AQUATIC AND WATER QUALITY ASSESSMENT:

SPECIALIST REPORT FOR THE TWO RIVERS URBAN PARK DEVELOPMENT FRAMEWORK, CAPE TOWN

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EXECUTIVE SUMMARY

Two Rivers Urban Park is located at the confluence of the Black and Liesbeek Rivers within the City of Cape Town. In 2015 a multidisciplinary team was commissioned to formulate a Development Framework and to facilitate the necessary authorisations for the development of the Park. This aquatic and water quality assessment study was commissioned in order to inform the project team of the aquatic and water quality related constraints and opportunities for the site as well as the potential impact of proposed development framework proposals in order to facilitate the authorisation processes for the project.

The main freshwater features within the TRUP site are the Liesbeek and Black Rivers. Associated with the rivers are a number of wetland areas that comprise remnant floodplain wetland and artificially created and storm water dominated wetlands. Of the wetland areas within the site, the Raapenberg, Vincent Pallotti and Valkenberg wetlands are considered to be the most important, as remnants of the Black River floodplain wetland area. The ecological condition of these aquatic ecosystems range from being moderately to largely modified for the wetland areas and largely to seriously modified for the rivers. The ecological importance and sensitivity of these aquatic ecosystems is deemed to be moderate to high in general with only the Black River being low to moderate.

The Raapenberg, Valkenberg and Vincent Pollotti wetland complex is considered to have a high sensitivity. The remaining valley bottom and floodplain wetland areas and riparian zones of the Liesbeek and Black Rivers, including the old channel of the Liesbeek River, are considered to be of medium sensitivity. Minimal development should take place within the more sensitive wetland areas and the recommended buffers.

The water quality in the two river systems is highly variable and is linked to the seasonal flow variability. The quality of the water in the Black River is significantly more degraded than in the Liesbeek River. A trend of improving water quality is evident in the rivers over the past 20 years.

The proposed development of the site is likely to have an impact of low significant on the aquatic ecosystems on the site, with a potential for a positive impact. The following are proposed to improve the ecological condition of the aquatic features within the site:

- *The impact of storm water runoff from the surrounding developed areas into the aquatic features should be mitigated. Where possible, litter traps should be constructed to reduce litter entering the rivers. The functionality of the rivers and wetland areas should also be enhanced.*
- *Invasive alien vegetation within the aquatic ecosystems and their buffer areas should be removed and these areas kept free of alien invasive plants;*
- *A buffer area of approximately 35m should be maintained adjacent to the delineated edge of the aquatic features; and*
- *The river corridors and their associated wetlands areas represent key corridors for the movement of aquatic biota. Connectivity within these corridors within the site should be maintained or restored where possible. While the connectivity along the Black River within the site is still largely*

intact, Observatory Road and the canalised section of the lower river have significantly impacted on the connectivity of Liesbeek River. Rehabilitation of the lower Liesbeek River should be undertaken according to an approved rehabilitation plan.

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1. BACKGROUND

Two Rivers Urban Park (TRUP) is located at the confluence of the Black and Liesbeek Rivers within the City of Cape Town (CCT) (Figure 1). The site is approximately 300ha in extent and is considered to be a unique and special place as it contains wide open space areas with sensitive ecological systems and habitats, as well as significant institutions, historical buildings and cultural landscapes within an urban landscape. The process to develop the area into an urban park was initiated in 1998 (referred to then as the Black River Urban Park Development Framework process). In 2015 a multidisciplinary team was commissioned to formulate a Development Framework and to facilitate the necessary authorisations for the TRUP development.

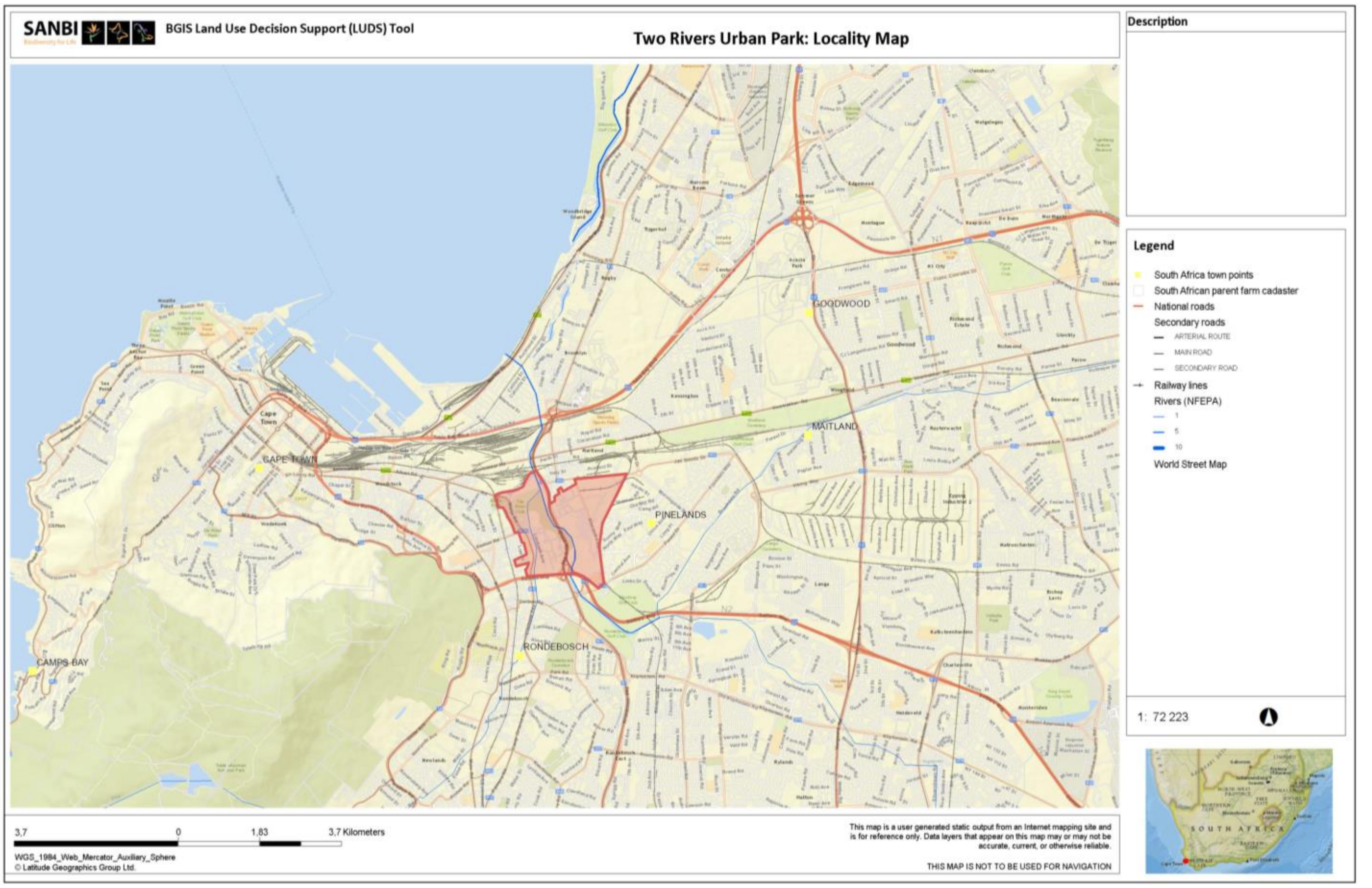


Figure 1. Location of the Two Rivers Urban Park (SANBI Biodiversity GIS, 2016)

Table 1. Water resource information related to the proposed activity

Descriptor	Name / Details	Notes
Water Management Area	Berg	
Catchment Area	Black/Salt River	Liesbeek is tributary of the Black/Salt River
Quaternary Catchment	G22C	
Present Ecological state	Liesbeek River: E category (seriously modified) Black River: F category (critically modified)	DWA 2012 (Appendix C)
Ecological Importance and Ecological Sensitivity	Liesbeek River: Low and High Black River: Very low and Moderate	
Latitude	33° 56' 7.6"S	Centre of site
Longitude	18°28'51.9"E	

This aquatic and water quality assessment study was commissioned in order to inform the project team of the aquatic and water quality related constraints and opportunities for the site as well as the potential impact of proposed development framework proposals in order to facilitate the authorisation processes for the project.

2. TERMS OF REFERENCE

The Terms of Reference for this aquatic and water quality assessment is as follows:

The findings of the river and wetland specialist reports must include the following:

- *Provide full requirements for a water quality assessment such water temperature, dissolved oxygen, pH, electrical conductivity, total dissolved solids, etc.;*
- *Co-ordinates where samples were taken and a map illustrating where samples were taken;*
- *Map indicating ecosystems within the Department of Water and Sanitation 500m buffer zone;*
- *Provide full requirements for an aquatic assessment such:*
    - *Description of the condition of the habitat; and*
    - *Potential impacts to water quality and quantity; & condition and character of habitat and fauna in terms of: Consequence; Intensity; Extent; Duration; Significance; and Probability;*
- *Provide all maps in GIS format – or as a minimum as kmz / kml files;*
- *Recommendations regarding possibilities for (a) connectivity of the site to the surrounding landscape, (b) for the design and development of the area with regards to landscaping, rehabilitation, species and management, and mitigation measures;*
- *Provide all reports in Microsoft Word format; and*
- *Provide all mapping in GIS shape file or kmz format.*

3. METHODOLOGY, ASSUMPTIONS AND LIMITATIONS OF THE STUDY

Input into this report was informed by a combination of desktop assessments of existing aquatic ecosystem and water quality information for the study area and catchment, as well as by a more detailed assessment of the freshwater features at the site. The site was visited in August 2016. During the field visit, the characterisation and integrity assessments of the freshwater features were undertaken. Mapping of the freshwater features was undertaken using a Garmin Colorado 300 GPS and mapped in

PlanetGIS and Google Earth Professional. The SANBI Biodiversity GIS website was also consulted to identify any constraints in terms of fine-scale biodiversity conservation mapping as well as possible freshwater features mapped in the Freshwater Ecosystem Priority Areas maps. This information/data was used to inform the resource protection related recommendations.

Limitations and uncertainties often exist within the various techniques adopted to assess the condition of ecosystems. The following techniques and methodologies were utilized to undertake this study:

- The river health assessments were undertaken according to methodologies developed as part of the national River Health Programme. Existing river health data was also utilised for the Liesbeek River;
- The guideline document, "A Practical Field Procedure for the Identification and Delineation of Wetlands and Riparian Areas" document, as published by DWAF (2005) was followed for the delineation of the riparian and wetland areas. According to the delineation procedure, the wetlands were delineated by considering the following wetland indicators: terrain unit indicator; Soil form indicator; Soil wetness indicator; and vegetation indicator.
- Wetland boundaries reflect the ecological boundary where the interaction between water and plants influences the soils, but more importantly the plant communities. The depth to the water table where this begins to influence plant communities is approximately 50 centimetres. This boundary, based on plant species composition, can vary depending on antecedent rainfall conditions, and can introduce a degree of variability in the wetland boundary between years and/or sampling periods.
- The wetlands were classified according to their hydro-geomorphic determinants based on a classification system devised by Kotze et al (2004) and SANBI (2009). Notes were made on the levels of degradation in the wetlands based on field experience and a general understanding of the types of systems present.
- A Present Ecological State (PES) assessment was conducted for each hydro-geomorphic wetland unit identified and delineated within the study area. For the purpose of this study, the tool WET-Health as defined in the WET Health Series developed for the Water Research Commission was used to assess the present ecological state of each wetland unit.
- The functional wetland assessment technique, WET-EcoServices, developed by Kotze et al (2009) was used to provide an indication of the ecological benefits and services provided by delineated wetland habitat. This technique consists of assessing a combination of desktop and infield criteria in order to identify the importance and level of functioning of the wetland units within the landscape.
- The ecological importance and sensitivity assessment was conducted according to the guidelines as developed by DWAF (1999).

- Water quality data utilized for the assessment was obtained from the City of Cape Town and the Department of Water and Sanitation (DWS) for the sites and periods indicated in the water quality assessment section of this report. These water quality results (median and 95th percentile values) were evaluated against the South African water quality guidelines for aquatic ecosystems (DWAF, 1996) as well as the General and Special Limit values as stipulated in Government Notice 665, dated 6 September 2013 for the discharge of treated wastewater into a water resource;

- The Resource Quality Objectives (RQOs) was based on available data (recent as well as historical). In many cases these data sets are patchy and that analysed for is not always what is required for management purposes. The analysis of the data however requires long data records that such a project life-time cannot allow for (e.g. usually a minimum data set of 12 samples is required for statistical assessments that need to be carried out over a period of one year to ensure that seasonal variability is also included in the assessment);

- The RQOs are generated through models that have been developed for the Department of Water Affairs and Forestry, which contain certain assumptions and extrapolations to accommodate for the lack of reliable and comprehensive data sets; and

- Recommendations are based on professional opinion and best practise guidelines.

The level of aquatic and water quality assessments undertaken was considered to be adequate for this study.

4. USE OF THE REPORT

This report reflects the professional judgment of its authors. The full and unedited content of this should be presented to the client. Any summary of these findings should only be produced in consultation with the authors.

5. PHYSICAL CHARACTERISTICS OF THE STUDY AREA

5.1. OVERVIEW OF STUDY AREA

TRUP is located approximately 5km from the City Central Business District, at the intersection of the N2, M5 and N1 freeways (Figure 2). The TRUP site is approximately 300ha in extent and includes provincial and local government properties; as well as private landowners.The site is at the confluence of the Black and Liesbeek Rivers within the Salt/Black River System.

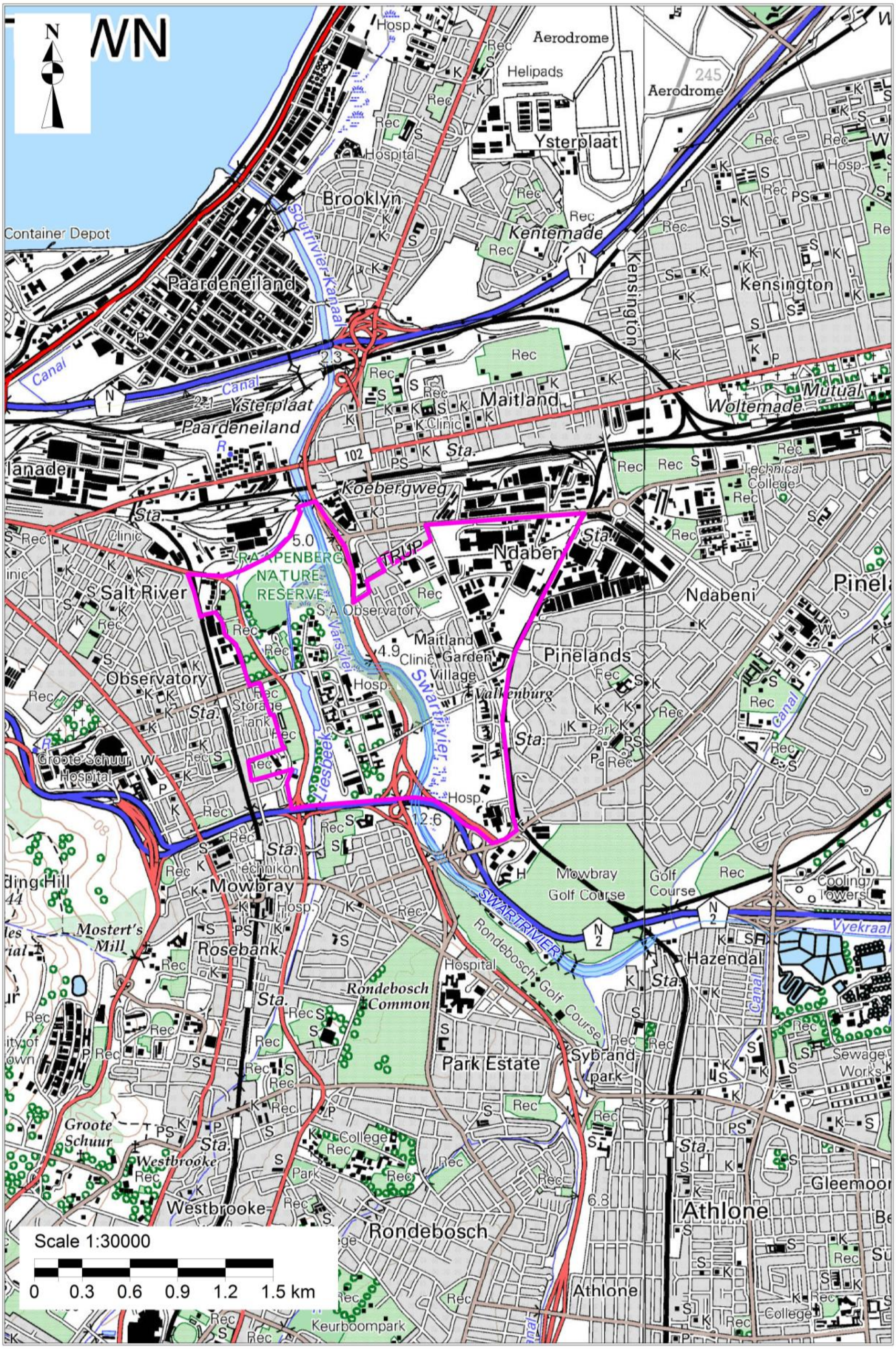


Figure 2. Topography map (3318CD&DC) of the study area

The Salt/Black River Catchment covers an area of approximately 254km^2, draining the Tygerberg Hills, the north-western parts of the Cape Flats and some of the east facing slopes of Table Mountain. The catchment includes the Elsieskraal, Blomvlei, Jakkalsvlei, Vygekraal, Black and Liesbeek Rivers, and Salt River Canal. It is the most urbanised of all the catchments in the City of Cape Town.

The river system is typical of an urban river system with extensive impervious areas where the natural vegetation cover in the wider catchment area has been transformed and consists largely of hardened / paved surfaces and grassed areas. Large portions of the rivers have been canalised or piped. The flow and water quality in the rivers have been significantly modified by treated wastewater and storm water discharges. The Athlone, Borcherds Quarry and Parow Wastewater Treatment Works (WWTW) are in the Salt River Catchment.

The Liesbeek River rises on the eastern slopes of Table Mountain and in its upper reaches flows through Kirstenbosch National Botanical Gardens. Immediately downstream of the Gardens, the river flows through the residential areas with major sections of the lower reaches of the river having been canalised and parts of the banks and river beds artificially stabilised or reinforced with gabion structures. There are a number of sewage pump stations along the Liesbeek River.

The Black River occurs downstream of the confluence of the Vygekraal River and the Elsieskraal River. It drains parts of the Cape Flats and flows past the suburbs of Claremont, Rondebosch, Rosebank and Mowbray before it becomes the Salt River Canal after the confluence with the Liesbeek River. The river is mostly surrounded by residential suburbs and is canalised. There are approximately three sewage pump stations in the vicinity of the Black River.

Within the TRUP site, these rivers flow within wider, greened areas with adjacent wetland areas that provide both habitat for aquatic life and important services in flood attenuation and storm water mitigation. The Raapenberg and Vincent Pallotti / Valkenberg wetlands are all that remain of the once extensive wetland system that originally occurred along the Black River.

5.2. TOPOGRAPHY

The site is located within the lower Liesbeek River and Black River Valley, within the floodplain of these rivers. The area is thus relatively flat with a gentle slope from the eastern and western extents of the site towards the Black River and from the south of the site towards the sea in the north. Altitudes within the site range from about 5m above mean sea level (amsl) in the river floor to 16m amsl at the north-eastern extent of the site. Slightly raised areas (11-12m amsl) occur between the two rivers at Valkenberg Hospital and at the Observatory (Figure 3). The site has also been subjected to some infilling, particularly at the River Club site and just north of the site where extensive land reclamation project initiated in the 1930‟s to rejuvenate and expand the City and the harbour.

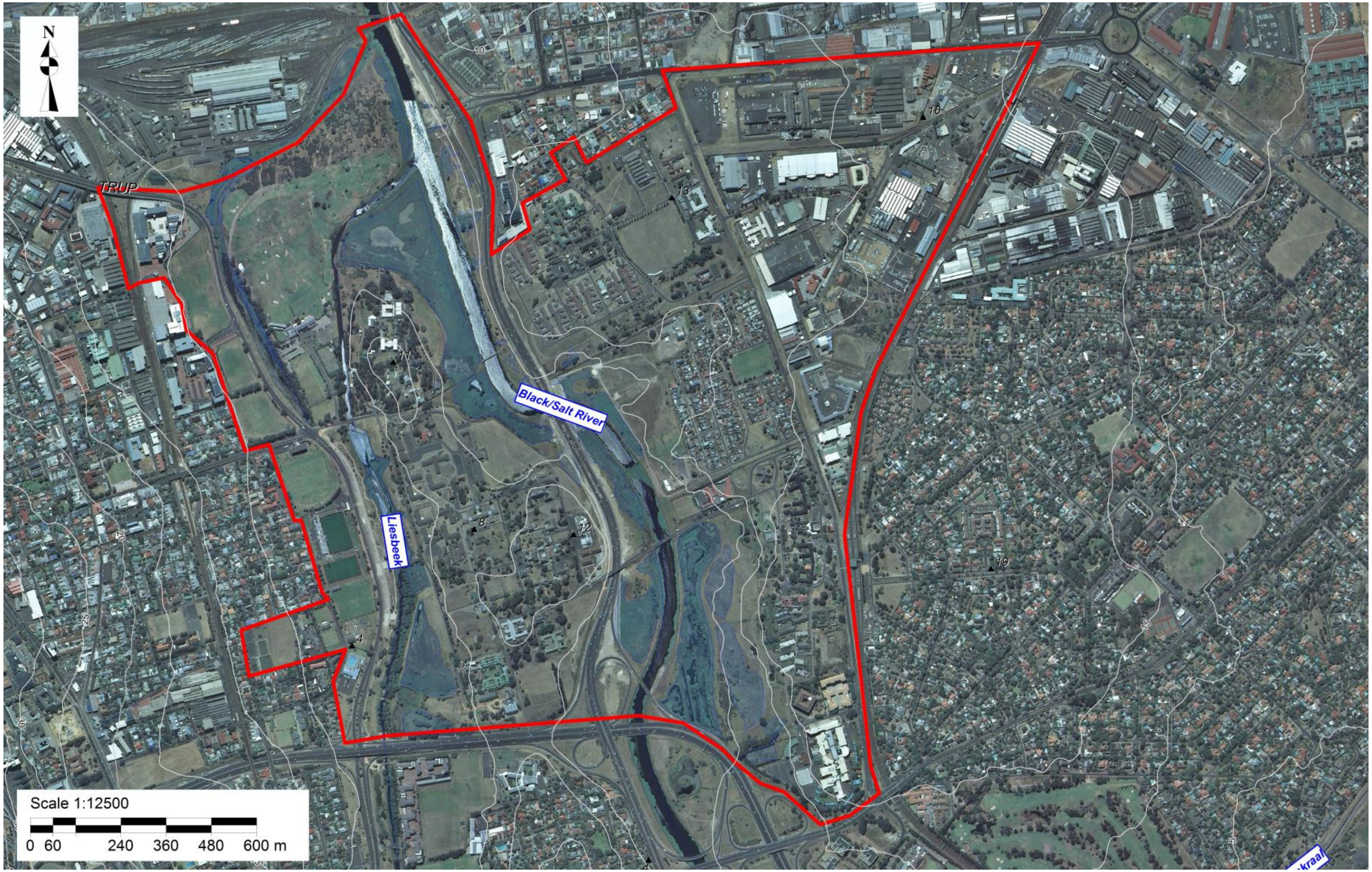


Figure 3. Orthophotograph for the study area showing the 5m contours

5.3 CLIMATE

The area has a Mediterranean climate and normally receives about 700mm of rain per year, mostly during winter. It receives the lowest rainfall (7mm) in January and the highest (94mm) in July (Figure 4). As a result the rivers in the area would naturally have ceased to flow in the period December to April and had their highest flow in July and August (Figure 5). This flow pattern has however been significantly modified by the discharge of treated wastewater and storm water into the river system. There is however no flow gauging of the lower river system to reflect the present day modified flow pattern.

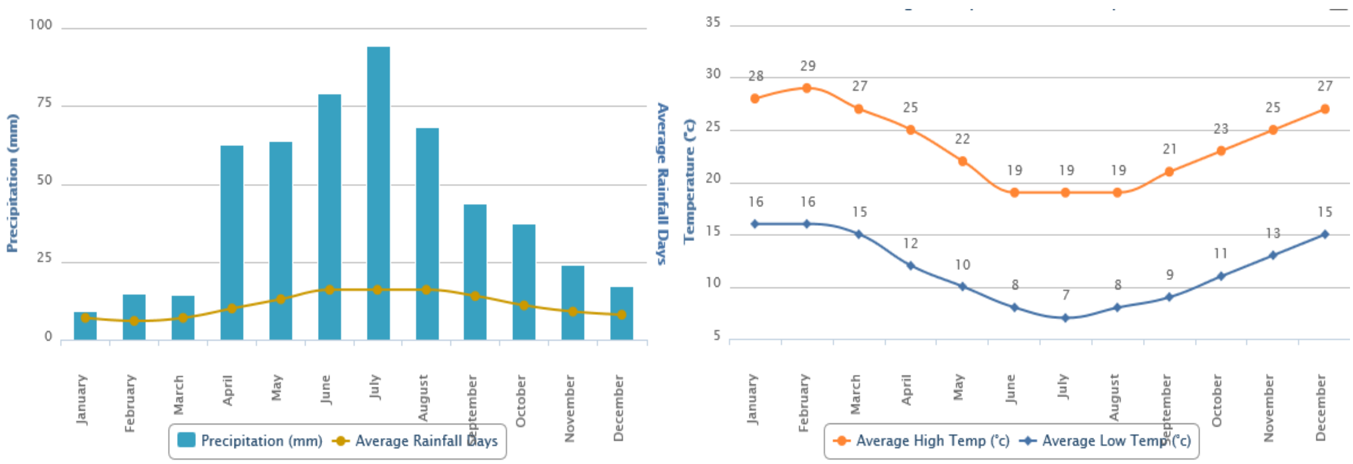


Figure 4. Average monthly rainfall and temperatures for the area (Worldweatheronline, 2014)

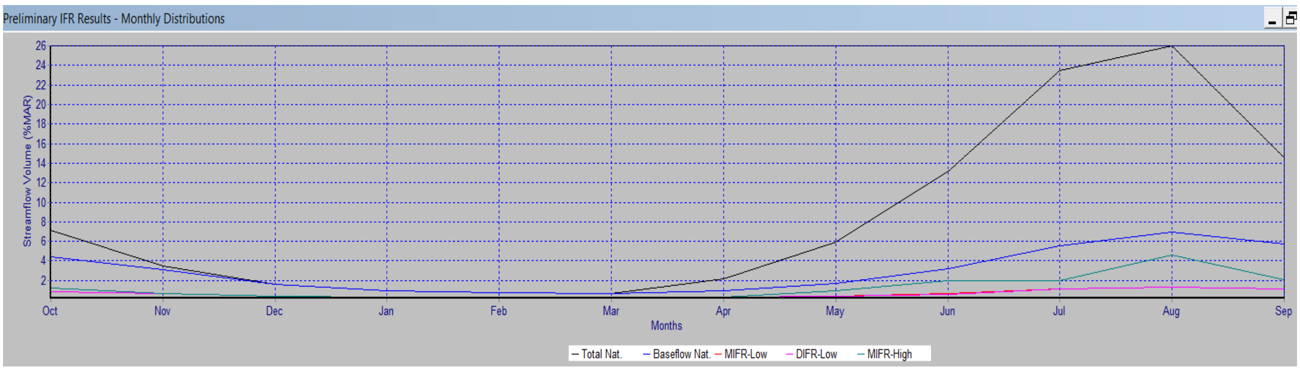


Figure 5. Monthly flow distribution for the Black/Salt River (black line) where the blue line represents the natural baseflow and the green and pink lines indicate the high and low flows required to maintain the aquatic ecosystem

The monthly distribution of average daily maximum temperatures shows that the average midday temperatures range from 19°C in July to 29°C in February. The region is the coldest during July when the mercury drops to 7°C on average during the night. (Figure 4). The prevailing wind directions are the south easterly and the north westerly, with south westerly winds also occurring frequently.

5.4 GEOLOGY AND SOIL

The geology of the area is characterised by Sandveld Group sands, Quaternary aeolian sands characteristic of the Cape Flats area. In the Cape Flats District, the Sandveld Group is mainly represented by the Springfontyn Formation, which was developed through the deposition of windblown sand (an aeolian deposit) and consists of reddish to grey, unconsolidated quartzose aeolian sand. The soils within the site and surrounding area (brown in Figure 6) are classified as soils with a diagnostic ferrihumic horizon (Ga). These deeper, sandy, calcareous soils dominate the low-lying areas of the Cape Flats. They tend to be less acidic and slightly higher nutrient content than the surrounding red and yellow apedal soil types. These soils are often subject to waterlogging during the winter months and have a subsurface accumulation of organic matter typical of wetland areas.

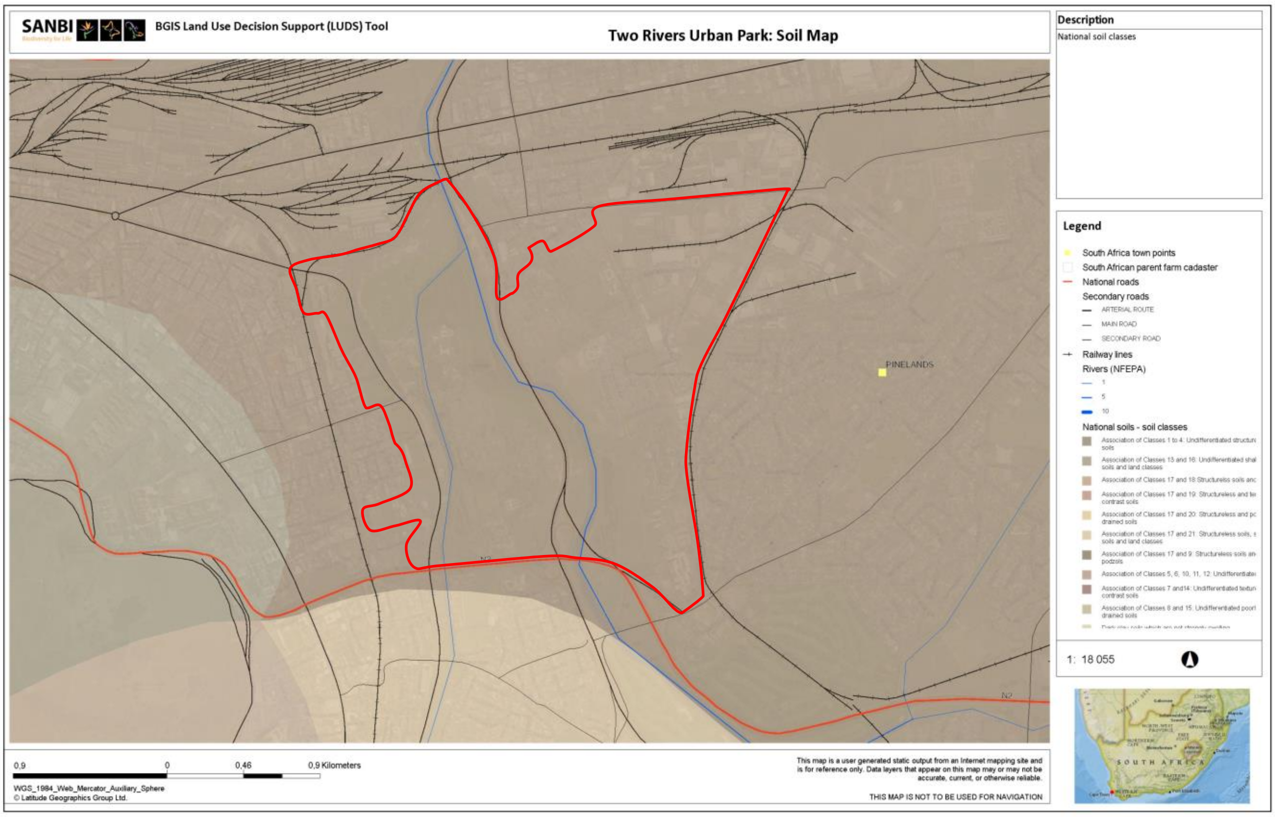


Figure 6. Soil map for the area (SANBI Biodiversity GIS, 2016)

5.5. FLORA

The natural vegetation of the study area is mapped as a mosaic of Cape Flats Sand Fynbos (FFd5: pink-mauve in Figure 7) which occurs on acid sands, Cape Flats Dune Strandveld (FS6, green in Figure 7) which would have occurred on dunes at the lower river system and mouth and Peninsular Shale Renosterveld (FRs10: grey-blue areas in Figure 7) which occurs on shale derived clays along the Black River Valley. Due however to the area being highly modified and largely consisting of transformed areas, the vegetation types are classified as "Endangered" or "Critically Endangered", and have the highest priority for conservation of all the remaining patches existing in small pockets scattered through the Cape Flats and Peninsular.

All the freshwater features within the study area tend to consist of a mix of exotic and invasive alien as well as indigenous plants. Exotics and alien invasive plants include weeping willows (*Salix babylonica*), red sesbania (*Sesbania punicea*), Acacia saligna (*Port Jackson*), manitoka (*Myoporum serratum*), syringa (*Melia azedarach*), kikuyu grass (*Pennisetum clandestinum*), Elephant's ear (*Colocasia escilenta*), nasturtiums (*Tropaeolum majus*), watercress (*Nasturtium officinale*), spiked watermilfoil (*Myriophyllum spicatum*) and water hyacinth (*Eichhornia crassipes*). Indigenous plants associated with the rivers and wetland areas include common reeds (*Phragmites australis*), bulrushes *Typha capensis,* sedges and rushes such as *Cyperus textilis, Pycreus polystachyos, Bolboschoenus maritimus, Isolepis* spp.*, Juncus acutus, Carpha glomerata* as well as arum lilies (*Zantedeschia aethiopica*) and slender knotweed (*Persicaria lapathifolia*).

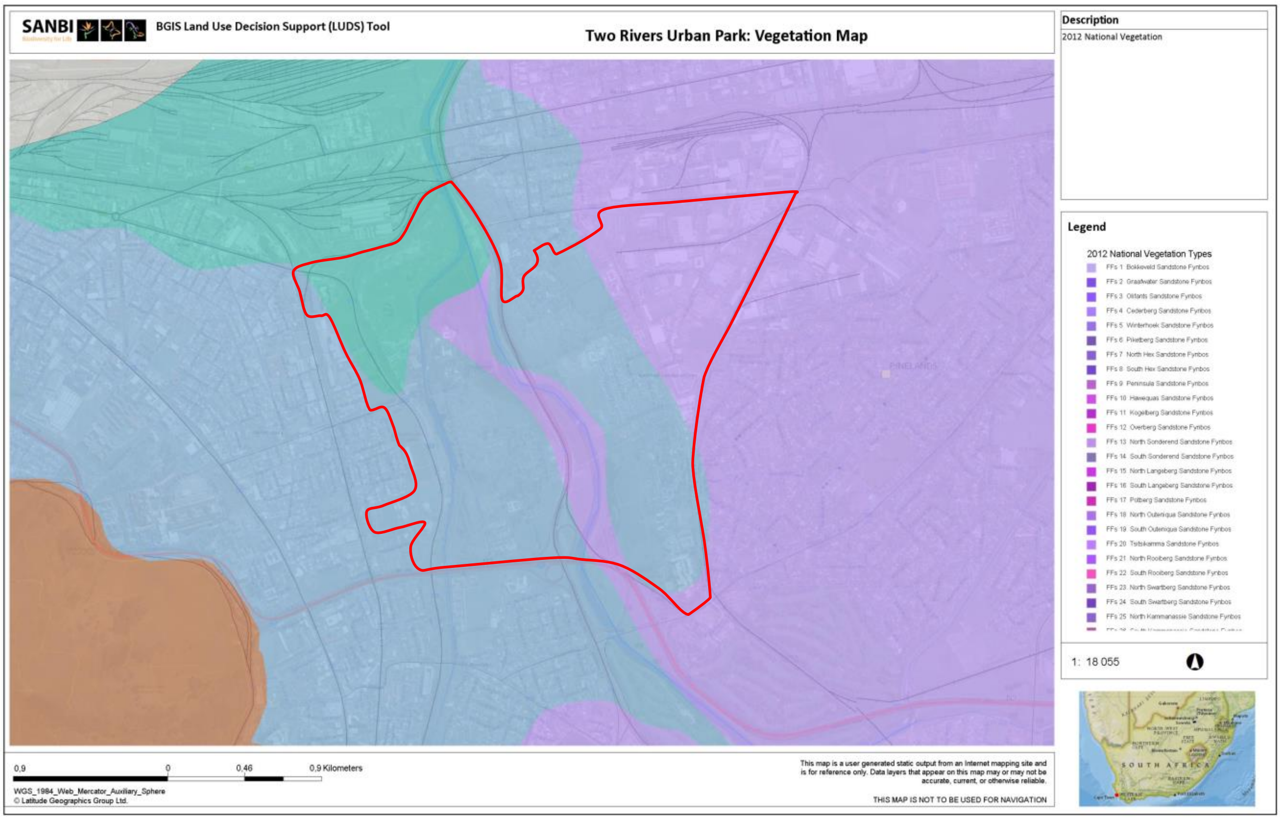


Figure 7. Vegetation types for the study area (SANBI Biodiversity GIS, 2016)

5.6. AQUATIC FEATURES

The main freshwater features within the TRUP site are the Liesbeek and Black Rivers. Associated with the rivers are a number of wetland areas that comprise remnant floodplain wetland and artificially created and storm water dominated wetlands. Of the wetland areas within the site, the Raapenberg, Vincent Pallotti and Valkenberg wetlands are considered to be the most important, as remnants of the Black River floodplain wetland area (Figure 8).

The Black River, for much of its course within the study area, flows within an earthen channel while the Liesbeek River flows within a more natural channel upstream of Observatory Road downstream of which it enters a concrete channel that stretches to 230m short of the rivers confluence with the Black River. An old channel of the Liesbeek River occurs to the east of the current channel that is largely fed by storm water runoff and contains water the backs up from the Black River.

Figure 8. Google Earth image showing the delineated aquatic features within and adjacent to the site based on site assessment

Historically, the Black River was likely to have been flowing only seasonally, as it drained a relatively flat sandy catchment within the Cape Flats. Today flow in the lower reaches rivers occurs throughout the year as a result of storm water and treated wastewater discharges and the channels have been formalised within canals. The Liesbeek River on the other hand was naturally perennial but due to abstraction in its upper reaches ceases to flow in the low flow period on occasion.

The lower reaches of the two rivers were likely to have been dominated by wetland plants and characteristics, with largely unconfined river channels. The indigenous riparian vegetation has largely been removed and replaced with invasive alien kikuyu grass and garden escapees. The instream aquatic vegetation tends to be dominated by indigenous *Phragmites* reeds with bulrushes dominating the storm water driven freshwater features. The freshwater features are assessed and discussed in more detail in the following section.

5.7. LAND USE

The surrounding land use consists of largely of the urban areas of Observatory, Maitland and Pinelands (grey areas in Figure 9) that form part of the Table Bay District within the boundaries of the City of Cape Town. The National N2 Highway lies along the southern boundary of the site and the M5, Black River Parkway passes through the site, east of the Black River. The yellow (cultivated areas) in Figure 9 represent the River Club and Rondebosch Golf Courses.

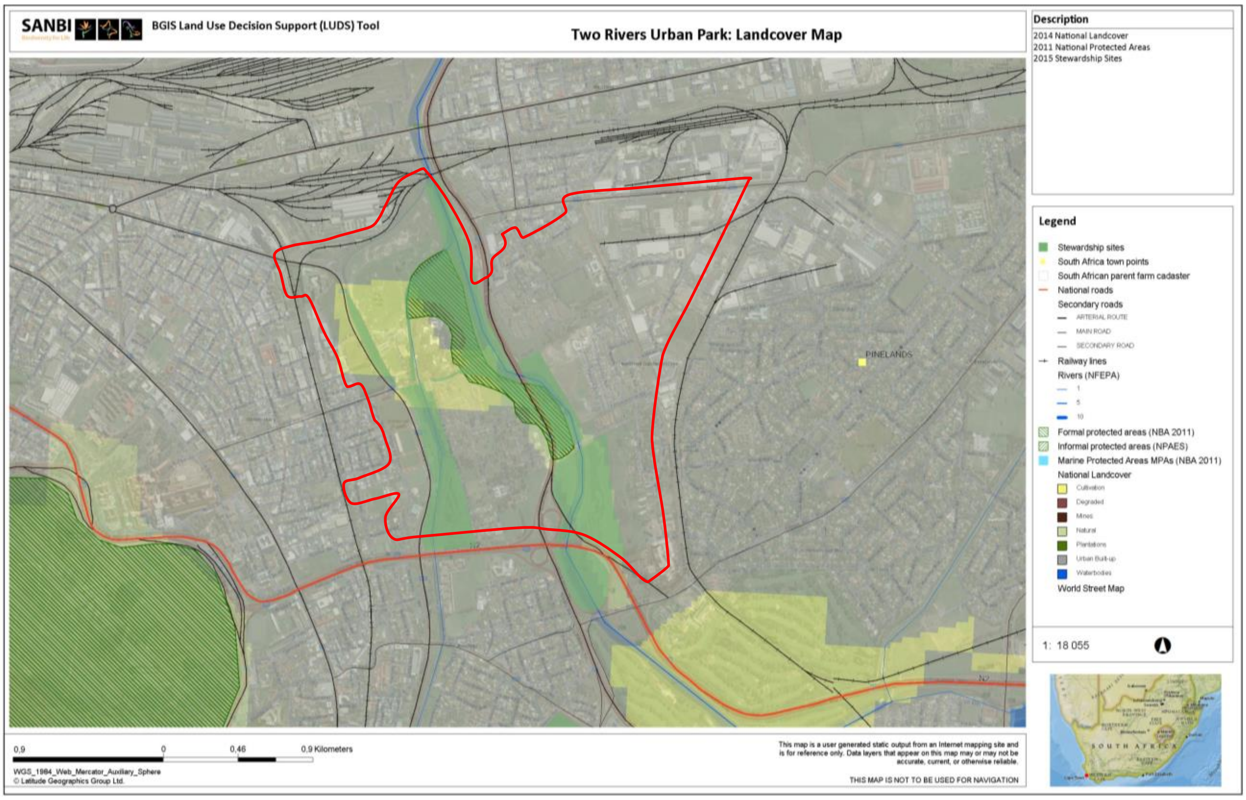


Figure 9. Land use map for the TRUP site and surrounding areas (SANBI Biodiversity GIS, 2016)

The rivers and wetlands within the site are located within an area for which there is a signed Biodiversity Agreement between City Parks and CapeNature (pale green areas in Figure 9). The Raapenberg Wetlands are also located within the Raapenberg Bird Sanctuary Nature Reserve (hatched green area in Figure 9).

Figure 10 shows the proposed Spatial Development Plan (SDP) for the Table Bay District of the City of Cape Town. The Black and Liesbeek Rivers lie within open space for much of site with the river corridors being indicated as Critical Biodiversity Areas.

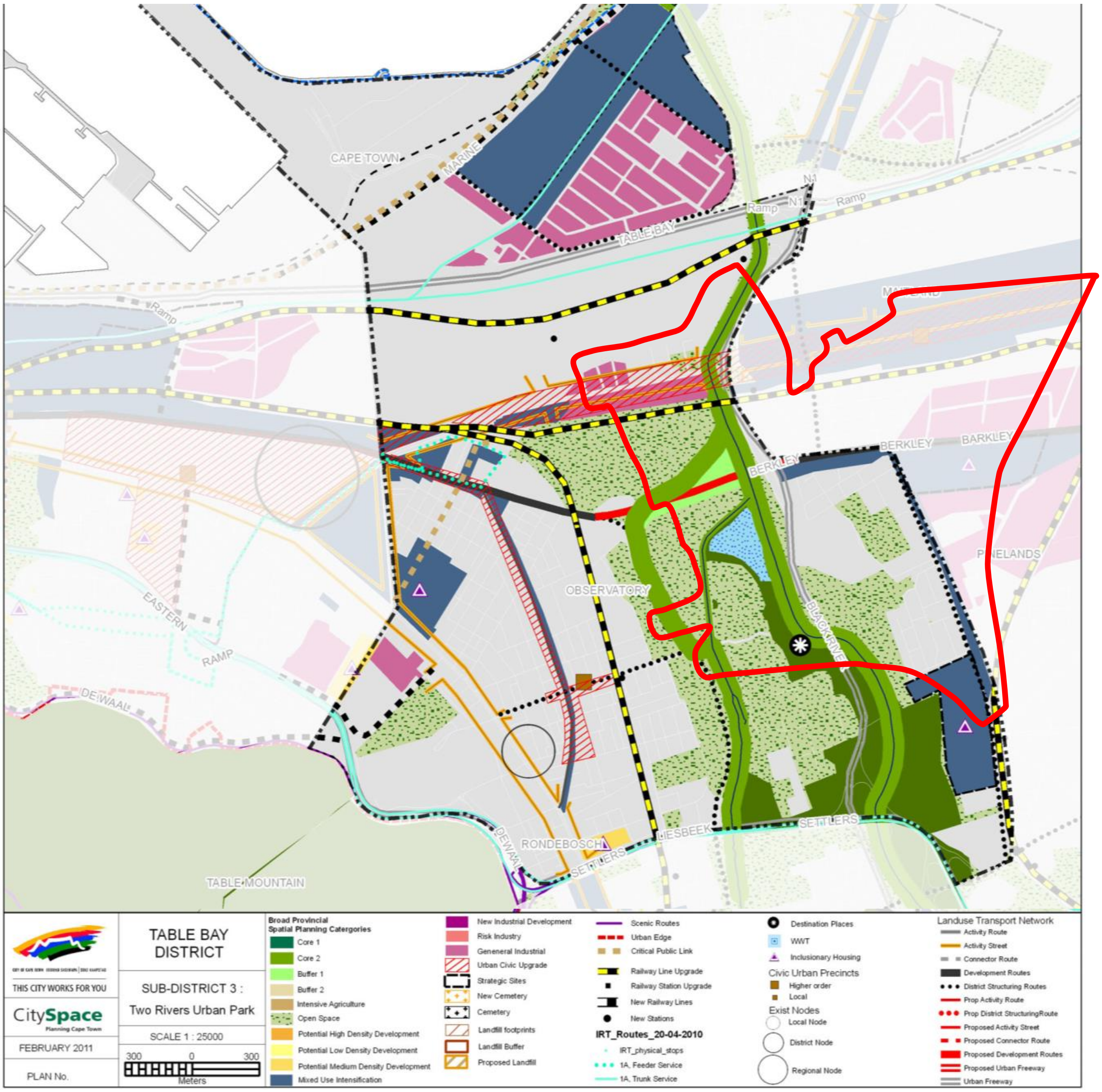


Figure 10. Spatial Development Plan for the area (red polygon)

6. ASSESSMENT OF FRESHWATER FEATURES AND THEIR SIGNIFICANCE

The following aquatic features (Figure 8) have been identified and are discussed further in this section:

- The Liesbeek and Black Rivers in the Black/Salt River System; and
- Wetland areas within the site that have been divided into the Raapenberg Wetlands, Valkenberg Wetlands, Vincent Pallotti Wetlands, wetlands associated with the Liesbeek River and wetlands associated with the Liesbeek / Black River confluence and old Liesbeek River.

6.1. ECOLOGICAL ASSESSMENT OF THE LIESBEEK AND BLACK RIVERS

The Index for Habitat Integrity (IHI), Site Characterisation Assessment, geomorphology, riparian vegetation, macroinvertebrate, fish and water quality data obtained from past river health assessments and water quality sampling as well as from the site visit in august 2016 were used to provide information on the ecological condition of the Liesbeek and Black Rivers. In terms of river health, previous assessments have been undertaken at two sites in the Liesbeek River. The site where there is more data available that is recent and most applicable to the TRUP site is shown in Figure 11 (G2LIES-OBSER). This data has been used for this assessment.

Water quality data was utilised from the Department of Water and Sanitation (DWS) and CCT water quality databases, where water quality data was available for three sites in the study area, that is, NR8 in the Liesbeek River upstream of Observatory Road and NR7 and the DWS site (G22-200000766 – see Appendix D) on the Black River at the footbridge as shown in Figure 11. There are also CCT water quality monitoring points upstream of the site at Raapenberg Road (NR6) and downstream in the Salt River at Voortrekker Road (NR7). No flow data is available for the Liesbeek or Black Rivers.

Table 2. Location and descriptions of monitoring sites considered in this assessment

Site name	Description	Latitude	Longitude
G2LIES-CANAL	River health site on the old canal of the Liesbeek River near River club	33°55'56.76"S	18°28'21.86"E
G2LIES-OBSER	River health site on the Liesbeek River upstream of River Club	33°56'12.49"S	18°28'35.65"E
NR6	CCT site on the Black River at Raapenberg bridge	33°56'47.80"S	18°29'10.00"E
NR7	CCT site on the Black River at the Footbridge to Alexandra Institute	33°56'4.58"S	18°28'49.23"E
NR8	CCT site on the Liesbeek River downstream of Lake weir, opposite Hartleyvale	33°56'11.32"S	18°28'35.37"E
NR9	CCT site on the Salt River Canal downstream of the confluence of the Black and Liesbeek Rivers	33°55'28.89"S	18°28'34.61"E
DWS site	WMS 200000766 upstream the confluence of the Black and Liesbeek Rivers	33°56'4.58"S	18°28'49.23"E

Figure 11. Monitoring sites in the Black River System at the TRUP site as shown in Google Earth

6.1.1. DESCRIPTION OF THE LIESBEEK AND BLACK RIVERS

Originally the Salt River had two mouths that entered into Table Bay with Paarden Eiland lying in between, surrounded by a lagoon that linked the mouths (Figure 12). Of these two mouths, only the northern mouth remains today. The Liesbeek was originally called the Soete or Varsche River, distinguishing it from the Salt or Zoute River. The lower reaches of the Liesbeek River within the flat coastal plain also split into two arms, one that drained into the Salt River Lagoon and one that joined the Black or Zwart River. The area between the two arms of the Liesbeek River and the Black River was referred to as the “Varsche Vlei” and was described as “a low-lying marshy strip with pools, reeds, bushes and a multitude of wild fowl” (Burman, 1962). The Liesbeek River at the time of Jan van Riebeeck in 1660 as a dangerous river in which a horse and rider had drowned.

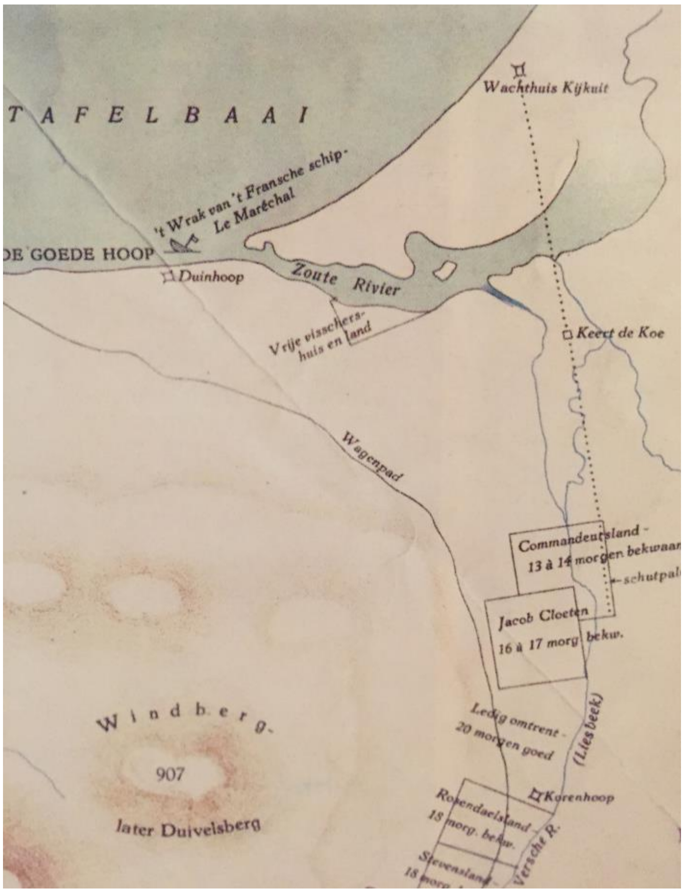


Figure 12. Early map of the Zoute (Salt) and Varsche (Liesbeek) Rivers compiled in 1662 (State Archives)

Due to the fact that the Liesbeek River, with its high rainfall and steep catchment, is prone to flooding in its lower reaches, the river channel was canalised and straightened in Newlands in 1942 and in Rondebosch in 1962 to facilitate urban development of the area. The section of river between the N2 and Hartleyvale was also placed within an earthen canal in 1943 in an attempt to allow boating in the river.

These works included diverting the river through old borrow pits adjacent to the channel to widen the channel and create Liesbeek Lake (Figure 13). Prior to 1956, a new concrete channel was constructed to link to the Black River downstream of Observatory Road with the original channel of the river being maintained to the west of River Club (Figure 13). Shortly hereafter the N2 Highway and M5 were constructed and the Black River within the site needed to be realigned (Figure 14).

From Figure 15, it can be seen that the main alterations that have taken place in terms of the aquatic features within the site are the realignment and canalisation of the Black and Liesbeek River channels. Significant loss of wetland has taken place at the confluence of the Liesbeek River and the Black River. Loss of wetland areas associated with the Black River as a road construction while the wetland areas associated with the Liesbeek River at Harleyvale have increased as a result of the past construction of Liesbeek Lake.

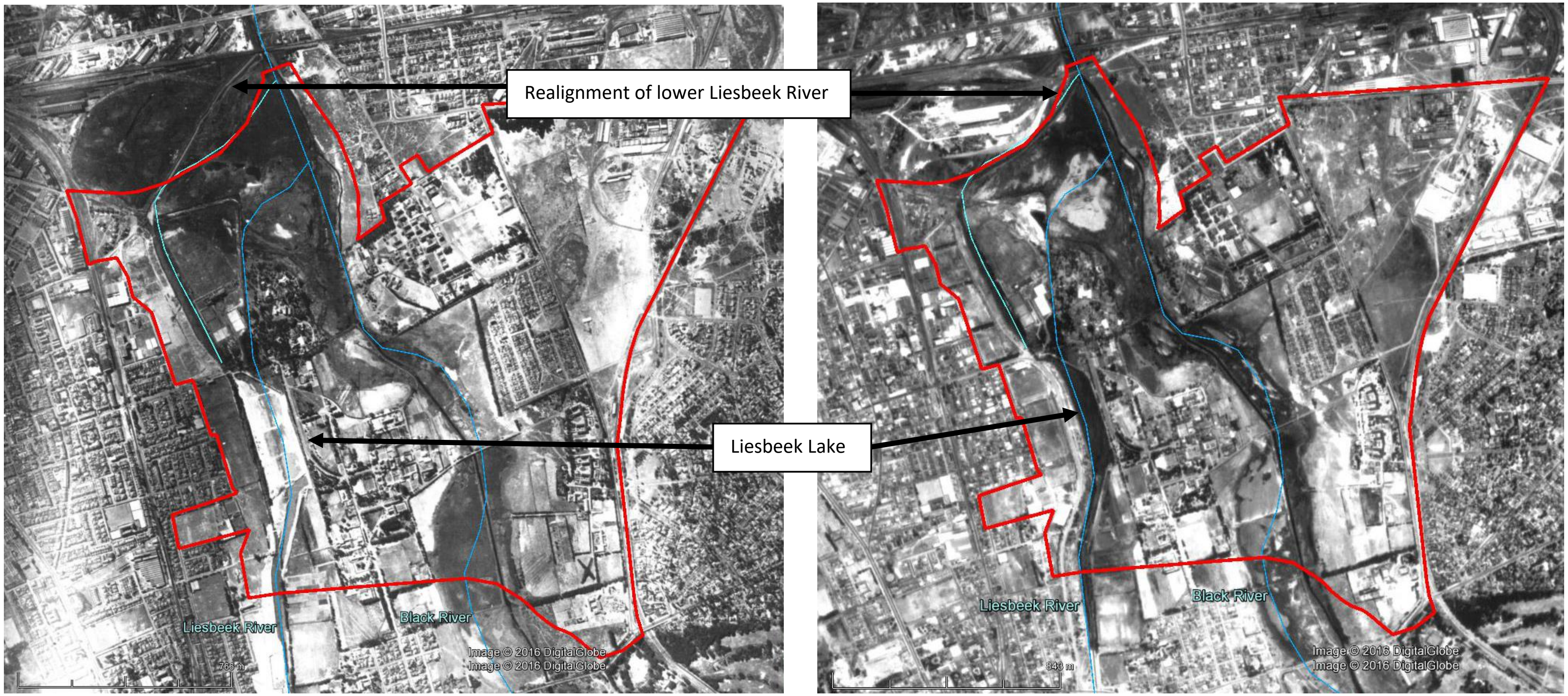


Figure 13. Aerial photograph taken in 1944 (left) and 1956 (right) obtained from National Geo-Spatial Information and overlaid in Google Earth with the rivers and TRUP boundary indicated. The construction of Liesbeek Lake and the realignment of the Liesbeek River just upstream of the Black River confluence can be seen.

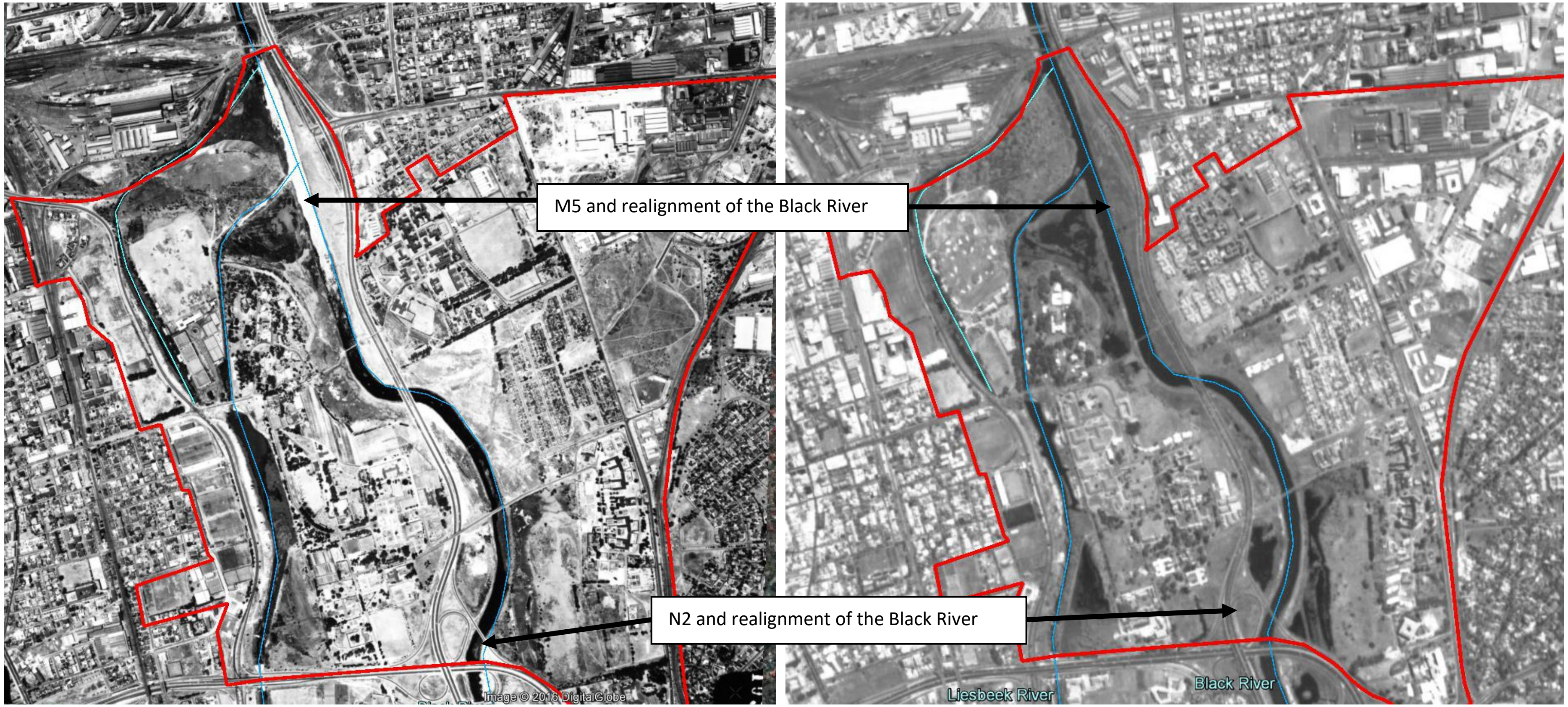


Figure 14. Aerial photograph taken in 1966 (left) and 2001 (right) obtained from National Geo-Spatial Information and overlaid in Google Earth with the rivers and TRUP boundary indicated. The construction of the N2 and M5 as well as the realignment of the Black River within the site can be seen.

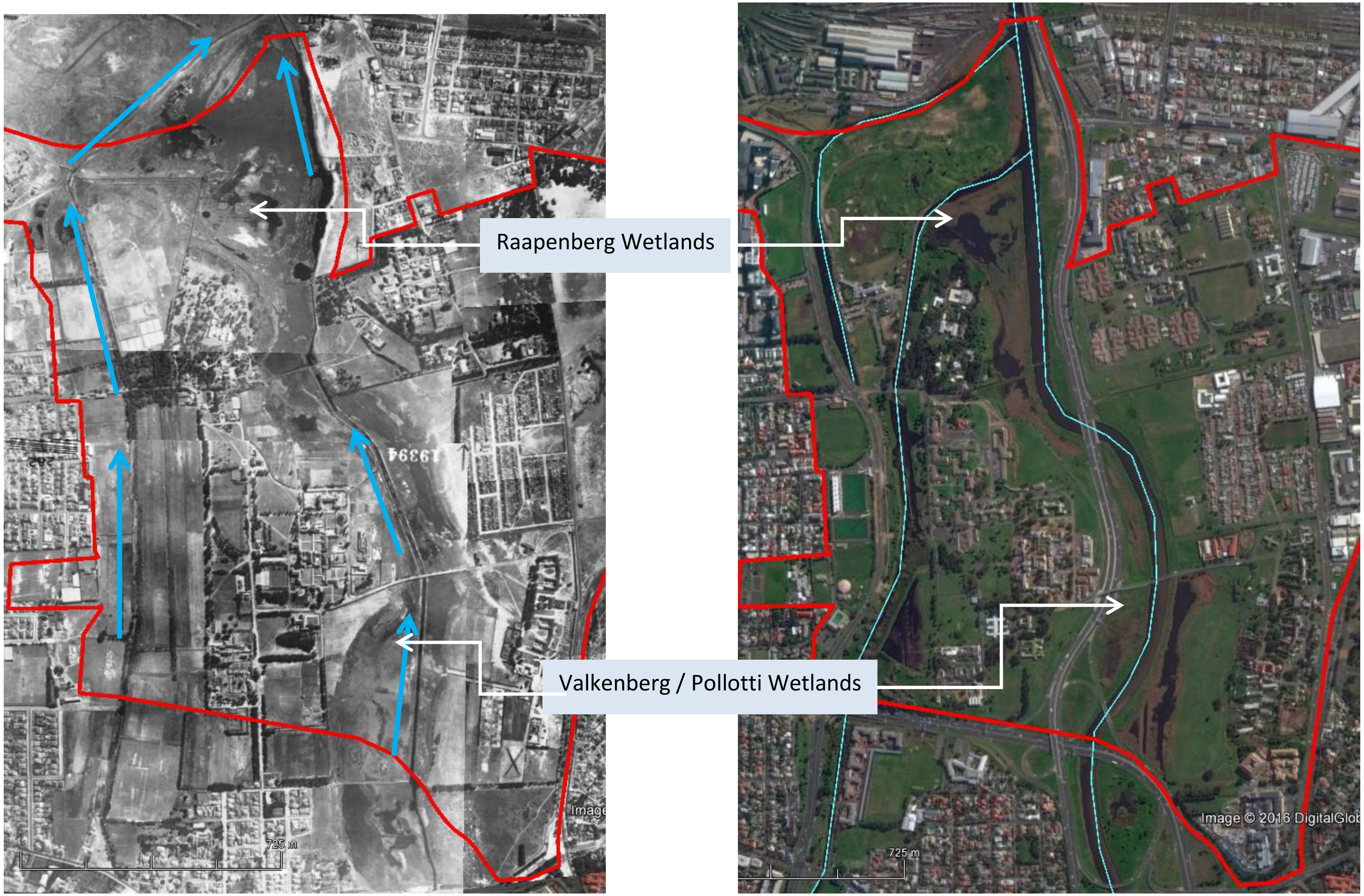


Figure 15. Comparison of the earliest aerial photograph for the site taken in 1937 (obtained from National Geo-Spatial Information) with the latest Google Earth image taken in May 2016. Changes in the wetland areas and river alignments are highlighted.

LIESBEEK RIVER

The Liesbeek River historically consisted of a perennial stream that flowed in its lower reaches within two channels that were largely unconfined within the deep sands of the Cape Flats. Wetland vegetation was largely associated with these lower reaches of the river. The river has however long been modified by the increasing urbanisation of the surrounding area. In the earliest aerial photographs taken of the area in 1937 (Figure 15), it can be seen that the agricultural and urban development had already extended into the riparian zones of the river. The watercourse was canalised in the 1940s and 1950s or 'formalised' to drain the surrounding areas and reduce flood risk to the surrounding areas.

The lower reaches of the Liesbeek River currently flows within an approximate 10m earthen channel through public open space upstream of Observatory Road (Figure 16, top). The river channel widens (approx. 40m) into Liesbeek Lake with islands that have been formed within the channel. For this stretch of the river, the riparian vegetation consists mostly of exotic grasses and garden escapees with some indigenous sedges and reeds. There are a number of storm water discharge outlets along the river that drain from the west bank. The levels of litter and rubble dumping within the stream are relatively low. The banks are relatively steep and eroded.

Downstream of Observatory Road, the main flow of the river is canalised within a 13m wide concrete canal (Figure 16, bottom) that extends to about 230m short of the confluence of the Black River. The west bank is located within the River Club golf course and is dominated by kikuyu grass and exotic as well as alien invasive trees. The east bank adjoins the Raapenberg Wetland area and is dominated by common *Phragmites* reeds.

The old Liesbeek River channel immediately at Observatory Road consists of a 35m wide and steep-sided earthen channel that is sparsely vegetated (Figure 17). A number of storm water drains discharge into this section of the channel and litter is deposited along the channel. The channel width reduces down to approximately 15m upstream of the confluence with the Black River that is densely vegetated with *Phragmites* reeds in places. There are also fragmented wetland areas on its northern bank that are either *Phagmites* reed or bulrush dominated.

Figure 16. View of the Liesbeek River upstream (top) and downstream (bottom) of Observatory Road

Figure 17. View of the old Liesbeek River channel at River Club

BLACK RIVER

The Black River originates as the Black Canal which starts just south of the Kromboom Park in Rondebosch and flows north-eastward to its confluence with the Kromboom Canal. The canal then discharges the Vygeboom / Elsieskraal Rivers that become the Black River. The Black River then joins with the Liesbeek River to form the Salt River which flows for a short distance before discharging into Table Bay just east of the Cape Town Harbour. The river consists largely of concrete or earthen channels with grassed banks. The Black River was likely to have received its name as a result of the darkly stained organic waters that drained the marshlands to flow of the whiter sands of the Cape Flats.

Historically the Black River was also a seasonal river that drained into the wetlands and mudflats associated with the Salt River Estuary. Due to the fact that this area consisted of a wide area of marshland and shifting sands, the area remained largely undisturbed for a long period of time. The river channel was widened and formalised form 1940 onwards when it was modified to accommodate increasing runoff as well as to make way for the N2 Highway. In the 1960's the river was moved 100m westwards and the wetland areas at Black River Parkway were filled in.

At the site, the river channel is relatively straight and approximately 55m wide. Most of the indigenous vegetation has been removed with only patches of *Phragmites* reeds remaining. Much of the riparian vegetation consists of invasive kikuyu grass and weeds (Figure 18). Downstream of the site, the river enters the Salt River Canal from where it drains into Table Bay.

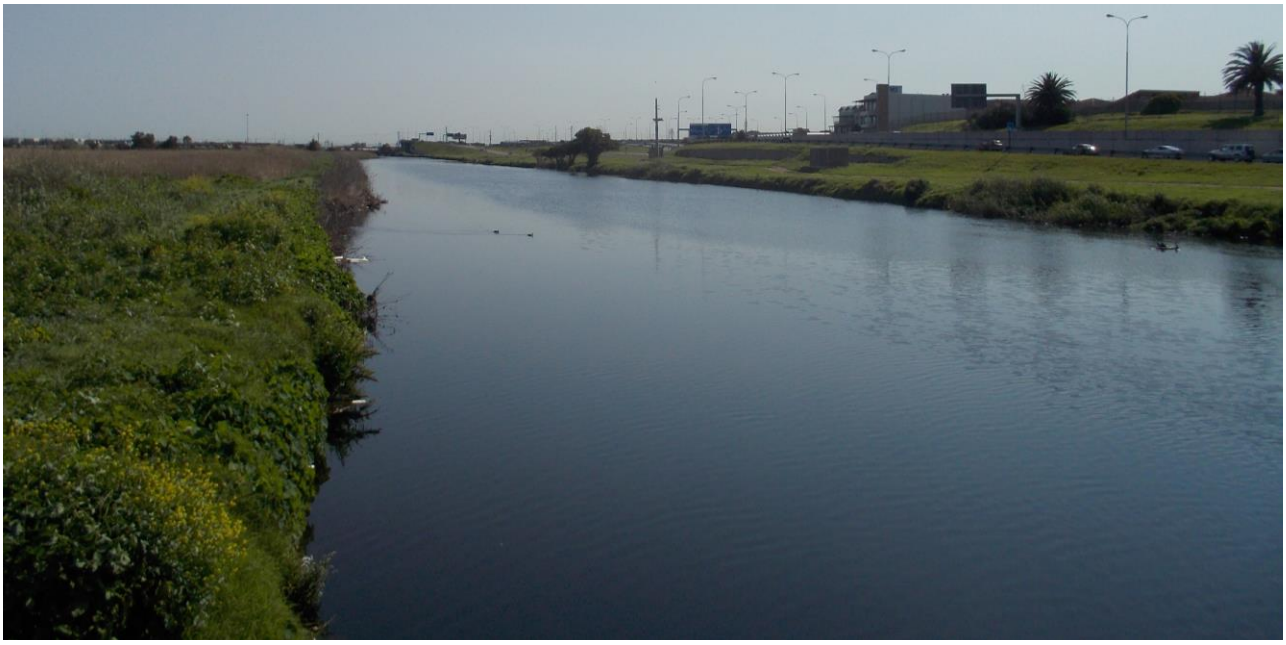


Figure 18. View of the Black River at the site

6.1.2. RIVER CLASSIFICATION

In order assess the condition and ecological importance and sensitivity of the Liesbeek and Black Rivers, it is necessary to understand how these rivers might have appeared under unimpacted conditions. This is achieved through classifying rivers according to their ecological characteristics, in order that it can be compared to ecologically similar rivers.

River typing or classification involves the hierarchical grouping of rivers into ecologically similar units so that inter- and intra-river variation in factors that influence water chemistry, channel type, substratum composition and hydrology are best accounted for. Any comparative assessment of river condition should only be done between rivers that share similar physical and biological characteristics under natural conditions. Thus, the classification of rivers provides the basis for assessing river condition to allow comparison between similar river types. The primary classification of rivers is a division into ecoregions. Rivers within an ecoregion are further divided into sub-regions.

Ecoregions are groups of rivers within South Africa, which share similar physiography, climate, geology, soils and potential natural vegetation. For the purposes of this study, the ecoregional classification presented in Department of Water Affairs and Forestry in 1999, which divides the country's rivers into ecoregions, was used. The rivers assessed lie within the South Western Coastal Belt Ecoregion, with the characteristics as described in Table 3.

Sub-regions (or geomorphological zones) are groups of rivers, or segments of rivers, within an ecoregion, which share similar geomorphological features, of which gradient is the most important. The use of geomorphological features is based on the assumption that these are a major factor in the determination of the distribution of the biota. Table 4 provides the geomorphological features of the rivers.

Table 3. Characteristics of the South Western Coastal Belt Ecoregion

Main Attributes	Characteristics
Terrain Morphology	Plains; Low Relief; or Plains Moderate Relief; E: Closed Hills; Mountains; Moderate and High Relief
Vegetation types	Sand Plain Fynbos; Mountain Renosterveld; West Coast Renosterveld; Dune Thicket; Strandveld Succulent Karoo
Altitude	0-300; 300-900 limited (m a.m.s.l)
MAP	100 to 1000 (mm)
Coefficient of Variation	20 to 39 (% of annual precipitation)
Rainfall concentration index	30 to 60
Rainfall seasonality	Winter
Mean annual temp.	14 to 20 (°C)
Median annual simulated runoff	<5; 20 to >250 (mm) for quaternary catchment

6.1.3. SITE CHARACTERISATION

From the Site Characterisation assessment, the geomorphological and physical characteristics of the rivers assessed can be classified as follows:

Table 4. Geomorphological and Physical features of the Liesbeek and Black Rivers

River	Liesbeek and Black
Geomorphological Zone	Lowland River
Lateral mobility	Confined
Channel form	Simple
Channel pattern	Single thread: very low sinuosity
Channel type	Alluvium or concrete
Channel modification	High level of modification (flow and water quality impacts; channelization and removal of indigenous riparian vegetation)
Hydrological type	Perennial (present day as a result of storm water discharges to the rivers – historically the rivers would have much more of a seasonal flow, in particular the Black River which is also subjected to treated wastewater discharges as well)
Ecoregion	South Western Coastal Belt
DWA catchment	G22C
Vegetation type	Cape Flats Sand Fynbos
Rainfall region	Winter

6.1.4. INDEX OF HABITAT INTEGRITY

The evaluation of Index of Habitat Integrity (IHI) provides a measure of the degree to which a river has been modified from its natural state. This assessment was undertaken for the Liesbeek and Black Rivers (Table 5 and Table 6). The methodology (DWAF, 1999) involves a qualitative assessment of the number and severity of anthropogenic perturbations on a river and the damage they potentially inflict upon the system. These disturbances include both abiotic and biotic factors, which are regarded as the primary causes of degradation of a river. The severity of each impact is ranked using a scale from 0 (no impact) to 25 (critical impact). The IHI assessment is based on an evaluation of the impacts of two components of the river, the riparian zone and the instream habitat. The total scores for the instream and riparian zone components are then used to place the habitat integrity of both in a specific habitat category (Table 7).

Table 5. Index of Habitat Integrity: Instream Assessment for the Liesbeek and Black Rivers

Instream Habitat Integrity	Liesbeek River	Black River	Comment
Water Abstraction	15	6	Flow reduction due to abstraction in the upper catchment
Flow Modification	11	18	Flow pattern changes due to treated wastewater and storm water discharges, hardening of catchment & removal of cover vegetation
Bed Modification	12	16	Channelisation and modified sediment transport
Channel Modification	18	16	Straightening and narrowing of channel
Water Quality	16	19	Storm water, litter and treated wastewater
Inundation	10	12	Due to weirs / structures in channel as well as modified channel
Exotic Macrophytes	8	10	Clumps of *Myriophyllum* and in places kikuyu grass
Exotic Fauna	8	7	Carp and sharptooth catfish increasing turbidity
Rubbish Dumping	12	12	Largely storm water related litter
Instream Habitat Integrity Score	39	28	
Integrity Class	**D/E**	**E**	**Seriously modified**

Table 6. Index of Habitat Integrity: Riparian Assessment for the Liesbeek and Black Rivers

Riparian Zone Habitat Integrity	Liesbeek River	Black River	Comment
Vegetation Removal	19	22	Little of the indigenous riparian vegetation remains, only common reeds
Exotic Vegetation	18	18	Garden escapes and invasive alien plants dominate riparian zones
Bank Erosion	9	6	Some eroded banks
Channel Modification	18	16	As above
Water Abstraction	10	6	As above although a lesser impact on riparian habitat
Inundation	8	10	As above although a lesser impact on riparian habitat
Flow Modification	11	18	As above although a greater impact on riparian habitat
Water Quality	12	16	As above although a lesser impact on riparian habitat
Riparian Zone Habitat Integrity Score	13	5	
Integrity Class	**F**	**F**	**Critically modified**

Table 7. Habitat Integrity categories (From DWAF, 1999)

Category	Description	Score (% of Total)
A	Unmodified, natural.	90-100
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.	80-90
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In worst instances, basic ecosystem functions have been destroyed and changes are irreversible.	0

The instream habitat integrity of the Liesbeek and Black Rivers is in a seriously modified state, while the riparian habitat integrity is more degraded due to direct impact from adjacent land use activities and is a critically modified state.

6.1.5. BIOTIA ASSESSMENTS

The aquatic macro-invertebrate community comprises an important component of most riverine ecosystems. In addition to contributing to the biodiversity of the river, it plays a role in the functioning of the river. Due to the differing sensitivities of the organisms, the composition of the communities present can be used as an indicator of the water quality and general river health at the sampling site. The SASS (South African Scoring System, Version 5) rapid bioassessment method was used to assess the aquatic invertebrate community. Each family is assigned a score depending on their sensitivity to changes in aquatic ecosystems. The sum of scores provides a total SASS score.

Under natural conditions the expected macroinvertebrate species for both rivers within the site include: turbellaria, oligochaete, hirudinea, baetidae, caenidae, coenagrionidae, aeshnidae, corduliidae, gomphidae, libellulidae, corixidae, notonectidae, dytiscidae, ceratopogonidae, chironomidae, lymnaeidae and physidae. Under these conditions the SASS score for the rivers would be approximately 70 and the average score per taxon (ASPT) 4. Table 8 provides results from SASS sampling undertaken in the rivers in the site

Table 8. Results of SASS sampling undertaken (Rivers Database and DWS)

Site	Date	Total SASS Score	No. of taxa	ASPT	River health category
G2LIES-OBSER	1999	47	12	3.9	D
	2004	61	14	4.4	C/D
	2010	47	14	3.4	D
	2014	52	13	4	C/D
G2LIES-Canal	1999	36	8	4.5	D
	2000	37	10	3.7	D/E
	2004	25	8	3.1	E
NR7 on the Black River	1999	30	9	3.3	D/E
	2002	43	12	3.6	D/E

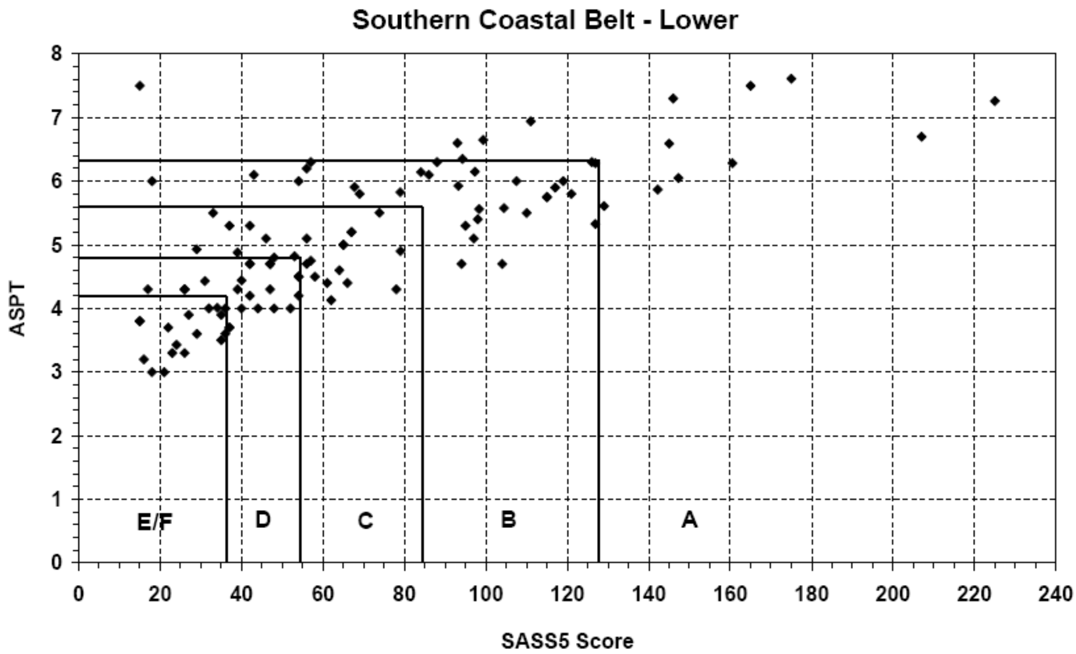


Figure 19. Data interpretation guidelines generated for SASS5 results, based on available data for the Southern Coastal Belt, lower geomorphological zones

The results were assessed according to Figure 19 that indicates the biological bands for the Southern Coastal Belt lower geomorphological zones. The results generally equate to D/E category (largely to seriously modified). The samples consisted of hardy macro-invertebrate families in low abundances, such as, oligochaete (aquatic earthworm), hirudinea (leeches), corixidae (water boatmen), physidae (pouch snails), dytiscidae (predacious diving beetles), baetidae (mayfly larvae), , and chironomidae (midge larvae). Most of these families are more tolerant of low flow conditions with low dissolved oxygen levels.

In terms of fish species occurring within the Liesbeek and Black River, only exotic fish species (sharp-tooth catfish *Clarias gariepinus* and carp *Cyprinus carpio*) occur in the lower river. These fish species have displaced the indigenous fish species (Cape Galaxias *Galaxias zebratus*).

6.1.7. ECOLOGICAL IMPORTANCE AND SENSITIVITY (EIS)

The EIS Assessment considers a number of biotic and habitat determinants surmised to indicate either importance or sensitivity. The determinants are rated according to a four-point scale (Table 10). The median of the resultant score is calculated to derive the EIS category (Table 11).

Table 9. Results of the EIS assessment for the Liesbeek and Black Rivers

Biotic Determinants	Leisbeek River	Black River
Rare and endangered biota	1	1
Unique biota	2	1
Intolerant biota	1	1
Species/taxon richness	2	1
Aquatic Habitat Determinants		
Diversity of aquatic habitat types or features	2	1
Refuge value of habitat type	2	2
Sensitivity of habitat to flow changes	2	2
Sensitivity of flow related water quality changes	2	1
Migration route/corridor for instream & riparian biota	2	1
National park, wilderness area, Nature Reserves, Natural Heritage sites, Natural areas, PNEs	2	2
RATINGS	**1.8**	**1.2**
EIS CATEGORY	**High to Moderate**	**Moderate to low**

Table 10. Scale used to assess biotic and habitat determinants in terms of importance or sensitivity

Scale	Definition
1	One species/taxon judged as rare or endangered at a local scale.
2	More than one species/taxon judged to be rare or endangered on a local scale.
3	One or more species/taxon judged to be rare or endangered on a Provincial/regional scale.
4	One or more species/taxon judged as rare or endangered on a National scale (i.e. SA Red Data Books)

Table 11. Ecological importance and sensitivity categories (DWAF, 1999)

EISC	General description	Range of median
Very high	Quaternaries/delineations considered to be unique on a national and 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.	>3-4
High	Quaternaries/delineations that are considered to be unique on a national scale based on their 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 substantial capacity for use.	>2-≤3
Moderate	Quaternaries/delineations that are considered to be 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 not usually very sensitive to flow modifications and often have substantial capacity for use.	>1-≤2
Low/ marginal	Quaternaries/delineations are not unique on any scale. The rivers are generally not very sensitive to flow modifications and usually have substantial capacity for use.	≤1

The ecological importance and sensitivity of the Liesbeek River is considered to be high to moderate while the Black River is moderate to low.

6.1.6. WATER QUALITY

Water quality sampling is undertaken by the CCT on a monthly basis at the following sampling sites with TRUP:

- NR8 on the Liesbeek River downstream of the Liesbeek Lake weir; and
- NR7 on the Black River at the footbridge.

DWS also samples on a monthly basis the in the Black River at the sample point (G22_2000000766) which is upstream of its confluence with the Liesbeek River (Figure 11). These water quality results were evaluated against the target water quality guidelines which apply to the quality of water occurring in rivers required to minimise the impact of poor water quality on aquatic ecosystems in South Africa (DWAF, 1996) as well as the General and Special Limit values as stipulated in Government Notice 665, dated 6 September 2013 for the discharge of treated wastewater into a water resource. A summary of the median concentrations measured at the sites for the period 2009 until 2015 is provided in Table 12.

Table 12. Black and Liesbeek River water quality (2009–2015) and water quality limits and guidelines for aquatic ecosystems

Variable		Black River (DWS)	Black River (CCT site NR 7)	Liesbeek River (CCT site NR8)	General Limit	Special Limit	WQ Guideline: Aquatic Ecosystem
Faecal Coliforms (per 100ml)	Median		180 000	2 400			-
	95%ile		2 640 000	2 550	1000	0	
Suspended solids (mg/l)	Median	15	13	6			<10% increase on background
	95%ile	148	74	68	25	10	
Chemical Oxygen Demand (mg/l)	Median	48	58	21			-
	95%ile	91.5	100	54	75	30	
Electrical Conductivity (mS/m)	Median	114	115	28			<15% change
	95%ile	128	130	41	150	100	
pH (pH units)	Median	7.5	7.5	7.2			>0.5 units of 5% change
	95%ile	7.8	7.8	8.3	5.5 - 9.5	5.5 – 7.5	
Ammonia (NH_3) (ionised and un-ionised) (mg/l)	Median	0.027	5.7	0.1			<0.007 target or 0.1 acute toxicity value
	95%ile	0.331	19.7	0.83	6	2	
Nitrate/Nitrite (NO_2/NO_3) (mg/l)	Median	1.3	1.4	0.6			-
	95%ile	4.2	3.9	0.92	15	1.5	
Ortho-phosphates (PO_4) (mg/l)	Median	1.7	2	0.02		1	>15% change
	95%ile	4.7	7.2	0.18	10	2.5	

The water variables for which there are data are discussed below. The microbiological quality of the rivers is not discussed as it is not a variable of concern from an aquatic ecosystem point of view.

TOTAL SUSPENDED SOLIDS

Suspended solids in water consist of inorganic and organic matter, such as clay, particles or suspended mineral matter, and a combination of decay products and living organisms respectively. The amount of suspended matter found in the rivers usually reflects the degree of soil erosion (DWAF, 1996). Activities which result in accelerated soil erosion therefore increase suspended solids in rivers. Target water quality guidelines for Total Suspended Solids (TSS) concentrations (or turbidity) should be less than 10% increase of the background TSS concentrations at a specific site and time. This is applicable for sites where the background TSS concentration is less than 100 mg/l. The median values for suspended solids in the Liesbeek and Black Rivers was relatively low 6 mg/l and 13 mg/l respectively) with higher values occurring mostly in the winter months associated with higher runoff from the catchment and increased turbulence in the rivers. A large seasonal variability in electrical conductivity values occurs that is associated with the increased runoff from the catchments in winter. There also is a long term decreasing trend in the total suspended solids measured within both these rivers (Figure 20).

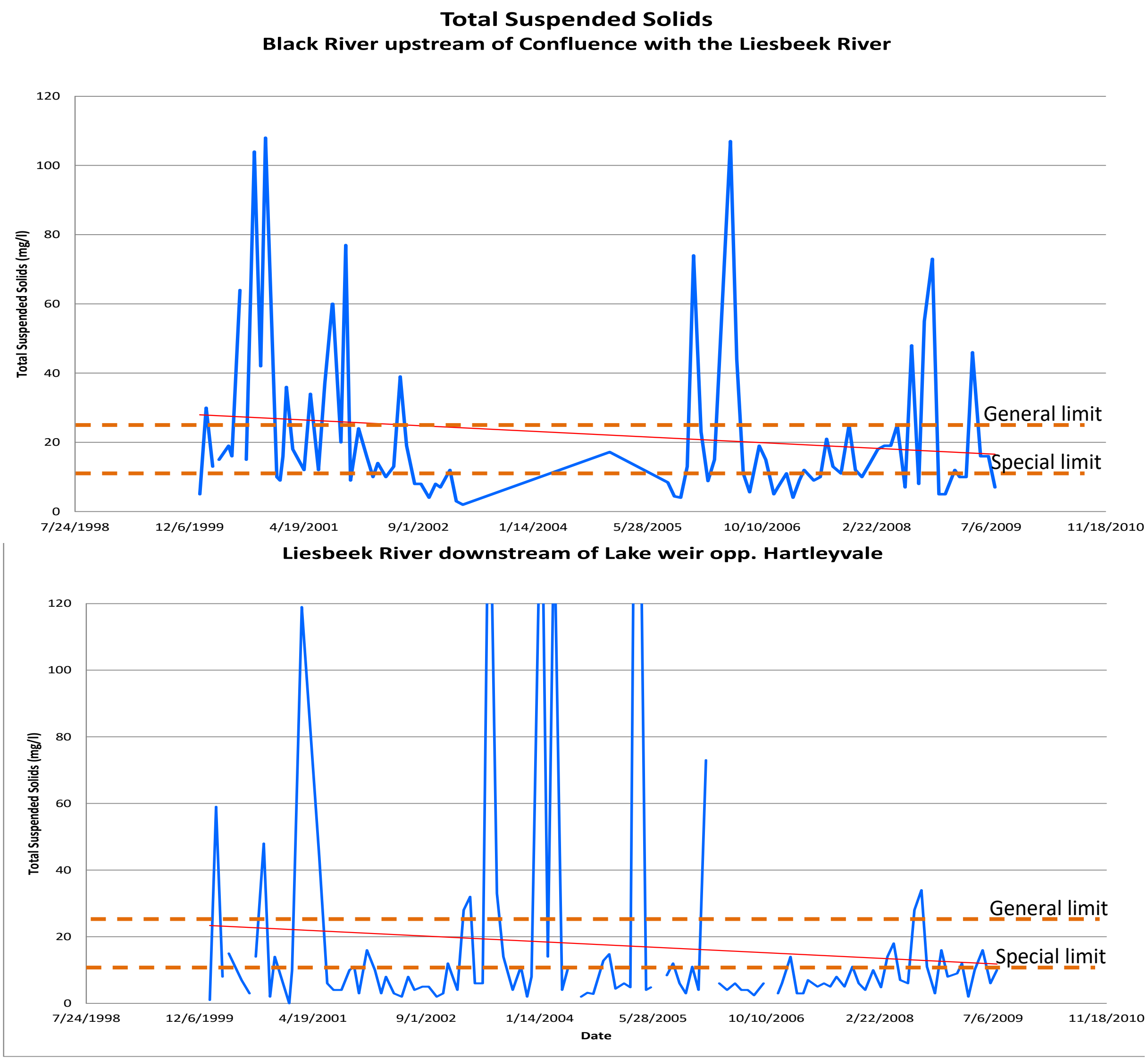
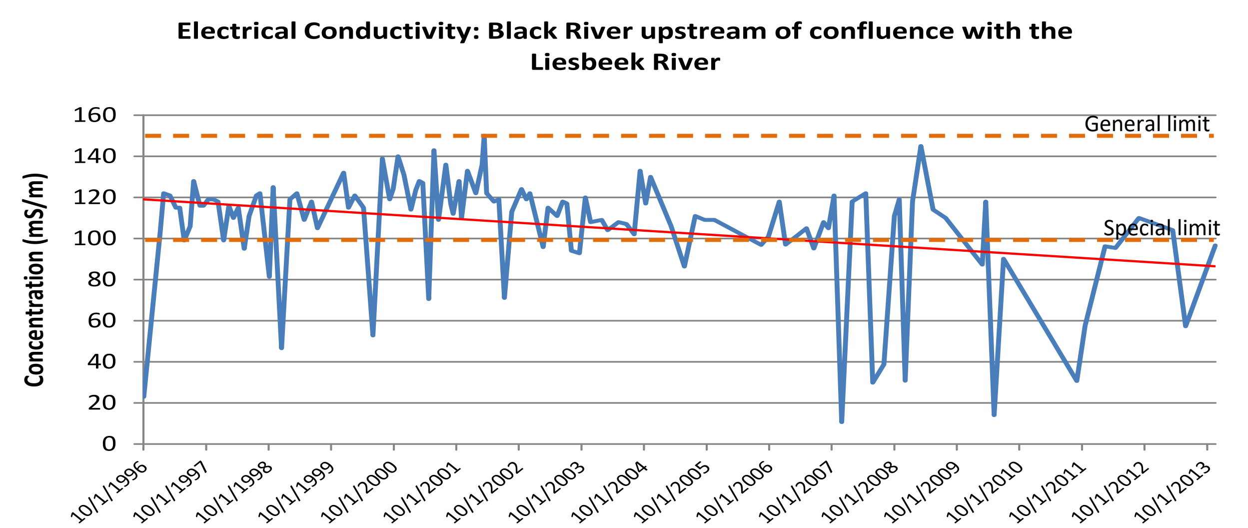


Figure 20. Total suspended solid concentrations for the Black (top) and Liesbeek Rivers

ELECTRICAL CONDUCTIVITY AND TOTAL DISSOLVED SALTS

The Total Dissolved Salts (TDS) concentrations and Electrical Conductivity (EC) usually correlate closely for a particular type of water. Natural TDS and EC in rivers is determined by geological or atmospheric conditions while anthropogenic activities such as industrial effluents, irrigation and water re-use lead to increases in TDS and EC. Generally it is the rate of change rather than the absolute change in TDS and EC that impact on aquatic biota. As EC is easier to measure, it is usually used to estimate the amount of compounds or salts dissolved in water. Within the Liesbeek and Black Rivers, the median values for EC were 28 mS/m and 115 mg/l for EC respectively. These values reflect the natural salt content of the rivers with the Liesbeek having a low salinity and the Black River being a naturally more saline river due to the underlying geology (Quaternary aeolian sands). A large seasonal variability in electrical conductivity values occurs that is associated with the increased runoff from the catchments in winter. There also is a long term decreasing trend in the electrical conductivity measured within both these rivers (Figure 21).



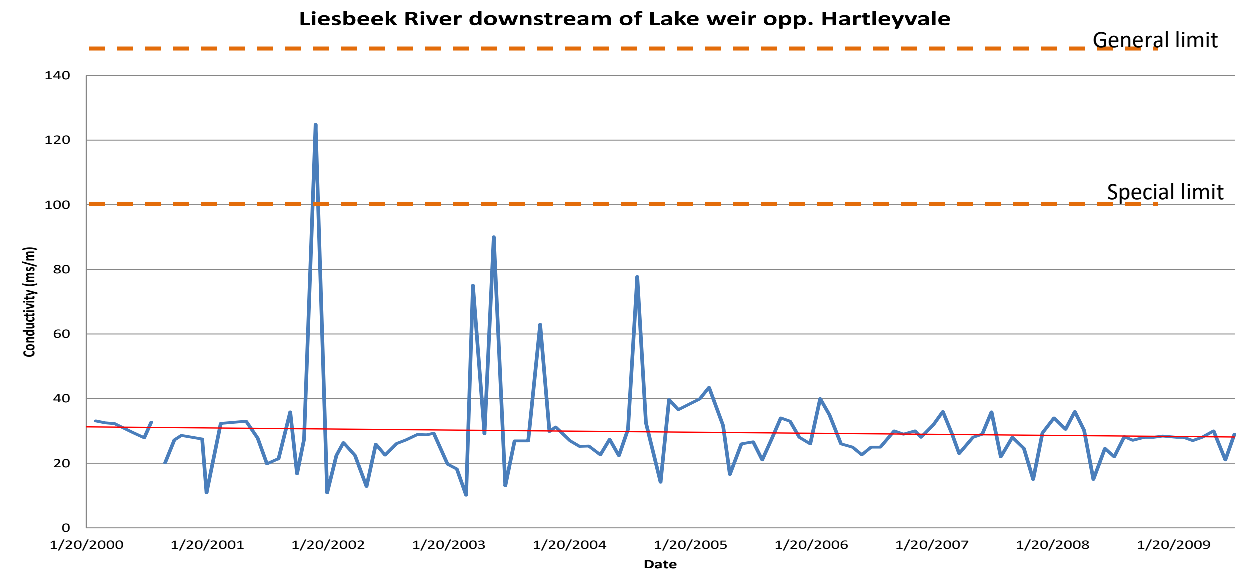


Figure 21. Electrical conductivity concentrations for the Black River (top) and Liesbeek River within the site for the period 1996 to 2013

PH

The relative proportions of the major ions, and as a result the pH, of natural waters, are determined by geological and atmospheric influences. Most fresh waters, in South Africa, are relatively well buffered and more or less neutral, with pH ranges between 6 and 8. Relatively small changes in pH are seldom lethal but may result in reduced growth rates and fecundity. Increased pH values is normally the result of industrial effluents, mine drainage and acid precipitation while reduced pH values may result from certain industrial effluents and anthropogenic eutrophication. The Target Water Quality Range is stated in terms of the background site-specific pH regime, that is, that pH values should not be allowed to vary from the range of the background pH by more than 0.5 of a pH unit, or by more than 5%. Within the Liesbeek and Black Rivers, the median values are 7.2 and 7.5 pH units respectively.

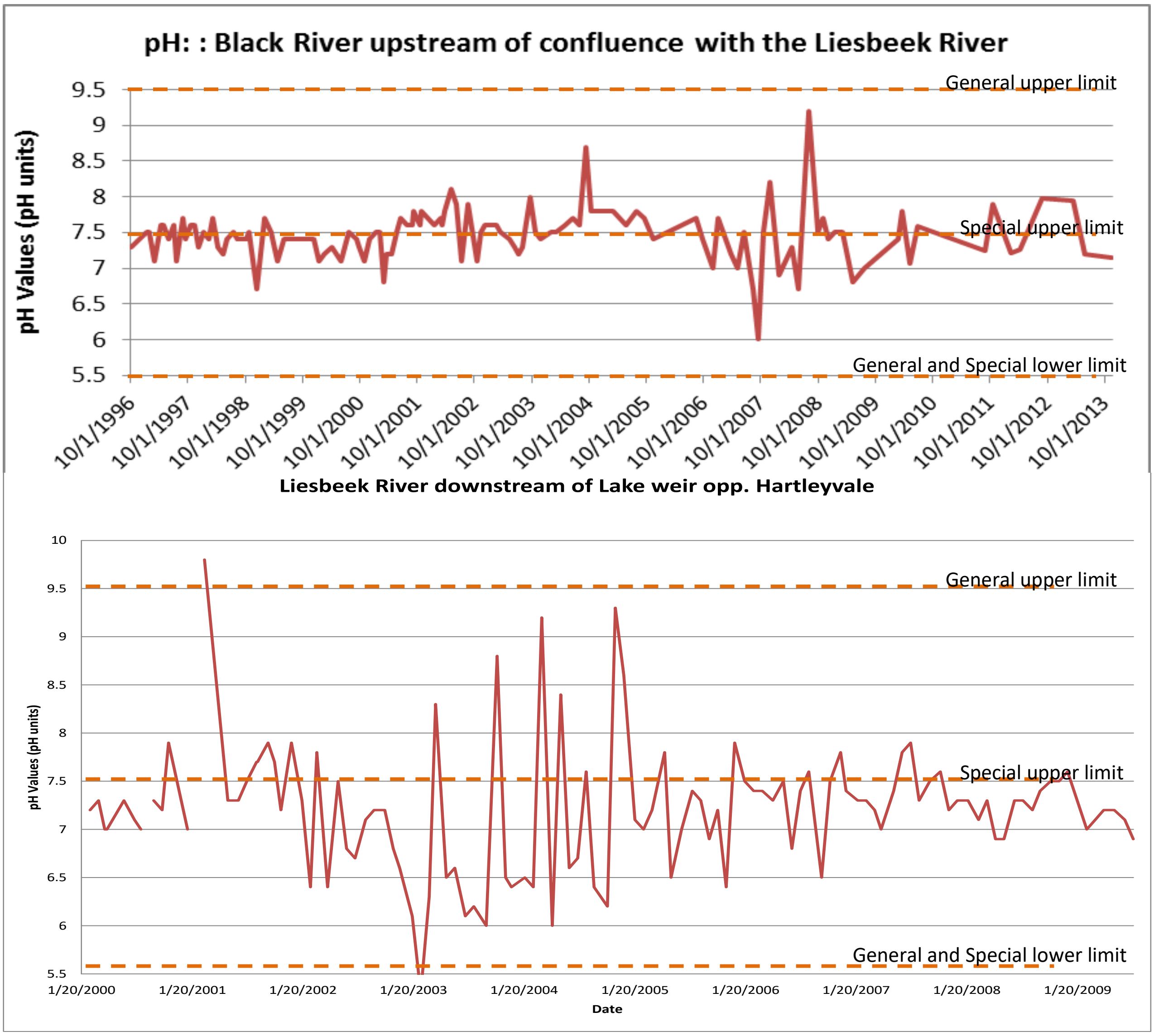


Figure 22. pH concentrations for the Black River (top) and Liesbeek River within the site

AMMONIA AND AMMONIUM

Nitrogen occurs abundantly in nature and is an essential constituent of many biochemical processes. Inorganic nitrogen may be present in many forms including ammonia (NH_3), ammonium (NH_4^+), nitrites (NO_2^-) and nitrates (NO_3^-). On entering aquatic systems, nitrates are rapidly converted to organic nitrogen in plant cells. Unionized ammonia (NH_3) is also toxic to aquatic organisms and its toxicity increases as pH and temperature increase (water quality guideline value of 0.007 mg/l). The ammonium ion (NH_4^+) has little or no toxicity but does contribute towards eutophication. No guidelines or standards have been set that relate to ammonium, it does however provide a good indication of the amount of pollution ocuring in the river mostly as a result of the discharge of treated wastewater. Within the Black River, as a result of the discharge of treated wastewater, the median value for ammonia (5.7 mg/l with a 95 percentile value of 19.7) exceeds target values. The median value for the Liesbeek River is much lower at 0.1 mg/l.

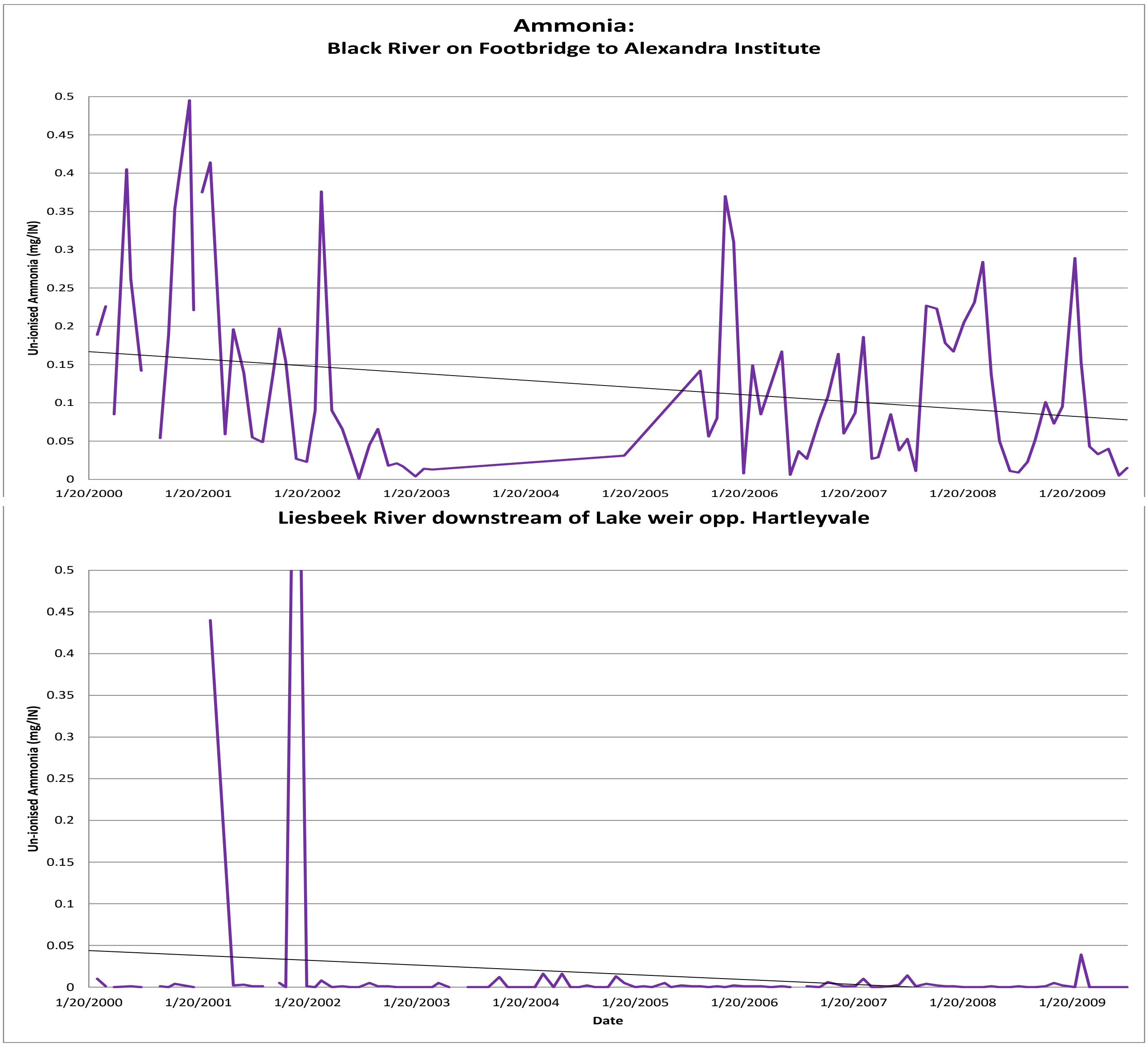


Figure 23. Ammonia concentrations for the Black River (top) and Liesbeek River (bottom) within the site

The ecological impact of ammonia in aquatic ecosystems is likely to occur through chronic toxicity to benthic invertebrates and fish populations as a result of reduced reproductive capacity. This impact is usually not noticed and linked to the WWTW discharge. Typically the result is a decline in the numbers of sensitive species. Unless there is continual recruitment from unaffected populations, the affected populations may die out over time. Toxic impacts on aquatic ecosystems can extend for many kilometers below a large WWTW discharge. Impacts on fish populations are very difficult to determine due to the mobile nature of many fish species and to recruitment of fish from non-impacted areas. Benthic invertebrates are a much better indicator of impact, as they are not very mobile for much of their life cycle.

NITRATE/NITRITE

Inorganic nitrogen is primarily of concern due to its stimulatory effect on aquatic plant growth and algae. Nitrite (NO_2) is the inorganic intermediate in the conversion of ammonia to nitrate (NO_3) and is toxic to aquatic organisms. Nitrate is thus the more stable of the two forms and is usually far more abundant in the aquatic environment. Nitrite and nitrate are usually measured and considered together.

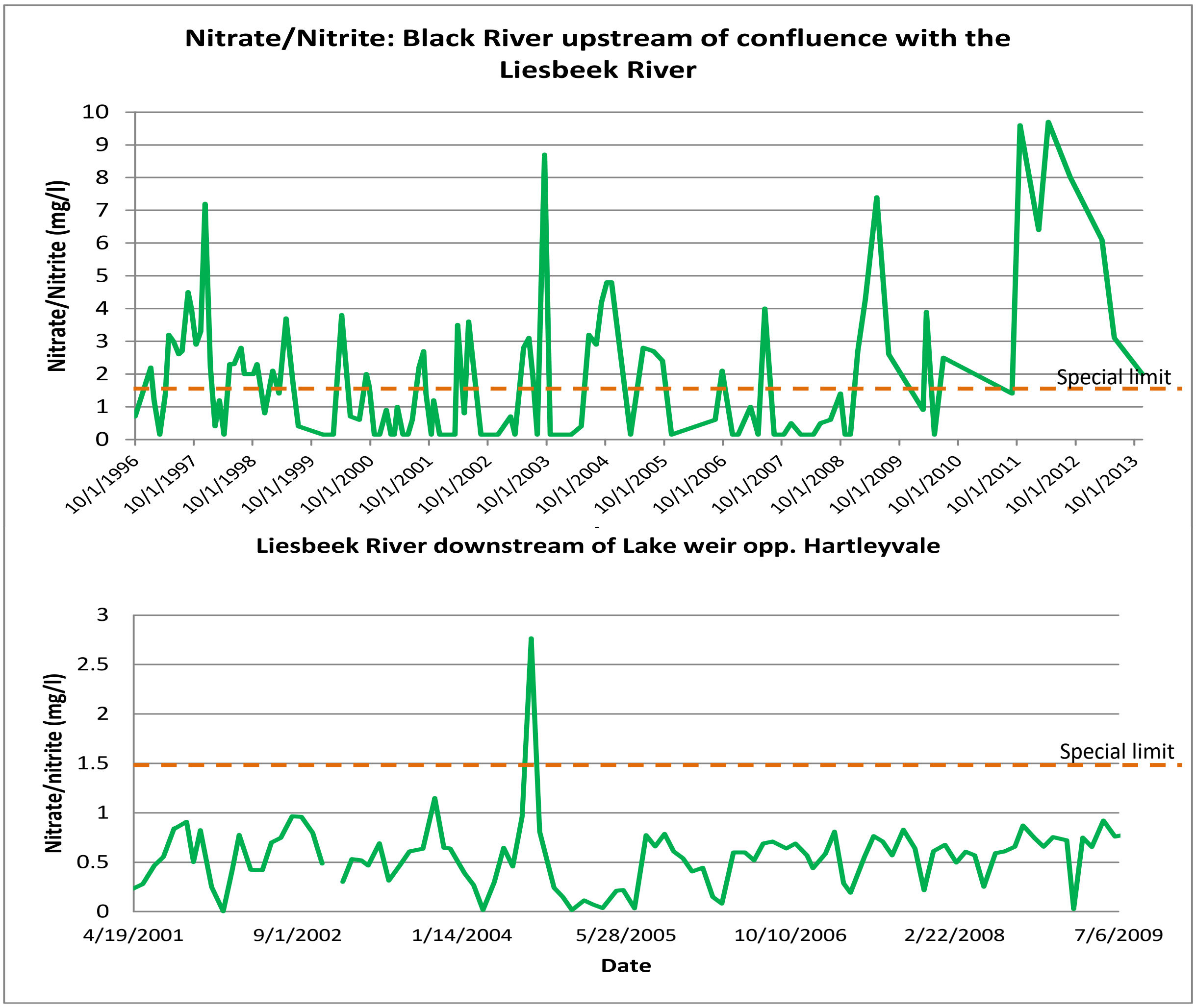


Figure 24. Nitrate/nitrite concentrations for the Black River (top) and Liesbeek River (bottom) within the site

The median value for NO_2/NO_3 in the Black River is slightly elevated (1.4 mg/l), also largely as a result of the discharge of treated wastewater when compared to the median value for the Liesbeek River (0.6 mg/l). The values are however still low in comparison with target values.

ORTHO-PHOSPHATES

In South Africa, phosphorus is seldom present in high concentrations in unimpacted surface waters because it is actively taken up by plants. Concentrations are generally between 0.01 and 0.05 mg/l for unimpacted water bodies. Elevated levels of phosphorus result from wastewater discharges and from urban and agricultural runoff (DWAF, 1996). The most significant effect of elevated phosphorus concentrations is increased growth of aquatic plants, where inorganic phosphorus concentrations of 0.025 to 0.25 mg/l result in eutrophic conditions.

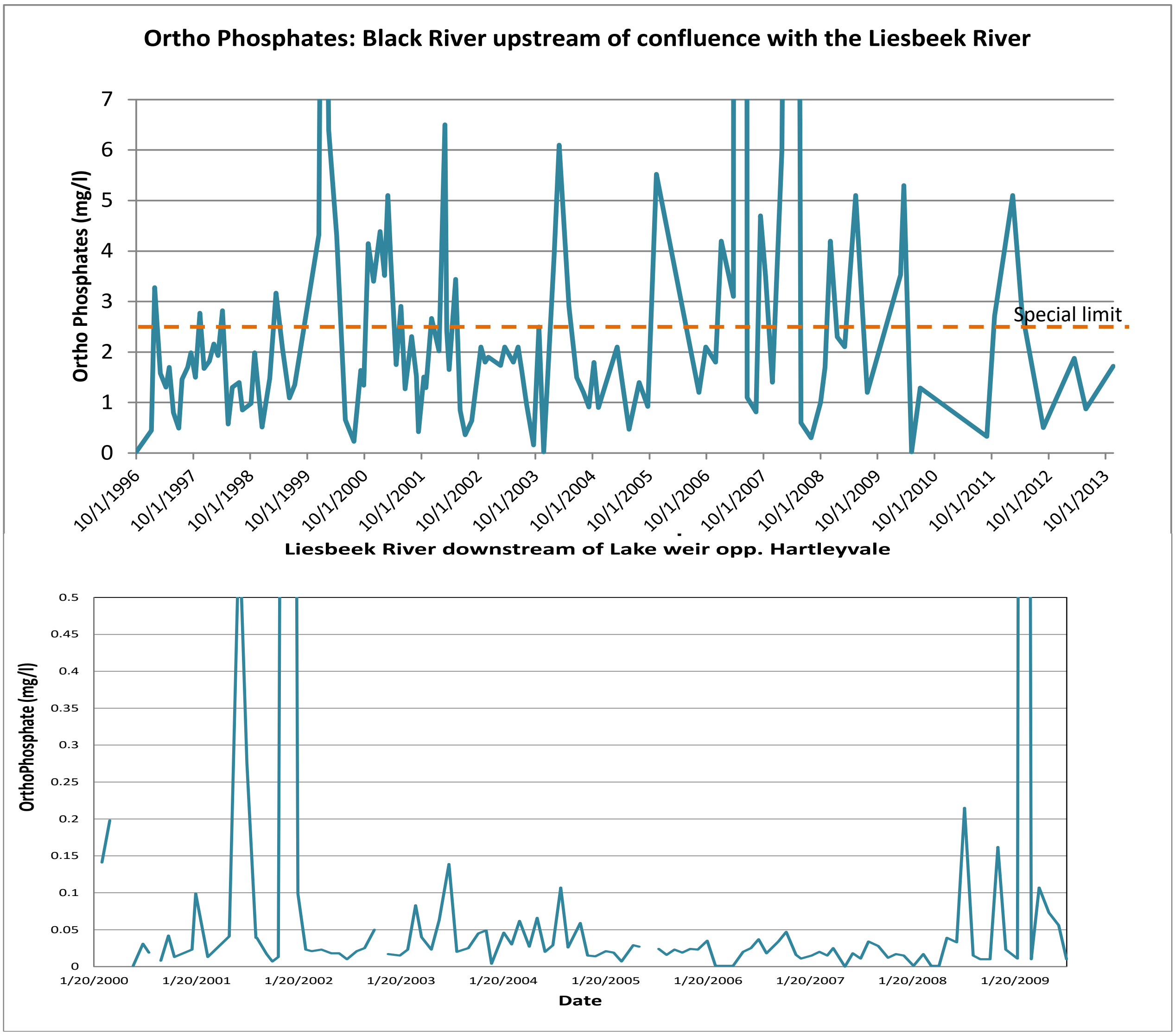


Figure 25. Ortho Phosphate concentrations for the Black River (top) and Liesbeek River (bottom) within the site

Within the Liesbeek River, the median values for PO_4 are still relatively low at 0.02 mg/l while the median values for the Black River were elevated at 1.4 mg/l. In South Africa, phosphorus is seldom present in high concentrations in unimpacted surface waters because it is actively taken up by plants. Concentrations are generally between 0.01 and 0.05 mg/l for unimpacted water bodies. Elevated levels of phosphorus result from wastewater discharges and from urban and agricultural runoff (DWAF, 1996). The most significant effect of elevated phosphorus concentrations is increased growth of aquatic plants, where inorganic phosphorus concentrations of 0.025 to 0.25 mg/l result in eutrophic conditions. The concentration of inorganic phosphorus in the Black River is likely to result in hypertrophic conditions, with associated low species diversity and nuisance levels of plant and algal growth.

6.2. WETLAND ASSESSMENT

In terms of the Ramsar Convention on Wetlands, to which South Africa is a contracting party, "*… wetlands include a wide variety of habitats such as marshes, peatlands, floodplains, rivers and lakes, and coastal areas such as salt marshes, mangroves, and sea grass beds, but also coral reefs and other marine areas no deeper than six meters at low tide, as well as human-made wetlands such as waste-water treatment ponds and reservoirs*".

In South Africa, wetlands are defined as "*…land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil*" (National Water Act, Act No. 36 of 1998). Wetlands are also included in the definition of a watercourse within the NWA, which implies that whatever legislation refers to watercourses will also be applicable to wetlands. The types of features included within the definition of a watercourse include:

- *"…a river or spring…"*
- *"…a natural channel in which water flows regularly or intermittently…"*
- *"…a wetland, lake or dam into which, or from which, water flows…"*
- *"…any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse…"*

The wetland areas within the site have been classified and delineated (

Figure 26) according to nationally developed guidelines. Delineation of the wetland areas was based on terrain morphology, vegetation, soil form and soil wetness. WET-EcoServices and WET-Health were utilised to assess the benefits and services supplied by the wetlands within the study area as well as to determine the integrity of the ecological processes for the wetland areas. An Ecological Importance and Sensitivity assessment was also undertaken of the wetland areas.

The following wetland features (green areas in

Figure 26) were identified within the study area:

- Raapenberg, Valkenberg and Vincent Pollotti Wetlands adjacent to the Black River (Figure 27),
- Wetland areas associated with the Liesbeek River between the N2 of Observatory Road (Figure 28); and
- Remnant floodplain wetland adjacent to the lower Liesbeek (old channel) and Black Rivers (Figure 29).

Figure 26. Wetland areas within the study area delineated in Google Earth based on site assessment

6.3.1 WETLAND CLASSIFICATION

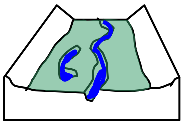
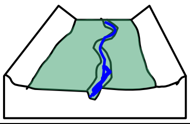
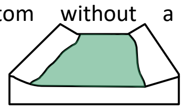
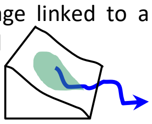
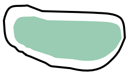
The wetland areas assessed within the study area have been classified according to Table 13 and their characteristics described in Table 14.

Figure 27. Photographs of the Raapenberg (top and middle), Valkenberg and Vincent Pollotti Wetlands (bottom) adjacent to the Black River

Figure 28. Photograph of the wetland areas associated with the Liesbeek River between the N2 of Observatory Road

Figure 29. Photographs of wetland areas adjacent to the lower Liesbeek River (old channel)

Table 13. Wetland hydro-geomorphic types typically supporting inland wetlands in South Africa

Hydro-geomorphic types	Description	Wetland water source[1]	
		Surface	Sub-surface
Floodplain 	Valley bottom areas with a well-defined stream channel, gently sloped & characterized by floodplain features and alluvial transport and deposition of sediment, usually leading to a net accumulation of sediment. Water inputs from main channel and from adjacent slopes.	***	*
Valley bottom with a channel 	Valley bottom areas with a well-defined channel but lacking characteristic floodplain features. May be gently sloped & characterized by accumulation of alluvial deposits or may have steeper slopes & be characterized by net loss of sediment. Water inputs from main channel and adjacent slopes.	***	*/ ***
Valley bottom without a channel 	Valley bottom areas with no clearly defined stream channel usually gently sloped & characterized by alluvial sediment deposition, generally leading to a net accumulation of sediment. Water inputs mainly from channel entering the wetland and adjacent slopes.	***	*/ ***
Hillslope seepage linked to a stream channel 	Slopes on hillsides, which are characterized by the colluvial movement of materials. Water inputs are mainly from sub-surface flow and outflow is usually via a well-defined stream channel connecting the area directly to a stream channel.	*	***
Isolated Hillslope seepage 	Slopes on hillsides, characterized by the colluvial movement of materials. Water inputs mainly from sub-surface flow and outflow either very limited or through diffuse sub-surface and/or surface flow but with no direct surface water connection to a stream.	*	***
Depression (includes Pans) 	A basin shaped area with a closed elevation contour that allows for the accumulation of surface water. It may also receive sub-surface water. An outlet is usually absent and thus is usually isolated from the stream channel network.	*/ ***	*/ ***

[1] Precipitation is an important water source and evapotranspiration an important output

Water source:
- * Contribution usually small
- *** Contribution usually large
- */ *** Contribution may be small or important depending on local circumstances

 Wetland

Table 14. Classification of wetland area within study area

Name	Raapenberg Wetland	Valkenberg Wetland	Vincent Pollotti Wetland	Liesbeek Lake	Lower Liesbeek/Black River wetland
Catchment	Hydrologically linked to the Liesbeek and Black Rivers (Quaternary Catchment G22C)				
Water Management Area	Berg River WMA				
System	Inland				
Ecoregion	South Western Coastal Belt				
Longitudinal zonation	Lowland/Floodplain				
Hydro-geomorphic type	Floodplain wetland	Floodplain wetland	Depression	Depression linked to Liesbeek River	Valley bottom/floodplain wetland
Drainage	Groundwater and surface water inflow and outflow			Tributary in and outflow	Water inputs from main channel and adjacent slopes
Seasonality	Permanently inundated	Seasonally to permanently inundated	Permanently inundated	Seasonally to permanently inundated	Permanently inundated
Modification	Moderately modified	Moderately modified	Moderately modified	Largely modifed	Moderately to largely modified
Terrestrial Vegetation	Cape Flats Sand Fynbos	Cape Flats Sand Fynbos	Peninsular shale renosterveld	Peninsular shale renosterveld	Cape Flats Dune Strandveld
Dominant wetland vegetation	Indigenous plants – permanently inundated areas: common reeds (*Phragmites australis*), bulrushes *Typha capensis,* sedges and rushes such as *Cyperus textilis, Isolepis* spp., and *Carpha glomerata* Indigenous plants – seasonally inundated areas*:* sedges and rushes such as *Pycreus polystachyos, Bolboschoenus maritimus, Juncus acutus,* as well as arum lilies (*Zantedeschia aethiopica*) and slender knotweed (*Persicaria lapathifolia*). Alien riparian plants: kikuyu grass (*Pennisetum clandestinum*), Elephant's ear (*Colocasia escilenta*), nasturtiums (*Tropaeolum majus*) and watercress (*Nasturtium officinale*) Alien aquatic plants: spiked watermilfoil (*Myriophyllum spicatum*) and water hyacinth (*Eichhornia crassipes*).				

6.3.2 WETLAND INTEGRITY

The Present Ecological Status (PES) Method (DWAF 2005) was used to establish the integrity of the wetlands in the study area and was based on the modified Habitat Integrity approach developed by Kleynhans (DWAF, 1999; Dickens *et al*, 2003). Table 15 below displays the criteria and results from the assessment of the habitat integrity of the wetlands. These criteria were selected based on the assumption that anthropogenic modification of the criteria and attributes listed under each selected criterion can generally be regarded as the primary causes of the ecological integrity of a wetland.

Table 15. Habitat integrity assessment criteria for palustrine wetlands (Dickens et al, 2003)

Criteria/Attributes	Relevance
Hydrologic	
Flow Modification	Consequence of abstraction, regulation by impoundments or increased runoff from settlements or agricultural land. Change in flow regime, volumes, velocity altering inundation of wetland habitats and change to flora or give incorrect cues to biota. Abstraction of groundwater flows to the wetland.
Perm. Inundation	Consequence of impoundment results in destruction of wetland habitat and cues for wetland biota.
Water Quality	
Water Quality Modification	From point or diffuse sources. Measure directly or assess indirectly from upstream agricultural activities. Aggravated by volumetric decrease in flow delivered to the wetland.
Sediment Load Modification	Consequence of reduction due to entrapment by impoundments or increase due to land use practices. Cause of unnatural erosion rates, accretion or infilling of wetlands and change in habitats.
Hydraulic/Geomorphic	
Canalisation	Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage.
Topographic Alteration	Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railway lines and other substrate disruptive activities that reduce or change wetland habitat directly in inundation patterns.
Biota	
Terrestrial Encroachment	Consequence of desiccation of wetland and encroachment of terrestrial plant species due to changes in hydrology or geomorphology. Change to terrestrial habitat and loss of wetland functions.
Indig. Vegetation Removal	Direct destruction of habitat through farming activities, grazing or firewood collection affecting wildlife habitat and flow attenuation function, organic matter inputs and increases erosion potential.
Invasive Plant Encroachment	Affects habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading).
Alien Fauna	Presence of alien fauna affecting faunal community structure.
Over utilise biota	Overgrazing, over fishing, etc.

Table 16. Relation between scores given and ecological categories

Scoring Guidelines	Interpretation of Mean* of Scores: Rating of Present Ecological Status Category (PESC)
Natural, unmodified - score=5.	Within general acceptable range CATEGORY A >4; Unmodified, or approximates natural condition.
Largely natural - score=4.	CATEGORY B >3 and ≤4; Largely natural with few modifications, but with some loss of natural habitats.
Moderately modified- score=3.	CATEGORY C >2 and ≤3; moderately modified, but with some loss of natural habitats.
Largely modified - score=2.	CATEGORY D ≤2; largely modified. Large loss of natural habitat & basic ecosystem function has occurred. OUTSIDE GENERALLY ACCEPTABLE RANGE
Seriously modified - rating=1.	CATEGORY E >0 and <2; seriously modified. Losses of natural habitat & ecosystem function are extensive.
Critically modified - rating=0.	CLASS F 0; critically modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat.

Table 17. Wetland habitat integrity assessment (score of 0=critically modified to 5=unmodified)

Criteria & Attributes	Raapenberg Wetland	Valkenberg Wetland	Vincent Pollotti Wetland	Liesbeek Lake	Lower Liesbeek/Black River wetland
Hydrological					
Flow Modification	2.1	2.4	2.8	2.5	1.8
Permanent Inundation	2.5	2.3	2.1	1.8	1.6
Water Quality					
Water Quality Modification	2	2.2	2.8	2.5	2.1
Sediment Load Modification	2.1	2	2	2.4	2.3
Hydraulic/Geomorphical					
Canalisation	1.7	1.9	2.9	1.5	1.8
Topographic Alteration	2.6	3	3.1	1.5	2
Biota					
Terrestrial Encroachment	2.1	2.7	2	1.8	2.0
Indigenous Vegetation Removal	2	2.3	2.1	2	2.5
Invasive Plant Encroachment	2.1	2.6	2.6	2	2
Alien Fauna	2	2	2.5	2	2
Over utilisation of Biota	2.5	2.8	2	2.1	2.6
Category	**C/D (Moderately to largely modified)**	**C (Moderately modified)**	**C (Moderately modified)**	**D (Largely modified)**	**D (Largely modified)**

The WET-Health method was also then used to determine the Present Ecological Status (PES) scores for the hydrology, geomorphology, water quality and vegetation of the wetland and generate an overall PES and ecological category for the wetland (Table 18).

Table 18: WET-Health assessment of the present ecological status of the wetlands

Wetland	Raapenberg Wetland		Valkenberg Wetland		Vincent Pollotti Wetland		Liesbeek Lake		Lower Liesbeek/Black River wetland	
Components	**PES% Score**	**Eco Category**	**PES% Score**	**Eco Category**	**PES% Score**	**Eco Category**	**PES% Score**	**Eco Category**	**PES% Score**	**Eco Category**
Hydrology PES	60 %	**C/D**	60 %	**C/D**	60 %	**C/D**	60 %	**C/D**	60 %	**C/D**
Geomorphology PES	55 %	**D**	55 %	**D**	67 %	**C**	62 %	**C/D**	38 %	**D/E**
Water quality PES	53 %	**D**	53 %	**D**	53 %	**D**	53 %	**D**	53 %	**D**
Vegetation PES	56 %	**D**	63 %	**C**	47 %	**D**	21 %	**E/F**	34 %	**E**
Overall Wetland PES	57 %	**D**	60 %	**C/D**	58 %	**C/D**	49 %	**D**	46 %	**D**

From Table 17 and Table 18 it can be seen that the Raapenberg, Valkenberg and Vincent Pollotti wetlands associated with the Black River are in a slightly better ecological condition than the wetland areas associated with the Liesbeek River. This ecological state is largely related to the type of wetland and the surrounding land use impacts (present day and historical).

6.3.3. ECOSYSTEM SERVICES SUPPLIED

The assessment of the ecosystem services supplied by the identified wetland was conducted according to the guidelines as described by Kotze *et* al (2005). An assessment was undertaken that examines and rates the services listed in Table 19. The characteristics were scored according to the general levels of services provided.

Table 19. Goods and services assessment results for wetlands (high=4; low=0)

Goods and services	Raapenberg Wetland	Valkenberg Wetland	Vincent Pollotti Wetland	Liesbeek Lake	Lower Liesbeek/Black River wetland
Flood attenuation	3.2	3.2	2.1	3.3	2.8
Stream flow regulation	3.2	3.2	2.3	3.0	2.7
Sediment trapping	2.8	2.8	2.4	2.8	2.5
Phosphate trapping	2.6	2.2	2.0	2.4	2.5
Nitrate removal	2.5	2.2	2.0	2.0	2.3
Toxicant removal	2.0	2.0	1.0	2.0	2.0
Erosion control	1.5	1.8	2.1	1.7	2.5
Carbon storage	2.5	2.3	2.0	1.8	1.8
Maintenance of biodiversity	2.8	3.0	2.0	2.0	2.0
Water supply for human use	0.5	0.5	1.0	0.7	0.5
Natural resources	1.5	1.5	1.0	1.0	1.0
Cultivated foods	0	0	0	0	0
Cultural significance	1.5	1.5	1.5	1.0	1.0
Tourism and recreation	2.0	2.0	2.0	2.8	2.0
Education and research	1.0	1.2	0.5	0.5	0.5

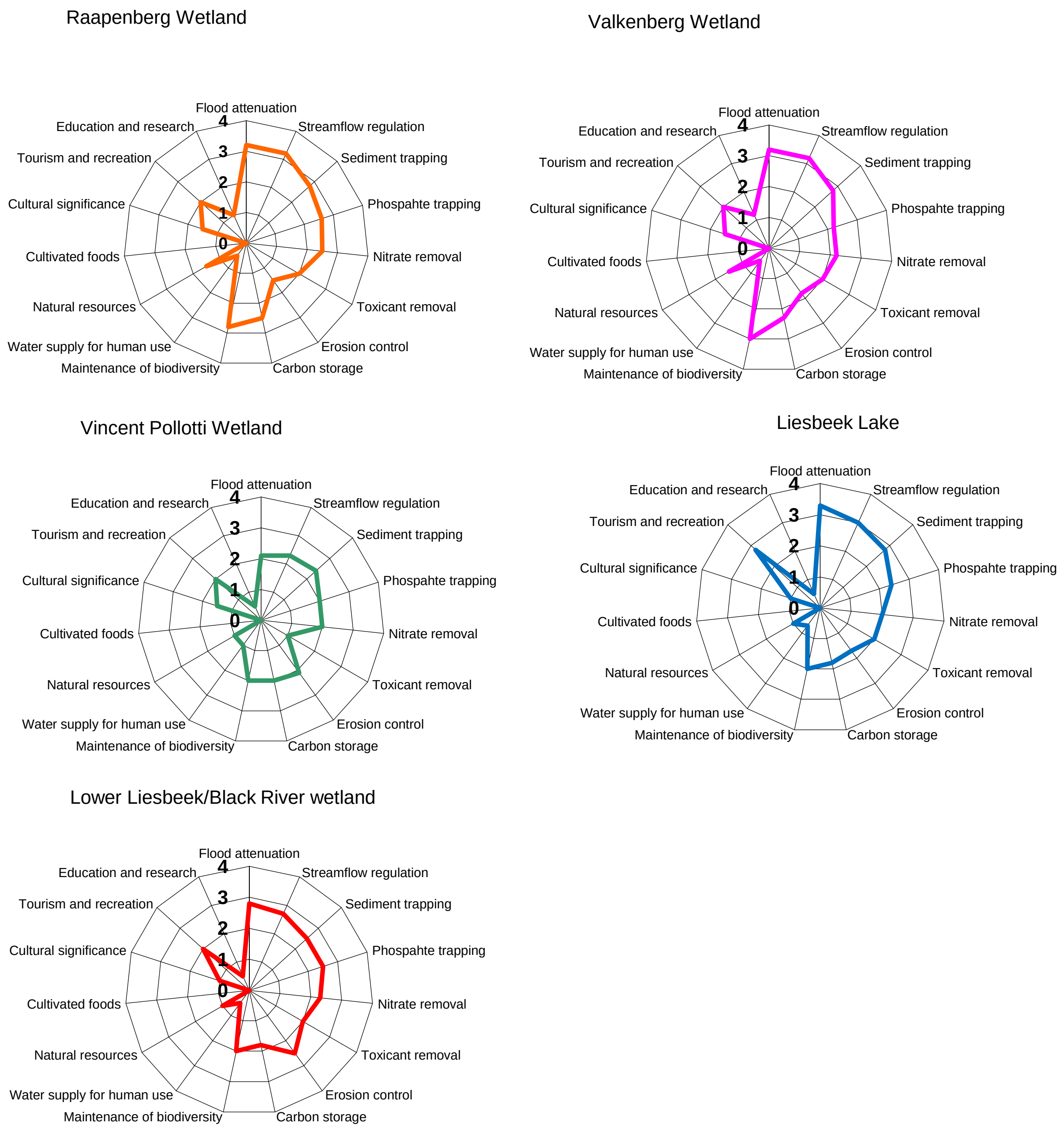


Figure 30. Ecosystem services provided by the wetland areas

The floodplain and valley bottom wetlands (Raapenberg, Valkenberg and Lower Liesbeek/Black River wetlands) provide similar and valuable goods and services in terms of flood attenuation and streamflow regulation together with some trapping of sediment, phosphates and nitrates as the provision of habitat for biota. The wetland area associated with Liesbeek Lake provides some of the goods and services associated with a valley bottom wetland (flood attenuation as well as storm water mitigation) as well as other valuable services in terms of recreational value. The Vincent Pollotti Wetland provides some services for mitigation of storm water and providing habitat for biota.

6.3.4. ECOLOGICAL IMPORTANCE AND SENSITIVITY (EIS)

The EIS assessment undertaken for the wetland areas follows the same approach as that undertaken for rivers/streams as described for rivers.

Table 20. Results of the EIS assessment for the wetlands assessed

Biotic Determinants	Raapenberg Wetland	Valkenberg Wetland	Vincent Pollotti Wetland	Liesbeek Lake	Lower Liesbeek/Black River wetland
Rare and endangered biota	2	2	2	2	2
Unique biota	2	2	2	2	2
Intolerant biota	2	2	2	1	2
Species/taxon richness	2	3	2	2	1
Aquatic Habitat Determinants					
Diversity of aquatic habitat types or features	2	3	2	2	1
Refuge value of habitat type	2.5	2.5	1.5	2	2
Sensitivity of habitat to flow changes	2	3	2.5	2	2
Sensitivity of flow related water quality changes	2	2.5	2.5	2	2
Migration route/corridor for instream and riparian biota	1.5	1.5	1	2	2
National parks, wilderness areas, Nature Reserves,	2	2	2	2	1
EIS Category	Moderate/High	Moderate/High	Moderate/High	Moderate	Moderate

The Raapenberg, Valkenberg and Vincent Pollotti wetland areas are all considered to have a moderate to high Ecological Importance and Sensitivity while the wetlands along the Liesbeek River are slightly lower and are of a moderate ecological importance and sensitivity.

7. LEGISLATIVE AND CONSERVATION PLANNING REQUIREMENTS

The proposed development of the TRUP needs to take cognisance of the legislative requirements, policies, strategies, guidelines and principals of the relevant regulatory documents of the City of Cape Town area, such as the National Spatial Development Framework, the City of Cape Town's Integrated Development Plan and Biodiversity Plan, the River Corridor and Floodplain Management Policy, as well as the National Water Act (NWA) and the National Environmental Management Act (NEMA).

7.1. NEMA AND ENVIRONMENTAL IMPACT ASSESSMENT REGULATIONS

NEMA is the overarching piece of legislation for environmental management in South Africa and includes provisions which must be considered in order to give effect to the general objectives of integrated environmental management. These provisions are contained in Section 24 (4)(a)(b) of the Act, and will be considered during the EIA process. Chapter Seven of the NEMA states that:

"Every person who causes, has caused or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring, or, in so far as such harm to the environment is authorised by law or cannot reasonably be avoided or stopped, to minimise and rectify such pollution or degradation of the environment".

The Act also clearly states that the landowner, or the person using or controlling the land, is responsible for taking measures to control and rectify any degradation. These may include measures to:

"(a) investigate, assess and evaluate the impact on the environment;

(b) inform and educate employees about the environmental risks of their work and the manner in which their tasks must be performed in order to avoid causing significant pollution or degradation of the environment:

(c) cease, modify or control any act, activity or process causing the pollution or degradation:

(d) contain or prevent the movement of pollutants or degradation: or

(e) eliminate any source of pollution or degradation: or

(f) remedy the effects of the pollution or degradation."

NEMA ENVIRONMENTAL IMPACT ASSESSMENT REGULATIONS, GN R982 OF 2014

Activities listed in terms of Chapter 5 of NEMA in the Environmental Impact Assessment Regulations, 2010, Government Notice (GN) R. 544, and more recently, GN R. 983, 984 and 985, dated 4 December 2014, trigger a mandatory Basic Assessment, or even a full scoping EIA process, prior to development.

The National Environmental Management Second Amendment Act (Act No.8 of 2004) provided for formal procedures for offenders in terms of Section 24G to apply for rectification of the unlawful commencement of listed activities.

7.2. NATIONAL WATER ACT, 1998 (ACT NO. 36 OF 1998)

The NWA guides the management of water in South Africa as a common resource. The Act aims to regulate the use of water and activities (as defined in Part 4, Section 21 of the NWA), which may impact on water resources through the categorisation of 'listed water uses' encompassing water abstraction and flow attenuation within catchments as well as the potential contamination of water resources, where the DWS is the administering body in this regard.

Defined water use activities require the approval of DWS in the form of a General Authorisation or Water Use Licence authorisation. Government Notice No. 665 of 6 September 2013 provides for General

Authorisations for certain specified water use activities in terms of the disposal of wastewater which then do not require a licensing process. There are restrictions on the extent and scale of listed activities for which General Authorisations apply.

Section 22(3) of the National Water Act allows for a responsible authority (DWS) to dispense with the requirement for a Water Use Licence if it is satisfied that the purpose of the Act will be met by the grant of a licence, permit or authorisation under any other law.

Potential other water use activities are of relevance to the proposed activities are:

- Section 21(c): Impeding or diverting the flow of water in a watercourse; and
- Section 21(i): Altering the bed, banks, course or characteristics of a watercourse.

In terms of the definitions provided, activities included under Sections 21(c) and 21(i) are (amongst others) the construction of roads, bridges, pipelines, culverts and structures for slope stabilisation and erosion protection. DWS will however need to be approached to provide guidance on whether approval for Section 21 (c) and (i) water uses would be required.

GENERAL AUTHORISATION IN TERMS OF SECTION 39 OF THE NWA

According to the preamble to Part 6 of the NWA, "*This Part established a procedure to enable a responsible authority, after public consultation, to permit the use of water by publishing general authorisations in the Gazette…*" "*The use of water under a general authorisation does not require a licence until the general authorisation is revoked, in which case licensing will be necessary…*"

The General Authorisations for Section 21 (c) and (i) water uses (impeding or diverting flow or changing the bed, banks or characteristics of a watercourse) as defined under the NWA have recently been revised (Government Notice R509 of 2016). Determining if a water use licence is required for these water uses is now associated with the risk of degrading the ecological status of a watercourse. A low risk of impact could be authorised in terms of a General Authorisations (GA).

REGULATIONS REQUIRING THAT A WATER USE BE REGISTERED, GN R. 1352 (1999)

Regulations requiring the registration of water users were promulgated by the minister of DWA in terms of provision made in Section 26 (1)(c), read together with Section 69 of the NWA, 1998. Section 26 (1)(c) of the Act allows for registration of all water uses including existing lawful water use in terms of Section 34(2). Section 29(1)(b)(vi) also states that in the case of a general authorisation, the responsible authority may attach a condition requiring the registration of such a water use. The regulations (Art. 3) oblige any water user as defined under Section 21 of the Act to register such use with the responsible authority and effectively to apply for a Registration Certificate as contemplated under Art. 7(1) of the Regulations.

7.3. CITY OF CAPE TOWN'S BIODIVERSITY NETWORK

In 2003, the City of Cape Town committed to implementing a Biodiversity Strategy. This Strategy requires, amongst others, that a Biodiversity Network be established to enable the conservation of Critical Biodiversity Areas. These areas represent the minimum amount of terrestrial and freshwater habitat that is required to meet the City's biodiversity conservation targets.

Wetland prioritization was analysed separately by specialist consultants (Snaddon et al. 2009). Priority wetlands occurring on natural remnants were included post-hoc into the BioNet as Critical Biodiversity Area (CBA) wetlands. Wetland ground-truthing indicated that priority wetlands located in transformed areas were degraded and in practice would be difficult to restore and conserve. The latter were assigned to either Ecological Support Area (ESA) status based on level of transformation. Wetland ground-truthing has continued since the 2009 BioNet re-analysis and the wetland layer updated accordingly.

The TRUP area has been mapped as a CCT managed Conservation Area (light green area in Figure 31). The Liesbeek and Black Rivers are also seen as Ecological Support Areas that are importance corridors for the movement of biota.

The Spatial Development Framework for the TRUP in particular lists the following constraints:

- *"The Black River is highly polluted and not suitable for human contact, and the possibility of restoring it to its natural state is remote as the pollutants originate upstream from a variety of diffuse sources that cannot be controlled by the future management of the Park.*
- *The possible widening of the Black River to accommodate future runoff from the catchment would negatively impact on the Raapenberg wetlands."*

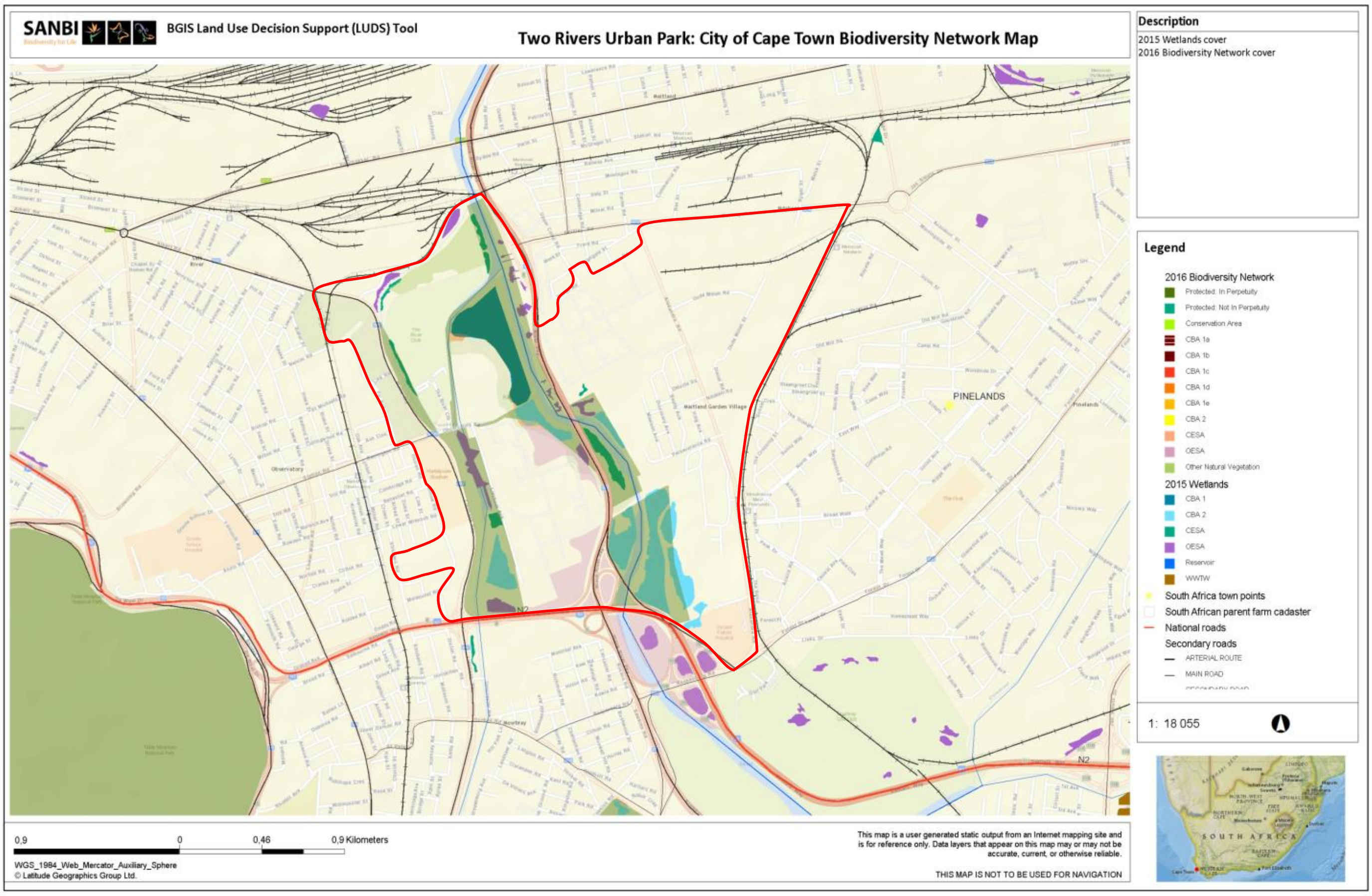


Figure 31. City of Cape Town Biodiversity Network for the area (SANBI Biodiversity GIS, 2016), where:

	Critical Biodiversity Area Category	Critical Biodiversity Area Name
	Protected: In Perpetuity	Protected Area that is Proclaimed in Perpetuity
	Protected: Not In Perpetuity	Protected Area that is Proclaimed for a Limited Period
	Conservation Area	Conservation Area that is not Yet Proclaimed
	CBA 1a	Irreplaceable Core Flora site
	CBA 1b	Irreplaceable High & Medium Condition site
	CBA 1c	Minset (Minimum Set C-plan algorithm) High & Medium Condition site
	CBA 1d	Irreplaceable Consolidation site
	CBA1e	Connectivity Site
	CBA 2	Restorable Irreplaceable site
	CESA	Unselected Natural Vegetation of Conservation Significance
	OESA	Transformed Site of Conservation Significance
	Other Natural vegetation	Unselected Natural Vegetation in high, medium or restorable condition
	No Natural Habitat	Unselected Transformed Site

7.4. FRESHWATER ECOSYSTEM PRIORITY AREAS

Freshwater Ecosystem Priority Areas (FEPAs) are intended to provide strategic spatial priorities for conserving South Africa's freshwater ecosystems and supporting sustainable use of water resources.

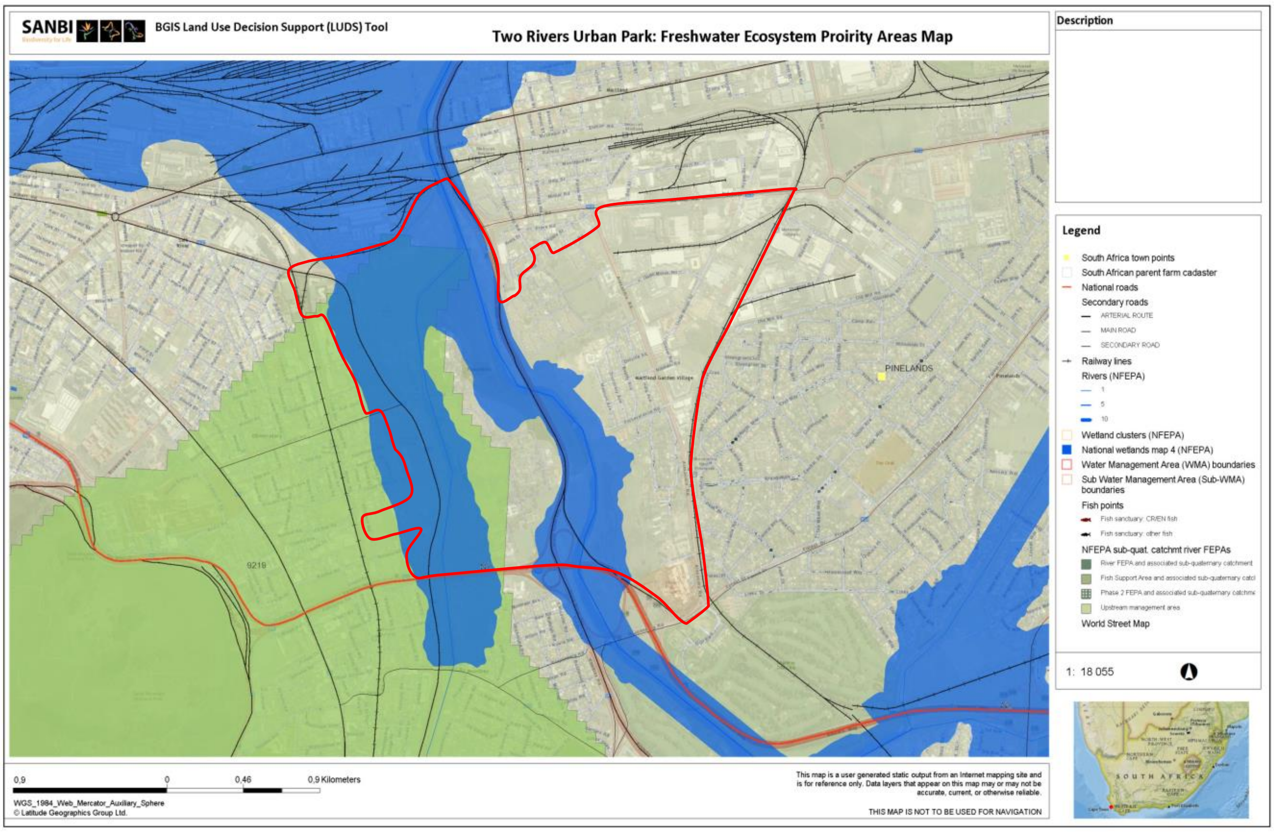


Figure 32. Freshwater Ecosystem Priority Areas for the study area (SANBI Biodiversity GIS, 2016)

FEPAs were determined through a process of systematic biodiversity planning and were identified using a range of criteria for serving ecosystems and associated biodiversity of rivers, wetlands and estuaries. In terms of Freshwater Ecosystem Biodiversity Areas mapped within the study area, there are no river FEPAs, nor Fish Sanctuaries/Support Areas in the Black River Catchment. The Liesbeek River Catchment is however mapped as a Fish Support Area due to the Cape galaxias that still occur within the river. The river corridors and associated wetland areas are also mapped as FEPA wetland areas (Figure 32).

8. FRESHWATER CONSTRAINTS MAPPING

The DWS has defined any activity that is within 500m of a delineated wetland area and is within the one in 100 year floodline or the delineated riparian zone of a river as potentially triggering a water use in terms of Section 21(c) and (i) water uses. This area thus simply indicates a 'red flag' of the area in which proposed activities may impact on aquatic features however this generic area needs to be groundtruthed to determine the actual area of influence based on the site and the proposed activity. The delineated 'red-flag' area as described above is indicated in Figure 33. Only the north-eastern extent of the site is located outside of the 'red-flag' area.

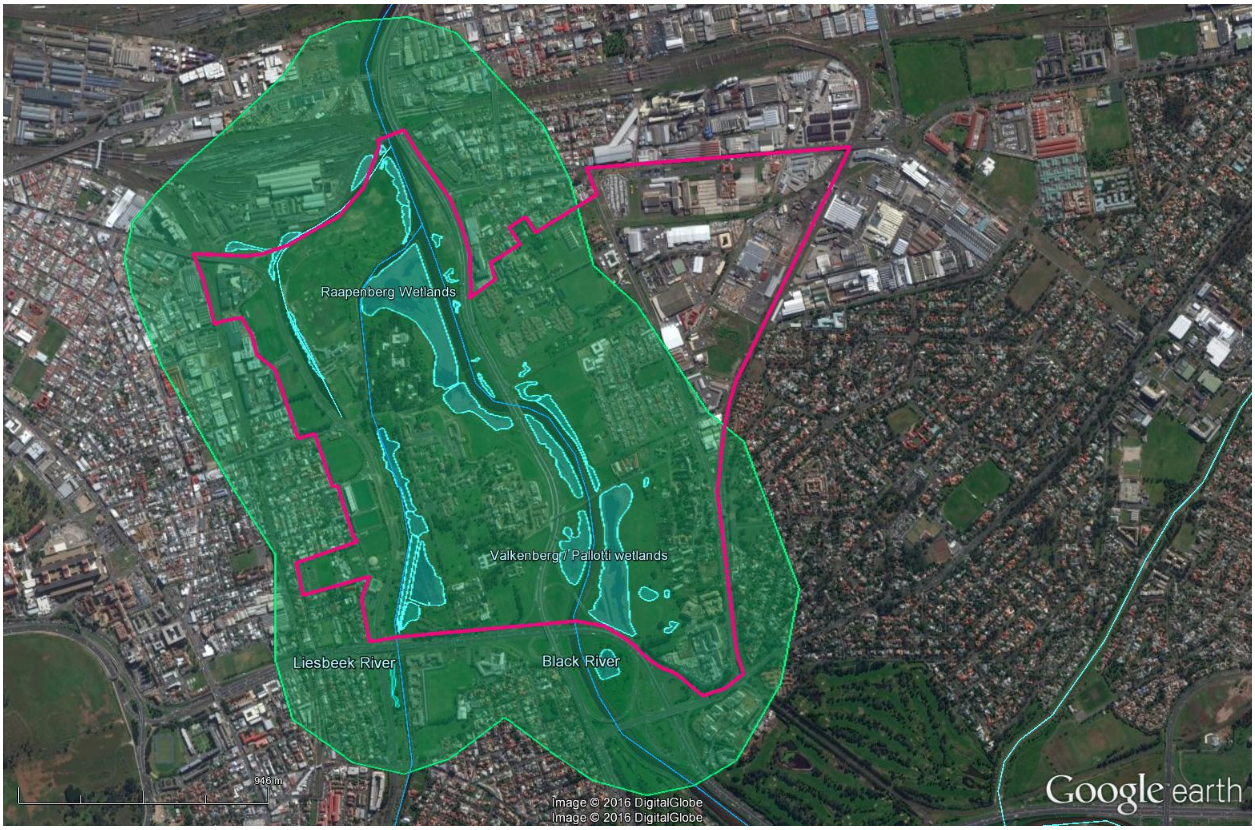


Figure 33. Google Earth image showing the site with its delineated aquatic features with a 500m surrounding area

Freshwater constraints within the study area consist of the Liesbeek and Black River corridors that also encompass their valley bottom and floodplain wetlands areas. The only wetland area that is largely outside of the corridors is the Vincent Pollotti Wetland. While these aquatic ecosystems are in general in a largely to serious modified ecological condition, they are nevertheless considered to be of a moderate to high ecological importance and thus require protection. They also provide valuable goods and services, particularly in terms of flood attention, storm water mitigation, water quality amelioration and providing habitat for biota in an increasing urbanised environment. The Wetland Buffer tool of DWS was used to determine the minimum buffer wides required to protect the aquatic features given their current ecological state, ecological importance and sensitivity and the development of the surrounding catchment. A buffer width of 35 m is recommend that would need to extend along the river corridors, as measured from the top of bank of the rivers or the outer delineated edge of the wetland areas.

In terms of sensitivity of the aquatic feature within the study area, the Raapenberg, Valkenberg and Vincent Pollotti wetland complex is considered to have a high sensitivity. The remaining valley bottom and floodplain wetland areas and riparian zones of the Liesbeek and Black Rivers, including the old channel of the Liesbeek River, are considered to be of medium sensitivity. Minimal development should take place within the more sensitive wetland areas and the recommended buffers.

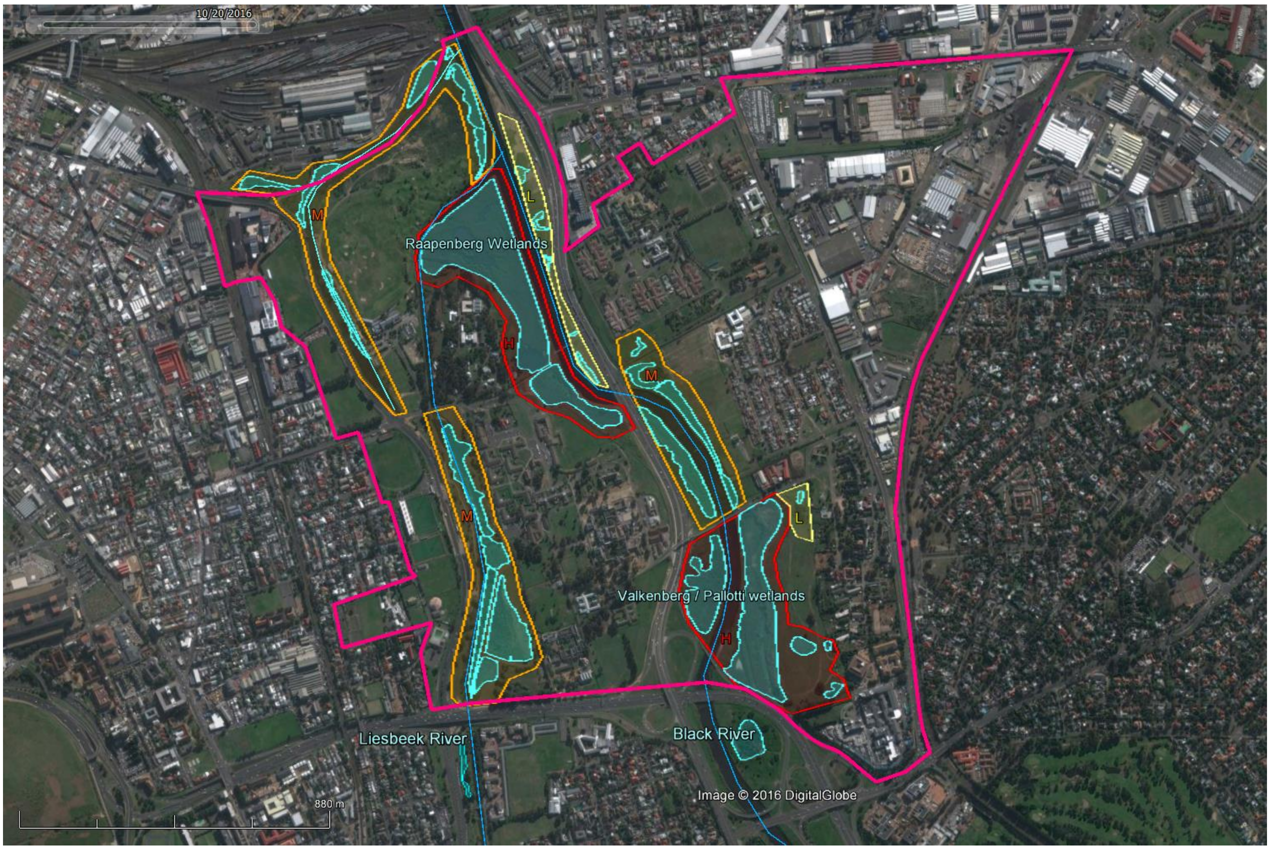


Figure 34. Constraints mapping of the freshwater features within TRUP mapped in Google Earth where the red areas indicate those areas considered of high sensitivity, the orange areas medium sensitivity and the yellow areas low sensitivity

Given the existing development within the proposed buffers and the sensitivity of the various aquatic ecosystems, the buffers vary from the recommended widths to encompass aspects such as existing developed areas.

The river corridors and their associated wetlands areas represent key corridors for the movement of aquatic biota. Connectivity within these corridors within the site should be maintained or restored where possible. While the connectivity along the Black River within the site is still largely intact, Observatory Road and the canalised section of the lower river have significantly impacted on the connectivity of Liesbeek River. Two alternatives could be considered to improve the connectivity and functioning of the lower Liesbeek River downstream of Observatory Road:

- Maintain the status quo, that is, retain the original Liesbeek River channel as well as the canalised portion. Due to the extremely degraded condition of the original channel, it is recommended that the following be undertaken to improve its ecological condition:
    - Reinstate the lower flows from the Liesbeek River in the channel;
    - Mitigate storm water quality being discharged into the channel with silt traps; and

  - Enhance functionality of aquatic ecosystem with reshaping of the channel and revegetating with suitable aquatic vegetation.

- Replace the original channel with a series of smaller wetland areas and rehabilitate the canalised section of the river channel by removing concrete bed and banks, shaping the channel and revegetating the river banks with indigenous riparian vegetation.

9. CONSIDERATION OF CONCEPTUAL IDEAS FOR THE GREEN CORRIDOR AND PROPOSED MITIGATION MEASURES

Draft conceptual ideas include amongst other possibilities, the following:

- Limited development of the site;
- Agricultural areas and an orchard;
- Additional storm water detention ponds and silt traps;
- Berms along roadways;
- Additional access pathways that will cross the site from west to east. These pathways are proposed to cross the Black River in two places as well as cross the original Liesbeek River channel; and
- A docking station on the east bank of the lower Black River.

The potential impacts and the recommended mitigation measures are discussed below for each of these elements:

Limited development: The development of the site should take place outside of the proposed buffers or development setback lines. The impact of storm water runoff to the site from the developed areas should be mitigated to minimise the potential flow and water quality impacts. With mitigation, these proposed development areas should have a low impact on the aquatic ecosystems in the area however each of the proposed developments would need to be assessed separately.

Agricultural areas: As for the proposed limited development, the impact of the proposed agricultural areas and orchard should be low to very low with mitigation, that is, development should take place outside of the proposed buffer areas and the potential impacts of contaminated storm water should be mitigated from entering the wetland areas and rivers.

Additional storm water ponds and silt traps: The potential impact of this proposed activity should be positive provided the activities within the aquatic ecosystems and the recommended buffers is minimised and the disturbed areas rehabilitated after construction. To improve the water quality of the aquatic ecosystems in the area, enhancement of the existing storm water facilities and associated wetland areas is essential. As far as possible the functionality of the aquatic features should also be enhanced.

Berms: With mitigation, the proposed berms are likely to have a very low impact on the aquatic features within the site. It is recommended that the proposed berms should not result in infilling of the delineated aquatic features within the site. These features should also not alter impede or divert flow within the rivers or to the wetland areas. Care will also need to be taken that the soils imported onto the site to create the berms do not introduce invasive alien plant seed especially where the berms are to be located adjacent to aquatic features. Regular monitoring and clearing of invasive alien vegetation will thus be required in these areas.

Pathways and bridges: The proposed pathways and bridges should as far as possible be located within the footprint of the existing pathways if located within the aquatic features and the recommended buffer areas. Siting of the pathways and bridges within the wetland areas that are to be located outside of existing pathway footprints would need careful consideration, in particular where they may impact on the more sensitive wetland areas. No infilling of the high sensitivity wetlands should take place for the construction of the pathways and bridges. The bridge structures should also be constructed such that they do not constrict or impede flow in the rivers. If the infrastructure is placed within the more sensitive wetland areas there may be longer term impacts to these wetland areas as there will be increased access and disturbance of these areas on an ongoing basis.

Docking station: The proposed docking station would be located along the Black River where it has been canalised and most of the associated wetland areas have been modified and are in a very degraded condition if still present. Many of the wetland areas have been modified an now only consist of filled areas with storm water drainage channels to the river. The proposed activity would thus be of a very low significant provided any water quality and flow impacts associated with the docking station are adequately mitigated.

10. CONCLUSIONS AND RECOMENDATIONS

The main freshwater features within the TRUP site are the Liesbeek and Black Rivers. Associated with the rivers are a number of wetland areas that comprise remnant floodplain wetland and artificially created and storm water dominated wetlands. Of the wetland areas within the site, the Raapenberg, Vincent Pallotti and Valkenberg wetlands are considered to be the most important, as remnants of the Black River floodplain wetland area. The ecological condition of these aquatic ecosystems range from being moderately to largely modified for the wetland areas and largely to seriously modified for the rivers. The ecological importance and sensitivity of these aquatic ecosystems is deemed to be moderate to high in general with only the Black River being low to moderate.

The Raapenberg, Valkenberg and Vincent Pollotti wetland complex is considered to have a high sensitivity. The remaining valley bottom and floodplain wetland areas and riparian zones of the Liesbeek and Black Rivers, including the old channel of the Liesbeek River, are considered to be of medium sensitivity. Minimal development should take place within the more sensitive wetland areas and the recommended buffers as indicated in Figure 34.

The water quality in the two river systems is highly variable and is linked to the seasonal flow variability. The quality of the water in the Black River is significantly more degraded than in the Liesbeek River. A trend of improving water quality is evident in the rivers over the past 20 years.

The proposed development of the site is likely to have an impact of low significant on the aquatic ecosystems on the site, with a potential for a positive impact. The following are proposed to improve the ecological condition of the aquatic features within the site:

- The impact of storm water runoff from the surrounding developed areas into the aquatic features should be mitigated. Where possible, litter traps should be constructed to reduce litter entering the rivers. The functionality of the rivers and wetland areas should also be enhanced.
- Invasive alien vegetation within the aquatic ecosystems and their buffer areas should be removed and these areas kept free of alien invasive plants;
- A buffer area of approximately 35m should be maintained adjacent to the delineated edge of the aquatic features;
- The river corridors and their associated wetlands areas represent key corridors for the movement of aquatic biota. Connectivity within these corridors within the site should be maintained or restored where possible. While the connectivity along the Black River within the site is still largely intact, Observatory Road and the canalised section of the lower river have significantly impacted on the connectivity of Liesbeek River. Rehabilitation of the lower Liesbeek River should be undertaken according to an approved rehabilitation plan.

11. REFERENCES

City of Cape Town. 2002. Two Rivers Urban Park Spatial Development Framework and Phase 1 Management Plan.

Department of Water Affairs and Forestry. (1996). *South African Water Quality Guidelines.*

Department of Water Affairs and Forestry. (1999). *Resource Directed Measures for Protection of Water Resources. Volume 3: River Ecosystems Version 1.0*. Resource Directed Measures for Protection of Water Resources, Pretoria, South Africa.

Department of Water Affairs and Forestry. (2005). *River Ecoclassification: Manual for Ecostatus Determination (Version 1)*. Water Research Commission Report Number KV 168/05. Pretoria.

Department of Water Affairs and Forestry. (2007). *River Ecoclassification: Manual for Ecostatus Determination (Version 2)*. Riparian Vegetation Response Index, Water Research Commission Report Number KV 168/05. Pretoria.

Holmes P, Stipinovich A & Purves A. (2012). City of Cape Town Biodiversity Network: Methods and Results - Technical Report (C-Plan & Marxan Analysis). City of Cape Town, South Africa.

Kotze, D., Marneweck, G.C., Batchelor, A.L., Lindley, D.S. And Collins, N.B. (2005). *WET-EcoServices: A technique for rapidly assessing ecosystem services supplied by wetlands.* Dept. Tourism, Environmental and Economic Affairs, Free State.

River Health Programme of South Africa (2004). *State of Cape Town Rivers*. Department of Water Affairs & Forestry, Pretoria.

SANBI Biodiversity GIS. http://bgis.sanbi.org

Snaddon K, Turner R, Job N, Ollis D and Jones L. (2009). *City Wetlands Map: Phase 5 - Ground-truthing and map update*, Report submitted to the City of Cape Town.

Snaddon K. & Day E. (2009) *Prioritization of City Wetlands.* Report submitted to the City of Cape Town.

APPENDIX A: DECLARATION OF INDEPENDENCE

I Antonia Belcher, as the appointed independent specialist hereby declare that I:

- act/ed as the independent specialist in this application;
- regard the information contained in this report as it relates to my specialist input/study to be true and correct, and
- do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the NEMA, the Environmental Impact Assessment Regulations, 2010 and any specific environmental management Act;
- have and will not have no vested interest in the proposed activity proceeding;
- have disclosed, to the applicant, EAP and competent authority, any material information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the NEMA, the Environmental Impact Assessment Regulations, 2010 and any specific environmental management Act;
- am fully aware of and meet the responsibilities in terms of NEMA, the Environmental Impact Assessment Regulations, 2010 (specifically in terms of regulation 17 of GN No. R. 543) and any specific environmental management Act, and that failure to comply with these requirements may constitute and result in disqualification;
- have ensured that information containing all relevant facts in respect of the specialist input/study was distributed or made available to interested and affected parties and the public and that participation by interested and affected parties was facilitated in such a manner that all interested and affected parties were provided with a reasonable opportunity to participate and to provide comments on the specialist input/study;
- have ensured that the comments of all interested and affected parties on the specialist input/study were considered, recorded and submitted to the competent authority in respect of the application;
- have ensured that the names of all interested and affected parties that participated in terms of the specialist input/study were recorded in the register of interested and affected parties who participated in the public participation process;
- have provided the competent authority with access to all information at my disposal regarding the application, whether such information is favorable to the applicant or not; and
- am aware that a false declaration is an offence in terms of regulation 71 of GN No. R. 543.

Signature of the specialist:

Date: 7 October 2016

APPENDIX B: BACKGROUND AND QUALIFICATIONS OF SPECIALIST CONSULTANT

Contact details: PO Box 445, Somerset Mall, 7137

Names: Antonia Belcher and Dana Grobler

Profession: Aquatic Scientists

Fields of Expertise: Specialist in freshwater assessments, monitoring and reporting

Relevant work experience:

Due to involvement in the development and implementation of the River Health Programme in the Western Cape, as well as numerous freshwater assessments through the province and greater Southern Africa, we have taken part in many 'state-of-river' assessments as well as routine monitoring and specialized assessments of rivers and wetlands in the area.

Recent publications:

- Freshwater Assessment Input into the Storm water Master Plan for the Upper Mosselbank River near Durbanville, City of Cape Town, 2007.
- Freshwater Assessment: Proposed Bella Riva Development near Fisantekraal, 2009.
- Freshwater Assessment for the Proposed Process and Other Improvements to the Cape Flats Wastewater Treatment Works and Future Associated Infrastructure, Cape Town, 2013.
- Aquatic Specialist on the City of Cape Town project (Contract No. 357C/2011/12): Identification and Evaluation of Environmentally Friendly Remediation Products for Mitigating Various Types of Pollution in Stormwater Systems, 2013.
- Freshwater Inventory for Klapmuts Precinct Plan by Drakenstein Municipality: Strategic Environmental Assessment, 2013.
- Freshwater Input into the Wellington Industrial Park Strategic Environmental Assessment, 2014
- Freshwater Assessment for the Proposed Expansion of the Existing Macassar and Zandvliet Wastewater Treatment Works, Cape Town, 2015

APPENDIX C: PES AND EI&ES FOR THE BLACK AND LIESBEEK RIVERS

SELECT SQ REACH	SQR NAME	LENGTH km	STREAM ORDER	PES ASSESSED BY XPERTS? (IF TRUE="Y")	REASONS NOT ASSESSED	PES CATEGORY DESCRIPTION	PES CATEGORY BASED ON MEDIAN OF METRICS
G22C-09218	Black	1.99	2	Y		CRITICAL MODIFICATION	F
MEAN EI CLASS	MEAN ES CLASS	DEFAULT ECOLOGICAL CATEGORY (DEC)	RECOMMENDED ECOLOGICAL CATEGORY (REC)				
VERY LOW	MODERATE	C	0.00				

PRESENT ECOLOGICAL STATE		ECOLOGICAL IMPORTANCE				ECOLOGICAL SENSITIVITY	
INSTREAM HABITAT CONTINUITY MOD	CRITICAL	FISH SPP/SQ		INVERT TAXA/SQ	18.00	FISH PHYS-CHEM SENS DESCRIPTION	
RIP/WETLAND ZONE CONTINUITY MOD	CRITICAL	FISH: AVERAGE CONFIDENCE		INVERT AVERAGE CONFIDENCE	2.78	FISH NO-FLOW SENSITIVITY DESCRIPTION	
POTENTIAL INSTREAM HABITAT MOD ACT.	CRITICAL	FISH REPRESENTIVITY PER SECONDARY: CLASS		INVERT REPRESENTIVITY PER SECONDARY,	LOW	INVERT PHYS-CHEM SENS DESCRIPTION	MODERATE
RIPARIAN-WETLAND ZONE MOD	CRITICAL	FISH REPRESENTIVITY PER SECONDARY: CLASS		INVERT RARITY PER SECONDARY: CLASS	MODERATE	INVERTS VELOCITY SENSITIVITY	HIGH
POTENTIAL FLOW MOD ACT.	CRITICAL	FISH RARITY PER SECONDARY: CLASS		ECOLOGICAL IMPORTANCE: RIPARIAN-WETLAND-INSTREAM VERTEBRATES (EX FISH) RATING	HIGH	RIPARIAN-WETLAND-INSTREAM VERTEBRATES (EX FISH) INTOLERANCE WATER LEVEL/FLOW CHANGES DESCRIPTION	VERY HIGH
POTENTIAL PHYSICO-CHEMICAL MOD ACTIVITIES	CRITICAL	ECOLOGICAL IMPORTANCE: RIPARIAN-WETLAND-INSTREAM VERTEBRATES (EX FISH) RATING	HIGH	HABITAT DIVERSITY CLASS	MODERATE	STREAM SIZE SENSITIVITY TO MODIFIED FLOW/WATER LEVEL CHANGES DESCRIPTION	LOW
		RIPARIAN-WETLAND NATURAL VEG RATING BASED ON % NATURAL VEG IN 500m (100%=5)	VERY LOW	HABITAT SIZE (LENGTH) CLASS	VERY LOW	RIPARIAN-WETLAND VEG INTOLERANCE TO WATER LEVEL CHANGES DESCRIPTION	VERY LOW
		RIPARIAN-WETLAND NATURAL VEG IMPORTANCE BASED ON EXPERT RATING	VERY LOW	INSTREAM MIGRATION LINK CLASS	VERY LOW		
				RIPARIAN-WETLAND ZONE MIGRATION LINK	VERY LOW		
				RIPARIAN-WETLAND ZONE HABITAT INTEGRITY CLASS	VERY LOW		
				INSTREAM HABITAT INTEGRITY CLASS	VERY LOW		

SELECT SQ REACH	SQR NAME	LENGTH km	STREAM ORDER	PES ASSESSED BY XPERTS? (IF TRUE="Y")	REASONS NOT ASSESSED	PES CATEGORY DESCRIPTION	PES CATEGORY BASED ON MEDIAN OF METRICS
G22C-09219	Liesbeek	10.92	1	Y		SERIOUS MODIFICATION	E
MEAN EI CLASS	MEAN ES CLASS	DEFAULT ECOLOGICAL CATEGORY (DEC)	RECOMMENDED ECOLOGICAL CATEGORY (REC)				
LOW	HIGH	B	0.00				

PRESENT ECOLOGICAL STATE		ECOLOGICAL IMPORTANCE				ECOLOGICAL SENSITIVITY	
INSTREAM HABITAT CONTINUITY MOD	MODERATE	FISH SPP/SQ	1.00	INVERT TAXA/SQ	45.00	FISH PHYS-CHEM SENS DESCRIPTION	MODERATE
RIP/WETLAND ZONE CONTINUITY MOD	SERIOUS	FISH: AVERAGE CONFIDENCE	5.00	INVERT AVERAGE CONFIDENCE	4.91	FISH NO-FLOW SENSITIVITY DESCRIPTION	MODERATE
POTENTIAL INSTREAM HABITAT MOD ACT.	SERIOUS	FISH REPRESENTIVITY PER SECONDARY: CLASS	VERY LOW	INVERT REPRESENTIVITY PER SECONDARY,	HIGH	INVERT PHYS-CHEM SENS DESCRIPTION	VERY HIGH
RIPARIAN-WETLAND ZONE MOD	CRITICAL	FISH REPRESENTIVITY PER SECONDARY: CLASS	VERY LOW	INVERT RARITY PER SECONDARY: CLASS	VERY HIGH	INVERTS VELOCITY SENSITIVITY	VERY HIGH
POTENTIAL FLOW MOD ACT.	SERIOUS	FISH RARITY PER SECONDARY: CLASS	FALSE	ECOLOGICAL IMPORTANCE: RIPARIAN-WETLAND-INSTREAM VERTEBRATES (EX FISH) RATING	HIGH	RIPARIAN-WETLAND-INSTREAM VERTEBRATES (EX FISH) INTOLERANCE WATER LEVEL/FLOW CHANGES DESCRIPTION	VERY HIGH
POTENTIAL PHYSICO-CHEMICAL MOD ACTIVITIES	LARGE	ECOLOGICAL IMPORTANCE: RIPARIAN-WETLAND-INSTREAM VERTEBRATES (EX FISH) RATING	HIGH	HABITAT DIVERSITY CLASS	VERY HIGH	STREAM SIZE SENSITIVITY TO MODIFIED FLOW/WATER LEVEL CHANGES DESCRIPTION	HIGH
		RIPARIAN-WETLAND NATURAL VEG RATING BASED ON % NATURAL VEG IN 500m (100%=5)	VERY LOW	HABITAT SIZE (LENGTH) CLASS	LOW	RIPARIAN-WETLAND VEG INTOLERANCE TO WATER LEVEL CHANGES DESCRIPTION	LOW
		RIPARIAN-WETLAND NATURAL VEG IMPORTANCE BASED ON EXPERT RATING	LOW	INSTREAM MIGRATION LINK CLASS	HIGH		
				RIPARIAN-WETLAND ZONE MIGRATION LINK	LOW		
				RIPARIAN-WETLAND ZONE HABITAT INTEGRITY CLASS	VERY LOW		
				INSTREAM HABITAT INTEGRITY CLASS	LOW		

APPENDIX D: WATER QUALITY DATA

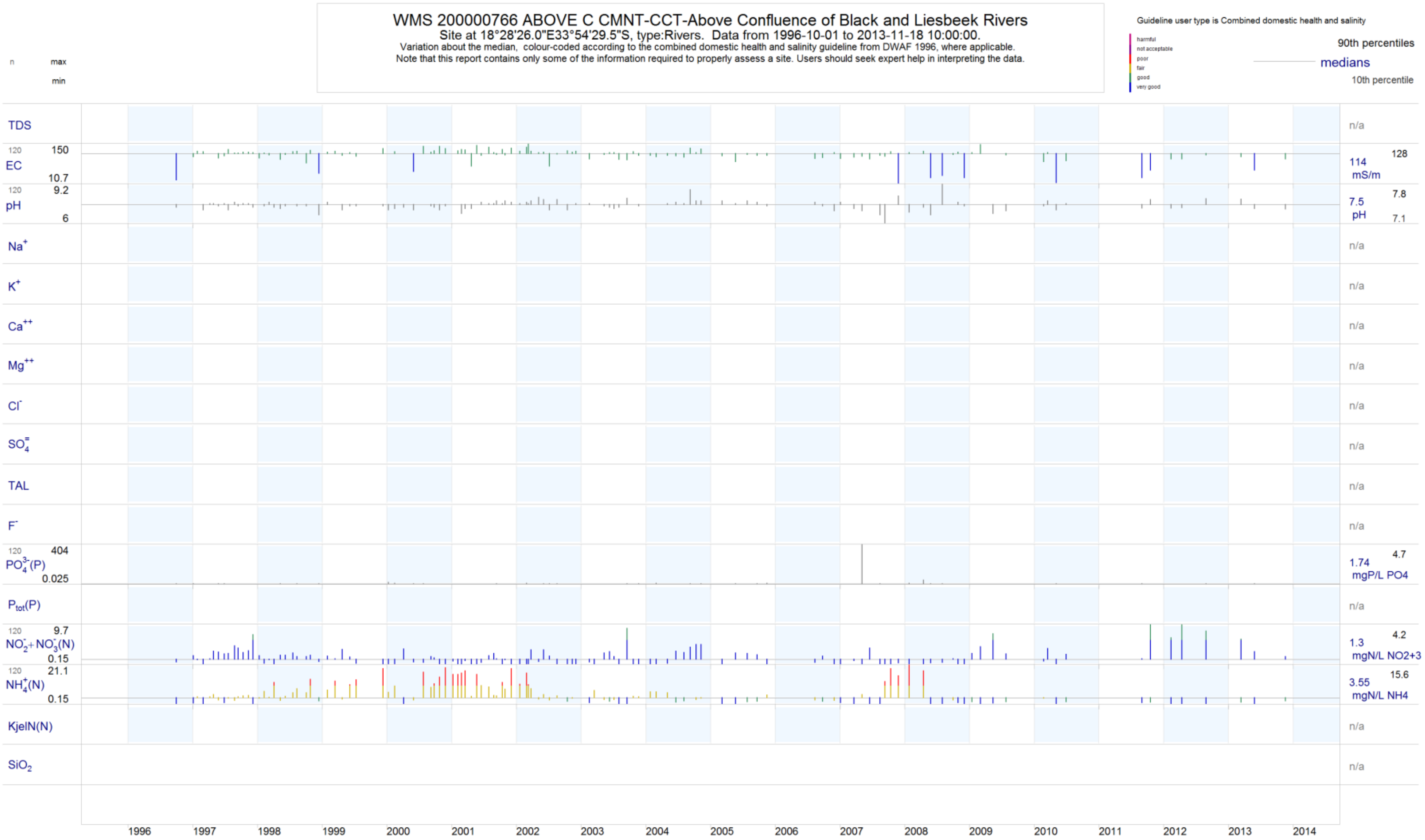


Figure A1. Barcode graph for DWA monitoring site upstream of the Liesbeek and Black confluence