**Makana Municipality**

**Local Environmental Action Plan**

**Monitoring Framework**

**Submitted 16 July 2004**

Abbreviations

AEP - Alicedale Evaporation Ponds

CMA - Catchment Management Agency

DEAT - Department of Environmental Affairs and Tourism

DEAET - Department of Economic Affairs, Environment and Tourism

DEEEP - Direct Estimation of Ecological Effect Potential

DWAF - Department of Water Affairs and Forestry

ECA - Environment Conservation Act

GDW - Grahamstown Disposal Works

IAQ - Indoor Air Quality

IDP - Integrated Development Plan

MM - Makana Municipality

MOP - Mayfield Oxidation Ponds

NEMA - National Environmental Management Act

NMMM - Nelson Mandela Municipal Metropole

NWA - National Water Act

SDF - Sustainable Development Framework

STW - Sewage Treatment Works

UCEWQ-IWR - Unilever Centre for Environmental Water Quality, Institute for Water Research, Rhodes University, Grahamstown

WHO - United Nations World Health Organisation

WMA - Water Management Area

WUA - Water User Association

# 1. GENERAL INTRODUCTION

The primary strategy for economic growth, employment creation, poverty eradication and income redistribution is the Eastern Cape Strategy Framework for Growth and Development for 2004-2014 (Province of the Eastern Cape, 2003). According to Abrahams and Goldblatt (1997) there are three priority services required for the promotion of health, convenience and quality of life: water; sanitation; and electricity. Other services such as telecommunications are important for economic development and improvement of quality of life. The Eastern

Cape Province has set quantifiable targets for growth and development for the period 2004 to 2014, with 2003 as the base year. Two of these targets are:

• To provide clean water to all by 2008; and

• To eliminate sanitation problems by 2010.

Achieving these goals will also act as drivers of environmental change and will influence environmental sustainability. Driving forces can be described as the human influences and activities that, when combined with environmental conditions, underpin environmental change (DEAT, 1999). At a local government level, the review of IDPs suggested that there is less commitment and prioritisation of environmental issues by municipalities than is needed for sustainability (CSIR, 2004).

Enforcement and compliance monitoring of the environment are considered weakly enforced throughout the Eastern Cape Province (CSIR, 2004). The lack of capacity for monitoring has been recognised by both the Department of Water Affairs and Forestry (DWAF) and the Department of Economic Affairs, Environment and Tourism (DEAET). Environmental management and governance is, however, multi-faceted and involves role-players from all levels of government, the private sector and civil society.

## 2. AIR QUALITY

Air Quality can be divided into Ambient Air Quality and Indoor Air Quality.

### 2.1. Ambient Air Quality

Since ambient air quality is believed to be relatively good within the Makana Municipality, general air quality monitoring is not a high priority at this time. This is the result of a relatively low number of fixed sources due to the lack of major industry in the region. However, regional sources, such as the industrialized zones of Port Elizabeth and the newly developing Coega region, could potentially impact air quality within the Makana Municipality depending upon climatic factors. Existing undocumented sources can also significantly impact local air quality. These include emissions from hospital incinerators, dry-cleaning establishments, bakeries, tanneries, and petrol stations. New industrial sources in Makana could cause a decline in ambient air quality levels. Within South Africa, studies have shown

that 70 percent of the particulate matter in ambient air is from domestic fuel use and dust (CSIR 2004).

Consequently, source and emission tracking is recommended as part of the overall air quality monitoring program, and an increased emphasis on reducing domestic fuel use should be implemented.

### 2.1.1. Responsibility for monitoring

Chapter 5, Section 29 of the National Environmental Management Air Quality Bill (which repeals the Atmospheric Pollution Prevention Act of 1965), stipulates that, "Metropolitan and district municipalities are charged with implementing the atmospheric emission licensing system... and must for this purpose perform the functions of licensing authority." Recording of source points is the responsibility of the local government through the licensing or permitting of new projects and reauthorization of existing ones. The applicant should provide the details of the emissions, including pollutants, rates, and point source locations. Daily, weekly, monthly and yearly peaks and averages should be estimated. Monitoring of point source emissions should be the responsibility of the company with reports submitted on a yearly basis to the relevant authorities and the Municipality. The Municipality should then collate the emissions, keeping a running tally of the total emissions per location and for the region. This information should also be made available to the public via the Internet or yearly summaries prepared by the Municipality.

Trigger events should be set by the preparation of human health risk assessments to be completed when major new emission sources are proposed. Human health risk assessments for major industrial pollutant sources should form a part of the Environmental Impact Statement (EIA) as required by the Environment Conservation Act and be made available to the local Municipality for review and comment prior to project approval.

### 2.1.2. Budget required for monitoring

The cost for monitoring of stationary sources is low to the Municipality and moderate to high to the companies. This is dependent upon the nature of pollutant discharges and the frequency of monitoring. In addition, specific costs are also dependent upon the type of monitoring needed, (i.e.,fugitive emissions, stack exhausts, etc.) and the pollutants to be tested for (i.e. dust, sulphur dioxide, nitrous oxide, volatile organic compounds, etc.).

### 2.1.3. Potential Indicators

The Eastern Cape State of the Environment Report (CSIR 2004) provides sustainability indicators for air quality based on the United Nations World Health Organisation (WHO) and South African standards as applicable.

Sulphur dioxide (SO2): the 24-hour time weighted average (twa) value is 125 µm/m³ per the DEAET. The DEAET and the WHO set the sulphur dioxide (SO2) yearly average of 50 µm/m³. No specific ambient levels of SO2 are available for Makana.

Particulate Mater (PM10): South African 24-hour guideline is 180 µm/m³ with a yearly average of 60 µm/m³. No monitoring results are available for Makana Municipality.

Nitrogen Oxides (NOx): South African standard is 94 µm/m³ annual guideline value. No monitoring results are available for Makana Municipality.

## 2.2. Indoor Air Quality

Indoor Air Quality (IAQ) has been identified as a stakeholder concern during initial public consultations. IAQ relates to the dependency on fuel wood and paraffin for heating and cooking in low-income households. In addition, the use of asbestos containing building materials (ACBM) may also potentially lead to poor indoor air quality.

IAQ can be interpolated by analyzing the level of fossil fuel use by households. The Rhodes University Department of Environmental Science is conducting specific household surveys within the Makana Municipality. These will help to quantify the specific level of fossil fuel use within certain households. As rural and low-income households are electrified and make use of electricity for cooking and heating, IAQ will improve. The South Africa Census records the use of household energy sources. These statistics should be reviewed to determine the level of clean energy use and trends over time. If trends indicating an increase in fuel wood and/or paraffin are identified, specific interventions may be necessary.

### 2.2.1. Budget required for monitoring

The cost to track these trends is minimal as the data are collected by the national census takers and released to the public. Specific surveys of household fuel use within the Municipality should be conducted by the Municipality. These surveys will help to corroborate the data provided in the census and fill in data gaps. Surveys may be conducted on a cooperative basis with Rhodes University and should be conducted every five years using the 2004 survey as a benchmark.

# 3. BIODIVERSITY

## 3.1. Introduction

Biodiversity supplies goods and services that are essential for human well-being (Alcamo et al., 2003). Conservation of biodiversity is therefore crucial. Noss (1999) outlined four general goals for the conservation of biodiversity. These are to: (1) represent all kinds of communities or ecosystems across their natural range of variation in a system of protected areas, (2) maintain or restore viable populations of all native species in natural patterns of abundance and distribution, (3) sustain key geomorphological, hydrological, ecological, biological, and evolutionary processes within normal ranges of variation, while being adaptable to a changing environment, and (4) encourage human uses that are compatible with the maintenance of ecological integrity, and discourage those that are not. Despite these noble goals, there are several threats to biodiversity in the Makana Municipality that lies in a biodiversity hotspot of global significance (Van Wyk and Smith, 2001).

The major threats to biodiversity in the Makana Municipality have been defined by a wide range of stakeholders (Table 1), and include habitat loss through preparation of cultivated lands, urbanisation, invasion by alien plants, collection of ornamental plants and harvesting of medicinal plants (Victor and Dold, 2003). Cultivation for agriculture has transformed 4.83% of the surface area of the Succulent Thicket region (Lloyd et al 2002), while urbanisation (1.42%) and alien plants and commercial plantations account for 0.8%. Makana contains a significant portion of the Succulent Thicket, and the extent of degradation of the thicket vegetation due to over-grazing by domestic herbivores (Table 2) remains a significant threat to biodiversity. Similar threats have been reported in the Cape Floristic Region, another biodiversity hotspot (Rouget et al., 2003). Furthermore, they predicted that at least 30% of the currently remaining natural vegetation could be transformed within 20 years. These

threats are relevant to Makana and it is clear that there is a need to monitor threats to biodiversity.

| | | |
|---|---|---|
| Loss of biodiversity limits local opportunities | Encroachment of woody shrubs | Wetlands being drained, overgrazed and overexploited |
| Deforestation and land degradation | Threatened by alien species | Endangered species being lost |
| Unregulated extraction of medicinal plants | Over harvesting of indigenous plants | Absence of management of exiting nature reserves (Blaukrantz/Ecca) |
| Unregulated development of private game reserves | Non-indigenous fauna being stocked on private game reserves | Natural environment overtaken by private interests, excludes the populace |
| Unsustainable veld management practices | Overgrazing of commonage and commercial rangeland | Ignorance about carrying capacity |
| | | Soil erosion with loss of nutrients |

Table 1. Threats to the biodiversity of Makana identified by stakeholders during public consultation (February 2004-July 2004).

| **ARC MAPPED CLASS DESCRIPTION** | **AREA ($km^2$)** | **% STEP STUDY AREA** |
|---|---|---|
| No ARC data | 52.10 | 0.04 |
| Urban | 954.67 | 0.82 |
| Rural Settlement | 704.18 | 0.60 |
| Cultivated lands | 5,625.32 | 4.83 |
| Mines & Quarries | 15.82 | 0.01 |
| Commercial | 949.53 | 0.81 |

| | | |
|---|---|---|
| Plantations | | |
| Natural Wetlands & Pans | 51.34 | 0.04 |
| Water Bodies | 357.44 | 0.31 |
| Sand Dunes | 210.29 | 0.18 |
| Non Thicket | 63,683.25 | 54.63 |
| Thicket (Pristine) | 4,794.50 | 4.11 |
| Thicket (Moderately degraded) | 12,653.59 | 10.85 |
| Thicket (Severely degraded) | 26,522.79 | 22.75 |

Table 2. Categories of transformation and rangeland condition within the Subtropical Thicket Biome (Lloyd et al 2002).

Managers and policy makers require up-to-date information on the state and changes in the condition of biological resources to make decisions. Monitoring is a useful technique for gathering this information. Monitoring can be defined broadly as the measurement of changes at regular intervals in predefined properties of a system. It is important to determine the magnitude and direction of these changes. Indicators are commonly used in monitoring the state and condition of biological resources. The choice of what indicators to use is highly contentious (Carignan and Villard, 2002). Nevertheless, it is generally agreed that indicators should be chosen at different levels of biological organisation (Noss, 1990; 1999).

This report will outline the current monitoring programme, propose what should be monitored and the indicators for monitoring. The responsibility for monitoring and ways of analysing and reporting the results of monitoring are presented. The report ends by suggesting responses to the monitoring results.

### 3.2. Current monitoring programme

Monitoring of natural resources and biodiversity within Makana has been left up to the activities of national initiatives. There are few regular natural resource monitoring programmes specific to Makana Municipality. The National Land Cover Programme, initiated in 1993 and currently being repeated, provides the most comprehensive data set for

use in evaluating changes in Makana. The STEP programme provides a one-off database for describing land and rangeland condition classes within Makana (Lloyd et al 2002). The Selmar Schonland Herbarium (Albany Museum) and the PRECIS database of the National Botanical Institute provide reference material from which to assess loss of plant species diversity. The Department of Water Affairs and Forestry continues to monitor water quality at selected sites throughout Makana. Rhodes University's Institute for Water Research has been monitoring the quality of water in selected rivers within the Municipality. It is important to also monitor terrestrial fauna and flora and ecological processes. Details of what should be monitored and how are given in the next section.

## 3.3. Proposed monitoring programme

### 3.3.1. Indicators of biodiversity

For the purposes of this report indicators will be chosen at the species level and landscape scale. The choice of indicators is based on recognised threats to biodiversity (Lloyd et al 2002, Rouget et al., 2003; Victor and Dold, 2003) and those that have been chosen for the Eastern Cape State of the Environment Report (CSIR, 2004) to allow comparisons with other regions in the Eastern Cape.

The following indicators will be used for monitoring biodiversity in the Municipality:

- extent of conserved areas in the municipality;
- extent and condition of wetlands;
- habitat transformation;
- distribution and abundance of selected alien plant species;
- urbanisation;
- extent of roads;
- viability of populations of endangered endemic species;
- extinct, threatened and endemic species per taxonomic group, and the occurrence of natural disturbances (e.g. fire).
- woody species encroachment
- soil erosion

Details on the monitoring of each indicator are highlighted below. The indicators should be monitored once in every five years. The five-year interval has been chosen to reduce the cost of monitoring and also it is a reasonable time interval to assess changes in the above indicators except for the viability of populations of endangered endemic species. These should be monitored annually for at least three years.

### 3.3.2. Extent of conserved areas in the municipality

Protected areas play an important role in the preservation of biodiversity. Their importance is highlighted by the increased threats to biodiversity in unprotected areas. Trends in the extent of protected areas can be detected using four descriptors (CSIR, 2004). These are:

- the percentage of the Makana Municipality's surface area covered by national, provincial, municipal and private protected areas;
- the percentage of each STEP target conserved (Figure 1)
- the proportion of the Makana Municipality's area conserved, and
- the size and distribution of the Makana Municipality's protected areas.

Together, the four descriptors will indicate the success of conservation efforts (CSIR, 2004) in the Makana Municipality. It should be noted, however, that unprotected areas are also extremely important for the conservation of biodiversity. The data for the descriptors can be obtained from literature and government departments and used to produce maps using GIS of conservation areas in the Makana Municipality.

### 3.3.3. Extent and condition of wetlands

Wetlands are defined under the Ramsar 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 salty, including areas of marine water the depth of which at low tide does not exceed six metres". They play an important role in conserving biodiversity, controlling floods, purifying water and in providing grazing (Anon., undated; O'Connell, 2003). They can also provide a variety of materials used for thatching and crafts.

Like other ecosystems, wetlands are threatened by several factors. These include (Anon., undated; O'Connell, 2003):

- wetland drainage and cropping
- overgrazing
- over-harvesting of plants
- invasion by alien plant species
- fire
- the building of dams
- mining and industrial pollution
- urbanisation.

According to Ms E.Haigh (Wetlands Research Group within the Institute for Water Research, Rhodes University) there are two types of wetlands in the Makana Municipality:

- upper catchment groundwater seeps, *e.g.* Featherstone Kloof wetland;
- small endorheic pans, *e.g.* golf course, Grahamstown.

Extensive research and rehabilitation has been completed (Haigh and Ilgner, 2001; REFYN, 2002) and is being completed (Rhodes University Botany Department and Working for Water) on the Featherstone Kloof wetlands and catchment area. As a valuable source of plants for medicinal and other purposes, recommendations were made (REFYN, 2002) that urgent management strategies were needed. Present management by Working for Water was not long term.

Further information and databases on wetlands in the Makana Municipality are not available to date. However, the Wetlands Conservation Programme and Working for Wetlands (DEAT; contact Rose Clark, CSIR Environmentek, Pretoria) have started a National Wetland Inventory of all wetlands 0.5ha or larger.

### 3.3.4. Habitat transformation

Habitat transformation reduces biodiversity. Cultivation, over-grazing, urban developments, afforestation, planted pastures, mining and invasion by alien plants are the main factors that transform habitats (Lloyd et al 2002, Rouget et al., 2003; Victor and Dold, 2003; CSIR, 2004). It is therefore important to monitor the percentage of habitat that is transformed in Makana Municipality. Lloyd et al (2002) report on various levels of land transformation,

including cultivation (Figure 2), degradation of thicket from over grazing (Figure 3 and 4) and urbanization. These data are all available for Makana in ArcView shape files. They can be used as the benchmark from which to assess future trends in transformation within Makana. The Makana Municipal GIS should contain all the layers available of existing national surveys, including the National Land Cover Map and the map of existing wetlands. Maps of the distribution of rare or endangered species are available for research purposes. Selection of an appropriate minimum mapping unit is essential for accurate assessments of plant diversity patterns (Stohlgren et al., 1997a,b,c).

### 3.3.5. Distribution and abundance of selected alien plant species

Alien plants (both woody and herbaceous) are a major threat to biodiversity and ecosystem functioning (Milton, 2003; Richardson and van Wilgen, 2003). It is important to map the distribution of selected woody alien species. Remote sensing can be used as described by Rouget et al. (2003). CSIR (2004) has suggested three elements of this indicator that should be measured. These are: (1) the proportion of the Makana Municipality‘s surface area covered by alien plants, (2) the number and distribution of Working for Water project sites in the Municipality, and (3) the area infested by two indicator invasive alien woody plant species, namely *Acacia mearnsii* and *A. cyclops*. It is also important to monitor the recovery of vegetation in areas cleared of alien plants. A modified Whittaker plot can be used for this purpose (Stohlgren, Falkner and Schell, 1995). The map of commercial plantations provides contemporary distribution of selected woody aliens in Makana. (Figure 5). This does not however include many important weeds such as prickly pear and jointed cactus, which are not included in this map.

The success of the biological control of water hyacinth by beetles on the New Years Dam will continue to be monitored by Zoology Department (Professor Hill) and Working for water (Uitenhage). They request that there be NO pesticide or other spraying to control the water hyacinth, or the biological control will discontinue.

### 3.3.6. Urbanisation

Urbanisation has been identified as a major threat to biodiversity in the thicket biome (e.g. Lloyd et al 2002, Victor and Dold 2003). The extent of urbanisation within the Makana Municipality has been assessed using remote sensing Lloyd et al. (2002). Maps showing the extent of urban areas are available.

### 3.3.7. Extent of roads

The condition of the road network is a good indicator of potential human impacts on habitats. The density of roads (km) per biome area ($km^2$) should be measured using GIS techniques. Unsealed or poorly drained roads have a significant impact on water quality, and efforts should be made to maintain high road quality throughout Makana. Poorly planned roads on freehold land should also be monitored as they also contribute to reduced quality of run-off.

### 3.3.8. Viability of populations of endangered endemic species

Fine-scale monitoring of populations of endangered endemic species will be required to assess their viability. Size/age class distributions, reproduction, growth and mortality of individuals will need to be recorded. Matrix modelling can be used to assess the viability of the populations.

### 3.3.9. Extinct, threatened and endemic species per taxonomic group

There are approximately 4000 vascular plant species in the Albany Centre of Endemism. This is an extremely high level of floral biodiversity and compares favourably with some of the highest international plant biodiversity hotspots. About 15% of these are endemic or near-endemic (van Wyk and Smith, 2001). In an analysis of the flora of Makana by the LEAP Project Team and the Selmar Schonland Herbarium, 2829 vascular plants have been recorded (Table 3). This includes 136 endangered, critically threatened and rare taxa, and 101 alien species. It would be impossible to monitor the population sizes of all these species. A useful indicator of the success of biodiversity conservation is the absolute number of extinctions and the rate of extinctions (CSIR, 2004). The IUCN (2001) Red List criteria are used to classify species according to four categories of threat (critically endangered, endangered, vulnerable and rare) and three categories of lower risk of extinction (near threatened, least concern and data deficient). Species are classified into categories of threat based on trends in estimates of area of occupancy, extent of occurrence and population size.

The distribution of threatened taxa and their population sizes should be re-assessed regularly to monitor their status. Victor and Dold (2003) report that six plant species had become extinct during the last 100 years. These are *Alepidea multisecta*, *Aspalathus cliffortiifolia*, *Brachystelma tabularium*, *Brachystelma schoenlandianum*, *Ceropegia bokeri* and *Holothrix longicornu* (Victor and Dold, 2003). There is also a need to monitor the number of species in

different threat categories within the Makana Municipality. The information can be collected from field surveys, herbarium records and literature.

| Category | Abbreviation | Number of taxa |
|---|---|---|
| Extinct | EX | 6 |
| Critically endangered | CR | 6 |
| Endangered | EN | 5 |
| Near threatened | NT | 26 |
| Rare | R | 28 |
| Vulnerable | VU | 17 |
| Data deficient | DD | 6 |
| Least concern | LC | 49 |

Table 3. Categories of threatened plant species (IUCN version 3.1, 2001) in Makana.

The Eastern Cape State of the Environment Report (CSIR, 2004) gives estimates of threatened species of fish (4 endemic freshwater species), herpetiles (amphibians (6) and reptiles (19)), mammals (15) and birds (62). It is important to determine the number of threatened fauna in Makana Municipality.

### 3.3.10. Occurrence of disturbances (fire)

The occurrence of common disturbances such as fire and episodic disturbances (e.g. floods) should be recorded since these have huge impacts on ecosystems. However, some plant species require fire for persistence. The extent (size of the area affected), timing (date of occurrence) should be recorded. Causes of disturbances such as fire should be recorded.

## 3.4. Energy Needs

The Rhodes University Department of Environmental Science is completing a local energy use survey to more accurately characterise the levels of biofuel use in Makana. In addition, the areas that are currently used for fuelwood harvesting are being surveyed to determine the impacts of wood collecting on the biodiversity and soil degradation. The results of this work will be included in the final Environmental Audit.

Future monitoring of the impact of wood collection may be required. This impact will be dependent on the trends in energy use, the demand for locally harvested fuelwood and the capacity of local forests and bush to support the consumption. Monitoring of this condition is recommended on a five year basis.

Energy use surveys should be completed by the Municipality, potentially in conjunction with the Department of Environmental Science, and will have a low cost associated with the work. The framework for monitoring is being established as part of the LEAP implementation plan and can be repeated as conditions warrant. Significant increases in the use of fuelwood as a result of changing demographics, economic conditions or weather should trigger a more frequent monitoring programme.

### 3.5. Responsibility for monitoring and expertise needed

The Makana Municipality is responsible for the monitoring programme. Monitoring is a rigorous science requiring appropriate statistical design and analyses (Eberhardt and Thomas, 1991; Nusser et al., 1998; McDonald, 2003). Data cannot be used for making management decisions if the statistical design is faulty. The Municipality should therefore work together with the Albany Museum, conservation agencies, non-governmental organisations, private landowners, Rhodes University and independent consultants to monitor biodiversity. Expertise is needed for designing sampling strategies and analysing data.

#### 3.5.1. Data analysis and storage

Data analysis and storage is a key component of any monitoring programme. Data should be analysed as soon as possible after collection. Rhodes University and independent consultants can assist the Municipality in analysing the data. The monitoring results should be communicated to the Municipality in the form of tables and maps. The Municipality in turn can produce reports on the state of biodiversity within the Makana Municipality every five years. The five-year reporting interval should coincide with the five-year monitoring surveys for the indicators suggested above.

The data can be stored in both digital form and in maps. The Environmental section of the Municipality should be responsible for data analyses and storage.

### 3.5.2. Guidelines for response

There are ten broad classes of responses to loss of biodiversity (O'Connell, 2003). These are:

- advocacy;
- capacity building;
- habitat creation or restoration;
- *in situ* and *ex situ* action;
- legislation/agreements;
- protected areas;
- public awareness;
- research, and
- site management planning.

The response adopted by the Municipality will depend on the severity of the problem and availability of funding.

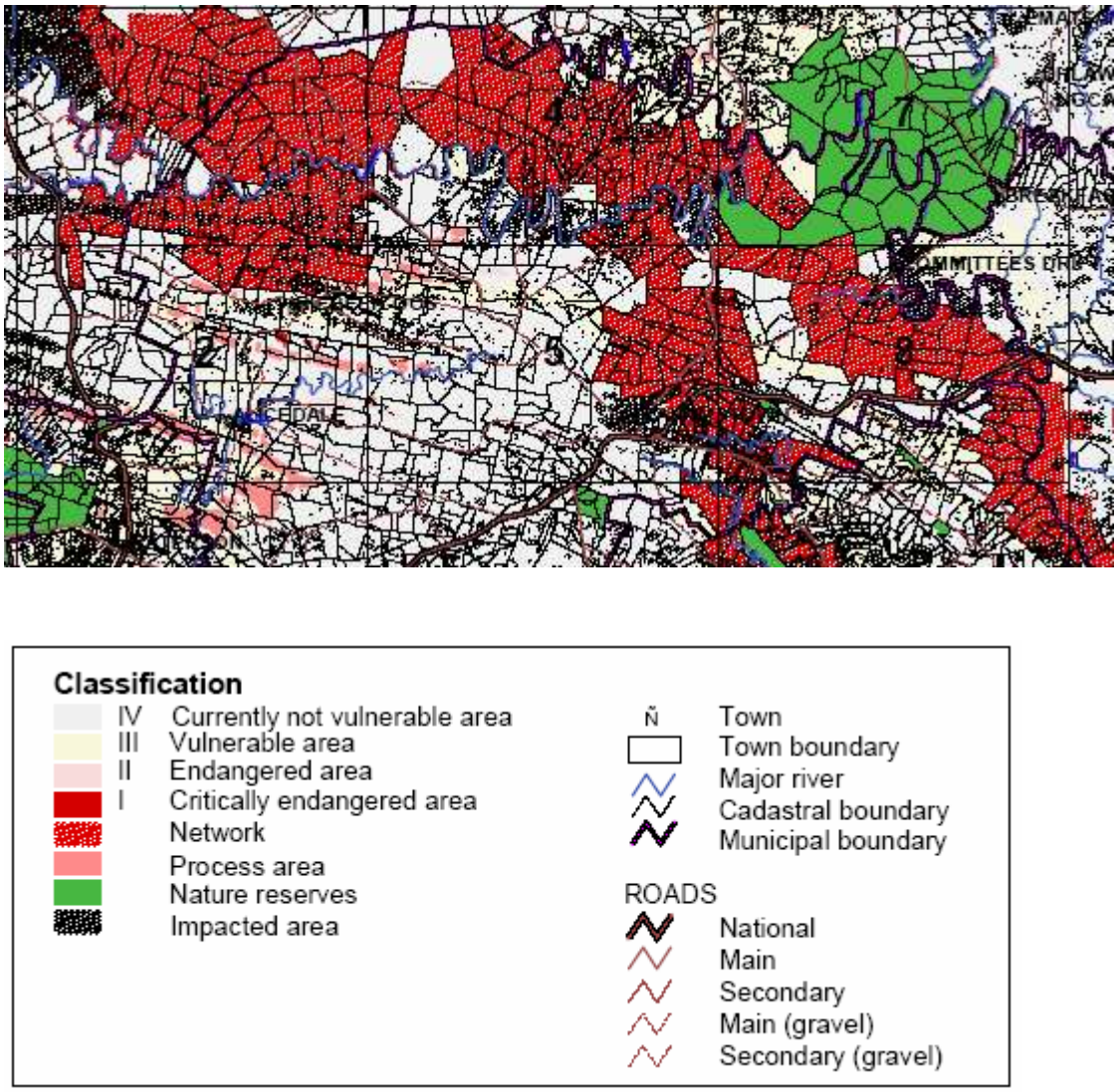


Figure 1. STEP Conservation targets within Makana

Figure 2. The extent of transformed cultivated land in Makana (Lloyd et al 2002).

Figure 3. Severe degradation of succulent thicket in Makana (Lloyd et al 2002).

Figure 4. The extent of moderately degraded thicket in Makana (Lloyd et al 2002)

Figure 5. The distribution of commercial plantations in Makana (Lloyd et al 2002). These can be used as surrogate for woody aliens infestations.

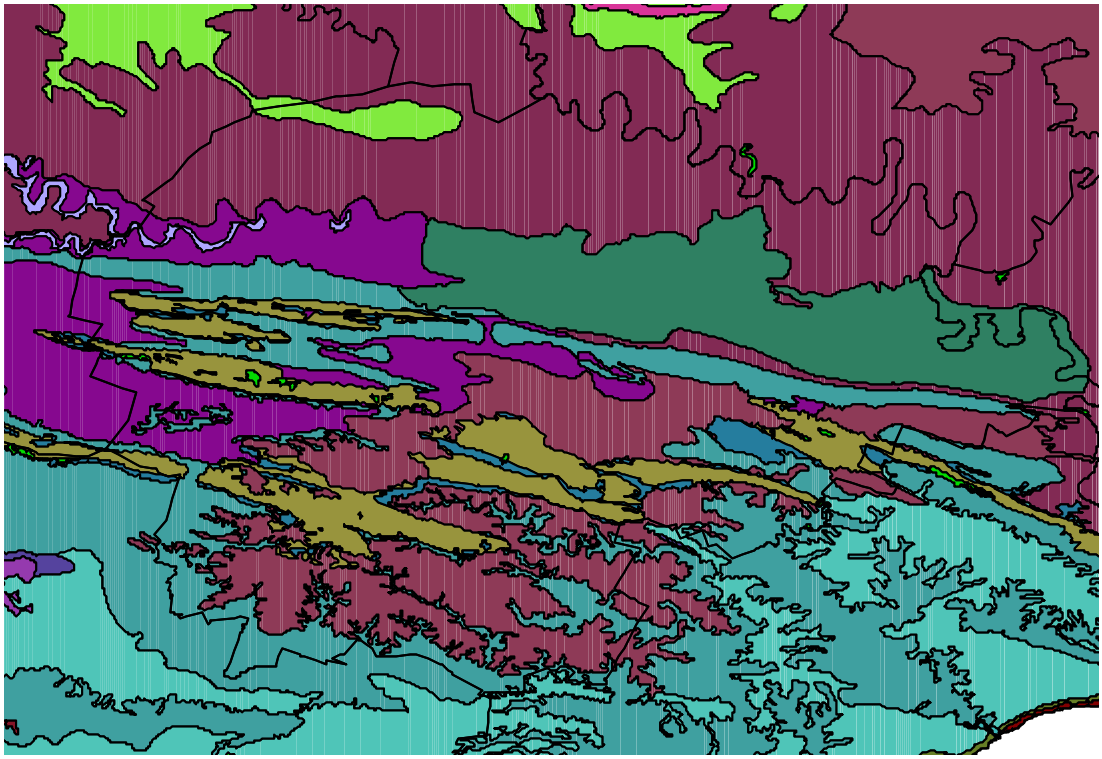

Figure 6. Portion of the new national vegetation map of South Africa, showing the distribution of vegetation types in Makana. The new vegetation types defined within Makana include: Bedford Dry Grassland, Great Fish Thicket, Great Fish Noorsveld, Kowie Thicket, Eastern Cape Thornveld, Albany Broken Veld, Southern Karoo Riviere, Suurberg Quartzite Fynbos, Suurberg Shale Fynbos and Southern Mistbelt Forest.

# 4. BUILT ENVIRONMENT

Built Environment includes open space, drainage and flooding, sanitation and water supply, electric supply and solid waste management.

## 4.1. Open Space

Open space and recreational lands are a function of land use planning within the Municipality. Monitoring of land use change is also a function of the National Land Use and Land Cover database and mapping project. This information is made available from the Department of Water Affairs and Forestry (DWAF). Monitoring of local open space needs is, again, a function of local government. The Municipality has identified specific open space projects

within IDP. These projects should be monitored for their implementation by the Municipal Department of Sports, Recreation and Culture.

#### 4.1.1. Indicators to monitor

The percent of land under conservation protection (including national, provincial or private) for the Eastern Cape is 10.18% but for the Makana Municipality it is only 4.0% (CSIR 2004). The target level of 10% is recommended in order to be consistent with the Eastern Cape as a whole, and international recommendations for protection of terrestrial biodiversity. A level of 10% will equate to approximately 422 square kilometres of land. However, land that is protected as private reserve is not always accessible to the local population. Therefore, at least one half of this area should be dedicated to the public as either national, provincial or municipal parkland. This parkland can then be developed as either passive open space (nature oriented recreation with little infrastructure improvement) or active open space (sports oriented recreation with higher levels of infrastructure and management).

Specific goals need to be identified and added to the IDP (specifically, IDP 86) with yearly targets established and monitored.

#### 4.1.2. Budget required for monitoring

No additional staffing is needed to complete the monitoring and the data can be captured in the Municipal GIS.

### 4.2. Drainage and Flooding

Improper drainage and development within floodplains was identified by stakeholders as an environmental issue of concern. The Water Services Act (Act 108, 1997) states that the Makana Municipality must take measures to prevent substances other than uncontaminated storm water from entering any storm water drain, or any water course, except in accordance with the NWA. The Municipality does not presently fully comply with this directive. The present state of storm water removal in particularly the low income high density areas of Makana, together with the poor litter control (see later), ensures serious contamination of storm water drains and ultimately water resources.

Drainage and flooding concerns are best monitored by the Municipality during the project review process. The Preliminary Sustainable Development Framework seeks to strengthen the Municipality's capacity in this regard.

One option for monitoring is to track complaints of improper drainage and flooding. The complaints should be mapped (via GIS) and cause identified. New developments proposed within the catchment may have a moratorium imposed until problems are alleviated or funding is provided for necessary reconstruction of drainage systems. This type of tracking system is the responsibility of the Municipal Engineering Department and can be accomplished within their current capacities. The cost of the tracking system is low given the existence of trained personnel and the GIS system already in place.

Monitoring of development within the floodplains of Makana are also part of the responsibilities of the Engineering Department. However, this is complicated by the lack of definition of floodplains within the Municipality, particularly within the urban areas. Therefore, monitoring of development within the floodplains of Makana is not possible at this time. However, the Sustainable Development Framework (SDF) has recommended a comprehensive assessment of floodplains within the Municipality. The mapping of known 100 year floodplains will greatly influence the ability of the Municipality to render decisions on proposed land use changes.

The SDF recommends the development of a floodplain identification system to identify those properties at risk of flooding during storms. This system can be created through the application of hydraulic and hydrologic analyses of the catchments within Makana. Once the areas at risk for flooding are identified, a specific monitoring and development control plan can be implemented.

The data for the storm drain system; natural drainage pathways and floodplains can be stored in the Municipal GIS system and displayed via the Municipal website, or on hard copy maps for display at the City Engineering Office. This information should also be made available to the Environmental, Disaster Management and Heritage Portfolio Committee; and integrated into the Disaster Management Plan for the Municipality. Specific interdictions should be considered in light of the lack of current knowledge concerning the potential for flooding within the Municipality. For instance, proposed development projects that include or are in

close proximity to drainage channels should be required to show the limits of the 10, 25, 50 and 100 year floodplains and to design the project so that it does not increase the flood elevations of the projected flows.

Specific proposals in the approved IDP, specifically, IDPs 57-61 should be reconsidered. These IDPs call for the concreting and channelization of existing natural drainage channels, which will assist in minimizing flooding and controlling runoff.

# 5. WATER

## 5.1. Introduction

With the pressures of population growth, together with the increased need for economic activities, waste generation and land use, and poor precipitation in Makana, our freshwater resources will be under even greater stress than they are at present.

The Water Services Act 108 of 1997 (RSA, 1997a) stipulates that everyone has the right of access to a basic water supply (i.e. the prescribed minimum standard of water supply services necessary for the reliable supply of a sufficient quantity and quality of water to households, including informal households, to support life and personal hygiene). The Act also states that everyone has the right to 'basic sanitation' (the prescribed minimum standard of services necessary for the safe, hygienic and adequate collection, removal, disposal or purification of human excreta, domestic waste-water and sewage from households, including informal households). Although Makana Municipality continues to address the sanitation needs within the Makana area, the improvement of sanitation and the supply of water to a greater number of households were concerns voiced at a recent stakeholders meeting (Preliminary LEAP Report). Fulfilling stakeholder concerns and demands places much pressure on the Makana Municipality to continually monitor the status of water supply, both in terms of quality and quantity, with continual review over time, to ensure sustainability of resources.

The National Water Act (Act 36 of 1998) and the National Water Resource Strategy (2004) place water resource management in the hands of Catchment Management Agencies (CMAs). There are 19 designated CMAs nationally, within 19 Water Management Areas (WMAs) with the Makana region forming part of WMA 15. A guide providing an overview of CMAs and their development can be obtained from the Department of Water Affairs and Forestry

(DWAF) [Water Management Institutions, Overview]. The governing body of each CMA will represent all stakeholders (interested persons and institutions), who should facilitate and play a role in the decisions around the [local] water resource management. The CMAs will contribute to ensuring the effective management of water resources and will co-ordinate all water-related activities. Water management activities can be devolved to lower tiers called the Water User Associations (WUAs). Makana Municipality can and should eventually be a major stakeholder within a WUA.

Each CMA will eventually form a vision for what they want from the water resources in the catchment. This vision must include both the socio-economic aspirations of the people and the ongoing ecological health of the aquatic ecosystems within the catchment.

The development of CMAs and WUAs by DWAF is still ongoing. Until CMAs and WUAs are established, DWAF will act as the CMA for the specific water management area within which Makana Municipality lies. However, within the progressive LEAP, the present role of the Makana Municipality is to contribute to this process of water management decision-making. The National Water Resources Strategy (2004) promotes a strategic adaptive management style. Details of this are simplistically presented in the WRC Handbook by Palmer et al. (in press; copies available from Institute for Water Research, Rhodes University).

## 5.2. Water quality

A vital component of this management is monitoring. In managing water quality in particular, the NWA makes use of two different kinds of mechanisms to protect water resources, Resource Directed Measures (RDM) and Source Directed Controls (SDC). RDM provide descriptive and quantitative goals for the state of the resource; SDC specify the criteria for controlling impacts such as waste discharge licences and abstraction licences.

General water concerns noted within the 2004 Eastern Cape State of the Environment Report included the following:

> Declining resource quality; eutrophication; implementation of CMA's; non-compliance of sewage works; over-abstraction of surface & groundwater; pollution

into surface & groundwater; resource use and exploitation; habitat change; and loss of biodiversity.

The core indicators for freshwater resources reporting include:

• Surface water nutrients;

• Surface water toxicity;

• Groundwater nutrients;

• Total surface water demand; (relate directly to the monitoring required with RDM), and

• Effectiveness of water resource management (relates directly to the auditing required with SDC).

## 5.3. Source Directed Controls (SDC)

As a potential major stakeholder within WMA15, Makana Municipality will continue to contribute to decisions with regards the issuing and review processes of general authorisations and licences for water use subject to conditions.

### 5.3.1. Current Water Quality Monitoring

Environmental monitoring is required to understand what pollutants exist in the environment, what the quantities are, and the toxicity of the pollutants. Monitoring should target chemicals or substances which are associated with the industries or institutions which are discharging into the environment. Currently monitoring occurs at different levels in the Makana area. Some of this is undertaken by the Municipality and DWAF, and some by institutions outsourced or contracted by the Municipality. The following monitoring and proposed monitoring plans were identified from the preliminary investigations:

***Sewage Treatment Works***

Performance monitoring of Sewage Treatment Works (STW) effluent is required by the NWA to ensure effluent quality is in compliance with standards outlined. These standards have been drawn up to ensure the ecosystem health of the receiving water body according to these water bodies' classification under the NWA. There are no water bodies which are classified as 'a resource' i.e. require stricter standards, in Makana and therefore all sewage works which discharge effluent must comply with General Limits as laid out in Section 21(f) and (h) of the NWA. In addition to these legal requirements, monitoring is also important for works

managers and engineers to allow for informed decision making on infrastructural maintenance, planning for expansions, and general optimal operations of treatment works.

***Grahamstown Disposal Works (GDW)***

The GDW is currently monitored by Makana Municipality on a daily basis for hydraulic loading via a flow meter at the head of the works; and pH is monitored at the anaerobic sludge digesters (Everton, pers. comm. 2004). This is done in order to determine the amount of lime which must be added for pH balancing and optimum operation of the works. Sampling of final effluent quality is also taken and analysis done by the Rhodes University Environmental Biotechnology Research Unit located on the premises. In addition to this monitoring of the STW, Makana has contracted the quarterly monitoring to the Nelson Mandela Municipal Metropol (NMMM) under Mr A.M. Mancotywa, Acting Water Reclamation Officer. Sampling is taken at 10 points along the treatment process and analysed for pH, conductivity, total dissolved solids, chlorine, nitrogen, ammonia, chemical oxygen demand total solids, suspended solids and volatile matter.

Additional monitoring of various other institutions' effluent, such as the hospital, is done on an ad hoc basis. There are plans by the Engineering Department to outsource monthly monitoring to a local laboratory.

DWAF monitors GDW final effluent quality where it is released into the Bloukrans River, according to the NWA, Section 21(f) and (h). A full sanitary analysis of final effluent is done on a monthly basis by a contracted laboratory in Port Elizabeth. DWAF are responsible for compliance monitoring against the General Limits of effluent discharged into a water body and can take legal action against the Municipality if effluent does not comply with standards for a continuous length of time. There is currently little cooperation between DWAF monitoring procedures and municipal monitoring which results in duplication of testing and there is no information sharing between the two bodies.

***Mayfield Oxidation Ponds (MOP)***

The MOP monitor flow of water borne influent and estimate input from the bucket system. The NMMM also monitors MOP on a quarterly basis. There is no bulk discharge of effluent from the MOP as final effluent is used for irrigation and therefore DWAF monitoring

requirements and effluent quality standards differ to those of the GDW. The final effluent must therefore comply with DWAF water quality guidelines for irrigation (the permit conditions).

***Alicedale Evaporation Ponds (AEP)***

The AEP were designed for a low flow rate and therefore to have no effluent discharge at all. No effluent quality monitoring is therefore required by law. However, due to the increase in number of houses recently added to the water borne sewerage system of Trans Riviere and Kwanonzwakazi, the design capacity of the ponds has been exceeded. There is a significant quantity of effluent discharging into the environment with no adequate planning and upgrading of facilities. DWAF officials were not aware of this situation at the time of investigation. This highlights the need for flow rate monitoring and cooperation between Municipal monitoring and DWAF monitoring; and interpretation of monitoring results.

***Expertise needed***

Microbiological or at least laboratory skills are necessary to carry out correct testing. These are currently outsourced. Expertise is required within the Municipality to interpret results; and knowledge of individual works is necessary to carry out the follow up actions required to remedy problems.

***Data***

Monitoring of sewage treatment works can contribute directly to the monitoring of community and river health as well as help in identifying sources of pollution and control industrial effluent. Though some monitoring is occurring, access to the monitoring results are difficult to come by.

- DWAF results are held in the Port Elizabeth DWAF offices, with data collation presently three to four months behind time of collection due to DWAF staff shortages.
- DWAF data are received from the laboratory and then entered into a spreadsheet database by DWAF staff. Copies of reports of the monitoring results from the NMMM are sent to the STW and are kept on file by the works manager and an additional copy is kept at the City Engineering Department.

A centralised and coherent data management system for collation and reporting of monitoring data would make accessing and interpreting data less complicated.

***Guidelines for response***

DWAF are required to inform the Municipality in writing of compliance concerns to the appropriate municipal officer. A procedure is in place for this process. DWAF relies on municipal officers and the public to inform them of any illegal or potentially illegal operation within the Municipality but no formal procedure exists in this regard. Makana Municipality rely on community reporting for sewage spill from buckets, leaks and broken pipes in residential areas and on the works managers to report the on treatment works needs.

***Response triggers***

The Works Manager at the GDW monitors performance of the STW and through knowledge and experience has come to recognise certain factors indicating a release of effluent from the various industries in Grahamstown that affect the influent quality.

***Budget required for monitoring***

For this more full suite of monitoring to occur, the Municipality will have to budget for outsourcing of relevant expertise with access to laboratory infrastructure, monitoring equipment as well as labour or time for collection of actual samples. Note that a monitoring programme should not be in addition to the existing monitoring system but should rather be used to assist the Municipality in gathering information on problem areas.

### 5.3.2. Bulk Water Supply

Bulk water supply quality monitoring is outlined in the Water Services Act No. 108 of 1997 Chapters II 9(1)b and Chapter II Section 12 as Gazetted in Regulation Gazette 7414 dated 19 July, 2002. Provision of high quality potable water to Makana is vital to good health of the people and prevention of water borne diseases such as cholera. With the increasing incidents of HIV/AIDS in the area and the compromising of sufferers' immune systems means that people are more vulnerable to diseases associated with poor quality and inadequately treated water.

Bacterial counts of faecal coliforms, pH, turbidity, are tested daily by the appropriate person at the Grahamstown Municipal Water Purification Works (Waainek, James Kleinhans) with

more detailed analyses completed monthly by an external contractor. In addition, detailed testing is done on an ad hoc basis in compliance with SABS standards for potable water. Water purification at Alicedale and Riebeck East are done through sand filters.

There is concern by the Alicedale Administrative Unit that tourist chalets above the New Years Dam have inadequate sewage disposal. On days of high rainfall, sewage disposal will be effected into the dam directly.

***Contribution to other environmental monitoring programmes***

Water testing prior to treatment can give an indication of the health and quality of the supply water body of ground water resources.

***Expertise needed***

Microbiological or at least laboratory skills are necessary to carry out correct testing. These are currently outsourced. Expertise is required within the Municipality to interpret results; and knowledge of individual works is necessary to carry out the follow up actions required to remedy problems.

***Data***

Similar to the STW, copies of reports of the monitoring results from the external contractor are sent to the STW and are kept on file by the works manager, and an additional copy is kept at the City Engineering Department.

Data collection, reporting requirements and transparency must be stipulated in the contract to the service provider as laid out in the Water Services Act, Regulation Gazette 7414 of 19 July, 2002.

***Budgeting required for monitoring***

An adequate budget is needed for correct testing equipment, chemicals and for external contractors. However, a good monitoring programme should help to reduce wastage of chemicals used in treating water when not justified and should help identify the source of problems such as poor water quality.

### 5.3.3. Landfill Sites

The monitoring of landfill sites is required under Section 20 (1) of the Environment Conservation Act (ECA). Minimum requirements for monitoring of landfills are laid out in DWAF's Minimum Requirement for Waste Disposal by Landfill (1998) and Minimum Requirement for Monitoring at a Waste Management Facility (1998), and depend on classification of the landfill. The responsibility of overseeing management and permitting process of landfill sites has recently been transferred from DWAF to the DEAET under the Amendment of the ECA in March 2004. The handover at ground level will in reality be gradual as transfer of records and responsibilities must take place at the local branch level. It is beyond the scope of this report to outline the detailed monitoring requirements. These are outlined in detail in the above-mentioned documents. However, DWAF will retain some involvement where water or leachate monitoring is required.

Although waste is currently collected throughout the urban areas of Makana Municipality, Makana has a major problem with illegal dumping. Monitoring of waste collection services and illegal dumping will help to identify problem areas, underlying patterns and causes of illegal dumping. Waste washed away with stormwater runoff is a serious problem in the Belmont Valley / Bloukrans River area in particular. Reduction of waste dumping will decrease waste washed into the rivers, with consequent improvements in water quality of these water resources from both an ecological and a human health perspective.

***Required Operation Monitoring***

***GHT Landfill, classified by DWAF as G:M:B+***

G General Waste - as in non-hazardous
M Medium Sized Landfill Site
B+ Is leachate producing

| ***What? Prioritise*** | ***How often?*** | ***By whom?*** |
|---|---|---|
| Landfill Site Auditing | Every 6 months | Audit committee set up in consultation with DWAF |
| Appropriate records and data collection | daily | The Responsible Person |

| | | |
|---|---|---|
| Deposition Rates | annually | The Responsible Person |
| Waste stream Surveys | annually | The Responsible Person |
| Landfill Volume Surveys | annually | The Responsible Person |
| Collection of climatic statistics | continuous | The Responsible Person or appointed specialists |
| Water quality monitoring | according to permit condition | DWAF |
| Monitoring of progressively rehabilitated areas | ongoing | The Responsible Person |
| Health of workers – flagged* (Occupational Health and Safety Act) | decided by the Responsible Person | Occupational Health Specialist |
| Gas emissions – flagged | decided by the Responsible Person and IAPS | The Responsible Person or appointed specialists |
| Air quality – flagged | decided by the Responsible Person and IAPS | The Responsible Person or appointed specialists |

*flagged items: the designated responsible person together with DWAF and interested and affected parties decide if these aspects need monitoring.

### Alicedale Landfill, classified by DWAF as G:C:B-

G General Waste - as in non-hazardous

C Communal Landfill Site

B- Not producing leachate.

| ***What? Prioritise*** | ***How often?*** | ***By whom?*** |
|---|---|---|
| Landfill Site Auditing | | Audit committee set up in consultation with DWAF |
| Appropriate records and data collection | daily | The Responsible Person |
| Deposition Rates | annually | The Responsible Person |
| Waste stream Surveys | annually | The Responsible Person |
| Water quality monitoring – flagged | | DWAF |

| | | |
|---|---|---|
| Monitoring of progressively rehabilitated areas | ongoing | The Responsible Person |
| Health of workers – * flagged (Occupational Health and Safety Act | decided by the Responsible Person | Occupational Health Specialist |
| Gas emissions – flagged | decided by the Responsible Person and IAPS | The Responsible Person or appointed specialists |
| Air quality – flagged | decided by the Responsible Person and IAPS | The Responsible Person or appointed specialists |

*flagged items: the designated responsible person together with DWAF and interested and affected parties decide if these aspects need monitoring.

***Riebeck East Landfill, classified by DWAF as G:S:B-***

G General Waste - as in non-hazardous
S Small Sized Landfill Site
B- Not producing leachate

| ***What? Prioritise*** | ***How often?*** | ***By whom?*** |
|---|---|---|
| Appropriate records and data collection | daily | The Responsible Person |
| Health of workers – * flagged (Occupational Health and Safety Act | decided by the Responsible Person | Occupational Health Specialist |
| Monitoring of progressively rehabilitated areas - flagged | decided by the Responsible Person | The Responsible Person |
| Water quality monitoring – flagged | decided by DWAF | DWAF |

*flagged items: the designated responsible person together with DWAF and interested and affected parties decide if these aspects need monitoring.

***Expertise required***

A full knowledge of the DWAF (and now DEAET) Minimum Requirements is necessary as well as the capacity and infrastructure to carry out the necessary duties and monitoring. Data collation and adequate record keeping skills are vital to the success of a good monitoring programme.

***Responsibility***

Mr Malcolm Grant is presently responsible for the overall management of landfill sites in Makana Municipality.

***Budgeting required for monitoring***

Costs involved in monitoring of landfill sites include a qualified person who oversees general running and maintenance of landfill sites. Costs of monitoring depend on the classification of individual landfill sites with requirements listed above. The designated responsible person may decide if flagged parameters need monitoring, depending on interest and affected parties (including the environment). Water quality monitoring to external contractors may be necessary depending on skills and infrastructure of the Municipality.

Huge costs are incurred through the continuous cleaning up of illegally dumped domestic refuse, amounting to over a million rand per annum.

### 5.3.4. Recommended Water Quality Monitoring

***Drainage and Flooding***

This was referred to earlier under the Built Environment.

***Industrial Effluent***

There are currently no by-laws in Makana Municipality that govern Trade Effluent Standards. Industrial effluent and waste should be monitored, to ensure the health of the environment and the biological and hydraulic capacity of the receiving STW to treat that effluent to an acceptable standard for discharge into the receiving water bodies.

Toxins, heavy metals, organic loading and discharge quantities relevant to each industry type must be monitored at point of release into the receiving sewer.

***Tanneries***

The industry with the largest water consumption, and therefore effluent discharge, in Grahamstown is the tannery industry. There are a variety of processing technologies used. Initial testing for sodium content, chrome and organic loading of effluent should be done to establish current levels and targets for tanneries to strive towards.

In Alicedale, a local tannery uses a holding tank for effluent where evaporation of water is the method of quantity control. However, during high rainfall excess flows occur onto the surrounding land. Groundwater and high flows during storms will cause runoff directly into the Bushmans River just upstream of Alicedale itself; and downstream to other water users.

***Abattoirs***

Abattoir wastewater consists primarily of organic wastes such as fats and blood as well as disinfectants and detergents used in washwater. These elements combined can affect the biological capacity of sewage treatment works as well as increase the organic loading beyond its design capacity resulting in poorly treated effluent. Monitoring of discharge must be done to establish current discharge quantities, organic loading rates and to identify any other potential toxins present in abattoir wastewater.

***Laboratories***

Current investigations have shown all laboratories and clinics to have adequate mechanisms for disposal of liquid as well as solid hazardous waste. The disposal of hazardous waste into the sewers would be environmentally disastrous and therefore should be considered for monitoring. Rhodes University has been identified as a potential source of such waste if disposal mechanisms fail. A sampling point should be identified for random monitoring to ensure no hazardous waste is released into municipal sewers.

***Sewage treatment works***

The monitoring of industries' discharge at the point of release into the sewers must be combined with the current monitoring data of influent quality and quantities at the inlet of the Grahamstown Disposal Works. The results of this comparative monitoring will allow

combined toxicities to be examined, which will help determine individual effluent standards for each industry. All results should be compared to the engineering specifications and design capacity (including biological capacity) of the sewage treatment infrastructure to determine its capacity to treat the identified toxins to an adequate standard for release. Comparison of identified industrial wastewater and the influent into the GDW will also identify unknown pollution sources and allow further investigation into control of these toxins e.g. oils, organic solvents and heavy metals.

*Other*

Other industries which should have effluent monitoring are any dairies discharging effluent into sewers or significant quantities (more than 50m3 as stipulated by the NWA and DWAF) into the environment without adequate prior treatment or containment. Currently the industries identified in this category include Bushman's River Taxidermy in Alicedale, currently being inspected by DWAF; dairies; piggeries; and abattoirs.

Settlers Hospital should be included in point source monitoring programmes.

***Trade Effluent Standards***

The monitoring of industrial effluent and comparison to sewage influent monitoring data will enable Trade Effluent Standards, appropriate to Grahamstown, to be drawn up by the Municipality with a view to appoint an inspector as stipulated in the latest bill of the Municipal Systems Act. Once Trade Effluent Standards are established, compliance monitoring will be necessary to ensure compliance. Non-compliance to these standards should result in a fine to the polluter. There is currently no known industry which discharges effluent into the Mayfield Oxidation Ponds or the Alicedale Evaporation Ponds; and no industry with significant discharge exists in Riebeck East.

***Frequency of Monitoring***

Initial industrial effluent monitoring should take place monthly to establish norms for each industry. Random sampling by a municipal official or municipal contractor must also be carried out to ensure sampling is being carried out according to stipulated conditions; and undesirable effluent is not discharged at other times. Once trade effluent standards are in place, monthly monitoring should continue as compliance monitoring.

***Responsibility of Monitoring***

A large proportion of the responsibility for monitoring will lie with individual industries. The responsibility of random monitoring should fall to the municipal inspector to be appointed under the latest Amendment to the Municipal Systems Act, or to an external contractor or laboratory to ensure realistic results.

***Expertise required***

Correct identification of sampling points and sampling techniques are necessary to ensure value of data collected. Expertise in wastewater analysis is necessary to identify toxicity and specific toxins present. The City Engineers and experts in wastewater treatment technologies will be able to determine the capacity of the current sewage treatment infrastructure to treat identified toxins adequately. Expertise in interpretation of results from the industrial effluent monitoring will be necessary to establish Trade Effluent Standards.

***Data management***

All data should be kept at a common point and be accessible to any interested and affected parties. Data should be collated and assessed by a relevant expert either within the Municipality or outsourced, initially with recommendations for the drafting of Trade Effluent Standards. It is understood a template of the Trade Effluent Standards has been developed by the City Engineers (Grahamstown).

Monitoring is meaningless unless data are interpreted and reported over time. Improvements in individual industries' effluent qualities can and should be tracked over time, allowing for award schemes, tariff reductions or fines to be issued according to performance. Data reporting will allow for more transparency within the Municipality and cross-sectoral communication. Public access via the Municipal website will allow complete transparency and ease of access.

***Guidelines for responses***

Once trade effluent standards are compiled, a set of guidelines must be laid out as to the response mechanisms when the standards are contravened for a continuous period. A lag time should be set with a deadline as to when all industries must be compliant to new standards, after which, if the industry continues to fail to comply with standards, a fine should be issued on each consecutive occasion of contravention.

Improvement in industrial effluent quality and quality will decrease pressure on the STW and can bring in additional income if complex industrial wastes are discharged through fining.

***Budget required for monitoring***

The expenses of monitoring will lie with individual industries. The Municipality will have to budget for the random monitoring by the municipal inspector.

***Mining***

The Kaolin Mines and Brick Making industries in the Makana District are governed by the Department of Minerals and Energy and must contribute to a rehabilitation fund. As yet, no mines have successfully received closure certificates. Once a mine plans to close, monitoring of rehabilitation will have to take place. The Minerals and Petroleum Resources Development Act, 2002, lays down the steps required to be taken to get approval for mining or prospecting to take place. All mines in the Makana area should be compliant with this requirement. In terms of monitoring, a system should be set up to ensure that companies comply with the Act and that environmental management programmes as defined by the act are in line with community needs. An annual audit of compliance to environmental management programmes should be set up with assistance from the Department of Minerals and Energy (DME). In addition, funding for old abandoned mines and quarries needs to be sought with assistance from the DME and possibly the Chamber of Mines before any rehabilitation of these can take place.

### 5.3.5. Progress Water Quality Monitoring

***Sanitation and Water Services Provision***

The provision of adequate water and sanitation according to RDP standards is a matter of primary concern to a large proportion of people living in Makana Municipality. The primary concerns raised at every public meeting, by both municipal officials and members of the public, is the eradication of the bucket system. Although progress may be happening in terms of achieving targets within the Municipality, little is known beyond the immediately impacted areas. Annual targets, with target dates, for service delivery should be made public through the media such as the newspapers and the Makana Municipal website with progress reports

appearing every 6 months to a year. This will allow the public to monitor the real progress of service delivery, ensuring accountability; other data sources such as the census data have large margins of error. The greater transparency from the Municipality will create a sense of pride within the citizens of Makana and support for local authorities.

***Expertise needed***

The expertise of adding information to the existing website will be necessary but could be outsourced to a webmaster if the expertise does not already exist within the Municipality. Interdepartmental information sharing will be necessary to capture all aspects of interest.

***Budget required for monitoring***

Little extra time or costs will be involved in collating data into a simple progress report which outlines matters of sanitation and access to water as information of this nature should already be recorded within the Municipality.

## 5.4. Resource Directed Measures (RDM)

Resource-directed measures at this level are aimed at giving effect to the environmental values adopted for a water resource. They will be applied on a catchment basis within Water Management Areas. Practical effect will be given by the collective application of resource-directed measures, which encompass resource classification, reserve determination and the setting of resource quality objectives, and water quality specific measures, formulation of source management objectives and associated single source interventions, and the formulated water quality management strategies and associated water quality management plans.
Their joint application will ultimately culminate in a coherent and implementable catchment management strategy. In the identification and consideration of environmental values and eventual translation of these into resource quality objectives, the following recognised water users are initially considered:

- Aquatic ecosystems
- Basic human needs
- Domestic water supply
- Agriculture
- Industry

- . Recreation.

The priority right of water use is conferred upon basic human needs and the aquatic ecosystem by virtue of the Reserve. Hence, in the execution of the water quality management function, the water quality requirements for basic human needs and the aquatic ecosystem will receive priority. As part of the water quality management function, DWAF, in cooperation with other agencies, is currently actively involved in the development and implementation (on a pilot basis) of catchment management strategies and associated catchment management plans. The experience gained will guide the development of other catchment management strategies, including those to be implemented and reviewed by Makana, as well as the revision of those strategies already in place.

Monitoring water quality within the Makana water resources requires an integrated approach. There are three components to monitoring, aspects of which will be expanded on in the Comprehensive Report due in February 2004:
physico-chemistry analyses
biomonitoring which gives information about the presence, absence and abundance of biota in the ecosystem
ecotoxicology which gives information about the responses of specific biota to specific concentrations of chemicals or mixtures.

***Physico-chemical data***

Water quality variables potentially affecting aquatic ecosystems have been grouped as:

- system variables; which are characteristics of particular sites or regions e.g. temperature, pH, total dissolved solids, dissolved oxygen concentration and total suspended solids;
- nutrients; which are food for plants and microbes e.g. phosphates, nitrates and nitrites; and
- toxic substances e.g. metal ions, ammonia, pesticides and herbicides.
-

***Biomonitoring***

The measurement of surface water nutrients does not allow evaluation of the potential harm contaminated water may have on both people and ecosystems. Instead, the data highlight the potential impact of impaired water quality on people and ecosystems.

Living organisms experience the cumulative results of all chemical interactions that affect them, including the full frequency and duration of high and low chemical concentrations. They respond to the whole integrated chemical condition. If the chemical conditions are favourable, the biota have the potential to thrive. If chemical conditions approach or exceed their tolerance limits, they will diminish or disappear.

Biomonitoring is based on different organisms having different tolerance levels. In any sample of water, the presence or absence of sensitive organisms, or simply a change in community composition, can indicate the effects of changed water chemistry which may not be detected by the chemical data record. Invertebrates, fish, algae, the riparian vegetation and the geomorphology can all be monitored to assess aquatic ecosystem health. The most useful to monitor are invertebrates, because there are so many of them, and they have a diverse range of tolerances. Invertebrates also have the advantage of being mainly sedentary. Fish are also useful indicators of pollution, but they are fewer, larger, and generally respond negatively only to higher concentrations. Being mobile, they can swim away from temporarily unfavourable conditions.

Biomonitoring has been recognized as a valuable, cheap tool for monitoring water quality. Causal links can be found when chemical data, biomonitoring, and ecotoxicity data all indicate the same thing.

***Ecotoxicology***

Ecotoxicology is the study of the effects of chemical solutions and mixtures on living organisms. Selected organisms, or communities of organisms, are exposed to single substance solutions or complex mixtures, in the laboratory. The concentrations are carefully controlled and responses are reported as statistical probabilities. Ecotoxicology provides a quantifiable, causal link between the chemical concentrations that are routinely monitored in water resources and the instream biological responses (biomonitoring).

### 5.4.1. Surface Water: Current Water Quality Monitoring

***Physico-chemical data***

A list of the DWAF water quality monitoring points within Makana are detailed in Table 4 and in Figure 7.

Two indicators are used to assess the state of surface water nutrients in the Eastern Cape Province, namely surface water nutrients and surface water toxicity. Details of interpretation are given in the Preliminary Report and will be expanded on within the Comprehensive Report. In the Makana region, levels of aluminium, copper, iron, manganese, nickel, lead and zinc are not measured or monitored in any of the water courses by DWAF (CSIR, 2004). This is because there is very little activity which may cause elevated levels of these metals (such as mining and heavy industry). However, at the extra monitoring sites introduced by DWAF around the Grahamstown STW (Table 4), chromium is now monitored.

The water physico-chemical data are interpreted as percentage exceedance of the South African Water Quality Guideline values for the aquatic environment, surface waters (DWAF, 1996a and 1996b) to give an indication of the potential toxicity of those waters to the aquatic biota. Data are collated at the Port Elizabeth DWAF offices, and data such as for the STW are sent to the Makana Municipality. However, data collation is slow at DWAF due to staff shortages. Any adverse trends are therefore only noted 4-6 months post collection.

In terms of the Grahamstown STW licensing, the quality of water from the STW entering the Bloukrans River catchment should to be monitored every one to two months. The DWAF Port Elizabeth offices have presently taken over this monitoring. Upstream of the STW, the possible influences of town water runoff etc are monitored in the East and West Market Street regions, within the Bloukrans River. With the intention of monitoring STW effects on resource quality, three further sites are monitored above and below the Grahamstown STW (Table 4).

The New Years Dam in Alicedale has no water quality sampling occurring, despite the dam being the only water supply for the town. New equipment for pH and turbidity monitoring at the purification works has been budgeted for by the Municipality.

DWAF data are held in the Port Elizabeth DWAF offices, with data collation presently three to six months behind time of collection due to DWAF staff shortages. When DWAF data are

received from the laboratory, they are entered into a spreadsheet database by DWAF staff. Copies of reports of the monitoring results from the NMMM are sent to the STW and are kept on file by the works manager and an additional copy is kept at the City Engineering Department.

***Biomonitoring***

Biomonitoring was initiated in the Bloukrans River near Grahamstown in November 2002 and repeated at the same sites in September 2003. It was led by the Kowie Catchment Campaign, represented by specialist scientists Dr Ferdi de Moor and Ms Helen Barber-James (Departments of Freshwater Invertebrates) and Dr Jim Cambray (Department of Ichthyology), all of the Makana Biodiversity Centre, Albany Museum, Grahamstown. Seven sites were chosen for invertebrate and fish biomonitoring (Figure 1). Results were produced in the form of two reports, submitted to Makana Municipality for perusal (de Moor et al., 2002; Barber-James et al., 2003).

In establishing the preliminary LEAP audit (March 2004), UCEWQ-IWR, Rhodes University, completed invertebrate biomonitoring at the same sites as above; as well as at the confluence of the Palmiet and Berg Rivers; and at the Double Drift crossing on the Great Fish River (invertebrates). [This will be repeated in September 2004 to gauge any seasonal variability.]

Biomonitoring of invertebrates has been competed within the New Years Dam, by Rhodes University postgraduate students in conjunction with Professor Martin Hill, Department of Zoology and Entomology. The focus has been on the effects of the alien plant the water hyacinth presently in abundance on the dam, with the understanding that the invertebrates play a role in maintaining the ecological integrity of the dam water. Negative effects of the plant were shown. Professor Hill facilitated the introduction of a biological control beetle onto the dam in 1991, which consumes the water hyacinth. Success was good (reduction of 80% of the stand) and in 2004, three other beetle species were introduced. This biological control is a collaboration between Rhodes University, Bushman Sands, and the Working for Water Programme (Ms Abbey Heunis, Uitenhage).

***Ecotoxicology***

One comprehensive ecotoxicology study has been completed in the Makana region, on the Grahamstown STW.  Nozipho Hoohlo, a Rhodes University Masters student completed her

thesis entitled “Ecotoxicological evaluation of tannery effluent using Daphnia pulex”. This research was undertaken at UCEWQ-IWR. Ecotoxicology was applied as a tool for evaluating effluents from the leather tanning processes of a Grahamstown tannery. Her sampling regime included the influent at the Grahamstown STW, to monitor how effective the tannery detoxification processes were, with regards toxicity to the resource biota. Her conclusions related to implementation and application of the NWA through strategies such as Integrated Water Quality Management and Integrated Pollution and Waste Management.

On the basis of her results, further toxicity tests were and are being used by UCEWQ-IWR, within the context of the LEAP, to ascertain the toxicity of the sewage influent and effluent to aquatic biota. The test species is the standard laboratory organism Daphnia pulex (water flea) which is currently being bred as a genetically homogenous culture in the UCEWQ-IWR laboratories. Results will be presented within the LEAP Comprehensive Report.

### 5.4.2. Surface Water: Recommended Water Quality Monitoring

***Physico-chemical data***

DWAF are responsible for water resource quality monitoring. However, greater collaboration seems required between the Municipality, DWAF and industry, for more effective management of the water resource quality. A centralised and coherent data management system for collation and reporting of monitoring data would make accessing and interpreting data less complicated and possibly more efficient in monitoring trends, particularly on water resources.

New equipment for pH and turbidity monitoring at the purification works in Alicedale has been budgeted for by the Municipality. This is seen as an urgent matter.

***Biomonitoring***

There are many changes to water resource management within the context of the requirements of the NWA. DWAF, as custodians of water resources, hold the responsibility for providing Makana with the latest developments and introduction of new legislation. However, education (new developments and their implementation within Makana) is seen as a future requirement for both technical and managerial staff, and stakeholders. The formation of the CMAs will eventually facilitate this process.

Biomonitoring in the Bloukrans River, Grahamstown, can continue to be led by the Kowie Catchment Campaign. Both the Makana Biodiversity Centre, Albany Museum, and the UCEWQ-IWR, Rhodes University, are presently willing to make their expertise available for such monitoring. The seven sites used for invertebrate (and fish) biomonitoring should continue to be monitored as they will act as 'red flags' for any physico-chemical changes detrimental to the aquatic biota. This is commensurate with the environmental water quality approach as noted previously.

Biomonitoring should be initiated in the Bushmans River above and below Alicedale to monitor possible effects the town, developing golf course and tourist facilities, and nearby tannery may have on water resource quality.

The cost of the biomonitoring over a number of years will be the responsibility of the Municipality (transport and possibly consultancy fees), although collaboration with the Kowie Catchment Campaign and Rhodes University, in particular the UCEWQ-IWR, may facilitate cost sharing. The Water Boards may be a source of funding. Collection and interpretation of data require expert knowledge. However with the future appointment of further Environmental Officer(s) within Makana by DWAF or DEAET, this expertise can be transferred to the Environmental Officer(s) and others within the Makana Municipality. Similar training of invertebrate biomonitoring techniques have been extensively introduced to the Knysna Municipality by a concerned citizen of Knysna at little cost to the Municipality.

To complete the LEAP Preliminary exercise, UCEWQ-IWR will be continuing with further biomonitoring in September 2004 to assess any seasonal variability in community structures. Site location will be the same sites as listed for 2004 (above; invertebrates only).

The success of the biological control of water hyacinth by beetles on the New Years Dam will continue to be monitored by Zoology Department (Professor Hill) and Working for Water (Uitenhage).

***Ecotoxicology***

In South Africa, the use of ecotoxicology is not yet widespread. However, DWAF are in the initial stages of implementing the DEEEP process (direct environmental effect potential)

(DWAF 2003), which specifically targets the management of complex mixtures. It is due for implementation nationally June 2005, by DWAF water quality managers.

Toxicity tests using the standard laboratory organism Daphnia pulex (water flea) are ongoing by UCEWQ-IWR, within the context of the LEAP. The tests will be complete by September 2004 and assess and compare the toxicities to aquatic biota (if any) of the influent and effluent of the Grahamstown STW. Present results indicate the tests are a valuable indicator for identifying when toxicants are not being broken down or absorbed within the STW. The test results will be presented within the LEAP Comprehensive Report.

In the context of holistic environmental water quality, as suggested before, toxicity tests should be continued with STW effluent, compared to influent. The DEEEP process will also introduce compulsory industrial toxicity testing by June 2005, where industry will be responsible for tests and the costs therein. Data should be kept by the Municipality, as suggested with all other data, in an accessible place for all interested parties. The frequency for such tests depends on the industry(s) within Makana, and the requirements by DEEEP.

***Data management***

All data should be kept at a common point, and be accessible to any interested and affected parties.

### 5.4.3. Ground Water: Current Water Quality Monitoring

DWAF are responsible for the monitoring of groundwater quality. There are a number of gauges including the following waste disposal / treatment sites:

| AREA | WORKS |
|---|---|
| Alicedale | Waste disposal site |
| Alicedale | Sewage treatment works |
| Glen Melville Dam | Sewage treatment works |
| Grahamstown | Sewage treatment works |
| Grahamstown | Waste disposal site |
| Grahamstown | Rini sewage treatment works |

| | |
|---|---|
| Riebeeck East | Waste disposal site |

Nutrients in ground water are expressed as the concentration of nitrates and nitrites (mg/l NOx-N). Increased nitrate concentrations in groundwater can be caused by ineffective sewage disposal and faecal contamination. These increased concentrations can cause diarrhoea and vomiting if ingested by humans. When measuring this indicator, it is important to determine whether elevated concentrations of nitrates and nitrites in the groundwater are as a result of anthropogenic pollution or are typically natural in the area. The target water quality threshold for domestic water is set at 6 mg/l. Ingestion of water with NOx-N concentrations below this level will not cause any significant human health effects (WRC, 1998).

Data are presently held in the DWAF Port Elizabeth offices. However, staff shortages mean data are not being analysed, with no collaboration with Makana Municipality.

### 5.4.4. Ground Water: Recommended Water Quality Monitoring

DWAF should continue to be responsible for the monitoring of groundwater quality. However, careful consideration of the Makana Water Development Plan and projections of growth points including the sighting of small industrial growth within Makana should be made by the City Engineer. Sustainability of water resources is a key concern.

## 5.5. Water Quantity

Water scarcity can have far-reaching effects on the sustainability of environmental and ecological systems and can negatively affect regional development. More than ever before, improvement in water resource management requires that the water quantity and quality aspects of the resource be viewed and managed in an integrated manner. Water quality related decisions invariably involve water quantity effects and vice versa, relating primarily to water use decisions such as: allowing discharge of effluent; allowing impoundment of contaminated water; and allowing development of surface water resources to proceed within groundwater recharge areas and/or catchment areas. Conversely, changes in flow patterns, re-routing of water resources and changes to water allocation profiles could all have pronounced effects on water quality. Advance knowledge and the proactive engagement of these possible changes in the water resource are essential for effective water quality management.

Over-abstraction of surface and groundwater is a key concern in Makana. The inter-basin transfer of water into the Fish River from Gariep Dam underlines this concern. Groundwater resources are vulnerable to land-based activities, difficult to rehabilitate once polluted and are slow to recover from over-exploitation. The integrity of groundwater resources should be evaluated over time to ensure that these resources are protected and managed.

### 5.5.1. Current Water Quantity Monitoring

DWAF are responsible for the monitoring of surface and groundwater quantity, with many of the DWAF hydrological monitoring points also measuring water quantity. However there is no assessment of:

existing lawful use of water

collated data on the present water demands within Makana, and

projected estimates for domestic, educational (in particular Rhodes University's projected numbers of entrees), industrial and agricultural growth and therefore water demands.

### 5.5.2. Recomended Water Quantity Monitoring

The National Environmental Management Amendment Act (Section 31C of 2003) allows for environmental management inspectors to be appointed by the provincial government. Environmental progress reports on industries will likely to be completed by these environmental inspectors. However, ecological monitoring and reporting should also be included when reporting to Makana Municipality.

By-laws for groundwater analyses promulgated by the Makana Municipality are required. Both domestic water use and borehole use on farms should be measured with meters; with the Makana Municipality monitoring water use data, with an integrated approach with DWAF. The development of CMAs will facilitate this integrated approach.

The Makana area needs a water reserve assessment. This should not include the Fish River itself, although it should include water extracted into the area from the Fish River. More information regarding the reserve determinations is given in the ecological Reserve determination procedure (DWAF 2002) and in the handbook by Palmer et al., 2004. To assess the Makana area, 4 experts (fish, invertebrate, hydraulics and hydrology) would determine the

needs of the 4 main rivers within Makana, over 2 days. The total cost is estimated at R120 000.

Alternatively, a hydrologist could be commissioned to design a model of the Makana area that would simulate present conditions. This model would focus on water quantity and include the present main water users, including present allocation and licences; irrigation and assessment of distribution of water from all dams within the area; and Bloukrans River return flows. The model can then be used to predict the future water demands of Makana using the estimated growth points that are presently not catered for in future estimations of consumption. This includes the golf course and tourist development at Alicedale, and the population growth and water demands presently under review at Riebeck East. The cost of this model development is estimated at R40 000. The expertise required to complete this model is within Makana, at the Institute for Water Research, Rhodes University. Most of this information could also be used in an ecological Reserve assessment.

The Free State DWAF biomonitoring programme within the River Health Programme has mapped extraction by farm pumps very successfully via GIS, in collaboration with the Department of Nature Conservation. Using excess time during game counts, helicopter surveillance has been noted on rivers presently within the biomonitoring area at the same time as alien vegetation surveillance, together with the state of dams and weirs. With the profusion of game farms within Makana, the very active Working for Water Programme, and the re-vamped Department of Nature Conservation in the Eastern Cape Province, it seems a similar co-ordinated effort by Makana Municipality to regularly map the Makana area would be possible, with little cost to Makana Municipality.

***Data management***

All data should be kept at a common point and be accessible to any interested and affected parties. The data presently monitored are stored by DWAF offices in Port Elizabeth.

### 5.5.3. Longer Term Objectives To Water Monitoring

The NWA requires ‘significant’ water resources to be classified according to an ecological health class (natural, good, fair, poor), which will define the Resource Quality Objectives that

will guide management decisions. The methods for the classification process are given in the ecological Reserve determination procedure (DWAF 2002). An ecological Reserve is therefore to be assigned to each water resource. The CMAs will eventually drive this process. More information can be found in the handbook by Palmer et al. (2004).

Table 4. Department of Water Affairs and Forestry water quality monitoring sites. Those listed without a DWAF number site are the sites introduced by Mr Pieter Retief (DWAF Port Elizabeth) as extra monitoring sites sampled monthly.

GHT = Grahamstown; STW = Sewage Treatment Works

| **Site code** | **DWAF site number** | **Location** | **Latitude : longitude** |
|---|---|---|---|
| Q1 | Q9H001 | Great Fish River | 33.127778 : 26.613889 |
| Q2 | Q9H012 | Great Fish River | 33.098333 : 26.445556 |
| Q10 | Q9H018 | Great Fish River | 33.237778 : 26.990278 |
| Q6 | P1H003 | Boesmans River | 33.329167 : 26.0775 |
| Q16 | P3R001 | Howisonpoort Dam | 33.387778 : 26.4875 |
| Q14 | P1R001 | Jameson Dam | 33.316667 : 26.4375 |
| Q9 | Q9H013 | Kap River | 33.355278 : 26.861944 |
| Q8 | P3H001 | Kariega River | 33.554444 : 26.603611 |
| Q15 | P1R002 | Milner Dam | 33.311111 : 26.428889 |
| Q7 | P1R003 | New Years Dam | 33.303056 : 26.113889 |
| Q5 | P3R002 | Settlers Dam | 33.412222 : 26.509167 |
| Q3 | Q9H022 | Brak River | 33.195 : 26.632222 |
| Q4 | Q9H023 | Brak River | 33.189722 : 26.629444 |
| Q11 | Q9H024 | Brak River | 33.190556 : 26.590833 |
| Q12 | Q9H021 | Brak River | 33.205833 : 26.681667 |
| Q13 | Q9H020 | Brak River | 33.202778 : 26.690278 |
| Market Street East GHT | | Bloukrans River | |

| | | |
|---|---|---|
| Market Street West GHT | Bloukrans River | |
| Upstream GHT STW | Bloukrans River | |
| GHT STW | Bloukrans River | |
| Downstream GHT STW | Bloukrans River | 33.1926:26.3559 |

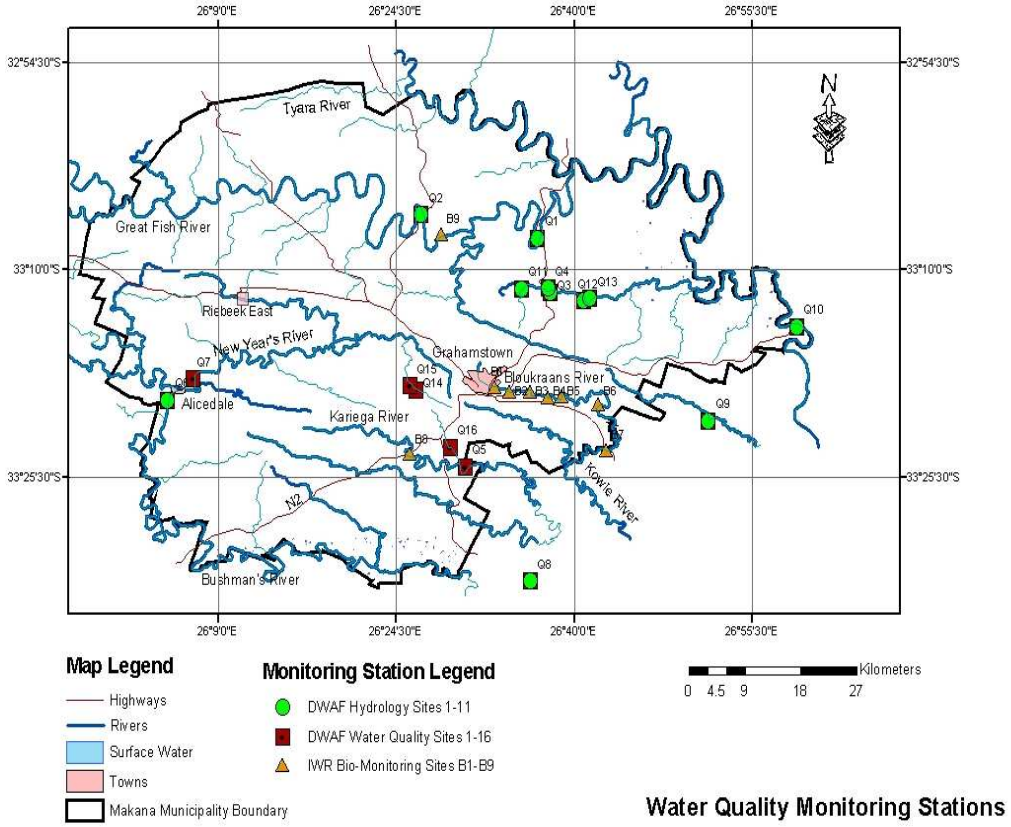


Figure 7. Map of the DWAF water quality monitoring stations, and biomonitoring sites within the Makana Municipality.

## 6. MONITORING THE LEAP PROCESS

The LEAP Terms of Reference, as prepared by the Steering Committee, introduces interventions as relatively small and strategic. Their effectiveness, sustainability and efficiency need to be monitored. Phase 2 will involve a 1 year cycle of implementations with structured monitoring of the effectiveness of the interventions. This monitoring should be achieved via regular meetings of the project implementation committees for each intervention. Using recognised administrative procedures (e.g. regular meeting scheduling, agenda preparation, announcement of the date and time of the meeting to all stakeholders, accurate minute taking, action review process during meetings), project chairpersons should direct the projects and report on progress.

The LEAP process itself should be monitored, evaluated and revised on an annual basis, with the Steering Committee helping to steer and monitor LEAP progress.

Before the Monitoring Plan can be introduced, the Implementation Phase needs to be clarified by Makana, DBSA and the LEAP Project Team.

**During the implementation phase, each project should (via stakeholder agreement):**

- Have a realistic, though challenging goal and a number of specific targets
- Use indicators to help verify progress in meeting specific set targets
- Include community awareness, job creation and project sustainability as targets
- Targets must address priority needs
- Agree on tasks which specific stakeholders/officials/individuals/employees must carry out and when to achieve targets
- Realign targets after a monitoring cycle is completed
- Use quantitative and qualitative data to measure success
- Use both compliance and effectiveness monitoring
- Use a timeframe in which to measure success
- Review the indicators used and reliability of data
- Use ongoing internal monitoring processes for own and stakeholder usage
- Be subject to external monitoring, including verification of internal monitoring.
- Include a detailed budget

## 7. REFERENCES

Alcamo, J., et al. 2003. Ecosystems and Human Well-being: A Framework for Assessment. Island Press, Washington.

Anonymous, undated. Wetlands and the Ecological Reserve. Institute of Water Resources, Rhodes University. pp 83.

Barber-James, H.M., Cambray, J.A. & de Moor, F.C. 2003. Report: September 2003. Survey of aquatic invertebrates and freshwater fish from the Bloukrans River near Grahamstown, to assess water quality and effects of pollution.

Carignan, V. and Villard, M.A. 2002. Selecting indicator species to monitor ecological integrity: a review. Environmental Monitoring and Assessment, 78: 45-61.

CSIR. 2004. 2004 Eastern Cape State of the Environment Report. CSIR. Division of Water, Environment and Forestry Technology. Durban, South Africa. Produced on behalf of the Eastern Cape Department of Economic Affairs, Environment and Tourism, Bisho.

de Moor, F.C., Barber-James, H.M. & Cambray, J.A. 2002. Report: November 2002. Survey of aquatic invertebrates and freshwater fish from the Bloukrans River near Grahamstown, to assess water quality and effects of pollution.

DWAF 2002. Method for assessing water quality in ecological Reserve determination for rivers. Version 2. Draft 15. Department of Water Affairs and Forestry, Pretoria.

DWAF 2003. The Management of complex industrial wastewater discharges. Introducing the DEEP approach. A discussion document.

Eberhardt, L.L. and Thomas, J.M. 1991. Designing environmental field studies. Ecological Monographs, 61: 53-73.

Haigh EH and Ilgner, P. 2001. The Featherstone Kloof Wetland: History, Environment and Rehabilitation. Institute for Water Research, Rhodes University, Grahamstown.

REFYN, 2002. REFYN, Putting Cape Heath Vegetation Back. Botany Department, Rhodes University, Grahamstown

IUCN. 2001. IUCN Red List Categories and Criteria: version 3.1. IUCN Species Survival Commission. Gland, Switzerland, and Cambridge, UK.

Lloyd, J.W., van den Berg, E.C. and Palmer A.R. (eds) 2002. Subtropical Thicket Ecosystem Planning Project (STEP). Patterns of Transformation and degradation in the thicket biome, South Africa. Report Number G/A/2002/30. Agricultural Research Council, Pretoria.

McDonald, T.L. 2003. Review of environmental monitoring methods: survey designs. Environmental Monitoring and Assessment, 85: 277-292.

Milton, S.J. 2003. Grasses as invasive alien plants in South Africa. South African Journal of Science, 100: 69-75.

Noss, R.F. 1990. Indicators for monitoring biodiversity: a hierarchical approach. Conservation Biology, 4: 355-364.

Noss, R.F. 1999. Assessing and monitoring forest biodiversity: a suggested framework and indicators. Forest Ecology and Management, 115: 135-146.

Nusser, S.M., Breidt, F.J. and Fuller, W.A. 1998. Design and estimation for investigating the dynamics of natural resources. Ecological Applications, 8: 234-245.

O'Connell, M.J. 2003. Detecting, measuring and reversing changes to wetlands. Wetlands Ecology and Management, 11: 397-401.

Palmer CG, Berold, R and Muller WJM. 2004. Environmental water Quality in Water Resources Management. Draft copy. Water Research Commission Handbook.

REFYN. 2002. REFYN: Putting Cape Heath Vegetation Back. Botany Department, Rhodes University, Grahamstown.

Republic of South Africa, Department of Water Affairs and Forestry 2002. Water Quality Management Series, Sub-Series No. MS7, National Water Quality Management Framework Policy, Draft 2 Pretoria.

Richardson, D.M. and van Wilgen, B.W. 2003. Invasive alien plants in South Africa: how well do we understand the ecological impacts? South African Journal of Science, 100: 45-52.

Rouget, M., Richardson, D.M., Cowling, R.M., Lloyd, J.W. and Lombard, A.T. 2003. Current patterns of habitat transformation and future threats to biodiversity in terrestrial ecosystems of the Cape Floristic Region, South Africa. Biological Conservation, 112: 63-85.

Stohlgren, T.J., Falkner, M.B. and Schell, L.D. 1995. A modified-Whittaker nested vegetation sampling method. Vegetatio, 117: 113-121.

Stohlgren, T.J., Chong, G.W., Kalkhan, M.A. and Schell, L.D. 1997a. Rapid assessment of plant diversity patterns: a methodology for landscapes. Environmental Monitoring and Assessment, 48: 25-43.

Stohlgren, T.J., Chong, G.W., Kalkhan, M.A. and Schell, L.D. 1997b. Multiscale sampling of plant diversity: effects of minimum mapping unit size. Ecological Applications, 7: 1064-1074.

Stohlgren, T.J., Coughenour, M.B., Chong, G.W., Binkley, D., Kalkhan, M.A., Schell, L.D., Buckley, D.J. and Berry, J.K. 1997c. Landscape analysis of plant diversity. Landscape Ecology, 12: 155-170.

Van Wyk, A.E. and Smith, G.F. 2001. Regions of Floristic Endemism in Southern Africa: A Review with Emphasis on Succulents. Umdaas Press, Pretoria.

Victor, J.E. and Dold, A.P. 2003. Threatened plants of the Albany Centre of floristic endemism, South Africa. South African Journal of Science, 99: 437-446.

## 8. Appendix 1

### Proposed Project Evaluation Form

**Project description**

Overview of project history, participating institutions, evaluation team, goals, and targets.

**Data collection information**

Selected indicators, reporting requirements, and data collection methods.

**Results**

1. Quantitative impacts: how well targets were achieved, actual

environmental improvements achieved, how well targets were achieved within specified timeframe, and whether costs were consistent with budgeted amounts.

2. Qualitative impacts: satisfaction level of project beneficiaries, unforeseen benefits beyond original goals.

3. Educational impacts: knowledge acquired, skills developed, attitudes altered or reinforced.

**Difficulties encountered**

Problems encountered in implementing actions caused by both internal factors (i.e. internal to the implementing institutions) and external factors; response to problems encountered.

**Lessons learned**

Analysis of what knowledge has been gained as a result of the project and recommendations for future implementation efforts.