1 BACKGROUND

1.1 INTRODUCTION

The Diep River drains into Table Bay, north of Cape Town (Figure 1). The Diep River has been subject to deterioration in water quality over decades due to bad farming practices and other landuses. Landuse in the upper catchment is predominantly agriculture, while in the lower catchment it is largely residential (formal and informal settlements) and industrial.

This study originated as a result of a request from the Western Cape Region of the Department of Water Affairs and Forestry (DWAF) in 1997 to the Institute for Water Quality Studies (IWQS), to conduct a situation assessment of the Diep River catchment. The main objective of this study was to provide a situational assessment of the water quality, quantity, and the aquatic ecosystem health for the surface, ground, and coastal waters of the Diep River catchment.

The intention of this Situation Assessment is to form an information base for decision making and the identification of management actions within the catchment. Development of management strategies in the catchment is an ongoing process and requires information. The work carried out in this project consisted of a situation assessment to identify the key issues that impact on the water resource quality, as well as the water user requirements.

This information will contribute towards the initial development of a management plan for the water resources in the Diep River Catchment. This study will later on be followed by the "Reserve" determination that will be considered as part of the second phase of the project.

1.2 APPROACH TO WATER RESOURCE MANAGEMENT

The National Water Act (Act No 36 of 1998), hereafter referred to as "the Act", states that "National Government, acting through the Minister, is responsible for the achievement of fundamental principles in accordance with the Constitutional mandate for water reform." The fundamental principles are sustainability and equity in the protection, use development, conservation, management, and control of water resources.

Uniform Effluent Standards were used up to the late 1980's in an attempt to prevent deterioration in the quality of water resources. But nowadays the Department is not only focusing on the quality of wastewater discharge, but also on the quality of the water resource receiving that wastewater. Requirements of the Act are to ensure sustainable use of water resources and the equitable allocation of water use for the "optimum social and economic benefit" of the country. Coupled with these is the need for a transparent and participative approach to water resources management, and the need to provide for a "Reserve". The "Reserve" is that quantity and quality of water required for basic human needs and to maintain the sustainability of the aquatic ecosystem.

These are trends that are being followed all over the world in the management of water resources. Water resource management has traditionally focused on controlling the depletion of water resources due to increased demand on water resources to meet the demands of urban and agricultural development (Belcher A et al, 1999). This kind of development has led to the deterioration of the water resource quality in the form of the removal of riparian vegetation, water abstraction, flow regulation and the intensive development of human activities in the floodplain. The shift to the need to provide water for the ecological functioning of aquatic ecosystems had a significant change in the approach to water resource management from a relatively simple and standardised system, to a complex and information intensive process, with a greater degree of integrated resource-based catchment management (Belcher A et al, 1999).

Catchment water resource management is based on the establishment of water resource objectives for various river reaches in that catchment and the formulation of catchment strategies to ensure that these objectives are attained. In order to develop a catchment management plan, the catchment characteristics and activities need to be assessed in terms of their effect on the water resource. Resources available in water management, however, dictate the need to prioritise the issues that should be addressed.

The Act defines water resource to include a watercourse, surface water, estuary, or aquifer. Water resource quality is described by the Act as the quality of all the aspects of a water resource including – the quantity, pattern, timing, water level and assurance of instream flow; the water quality, including the physical, chemical and biological characteristics of the water; the character and condition of the instream and riparian habitat; and the characteristic, condition and distribution of the aquatic biota. This reflects the fact that the sustainability of the ecosystem depends on the ecological interactions between the physical, chemical and biotic components of water. An integrated approach is now applied to water resource management, which recognises these different, but inter-linked, aquatic ecological compartments and their different management requirements. Water resource assessments are now undertaken in terms of water resource quality. This incorporates all the components of aquatic ecosystems, as well as the water quality needs of the various users.

The resource directed measures would be addressed during the second phase of the project for the Diep River catchment, that is, the classification system that will establish Resource Quality Objectives for each water resource. The resource quality objectives specify numeric and narrative objectives that may relate to quantity, quality, habitat, biota, or in-stream/land-based activities for different water bodies. This will be done in terms of the requirements of the “Reserve” and in terms of the needs of the other users, as part of the phase II of the project.

1.3 OBJECTIVES OF THIS REPORT

The main objective of this report is to provide a situational assessment of the water quality, quantity, and aquatic ecosystem health for the surface, ground, and coastal waters of the Diep River catchment. The following subsidiary objectives have been established for this study to achieve the main objective:

- To characterise the catchment's natural characteristics (Chapter 2).
- To characterise the land and water use activities within the catchment (Chapter 3).
- To characterise the water quality (Chapter 4).
- To assess the present water quality against water user requirements (Chapter 5).
- To assess aquatic ecosystem health (Chapter 6).
- To outline the impact that catchment characteristic and the land activities practised have upon the water resource quality and to provide some possible actions for the management of the resource (Chapter 8).

1.4 STRUCTURE OF THE REPORT

Sources of information that were used for the compilation of this report are:

- Existing information of the physical characteristics of the catchment, as well as land and water use activities in the catchment and;
- Data and information on the water resource quality in the catchment.

The report has been structured around this information/data. Chapters have been divided into two parts i.e. **general background information**, and issues that could have an impact on water resource quality. These issues are indicated in the box as indicated below:

ISSUES:
Implication for the water resource quality and water user requirements.

A general outline of the report structure is as follows:

Chapter 1: Discusses the general overview of the Diep River catchment, the format and structure of this report.

Chapter 2: Discusses the physical characteristics of the catchment and implications on water resource quality.

Chapter 3: Discusses the land and water use activities within the catchment and their possible impacts on the water resource quality.

Chapter 4: Gives the analysis of the water resource quality.

Chapter 5: Assesses the present water quality against water user requirements. This is done by assessing the available water quality data against the South African Water Quality Guidelines (DWAF, 1996) for the various Water users.

Chapter 6: Assesses the integrity of the aquatic ecosystem.

Chapter 7: Summarises the issues raised in previous chapters.

Chapter 8: Outlines the impacts that catchment characteristics and the land activities practised have upon the water resource quality and provides some possible actions for the management of the resource.

Appendix A is wetland plant communities. Appendix B is the history of impoundments, and existing monitoring points in the Diep River Catchment. Appendix C is a summary of the water quality classification system suitable for different users. Appendix D is estuarine bird species list. Appendix E is surface water quality data. Appendix F is the groundwater quality data. Appendix G is the coastal water quality data. Appendix H is the glossary of terminology. Appendix I is the glossary of abbreviations.

2 OVERVIEW OF THE CATCHMENT

This section describes the natural characteristics, and human activities in the catchment, and the impacts that they have on the water resource quality and its water users.

2.1 CATCHMENT DESCRIPTION AND TOPOGRAPHY

The Diep River is located in the South Western Cape Region, north of Cape Town. The towns of Riebeeck-West in the north, Paarl in the east, Atlantis in the west and Milnerton in the south bound the catchment. The catchment has a total area of about 1 495 km^2 (Figure 1).

The Diep River rises from the Riebeek-Kasteel Mountains, north-east of the catchment. It then flows in a south-westerly direction through Malmesbury before discharging into Table Bay, north of Cape Town. Diep River has a total length of approximately 65 km. The Diep River catchment is low lying and flat with isolated mountains on its eastern boundary, namely the Perdeberg, Kasteelberg, and Paarlberg.

The Diep River has one major tributary, the Mosselbank River, which rises in the Skurweberg Mountains and drains the south-eastern portion of the catchment, namely the Durbanville and Kraaifontein areas. The Mosselbank River has a tributary called the Klapmuts River. Other tributaries of the Diep River include the Riebeek River, Klein River, Swart River, Platklip River, and the Sout River.

The catchment falls into the western lowland area of the Western Cape. This area may be divided into the Swartland in the east and the Sandveld in the west. The Swartland consists of undulating lowland with relatively steep river valley slopes, while the Sandveld is flatter with wider, shallower river valleys. This lowland topography allows for almost the entire catchment to be developed.

The estuary is approximately 900 hectares in area and consists of the Rietvlei and Milnerton lagoon (see Figure 4). Approximately 6 km upstream of the river mouth the river splits into a number of channels, which flow through the marsh or vlei area of the Rietvlei. Rietvlei is roughly triangular in shape with a maximum width of over two kilometres in an east/west direction and a length of approximately 1.5 km north/south. The vlei area may be defined as that between the Otto du Plessis Drive Bridge and the Blaauberg Road Bridge. It is very flat, with an elevation of 1.0 to 2.0 m above Mean Sea Level (MSL) with the exception of the Flamingo Vlei (an artificial water body), which has been dredged to a depth of 9 m (Lochner P, L Barwell, and P Morant, 1994 (b)).

The lower estuary, generally called the Milnerton Lagoon, follows a narrow winding channel from the southern tip of Rietvlei to the river mouth. The riverbed is below the MSL and is shallow. The mouth is free to migrate along a sandbank of approximately 250 m but is then restrained by structures to the north and dunes to the south (Lochner P, L Barwell, and P Morant, 1994 (b)).

ISSUES:

- The Diep River flows through the Riebeek-Kasteel Mountains, where development is unlikely and runoff potential is high.
- Flamingo Vlei is dredged and this has the potential effect of increased siltation.
- Greater impacts can be expected in the lower catchment due to increasing human activity.

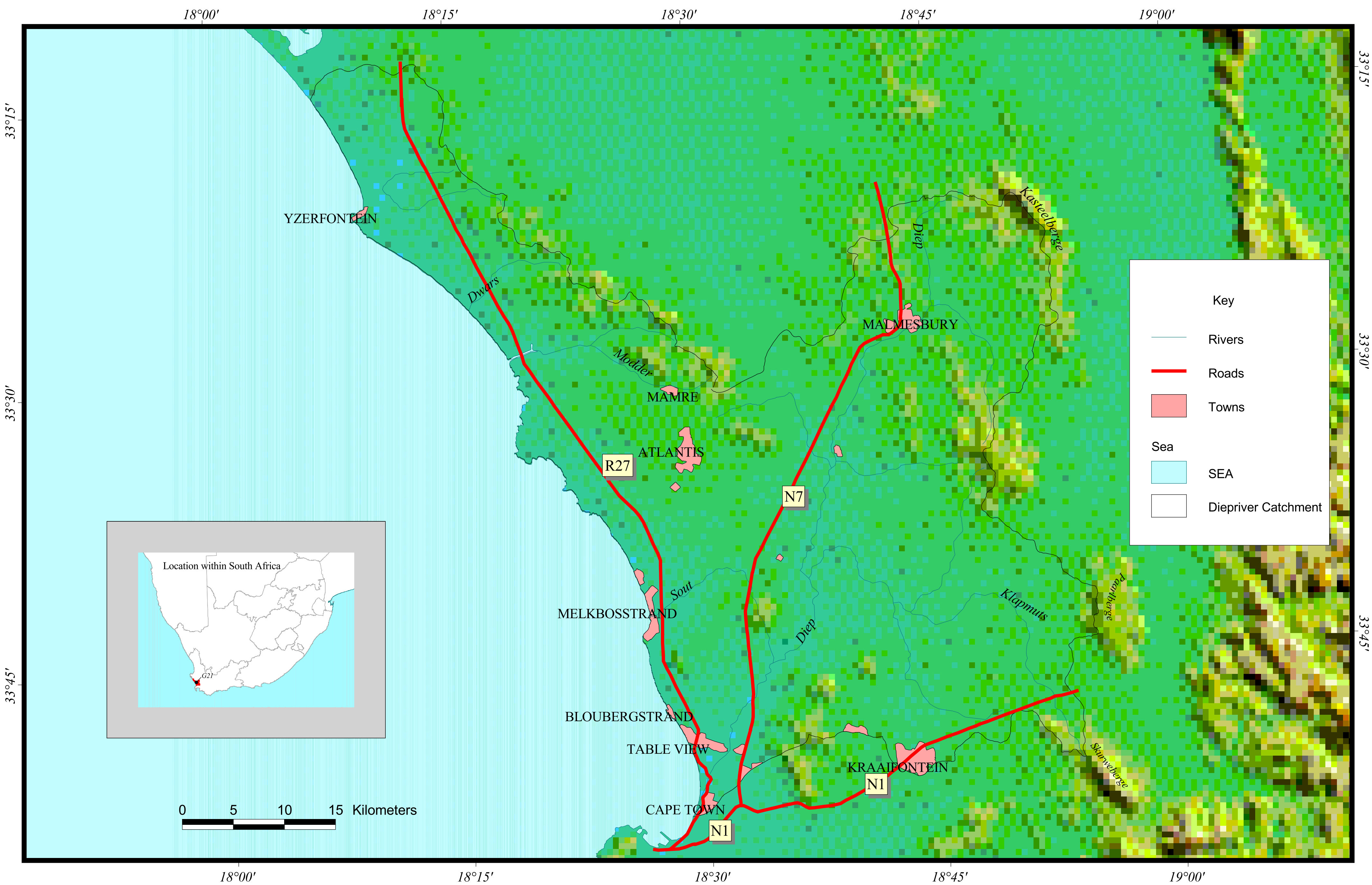

Fig1. General Map of The Diepriver Catchment

2.2 CLIMATE AND HYDROLOGY

This section of the report is mainly a summary of the report "Western Cape System Analysis, Hydrology of the Diep River System" (Richards C & Dunn P, 1994).

The Diep River and its tributaries lie in the winter rainfall region. Climatic conditions in the Diep River catchment are characterised by a winter rainfall regime with high summer evaporation. Precipitation is of a frontal nature with cold fronts approaching the catchment from the west. The mean annual precipitation in the catchment varies from approximately 1200 mm in the north-east to 400 mm in the south-west. The mean annual precipitation is approximately 500 – 600 mm. The wettest months are from May to October.

The mean annual evaporation rate is approximately 1600 mm. Hence the river tends to dry up in the summer seasons. Temperature varies from a minimum of 7 ^{0}C in winter to a maximum of 30 ^{0}C in summer. Bergwind conditions, however, can result in temperatures of up to 40 ^{0}C in summer.

The naturalised mean annual runoff for the Diep River Basin is 50 x 10^6 m^3, which represents a runoff to rainfall percentage of 7 %. Present day runoff from the basin given present day conditions of the catchment development is 45 x 10^6 m^3. This value is derived from combined simulated and observed flow sequences over the period 1920 to 1988.

Most cultivated areas are located in the west of the Diep River catchment within the Mosselbank River catchment and also in the north and east of the Diep River Basin. The capacity of farm dams in the catchment totals 18 x 10^6 m^3 of which 15.5 x 10^6 m^3 is located in the Mosselbank River catchment, the main tributary of the Diep River.

Development in the upper catchment consists of irrigation to the amount of 5 x 10^6 m^3, from the surface water for areas upstream of farm dams. Cultivated areas downstream of farm dams are assumed to be supplied from groundwater or include areas practising dryland farming.

TABLE 1. HYDROLOGICAL CHARACTERISTICS OF THE DIEP RIVER CATCHMENT

Flow gauge	Naturalised MAR (10^6 m^3)	Present Day MAR (10^6 m^3)	Change in MAR
G2H012	14.55	12.6	-13.4%
G2H013	15.5	14.0	-9.7%
G2H014	19.5	18.5	-5.1%
G2H014*	49.6	45.0	-9.3%

MAR - Mean Annual Runoff

* - Includes the inflows from upstream sub-catchments G2H012 and G2H013, there is a decrease in MAR, which might be due to exotic trees that take up much of the water, groundwater infiltration, evaporation and other factors.

Source: Richards C and Dunn P (1994).

Two distinct flood regimes are present in the Diep River/Rietvlei system; an upper one at Rietvlei which is dependent upon the river flow only and a lower one along Milnerton Lagoon, which is dependent on the opening of the estuary mouth.

ISSUES:

- The highest amount of rainfall occurs in the upper catchment.
- Development, e.g. irrigation amongst other uses, has significantly reduced the runoff.
- The river tends to dry up in some areas during the summer seasons.
- The number of impoundments in the upper catchment reduces the flushing abilities of the river.
- The simulated MAR does not clearly indicate the quantity contribution of the treated wastewater to the river (from the Malmesbury Wastewater Treatment Works (WWTW), Kraaifontein WWTW, and Milnerton WWTW).

2.3 GEOLOGY AND SEDIMENTATION

The predominant geological formation is the Malmesbury Group (Tygerberg & Moorreesburg). This is interspersed with the Cape Granite and Klipheuwel groups, while alluvium, sand, and calcrete are found on the coastal plain (Figure 2).

The Malmesbury Group rocks are poorly exposed, consisting of low rolling hills, and have been subject to low grade regional metamorphism (Truswell, 1970). The sediments consist of a variety of shales, greywackes, chert, basic lavas, and tuffs. In the catchment arenaceous slates (greywackes), alternate with more argillaceous shales. Quarries provide exposures of the greywackes and shales, where the arenaceous rocks are being quarried for building material.

The Cape Granite Group is characteristically light grey, porphyritic and intrudes into the sediments of the Malmesbury Group. The Klipheuwel Beds outcrop at the village of Klipheuwel and the contact with the Cape Granite is visible in a large disused quarry. At this intensive contact the feldspar of the granite is almost completely altered to kaolinite. However, due to the small areas of outcrop of the Cape Granite and Klipheuwel Beds their contribution to the lagoon sediments is small in comparison to that of the Malmesbury Group (Du Plessies, 1983).

The dominant source of clay minerals in the Milnerton Lagoon sediments is most likely to be the Malmesbury Group rocks which crop out or are present under the soil of most of the catchment area of the Diep River, Figure 2. Some clay minerals could be derived from the small areas of Cape Granite and Klipheuwel Group, but these are not expected to be important when compared with the contribution from the Malmesbury Group. The clay fraction of the sediments in the lagoon is detrital and not authigenically formed. The argillaceous Malmesbury rocks are preferentially depleted in potassium relative to rubidium on weathering (Du Plessies, 1983).

Rietvlei and the Diep River have silted up considerably in the past few centuries and extensive erosion has taken place in the Swartland and Sandveld (Grindley & Dudley, 1988). Extensive silt deposition due to erosion in the catchment has resulted in the substratum of both Rietvlei and most of the estuary being muddy.

Rietvlei acts as a large storage area of sediment-rich water during river floods and after the floods the water levels gradually drop because of the drainage of the vlei. During this period large amounts of sediment settles in the vlei. The rate of sedimentation is further enhanced by vegetation in the vlei, especially in the north-eastern area where treated sewage water is being released. The purpose of the recently (1991/1992) excavated channel between the Blaauwberg Road Bridge and the Otto du Plessis Bridge along the eastern border of the nature reserve was to enhance drainage of the nutrient rich treated sewage water and to indirectly reduce the sedimentation rate. This channel causes most of the river water to by-pass the main wetland area of the vlei. A major consideration for the excavation of the channel was the fear that increased siltation might lead to increased danger of flooding of adjacent residential properties during river flooding.

In the long term (50 to 100 years from now) the whole Rietvlei might silt up completely and totally loose its character as a wetland. It is important to determine the rate at which sedimentation is taking place and if warranted, to explore possible management options to delay or stop the process (Lochner P, L Barwell, and P Morant, 1994 (b)).

ISSUES:

- Disused quarries have the potential to increase the rate of sedimentation in the estuary
- Quarries provide exposures of the greywackes and shales, where the arenaceous rocks are being quarried for building material and it leads to a problem of siltation.
- The Estuary is muddy due to erosion in the catchment.
- Potential for Rietvlei to silt up and loose its character as a wetland.

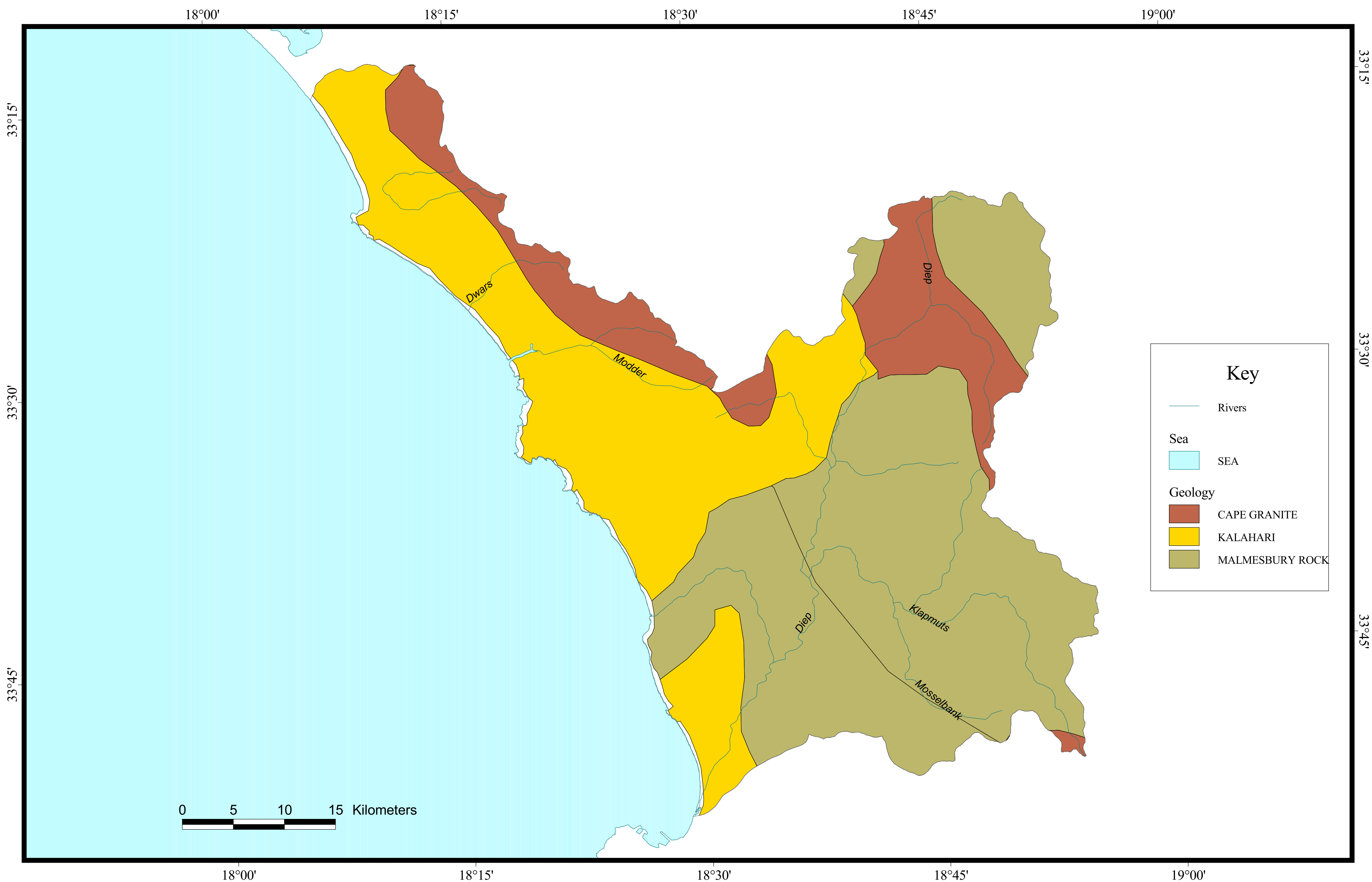

Fig2. Geology

2.4 SOILS

The riverbed is underlain by undifferentiated soils with a high brackish potential. The catchment consists mainly of shallow residual soils of the Mispah, Glenrosa, Swartland and Sterkspruit soil forms and medium to coarse sands (Kroonstad – Esteowt dominant, Sterkspruit – longlands subdominant soil forms). Red soils, shales and rocky soils also occur in the higher lying areas (Du Plessis S P B, 1983).

2.5 GEOHYDROLOGY

Geohydrology is strongly influenced by the geology of the area. According to the geology, this area can be divided into two distinct aquifer systems. Firstly, an upper primary aquifer located in the unconsolidated alluvial gravels and scree on the banks of the Diep River. Secondly, an unconfined to semi-confined deeper secondary aquifer located in the Granites and Malmesbury Group Rocks. In places these two aquifers are separated by a clay aquiclude, which is absent when the rock strata crop out at the surface.

1. Primary Aquifer: This aquifer is situated in a 2-3 m thick surficial scree and alluvial gravel deposit located next to the Diep River. These deposits are sub-angular to angular in nature and fairly well sorted. The rest-water level within this aquifer is shallow, about 0,5 m below the surface during the dry summer months. Therefore, many residents in Abbotsdale have dug wells into this aquifer to supplement their existing water supply.

2. Secondary Aquifer: The secondary aquifer is located in the underlying Granites and Malmesbury Group Rocks, which retain and transmit the groundwater in cracks, fissures, joints and faults caused by weathering, cooling and deformation.

2.6 VEGETATION

A summary of the results from the reports, “Estuaries of the Cape” (Grindley JR, S Dudley, 1988), “Caltex Rietvlei Wetland Reserve - Management plan and Appendices report” (Lochner P, L Barwell, and P Morant, 1994 (a) & (b)), “A preliminary Assessment of the vegetation of the Diep River” (Boucher, 1995), follows below. A map indicating the vegetation types is shown in Figure 3.

2.6.1 Diep River

Aquatic Vegetation (Plants located in free water)

Plants located in this zone are sensitive to the state of the water (depth, current strength, and nutrient status). Common dominant plants on the wet banks include *Phragmites australis*, *Paspalum distichum*, and *Paspalum vaginatum*. A reduced flow because of dams has resulted in an increase in these species, and they sometimes block the channels. The exotic fern *Azolla filiculoides* was the only aquatic species regularly recorded which could be used to typify the aquatic zone vegetation. It clogs waterways and provides shelter for aquatic organisms such as mosquitoes.

Moist to wet bank fringing vegetation

Common species along the wet banks are subjected to regular floods (inundation) during the winter months. The presence of very few indigenous species like bush willow is probably related to changes in the system rather than being the result of over utilisation. There are numerous accompanying species that have narrow habitat tolerances in this zone such as the foothill zone marsh species and the halophytes.

Dry bank riparian vegetation

Common widespread species are all weeds. Indigenous species that are regularly found in the West Coast Renosterveld are *Cynodon dactylon*, *Elytropappus rhinocerotis*, *Galenia africana*, *Lycium cinereum,* and *Olea europaea ssp. africana*. This vegetation generally consists of tall shrubs to short trees with weeds in the disturbed sandy areas in between. The indigenous tall shrub and tree flora, including *Acacia karoo* (referred to by Van der Stel), *Maytenus oleoides* (used for firewood), *Olea europaea ssp. africana* (used as durable fencing poles and firewood), *Podocarpus elongatus* (used for firewood and building timbers), etc., have all but disappeared from this river system (Boucher C, 1995).

Exotic vegetation

A third of all the species collected in this river were found to be exotic. It is claimed that their physical control will increase the summer flows in the Diep River system to the benefit of the river. Dense stands of these exotic invaders block the channels and result in the modification to the channel shape, usually resulting in a narrower and deeper sub-channel within the larger main channel. Siltation is more prevalent in the dense stands. Winter flood events are then more likely to flood adjoining farmland.

2.6.2 Estuary (Rietvlei and Milnerton lagoon)

The vegetation appears to be determined largely through interactions of hydrological variables with climate and soils. These have resulted in several well-defined habitats that can be distinguished mainly in terms of hydrology, nutrient input as well as, to a lesser extent, halophytic status. Such habitats provide, in effect, priority zones for sampling vegetation. The relatively clear-cut separation between wetland communities is made possible by the quite low overall diversity. Three broad vegetation types, viz. Dune Thicket, Sand Plain Fynbos and a transition between the two. See Table 18 in the Appendix A, which gives the plant communities, environment and invasion status.

ISSUES:

- A reduced spate flow in the Diep River caused by dams results in an increase in aquatic vegetation, and they sometimes block the channels.

- Indigenous tall shrub and tree flora has disappeared from the river system.
- Eutrophication and siltation prevailing in the dense stands of exotic invaders cause further alien vegetation infestation.

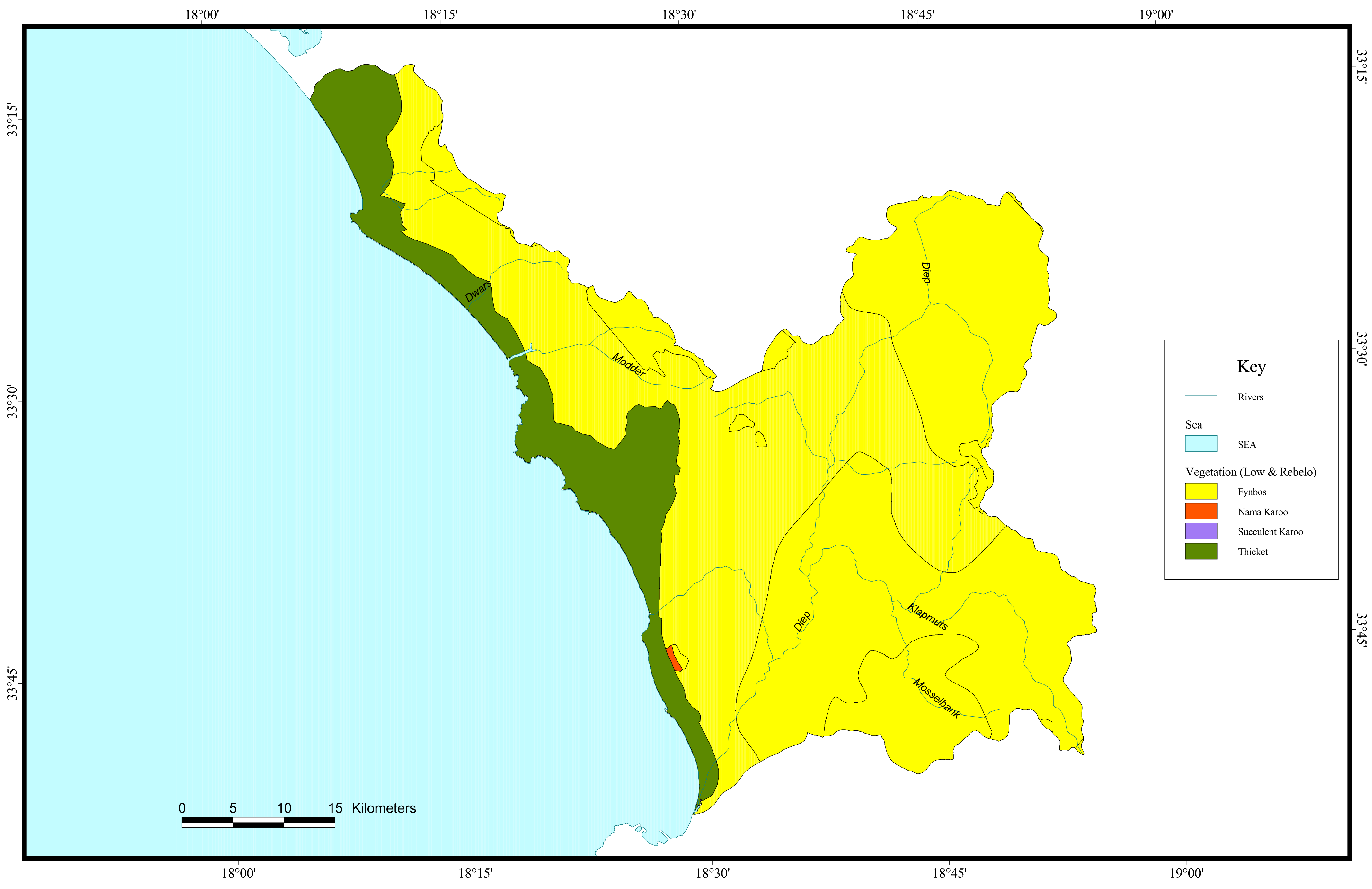

Fig3. Vegetation

2.7 ESTUARINE AND COASTAL FEATURES

Historical accounts indicate that the Diep River mouth was almost permanently open to the sea. Data collected between 1948 and 1953 show open mouth conditions during winter and closed mouth conditions during summer (Grindley JR & Dudley S, 1988).

Recently, the mouth has been closing more often, especially in summer. Sedimentation in the vlei and in the estuary probably results in a reduction in tidal flows, which become too weak to maintain open mouth conditions. More open mouth conditions were experienced after areas of the estuary were dredged as part of the Woodbridge Island development. The mouth did not close during the summer of 1992/1993 after the excavation of the channel between the Otto du Plessis Bridge and the Blaauwberg Bridge in the vlei (Lochner P, L Barwell, and P Morant, 1994 (b)).

The stability of an estuary mouth and especially the mouth openings and closures are mainly determined by river inflow, tidal flows and wave conditions. River inflow and tidal flows are the main aspects maintaining open mouth conditions and high waves are normally the main reason for mouth closures. However, the mouth of the Diep River is largely protected against south-westerly waves by the Green Point area of the Cape Peninsula. See Figure 4 for features of the estuary.

Wind driven currents are the predominant drivers of inshore water movement in Table Bay, with tides and the Benguela Current only making a small contribution. Under certain conditions deep sea swells may reach the river mouth. These waves are also responsible for the generation of the longshore current and sediment movement. The overall water movement is northward, where water enters Table Bay between Green Point and Robben Island and exits between Robben Island and Melkbosstrand. Current speeds and directions, due to their dependency on wind, are found to be generally weak and variable, especially during winter months. Residence times of water within Table Bay are thus also varied, generally 1-4 days or longer.

ISSUES:

- Closure of the mouth has been occurring more frequently, especially during summer.
- Sedimentation in the vlei and the estuary during the summer season reduces in tidal flows

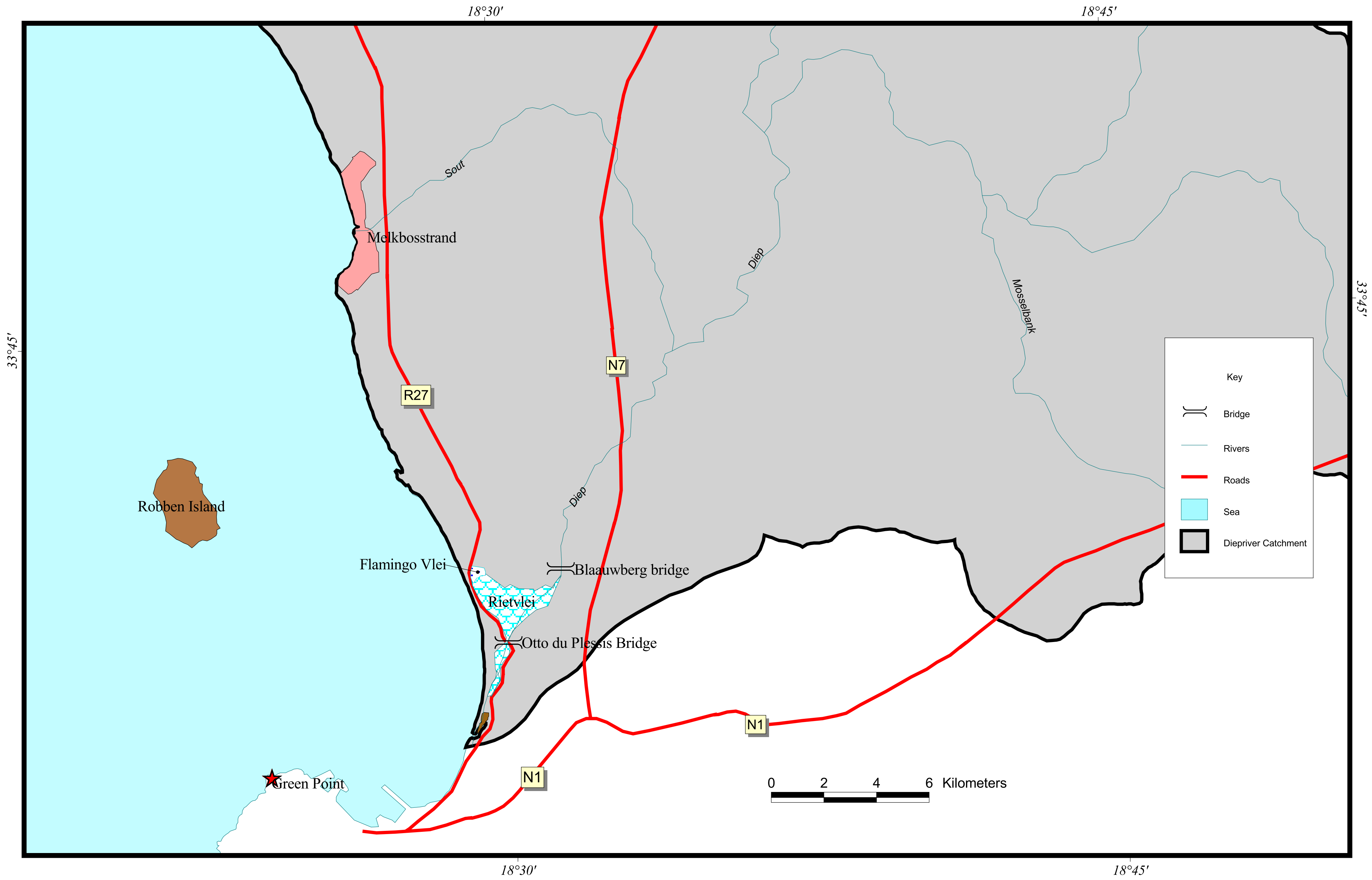

Fig4. Estuary Features

2.8 ISSUES

The key issues raised in this chapter, in terms of river, are summarised below:

TABLE 2. SUMMARY OF NATURAL CHARACTERISTICS AND HUMAN IMPACT ISSUES

Issue	Description
Alteration of flow/habitat	At the Riebeek-Kasteel Mountains, development is unlikely and runoff potential is high.
	The highest amount of rainfall takes place in the upper catchment.
	The river tends to dry up in some areas during the summer seasons.
	The numbers of impoundments upstream of the catchment reduce the flushing abilities of the river
	There is lack of confidence in the simulated MAR, that excludes the quantity of the effluent from the Malmesbury Wastewater Treatment Works (WWTW), Kraaifontein WWTW, and Milnerton WWTW.
	A reduced spate flow in the Diep River caused by dams results in an increase in aquatic vegetation, and they sometimes block the channels.
	Sediments of the vlei and estuary results in reduced tidal flows and increase in mouth closure during summer.
	Indigenous tall shrub and tree flora has disappeared in the river system.
Water Quality	Flamingo Vlei is dredged and this has a potential effect of increased siltation.
	Disused quarries have the potential to increase sedimentation in the estuary.
Development	Expect greater impacts in the lower catchment, due to increasing human activity (increased industrial activities and population).
	Development, e.g. irrigation amongst others, has significantly reduced the runoff.
	Urban encroachment result's in destruction of natural vegetation.
	Unregulated recreational utilisation of the river also destructs the natural vegetation.