitigation. It should be noted that all of the impacts assessed would have a negative impact on the aquatic systems, which were assessed with a high degree of confidence based on our understanding of aquatic systems, its catchment and past experience from assessing similar types of proposals.

The potential construction phase impacts would result from the physical changes to the catchment, i.e. removal of vegetation and the disturbance of soils. The operational phase would result in the diversion and or / alteration of flows (volume and velocity) due to the hard engineered structures such as the roads road and the bridge / culvert crossings. These changes in the hydrological regime then pose impacts such as erosion of the riverbed and then later sedimentation of downstream areas. However due to the nature of the Baakens River system, coupled to its current modified state, all the potential impacts would be similar for any of the proposed alternatives. This is also due to similarities in the structure and function seen in the study area.

The only notable impacts that would need careful consideration, and warrant individual assessments, would be the potential impacts of the road infrastructure on the plant and fish species of special concern. A separate study was initiated and was conducted by regional botanists on the presence, distribution and potential impact on the Critically Endangered and protected species of Honeybush (*Cyclopia pubescens*). This species although not strictly a wetland or aquatic species, i.e. hydrophyte, seems to be associated with seeps and drainage lines in the region.

Similarly the presence or absence of *Pseudobarbus afer*, also requires a separate assessment due to is conservation importance.

5.1 Impact 1: Diversion and increased velocity of surface water flows – Changes to the hydrological regime and increased potential for erosion

Nature of the impact

Due to the nature of the proposed project this would be an operational phase impact, limited to once the roads, stormwater management features, erosion protection structures and the crossings have been constructed. These structures could interfere with natural run-off patterns, diverting flows and increasing the velocity of surface water flows. This then has the potential to increase the potential for erosion in the study area, while increasing sedimentation of downstream areas, once flows subside. This would in turn limit the amount of available habitat for the development of a functional riparian zone and instream habitat for the fish. The downstream sedimentation would result in large unnatural sand bank areas that would be colonised by reeds. The reeds then later restrict flows within the system, resulting in flooding of upstream areas. This has already occurred due to the culvert crossing used for the N2 crossing of the Baakens River.

Significance of impacts without mitigation

The soils within the study area are susceptible to erosion when subjected to high flows (high volumes and velocities), with head-cuts readily forming within the water courses (Plate 4). This creates bed and bank instability in the aquatic ecosystems and consequent sedimentation of downstream areas. Should surface water flows be diverted, changes in regional hydrological patterns could also occur, i.e. lead to the drying out of certain areas or complete inundation of other areas. A particular concern would be the inundation, created by large road embankments within drainage lines that contain *Cyclopia pubescens* populations.

Due to the nature of the study area hydrology, its present state and the surrounding impacts (alien plants and eroded areas, Plate 4), the negative impact, although permanent would be localised and unlikely result in a medium intensity impact if bridges are used. Thus the overall significance of the impact would be rated as **Medium**. Should **only culverts** with large embankments be used in this area, an area already modified, the significance of the impact would be rated as **Very High**, due to the high number of culverts that would be required, together with the cumulative impact of all those already impacting on the system (Table 3).

Plate 2: Erosion as a result of an unprotected road crossing and increased runoff velocities downstream of the current water line crossing

Proposed mitigation

Stormwater and any runoff generated by the hard surfaces should be discharged into retention swales or areas with rock rip-rap. These could be used to enhance the sense of place, if they are grassed with indigenous vegetation. These energy dissipation structures should be placed in manner that flows are managed prior to being discharged back into the natural waters courses, thus not only preventing erosion, but would support the maintenance of natural base flows within these systems, i.e. hydrological regime (water quantity and quality) is maintained. The crossings should also not trap any run-off, thereby creating inundated areas, but allow for free flowing water courses. No flows within any drainage lines (seeps) should be altered due to the presence of *Cyclopia* within the area.

It is also proposed that only bridges across the Baakens River be used as this would minimise the potential hydrological impacts.

Significance of impact with mitigation

Although permanent changes to the local hydrological regime are probable, the intensity of negative impact in the operational phase would be low, thus the overall significance of this impact would be **Low** if bridges are used or **High** for the culvert option (Table 3). This impact is also partially reversible should the roads and related infrastructure be decommissioned, i.e. changes to local soil structure and surrounding vegetation would still be apparent in the long term, although it is envisage that the roads once constructed would become a permanent feature.

Table 3: A summary of the potential impacts of all the crossings, showing impact scores of bridge versus culvert options

Impact	Spatial Extent	Intensity	Duration	Consequence	Probability	Significance without mitigation	Significance with mitigation
Impact 1: Diversion and increased velocity of surface water flows – Changes to the hydrological regime and increased potential for erosion							
Culverts	Regional 3	High 3	Permanent 3	Very High	Definite	Very High (fish)	High
Bridges	Local 2	Medium 2	Permanent 3	High	Unlikely	Medium	Low
Impact 2: Diversion and increased velocity of surface water flows – reduction in permeable surfaces							
Culverts	Regional 3	High 3	Permanent 3	Very High	Definite	Very High (flora)	High
Bridges	Local 2	Medium 2	Permanent 3	High	Definite	High	Low
Impact 3: Impact of changes to water quality							
Culverts	Regional 3	High 3	Permanent 3	Very High	Definite	Very High (fish)	Very High
Bridges	Local 2	Medium 2	Permanent 3	High	Likely	High	Medium
Impact 4: Loss of riparian vegetation, aquatic habitat and stream continuity (migration corridors)							
Culverts	Regional 3	High 3	Permanent 3	Very High	Definite	Very High (fish & flora)	High
Bridges	Local 2	Medium 2	Permanent 3	High	Likely	High	Low
Impact 5: Loss of species of special concern (aquatic)							
Culverts	Regional 3	High 3	Permanent 3	Very High	Possible	Very High (fish)	High
Bridges	Local 2	Medium 2	Permanent 3	High	Unlikely	Medium (fish)	Low

5.2 Impact 2: Diversion and increased velocity of surface water flows – reduction in permeable surfaces

Nature of the impact

Road and bridge construction involves the creation of hard surfaces, which usually includes the provision of stormwater drainage. This will divert further flow away from one water body, while increasing flow velocities of run-off into another during the operational phase. This impact is closely linked to the previous impact, but the reduction in permeable surfaces does require a separate assessment is due to the need for surface water to permeate into shallow, as well as deeper groundwater systems. This is important in both the maintenance of local aquifers, as well as seeps (found down slope of the study area) and riparian associated vegetation dependent on subsurface flows, e.g. the *Cyclopia pubescens* populations. The action of percolating water through permeable surfaces also aids in the reduction and / or removal of organic and inorganic pollutants contained in the surface waters.

Significance of impacts without mitigation

The soils within the study area are susceptible to erosion when subjected to high flows (high volumes and velocities), with head-cuts readily forming within the water courses. This creates bed and bank instability of the aquatic ecosystems and consequent sedimentation of downstream areas. Should surface water flows be diverted, changes in regional hydrological patterns could also occur, i.e. lead to the drying out of certain areas. The drying out of areas also reduces the potential for surface water to recharge shallow and deep groundwater systems.

Due to the nature of the study area hydrology and its present state and the surrounding impacts (informal roads and alien plants – Plate 4), the negative impact, although permanent would be localised and probably result in a medium intensity impact. Thus the overall significance of the impact would be rated as **High** (bridge option) as downstream areas are still in a moderately modified state (Table 3). Similarly if only culverts, which require large embankments, downstream areas will become drier, while upstream areas will become more inundated. This is seen in other parts of the metro where on-off road embankments have created permanent wetlands, which would be an unnatural feature within the study area, and would impact on the *Cyclopia* plants. Thus the impact would have to be rated as **Very High**

Proposed mitigation

Stormwater and any runoff generated by the hard surfaces should be discharged into retention swales or areas with rock rip-rap. These could be used to enhance the sense of place, if they are grassed with indigenous vegetation. These energy dissipation structures should be placed in manner that flows are managed prior to being discharged back into the natural waters courses, thus not only preventing erosion, but would support the maintenance of natural base flows within these systems, while the use of grassed swales would allow for localised groundwater recharge, i.e. hydrological regime (water quantity and quality) is maintained. The degree of this mitigation would be rated as low (Table 3). It is further recommended that only bridges be used on the major crossings over the Baakens River

Significance of impact with mitigation

Although permanent changes to the local hydrological regime are probable, the intensity of negative impact in the operational phase would be low, thus the overall significance of this impact would be **Low** (bridge option). This impact is also partially reversible should the roads and related infrastructure be decommissioned, i.e. changes to local soil structure and surrounding vegetation would still be apparent in the long term (Table 3).

5.3 Impact 3: Impact of changes to water quality

Nature of the impact

Presently there are a number of water quality issues within the Baakens River. These are mostly associated with bacteriological issues, related to the occasional leaks from sewer lines. Originally the project proposed that a sewer line be realigned, and should a leak occur during construction, the impact would have been rated as **Very High**. Sewage, which contains high levels of nutrients and bacteria, usually results in fish kills within rivers, as the bacteria rapidly deplete all the oxygen in the water column, thus 'suffocating' any fish. The high nutrient levels also result in algal blooms and further decrease the Dissolved Oxygen levels, while blocking available sunlight within the water, which is required by other aquatic plants for survival. However the proposed sewer alignment will no longer take place within any of the known water courses or their floodlines and the impact requires no further assessment.

During the road construction various materials, such as sediments, diesel, oils and cement, will pose a threat to the continued functioning of the instream and adjacent areas, if by chance it is dispersed via surface run-off, or are allowed to permeate into the groundwater. The potential negative changes to water quality during the operational phase would be limited to sedimentation, erosion and hydrocarbon related issues. These negative impacts would persist into the medium term.

Significance of impacts without mitigation

Changes to water quality (surface and groundwater) impact on the functioning of plants and other instream biota. This impact without mitigation significance would be **Very High**, as excessive pollution will also impact on instream conditions due the introduction of toxins. Potential toxins include the following:

- Grout and concrete – these products contain cement which increases the pH (basic) of surfaces waters impairs the metabolism and breathing physiology of aquatic organisms
- Hydrocarbons (shutter oil, other lubricants, grease and fuels) – The persistent impact of these pollutants is varied, but can enact negatively on metabolic pathways, cellular structures (plant and animal), respiration and gene stability (heavy metals)

Proposed mitigation

- Chemicals used for road surfacing and bridge building must be stored safely on site and surrounded by bunds. Chemical storage containers must be regularly inspected so that any leaks are detected early
- Littering and contamination of water sources during construction must be prevented by effective construction camp management.
- Emergency plans must be in place in case of spillages onto road surfaces and water courses.
- No stockpiling should take place within a water course.
- All stockpiles must be protected from erosion, stored on flat areas where run-off will be minimised, and be surrounded by bunds.
- Stockpiles must be located away from river channels.
- Erosion and sedimentation into river channels must be minimised through the effective stabilisation (gabions and Reno mattresses) and the re-vegetation of any disturbed riverbanks.
- The construction camp and necessary ablution facilities meant for construction workers must beyond the 50m buffer described previously.
- Works should be limited to dry periods within the river bed.
- Any stormwater runoff should not be allowed to enter any water courses directly, to minimise the potential hydrocarbon related issues.

Significance of impact with mitigation

Should the construction site and the works be managed properly, the negative impacts would remain localised and in the short-term. This would result in an overall significance of **Medium (bridges)** and **Very High** for culverts, as culverts require a greater degree of works within the riverbed, while it is easier to use coffer dams in the Baakens River, to protect the bridge construction works, and prevent materials from entering the water courses. Similarly it is difficult to contain pollution from entering these systems when using culverts (Table 3).

5.4 Impact 4: Loss of riparian vegetation, aquatic habitat and stream continuity (migration corridors)

Nature of the impact

Riparian and aquatic corridors create of longitudinal links between a variety of habitats and refugia. The refugia are particularly important in times when surface flows are low, i.e. fish populations are able to survive in deeper pools during droughts, and then colonise the remaining river reaches, when reconnected by increased river flows.

Road crossings, and in particular culvert crossings disrupt both the instream and riparian continuity, both in terms of flows and physical habitat availability. It is thus important for road design to incorporate these aspects with the aim of retaining instream and riparian continuity. This not easily attained when using culverts, and thus bridges are always recommended.

Significance of impacts without mitigation

This impact without mitigation i.e. culverts with large embankments would have a **Very High** significance (culverts) and **Medium** for the bridge options.

Proposed mitigation

- Bridges rather than culverts are used
- Any embankments are outside of the floodline areas
- No bridge piers occur within the instream areas

Significance of impact with mitigation

Should the mitigations be considered, then negative impacts would remain localised and in the short-term. This would result in an overall significance of **High** for culverts, while the bridge option would be **Low** as the overall continuity of the instream areas, would remain (Table 3). This is assuming that the alien vegetation is removed from the catchment and the natural vegetation is allowed to recover, while the felled alien vegetation is kept from entering the water courses. The project does have to potential to have a positive impact by allowing for the removal of the alien vegetation, but this would only be of significance if all the alien plant matter is removed, and that continual follow-up clearing is conducted and the riverbeds and banks are rehabilitated.

5.5 Impact 5: Loss of species of special concern

Nature of the impact

Loss of riparian and instream habitat could possibly result in the loss of species of special concern as a result of their destruction during the construction phase, i.e. flora. While changes in the hydrological region in the operational phase, could limit on impact on the presence of other species, should surface water flows be diverted or refugia are disconnected from available habitat (fish).
However, no species of special concern were evident during the study within the Baakens River itself, due to the high degree of alien plant invasion. The presence of the Critically Endangered *Cyclopia pubsecens* is assessed in the botanical report, however the authors of this report agree with their findings.

Due to the possible presence of *Pseudobarbus afer*, and as precautionary step, it is important that all instream areas are protected during the construction phase of the project and the form and function of the river channels remain intact.

Significance of impacts without mitigation

This impact without mitigation i.e. culverts with large embankments would have a **Very High** (culverts) and **Medium** (bridges) significance (Table 3).

Proposed mitigation

It is advised that all riparian areas (i.e. areas within the 1:100 floodline) be excluded from the development footprint and that only bridges with suitable piers be used. During the operational phase, surface water flows should not be diverted or impeded. This will prevent future changes in the hydrological regime that supports habitats and the associated species.

Significance of impact with mitigation

This impact without mitigation i.e. culverts with large embankments would have a **High** significance due to the high number of crossings needed within the drainage lines, rivers and those already occurring within the localised areas (Table 3). The significance could be reduced to Low should the bridge options be used (Table 3).

6 CONCLUSION AND RECOMMENDATIONS

It would seem that the proposed project could proceed as current land use has a greater impact on the functioning and importance of the aquatic systems within the study region, i.e. the no-go option. This is largely due to the spread of alien vegetation, limiting the functioning and importance of the riparian zones within the study reach.

However the project, regardless of the alternative selected, i.e. they would all have a similar degree of impact regardless of the locality of the crossings, on fish, aquatic and riparian habitats, the main negative impacts associated are related to:

- Blocking of natural fish migrations: Rivers are longitudinal ecosystems and fish naturally migrate both upstream and downstream to find suitable breeding substrates, feeding areas, and refuge pools, etc. at different stages of their life cycle. Thus any poorly designed instream structure, such as culverts, causeways or even bridges, can block these natural longitudinal movements and threaten the survival of fish species. As a guideline, the natural longitudinal profile of the riverbed both upstream and downstream of the structure should be maintained, in order to allow the natural movement of mobile bed material, and to ensure there are no vertical drops in water flow and that water velocities are not increased downstream of or within the structure.
- Increased sediment load in the river: Elevated turbidity due to mobilization of fine sediment, particularly during the construction phase, can have a significant and even lethal impact on aquatic biota, including fish. These impacts include reduced primary production, smothering of benthic organisms and fish eggs, clogging and abrading of fish gills (leading to disease and death) and reduced feeding efficiency of visual predators. The current sedimentation and increased turbidity after rains in the degraded Baakens River catchment is probably as one of the major negative impacts on native fish populations.
- Chemical pollution during construction. During the construction of the infrastructure (culverts, bridges, roads) within the Baakens River channel and adjacent areas, a range of hazardous materials (hydrocarbons, bitumen, cement, paints, cleaning/shutter fluids, etc.) associated with the construction activities and machinery used, could pollute the river unless great care and adequate precautions are taken.
- Culverts or bridges: The relative impact of constructing either culverts or bridges will largely depend on the design of these structures. As a general rule, however, well-designed bridges have a comparatively small impact on flow patterns in the river and disturbance of the channel and riparian zones and thus have little impact on fish migrations and aquatic habitats. Bridges are thus the preferred option for this project in terms of the protection of fish and instream aquatic habitats for all the crossings and in particular areas over seeps / drainage lines that may affect the *Cyclopia* populations.

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