CAPE Estuaries Programme

Situation Assessment for the Zandvlei Estuary

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Prepared by Coastal & Environmental Consulting
1 Karakal Road,
Hout Bay 7806.
Acknowledgements

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City of Cape Town (undated) Zandvlei: Factors concerning Water Level Management. Pamphlet.


We would also like to thank all the individuals who contributed their time and knowledge.

The Coastal & Environmental Consulting Team

Lynn Jackson (CEC: Project Manager)
Julian Conrad (GEOSS)
Marilie Carstens (GEOSS)
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1. INTRODUCTION

1.1 Geographic location and definition of the estuary

The Zandvlei catchment falls entirely within the boundaries of the City of Cape Town, and is bordered by Muizenberg Mountain, Silvermine Plateau, Constantiaberg, Cecilia Ridge, Wynberg Hill, and a less conspicuous watershed along the eastern boundary. It is a relatively small catchment comprising an area of 92 km² or 9,655 ha, and is drained by a number of rivers and streams of which the main ones are the Little Princess Vlei Stream, Westlake Stream, the Keysers River, Langvlei Canal and the Sand River Canal/Diep River.
These rivers converge on Zandvlei, with the Keysers River and Westlake Stream entering it through an extensive reed bed on its north-western margin, while the Sand River canal enters the vlei east of Wildwood Island. The wetland area covers some 60 ha, while the main body of the vlei is 56 ha. In addition, the system includes a marina of 31 ha along its eastern margin, and an outlet channel of 9 ha which links to the sea on the north-western shore of False Bay.

For purposes of this Assessment and the Estuary Management Plan, the estuary is defined as the area from the estuary mouth, to the upstream end of the wetlands. Both the northern and lateral boundaries comprise the 100-year floodline as shown in Figure 2 below.
1.2 Climate and vegetation

The Zandvlei catchment falls into the Southern Management Area of Cape Town which has a mean annual precipitation of 711 mm and an estimated mean annual runoff of 73 million m\(^3\). Since the south-western Cape is a winter rainfall area, there is high seasonal variability with limited summer rainfall. The hot, dry and windy summers in the region also result in a mean annual evaporation rate of 1,400 mm (DWAF, 2005).

This area is part of the Cape Floral Kingdom, one of six global floral kingdoms, and is characterized by high levels of endemism. The ecoregion within which the Zandvlei catchment is situated is known as the Southern Folded Mountains and is characterized by Fynbos and Strandveld vegetation.

1.3 History and socio-economic context of the estuary

The proximity of Zandvlei to Cape Town and the warmer waters of False Bay made it suitable both as a source of agricultural products, and a holiday destination. Its location on the route between Cape Town and Simon’s Town also gave impetus to the development of the village of Muizenberg on its western bank. As Cape Town grew, so did the extent and scope of agricultural activities and urbanisation both within the Zandvlei catchment and on the margins of the estuary, with the result that Zandvlei has been progressively and significantly modified and degraded over the past few centuries. Nevertheless, it remains an important conservation and recreational resource.

1.3.1 Historical background

An early map of the Cape Colony depicts Zandvlei as an inlet on the False Bay coastline. It had apparently already been named by Jan van Riebeeck and in 1673, was selected as a site for the establishment of a cattle post for the Dutch East India Company. Some 70 years later, the area was fortified with Muizenberg village becoming a staging post for the journey between Cape Town and Simonstown. After the British took control of the Cape in 1806, the military role of Muizenberg was diminished and it became more important just as a halfway station to Simon’s Town and a resort area with the first hotel opening in 1851 (Urban-Econ, 2001).

Early interventions to the functioning of the vlei were linked to a period of drought and economic depression, when, in 1866, a decision was taken to close off and drain the vlei with a view to using the land for agricultural purposes. This plan was foiled by the onset of the winter rains and the re-flooding of the vlei. Nevertheless, there was an expansion of agricultural activities in the catchment and surrounding areas to include viticulture, market gardening, dairy and poultry farming. Starting in the 1930’s this resulted in the construction of weirs at the entry points of the rivers into Zandvlei so as to prevent salt water intrusion and preserve water quality for irrigation purposes. These weirs were later removed – the last being that at the railway causeway which was removed in 1989 - although some still remain higher up on the river courses – for example, at the southern end of Little Princess Vlei. There is also a gabion wall on the Keysers River where it passes under the van der Stel freeway.
The use of the area as a resort escalated following the establishment of a rail link in 1882. The railway line effectively cuts off the wetlands in the north-western corner of the vlei, although there is a causeway beneath it which allows the flow from the Westlake stream and Keysers River to enter the main body of the vlei. One of the consequences of this is that the flora to the west of the causeway has changed to one more characteristic of a freshwater system.

The establishment of the railway line also led to an increase in the number of permanent residents in the area, and in 1891, a village management board was established. By 1893, there were 1,456 residents in 189 houses. Associated with this urbanization, there was increasing recreational use of the vlei, with the first recorded rowing regattas being held in 1884. Fluctuations in the water levels impeded these activities and plans were therefore made to retain water in the vlei. Boating activities were expanded with the establishment of the Lakeside Boating Association in 1907. This later became the Imperial Yacht Club which is still in existence today, although it was disbanded between 1946 – 1962 when it was no longer useable as a result of siltation and weed infestation. The silt was removed by dredging between 1947 and 1961 with some 760,000 m$^3$ being removed.

In 1913 the area was incorporated into Cape Town resulting in a further escalation of its development as a tourist and seaside suburb. This included the development of a road network and beachfront infrastructure. The increasing recreational use also led to the canalization of the outlet channel in the 1950's and the construction of the Promenade and Royal Road Bridge over the mouth. A rubble weir was subsequently built just downstream of the bridge initially to protect a sewer pipeline against scouring. However, this was then also used in combination with the sandbar at the mouth to maintain water levels for boating and in 1983 was raised from 0.7m aMSL to 0.84m aMSL; and in 1989 from 0.84m to 0.9m aMSL. In 2001, it was lowered again to 0.7m aMSL.

From the 1950's, a variety of factors led to a decline in the use of Muizenberg as a holiday destination. This increased the importance of its residential function which in turn led to a greater appreciation of its conservation, cultural and historical significance. Residential developments included Marina da Gama – proposed by Anglo American and originally intended to incorporate most of Zandvlei – which was constructed on the eastern shore of the vlei between 1969 and 1973. The dredged material produced during the excavation of the marina canals was used to construct Wildwood and Park Islands which lie between the marina and the main body of the vlei.

At the same time, there was also significant urbanization of parts of the catchment, including the development of some industrial areas such as that in Retreat. By 1991, there were an estimated 35 – 45,000 people living in the catchment, and it was projected that another 40,000 would be accommodated in developments to the east of the marina (Thornton et al, 1995). More recent developments have, in fact, included the Westlake residential and office development to the west, the Capricorn Business and Technology Park to the east, and a number of low-cost housing areas to the north.

The first official recognition of the conservation value came with the approval of the establishment of the Zandvlei Nature Reserve by the Cape Town City Council in 1977. From 1982, calls were made for the expansion of the reserve and in October, 2006 the Greater Zandvlei Estuary Nature Reserve was formally established.
In summary, activities in the catchment, together with the intensive urbanization around the estuary, have, over the centuries, not only physically modified it, but have brought a variety of problems, including reduced water flows, siltation and changes in the drainage patterns, a deterioration in water quality and changes to the biodiversity.

1.3.2 Current socio-economic context

Land-use in the catchment is highly varied ranging from light industry to housing, agriculture, forestry and conservation. In general, the more heavily urbanized areas – including industrial and commercial areas and middle to lower-income housing – are situated in the eastern part of the catchment (42%) centering around the Diep and Sand Rivers and Langvlei Canal. Agricultural land, forested areas and middle to high-income housing are located in the west of the catchment (58%) along the Keysers River and Westlake Stream and their tributaries. The light industrial area of Retreat however, is adjacent to the Keysers River a short distance upstream of where it discharges into Zandvlei. A map of land-use in the catchment, reproduced from the Sand River Catchment Management Plan is shown in Fig. 3 below.

Fig. 3 Land-use in the catchment (reproduced from the Catchment Management Plan (Jeffares & Green, 2003)
Although the catchment as a whole has a relatively low population, the eastern parts, together with lower reaches of the river – including the estuary – fall within a highly urbanised environment. The 1996 census data put the population figure at 10,472 for Muizenberg, Lakeside and Marina da Gama alone while the projections from Thornton et al (1995) quoted above, suggest that the population for the catchment as a whole could be of the order of 100,000.

Despite the modifications that have taken place, Zandvlei remains highly valued for its natural attributes and the recreational opportunities which it affords. Recreational use includes various boating activities, picnicking, birdwatching, hiking and a limited amount of fishing, although bait collection is not permitted. It is regarded as being of regional importance in recreational terms, and hosts a number of sports events including an international kite-flying competition, provincial canoe championships, and various yachting events.

There is also an increased understanding of the need to maintain the environmental health of Zandvlei in order to optimize the recreational and conservation benefits. The GZENR also has a strong environmental education programme involving both learners from local schools, and a number of environmental clubs, and local residents are actively involved in the management of the area.
2. BIO-PHYSICAL DESCRIPTION OF THE ESTUARY

Based on historical maps, Morant and Grindley (1982) surmised that when the first European settlers arrived in the Cape, Zandvlei would have had a wide mouth within which the outlet channel moved in response to various natural, physical factors. It would most likely have functioned as a true, tidally flushed estuary for most of the year, with the mouth closing only seasonally. Water levels would have fluctuated widely, and an aerial photograph from 1944 (in Ninham Shand (2000) Annexure 6) shows that large areas of the vlei even dried up at times, leading to hypersaline conditions. According to Stephens (1929), the shoreline was a gentle slope and the water body was surrounded by extensive muddy marshlands.

Over the past 300 years the estuary has been subjected to significant physical modifications. The mouth has been canalized and a weir placed across it, parts of the vlei have been dredged, the shores which were originally gently sloping have been replaced by artificially stabilized steep banks, the north-western corner has been separated from the main body of the vlei by a railway embankment, and the eastern boundary has been converted into a marina. Although much of the shoreline is reserved as public open space for at least 50 – 100 metres from the water’s edge, it is effectively surrounded by urban development and there is no doubt that it bears little resemblance to its original form.

In addition to the physical alterations, the water levels in the vlei – which would originally have been subject to wide seasonal fluctuations – have been manipulated for a variety of purposes from the prevention of flooding to enhancing recreation.

Zandvlei estuary today comprises a wetland area covering some 60 ha on its north-western extremity, the main body of the vlei, which is 56 ha, a marina of 31 ha along its eastern margin, and an outlet channel of 9 ha which links to the sea on the north-western shore of False Bay. The Westlake stream and Keysers River enter the vlei through the wetland, while the Sandvlei canal discharges into it on the northern boundary, east of Wildwood Island.

Despite these changes, Zandvlei still supports a wide diversity of birds, and is especially important as a refuge for waterbirds during the summer months. It is also the only semi-functional estuary on the False Bay coastline and was ranked 46th out of South Africa’s 250 estuaries in terms of conservation importance (Turpie, 1995).

2.1 Geology of the catchment

The geology of the catchment is important in as much as it determines the extent and nature of the groundwater as well as the characteristics of the water and sediments which flow down river. The geology of the area is shown in Figure 4.

Within the Zandvlei Catchment the basal geology comprises a very small outcrop of the Malmesbury Group. This outcrop is in the northwest of the catchment comprises the Tygerberg Formation (Nt) of the Malmesbury Group. This formation consists mainly of alterations of greyish-to-greenish, medium-to-fine-grained greywacke, phyllitic shale, siltstone and immature quartzite (Theron et al, 1992). The specific outcrop in the
Zandvlei catchment is anticipated to be a greywacke (angular-to-poorly rounded quartz and feldspar grains and lithic fragments, all set in a clay rich matrix). The Malmesbury Group (Ma) is of Namibian Age, approximately 600 million years old.

Cape granite also occurs in the catchment and is intrusive into the Malmesbury Group. The granites are high level diapiric plutons which crystallised from magma formed by anatexis at progressively higher levels in the crust. The youngest Cape granites are dated at 530 +/- 15 Ma. The granite within the catchment is part of the Cape Peninsula Pluton (N-Cc). The granite in the study area is a course grained, porphyritic biotite granite, typically containing large feldspar crystals (orthoclase). The granite outcrops in the western portion of the catchment lie beneath the picturesque sandstone cliffs which form the western rim of the catchment.

The granites are overlain by the Peninsula Formation (Os) of the Table Mountain Group (TMG). The Peninsula Formation in the area is in excess of 500 m thick. The Table Mountain Group is approximately 450 Ma. The Peninsula Formation directly overlies the pre-Cape rocks and coarse sandstone and grit layers with granite, vein quartz or even Malmesbury Group hornfels pebble can occur at the geological contact. The Peninsula Formation consists of uniformly light grey, medium-to-course grained, well bedded quartzitic sandstone. It is generally thick bedded. The Peninsula Formation is very hard and resistant to erosion, thus forming the mountain ranges around the Cape Peninsula. It also forms the well defined western rim of the catchment.

The next youngest formation within the study area comprises the Quaternary age deposits (<1.8 Ma). The Quaternary deposits consist largely of aeolian sand, but minor fluvial-to-marine deposits also occur. The Springfontyn Formation (Qs) covers the majority of the catchment area, especially the low relief area. The formation is a well-sorted, fine-to-medium-grained quartz sand and light grey-white to pale red in colour. It can range in thickness from 25 m to 65 m. In places the Springfontyn Formation does contain peaty layers. The silica sand deposits of the Cape Flats are considered part of the Springfontyn Formation.

The Witzand Formation, also of Quaternary Age, overlies the Springfontyn Formation in the catchment. Importantly, Zandvlei itself is within the Witzand formation which extends from the coast (False Bay) in a northerly direction up to Princess Vlei. The Witzand Formation consists of light coloured, calcareous dune sand. It is easily recognised by its light colour as the name implies and often is exposed as un-vegetated, shifting dune sand deposits.

Also within the catchment reddish-to-light-brown, sandy-to-gritty, clayey soils occur (Qgg) which are weathering products of the granite and are in close association to granitic outcrops. The slopes beneath the sandstone outcrops in the western portion are covered by boulders and scree, which are products derived from the weathering of the Peninsula Formation.
2.2 Geohydrology and the contribution of aquifers to flow

The groundwater quantity and quality within the Zandvlei catchment varies with the geology, with electrical conductivities ranging from 10 to 1,000 mS/m.

In the Malmesbury Group, the groundwater is generally of a sodium-chloride-alkaline nature (Meyer, 2001). However the occurrence of the Malmesbury Group within the Zandvlei Catchment is very limited.

The Cape Granite Suite does constitute an aquifer but borehole yields are typically low (< 1 l/s). Occasionally higher yielding boreholes can be drilled in the granites but these are rare. Although groundwater quality varies in the granites (30 to 350 mS/m, Meyer 2001) in most cases it is good quality (EC <70 mS/m). Groundwater in the granites generally displays a sodium-chloride sulphate nature.
The Table Mountain Group (TMG) (especially the fractured arenaceous components – e.g. the Peninsula Formation) is largely anisotropic and does not display uniform aquifer characteristics. An intricate network of fissures, joints, fractures and even cavities, govern the infiltration, storage and transmission of groundwater in the largely competent and brittle-natured, arenaceous units of the TMG. The TMG constitutes the mountainous areas which, in turn, influence precipitation to a significant extent. Due to the fractured nature of the sandstones and occurrence in generally high rainfall regions, groundwater recharge is favourable and a recharge rate of 15% precipitation in certain areas is possible (Meyer, 2001). Groundwater springs are a further characteristic of the TMG and it is quite feasible that there are a number of springs within the catchment area. The quality of groundwater from the TMG is usually excellent with ECs ranging between 5 mS/m and 70 mS/m. The groundwater is generally of a sodium-chloride character and typically quite acidic.

The Springfontyn Formation hosts an intergranular aquifer and the eastern boundary of the Sand River Catchment is in close proximity to the Cape Flats aquifer. This is one of the most extensive primary aquifers in South Africa. The Cape Flats Aquifer has a high storage capacity (1 500 x 10^6 m^3), a high yield (15 x 10^6 m^3/a), and based just on EC, acceptable water quality (60-135 mS/m).

The groundwater potential from the Witzand Formation is also good in terms of both quality and quantity. It also constitutes a significant intergranular aquifer. The Sandveld Group aquifers (i.e. Springfontyn and Witzand Formations) generally display a sodium-chloride-calcium-alkaline nature.

In summary, of the fractured aquifers, the Table Mountain Group (Peninsula Formation) is the most significant within the Sand River Catchment. It contains significant volumes of groundwater and may possibly even give rise to springs. Although the TMG is not in direct contact with Zandvlei, there may be recharge of the underlying granites and discharge into the western side of Zandvlei. Groundwater and streams emanating from the TMG will be of very good quality (low EC) and acidic. The groundwater level to the north and east of Zandvlei is shallow and contribution of groundwater to the Zandvlei will be significant. This groundwater may be slightly alkaline and will have a higher EC than TMG water, but in its natural state is still good quality water. However, the shallow groundwater level, porous nature of both the unsaturated (vadose) and saturated zone, the high vertical groundwater recharge, flat lying ground surface and shallow groundwater gradients, within a highly urbanised setting, results in an aquifer that is very vulnerable to contamination from both point and non-point sources of pollution. It is highly probable that the groundwater in the intergranular aquifers in the Zandvlei region has been negatively impacted.

Despite the availability of groundwater in the catchment, its contribution via interflow or baseflow to the river systems within the catchment area will be limited due to the extensive canalisation of the river channels.
2.3 Hydrology

The Zandvlei catchment lies in the southwestern Cape, where climatic conditions 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.

Morant and Grindley (1982) gave the mean annual rainfall for two rain gauges in the area as follows:

<table>
<thead>
<tr>
<th>Location</th>
<th>Period of records</th>
<th>Mean annual rainfall (mm)</th>
<th>Monthly rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tokai State Forest Station</td>
<td>72 years</td>
<td>983.6</td>
<td>164.5 164.5 21.1</td>
</tr>
<tr>
<td>Plumstead</td>
<td>30 years</td>
<td>887.4</td>
<td>193.8 193.8 13.7</td>
</tr>
</tbody>
</table>

For both locations, the highest precipitation occurs in June, and the lowest in February. More recent rainfall data is available on the Zandvlei Trust website under the Zandvlei Inventory and Monitoring Programme (ZIMP).

Temperature varies from a minimum of 7 °C in winter to a maximum of 30 °C in summer. Bergwind conditions, however, can result in temperatures of up to 40 °C in summer. The mean annual evaporation rate is 1477 mm (DWAF, 2005).

The main rivers within the Zandvlei Catchment are (see also Fig. 1):

- Little Princess Vlei Stream (1.05 km)
- Westlake Stream tributaries (1.10 km)
- Keysers River tributaries (2.20 km)
- Langvlei Canal (3.95 km)
- Westlake Stream (4.70 km)
- Keysers River (7.50 km)
- Sand River Canal/Diep River (12.60 km)

Of the two longest rivers, the Keysers River runs parallel to the railway embankment on the embankments western side and enters the Westlake portion of Zandvlei through an extensive reed bed. The Westlake Stream also enters this reed bed at its western extremity, and the combined waters of the Keysers Rivers and Westlake Stream then enter the main basin of Zandvlei via the single bridge in the railway embankment. The confluence of the Sand River and Langvlei Canal lies approximately 1 km north of Zandvlei. These combined canalised streams enter the vlei on the east side of the Wildwood Island (Morant and Grindley, 1982).

The installation of flow gauges on the inflowing streams and at the estuary mouth has been recommended a number of times previously. To date, however, no flow gauging stations have been installed with the result that accurate data for the inflowing streams is not available. However, according to Thornton et al (1995) there is a flow gauging station at the outlet of Little Princess Vlei, and this, together with a level recorder in Zandvlei and rainfall data, was used to construct a water balance for the vlei based on records between 1983 –1987. On this basis, the mean annual freshwater inflow to Zandvlei was estimated to be 22 x 10^6 m^3/annum, with 45% of the flow coming from the Keyser’s River; 43% from the Sand River, and 12% from Westlake.
The model used in the Ninham Shand study (2000) showed that during a 1 in 50 year flood there would be a maximum of 57 m$^3$/s discharging into Zandvlei.

Zandvlei is a shallow basin approximately 2.5 km long and with a maximum width of 0.5 km (excluding the marina) near the northern end. The total volume of Zandvlei – including the marina and outlet channel - was estimated to be 1.33 x 10$^6$ m$^3$ (Harding, 1994). The orientation of the vlei on a north-south axis coincides with the prevailing winds thus promoting good wind-induced mixing of the water.

Historically there was also significant intrusion of saline waters into the system as a result of tidal fluctuations. As a consequence of various physical alterations to the mouth, this now only occurs on an intermittent basis as is further discussed below. Nevertheless, seawater inflows were estimated at 3.1 x 10$^6$ m$^3$/annum (Thornton et al, 1995).

The water quantity requirements of the estuary have not been determined.

2.4 Sedimentation

Morant and Grindley (1982) stated that loose material from unstablised areas (e.g. building sites) entered streams flowing into Zandvlei and that at times, a delta of up to 7,000 m$^3$ had developed where the Sand River enters the vlei. To contain this, a sediment and garbage trap has been built downstream of the Sand River and Langvlei canal confluence. Moreover, the extensive Phragmites and Typha reed beds in the West Lake (northwest) area of Zandvlei trap much of the sediment which would otherwise enter the main vlei basin from the Keyser and Westlake rivers. However with continual development and urbanisation, silt levels are anticipated to increase in the inflowing rivers. This is exacerbated by the strong, south-easterly winds in the summer which add to the sediment load.

Ninham Shand (2000) estimated that a total of 44 000 m$^3$ of sediment had accumulated in the vlei between 1988 and 2000. This equates to approximately 6.5 mm per year over the total vlei area or 77 mm for the 12 year period, compared with 50 mm for the 12 year period from 1958 to 1970. Most of the sedimentation took place in the “delta area” (where the Keysers and Westlake Rivers and Sand River canal enter the vlei). This is in spite of regular clearing of the lower reaches of the rivers.

The thickness of the organic silt depth is approximately 0.5 m in the stagnant areas of the vlei and reduces to approximately 0.1 m in the main vlei body and in the marina.

In addition to the sediments from upstream, there is considerable encroachment of sea-borne sand (up to 6 000 m$^3$) into the Zandvlei outlet channel downstream of Thesen’s footbridge (City of Cape Town, 1989).

2.5 Mouth dynamics and water levels

According to early maps, Zandvlei had a wide mouth and it is likely that the drainage channel moved within that in response to various factors. At that time, it most probably functioned as a true, tidally flushed estuary for most of the year, with the mouth only
closing in the late summer months when there was insufficient inflow from the rivers to keep it open.

Under these conditions, water levels of between 2.5 and 3 m aMSL would have been reached in the estuary. As reported in Ninham Shand (2000), this would have resulted in large areas adjacent to Zandvlei being flooded before breachings occurred. After breachings, large amounts of sediments would have been flushed from the mouth opening, resulting in scoured channels with depths of -4.0 m aMSL, immediately after breachings and a wide open mouth. Strong tidal exchange would have occurred after the breachings, resulting in gradual build-up of sediments again. The mouth would have remained open for long periods because of the tidal and river flows. The exchange of seawater through the tidal flows would have resulted in a general increase in the salinity of the vlei which would have been similar to that of seawater. After breachings, under natural conditions, the water level at the mouth of the vlei would have dropped to levels between 0.0 m and 0.3 m aMSL. The tidal cycle and associated lag due to the storage in the vlei would prevent water levels from dropping much below 0.0 m and 0.3 m aMSL, as the frequency of the next high tide cycle would result in an inflow of sea water while the vlei was draining, again raising water levels. It must be noted that in the dry summer months, when inflow to the estuary was minimal (and the mouth closed), high evaporation rates led to large areas of the vlei drying up, resulting in hypersaline conditions, as observed in aerial photographs dated 1944.

However, over the years, there have been a variety of initiatives aimed at manipulating the level of water in the vlei to retain water for recreational purposes while preventing flooding and trying to maintain estuarine conditions. The mouth dynamics and water levels are thus now artificially controlled. These management initiatives are discussed in detail in Section 5.2.

2.6 Physico-chemical characteristics

The Cape Town City Council has measured a variety of parameters in Zandvlei since at least 1973. Unfortunately the value of this data has been compromised to some extent by the fact that at least some of the stations have been moved, while others have been discontinued. Nevertheless, this data, together with salinity readings obtained through a Community Monitoring Programme which has been in place since March 2002, does provide an overview of the physico-chemical characteristics of the estuary.

Morant and Grindley (1982) summarized data on a variety of parameters measured by the Municipality between 1973-1978. A selection of the data from their report is reproduced in Table 1 below, and discussed in the subsequent paragraphs together with the salinity readings from Community Monitoring Programme (Table 2 and Figure 5 a-d), information presented by Ninham Shand (2000), and more recent City Council data (from 2000). The latter is summarized in Table 3.

*pH*

Water draining from areas of Table Mountain Sandstone is generally soft, peat-stained and slightly acidic. On the other hand, the calcareous material of the coastal plain produces a slightly alkaline runoff. This is consistent with the values reported in Morant
and Grindley (1982) which suggest that the Sand River/Langvlei canal system was more alkaline than other rivers discharging into Zandvlei.

pH values from the various data sets seem to have remained reasonably consistent over time, varying from 5.9 to 9.2. These are considered to be within guideline values.

**Salinity**

The data collected by the City Council between 1973 and 1978 shows relatively uniform salinities across the estuary, with maximum salinities even at the northern-most station reaching almost 20 ppt while in the marina, maximum levels were between 25 and 27 ppt. (see Table 1). Since mean values were not provided, it is difficult to compare these directly to later records, but the Ninham Shand and Southern Waters reports (2000) cover the period immediately after this. They showed a gradual decline in salinities from a mean of around 10 ppt in 1980 to 7ppt between 1985 and 1989, and 5ppt in the early 1990’s. They attributed this to the change in the height of the weir from 0.7m aMSL to 0.9m aMSL.

The results from the Community Monitoring Programme (Table 2 and Figures 5 a – d) suggest a recovery in the mean salinities to between 9 and 11 ppt, with a gradation in the mean and maximum values from the mouth to the head of the estuary, with salinities in the marina being slightly lower. The Scientific Services results for the period 2000 - 2009 are similar, with mean values of: North – 8.98 ppt; Centre – 8.74 ppt; South - 11 ppt; Outlet channel – 14 ppt; and Marina – 5.99/ 9.3ppt. It should be noted that, apart from the Zandvlei Centre station, the Scientific Services results are based on very few samples and monitoring at most stations was terminated some years ago (see Table 3). Moreover, no attempt has been made to link the salinities to water levels and mouth conditions. However, it seems likely that the increase in salinities is linked to the reduction in the height of the weir back to 0.7 m aMSL (see also Section 5.2)
With respect to salinity stratification, early reports were conflicting, with Noble and Hemens (1978) suggesting no vertical stratification, while Furness (1978) and Benkenstein (1982) found clear evidence of stratification. This may have been due to
seasonal factors although Harding (1999) suggested that while vertical stratification might be more clearly defined in winter, it was also evident in summer despite the high levels of wind-induced mixing.

**Temperature**

The water temperature in the estuary seems to be fairly uniform across the water body and with depth, and has not shown any significant changes over time. In general, temperatures vary from a maximum of around 24 °C to a minimum of between 9 and 12°C. The lack of pronounced stratification is attributed to wind-induced mixing.

**Dissolved oxygen**

The solubility of oxygen in the water varies with temperature. Guideline values are therefore generally given as % saturation, with those for aquatic ecosystems being between 80 and 120% saturation, with a minimum allowable of 40%. Where these values are not available, there is a guideline for aquaculture in mg/l, with the recommended range being between 5-8mg/l.

The 1973-1978 data indicate that while dissolved oxygen at the water surface is generally acceptable, it is unacceptably low at bottom stations across the estuary apart from the mouth, although even this is low. The more recent Scientific Services data (2000 – 2009) also shows reasonable surface oxygen levels. Data on dissolved oxygen levels at the bottom is limited to a single station at Zandvlei Centre, and unfortunately even that was discontinued in 2004.

Other significant chemical constituents of the water are pollutants such as nutrients, and are discussed further in the section on water quality.
Table 1. Physico-chemical data from selected sampling sites in Zandvlei: 1973 – 1978 (after Morant and Grindley, 1982).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Zandvlei North</th>
<th>Zandvlei Centre</th>
<th>Zandvlei South</th>
<th>Zandvlei Mouth</th>
<th>Tiller Arm Beat</th>
<th>Burgee Cove</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface temperature °C</td>
<td>11.7</td>
<td>24.2</td>
<td>11.0</td>
<td>24.3</td>
<td>11.5</td>
<td>24.0</td>
</tr>
<tr>
<td>Bottom temperature °C</td>
<td>13.5</td>
<td>24.2</td>
<td>12.2</td>
<td>23.1</td>
<td>12.0</td>
<td>23.7</td>
</tr>
<tr>
<td>Ph</td>
<td>6.8</td>
<td>9.2</td>
<td>8.0</td>
<td>9.2</td>
<td>6.5</td>
<td>8.9</td>
</tr>
<tr>
<td>Salinity o/oo</td>
<td>5.62</td>
<td>19.52</td>
<td>2.23</td>
<td>19.34</td>
<td>0.89</td>
<td>21.33</td>
</tr>
<tr>
<td>Dissolved oxygen (mg/l) -</td>
<td>6.4</td>
<td>11.8</td>
<td>6.8</td>
<td>17.0</td>
<td>2.5</td>
<td>14.1</td>
</tr>
<tr>
<td>surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissolved oxygen (mg/l) -</td>
<td>0</td>
<td>8.8</td>
<td>0</td>
<td>12.0</td>
<td>0.5</td>
<td>9.7</td>
</tr>
<tr>
<td>bottom</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Salinity o/oo</th>
<th>Mouth/channel</th>
<th>Vlei South</th>
<th>Vlei Centre</th>
<th>Vlei North</th>
<th>West lake</th>
<th>Marina da Gama</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station</td>
<td>1</td>
<td>2 (ZAV 5)</td>
<td>3 (ZAV 4)</td>
<td>4</td>
<td>5 (ZAV 3)</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>7 (ZAV 2)</td>
<td>8</td>
<td>9 (ZAV 1)</td>
<td>10 (WLW)</td>
<td>11 (ZAV 6)</td>
<td>12 (ZAV 7)</td>
</tr>
<tr>
<td>Min</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Max</td>
<td>35</td>
<td>35</td>
<td>27</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Average</td>
<td>12</td>
<td>14</td>
<td>12</td>
<td>10</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td># of readings</td>
<td>55</td>
<td>376</td>
<td>136</td>
<td>135</td>
<td>114</td>
<td>90</td>
</tr>
</tbody>
</table>

1. In the outlet canal next to the parking lot at the “super slide”
2. Taken 40m upstream of Royal Road Bridge (ZAV5)
3. Take at the bend of the canal near a storm water input (ZAV4)
4. In the centre of the canal opposite the huts near Playwaters
5. Vlei body south (before narrows to form canal near Playwaters (ZAV3)
6. Taken in the centre vlei opposite park on western side.
7. Vlei body centre, opposite the Imperial Yacht Club (ZAV2)
8. Taken opposite Scouts Club, midway between ZAV1 & ZAV2
9. Vlei body north (between two inlet rivers) (ZAV1)
10. Westlake Wetland - down Rutter Road (WLW)
11. South entrance to Marina Da Gama (ZAV6)
12. North entrance to Marina Da Gama (ZAV7)
13. Marina Da Gama channel (The Anchorage) (ZAV8)
14. Marina Da Gama channel (Spearhead) (ZAV9)
15. Baleen Pond
16. T Wagon Bridge
17. Uitsig (new pt added April 04)

---

1 Kindly provided by Candice Haskins
Table 3. Physico-chemical data from sampling sites in Zandvlei (analysed by Scientific Services)\(^2\)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Zandvlei North</th>
<th>Zandvlei Centre</th>
<th>Zandvlei South</th>
<th>Outlet channel</th>
<th>Marina south entrance</th>
<th>Marina north entrance</th>
<th>Marina at The Anchorage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface temperature °C</td>
<td>9.4</td>
<td>24.2</td>
<td>10.4</td>
<td>24.1</td>
<td>12.4</td>
<td>23.6</td>
<td>12.5</td>
</tr>
<tr>
<td>Bottom temperature °C</td>
<td></td>
<td></td>
<td>12.6</td>
<td>26.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ph</td>
<td>6.2</td>
<td>9.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salinity o/oo</td>
<td>1</td>
<td>20.4</td>
<td>0.5</td>
<td>30.3</td>
<td>1.6</td>
<td>23.2</td>
<td>1.9</td>
</tr>
<tr>
<td>Dissolved oxygen (mg/l) - surface</td>
<td>4.5</td>
<td>15.9</td>
<td>1.3</td>
<td>17.3</td>
<td>5.6</td>
<td>15.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Dissolved oxygen (mg/l) - bottom</td>
<td>3.7</td>
<td>16.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sample code | Description                                                                 | Period of readings
ZA01S        | Zandvlei - north, surface                                                  | Jan 2000 – May 2004
ZA02B        | Zandvlei - centre (opp Imperial Y.C.), bottom                              | Jan 2000 – May 2004
ZA02S        | Zandvlei - centre (opp Imperial Y.C.), surface                             | Jan 2000 – Dec 2009
ZA03S        | Zandvlei - south (opp Playwaters), surface                                 | Jan 2000 – May 2004
ZA05S        | Outlet channel near Royal Rd bridge, surface                               | Jan 2000 – Mar 2003
ZA06S        | South entrance to Marina da Gama canals, surface                           | Jan 2000 – Mar 2003
ZA07S        | North entrance to Marina da Gama canals, surface                           | Jan 2000 – Mar 2003

\(^2\) Kindly provided by Candice Haskins
2.7 Biodiversity

The biodiversity of an estuary is largely determined by its physical and chemical characteristics. Those of Zandvlei have been significantly altered as a result of various human interventions over the last two centuries. It is therefore inevitable that there have therefore been substantial changes in the biodiversity over time.

The most comprehensive description of the biodiversity was provided in Morant and Grindley (1982) and the description below is largely based on that (and the references cited by them). These publications all preceded the decline in salinity in the mid-1980’s and are therefore more likely to reflect the natural biodiversity of the estuary, whereas more recent descriptions portray the altered state. Nevertheless, some reference has been made to the recent literature in the appropriate sections, while examples of some more specific changes are described in Section 2.8.

The GZENR staff maintain a database of species records for certain groups, and information on the biodiversity is also available on the Zandvlei Trust website (www.zandvleitrust.org.za) under the Zandvlei Inventory and Monitoring Programme (ZIMP).

2.6.1 Microalgae and diatoms

Microalgae reported from Zandvlei by Begg (1975 a; 1976) and Bourgeois (1948) include:

- **Cyanophyta** (Cyanobacteria): – 4 species of which *Oscillatoria* was reported to cause unsightly seasonal blooms;
- **Chlorophyta**: - 8 species; and
- **Chrysophyta**: (which include diatoms (class Bacillariophyta), golden/golden-brown algae (class Chrysophyceae), and yellow-green algae (class Xanthophyceae) – 18 species. The majority of those listed are diatoms, many of which are epiphytic on the submerged plants. One of the exceptions is the golden algae, *Prymnesium parvum*, a toxic species capable of killing aquatic organisms and which was held to be responsible for a fish kill in Zandvlei in June, 1973.

More recently, identification of micro-algae has been undertaken by Scientific Services as part of the water quality monitoring programme. This analysis has not yet been completed, but species identified between October and December, 2009, are summarized in the table below.

<table>
<thead>
<tr>
<th>FAMILY</th>
<th>GENUS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BACILLARIOPHYCEAE</strong></td>
<td>Centric diatoms, Pennate diatoms, <em>Melosira</em></td>
</tr>
<tr>
<td><strong>CHLOROPHYCEAE</strong></td>
<td><em>Actinastrum</em>, <em>Carteria</em>, <em>Chaetopeltis</em>, <em>Chlorococcum</em>, <em>Cocconeis</em>, <em>Cocconis</em>, <em>Cosmarium</em>, <em>Crucigenia</em>, <em>Kirchneriella</em>, <em>Myrmecia</em>, <em>Oocystis</em>, <em>Pediastrum</em>, <em>Penium polymorphum</em>, <em>Scenedesmus</em>, <em>Spirogyra</em>, <em>Tetraedron</em>, <em>Ulothrix</em>.</td>
</tr>
<tr>
<td><strong>CYANOPHYCEAE</strong></td>
<td><em>Anabaena</em>, <em>Microcystis</em>, <em>Nostoc</em>.</td>
</tr>
<tr>
<td><strong>EUGLENOPHYCEAE</strong></td>
<td><em>Lepocinclis</em></td>
</tr>
</tbody>
</table>

* Also identified by Begg (1976).
An indication of the quantity of phytoplankton – and the ecological condition of the vlei - is the level of chlorophyll a. Measurements of chlorophyll a have been taken for many years and are discussed further in the section on water quality.

2.6.2 Macroalgae

Macroalgae identified as growing in Zandvlei include Enteromorpha spp, Chara fragilis, Cladophora sp, Lyngbya sp, Nitella sp, and Lamprothamnium sp. (Begg, 1975a, and Shelton, 1975). Some of these are associated with the artificially stabilized banks, especially the canals of Marina da Gama, and can cause problems when they decay.

2.6.3 Aquatic and Semi-aquatic Vegetation

The most common aquatic plants were identified as the pondweed, Potamogeton pectinatus and Ruppia maritime (Shelton, 1975). The Cape pondweed, Aponogeton distachyus, was reported from the streams entering the vlei. There are also a number of alien invasive species, including Parrots Feather (Myriophyllum aquaticum), hornwort (Ceratophyllum demersum), Azolla filiculoides (Red waterfern) and water hyacinth (Eichornia crassipes). All of these species tend to grow prolifically in high nutrient conditions and most have become problematic in Zandvlei. This issue is discussed in more detail in Section 5.

Morant and Grindley (1982) distinguished between two types of semi-aquatic vegetation: reed swamps and marshes. The most common species in the reed swamps is Phragmites australis, with others including Typha capensis and several sedges (Scirpus spp and Juncus kraussii). The marsh areas include more salt tolerant species such as Sarcocornia natalensis. The reeds in particular also show increased growth in response to high nutrient levels.

The semi-aquatic vegetation is concentrated towards the head of the estuary, in the nature reserve and Westlake Wetland. A map showing the distribution of the semi-aquatic and terrestrial vegetation types is shown in Figure 6 (reproduced from Morant and Grindley, 1982).

The wetland plant communities of Westlake and Zandvlei Bird Sanctuary were also mapped in 1988 by Azorin as a prerequisite for the compilation of a management plan for the area. The report identifies three sub-groups of plants:

- Alien stand-scrub forest (terrestrial);
- Swamp; and
- Flood-plain marsh vegetation.

The report also noted the more freshwater nature of the wetland in Westlake, as opposed to the estuarine character of that in the Zandvlei Bird Sanctuary. Dominant plants in Westlake included Scirpus, Typha and Phragmites; while those in the Bird Sanctuary were Paspalum, Juncus, Scirpus, Sporobolus and Arthrocnemum. The report also noted the high percentage of cover by alien plant species.
Figure 6: Semi-aquatic and terrestrial vegetation around Zandvlei (reproduced from Morant and Grindley, 1982).
2.6.4 Terrestrial Vegetation

As can be seen in Figure 6, even in 1982, the entire west bank of the vlei (up as far as the Westlake Wetland) and much of the east bank consisted of recreational and/ or residential areas. Since then, Marina da Gama has been further developed and the only remaining natural or semi-natural vegetation occurs along the northern boundary of the vlei. This comprises disturbed dune vegetation, hind dune scrub and low sparse shrubland. According to Ninham Shand (2000), the original Nature Reserve area (east of the railway line) consisted of wetland and Strandveld plant communities including 107 indigenous plants, 3 of which were red data species. There was also a small stretch of fore dune vegetation north of the estuary mouth.

An updated list of plants for the GZENR totals 360 species, of which at least 36 are invasive aliens (C. Sheasby, pers. comm.).

The alien invasive species include trees and grasses such as rooikrans (*Acacia cyclops*), Port Jackson (*Acacia saligna*), Manatoka (*Myoporum insulare*), Vaseys grass (*Paspalum urvillei*), kikuyu (*Pennisetum clandestinum*), and saltwater couchgrass (*Paspalum vaginatum*) which occurs along the banks.

2.6.5 Invertebrates

Zooplankton

The zooplankton of Zandvlei was first described by Hutchinson et al (1932). According to them, the dominant species were a Crustacean (the copepod *Paradiaptomus capensis*) and two rotifers (*Brachionus plicatilis* and *Pedalia fennica*). Other crustacean groups included Cladocera and Ostracoda.

Later reports (Bourgeois, 1948, Begg, 1975a and Shelton, 1975) listed a number of additional species of these and other groups, and identified the copepod *Pseudiaptomus hessei* as the dominant species and it seems possible that the original identification (*P. capensis*) was incorrect. Apart from Crustacea and rotifers, the zooplankton includes Protozoa, Turbellaria, Tardigrada, Gastrotricha, and Nematoda. Additional Crustacea included amphipods and the larval stage of the crab, *Hyemnosoma orbiculare*. A full list of these species can be found in Appendix III of Morant and Grindley (1982).

Other aquatic invertebrates

The most common species found on hard substrates within the vlei was the polychaete *Ficopomatus enigmatica*. Southern Waters (2001) in the report on the baseline monitoring, noted that the spatial coverage appeared to be less than the 1980’s or 1990’s, and that, in general, higher biomass levels occurred in the southern marina and vlei than in the northern marina (probably related to salinity levels). On the other hand, in 2004 there were complaints from the public regarding the build-up of the polychaete (coral worm) in the marina, particularly around Park Island Bridge (Borden, 2004).

Of interest is that it seems likely that *Ficopomatus enigmatica* is not indigenous to South Africa (www.europe-aliens.org). It has been widely introduced across the world and,
while it can have beneficial effects on water quality (Davies, Stuart and de Villiers, 1989), it has become a nuisance in many areas. Significantly, it was not reported by Bourgeois (1948) but was present in the publication by Muir (1974).

In terms of soft substrates, the sandprawn (*Callianassa kraussi*) was abundant in sandy areas, especially the outlet channel, with numbers of up to 576/m² being reported by Shelton (1975). More recent investigations report significantly lower numbers: a maximum of 195/m² (Southern Waters, 1999), 107/m² (Fowler, 2000), and 114/m² (Southern Waters, 2001). The first two of these were before and after the reconstruction of the Thesens footbridge during which the substrate was disturbed by dredging activities and, in some areas, completely altered.

The polychaete, *Capitella capitata*, which is typical of polluted sediments, was found in the more muddy anoxic areas.

Other common species included the crown crab, *Hymenosoma orgbiculare*, and the shrimp, *Palaemon pacificus*.

A variety of other species from the following groups were also recorded: Bryozoa, Nematoda, Oligochaeta, Polychaeta, Ostracoda, Amphipoda, Isopoda, Mysidacea, Decapoda, and Mollusca (Bourgeois, 1948; Muir, 1974; Shelton, 1975; Begg, 1976 and unpublished data from Grindley). Many of these are associated with the aquatic plants in the vlei eg. pondweed. A full list can be found in Appendix IV of Morant and Grindley, 1982.

*Insects*

Some 20 species of insects were recorded from Zandvlei between Muir (1974), Begg (1975a, 1976) and Shelton (1975). These included species from the orders: Collembola, Epheneoptera, Odonata, Hemiptera, Coleoptera and Diptera. A full list can be found in Appendix VI of Morant and Grindley, 1982.

2.6.6 Fish

Begg (1976) produced an initial review of the fish of Zandvlei which included a list of species recorded between 1917 and 1973 – including freshwater, estuarine and marine. Gaigher and Thorne subsequently undertook two gill-net surveys for the Provincial Department of Nature and Environmental Conservation (reported in Furness, 1979), with later studies including a survey by Quick and Bennett (1989); a report by Clark, Bennett and Lamberth (1994) and a survey as part of the baseline monitoring undertaken by Southern Waters in 2001. The Southern Waters report (2001) includes a consolidated list of the species recorded in all previous reports. This is produced in an amended form in Table 4 below (details courtesy of Steve Lamberth).
Table 4. List of all indigenous and introduced species recorded in Zandvlei estuary.

**Estuarine species that breed in estuaries or freshwater**

<table>
<thead>
<tr>
<th>Species</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gilchristella aestuaria</td>
<td>Estuarine roundherring</td>
</tr>
</tbody>
</table>

**Estuarine residents with marine and estuarine breeding populations**

<table>
<thead>
<tr>
<th>Species</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atherina (Hepsetia) breviceps</td>
<td>Cape silverside</td>
</tr>
<tr>
<td>Clinus superciliosus</td>
<td>Super klipvis</td>
</tr>
<tr>
<td>Caffrogobius gilchristi</td>
<td>Prison goby</td>
</tr>
<tr>
<td>Caffrogobius/Gobius nudiceps</td>
<td>Barehead goby</td>
</tr>
<tr>
<td>Psammogobius knysnaensis</td>
<td>Knysna sandgoby</td>
</tr>
<tr>
<td>Syngnathus temminckii</td>
<td>Longsnout Pipefish</td>
</tr>
</tbody>
</table>

**Marine species with juveniles entirely dependent on estuaries**

<table>
<thead>
<tr>
<th>Species</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lichia amia</td>
<td>Leervis</td>
</tr>
<tr>
<td>Mugil cephalus</td>
<td>Flathead mullet</td>
</tr>
<tr>
<td>Lithognathus lithognathus</td>
<td>White steenbras</td>
</tr>
<tr>
<td>Monodactylus falciformis</td>
<td>Cape Moony</td>
</tr>
<tr>
<td>Argyrosomus hololepidotus/japonicus/inodorus</td>
<td>Kob</td>
</tr>
<tr>
<td>Rhabdosargus holubi</td>
<td>Cape stumpnose</td>
</tr>
</tbody>
</table>

**Marine species whose juveniles occur mainly in estuaries, but are also found at sea**

<table>
<thead>
<tr>
<th>Species</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heteromycterus capensis</td>
<td>Cape sole</td>
</tr>
<tr>
<td>Liza tricuspidens</td>
<td>Striped mullet</td>
</tr>
<tr>
<td>Liza dumerilli</td>
<td>Groovy mullet</td>
</tr>
<tr>
<td>Solea bleekeri</td>
<td>Blackhand sole</td>
</tr>
</tbody>
</table>

**Marine species whose juveniles occur in estuaries, but are more common at sea**

<table>
<thead>
<tr>
<th>Species</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liza richardsonii</td>
<td>Harder</td>
</tr>
<tr>
<td>Pomatomus saltatrix</td>
<td>Elf</td>
</tr>
<tr>
<td>Diplodus sargus</td>
<td>Blacktail/dassie</td>
</tr>
<tr>
<td>Sarpa salpa</td>
<td>Strepie</td>
</tr>
<tr>
<td>Amblyrhyncotes honkenii</td>
<td>Evil eyd puffer/blaasop</td>
</tr>
<tr>
<td>Rhabdosargus globiceps</td>
<td>White stumpnose</td>
</tr>
<tr>
<td>Iso natalensis</td>
<td>Surf sardine</td>
</tr>
<tr>
<td>Scomberoides sp</td>
<td>Queenfish</td>
</tr>
<tr>
<td>Lithognathus mormyrus</td>
<td>Sand steenbras</td>
</tr>
<tr>
<td>Rhinobatos annulatus</td>
<td>Lesser guitarfish</td>
</tr>
</tbody>
</table>

**Indigenous freshwater species**

<table>
<thead>
<tr>
<th>Species</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandelia capensis</td>
<td>Cape kurper</td>
</tr>
<tr>
<td>Galaxias zebratus/punctifer</td>
<td>Cape galaxias</td>
</tr>
</tbody>
</table>

**Introduced species**

<table>
<thead>
<tr>
<th>Species</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyprinus carpio</td>
<td>Carp</td>
</tr>
<tr>
<td>Oreochromus mossambicus</td>
<td>Mozambique tilapia</td>
</tr>
<tr>
<td>Microperus salmoides</td>
<td>Black/largemouth bass</td>
</tr>
<tr>
<td>Tilapia sparmannii</td>
<td>Banded tilapia</td>
</tr>
<tr>
<td>Gambusia affinis</td>
<td>Mosquito fish</td>
</tr>
<tr>
<td>Clarias gariepinus</td>
<td>African/sharptooth catfish</td>
</tr>
<tr>
<td>Carrasius auratus</td>
<td>Goldfish</td>
</tr>
<tr>
<td>Onchorhynchus mykiss</td>
<td>Rainbow trout</td>
</tr>
</tbody>
</table>

**Catadromous species**

<table>
<thead>
<tr>
<th>Species</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anguilla bengalensis labiata</td>
<td>African mottled eel</td>
</tr>
<tr>
<td>Anguilla marmorata</td>
<td>Madagsacan mottled eel</td>
</tr>
</tbody>
</table>
Southern Waters (2001) also looked at the relative proportions of resident (estuarine), marine and freshwater fish and compared them – as well as the size composition of the more abundant species – to the results of earlier studies. Results were similar, with marine species making up between 21.2 and 49.5% of the catch; residents between 60.7 and 77.3%; and freshwater between 0.1 and 1.5%. The most common species were the silverside (56%), harder (34.9%) and estuarine round herring (4.9%). Very few specimens of those species with juveniles entirely dependent on estuaries were present emphasising concerns that the function of the estuary as a fish nursery has been compromised by the weir.

Since 2000, Marine and Coastal Management have undertaken quarterly fish surveys in Zandvlei. Although the data has not yet been analysed in detail, the last few fish treks have shown an increase in number of species recorded including Leervis, Mullet, Cape and White Stumpnose. Juvenile White Steenbras have also been recorded for the first time in 11 years (report by C.Sheasby to ZAC, Nov. 2009). This suggests there has been some recovery of the ichthyofauna since the lowering of the weir in 2001.

Another potentially significant influence on the fish populations is the presence of various alien species. Begg (1976) reported that the carp (Cyprinus carpio) was introduced to Zandvlei in 1896, while large numbers of Mozambican tilapia (Oreochromis mossambicus) were introduced between 1973 and 1976. The African catfish is believed to have been introduced to Zandvlei by the conservation authorities in the 1960’s (www.zandvleitrust.org). The Goldfish was probably an individual introduction having last been recorded in 1973 (GZENR database). However, the Largemouth bass has been recorded in the Rutter Road area in recent years (C.Sheasby, pers. comm.), while the carp and both Tilapia spp were found in the 2001 survey although in relatively small numbers, making up a total of 1.5% of the fish caught.

2.6.7 Amphibians and Reptiles

Specific surveys of amphibians and reptiles in Zandvlei do not seem to have been undertaken, and the list in Appendix IX of Morant and Grindley (1982) is derived from records for the general area. It includes 16 species of frogs and toads; 23 species of snakes; 15 species of lizards; and 3 species of tortoises.

The GZENR database lists six species of amphibians: the Western Leopard Toad, the Clicking Stream Frog, the Cape Sand Frog, the Cape Stream Frog, the Common Platanna, and the Cape Rain Frog. It also includes nine snakes, six skinks/lizards, one chameleon (Cape Dwarf Chameleon), one tortoise and one terrapin.

The Western Leopard Toad (Amietophrynus pantherinus/ Bufo pardalis (syn)) is of particular importance from a conservation perspective and is listed as Endangered on the IUCN’s Red Data List. One of the potential threats to the Western Leopard Toad is an introduced species, the gutturral toad (Amietophrynus gutturalis). The latter species has been recorded in the Constantia area and more recently has been heard in Zeekoevlei and Zandvlei. The status of the Western Leopard Toad is discussed in more detail in Section 2.7.
2.6.8   Birds

Bird counts have been undertaken at Zandvlei for many years. Most of the historical counts were conducted under the auspices of the Cape Bird Club, and generated reports by Winterbottom (1960 and 1981); Begg (1975b), and Summers et al (1976). The information from the latter two of these reports – together with some unpublished data was summarized in Morant and Grindley (1982) together with a list of species in Appendix X. The Appendix includes 128 species, although the text noted that Winterbottom (1981) had listed 150 species. The GZENR database lists 153 species. Since 1992, Zandvlei has been one of the sites of the ADU/Citizens Birds in Reserves Project (BIRP). According to the records on their website, there are 143 species in Zandvlei, of which 39 are breeding species. Detailed information based on the CWAC counts can be found on the ADU website (http://cwac.adu.org.za/cwac_map.php?Pv=WC).

In addition to the apparent fluctuations in the number of species, there have been changes in both the number of birds and the species composition. In general, there appears to have been a general decline in the number of birds, and a decrease in the number of wading birds – such as flamingoes and Little Stint – in favour of more piscivorous species and species associated with *Potamogeton*. Piscivores includes the White Pelican, Darter, cormorants and grebes, while the Red-knobbed Coot is linked to *Potamogeton*. The coot is one of the most common species, although its numbers fluctuate seasonally and in relation to the harvesting of *Potamogeton*.

According to the CWAC report for 1992 – 1997, other species which have declined include Hartlaub’s Gull (386 to max 47), Curlew Sandpiper (160 to absent in all counts), Yellow-billed Egret, Cape Teal, Yellow-billed Duck, Southern Pochard, Ruff, Marsh Sandpiper, Greenshank, White-winged and Common Terns, Cape Wagtail. The only species to increase over this period was the Mallard Duck – an invasive alien3.

Overall the decline in birdlife at Zandvlei has been attributed to a variety of human activities, including the harvesting of *Potamogeton*, changes to the habitat caused by dredging, increased sailing and the extension of residential development around the banks of the vlei. Invasive alien species such as the Mallard Duck have also contributed.

2.6.9   Mammals

Morant and Grindley (1982) listed some 30 species of mammals (Appendix XI) which could occur in the general area of Zandvlei. These ranged from bats, to seals, cats, mongooses, porcupine and a variety of rats and mice and included the American grey squirrel – an introduced species.

The GZENR lists 19 wild species, one of which – the Cape hare (*Lepus capensis*) - was re-introduced to Park Island in 2004 (Zandvlei Inventory and Monitoring Programme (ZIMP) (www.zandvleitrust.org.za)). Observations on this site also suggest that the numbers of the Cape Clawless Otter (*Aonyx capensis*) may be increasing.

3 Information provided by Peter Ryan.
The consolidation of the nature reserve into the Greater Zandvlei Estuary Nature Reserve has probably increased the chances of some of these species surviving in the area despite the ongoing urbanization in the surrounding areas.

2.8 Threatened and protected species

Species which are considered to be threatened can fall into a number of different categories depending on the extent of the threat. These categories may vary depending on the organization which has undertaken the assessment, but they generally include Critically Endangered, Endangered, Vulnerable, Near Threatened and Species of Least Concern. The official South African lists also include species which are recommended to be protected. A list of animal species which have been recorded at Zandvlei and which fall into one or other of these categories in terms of the IUCN’s Red Data List (international), the draft TOPS list for South Africa, and a draft list for the Western Cape, is shown in Table 5 below.

Of these, the Western Leopard Toad (*Amietophrynus pantherinus*) seems to have been a focus of attention in the Zandvlei area. Although it does not appear in official national or provincial lists, it is listed as endangered by the IUCN. It now has its own website ([www.leopardtoad.co.za](http://www.leopardtoad.co.za)) compiled by Atherton de Villiers (2009) on which the text below is based:

"It is restricted to a small area of the Cape Peninsula, the southern reaches of the Cape Flats, and an isolated, unprotected and severely fragmented population in the Gansbaai, Stanford and Hermanus region. The endangered status is based on: its restricted distribution and habitat, habitat that is severely fragmented; and a continuing decline in the extent of distribution, area and quality of habitat, and the number of locations/populations and mature individuals. In particular, although the largest recorded populations occur in a largely urban environment on the Cape Peninsula and Cape Flats, they are increasingly being threatened by urbanization; and there have been no recent records of this toad from the middle part of its distribution range, extending from Pringle Bay to Hermanus.

Furthermore, although this toad occurs in some protected nature areas, most of the known breeding and foraging habitat is situated outside of these areas. Protected areas that have suitable breeding habitat include: Zandvlei Nature Reserve (including the adjoining Westlake Wetland Conservation area), Rondevlei and Zeekoevlei nature reserves, and Table Mountain National Park (e.g. Cape of Good Hope area).

Red Data plants recorded at Zandvlei include:
- *Euphorbia marlothiana* – Medusa’s Head
- *Ixia paniculata* – African corn-lily
- *Lampranthus reptans* – Vygie
- *Lampranthus explanatus* - Vygie
- *Leucadendron levisanus* - Cape Flats Conebush
- *Muraltia mitior* – Flats purple-gorse
- *Passerina paludosa* – Cape Flats Gonnabos
- *Psoralea glaucina* – Muizenberg Fountainbush/ Blouteebossie
- *Psoralea repens*
- *Satyrium carneum* - Rooikoppie/ Pink Trewwa
2.9 Changes to biodiversity

There have been significant changes to the biodiversity of Zandvlei and its surrounds over the years primarily as a result of physical alteration of the habitat including changes to the water levels and salinity of the estuary, increased nutrients, and the introduction of a variety of alien species. Many of these changes have been gradual and without detailed study are not immediately obvious. However, there are some examples where changes are clearly evident, either because they are dramatic, or because records have been kept over a long period. For example:

- Southern Waters (2000) reported a collapse of pondweed and tube worm communities in 1991 which they attributed to reduced mean ambient salinities. Recent observations suggest that both have recovered.
- There have also been changes to the floral composition of the wetlands due to salinity reduction (Southern Waters, 1999) High water levels and nutrients have also encouraged the expansion of freshwater reeds.
- There has been a reduction in the number of waders due in some cases to the lack of seasonal changes in water levels which prevent the pans in Zandvlei Nature Reserve from drying up in later summer as they used to do (Gavin Lawson, quoted in Ninham Shand, 2000).

![Figure 7. The apparent decline in numbers of Cape Teal (CWAC data).](image-url)
### Table 5: THREATENED AND PROTECTED ANIMAL SPECIES RECORDED IN ZANDVLEI

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Western Leopard Toad</td>
<td>Amietophrynus pantherinus</td>
<td>Endangered</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cape platanna <strong>4</strong></td>
<td>Xenopus gilli</td>
<td>Endangered</td>
<td></td>
<td>Endangered</td>
</tr>
<tr>
<td>White steenbras</td>
<td>Lithognathus lithognathus</td>
<td>Endangered</td>
<td>Vulnerable</td>
<td></td>
</tr>
<tr>
<td>Dusky kob</td>
<td>Argyrosomus japonicus</td>
<td>Vulnerable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cape Caco *</td>
<td>Cacosternum capense</td>
<td>Vulnerable</td>
<td></td>
<td>Protecte</td>
</tr>
<tr>
<td>Arum lily frog</td>
<td>Hyperolius horstockii</td>
<td>Vulnerable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lesser Flamingo</td>
<td>Phoeniconaias minor</td>
<td>Near threatened</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cape cormorant</td>
<td>Phalacrocorax capensis</td>
<td>Near threatened</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little Bittern</td>
<td>Ixobrychus minutus</td>
<td>Least Concern</td>
<td></td>
<td></td>
</tr>
<tr>
<td>African Marsh Harrier</td>
<td>Circus ranivorus</td>
<td>Least concern</td>
<td></td>
<td>Vulnerable</td>
</tr>
<tr>
<td>Caspian Tern</td>
<td>Sterna caspia</td>
<td>Least concern</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Great White pelican</td>
<td>Pelecanus onocrotalus</td>
<td>Least concern</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horseshoe bat *</td>
<td>Rhinolophus clivosus</td>
<td>Least concern</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cape clawless otter</td>
<td>Aonyx capensis</td>
<td>Least concern</td>
<td></td>
<td>Protected</td>
</tr>
<tr>
<td>Cape fox</td>
<td>Vulpes chama</td>
<td>Least concern</td>
<td></td>
<td>Protected</td>
</tr>
<tr>
<td>Caracal</td>
<td>Caracal caracal</td>
<td></td>
<td></td>
<td>Protected</td>
</tr>
<tr>
<td>Porcupine</td>
<td>Hystrix africaeaustralis</td>
<td></td>
<td></td>
<td>Protected</td>
</tr>
<tr>
<td>Cape dwarf chameleon</td>
<td>Bradypodium pumilum</td>
<td></td>
<td></td>
<td>Protected</td>
</tr>
<tr>
<td>Cape kurper</td>
<td>Sandelia capensis</td>
<td></td>
<td></td>
<td>Protected</td>
</tr>
</tbody>
</table>

* The species marked * were listed by Morant and Grindley (1982), but according to C.Sheasby (pers. comm.) do not occur in the GZENR.
3. SOCIO-ECONOMIC IMPORTANCE OF THE ESTUARY

3.1 Introduction

Estuaries provide a range of goods and services which, together with their attributes, contribute to the well-being of society. Goods are primarily resources such as fish or reeds which can be harvested for subsistence or commercial purposes, while services include flood control, water purification and the provision of nurseries for marine fish. The attributes comprise the physical and biological features of estuaries which make them suitable for a variety of recreational and cultural activities. In preparing a management plan for an estuary, it is important that the value of these goods and services be taken into consideration, especially where there might need to be a trade-off between different uses.

Over the past few years valuations have been undertaken for a number of South African estuaries, and in 2007 Turpie and Clark produced a preliminary estimate of the value of all South Africa’s temperate estuaries, including the Zandvlei Estuary. This study – together with some additional information - provides the basis for the outline below.

3.2 Direct use values

Direct use values comprise the use of the natural resources of the estuary for commercial or subsistence purposes. Such use can be consumptive – for example, the use of fish as food – or non-consumptive, such as the use of the estuary for recreation.

3.2.1 Consumptive uses

Bait collection is not permitted in Zandvlei, while fishing is restricted to rods (recreational) and even that requires a permit. The latter is not well regulated and there have been complaints about poaching after hours. However, there is no information available on catches – legal or illegal.

3.2.2 Non-consumptive uses

Property values

The property price premium for Zandvlei was estimated by Van Zyl and Leiman (2001) using two different methodologies. Despite limitations in the availability of data, both gave similar results – R 76.7 and R 87.5 million. Using the approach adopted by Turpie and Clark (2007) to produce annual values, this translates to an annual income to the real estate sector of approximately R 4.5 million.

Since municipal property rates are linked to property value, the estuary can also be considered to contribute to the income of the local authority.
Recreation and tourism

Most estuaries in South Africa are mainly used by locals and play a very limited role in tourism. This is probably true for Zandvlei, although it is considered to be of regional importance in terms of recreation.

Turpie and Joubert (2001) (quoted in Turpie and Clark, 2007) estimated the recreational value of the Zandvlei estuary in Cape Town to be around R 713,500. This is likely to have been enhanced by its incorporation into the Greater Zandvlei Estuary Nature Reserve in 2006 and, in fact, Turpie and Clark (2007) estimated the recreational value as between R 1 – 5 million/year.

3.3 Indirect use values

Indirect uses are the ecosystem services or functions provided by the estuary, and include nursery areas, breeding grounds and feeding habitat for species which are important to the economy, as well as waste treatment or water purification.

3.3.1 Nursery areas for marine fish

Historically Zandvlei is likely to have been an important nursery area for a number of species whose juveniles are entirely dependent on estuaries, including flathead mullet, leervis, white steenbras and Cape stumpnose. This function has been compromised by the construction of the rubble weir across the mouth and the artificial closure of the mouth during the summer months to maintain water levels for recreation. Although the sandbar is opened at high spring tides to allow the ingress of saline water – and associated organisms – this is unlikely to approximate the natural condition.

Nevertheless, Turpie and Clark( 2007) attributed a nursery value of between R 1 – 5 million/year to Zandvlei.

3.3.2 Critical habitats

Zandvlei was ranked 16th among coastal wetlands in terms of numbers of birds in the South Western Cape based on a count of 1979 birds of 44 species (Ryan et al, 1988),

The GZENR is also one of the very few protected areas which provides suitable breeding habitat for the endangered Western Leopard Toad.

3.3.3 Waste disposal/ water purification

Wetlands and estuaries are widely considered to have the capacity to dilute, absorb and/or recycle wastes, and are commonly used for this purpose. Although there are no major discharges directly into Zandvlei, the influent rivers all carry a pollution load. Moreover, there are a number of stormwater drains discharging into the estuary. There are no estimates of the value of this, but it is important to note that any water quality problems within the estuary are likely to detract from other values – in particular its recreational value.
3.4 The attributes of the Zandvlei Estuary (non-use values)

Estuaries, in addition to the values they attract for their use – either direct or non-direct – can also be valued for non-use – for example, in terms of their scenic or existence value. The calculation of this value is based on the willingness of people to pay to ensure that the estuary and its biodiversity are protected – perhaps because it is part of their heritage, culture and traditions. It is generally estimated on the basis of interviews with a set of relevant respondents.

Only a limited number of such surveys have been conducted in South Africa. One example was a study by Turpie and Savy (2005) on the Knysna Estuary, which estimated the non-use value for Knysna as R 9.7 million per annum. Although the information was insufficient to extrapolate numerically, Turpie and Clark (2007) evaluated the relative existence values of the temperate estuaries in terms of high, medium and low. The Zandvlei Estuary was listed as having a low existence value presumably on the basis that it is valued more as a recreational resource than for its conservation value.

3.5 Socio-economic importance and the need for conservation

From an economic perspective, the conservation of an estuary has both pros and cons. For example, ensuring that the estuary is provided with sufficient water by the river to keep it functioning, may result in reduced water availability for economic activities upstream. On the other hand, it protects the potential for eco-tourism, recreation and natural resources such as fisheries.

Based on a set of overall goals for an Estuarine Protected Area network – including representativeness, maintenance of ecological processes, maintenance of fishery stocks, minimization of economic opportunity costs and implementability – Turpie and Clark (2007) recommended that the Zandvlei Estuary be one of the core estuaries in terms of meeting biodiversity targets, that the extent of protection be half, that 25% of the margin remains undeveloped, that it is assigned to class A or B in terms of minimum water requirements (with A being near natural), and that it be considered as high priority in terms of rehabilitation.
4. REGULATORY FRAMEWORK

There are a number of international agreements as well as national and provincial laws that are directly or indirectly relevant to the management of estuaries in South Africa. These, together with relevant municipal by-laws, management policies and strategies are summarized in the various tables below, while the key legislation is discussed in more detail.

4.1 International obligations

Convention on Wetlands of International Importance especially as Waterfowl Habitat, 1971 (Ramsar Convention)

The mission of the Ramsar Convention is “the conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world” (www.ramsar.org). Wetlands are defined in the convention as “areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.” This definition therefore includes estuaries.

Contracting Parties are required to designate suitable wetlands within their territory for inclusion in a List of Wetlands of International Importance. Contracting Parties are then required to formulate and implement their planning so as to promote the conservation of wetlands included in the list and the wise use of wetlands in their territory. Where the ecological character of a wetland included on the Ramsar List has changed, is changing or is likely to change as a result of technological developments, pollution or other human interference, information on such changes must be produced to the Secretariat of the Convention. Contracting parties are also required to establish nature reserves on wetlands whether they are included in the list or not, and to provide adequately for their management. Where the boundary of a wetland that has been included in the list has been deleted or restricted by a party in its urgent national interest, the party should compensate for any loss of wetland resources. In particular, it should create additional nature reserves for waterfowl and for the protection, either in the same area or elsewhere, of an adequate portion of the original habitat.

Criteria for the designation of Ramsar status include sites which contain representative, rare or unique wetland types; sites supporting vulnerable, endangered or critically endangered species or threatened communities; sites supporting species important for maintaining the biodiversity of a particular geographic region; and sites supporting species at a critical stage in their life cycles or providing refuge during adverse conditions. Additional, more specific criteria are based on specific taxa, for example, fish and waterbirds.

South Africa acceded to the Ramsar Convention in 1975, and has 17 designated Ramsar sites.
**Convention on the Conservation of Migratory Species of Wild Animals, 1979 (Bonn Convention)**

The Bonn Convention was developed to facilitate cooperation between states in the conservation of animals that migrate across their borders. Appendix I of the Convention lists migratory species which are endangered. Parties that are Range States of a migratory species listed in Appendix I are required to conserve and restore their habitats with a view to reducing the threat of extinction.

Appendix 2 of the Convention lists migratory species which are to be the subject of more specific agreements. These are species which have an unfavourable conservation status and which require international agreements for their conservation and management as well as those species which have a conservation status which would significantly benefit from international cooperation. The purpose of such agreements is to restore the migratory species concerned to a favourable conservation status or to maintain it in such a status.

Where appropriate and feasible, such agreement should provide for co-ordinated conservation and management plans and the prevention, reduction or control of the release into the habitat of the migratory species of harmful substances. Of significance is the fact that the convention provides that each agreement should cover the whole of the range of the migratory species concerned and should be opened to accession by all Range States of that species regardless of whether they are parties to the convention.

South Africa acceded to the Convention in 1991.

**Convention on Biological Diversity, 1992**

The Convention establishes three main goals: the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits from the use of genetic resources. Contracting Parties are required to develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity or adapt for this purpose existing strategies, plans or programmes which reflect the measures in the Convention. States must integrate the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programmes and policies.

The Convention also provides for the establishment of a system of protected areas or areas where special measures need to be taken to conserve biological diversity. Parties are required to promote the protection of ecosystems, natural habitats and the maintenance of viable populations of species in natural surroundings. They must rehabilitate and restore degraded ecosystems and promote the recovery of threatened species through the development and implementation of plans or other management strategies. Parties must also prevent the introduction, control or eradication of those alien species which threaten ecosystems, habitats or species.

South Africa ratified the convention in 1995.
Table 6. Summary of International Conventions

<table>
<thead>
<tr>
<th>International Obligations</th>
<th>Description</th>
<th>Management Implications</th>
<th>Relevance WQL/WQN/HA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Convention on Wetlands of International Importance especially as Waterfowl Habitat,</td>
<td>Aims to stem the progressive encroachment on and loss of wetlands. Contracting parties are to designate suitable wetlands within their territory for inclusion in a List of Wetlands of International Importance.</td>
<td>Planning must be formulated &amp; implemented to promote not only the conservation of wetlands included in the list but also the wise use of wetlands within the territory of contacting parties.</td>
<td>HA</td>
</tr>
<tr>
<td>1971 (Ramsar Convention)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Convention Concerning the Protection of the World Cultural and Natural Heritage, 1972</td>
<td>Recognises that parts of the cultural and natural heritage need to be preserved. Parties are to submit an inventory of sites for inclusion on the World Heritage List.</td>
<td>The convention is applicable not only to World Heritage Sites within a State’s territory, but also extends to natural heritage more generally, including estuaries.</td>
<td>HA</td>
</tr>
<tr>
<td>(World Heritage Convention)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Convention on the Conservation of Migratory Species of Wild Animals, 1979 (Bonn</td>
<td>Recognises that states must be the protectors of migratory species of wild animals that live within and pass through their national jurisdictional boundaries.</td>
<td>Where migratory species occur, concerted action is required for their conservation and effective management.</td>
<td>HA</td>
</tr>
<tr>
<td>Convention)</td>
<td></td>
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<tr>
<td>Convention for the Co-operation in the Protection and Development of the Marine and</td>
<td>Covers the marine environment, coastal zones and related inland waters falling within the jurisdiction of the states of the west and central African region which are contracting parties to it.</td>
<td>Requires parties to take all appropriate measures to prevent, reduce, combat and control pollution of the Convention area caused by discharges from estuaries.</td>
<td>WQN</td>
</tr>
<tr>
<td>Convention on Biological Diversity, 1992</td>
<td>Contracting parties are to promote the protection of ecosystems, natural habitats and the maintenance of viable populations of species in natural surroundings.</td>
<td>Requires the integration of conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programmes and policies.</td>
<td>HA</td>
</tr>
<tr>
<td>United Nations Framework Convention on Climate Change, 1992</td>
<td>Aims to achieve stabilisation of greenhouse gas concentration in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.</td>
<td>Requires that precautionary measures be taken to anticipate, prevent or minimise the cause of climate change and mitigate its adverse effects (including sea level rise).</td>
<td>HA WQN</td>
</tr>
</tbody>
</table>
4.2 Key National legislation

One of the issues highlighted during the development of the National Biodiversity Strategy and Action Plan was the lack of effective management of estuaries, largely due to the fact that they do not clearly fit within the mandate of any one Department. This gap has to a large extent been addressed in the National Environmental Management: Integrated Coastal Management Act (Act 24 of 2008) which includes a requirement for Estuary Management Plans. Even while it was still a Bill, this was a key driver behind the CAPE Estuaries Programme and the Act, together with other relevant legislation, is discussed further below.

National Environmental Management: Integrated Coastal Management Act, 24 of 2008

The National Environmental Management: Integrated Coastal Management Act was approved in 2008 and gazetted in February 2009. The Act establishes a system of integrated coastal and estuarine management including norms, standards and policies, in order to promote the conservation of the coastal environment. Amongst others, it defines rights and duties and determines the responsibilities of organs of state in relation to coastal areas, it controls pollution in the coastal zone and inappropriate development of the coastal environment, and gives effect to relevant international obligations.

In terms of the Act, estuaries are to be managed in accordance with a national estuarine management protocol to be prescribed by the Minister of Environmental Affairs with the concurrence of the Minister responsible for Water Affairs within four years of the commencement of the Act. The protocol must:

- determine a strategic vision and objective for achieving effective integrated management of estuaries;
- set standards for the management of estuaries;
- establish procedures and guidance regarding how estuaries must be managed and how the management responsibilities are to be exercised by different organs of state and other parties;
- establish minimum requirements for estuarine management plans;
- identify who must prepare estuarine management plans and the process to be followed in doing so;
- specify the process for reviewing estuarine management plans to ensure that they comply with the requirements of the Act; and
- be published for public comment.

In more general terms, the Act also provides that the duty of care in NEMA applies, subject to the necessary changes, to any impact caused by any person that has an adverse effect on the coastal environment. This duty of care extends to persons, including:

- a user of coastal public property;
- the owner, occupier, person in control of or user of land or premises on which an activity that caused or is likely to cause an adverse effect occurred, is occurring or is planned;
• the operator of a pipeline that ends in the coastal zone; and
• any person who produces the substance which caused, is causing or likely to cause an adverse effect.

Where the Minister has reason to believe that a person is carrying out or intends carrying out an activity that is likely to have an adverse effect on the coastal environment, he or she may issue a written coastal protection notice to the person responsible for that activity prohibiting the activity and instructing the person to take appropriate steps in terms of applicable legislation; instructing the person to investigate and evaluate the impact of the activity; or to stop or postpone the activity for a reasonable period to allow for the investigation to be carried out.

Such a coastal protection notice may instruct the person to whom it is addressed, to among other matters, rehabilitate land at a specified place, take measures to protect indigenous fauna or to stop damaging indigenous vegetation at a specified place. Where a person fails to comply with the coastal protection notice, the Minister or the MEC may instruct appropriate persons to carry out what is required by the notice and recover from the person to whom the notice was addressed the costs reasonably incurred in carrying out the required action.

The Act further provides that effluent that originates from a source on land may not be discharged into an estuary unless authorised in terms of a general authorisation or a coastal waters discharge permit. A person who at the commencement of the Act is discharging effluent into coastal waters and not authorised to do so in terms of a general authorisation must apply for a coastal water discharge permit. A person who discharges effluent into coastal waters must comply with any applicable waste standards or water management practices, must register the discharge with the department responsible for water affairs and must discharge the effluent subject to any condition contained in the relevant authorisation. An application for a coastal waters discharge permit may not be granted if it is likely to cause irreversible or long-lasting adverse effects that cannot satisfactorily be mitigated, prejudice significantly the achievement of any coastal management objectives contained in a coastal management programme or be contrary to the interests of the whole community.

The Act also provides for the MEC after consultation with the Minister to declare an area that is wholly or partially within the coastal zone to be a special management area. An area may be declared as a special management area only if environmental, cultural or socio-economic conditions in that area require the introduction of measures which are necessary in order to more effectively:

• attain the objectives of any coastal management programme in the area;
• facilitate the management of coastal resources by local communities;
• promote sustainable livelihood for local communities; or
• conserve, protect and enhance coastal ecosystems and biodiversity in the area.

National Environmental Management Act, 107 of 1998 ("NEMA")

The principles set out in NEMA serve as guidelines to organs of state when exercising any functions or taking decisions that may have a significant impact on the environment.
A significant principle in NEMA, for the purposes of estuary management, provides that sensitive, vulnerable, highly dynamic or stressed ecosystems such as estuaries require specific attention in management and planning procedures.

Section 28 of NEMA imposes a duty of care and remediation of environmental damage on every person who causes significant pollution or degradation of the environment. This requires that the person take reasonable measures to prevent such pollution and degradation from occurring or in so far as such harm to the environment is authorised by law, or cannot be reasonably avoided or stopped, to minimise and rectify it.

This duty of care extends to an owner, a person in control of land or premises or a person who has the right to use land or premises on which a situation exists which causes or which is likely to cause significant pollution or degradation of the environment. Measures required to be taken include containing or preventing the movement of pollutants or the cause of the degradation, eliminating any source of pollution or degradation, or remediying its effects.

Where a person fails to take such measures, the Director-General or a provincial head of department may issue such person with a directive requiring him to commence taking specific reasonable measures. Where such person fails to comply or inadequately complies with the directive, the authority may take reasonable measures to remedy the situation and may recover all costs incurred as a result of taking such measures.

National Environmental Management: Protected Areas Act, 57 of 2003

The Protected Areas Act provides for the protection and conservation of areas representative of South Africa’s biodiversity and ecosystems through the declaration and management of protected areas. The system of protected areas includes, amongst others, special nature reserves, national parks, nature reserves, and protected environments. The Minister may prescribe norms and standards for the management and development of protected areas, and indicators to measure compliance therewith.

The Minister or MEC may assign the management of a protected area to a suitable person, organization or organ of state or to a group of such bodies. The assigned management authority must then within 12 months, submit a management plan for the protected area to the Minister or the MEC for approval. The Minister or MEC may also establish indicators to monitor the performance with regard to the management of the area, in which case the management authority must submit annual reports on the achievement or otherwise of these indicators. External auditors may also be appointed to verify compliance.

Although the application for the establishment of the Greater Zandvlei Estuary Nature Reserve for Local authority nature reserve status was done under the Nature Conservation Ordinance 19 of 1974, Section 28(7) of the Protected Areas Act provides that an area which was a protected environment before the section took effect, must be regarded as having been declared in terms of the section. Thus the provisions of the Act are directly applicable. The responsibility for overseeing implementation of these provisions however, lies with the Province, the responsibility for Protected Natural Environments having been delegated to the provinces by the Environment Conservation
As far as can be ascertained, this oversight function has not been established as yet.

National Environmental Management: Biodiversity Act, 10 of 2004 (NEMBA)

The objectives of the Biodiversity Act include:
- the management and conservation of biological diversity;
- the use of indigenous biological resources in a sustainable manner;
- to give effect to international obligations under the Convention on Biological Diversity, Ramsar and the Bonn Convention.

This includes the protection of threatened species and ecosystems, and the management of threats to biodiversity – such as alien and invasive species. Both aspects are pertinent to the Zandvlei Estuary in as much as it is inhabited by a number of threatened species (see Section 2.7), and has been invaded by a number of alien species, both terrestrial and aquatic.

With respect to invasive species, Section 76 (2) of NEMBA requires all organs of state in all spheres of government to prepare invasive species monitoring, control and eradication plans for land under their control. In the case of municipalities, such plans must be part of their integrated development plans. This plan must include the following:

- a detailed list and description of any listed invasive species occurring on the relevant land;
- a description of the parts of that land that are infested with such listed invasive species;
- an assessment of the extent of such infestation;
- a status report on the efficacy of previous control and eradication measures;
- the current measures to monitor, control and eradicate such invasive species; and
- measurable indicators of progress and success, and indications of when the control plan is to be completed.

Where the area is a protected area in terms of the Act, the management authority of the protected area must incorporate an invasive species control and eradication strategy into the management plan of the area. The management authority must also at regular intervals prepare and submit to the Minister or the MEC for environmental affairs in the province a report on the status of any listed species that occurs in that area.

The Act also provides for the Minister to publish a national list of invasive species and for the MEC of environmental affairs in a province to publish a provincial list of invasive species. The Minister published draft Alien and Invasive Species Regulations in 2007, including a draft list of invasive species. These regulations are in the process of being finalized.

National Water Act, 36 of 1998

The purpose of the Act is to ensure that the national water resources are protected, used, developed, conserved, managed and controlled appropriately. This involves a variety of activities, two of which are of particular relevance to the management of the
Zandvlei Estuary, namely catchment management, and management of the use of water.

The Act provides for the establishment of Catchment Management Agencies so that water resource management can be delegated to the regional or catchment level. The Minister of Water Affairs assumes the powers of a Catchment Management Agency in areas where such agencies have not been established. While such an agency has not been established for the Zandvlei catchment, the local authority has established a Catchment Management Forum.

Catchment Management Agencies are required to establish catchment management strategies for the conservation and management of water resources within its water management area. The establishment of a catchment management strategy includes a public participation component which requires inviting written comments to be submitted on the proposed strategy. A catchment management strategy must, among other things:

- take into account the class of water resources and resource quality objectives and the requirements of the reserve;
- set out strategies and objectives for the protection, management and control of water resources within the water management area;
- enable the public to participate in managing water resources within the water management area; and
- set out the institutions to be established.

In developing a catchment management strategy, a Catchment Management Agency must also consult with persons whose activities affect or might affect water resources within the management area and who have an interest in the content or implementation of the catchment management strategy.

The Act provides for the Minister to prescribe a system for classifying water resources which may establish guidelines and procedures for determining different classes of water resources. It may also set out water uses for instream or land-based activities which must be regulated in order to protect the water resources. Once the Minister has prescribed the system for classifying water resources, he or she must determine, for every significant water resource, quality objectives based on such classification. Such objectives may relate to the reserve, the instream flow, the water level, the presence and concentration of particular substances in the water, and the characteristics and quality of the water resource. The Minister is required to determine the Reserve for all or part of that water resource. The Act provides for a preliminary determination of the reserve to made until a system for classifying water resources has been prescribed or a class of a water resource has been determined.

Section 21 sets out water uses which require a water use licence. Those relevant to estuaries include:

- impeding or diverting the flow of water in a water course;
- discharging waste or water containing waste into a water resource through a pipe, canal, sewer, sea outfall or other conduit;
- disposing of waste in a matter which may detrimentally impact on the water resource;
- altering the bed, banks, course or characteristics of a water course; or
- disposing in any manner of water which contains waste from, or which has been
  heated in, any industrial or power generation process.

The Act further makes provision for the Minister to make regulations. Such regulations
may create offences and prescribe penalties. The Minister when making regulations
must take into account relevant considerations including the need to protect water
resources and facilitate the monitoring of water use and water resources. The
regulations may further control the discharge of waste into a water resource.

*Marine Living Resources Act, 18 of 1998 (amended in 2000)*

The Marine Living Resources Act provides for the utilization, conservation and
management of marine living resources. In so doing, it recognizes the need for the
conservation of marine ecosystems, protection of marine biodiversity and the
minimization of marine pollution. In order to accomplish this, the Minister may declare
marine protected areas, where certain activities are prohibited. These include fishing or
attempting to fish, constructing or erecting any building or other structure on or over any
land or water within a marine protected area or discharging or depositing waste or any
other polluting matter. An area may be declared to be a marine protected area for the
protection of fauna and flora, to facilitate fishery management or to diminish any conflict
that may arise from competing uses in that area.

Table 7. Summary of Applicable National Legislation

<table>
<thead>
<tr>
<th>National legislation</th>
<th>Description</th>
<th>Management Implications</th>
<th>Lead Agent</th>
<th>Relevance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marine Living Resources Act, 18 of 1998</td>
<td>Provides for the conservation of marine ecosystems and biodiversity, and the sustainable utilisation of marine living resources.</td>
<td>The Minister may declare certain areas as Marine Protected Areas, within which permission is required to carry out certain activities including fishing, the construction or erection of buildings and the dredging, or extracting of sand or gravel.</td>
<td>Department of Environmental Affairs (Marine and Coastal Management)</td>
<td>HA WQL WQN</td>
</tr>
<tr>
<td>National Environmental Management Act, 107 of 1998 (“NEMA”)</td>
<td>Provides for co-operative environmental governance by establishing principles for decision-making, institutions to promote co-operative governance &amp; procedures for co-ordinating environmental functions.</td>
<td>A duty of care is imposed to prevent or remedy significant pollution or degradation of the environment - especially sensitive, vulnerable, highly dynamic or stressed ecosystems, such as estuaries.</td>
<td>Department of Environmental Affairs</td>
<td>HA WQL WQN</td>
</tr>
<tr>
<td>Environmental Impact Assessment (“EIA”)</td>
<td>Regulates procedures, and criteria for the submission, processing, consideration and</td>
<td>Approval by the environmental authorities is required for activities listed in the EIA Regulations. This</td>
<td>Department of Environmental Affairs / Department of</td>
<td>HA WQL WQN</td>
</tr>
<tr>
<td>National legislation</td>
<td>Description</td>
<td>Management Implications</td>
<td>Lead Agent</td>
<td>Relevance</td>
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<tr>
<td>Regulations, 2006 (made under NEMA)</td>
<td>decision of applications for environmental authorisation of activities.</td>
<td>includes certain activities in the coastal zone. Approval is dependent on the findings of the environmental impact assessment.</td>
<td>Environmental Affairs and Development Planning</td>
<td>WQL/WQN/HA</td>
</tr>
<tr>
<td>National Water Act, 36 of 1998</td>
<td>Aims to ensure that water resources are protected, used, developed, conserved, managed and controlled appropriately.</td>
<td>Water resources are defined in the Act to include estuaries. The Act sets out various water uses for which a water use licence is required, including the taking of water from a water resource.</td>
<td>Department of Water Affairs</td>
<td>HA WQL WQN</td>
</tr>
<tr>
<td>National Heritage Resources Act, 25 of 1999</td>
<td>Introduces an integrated and interactive system for the management of the national heritage resources. In terms of the Act, heritage resources may include landscapes and natural features of cultural significance.</td>
<td>The responsible heritage resources authority must be notified of certain categories of development where this may result in heritage resources being affected. The authority may then request that an impact assessment report be submitted.</td>
<td>South African Heritage Resources Agency / Heritage Western Cape</td>
<td>HA WQL WQN</td>
</tr>
<tr>
<td>Local Government: Municipal Systems Act, 32 of 2000</td>
<td>A municipal council must adopt a single, inclusive and strategic plan which links, integrates and co-ordinates plans and takes into account proposals for the development of the municipality.</td>
<td>An adopted integrated development plan is the principle strategic planning instrument which guides &amp; informs all planning &amp; development, and all decisions with regards to planning, management and development, in the municipality.</td>
<td>Department of Provincial and Local Government</td>
<td>HA WQL WQN</td>
</tr>
<tr>
<td>National Environmental Management: Protected Areas Act, 57 of 2003</td>
<td>Aims to establish a national system of protected areas as part of a strategy to manage and conserve biodiversity and ecosystems.</td>
<td>Where a protected area is declared, restrictions may be applied to development or activities that are inappropriate for the area.</td>
<td>Department of Environmental Affairs/ CapeNature</td>
<td>HA WQL WQN</td>
</tr>
<tr>
<td>National Environmental Management: Biodiversity Act, 10 of 2004</td>
<td>Provides for the management and conservation of biodiversity and of the components of such biological diversity within the framework of NEMA. Provides for co-operative governance in biodiversity management and conservation.</td>
<td>Gives effect to ratified international agreements relating to biodiversity (ie. Ramsar Convention, Bonn Convention &amp; Convention on Biological Diversity). Provides for identification and listing of vulnerable and threatened ecosystems and species and for bioregional plans.</td>
<td>Department of Environmental Affairs</td>
<td>HA</td>
</tr>
</tbody>
</table>
National legislation | Description | Management Implications | Lead Agent | Relevance WQL/WQN/HA
--- | --- | --- | --- | ---
National Environmental Management: Integrated Coastal Management Act, 2008 | Establishes a system of integrated coastal and estuarine management including norms, standards and policies, in order to promote the conservation of the coastal environment. Further aims to control dumping at sea, pollution in the coastal zone and inappropriate development of the coastal environment. Estuaries are to be managed in accordance with a national estuarine management protocol. This must set standards for the management of estuaries and establish procedures regarding how estuaries are to be managed and establish minimum requirements for estuarine management plans. | Estuaries would form part of "coastal public property" and "coastal waters" and would consequently be inalienable and under trusteeship of the State. The development of an estuarine management plan must follow a public participation process consistent with the national estuarine management protocol. Imposes a duty to avoid causing adverse effects on the coastal environment. The duty of care in the National Environmental Management Act applies to any impact that has an adverse effect on the coastal environment. Effluent that originates from a source on land may not be discharged into an estuary unless authorised in terms of a general authorisation or a coastal waters discharge permit. | Department of Environmental Affairs (Marine and Coastal Management) | HA WQL WQN

4.3 Provincial Legislation

*Nature and Conservation Ordinance, 19 of 1974 (as amended)*

The Ordinance provides for the establishment of provincial, local and private nature reserves and related conservation measures, including the regulation of hunting. It also provides, separately for the protection of flora, wild animals and fish in inland waters. With respect to fish, subject to various conditions and some exemptions, a permit is generally required to catch fish. The limitations cover issues such as the type and size of fish, bag limits, season, method of fishing and sale of fish. The Ordinance also prohibits the sale or purchase – except under permit – of bait species.

It further prohibits the depositing in any inland waters or in any place from where it is likely to percolate into inland waters, anything which is or is likely to be injurious to any fish or fish food or which, if it were so deposited in large quantities would be so injurious.
It is anticipated that the will eventually be replaced by a Western Cape Biodiversity/Nature Conservation Act. A draft Bill was produced in 2006, but is currently still under review.

Table 8. Summary of relevant Provincial legislation

<table>
<thead>
<tr>
<th>Provincial legislation</th>
<th>Description</th>
<th>Management Implications</th>
<th>Lead Agent</th>
<th>Relevance WQL/WQN/HA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal Ordinance, 20 of 1974</td>
<td>Consolidates and amends the law relating to municipalities, village management boards and local boards and deals with municipal services.</td>
<td>Provides for the draining of storm water or discharge of water from any municipal service work into any natural watercourse.</td>
<td>Municipality</td>
<td>HA WQL WQN</td>
</tr>
<tr>
<td>Cape Nature and Environmental Conservation Ordinance, 19 of 1974 (amended in 1999)</td>
<td>Deals with the establishment of nature reserves, the protection of wild animals, the protection of fish in inland waters and the protection of flora.</td>
<td>Prohibits the deposition of substances likely to be injurious to any fish or fish food. An angling licence is required for angling in inland waters.</td>
<td>CapeNature</td>
<td>HA WQL WQN</td>
</tr>
<tr>
<td>Land Use Planning Ordinance, 15 of 1985</td>
<td>Regulates land use planning applications in the Western Cape.</td>
<td>Applications for departure, rezoning and sub-division, where applicable need to be submitted in terms of this ordinance.</td>
<td>Department of Environmental Affairs and Development Planning</td>
<td>HA</td>
</tr>
<tr>
<td>Western Cape Planning and Development Act, 7 of 1999</td>
<td>Provides for principles, policies, guidelines and parameters for planning and sustainable development, including environmental protection and land development management.</td>
<td>Sets out general planning and development principles which apply throughout the province. This includes principles of environmental protection, including that development in unsuitable environments such as areas with a high water table, swamps, flood plains, steep slopes and areas sensitive to drift-sands should be discouraged. This Act has not yet however been brought into force.</td>
<td>Department of Environmental Affairs and Development Planning</td>
<td>HA</td>
</tr>
</tbody>
</table>

**4.4 Municipal By-Laws (City of Cape Town)**

*By-Law Relating to the Control and Use of Vleis and Boating Thereon, 1980 as amended*

The primary focus of this by-law is the licensing and use of power boats on vleis. The by-law also prohibits the use of power boats on a number of vleis — including Zandvlei -
except for in cases of emergencies, the provision of municipal services or to enforce the by-law.

The by-law also includes a number of more general provisions which prohibit, for example:

- the use of any vessel on the vlei for human habitation;
- the discharge of waste or pollution directly or indirectly into the vlei;
- the introduction of any fish or aquatic growth into the vlei;
- the removal of prawns, shrimp or flora from the vlei without a permit;
- the hunting of any animals in or on any vlei;
- the disturbance of birds and/or their nests; and
- bathing in the vlei where this is prohibited by notice.

In addition, the by-law regulates the manner in which fish may be caught in the vlei, as well as various activities which could cause a public nuisance (eg. stone-throwing, playing music, drinking etc.)

This by-law is currently in the process of being revised and updated. The draft suggests that while many of the provisions are similar, the regulation of boating will be expanded to vessels other than power-boats. The applicability of the by-law will be extended to all vleis under the control of the City.

**By-Law Relating to Stormwater Management, 2005**

This by-law provides for the management of stormwater in the City of Cape Town, including the regulation of activities which may have a detrimental effect on the development, operation or maintenance of the stormwater system. The stormwater system is defined to include natural facilities including water courses and their associated flood plains used for the disposal of storm water. Similarly, the definition of stormwater includes natural precipitation, groundwater and spring water conveyed by the stormwater system, and sea water within estuaries.

In terms of this by-law, the written consent of the Municipal Council of the City is required to discharge anything other than stormwater into the stormwater system. The following activities may not be carried out without the written consent of the Council:

- the discharging from any place, or place onto any surface, any substance other than stormwater where that substance could reasonably be expected to find its way into the stormwater system;
- discharge, permit to enter or place anything likely to contaminate or pollute the water in the stormwater system;
- construct or erect any structure in such a manner so as to interfere with or endanger the stormwater system; and
- excavating, landscaping, opening up or removing the ground immediately next to any part of the stormwater system.

Conditions that may be imposed by the Council when issuing consent include the undertaking of impact assessments and environmental impact studies or investigations which may be required by applicable environmental legislation. In the event of an
incident involving the discharge of pollutants into the stormwater system, the person responsible is required at his or her own cost to take all reasonable measures which in the opinion of the Council will contain and minimize the effects of the pollution by undertaking cleaning up procedures, including the rehabilitation of the environment as the Council may require.

Where it appears that any action or negligence by any person or owner of property may lead to a contravention of the provisions of this by-law, the Council may give notice in writing to such person to comply with such requirements as the council deems necessary. The by-law confers wide powers on the council including to:

- remove anything discharged into the stormwater system or natural water course in contravention of the by-law;
- sealing off or blocking any point of discharge if such discharge point is in contravention of the by-law irrespective of whether the point is used for lawful purposes; or
- repair and make good any damage done in contravention of the by-law or resulting from a contravention.

All reasonable costs incurred from the taking of the above steps may be recovered from the person who is responsible for the contravention or the owner of property on which the contravention occurred.

The by-law does also provide however that the Council may drain stormwater or discharge water from any municipal service works into any natural water course (which includes a vlei).

**Dumping and Littering By-law, 2002**

This by-law prohibits littering or the dumping of waste. Waste is described as any matter which is a by-product, emission, residue or remainder of any product, process or activity and which has been discarded. Where the littering or dumping of waste takes place, the City of Cape Town may by written notice direct the relevant persons to cease the dumping or littering or to prevent the continuation of the dumping or littering and to take whatever steps the City considers necessary to clean up or remove the waste, to rehabilitate the affected facets of the environment and to ensure that the waste and any contaminated material which cannot be cleaned or rehabilitated is disposed of lawfully.

The City may in its notice specify a reasonable time within which the directions must be complied with. In addition or as an alternative to the issuing of a written notice or if a person fails to comply with the directions given in a notice issued by the City, the City may itself take whatever steps it considers necessary to clean up or remove the waste, to rehabilitate the premises or place and affected facets of the environment at which the waste has been dumped and to ensure that the waste and any contaminated material which cannot be cleaned or rehabilitated is disposed of lawfully. The City may then recover the cost of taking these measures from the responsible parties.
Table 10. Summary of relevant municipal regulations

<table>
<thead>
<tr>
<th>Municipal By-Law</th>
<th>Description</th>
<th>Management Implications</th>
<th>Relevance WQL/WQN/ HA</th>
</tr>
</thead>
<tbody>
<tr>
<td>By-law relating to the Control and Use of Vleis and Boating Thereon, 1980 as amended.</td>
<td>Provides for the regulation of power boats on vleis, the discharge of waste and pollution into vleis, and the introduction or removal of plants or animals.</td>
<td>Permits are required for the removal of prawns, shrimp and flora as well as for the operation of power boats. The discharge of waste is prohibited as are various other activities.</td>
<td>HA WQL</td>
</tr>
<tr>
<td>Dumping and Littering By-Law, 2002</td>
<td>Provides that no person may litter or permit the littering of waste or dump or permit the dumping of waste.</td>
<td>The depositing, discharge, spill, or release of waste is prohibited.</td>
<td>HA WQL WQN</td>
</tr>
<tr>
<td>By-law relating to Stormwater Management, 2005</td>
<td>Provides for stormwater management and regulates activities which may have a detrimental effect on the operation of a stormwater system. Stormwater includes natural precipitation, groundwater and spring water conveyed by the stormwater system, and seawater within estuaries.</td>
<td>Written consent is required for activities affecting the stormwater system, including draining, abstracting or diverting water from the stormwater system, erecting any structure that would interfere with the stormwater system or discharging any substance likely to damage the stormwater system or contaminate the water therein.</td>
<td>WQL WQN</td>
</tr>
</tbody>
</table>

4.5 Institutional Management Plans and Strategies

Table 10: Summary of relevant institutional plans and strategies

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Description</th>
<th>Management Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>City of Cape Town Integrated Development Plan, 2007/8 – 2011/12</td>
<td>Is the principal strategic planning instrument that informs all planning and development within the City. Recognises that the City will seek to create an environment that is conducive to growth and development while at the same time protecting the environment to ensure sustainability.</td>
<td>The protection of natural aquatic environments is one of the objectives of the Sustainable Urban Infrastructure and Services strategic focus area.</td>
</tr>
<tr>
<td>The iKapa Growth and Development Strategy, 2008</td>
<td>Serves as a White Paper for the Western Cape. It aims to guide municipal integrated development plans, local economic development, and district and metropolitan growth and development strategies. Recognises that water, biodiversity, and coastal and marine systems and resources have been identified as</td>
<td>The promotion of ecologically sustainable development is one of the five goals of the strategy to guide policy-making, programming and resource allocation. Requires sustainable resource use to respond to climate change, ecosystem degradation and threats to key strategic natural resources.</td>
</tr>
</tbody>
</table>
## Zandvlei Estuary: Situation Assessment

| City of Cape Town Coastal Zone Management Strategy, 2003 | Presents an institutional management framework that will facilitate an effective and efficient Coastal Zone Management Strategy.  
Recognises that estuaries play a significant role in the coastal zone as essential components to healthy ecosystems, as nurseries to many fish species and as key recreation nodes.  
Aims to develop and implement management plans for each of the estuaries in Cape Town by working with relevant Directorates including Catchment Management Forums, City Health, Scientific Services and the Wastewater Department. | Estuary management is one of the coastal management strategic objectives.  
Management plans for each estuary must include mechanisms for monitoring the health of the estuary, a commitment to a continual improvement, emergency response mechanisms and clear accountability and responsibility for implementation of the management plan.  
The final estuary management plan must be integrated into the relevant Sustainable Coastal Management Plan for the area. |
| City of Cape Town Integrated Metropolitan Environmental Policy 2003 | Seeks to recognise and protect the unique coastal and marine environment and biodiversity of the City.  
The City commits to the integration of environmental considerations in all its functions and activities including strategic planning initiatives. | Is a commitment by the City to applying the precautionary principle which states that if the environmental consequences of a proposed activity are of significant impact or concern, and are uncertain, then the activity should not be undertaken. |
| City of Cape Town Biodiversity Strategy | Plans to ensure conservation by mainstreaming biodiversity; identifying key areas of biodiversity & establishing structures to manage the initiatives. | Has 7 strategic objectives:  
- A network of biodiversity areas and nodes;  
- Use of corridors, links & mixed use areas to connect the network;  
- Conservation of biodiversity in freshwater aquatic systems;  
- Invasive alien species management;  
- Biodiversity legislation & enforcement;  
- Biodiversity information & monitoring system;  
- Biodiversity education & awareness. |
5. MANAGEMENT OF THE ESTUARY

5.1 Legal status of the area

The northern part of the estuary around Wildwood Island was known as the Wildwood Bird Sanctuary for some years before it was officially recognised as the Zandvlei Nature Reserve by the Cape Town City Council in 1977. The Cape Bird Club was at the forefront of this initiative, and by November 1980 the area was properly fenced and two bridges and a small hide had been built. An Advisory Board was set up – on which the CBC was represented - and access to the reserve was controlled by the Parks and Forests Department of the Council through a permit system.

As far back as 1982, calls were made for the expansion of the reserve and in October, 2006 the Greater Zandvlei Estuary Nature Reserve was formally established with local authority nature reserve status under Section 7 of the Cape Nature Conservation Ordinance 19 of 1974. It is, however, also recognized under the NEM: Protected Areas Act 57 of 2003. The expansion took the area from 22 ha to 200 ha by including the Westlake Wetlands, the area between the railway line and the existing reserve, Wildwood, Little Australia and Park Islands, the water body of the estuary up to the 1-in-100 year floodline, and some outlying areas, for example, Bath Road and the Keysers River rehabilitation site. The boundaries of the reserve are shown in Figure 8 below.

![Figure 8: Boundaries of the Greater Zandvlei Estuary Nature Reserve.](image-url)
In addition, most of the Zandvlei shoreline not included in the reserve has been reserved as public open space for between 50 and 100 metres from the water’s edge.

5.1.1 Management responsibilities

Zandvlei – including the water body and the shoreline – and much of the catchment falls under the jurisdiction of the Cape Town City Council. However, responsibility for the management of the area – and/or activities which impact on the reserve – is split across a number of different departments within the City, including:

- Biodiversity Management Division of the Environmental Resources Management Department – responsible for overall management of the reserve;
- Catchment Planning (Southern Region) of the Catchment, Stormwater and River Management Department – responsible for management of the catchment, rivers and stormwater, including water quality monitoring and management of water levels;
- City Parks – responsible for the management of the public open space and recreational facilities along the margins of the estuary. They have also been responsible for the harvesting of the pondweed although a decision has recently been made to transfer this responsibility to Biodiversity Management from July, 2010.
- Environmental Health – responsible for implementation of the Environmental Health by-law, which includes dealing with anything which constitutes a health nuisance for example, pests (invasive or otherwise), weeds and pollution.

The activities of the various departments are at present coordinated through the Zandvlei Action Committee (ZAC).

5.1.2 Zandvlei Management Plan

The City of Cape Town report on the planning and development of recreational facilities for a Zandvlei Regional Leisure Park (1981) refers to the development of a management plan for the waters of Zandvlei with the assistance of a consultant from UCT. However, although there are procedures in place for the management of various problems in the reserve – for example, the management of water levels – it is not clear whether this plan was ever completed.

In mid-1987, the City’s inter-departmental Inland Waters Management Team established the Zandvlei Working Group which produced a technical report and made a number of management recommendations. Their findings are summarized in the Zandvlei Management Study Summary Report (January, 1989) and, according to Thornton et al (1995), the Inland Waters Management Team then developed a plan which was adopted by Council during 1990. Thornton et al (1995) listed the elements of this plan as follows:

- Maintenance of the existing management programmes for weed harvesting, litter collection, canal clearance and water level management in the absence of practicable alternatives;
- Augmentation of litter collection and weed harvesting programmes by increasing the frequency of efforts in recreational areas;
- Increased public awareness and participation programmes;
- Continuation of water quality monitoring programmes; and
A cost-benefit analysis of proposals to dredge and deepen the vlei, including an assessment of options to improve seawater circulation in conjunction with the reconstruction of the vlei mouth in 1992.

While it has not been possible to locate a copy of this plan, most of these elements are being implemented to a greater or lesser degree, although it is not clear exactly what was envisaged in terms of reconstructing the mouth. What is clear is that despite these efforts, most, if not all, of the problems are still present and are discussed in more detail in the next section.

5.2 Threats to the estuary and related management initiatives

As has been discussed earlier in this report, Zandvlei has not only been subjected to major physical alterations, but the opening and closing of the mouth – and the associated exchanges of saline and freshwater – are now determined by a management regime aimed primarily at maintaining water levels for recreational purposes and to prevent flooding. This – together with other factors - has altered the natural balance between the amount of seawater entering the mouth and the freshwater coming down the rivers which discharge into it, with major implications for the biological communities of the estuary. At the same time, developments in the catchment and urbanization of the areas around the estuary have had major impacts on water quality and siltation, and a variety of alien species have been introduced to the system. These threats – most of which are inter-related - need to be addressed, not only to protect the estuary and its biodiversity from further deterioration, but to maintain the vlei in a condition suitable for ongoing human use.

As indicated above, most of these issues have been the subject of management initiatives for years. They are discussed in more detail below, with a particular emphasis on current approaches.

5.2.1 Management of water levels and related issues

Attempts to manipulate the amount of water in the estuary go back to 1866 when a decision was taken to close off and drain it so as to use it for agricultural purposes. This failed, and later initiatives were instead focused on maintaining water levels for recreational boating and preventing flooding of the surrounding areas. The outlet channel was canalized in the 1950’s, and was followed by the construction of a rubble weir just below the Royal Road Bridge. Although its original purpose was to protect a sewage pipe from scouring, it has subsequently been used in the management of water levels in the estuary together with the artificial opening and closure of the mouth. To this end, it was raised in 1983 from 0.7m aMSL to 0.84m aMSL, and again in 1989 to 0.9 a MSL.

Concern over the impacts of the water level management regime led to the commissioning of a study to, amongst others, develop and assess various alternative engineering options with a view to mitigating the situation. According to the report (Ninham Shand, 2000), problems related to the management regime included:

- The construction of residential areas within the natural floodlines of the estuary – particularly in Marina da Gama – which preclude the re-establishment of the
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original range of water level fluctuations (see Fig. 9 below). This is estimated to have been from approximately 0 to 3m aMSL, whereas the current range is limited to between 0.7 and 1.4m aMSL. Some of the buildings within the marina are threatened with inundation once water levels reach 1.4 m aMSL;

- The revetments which were constructed along all the major channels in the marina were designed for an operating water level of 0.7 m aMSL. Some of these are now unstable at least in part because of the higher water levels, although the harvesting of the pondweed close to the revetments (within 2m) and wave action is also thought to contribute to the problem. Water levels in excess of 0.9m aMSL for extended periods pose a threat to revetment stability;
- The limitations placed on tidal exchange by the weir. Saline water only enters the estuary for a few hours at high spring tides every 14 days, and then only when the mouth is open. As a result, salinities in the estuary have declined with consequential changes in the biodiversity;
- By limiting tidal flows, the weir also exacerbates siltation in the outlet channel, while artificial breaching of the mouth at water levels lower than would be required for natural breaching means that the scouring of the mouth is insufficient to flush out the sediments.

The assessment of the various engineering options was based on a “vision” statement, which in turn guided the formulation of a set of criteria against which the options were evaluated. The vision statement was:

“Management should strive for a mutually-acceptable and cost-effective balance between flood control, ecological needs and recreation”.

The criteria included:

- Prevention of flooding of urban areas;
- Provision of water quality suitable for contact recreation and ecosystem health;
- Promotion of the natural functioning of the mouth and estuary as a whole;
- Enabling the migration of fish into and out of the estuary;
- Provision of water of sufficient depth for recreational purposes;
- Maintenance of aesthetics and minimisation of social nuisance factors;
- Low maintenance and capital costs and effort.

The options were also evaluated against some more specific ecological criteria – for example, salinities, with specific target levels being proposed.

On the basis of these criteria, Ninham Shand (2000) recommended an interim management regime based on a managed rubble weir with the weir crest elevation being managed on a seasonal basis between 0.6m and 0.9m a MSL. In the longer term, it was suggested that consideration should be given to maintaining the weir crest at 0.6m throughout the year in combination with a dredging programme to ensure sufficient water depth for the recreational users.
Ninham Shand (2000) also recommended the institution of a restoration monitoring programme to evaluate the effectiveness of the proposed management regime. This included observations on:

- catchment runoff
- ambient salinity
- water levels
- mouth conditions
- estuarine flora and fauna (eg. phytoplankton, pondweed, fish, sandprawns, zooplankton, tube worms, birds etc).

5.2.1.1 Current Management Regime (since 2001)

In light of the practical difficulties related to altering the height of the weir on a seasonal basis, the City has in fact reduced the height of the weir to around 0.7 m, with more emphasis being placed on the manipulation of the sandbar at the mouth to manage water levels as follows:
In the rainy winter months, the sandbar is kept open so as to avoid flooding of the surrounding areas – unless there is a particularly dry spell, in which case the sandbar may be closed for short periods to restore water levels so as to meet the needs of the recreational users.

During the summer months, the sandbar is kept closed except:
- When water levels become too high (in excess of 1.0 m aMSL for long periods) since such levels destabilise the revetments in the marina;
- When there is a high spring tide. This occurs 5 – 6 times each summer, and is intended to facilitate the intrusion of saline water into the estuary. The target ambient salinity is between 5 and 10 ppt although a salinity of 17 ppt needs to be maintained over the distribution range of sandprawns during their breeding period.

In combination with the above, and in the absence of funds for further dredging, the main yachting events are scheduled for neap tide periods, and there are guidelines for the management of pondweed which limit harvesting to within 2 metres of the banks.

5.2.1.2 Restorative Monitoring Programme

Some elements of the proposed monitoring programme have also been implemented as follows:

*Ambient salinity*

Salinity is being measured as part of the ongoing Catchment Planning (through Scientific Services) water quality monitoring programme as well as the Community Monitoring Programme discussed in Section 2.5. Target salinities for the main body of the estuary in winter are between 5 ppt (surface) and 7 ppt (bottom) and in summer 10 ppt throughout the water column. For the outlet channel they are 6 ppt (surface) and 18 ppt (bottom) in winter, and 11 ppt (surface) and 13 ppt (bottom) in the summer. The results suggest these are being met, although at present only surface salinities at a single station are being measured – and only on a monthly basis. The data from some additional stations commissioned by Biodiversity Management in 2008 has not yet been collated.

![Salinity (ppt) at Zandvlei Centre: 2000-2009](image)

*Figure 10: Salinity at Zandvlei Centre (Scientific Services data).*
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Water levels

Water levels are measured by a water level recorder at Thesen’s Bridge. There is intermittent information on water levels going back to the mid-1990’s available from the City Council on MS Access.

Mouth conditions

Records of the mouth opening and closing dates going back to 2000 are held by the City Council. Records for the current year are also available on the Zandvlei Trust website.

Biological monitoring

In 2001, Southern Waters was appointed to establish baselines for those species/groups which had not been the subject of previous monitoring. This included pondweed, sandprawns, tube worm, macrobenthos, zooplankton and fish. Phytoplankton and algae - which were also recommended - were identified as being part of the Catchment Planning monitoring programme. While this was a necessary exercise in terms of being able to evaluate future changes, it must be born in mind that the situation in 2001 can in no way be taken to reflect the historical natural condition of the estuary.

The Southern Waters study reported:

- **Pondweed**: mean values of 400 g dry mass/m² for the vlei, 600 g dry mass/m² for the marina, and 3155 g dry mass/m² for the reserve areas. However, since this weed is harvested on a regular basis, the relevance of these values is not clear. Further monitoring should perhaps be linked to the harvesting programme.

- **Sandprawns**: the sandprawn populations are largely confined to the southern end of the main body of the vlei and the outlet channel, with numbers ranging from 114/m² at the southern end, to 20/m² in the north. These are substantially lower than numbers reported by Shelton (1975) which were up to 576/m². The length-frequency distribution showed a peak between 51 – 80mm, but this is likely to vary with the season as *Callianassa* has two breeding seasons annually.

- **Tubeworm**: in general, higher biomass levels occurred in the southern marina and vlei than in the northern marina (probably related to salinity levels). It was also noted that the spatial coverage appeared to be less than the 1980’s or 1990’s.

- **Macrobenthos**: the species recorded were typical of brackish water rather than estuarine habitats, and there was low species richness.

- **Zooplankton**: there were relatively few typical estuarine taxa present and the absence of decapod larvae was surprising. The numbers per species were also low by comparison with other estuaries.

- **Fish**: the samples were dominated by the silverside (*Atherina breviceps*) – 56%; harder (*Liza richardsonii*) – 34.9%; and the estuarine roundherring (*Gilchristella aestuaria*) – 4.9%.

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Apart from the fish surveys being undertaken by MCM, and the algal monitoring being undertaken by Scientific Services as part of the water quality monitoring programme, no further biological monitoring has been done. Initial indications from the fish surveys are that there has been some improvement in terms of the nursery function of the estuary.

5.2.2 Water quality management

Estuaries are generally vulnerable to the accumulation of pollutants, and the reduction of flushing of Zandvlei associated with the water level management regime is likely to make it particularly so. This is exacerbated by the relatively limited circulation of water through the Marina da Gama canals leading to the development of anoxic conditions during prolonged calm periods. It is further aggravated by the fact that the canals are deeper than the main body of the vlei and therefore act as traps (Morant and Grindley, 1982).

There are a variety of potential sources of pollution to the estuary including run-off and effluent from residential, industrial and agricultural sources both from the catchment and directly into the estuary:

- Run-off from agricultural areas in the catchment – primarily vineyards in the Constantia Valley – is likely to contain fertilizers, organic waste and pesticides;
- According to Morant and Grindley (1982) there were 9 sewage pump stations in the vicinity of Zandvlei or the influent rivers. Currently there are 14, ten of which are in Marina da Gama, 3 along Military Road, and one on Henley Road. Overflows from those in Marina da Gama and Henley Road would flow directly into Zandvlei, while those along Military Road would flow into the rivers just upstream of Zandvlei. However, all pump stations are monitored by a telemetry system which alerts officials in the event of a fault, and while overflows do occur from time to time, none have been recorded since the beginning of 2009;
- Stormwater from residential areas generally contains a number of contaminants, including pathogens, nutrients and litter. There is an extensive system of stormwater drains around Zandvlei (see Fig. 11 below). Those from industrial and low-income housing areas are of greatest concern;
- The Retreat industrial area borders on the Keysers River a short distance before it discharges into Zandvlei. Begg (1975) identified a number of potential sources of pollution including a food factory, saw mill, textile mill, and electronics and engineering factories; and
- Both the western and eastern banks of the vlei are bordered to some extent by public open space which is used for a variety of recreational activities. This generates a certain amount of litter.

5 Information provided by Brian Thomson, CoCT.
Monitoring of pollutants in Zandvlei has been undertaken by the Scientific Services of the City Council (on behalf of various Departments) for many years, with the primary focus being nutrients and pathogens. These have been the subject of a number of internal reports and publications, and are discussed in more detail below.

5.2.2.1 Nutrients

Nutrients include nitrogen (and its various compounds – ammonia, ammonium, nitrate and nitrite) and phosphorus – which also occurs in a number of forms. In general, nutrients are only toxic at very high levels – unlikely to be found except in grossly polluted systems. The more likely concern, therefore, is their potential to stimulate excessive plant growth which can lead to high levels of decaying organic material, and depleted levels of oxygen. Low oxygen levels, in turn, can result in, for example, fish kills. Systems with levels of nutrients high enough to stimulate excessive plant growth are termed eutrophic.
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While there are no Receiving Water Quality Objectives specifically for estuaries, the criteria for inorganic Nitrogen and Phosphorus in freshwater Aquatic Ecosystems are summarized below:

Nitrogen concentrations in unimpacted, aerobic surface waters are usually below 0.5 mg/l, increasing to 5 – 10 mg/l in highly enriched waters. Since water bodies vary with respect to background levels of Nitrogen, the Target Range is stated as “Inorganic nitrogen concentrations should not be changed by more than 15% from that of the water body under local unimpacted conditions…”.

Similarly, phosphorus concentrations are generally between 0.001 and 0.050 mg/l in “pristine” waters, although they may be as high as 0.2 mg/l in enclosed saline waters, and the Target Range is: “Inorganic phosphorus concentrations should not be changed by more than 15% from that of the water body under local unimpacted conditions…”.

The guidelines also show levels in relation to trophic status as shown in Table 11 below:

<table>
<thead>
<tr>
<th>Average Summer Inorganic Nitrogen Concentrations (mg/l)</th>
<th>Average Summer Inorganic Phosphorus Concentrations (mg/l)</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.5</td>
<td>&lt; 0.001</td>
<td>Oligotrophic conditions  – low species diversity, low productivity, no nuisance growth of aquatic plants.</td>
</tr>
<tr>
<td>0.5 – 2.5</td>
<td>0.005 – 0.025</td>
<td>Mesotrophic conditions  – high species diversity, productive systems, some nuisance growth but algal blooms seldom toxic.</td>
</tr>
<tr>
<td>2.5 - 10</td>
<td>0.025 – 0.25</td>
<td>Eutrophic conditions  – low species diversity, highly productive systems, substantial nuisance growth sometimes including toxic blooms.</td>
</tr>
<tr>
<td>&gt; 10</td>
<td>&gt; 0.25</td>
<td>Hypertrophic conditions  – very low species diversity, highly productive systems, substantial nuisance growth frequently including toxic blooms.</td>
</tr>
</tbody>
</table>

According to the water quality criteria for the coastal zone, Total Ammonia-N should not exceed 600 ug/l (or 0.6 mg/l) (Lusher, 1984), while the DWA guidelines for aquatic ecosystems (freshwater) state that 90% of measurements of un-ionised ammonia should be below 7 ug/l (or 0.007 mg/l), and all measurements should be below 15 ug/l which is the level at which chronic toxicity sets in.

Nutrient levels in Zandvlei are shown for two time periods:
- 1973 – 1978 – based on the City Council’s monitoring results as presented in Morant and Grindley (1982) – see Table 12 below; and
- 2000 – 2009 – based on data from the monitoring programme undertaken by Scientific Services on behalf of Catchment Planning: Station ZA02S (Zandvlei Centre) which is sampled on a monthly basis. The results from this station are shown in Figures 12 - 15 below.

It is noted that monitoring at a number of additional stations - Stations BM 16 – BM 23 – is being funded by Biodiversity Management. These have been sampled on a quarterly basis since February, 2008. Their locations are indicated below. Some of them overlap...
with the Catchment Management stations (CR 20 and WLW). However, the data from these stations has not as yet been analysed.

BM 16  Langvlei canal at litter trap south of Military Road
BM 17  Keysers River at Military Rd Bridge (= CR20)
BM 18  Westlake Wetlands (= WLW)
BM 19  Silverhurst
BM 20  Marina – Eastlake Island Way
BM 21  Marina – Sonnet Quay
BM 22  Marina – Baalen Rd.
BM 23  Marina – Park Island Bridge

The data for the 1973 – 1978 period show that the maximum levels of Ammonia exceed the guidelines at a number of stations, particularly in the northern part of the estuary. This is no doubt related to the very high levels in the influent rivers (not shown here): 30.9 mg/l for the Langvlei Canal, and 5.28 mg/l for the Westlake River.


<table>
<thead>
<tr>
<th>Parameter</th>
<th>Zandvlei North</th>
<th>Zandvlei Centre</th>
<th>Zandvlei South</th>
<th>Zandvlei Mouth</th>
<th>Tiller Arm Beat</th>
<th>Burgee Cove</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia (N mg/l)</td>
<td>0.01</td>
<td>1.123</td>
<td>&lt; 0.01</td>
<td>2.6</td>
<td>&lt; 0.01</td>
<td>0.34</td>
</tr>
<tr>
<td>Nitrite (N mg/l)</td>
<td>&lt; 0.01</td>
<td>0.2</td>
<td>&lt; 0.01</td>
<td>0.29</td>
<td>&lt; 0.01</td>
<td>0.27</td>
</tr>
<tr>
<td>Nitrate (N mg/l)</td>
<td>&lt; 0.01</td>
<td>0.46</td>
<td>0.01</td>
<td>1.18</td>
<td>&lt; 0.01</td>
<td>1.48</td>
</tr>
<tr>
<td>Total phosphorus (P mg/l)</td>
<td>&lt; 0.01</td>
<td>0.26</td>
<td>&lt; 0.01</td>
<td>0.26</td>
<td>&lt; 0.01</td>
<td>0.27</td>
</tr>
</tbody>
</table>

The Scientific Services monthly data for Zandvlei Centre (ZA02S) for the period 2000 – 2009 also shows that the guideline is exceeded relatively regularly, although the levels seem to have declined in recent years.

Both data sets show levels of Total Phosphorus in excess of 0.025 mg/l, suggesting that the system is eutrophic. This was also the conclusion of Harding (1994) and a Water Quality Report by Haskins (2007) which reported a median Total Phosphorus (TP) concentration for Zandvlei as 0.129 mg/l for the second quarter of 2007. The same report gave TP levels of 0.159 mg/l for the Keysers River at Military Road, 0.107 for the Sand River at Oudevlei Road, and 0.102 for the Westlake Wetland at Rutter Road.

Morant and Grindley (1982) reported nitrogen levels and between 1 and 2 mg/l in the vlei, which is bordering on eutrophic. Similar values are reflected in the Scientific Services data (see Fig. 14 below).
Un-ionised ammonia (mg/l) in Zandvlei Central: 2000 - 2009

Figure 12: Levels of Ammonia in Zandvlei (Scientific Services data).

Total phosphorus in Zandvlei Centre: 2000 - 2009

Figure 13: Total Phosphorus levels at ZA02S falling between the range of 0.025 and 0.25mg/l which indicates eutrophic conditions.

Total N at Zandvlei Centre: 2000 - 2009

Figure 14: Nitrogen levels at ZA02S below the 2.5mg/l level which indicates eutrophic conditions.
The eutrophic status of the estuary is also reflected in the high levels of chlorophyll a as shown in Fig. 15 below. Levels are in excess of the recommended levels of between 1 – 15ug/l for recreational use (full contact).

It is likely that nutrient levels would be even higher were it not for the density of pondweed and reedbeds in the system which act as sinks. Moreover, the harvesting of these plants is a mechanism for the removal of nutrients from the system. Management of pondweed is discussed in the next section.

![Chlorophyll a (ug/l) at Zandvlei Centre: 2000 - 2009](image)

**Figure 15:** Chlorophyll a levels in relation to the 15ug/l guideline for recreational use.

5.2.2.2 Pathogens

The Water Quality Guidelines developed by the Department of Water Affairs and Forestry (DWAF) have different criteria for freshwater and marine water bodies, as well as for water bodies intended for different uses. Thus there are, amongst others, different criteria for water intended for industrial or agricultural use, for recreational use, and for water which is intended to support the conservation of aquatic ecosystems. The quality of water in the Zandvlei Estuary should be considered in the context of recreation and the maintenance of ecosystem functionality.

Criteria for recreational waters distinguish between two types: full contact recreation (swimming, diving etc); and intermediate contact recreation (water-skiing, sailing, windsurfing, canoeing, paddling, wading etc), with more stringent standards being applied to full contact recreation. There also a variety of indicators which can be used, but for purposes of this report, the faecal coliform count has been selected. The more stringent standard for this indicator is similar for both freshwater and marine waters, and would therefore also be applicable to an estuary.

For full contact recreation, the target water quality range is between 0 – 100 counts per 100 ml. To meet the standard, 80% of samples taken from the water body should fall within this range (i.e. less than 100 counts); and 95% of samples should be below 2,000 counts.

For intermediate recreation, the target water quality range is 0 – 1,000.

At the same time, the DWAF Water Quality Guidelines for Recreational Use (1996) note that even within the target range, health impacts such as gastro-intestinal illness can be
expected, and recommend that where water contact could be extensive – for example, for novice water-skiing and windsurfing – the more stringent standard should be applied.

As shown in Fig. 16 below, the bacteriological monitoring done by Scientific Services suggests a decline in water quality over the past 10 years. The water quality was only suitable for full contact recreation in 2000. Even for intermediate contact, the guideline has not been met in five of the past ten years. This is consistent with reports such as Quick and Harding (1994) who suggested that there was only marginal compliance with guidelines during the summer months.

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**Bacteriological water quality in Zandvlei Centre:**

% of samples meeting target levels for contact recreation

<table>
<thead>
<tr>
<th>Year</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 100</td>
<td>80%</td>
<td>70%</td>
<td>60%</td>
<td>50%</td>
<td>40%</td>
<td>30%</td>
<td>20%</td>
<td>10%</td>
<td>0%</td>
<td>10%</td>
</tr>
<tr>
<td>&lt; 2000</td>
<td>95%</td>
<td>90%</td>
<td>85%</td>
<td>80%</td>
<td>75%</td>
<td>70%</td>
<td>65%</td>
<td>60%</td>
<td>55%</td>
<td>50%</td>
</tr>
</tbody>
</table>

**Figure 16:** % compliance with the water quality standard for full contact recreation

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**Bacteriological water quality in Zandvlei Centre:**

% of samples meeting guideline for intermediate recreation

<table>
<thead>
<tr>
<th>Year</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1000</td>
<td>80%</td>
<td>70%</td>
<td>60%</td>
<td>50%</td>
<td>40%</td>
<td>30%</td>
<td>20%</td>
<td>10%</td>
<td>0%</td>
<td>10%</td>
</tr>
<tr>
<td>80%</td>
<td>95%</td>
<td>90%</td>
<td>85%</td>
<td>80%</td>
<td>75%</td>
<td>70%</td>
<td>65%</td>
<td>60%</td>
<td>55%</td>
<td>50%</td>
</tr>
</tbody>
</table>

**Figure 17:** % compliance with the water quality standard for intermediate contact recreation

---

It is noted that Scientific Services generally only take one sample/month, and that this analysis is based on a single sampling station.
5.2.2.3 Trace metals

There do not seem to have been any investigations into trace metals or other toxic compounds in Zandvlei despite the fact that the influent rivers pass through industrial and/or agricultural areas. Hughes (2002) reported elevated levels of copper and zinc in the lower Keyser’s River.

5.2.3 Pondweed (Potamogeton)

Although the pondweed, *Potamogeton pectinatus*, occurs naturally in vleis – and is, in fact, an important component of the ecosystem, providing food and shelter for a variety of organisms, and helping to oxygenate the water - under high nutrient conditions, it can become a nuisance. Pondweed has in fact been a problem in Zandvlei for many years, at times forming dense mats which restrict boating activities, exacerbate flooding and, when they start to decompose, causing unpleasant odours. Other problems include the loss of open water habitat for waterfowl, the provision of a substrate for other nuisance algae (eg. *Cladophora*), and depletion of dissolved oxygen (Harding, 1999).

There have therefore been ongoing efforts to reduce the volumes of pondweed in key areas while at the same time retaining a sufficient amount to maintain the ecological function. Harvesting using a mechanical harvester was initiated from at least 1976 (reported in Begg, 1976), but overharvesting led to a crash in the population in the late 1970’s. A second collapse which occurred in the early 1990’s was attributed to the decline in salinity in the estuary (Harding, 1999). By the late 1990’s the population had again reached excessive levels, and Southern Waters (Bill Harding) was contracted to develop management guidelines on the “technique, frequency and extent of pondweed harvesting, including the identification of nursery areas, as well as linkages to other key ecological associations (estuarine water quality, salinity balance and biota), and to pending/extant projects aimed at enhancing the sustainable management of these associations.” In addition, the consultant was to provide specifications for a monitoring programme to support the management efforts.

Amongst the conclusions of this report was that the recommended guidelines should be seen as a starting point for the management of pondweed, and that their implementation should be combined with monitoring and assessment with a view to fine-tuning the guidelines at a later stage. The recommendations included:

- At least 3 cuttings per season would be required to keep the recreational areas clear of pondweed;
- The harvesting protocol should be more flexible – and linked to monitoring – to allow for a more time and cost-effective approach;
- Education of operators;
- Harvesting should be concentrated around seasonal growth periods;
- At least 30% of the vlei and marina should be retained as “reserve” or nursery areas;
- Specific guidelines regarding depth of harvesting etc were provided for the recreational areas
- A detailed monitoring programme including seasonal surveys, logging of volumes of pondweed removed, and an assessment of the impact of harvesting on the fish nursery function.
It is not clear to what extent the guidelines were implemented, but a site visit after complaints from Marina da Gama residents in April, 2010 confirmed that there are currently excessive levels of pondweed in the system (see Fig. 18 below). Residents stated that although the harvesting programme has been successfully implemented at times in the past, there are now significant problems. These include:

- Despite the fact that there are now two machines, the maintenance programme is poorly implemented, and the machines are regularly out of commission;
- Even when the machines are operational, they only operate 5 – 6 hours a day, in part because of an insufficient number of trained drivers but also because of the lack of protection for the drivers in inclement weather;
- The machines are being used in other areas (i.e. other than Zandvlei);
- The harvested material is not being used effectively, and some of it is just dumped;
- Cyanobacteria and other material are being transferred by the machines.

Suggestions aimed at improving the situation included:
- maintaining a stockpile of spare parts to reduce down-time;
- increasing the number of trained drivers;
- budgeting for a 3rd machine and for over-time;
- constructing a canopy to protect the driver from the sun and rain.

The residents of Marina da Gama also indicated their willingness to assist with making such improvements.

Following a meeting with City officials, it was agreed that the responsibility for implementing the harvesting programme should be transferred to Biodiversity Management as of the 1st July, 2010.

Fig. 18: The mechanical harvester operating in the marina (April, 2010).
5.2.4 Invasive species

A variety of both indigenous and alien invasive species have affected Zandvlei and the surrounding areas, some for many years. A list of recorded alien species can be found in Table 13 below. A list of alien plants found in the lower Keysers River was included in Annex C of Hughes (2002).

To date efforts to manage these species have been relatively ad hoc, although annual operational plans have been implemented for the clearing of terrestrial species. However, given the nature of invasive species, efforts to eradicate or control invasive species cannot be limited to a specific site, but must be integrated with adjacent areas if they are to be effective. The City is therefore currently in the process of developing a policy on invasive species and, as required by Section 76 (2) of the National Environmental Management: Biodiversity Act (21004) (NEMBA) will prepare an invasive species monitoring, control and eradication plan for land under its control. NEMBA also requires the City, as the management authority for the GZENR, to prepare a management plan including invasive species control and eradication strategies. At the same time, plans are being prepared for individual species, or groups of species, at national or other levels – for example at catchment level for aquatic weeds.

Some of the more common invasive species in Zandvlei – and related management initiatives - are discussed in more detail below.

5.2.4.1 Invasions of aquatic and semi-aquatic plants

The reduction in salinities combined with high levels of nutrients has led to the expansion of a variety of aquatic weeds and semi-aquatic plants – both indigenous and alien – to nuisance proportions in Zandvlei. Common alien species include *Eichornia crassipes* (water hyacinth), *Ceratophyllum demersum* (hornwort), *Azolla filiculoides* (Red waterfern) and *Myriophyllum aquaticum* (Parrot’s feather), with the indigenous species being the reeds *Phragmites* and *Typha*. *Lemna spp* and *Salvinia molesta* have also been recorded (Archibald, 1998). These species are generally concentrated in the upper reaches of the estuary, Westlake Wetlands and the influent rivers, where they inhibit recreational use (particularly water hyacinth) and exacerbate the potential for flooding. Quick and Harding (1994) for example, described the riparian vegetation of the lower and middle reaches of both the Keysers and Westlake Rivers as being dominated by *Typha* and Kikuyu grass (also an alien), with patches of *Phragmites* and *Acacia*. The water surfaces of these areas were similarly infested with water hyacinth, waterfern, Parrot’s feather and hornwort.

From an ecological perspective, dense stands of the aquatic plants can decrease light penetration and, depending on the species, alter temperature, pH and dissolved oxygen (Archibald, 1998).

Various management options are available for aquatic weeds, including chemical and biological control methods, manual or mechanical removal, and increased salinity. According to Archibald (1998) chemical controls are expensive and may have side effects on the ecosystem, while biological controls have been tried elsewhere in the Western Cape and were unsuccessful.
The current management arrangements for aquatic weeds are as follows:

- In the main body of the vlei – where they are less common because of the salinity – any weeds that are present are removed as part of the Potamogeton harvesting programme, while weeds along the edges are removed by the GZENR staff;
- In Westlake, there are several components to the management programme as follows:
  - Annual mechanical clearing of weeds from the water courses (including river channels) by the City Council ahead of the winter rains to prevent flooding;
  - Ad hoc clearing of areas not reached by the mechanical clearing eg. within the reeds on the sides of the channels, done either by Working for Wetlands or contractors at the request of – and funded by – Zandvlei Trust.

In addition, GZENR and Zandvlei Trust are currently running an experimental programme using biological controls in collaboration with Rhodes University (John Fowkes, pers. comm.).

The reedbeds (dominated by Phragmites), together with dense patches of grass, constitute a fire hazard and were identified by Sheasby (2008) as a high priority for controlled and regular burning. It was noted that this would not only reduce the fire risk, but would serve to remove nutrients from the system.

Consultants are currently drawing up an alien weed management plan for the City which will be implemented in an integrated manner across catchments. It is anticipated that this will be piloted in the near future.

5.2.4.2 Invasive terrestrial plants

Invasive alien trees and grasses are common across the City including the GZENR. Those around Zandvlei include Acacia spp (Rooikrans and Port Jackson), Manatoka (Myoporum tenuifolium) and grasses such as Kikuyu (Pennisetum clandestinum), Pampas Grass (Cortaderia selloana) and the saltwater couchgrass (Paspalum vaginatum) which occurs along the banks of the estuary. Another well known invasive species recorded is Lantana camara. Alien Acacias have high water requirements and reduce river flow. They often form dense stands which heighten the risk of and intensity of fires and have had major impacts on the fynbos vegetation.

Clearing of these species is planned on an annual basis, using herbicides, foliar sprays or manual removal as appropriate. In 1999 there was a programme to eradicate alien vegetation from Park Island and to replace it with indigenous species (Ernest, 2002).

The proximity of urban areas not only makes it difficult to prevent invasions of vegetation such as kikuyu grass which is commonly used in gardens. Effectively controlling this would require a prohibition on its use, or the construction of some sort of barrier between the residences and the reserve.
## ALIEN INVASIVE SPECIES RECORDED IN THE GREATER ZANDVLEI ESTUARY NATURE RESERVE

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Origin</th>
<th>Date recorded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hornwort</td>
<td>Ceratophyllum demersum</td>
<td>North America</td>
<td>1976 (Begg)</td>
</tr>
<tr>
<td>Parrot’s Feather</td>
<td>Myriophyllum aquaticum</td>
<td>South America</td>
<td>1976 (Begg)</td>
</tr>
<tr>
<td>Water hyacinth</td>
<td>Eichornia crassipes</td>
<td>South America</td>
<td>1976 (Begg)</td>
</tr>
<tr>
<td>Red waterfern</td>
<td>Azolla filiculoides</td>
<td>South America</td>
<td>Unknown</td>
</tr>
<tr>
<td>Kariba weed, water fern</td>
<td>Salvinia molesta</td>
<td>South America</td>
<td>Unknown</td>
</tr>
<tr>
<td>Rooikrans</td>
<td>Acacia cyclops</td>
<td>Australia</td>
<td>Unknown</td>
</tr>
<tr>
<td>Port Jackson</td>
<td>Acacia saligna</td>
<td>Australia</td>
<td>Unknown</td>
</tr>
<tr>
<td>Manatoka</td>
<td>Myoporum tenuifolium</td>
<td>Australia</td>
<td>Unknown</td>
</tr>
<tr>
<td>Vasey's Grass</td>
<td>Paspalum urvillei</td>
<td>South America</td>
<td>1982 (Morant &amp; Grindley)</td>
</tr>
<tr>
<td>Kikuyu</td>
<td>Pennisetum clandestinium</td>
<td>East Africa</td>
<td>Unknown</td>
</tr>
<tr>
<td>Lantana</td>
<td>Lantana camara</td>
<td>South &amp; Central America</td>
<td>Unknown</td>
</tr>
<tr>
<td>Tube/ coral worm</td>
<td>Ficopomatus enigmatica</td>
<td>Unknown</td>
<td>1974 (Muir)</td>
</tr>
<tr>
<td>Common/Mirror/Wild carp</td>
<td>Cyprinus carpio</td>
<td>Europe &amp; Asia</td>
<td>Introduced 1896</td>
</tr>
<tr>
<td>African catfish</td>
<td>Claris gariepinus</td>
<td>Africa, Middle East &amp; E.Europe</td>
<td>1989 (Quick &amp; Bennet)</td>
</tr>
<tr>
<td>Mosquito fish</td>
<td>Gambusia affinis</td>
<td>SE United States &amp; Mexico</td>
<td>1989 (Quick &amp; Bennet)</td>
</tr>
<tr>
<td>Black/largemouth bass</td>
<td>Micropterus salmoides</td>
<td>North America</td>
<td>1976 (Begg)</td>
</tr>
<tr>
<td>Goldfish</td>
<td>Carrasius auratus</td>
<td>East Asia</td>
<td>1976 (Begg)</td>
</tr>
<tr>
<td>Rainbow trout</td>
<td>Oncorrhynchus mykiss</td>
<td>Asia &amp; N.America (Pacific)</td>
<td>1976 (Begg)</td>
</tr>
<tr>
<td>Guttural toad/Common African Toad</td>
<td>Amietophrynus gutturalis</td>
<td>Eastern &amp; Southern Africa</td>
<td>2009/10</td>
</tr>
<tr>
<td>Mallard duck</td>
<td>Anas platyrhynchos</td>
<td>Eurasia and North America</td>
<td>1940’s</td>
</tr>
<tr>
<td>House crow</td>
<td>Corvus splendens</td>
<td>Asia</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

7 This is not a comprehensive list. Additional exotic plants are listed on the Zandvlei Trust website, and in the list of Zandvlei plants provided by C.Sheasby.
5.2.4.3 Invasive animal species

Invasive animals include various species of fish mostly deliberately introduced by the conservation authorities to enhance fishing, as well as the guttural toad and mallard ducks. Common pests such as the rat are most likely also present and it is noted that from a conservation perspective, domestic cats and dogs pose a threat to small mammals and birds in the reserve area. As for garden plants, preventing these from entering the reserve would require construction of some sort of barrier between the residences and the reserve.

Fish

Introduced fish include carp, the Mozambique tilapia, banded tilapia, Mosquito fish, Rainbow trout, African catfish and even Goldfish. Most of these were introduced many years ago – the carp as far back as 1896 - and some have not been recorded in recent surveys. However, the baseline survey done in 2001 by Southern Waters did record carp, Mozambique tilapia and Banded tilapia.

The carp is a bottom feeder and churns up the sediments, uprooting macrophytes, increasing turbidity and severely altering the habitat thereby affecting native species. It has been recorded in relatively large numbers in the past (Quick and Harding, 1994), but is sensitive to salinity and therefore likely to be restricted to the upper reaches of the estuary. At a recent meeting of the Zandvlei Action Committee, it was proposed to hold a fishing competition to remove as many Carp as possible from the vlei. However, as for the aquatic weeds, to be effective such initiatives need to be integrated into catchment wide management plans.

Tilapia are prolific breeders and can become dominant where they become established, displacing native species by competing with them for food, habitat and breeding sites. The Mozambique tilapia is omnivorous, feeding on almost anything.

According to a report by Sheasby on the Zandvlei Trust website (www.zandvleitrust.org.za) a study was undertaken in 2004 by Linden Rhoda on the feeding preferences of the African catfish in Zandvlei. The catfish is known to be a voracious predator posing a danger to native species. It also has a wide environmental tolerance range.

Guttural Toad

As reported to a meeting of the Sand River Catchment Forum in May, 2009 (Otto Beukes): “The Guttural Toad (GT) is the same family as the Western Leopard Toad (WLT), which is critically endangered because of declining habitat, is not adequately protected and has a tiny patchy distribution. The guttural toad is opportunistic and invasive – it has a much longer breeding period and a better success rate as well as a longer life span. Its natural distribution is much larger, its habitat broader and it can breed anywhere. It also has very few natural predators in the Western Cape. Since first discovered here in 2000, its growth has been exponential and the population is estimated to be approximately 110 000.”
The City is currently drawing up an eradication plan in collaboration with other agencies, with a view to eradicating the guttural toad by 2014 (City of Cape Town, 2009).

**Mallard ducks**

The most serious conservation threat posed by the Mallard duck is that it hybridizes with related local indigenous species, thereby compromising their genetic integrity. It was introduced to South Africa in the 1940’s and now occurs across the country where it commonly hybridizes with the Yellow-billed duck. It has also been reported to hybridise with the Cape Teal, Egyptian Goose, African Black duck and the Cape shoveller (Stafford, 2010).

Mallards have been present in Zandvlei for many years, and in the CWAC report for 1992 – 1997, were reported to be the only species which had increased in numbers, with many others declining. Recent CWAC counts show increases in the numbers of hybrid mallards in both the Upper Estuary and Marina, as well as a decline in the number of Yellow-billed ducks (see Figs 19 a-c below – reproduced from the CWAC reports on the ADU website).

**Figure 19 a: Hybrid mallards in the Upper Estuary (CWAC data)**

**Figure 19 b: Hybrid mallards in Marina da Gama (CWAC data)**
Of particular concern is that the hybrids of Mallards and Yellow-billed Ducks are fertile and can produce more hybrid offspring. Without intervention, eventually only hybrids will occur and in the long term this will result in the extinction of the indigenous Yellow-billed Duck (Stafford, 2010).

Mallards have been culled on a relatively ad hoc basis in Zandvlei for many years despite some public opposition. At the ZAC meeting in February, 2010, for example, it was reported that over 160 birds were removed using sedative, but that a further 280 had been counted. In the future however, such operations will be integrated into a national Mallard Strategy which is currently in final draft form, and which has the following goals:

- **Goal 1**: Assess the extent, impact and risk posed by Mallards
- **Goal 2**: Coordinate Mallard management at national, provincial and local level.
- **Goal 3**: Prioritize areas for interventions
- **Goal 4**: Ensure a conducive legal and policy environment and adherence to ethical and best-practice guidelines and protocols
- **Goal 5**: Improve awareness of the impacts of Mallards and support for intervention
- **Goal 6**: Mallard impacts are reduced by means of a systematic national control programme
- **Goal 7**: Prevent spread of existing Mallard populations and introduction of Mallards to new areas or areas from which they were removed
- **Goal 8**: Implement monitoring and evaluation and reporting programme and support research.

**Figure 19 c**: Yellow-billed ducks in the Upper Estuary (CWAC data)

**Figure 20**: Mallard x Yellow-billed duck Hybrid (Dalton Gibbs)
5.2.5 Litter

Litter enters Zandvlei from two main sources: the influent rivers – particularly those draining low-income housing areas – and the areas along the banks of the estuary which are used for intensive recreation. It is a significant aesthetics problem, but can potentially also affect wildlife as a result of entanglement or ingestion.

Efforts to reduce the amount of litter entering Zandvlei from the rivers have been centred on the installation of nets and traps. There have, however, been numerous problems with regard to their functioning with contractors failing to clear the nets on a regular basis to the theft of grids for sale as scrap metal. As a result, a substantial amount of litter still enters Zandvlei via this route, and reserve staff have to expend a considerable amount of time clearing it.

![Figure 21: (a) Litter grill on Sand River Canal; and (b) Litter downstream of the grill and just above the discharge point into Zandvlei.](image)

Similar problems have been experienced with litter emanating from the picnic and braai areas where large volumes are generated over the festive season and during major events. Although additional bins have been placed – including doggy doo bins – the litter bags are not always collected by the contractors on a regular basis.

5.3 Balancing recreation with conservation

Zandvlei has been used for recreational purposes since at least 1884, and is currently regarded as a regional recreational centre. A survey undertaken by the City of Cape Town in 1988 concluded that there were between 2,000 and 3,000 visitors a day during peak holiday periods of which 50% came from outside the metropolitan area (cited in Thornton et al, 1995). Facilities around the estuary include Peninsula Park and the Zandvlei Camping Site, and popular activities include picnicking, braaiing, walking,

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8 Minutes of ZAC meetings.
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boardsailing and fishing. It is, however, also popular with residents of the immediate
surrounds and adjacent suburbs, particularly for boating and conservation-related
activities. The Imperial Yacht Club is located on the eastern bank of the estuary, together
with the Peninsula Canoe Club, Naval Cadet Base and a Sea Scout Centre.

There are a number of local and international events each year, with the biggest
International event being the Annual Kite Festival which is run by Cape Mental Health.
The Sea Scouts and the Naval Training Base organize an Annual Provincial Contikki
Expedition.

The earliest of the conservation-related activities was bird-watching which was centred
on the bird sanctuary on Wildwood Island. This was given more official recognition as
part of the Zandvlei Nature Reserve which was declared in 1997, and which was then
expanded from 22 ha to 200 ha as the Greater Zandvlei Estuary Nature Reserve in
2006. To a large extent this has been driven by non-governmental organizations,
including the Zandvlei Trust, Cape Bird Club and Friends of Park Island. There ia also an
Environmental Education Centre adjacent to the City’s offices to the north of the estuary,
with a flourishing Environmental Education Programme.

One of the objectives of the management of Zandvlei is therefore to achieve an
appropriate balance between conservation and recreational use of the estuary. An
important tool in achieving this objective should be the creation of zones within the
geographic boundaries of the estuary, each intended for a specific category of use.
These should include:

➢ Sanctuary and conservation zones

Estuaries (Turpie and Clark, 2007) recommended that Zandvlei be one of the core
estuaries in terms of meeting biodiversity targets, that the extent of protection be half,
that 25% of the margin remains undeveloped, that it is assigned to class A or B in terms
of minimum water requirements (with A being near natural), and that it be considered as
high priority in terms of rehabilitation (which needs to be taken into account during the
reserve determination).

Sanctuaries are areas where no human disturbance is permitted, while conservation
zones are areas where human use is allowed on a controlled basis. The latter can be
are sub-divided into areas of low, medium and high intensity use.

i) Low intensity use areas: in these areas only low impact activities such as
   bird-watching and walking are allowed.
ii) Medium intensity use areas: activities in these areas can include picnicking,
    bird-watching, walking, fishing, canoeing, swimming.
iii) High intensity use areas: these are areas where power-boating, water-skiing,
    and sailing are allowed. Such areas could also include dog-walking
Buffer Zones

Most of the land bordering the estuary – as well as some within the estuary boundaries – has already been developed. In the remaining areas, a strip of between 50 – 100m has been zoned as Public Open Space and should provide a sufficient buffer.

Developed Areas

As mentioned above, there has been some development within the boundaries of the estuary, primarily the section of Muizenberg to the east of the outlet channel and south of Marina da Gama. This area is prone to flooding.

A preliminary zonation map is presented in Fig. 22 below.

![Preliminary proposals for zonation at Zandvlei.](image-url)
5.4 Sand River Catchment management

While the management of the catchment is beyond the scope of this study, it is clearly critical to the effective management of the estuary. This section therefore summarises some of the relevant initiatives.

5.4.1 Sand River Catchment Forum

The Sand River Catchment Forum was established in 1998 with the objective of formulating management plans for the catchment. It includes representatives from the various tiers of government as well as civil society. Meetings of the Forum were discontinued from September, 2005 after the founding Chairman left the City, but were reinstated from July, 2007.

The process of developing a catchment management plan was divided into a number of phases, including data gathering and situation assessment, specialist studies, identification of management issues, public participation and formulation of the plan. The plan was based on the following vision:

“The Catchment Management Plan must ensure acceptable water quality and manage water quantity so as to support maximum biodiversity and optimize utilization of river corridors for the sustained benefit of all users”.

A Catchment Management Plan was produced in 2003. It was intended to cover a 5-year period and listed a number of actions/projects to be implemented over that period. These fall into three categories:

- Those aimed at reducing flood risk which included the construction of detention facilities, the widening of sections of the Diep and Keysers Rivers, the calibration of flow monitoring devices, and the installation of additional monitoring stations;
- Those aimed at improving water quality, which included the construction of silt and/or litter traps, determining the ecological reserve, the development of soil management and surveillance guidelines, determining the sources of pollution to the Keysers and Mocke rivers, and Langevlei, implementing pollution mitigation measures at Little Princess Vlei, and developing a plan to eliminate the inappropriate use of invasive alien vegetation and to replace alien plants with indigenous ones;
- Those aimed at improving the amenity value of the rivers and vleis, which included the construction of safety steps in canals, the placement of educational signage, the prevention of inappropriate waste disposal and illegal dumping, the continued harvesting of pondweed in Zandvlei, and management of the sand bar at Zandvlei mouth.

While it is clear that some of these projects have been implemented, there does not seem to have been a structured approach to monitoring its implementation. It is also noted that it was intended that the plan should be reviewed and updated after 5 years, and that this is now overdue.
5.5 Opportunities for conservation and rehabilitation

5.4.1 Conservation potential

Based on bird numbers, Ryan et al (1988) ranked Zandvlei 16th of all the coastal wetlands in the South Western Cape, while Turpie (1995) ranked it in the top 15 estuaries in the country based on bird species richness, and in the top 25 in terms of numbers. Despite the fact that it is a highly managed system, the estuary is also the most functional of all estuaries in False Bay, and therefore remains important as a nursery for fish species, especially species such as the white steenbras (*Lithognathus lithoganthus*) which are heavily dependent on estuaries during the juvenile phase. The GZENR is also one of few protected areas which provides suitable breeding habitat for the endangered Western Leopard Toad.

The Conservation Plan for Temperate Estuaries (Turpie and Clark, 2007) developed for CapeNature as part of the CAPE Estuaries Programme recommended that Zandvlei be one of the core estuaries in terms of meeting biodiversity targets, that 50% of it should be protected, that 25% of the margins should remain undeveloped, that it be assigned to class A or B in terms of minimum water requirements (with A being near natural), and that it be considered a high priority in terms of rehabilitation. This suggests that despite the extensive modification of the system over the past 300 years, it still has sufficient value in terms of biodiversity to warrant further conservation efforts.

5.4.2 Rehabilitation potential

Given the history and extent of development around the estuary there is clearly no chance of restoring it to its original condition. Nevertheless, there is potential to rehabilitate some portions of the reserve, and to restore some characteristics of the estuary to something closer to the natural condition than they are now.

On the terrestrial side, a rehabilitation programme was implemented on Park Island between 1998 and 2003 (Sheasby, 2008). Park Island is a 20 ha artificial island that was created using dredged material generated during the construction of the marina. It is situated between the main body of the vlei and the marina. The objectives of the rehabilitation programme were to:

- Eradicate the alien vegetation and replace it with indigenous species;
- Provide protection for the indigenous species, in particular a number of Red Data species. This included the creation of a separate island by clearing some canals, thus creating a refuge for wildlife;
- Provide controlled access for pedestrians.

The island has large salt marsh areas of conservation importance and a thicket of While Milkwood in its centre.

Other areas which have been partially rehabilitated, or which have potential for rehabilitation, are identified in the GZENR Fire Management Plan Sheasby (2008). These include:

- The road reserve immediately to the north of the reserve;
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- The Sand River Wetland area, which was rehabilitated by Working for Wetlands, but which requires further work;
- The area between the Road Reserve and the Salt Marsh canal which includes a number of Red Data plants, and is a prime Cape Dwarf Chameleon site;
- The old nursery area including the new wetland;
- Wildwood and Australia Islands;
- Boardsail Inn site;
- Bath Road site;
- The area north of Promenade Road and east of the railway line – this has high conservation priority as an example of the original vegetation found around Zandvlei;
- The Keyser’s River rehabilitation site.

Controlled burning would be a key tool in the rehabilitation of these sites.

A proposal for a restoration project involving the diversion of low flows from the Westlake River into the northern part of the Westlake Wetland to improve the quality of water entering Zandvlei was rejected on the basis that the wetland has a high conservation status and that this would be detrimental to it (Southern Waters, 1999)

Proposals were also prepared for the restoration of the lower portion of the Langevlei canal with the objective of restoring it to a near natural state to improve water quality and ecological functioning, create a riverine habitat, and provide a recreational and educational amenity. The recommended option was to create a meandering riverine ecosystem and seasonal wetland at the confluence of the Langevlei and Sand Rivers (Afridev, 2001). This does not appear to have been implemented.

Rehabilitation of the aquatic ecosystem is at present limited by the water level management regime which – in combination with physical changes to the estuary - restricts the fluctuations in water levels and limits intrusion of saline waters. The rehabilitation potential would be enhanced if mechanisms to overcome these limitations could be developed.
6. SUMMARY OF MAJOR FINDINGS

The fact that Zandvlei and its catchment have been progressively and extensively modified over the past 300 years has been well documented, as have the impacts of these modifications themselves and those of some of the management measures – in particular the management of water levels in the interests of protecting inappropriately sited residential areas and maintaining sufficient water depth for recreational purposes. Rather than re-iterating these, this summary is intended rather to capture some of the other salient points that have emerged. These are:

- Despite the various management measures that have been implemented, few, if any, of the problems have been solved. Rather, they are being managed or mitigated on an ongoing basis with the current list of issues being much the same as those identified thirty or more years ago. These include:
  - The impact of the mouth/water level management regime on the natural functioning of the estuary (salinities, role as a fish nursery etc);
  - Pondweed and other aquatic and semi-aquatic plants (alien or indigenous);
  - Other introduced and invasive species, including Mallard ducks;
  - Water quality issues – nutrients, bacteriological contamination and litter.

- Over the years, there have been a number of initiatives to develop management plans which cover the broad spectrum of issues – in addition to issue-specific plans - but, while it is clear that certain components of those have been implemented, there has been a significant amount of institutional memory loss with current staff being unaware of at least some of the earlier efforts. This is probably as a result of a combination of staff turnover and restructuring. As a result, there has not always been a proper assessment of the progress made – and effectiveness of – various management plans;

- There are a number of monitoring programmes in place and many more suggested. The responsibility for these lies with a number of divisions of the City and some other agencies. In a number of cases it seems that the information being generated is not being effectively utilized to assess and improve management measures. On the other hand, in some instances, the level of monitoring seems to be insufficient. It is therefore suggested that the monitoring be rationalized with better coordination between the various departments and with a clear understanding of the purpose thereof.

- There is a relative paucity of information on some animal groups – for example, invertebrates, amphibians, reptiles and mammals. In a number of cases, the historical species “lists” are based on records in the general area rather than specific surveys, and even the GZENR database is a list of sightings. Given the higher conservation profile of the GZENR, this could be improved.

In conclusion, Zandvlei is situated in a relatively small catchment all of which lies within the boundaries of the City of Cape Town – a big advantage from a management perspective. Given its limited size, it is not a significant source of water. Nor does it have any major effluents discharging directly into it – or even into the rivers making up the catchment. Moreover, there is already a Catchment Management Forum in place, as well as a Catchment Management Plan – although the latter may be due for review. In addition, there are a number of new broader developments and initiatives which are
pertinent to the management of the estuary. Over and above the proclamation of the Greater Zandvlei Estuary Nature Reserve in 2006, these include the promulgation of the Integrated Coastal Zone Management Act in 2009, the current CAPE Estuaries Programme, development of Invasive Species regulations under NEMBA, development of an Invasive Species Policy for the City and development of both catchment and species level invasive species strategies.

The development of an Estuary Management Plan provides an ideal opportunity to revisit the current management regime with a view to re-assessing its objectives management approaches and to enhancing the implementation thereof.
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