# The extent of Water Sensitive Urban Design in the George municipality

by
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Declaration

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## ABSTRACT

This study investigated the extent of Water Sensitive Urban Design activities in the George municipality in the Western Cape Province, in South Africa. Water resource management in urban areas worldwide had become unsustainable with the widespread implementation of outsized infrastructure, environmental degradation and overuse of natural resources. The result was a concept called Integrated Urban Water Management (IUWM). IUWM encapsulates the entire water cycle from rainwater to surface water, groundwater and wastewater, as part of urban water management, and not as separate entities. There was worldwide response to IUWM, with the USA formulating Low-Impact Development (LID), the UK designing their Sustainable Urban Drainage System (SUDS), and New Zealand articulating Low Impact Urban Design and Development (LIUDD), all to improve urban water resource management. Australia responded with Water Sensitive Urban Design (WSUD). WSUD explores the design and planning of water infrastructural development in an urban setting, vital in Australian cities which experience continuous severe water shortage conditions. The WSUD approach aims to influence design and planning from the moment rainwater is captured in dams, treated, and reticulated to consumers, to the point of wastewater re-use, as well as stormwater use. Various techniques are specified as part of the WSUD approach namely: the installation of greenroofs, demand reduction techniques, stormwater management and the re-use of treated wastewater for irrigation and fire-fighting. These WSUD activities can be implemented from large-scale efforts with whole suburbs working together to manage stormwater by construction of wetlands, as well as small-scale change in design and planning, e.g., with household rainwater tank installation for irrigation and toilet flushing. With South Africa's progressive legislation at a national, provincial and local municipal level, various WSUD activities can be implemented to aid and guide municipalities. The study aimed to investigate what type of WSUD activities the George municipality has implemented, and to what extent the activities had an impact on water consumption, since the drought in 2009. The reasons behind any lack of implementation were also explored. Proof of only eight WSUD activities implementation could be found. Water debtors' data and bulk water data was sourced in order to determine the effect of the eight WSUD activities on water consumption. Bulk meter data could however not be used to correlate with the debtors' data since readings from many bulk meters had not been recorded. Debtors' data did prove however that the WSUD activities had a short-term impact on water consumption in the suburbs where it was implemented. The reasons given for non-implementation were not satisfactory. Recommendations are that the municipality should focus on better planning and implementation of

diverse activities and that keeping records and data should be made a priority to determine any progress made.

# OPSOMMING

Hierdie studie ondersoek die omvang van die Water Sensitiewe Stedelike Ontwerp (WSUD) aktiwiteite in die George munisipaliteit in die Wes-Kaap, in Suid-Afrika. Waterhulpbronbestuur in stedelike gebiede in die wêreld het nie-volhoubaar geword met die grootskaalse implementering van buitenmaatse infrastruktuur, agteruitgang van die omgewing en die oorbenutting van natuurlike waterhulpbronne. Die gevolg was 'n konsep wat Geïntegreerde Stedelike Water Bestuur (IUWM) genoem is. IUWM omvat die hele watersiklus vanaf reënval, tot oppervlakwater, grondwater en afvalwater, as deel van die stedelike waterbestuur, en nie as aparte entiteite nie. Daar was 'n wêreldwye reaksie te IUWM, met die VSA se Lae-impak-Ontwikkeling (LID), die Verenigde Koninkryk se ontwerp van hul volhoubare stedelike dreineringstelsel (SUDS), en Nieu-Seeland se formulering van Lae-impak Stedelike Ontwerp en Ontwikkeling (LIUDD), om stedelike water hulpbronne beter te bestuur. Australië het reageer met Water Sensitiewe Stedelike Ontwerp (WSUD). WSUD verken die ontwerp en beplanning van waterbestuur infrastruktuur ontwikkeling, in 'n stedelike omgewing, waar dit noodsaaklik was in die Australiese stede wat deurlopende tekort aan water ervaar. Die WSUD benadering het ten doel om die ontwerp en beplanning te beïnvloed vanaf die oomblik reënwater in damme opgevang is, behandel, en aan verbruikers versprei word, tot by die punt van afvalwater hergebruik, sowel as stormwater gebruik. Verskeie tegnieke word verskaf as deel van die WSUD benadering, naamlik: die installering van “greenroofs”, wateraanvraagbestuur tegnieke, en stormwater gebruik en hergebruik van behandelde afvalwater vir besproeiing en brandbestryding. Hierdie WSUD aktiwiteite kan implementeer word vanaf grootskaalse pogings met die samewerking van hele voorstede met stormwater bestuur deur die konstruksie van die vleilande, sowel as kleinskaalse verandering in die ontwerp en beplanning by huishoudings, byvoorbeeld met reënwatertenk installasie vir besproeiing en toilet spoel. Met Suid-Afrika se progressiewe wetgewing op 'n nasionale, provinsiale en plaaslike munisipale vlak wat munisipaliteite steun en lei, kan die verskeie WSUD aktiwiteite ïmplementeer word. Die studie is gemik om ondersoek in te stel na watter tipe WSUD aktiwiteite deur die George-munisipaliteit implementeer word, en tot watter mate die aktiwiteite 'n impak gehad het op die water verbruik sedert die droogte in 2009. Die redes agter 'n gebrek aan implementering is ook ondersoek. Bewyse van implementering van net agt WSUD aktiwiteite kon gevind word. Data van die water debiteure en grootmaat water meters is verkry ten einde die effek van die agt WSUD aktiwiteite op die water verbruik te bepaal. Grootmaat water meter data kan egter nie gebruik word om te korreleer met die data van die debiteure aangesien die lesings van baie grootmaat water meters nie aangeteken is nie. Debiteure se data het egter bewys dat die WSUD aktiwiteite 'n korttermyn-impak op die

waterverbruik in die voorstede waar dit geïmplementeer is gemaak het. Die redes gegee vir nie-uitvoering is nie bevredigend nie. Aanbevelings is dat die munisipaliteit moet fokus op beter beplanning en implementering van diverse aktiwiteite en dat die hou van rekords en data prioriteit gemaak moet word om vas te stel of enige vordering gemaak is.

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# ACRONYMS AND ABBREVIATIONS

CMA: Catchment Management Agency

CUES: Centre for Urban Ecosystem Sustainability

DWA: Department of Water Affairs previously known as Department of Water Affairs and Forestry

FRST: Foundation for Research, Science and Technology

GSDP: George Spatial Development Framework

IDP: Integrated Development Plan

IPOS: Irrigated Public Open Space

IUWM: Integrated Urban Water Management

IWM: Integrated Waste Management

LID: Low Impact Development

LIUDD: Low Impact Urban Design and Development

MUSIC: Model for Urban Stormwater Improvement Conceptualisation

NWA: National Water Act

NWRS: National Water Resource Strategy

OSD: On-site Stormwater Detention system

SALGA: South African Local Government Association

SUDS: Sustainable Urban Drainage System

UK: United Kingdom

UNEP: United Nations Environmental Programme

USA: United States of America

WC/WDM: Water Conservation and Demand Management

WELS: Water Efficiency Labelling Scheme

WRAMS: Water Reclamation and Management Scheme

WSA: Water Service Authority

WSDP: Water Services Development Plan

WSUD: Water Sensitive Urban Design

WTP: Water Treatment Plant

WWTW: Waste Water Treatment Works

# CHAPTER 1: BACKGROUND TO STUDY

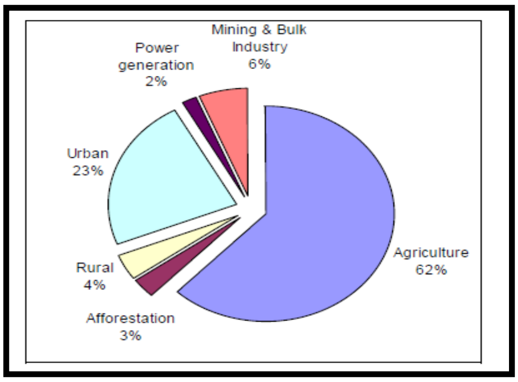
## 1.1 INTRODUCTION

In the South African yearbook of 2007/2008 Burger (2008:7), describes South Africa as "dry with an abundance of sunshine". Furthermore, Davies and Day (1998:30) assert that the country receives an average annual rainfall of 452mm, which is below the average of 500mm required for "successful dry land farming" and well below the world average rainfall at about 860mm. In addition, South Africa's per capita water availability "is decreasing year after year", says Kamara and Sally (2004:376) as a result of the increase of domestic water use. The south-western part of the country has Mediterranean climatic conditions, with mild and moderate rainy winters and long, hot and dry summers (Miller, 2004:134).

The introduction above paints a very bleak picture of South Africa's ability to satisfy the growing population's water needs. With the population set to grow at a rate of 2.3% per annum, by the year 2025, the water supply will no longer be able to satisfy water demand (Davies & Day, 1998:6). Considering these aspects, there is a clear need for creative solutions. One such potential solution is Water Sensitive Urban Design (WSUD), a strategy adopted by the Australian government in an effort to combat its dwindling water supplies. In a strategy document released by the South Australian authorities, WSUD is defined as "an approach to urban planning and design that integrates the management of the total water cycle into the land use planning and development process" (GSA, 2009:129). This means that the urban topography and sustainable water structures are designed to complement and enhance each other. For example, WSUD activities include installation of greenroofs (roofs that have vegetation growing on top of them) which can be used to filter rainwater into rainwater harvesting tanks, which in turn reduces pressure on the stormwater network. Flexibility is important – Speers and Mitchell (2000:3) say it best by stating that a "dogged adherence to one approach is counterproductive and likely to lead to a reduction rather than an increase in sustainability."

The following study aims to investigate WSUD in a South African context by examining the George municipality in the Eden district, Western Cape. Urban water use can be classified into four uses, namely (1) water for people, services and industries, (2) water for agriculture, (3) water for nature and (4) water for energy production (Zehnder, Yang & Schertenleib, 2003:2). The focus of this study will be on water for people, services and industries. The National Water Resource Strategy emphasises that urban water use in South Africa is defined as all water used in urban areas for domestic, industrial, commercial, and parks and other communal purposes (SA, 2004c:28). Various technologies for water supply are considered such as household connections, public standpipes, boreholes, protected springs and wells, as well as rainwater collection. Some technologies that are unsafe do however get used in urban areas such as truck tankers and water vendors but will not be elaborated upon (Zehnder, Yang & Schertenleib,2003:3). All three water users, people, services and industry, have an effect on the urban environment. In order for these users to obtain water, there needs to be a water supply network in place. The function of the urban water supply network would thus include: treatment of raw water to potable water (production), distribution of the potable water, collection and treatment of wastewater, as well as drainage of stormwater. The water supply network is highly dependent on technical efficiency, otherwise unsustainable malfunction occurs, such as excessive water leaks, which contribute to "unaccounted for water" (Zehnder, Yang & Schertenleib, 2003:10). South Africa, unlike other countries in the region, has a highly developed infrastructure which makes it possible to provide 1370 litres of water per person per day to a population of approximately 40 million people. But, according to data from the Department of Water Affairs, in the year 2000 some 17.5 million people still did not have access to a basic water supply. However if existing infrastructure were managed effectively this number would reduce drastically (Mwendera et al, 2003:765).

Davies and Day (1998:318) indicates that in 1998, households used about 7% of water, whereas industry and agriculture used about 12% and 69% respectively. More recently, Mukheibir said that power generation uses 2% of the water supply whereas agriculture still uses more than 62% and urban use (including domestic use) has grown to 23% (Mukheibir, 2005:2) as seen in Figure 1.1.




**Source:** Mukheibir (2005:2)
**Figure 1.1:** Water demand per sector

In addition it is estimated that water shortages in South Africa could lead to food shortages by 2025 (Kamara & Sally, 2004:376)**.** Domestic/household water use is also important; it is determined in the

Reserve and examined in Chapter 3 of the National Water Resource Strategy. In South Africa an allowance of free basic water must be granted by a municipality which provides water services. Free basic water relates to 25 litres of water per person per day and six kilolitres (6kl) per household per month for a household of seven to eight people (SA, 2004c:76)**.** A study of Cape Town residents indicates that household demand for water is alarmingly wasteful with 35% of water being used for watering the garden and 29% used for flushing the toilet. With a mere 3% for cooking and 13% for cleaning the last 20% also goes down the drain during bathing. The possible reasons for this anomaly are that residents are ignorant of how limited water resources are, and its ready availability coupled with a very low price makes water easy to waste (Davies & Day, 1998:9). Hence it is easy to assume that water shortages would have a serious negative impact on the economy and society.

"The main objective of South Africa's new water policy is to recoup water management costs and determine the most efficient, equitable, and sustainable use of South Africa's scarce water resources" as mentioned by Jacobson (2003:2). Furthermore, it is indicated that one of the key policy priorities for the South African government is to provide water for all which, at the time, was scheduled to be accomplished by 2008 (Jacobson, 2003:1). Describing these challenges as formidable, Kamara and Sally (2004: 367), say that the National Water Act aims to "strike a balance between efficient water utilisation and achieving equitable access for all."

In the Department of Water Affairs' (DWA) Strategic Planning for Water Resources in South Africa – a Situation Analysis document – the projects initiated by the DWA are still largely focused on finding new means of abstraction (like new dams), water conservation (reducing water consumption) and the re-use of wastewater (SA, 2009:1). There are no measures in place to take into account that, for example, evaporation often exceeds precipitation, with evaporation from dams reaching unacceptably high levels (Davies & Day, 1998:325).

Similarities between South Africa and Australia show that these two countries have some of the lowest conversion figures of rainfall to usable run-off from rivers in the world, with South Africa at only 8.6% conversion and Australia at 9.8%, compared to Canada at a massive 66% conversion (Davies & Day, 1998: 315). The reason for choosing the George municipality is that it was declared a disaster area when drought conditions manifested (Province of Western Cape, 2009). The drought is a cause for concern since the municipality is not seen as a water-deficient municipality, as described in the George Spatial

Development Framework (GSDF) Volume 2 (George Local Municipality, 2008:44). George experiences an average annual rainfall of 866mm and is situated in a "uniform rainfall zone" with rainfall throughout the year (George Local Municipality, 2008:18). During the drought records in the area indicate that from January to December 2009 it received 100mm less rainfall than in 1946, the lowest recorded rainfall for the same period (Mooiman, 2010, pers com).Hence this study aims to investigate if the George municipality is implementing WSUD activities and to what extent the activities had an impact on the water consumption of the municipality.

## 1.2 RESEARCH AIM AND OBJECTIVES

This research aims to investigate whether the George municipality is implementing WSUD activities and to what extent these had an impact on water consumption.

In order to achieve this aim, the following objectives were met:

1. Identify what constitutes WSUD activities out of Australian literature
2. Identify if there was mention made of WSUD activities in the George municipality documents
   - ✓ Strategies, plans and bylaws
   - ✓ WSUD activities project reports
   - ✓ The stormwater management plan to emphasise whether or not groundwater retention is possible
   - ✓ Stormwater pollution management information
3. Compare the extent of implementation of WSUD activities in the case study area by investigating the following:
   - ✓ Bulk water data from each relevant bulk water meter to see the response of the identified WSUD activities on bulk water use
   - ✓ Debtors' data for consumer consumption information which can either correspond to bulk water data or not
4. Identify the future plans of the municipality for new developments
5. Identify the reason for past implementation or non-implementation of WSUD activities
6. Make recommendations about possible regulation of WSUD in the George municipality and how it can be applied to other drought-stricken municipalities.

## 1.3 RESEARCH METHODOLOGY

### 1.3.1 Research design

This study can be classified as empirical research. This research type relies on observations made. It is data-based research that comes up with a conclusion which can then be verified by observation or experiment. Facts need to be sourced first and then stimulated to prove a certain outcome. A hypothesis need to be formulated and the process of manipulating information sourced need to be followed in order to prove the hypothesis wrong or right (Kothari, 1985, 5). This study is investigating the extent of Water Sensitive Urban Design (WSUD) in the George municipality whereby the hypothesis interprets that South Africa's legislation is creating an enabling environment for the implementation of water resource management activities such as what the WSUD concept promotes. Since there is similarities between the climatic conditions of South Africa and Australia the implementation of Australia's WSUD in a South African context is investigated.

### 1.3.2 Data collection

The first step in the research methodology as well as the first objective of this research was to consult relevant literature on the topic of Water Sensitive Urban Design in an Australian context. The history of implemented WSUD activities was identified as were the impediments experienced during implementation of the concept. The literature review also reflects the current legislative environment in South Africa regarding water resource management; the identification of the policies reflects the historical narrative of what was planned and what Water Services Authorities (WSAs) were asked to implement. Legislation is creating an enabling environment for WSUD activities identified in the Australian context; hence the study will see what WSUD activities have been implemented in the case study area.

For the sake of clarity, the WSUD activities are listed below:

- Drainage/Stormwater Management
    - Quantity
        - ✓ Rainwater harvesting tanks
        - ✓ No automatic irrigation methods
        - ✓ Water-wise gardening
        - ✓ Pervious pavements

  - ✓ Groundwater retention and recharge
- Quality
  - ✓ Constructed wetlands, lakes and ponds
  - ✓ Solid waste management
- Demand Reduction Techniques or Water Conservation and Water Demand Management
  - ✓ Retrofitting with water saving appliances
  - ✓ Leakage detection and fixing
  - ✓ Water use restrictions
  - ✓ Suitable tariff system (charge for volume used)
  - ✓ Accurate metering
  - ✓ Pressure reduction programmes
  - ✓ Reduction of seepage and evaporation in dam storage and irrigation systems
  - ✓ Better irrigation options
  - ✓ Educational campaigns on environmental and financial value of water
  - ✓ Reduced wastewater flow
- Re-use of water
  - ✓ Fit for purpose water use (e.g., using wastewater rather than potable water for irrigation, fire-fighting, dune stabilisation, dust settling, etc.)
  - ✓ Reclamation of treated wastewater for irrigation, industrial purposes or topping-up dam storage
  - ✓ Localised sanitation options (not linked to conventional sewage system) - vacuum sanitation systems, septic tanks, composting toilets, etc.
- Greenroof installation
  - ✓ Intensive greenroof - exotic and bigger vegetation, more maintenance
  - ✓ Extensive greenroof - indigenous, drought resistant vegetation, low to no maintenance
  - ✓ Linked to stormwater management - reduce quantity of water going to stormwater system as well as enhance the quality of stormwater via vegetation

The second step of the research methodology was to identify the data sources that would enable the study to meet the objectives – in order to answer the aim of the study, the objectives needed to be met. Both qualitative and quantitative methods of research gathering were utilised.

### 1.3.3 Data analysis

The third step in the research methodology was to analyse the data and establish the extent of implementation of the identified WSUD activities. The data sources used to achieve this objective are listed below in Table 1.1. The table indicates the legislative documents generated by the municipality to create an enabling environment for WSUD activity implementation, lists the data sources used to identify the WSUD activities, and compares the extent of WSUD activity implementation.

**Table 1.1:** Data collection and analysis summary

| Data Source | Types of data | Type of Analysis | Output |
|---|---|---|---|
| **Municipality legalisation** | | | |
| a) George Spatial Development Framework 2008<br>b) IDP 2009/10<br>c) WSDP 2009/10 & 2010/2011<br>d) Drought status report (January 2010)<br>e) Drought management policy<br>f) Water demand management strategy<br>g) Water Services Bylaw to limit or restrict the use of water | • Policy documents | • Identify the WSUD activities planned for the time before the drought, during the drought and after the drought. | • PDF documents<br>• WSUD activities correlating with the bulk water data, debtors' data and the Eden water crisis reports. |
| **WSUD activities identified** | | | |
| **Data Source** | **Types of data** | **Type of Analysis** | **Output** |
| Various activities initiated by municipality | • Emergency water tariffs since 2009<br>• Revised water restrictions since 2009<br>• Awareness campaign 2010;<br>• Local media articles (George Herald online)<br>• Localised sanitation services 2010<br>• Leakage detection and fixing (indigent and high consumer households) 2010<br>• Treated wastewater reuse project (Evaluation Report May 2010)<br>• Stormwater system management (stormwater | • Identification of suburb where projects commenced and the timeframe. | • PDF documents<br>• Establish what impact a certain activity had on the water consumption of the identified suburb. |

| | | | |
|---|---|---|---|
| | quality management)<br>• Stormwater system management (stormwater quantity management). | | |
| **Data to determine the extent of WSUD activities identified** | | | |
| **Data Source** | **Types of data** | **Type of Analysis** | **Output** |
| Bulk water data | • Tabular data<br>• Graphs/charts<br>• Data per year from January 2008- January 2010 for each month<br>• Digital format | • Compare bulk water use in suburb with debtors' data. | • Microsoft Excel programme generated graphs/charts to summarise the relevant data. |
| Debtors' data | • Tabular data<br>• Graphs/charts<br>• Data per month from 2008 to 2010 (33 months)<br>• According to sub-ID and per erf<br>• Digital | • Compare with bulk water data. | • Microsoft Excel programme generated graphs/charts to summarise the relevant data. |
| Eden Water Crisis Management Progress Reports and Water Supply Status Reports: January 2010 to February 2011 | • Monitoring documents sporadically compiled by Eden district municipality. | • Compare the amount of water saved as claimed by the municipality to the bulk water data and debtors' data. | • PDF documents |

In Chapter 1, research aims and objectives are examined as well as research methodology, elaborating on research design data collection and data analysis.

In order to answer the first objective of the study, a literature review is formulated in Chapter 2 to highlight what constitutes WSUD activities in Australia and explore the impediments of WSUD implementation in urban areas. Secondly, the chapter elaborates on the legislative context of South Africa, to indicate the enabling environment of water policy in the country that could possibly clear a path for WSUD activity implementation.

Chapter 3 sketches the George municipality as the study area to determine whether the area is suitable for certain WSUD activities. Discussions on the study area include the urban form of the area, water resources, the climate, the water consumer profile, and soil conditions for possible water retention as part of stormwater quantity management.

In Chapter 4 the findings of the investigation are detailed to illustrate the legislative environment in the municipality which guides the municipality in managing water resources. This chapter answers part of the second and fourth objectives of the study by identifying various strategies and plans promulgated by the municipality prior to the drought, as well as a response to the drought, using future plans.

In Chapter 5 the extent of WSUD activities on the municipality's water consumption is measured. This chapter answers the last part of Objective two, as well as objective three of this study. Eight projects are evaluated to investigate the degree/extent of WSUD activity implementation. Projects investigated include: the disaster response emergency tariff structure and water restriction implementation, leakage detection, localised sanitation services, awareness campaign and re-use of treated effluent as well as stormwater quantity and quality management. Projects are measured by looking at the response of bulk water meters and debtors' data to these projects. Newspaper articles on how the public responded to the drought and the awareness campaign are also mentioned. The measurements done in the study will be compared to what the Eden District Municipality reported on water consumption reduction in the George municipality by investigating the Eden Water Crisis Management Progress Reports and Water Supply Status Reports.

The last chapter, Chapter 6, summarises the six objectives of the study which include identifying why certain WSUD activities were not implemented and also gives recommendations to the municipality as well as to future research. Impediments experienced during the study period will be examined as well as the contribution this study provides to academic research.

## 1.4 CONCLUSION

To summarise, the study background emphasises that South Africa is a dry, water scarce country, similar to Australia. However, current legislation in South Africa still focuses on abstracting more water so that all citizens can enjoy the right to access. The unsustainable use of water has awakened a need for a solution; as a result, Australia's example of WSUD is offered as a potential solution to the problem, using better urban water resource management. The case study area of the George municipality was chosen since the municipality experienced a drought, and the investigation tracks the extent of WSUD activities to cope with the situation and manage future water resources. Data collection methods have been outlined in order to highlight how the investigation of the municipality was undertaken. The literature review of how WSUD came about as Australia's urban water resource solution is discussed in the next chapter.

# CHAPTER 2: LITERATURE REVIEW

## 2.1 INTRODUCTION

The literature review starts with explaining the need for urban water management changes by examining some of the negative impacts of the conventional urban water system. Secondly, a brief history of Water Sensitive Urban Design (WSUD) will be provided, with a description of Integrated Urban Water Management (IUWM). IUWM can be considered the original umbrella concept from which WSUD emerged in Australia, as a practical response to proper water resource management implementation, rather than conceptualisation. Three other management strategies also resulted from IUWM, namely, Low-Impact Development (LID), the Sustainable Urban Drainage System (SUDS) and Low-Impact Urban Design and Development (LIUDD). LID is the American equivalent of Australia's WSUD. The SUDS is the equivalent of WSUD in the United Kingdom and LIUDD is equivalent to WSUD in New Zealand. Since the study is focused primarily on WSUD, a much more detailed description will be given of this than the other international programmes. For example, the various activities of WSUD will be discussed as well as the impediments facing WSUD implementation in Australia. Lastly, in an effort to establish the background for the investigation into what possible WSUD activities the George municipality has implemented and to what extent, a detailed description of South Africa's water management legislation will be given.

## 2.2 CONVENTIONAL URBAN WATER SYSTEMS

Cities have grown bigger as the population has risen. With new innovations, water demand in cities is met by building new infrastructure and piping water wherever it is needed, even if it means low density development is being promoted (Newman, 2001:94). Urban planning focuses on the abstraction of more water and providing hygienic sanitation in a centralised urban system, which includes the water supply system (bulk potable water), sanitation (wastewater systems), and drainage (stormwater system) (Mitchell, 2006:590). The centralised system is designed to be central to the structure of the city as it spreads outward, to bring raw water in and take wastewater out over long distances. The centralised system, which is also known as the conventional system, ranges from open channelled systems to highly engineered piped systems.

One of the primary roles of conventional systems is to divert wastewater and stormwater away from human habitation. This system ensures that inhabitants of cities can remain healthy and safe, away from where wastewater can have an impact on other services, and the system has not changed in the last 120 years (Coombes & Kuczera, 2002:2). This diversion of wastewater relies heavily on the abundance of the water to make sure that all pollutants and waste are transported into the receiving aquatic environments; consequently, additional dams and boreholes need to be created to supply more water for the growing cities, with detrimental effects on river systems (Coombes & Kuczera, 2002:2). The large amounts of water needed for the transportation of pollutants and waste, along with the low quality of water reaching the receiving aquatic environment, makes the conventional system unsustainable (Butler & Parkinson, 1997:55). Treatment of wastewater before disposal minimises environmental damage in the short term, but often nutrients and synthetic chemicals accumulate over the long term in the aquatic environment. Stormwater run-off in a conventional system is not deemed as a valuable water resource and thus needs to be discarded, since it does not improve the urban area, especially if there is too much run-off. The main aim of a conventional stormwater system in an urban area is "centred towards getting rid of rainfall-run-off as quickly as possible, which resulted in 'end-of-pipe solutions' that have often involved the provision of large interceptor/relief sewers, massive storage tanks in downstream locations and centralised wastewater treatment facilities" according to Andoh et al (2001:2). Often stormwater systems are situated behind buildings, and of course underground to keep them out of sight, and because they are out of sight, stormwater run-off, along with the contaminants in the water, is often ignored or forgotten.

Two types of systems have been constructed in most urban areas to tranport wastewater and stormwater. The first system, known as the singular system, was based on the principle of using only one drainage sewage system (hence 'singular') which receives both sewage and stormwater at once, to be dealt with at the sewage works or Waste Water Treatment Works (WWTWs). The alternative to the singular system emerged during the first quarter of the twentieth century, which is two separate drainage systems whereby sewage goes to the WWTW and the stormwater goes directly to the rivers or open receiving spaces (Andoh et al, 2001:2). Stormwater systems are also a major source of pollution. Various pollutants such as oil, hydrocarbons, toxic micro-pollutants and heavy metals cling to suspended/floating solids and sediment which come from the run-off from paved areas and streets. These solids and sediments do not only enter and pollute water bodies via the stormwater systems, but also block stormwater systems, causing flooding during heavy rainfall in the streets, and spilling at the overflow point in WWTWs if a singular system is used (Andoh, et al, 2001:2). Extra pressure is then put on the urban environment during flooding, and also at WWTW when untreated water overflows.

There is thus a need for stormwater systems to be designed according to an urban planning and design process which ensures that site planning, architecture, landscape architecture and engineering infrastructure is looked at in an integrated manner as part of the whole urban system, and not in isolation (Wong, 2006:4).

Even though the centralised/conventional system was helpful in the past with regard to hygiene, it is not the case anymore (Coombes & Kuczera, 2002:2). Urban populations are now more prone to sewage spills because systems are overloaded and out dated. Older reticulation systems are not only costly to replace but it is also costly to keep treated water clean within the system until it reaches households, especially since the reticulation system has to reach more remote locations as the city grows. Replacing old drainage systems and building new reticulation systems for the outwardly growing cities is a necessity, but this will become more and more expensive, unless an alternative urban water management option is chosen (Coombes & Kuczera, 2002:3).

This “centralised systems approach” also has adverse effects on the urban economy and the natural environment of cities. These adverse effects include the modification of natural water bodies (needed for infrastructure), the large amounts of waste materials accumulating in water bodies, improper handling of contaminants in the water and the massive cost to rehabilitate and renew urban infrastructure (Mitchell, 2006:590). It became clear that management of the aforementioned systems was unsustainable which in turn led to the need for new ideas in the water-sustainable Future City (Newman, 2001:95). The term “unsustainable” is chosen to describe the conventional system, considering the definition of sustainable development from the Brundtland Report; the term is defined as development that meets the needs of the current generation without impacting on the ability of future generations to meet their own needs. In other words, sustainable solutions would address current issues ‘now’ but would not neglect the ‘future’ (Butler & Parkinson, 1997:54). The conventional system has thus become unsustainable, since there is no consideration for the quality of wastewater, no consideration for the aquatic environment and no consideration for the amount of water that is being used unnecessarily. The aim of more sustainable water resource management should thus be to “protect the environment in all streams of the urban water cycle, namely; (i) from where water is being diverted for urban consumption until (ii) treated wastewater and (iii) stormwater is discharged back into the receiving aquatic environment” (Wong, 2006:2).

## 2.3 HISTORY OF WSUD

### 2.3.1 Integrated Urban Water Management (IUWM)

Policy makers and experts argue that water use needs to go hand in hand with the protection of ecosystem functions (Falkenmark & Rockstrom, 2005). The urban water system thus needs to be more integrated, i.e., more environmentally responsible, socially sensitive, and economically efficient (Newman, 2001:94).

IUWM as a concept, idea or theory is initiating a reorientation within urban areas. The idea is that the conventional urban water system's separate components should become more integrated. For instance, the stormwater system is often separately designed from the wastewater system; consequently stormwater is not seen as a possible resource like treated wastewater (Mitchell, 2004:5). Planning, delivery and operation of the water supply, stormwater, and wastewater is often done with little reference to each other (Mitchell, 2004:5). This is why IUWM puts an emphasis on water management whereby both the demand and supply side of water resource management, as well as the use of unconventional water sources is promoted. Usage of unconventional sources of water is linked to the concept of fit-for-purpose water usage, whereby treated and/or recycled water are used for non-potable use, such as irrigation and fire-fighting (Mitchell, 2006:590). Mitchell (2006:590) asserts that the IUWM concept stipulates that policy makers should integrate land use policies, development approval processes, construction, the economy and social acceptance from the community. The highlight of the concept is that in order to create an integrated urban water system, it must be recognised that the physical system sits within an organisational framework as well as in the natural landscape (Mitchell, 2004:5). According to Mitchell, (2006:590) four principles of IUWM should be kept in mind:

- "Recognising that the water cycle includes the natural and built environment along with surface and groundwater
- Consideration of water use for both humans (anthropogenic) and the natural environment
- Include all role-players in the decision-making process and lastly,
- Aim for sustainability in the long and short-term with emphasis on the environment, society and the economy."

If planning is done properly the negative impact of water supply, sanitation and stormwater systems should be minimised and efficiency will be maximised. The multi-functionality of these systems should also be emphasised, because systems should be affordable, the receiving community should be satisfied, and there should be equity in the sharing of water resources. IUWM should however not only be about the infrastructure alterations but also the change in regulations, pricing incentives, as well as the sharing of knowledge (Mitchell, 2006:602). The tools of IUWM available for this include, among others, water-sensitive planning and design, urban layout and landscaping, and the use of ecological and infrastructural technologies. (Mitchell, 2004:5).

The materialisation and acceptance of the IUWM concept has spread all over the world in the last 25 years and North American scholars have evidently been significant contributors to its development (Mitchell, 2006:590): initial ideas for IUWM came from the Urban Water Resources Research Council of the American Society of Civil Engineers during the late 1960s and early 1970s (Mitchell, 2006:592).

Urban water management should however not remain at the conceptualisation stage, but should rather become practicable, implemented in the integrated manner stipulated by the concept of IUWM. The diverse response to the paradigm shift of IUWM was seen in Australia, the USA, Germany, the UK, Denmark and Japan but the international exchange of ideas is less significant, since each country experiences their own set of problems (Mitchell, 2006:592). Four separate implementation concepts emerged from IUWM in different corners of the world with new principles of urban design and stormwater technologies; namely Low-Impact Development (LID) from the USA, Sustainable Urban Drainage System (SUDS) from the UK, Low Impact Urban Design and Development (LIUDD) from New Zealand and lastly Water Sensitive Urban Design (WSUD) from Australia (Van Roon, 2007:438).

### 2.3.2 Low-Impact Development (LID)

There was a global response to IUWM. During the 1990s the Department of Environmental Resources in Prince George's County, Maryland, USA, initiated a new urban design approach called, Low-Impact Development (LID), and a manual was written by Maryland's Planning and Development Division. In Chapter 2 of the manual it is mentioned that several tools and practices are specified to enhance stormwater design in urban areas. The new stormwater design aims to protect surface and groundwater quality by making sure that there is "source control", by managing the stormwater from its source (Wynkoop, 1999:4). The techniques initiated under LID emphasise the creation of a hydrological functional landscape that mimics the natural hydrological system. LID encourages natural drainage capacity of the soil to be maintained in order to reduce the need for underground pipelines and minimises the clearing of open spaces that receive water from stormwater systems. Chapter 1 states that the manual was designed to assist developers in their site-designs to reproduce the pre-development hydrological functions of a site (Wynkoop, 1999:5). Stormwater design in developments must promote infiltration of water, groundwater recharge, open channels, filtration landscape areas, and storage of rainwater on-site. In Chapter 2 it is emphasised that the design of developments must move away from creating impervious surfaces that allow water to run away (for example, into drains) rather than being absorbed (Wynkoop, 1999:2). Stormwater systems are impacted upon by soil erosion and the need for proper sedimentation control, as these systems often receive sediments during rainfall. According to the manual, the design of a development needs to keep in mind the existing topography, the natural vegetation, the types of soil and the drainage channels. The fewer disturbances of the surface, the less maintenance and rehabilitation would be needed afterwards, thus buildings should be established according to the shape of the natural environment (Wynkoop, 1999:5). The ultimate goal of LID is to mimic the pre-development hydrology of an area, including the run-off volumes that existed before development occurred. This mimicry is needed since municipalities build stormwater systems to mitigate peak stormwater flow but do not address the extra stormwater flow created by the impervious nature of new developments since there is no natural pervious drainage area anymore (Dietz & Clausen, 2008:561).

One major benefit of LID is that it reduces the cost to create and maintain infrastructure such as pipelines and stormwater drains. (USA, 2000:3). It also reduces the need to clear spaces for drainage ponds to receive stormwater and thus keeps the environment in a natural state with more vegetation. But society has to be made aware of the cost and environmental benefits, since many homeowners prefer wider streets and paved areas. Regulations however still allow for development of impervious cover; basement flooding was a concern for American homeowners where stormwater systems were not in place to lead rainwater away from their homes. However with LID, green spaces can be conserved, while highly urbanised areas can be retrofitted to conserve water by capturing water in various ways. The capture of water can be done via rainwater harvesting tanks; vegetated roof tops (greenroofs) and permeable (grassed) pavements (USA, 2000:3). Pervious pavements and bio-retention areas which are designed to receive stormwater are also effective in colder climates and tight soils if installation and base design was done properly. Areas where LID is not viable include already contaminated spaces such as brownfield areas and recycling centres, and on steep slopes or spaces with a high groundwater table. Proper education of maintenance staff and homeowners would ensure that excessive fertilisation of bio-retention areas and greenroofs does not occur, which might have an impact on the load of phosphorus that enters the groundwater (Dietz, 2007: 361).

### 2.3.3 Sustainable Urban Drainage System (SUDS)

The second response to IUWM, also during the 1990s, was the Sustainable Urban Drainage System (SUDS) in the United Kingdom. Recognition of the problems that a conventional urban drainage system caused, initiated the search for a more sustainable approach. One major problem with the conventional system is its dependence on the availability of high volumes of water to transport waste. Authorities considered tackling the ineffective system as part of the natural water cycle once the cycle starts with clean water from the aquatic environment, to the point where wastewater has to be disposed of once again in the aquatic environment. The safe disposal of urban wastewater therefore has to be managed from the point of demand of water sources to the maintenance of natural resources and lastly the prevention of negative environmental impacts (Butler & Parkinson, 1997:54).

The current objectives of urban drainage systems in the developed world have three objectives: to protect and maintain the health and safety of the urban community; to protect the natural environment; and to create a sustainable urban drainage system. Sustainability means that the first two objectives would not be compromised but for the system to be cost-effective the system must be maintained, and the community must accept and adapt to the new system, displaying behavioural change in the long term (Butler & Parkinson, 1997:55).

There are three strategies to be followed in the implementation of SUDS. Firstly, there has to be a reduction in the need for excessive use of water to transport waste. Secondly, domestic waste and industrial waste should not be mixed. Thirdly, separate stormwater system handling should be adopted to restore natural drainage patterns (Butler & Parkinson, 1997:61). The transport of waste with high quantities of water can be reduced at household level by limiting the use of potable water for toilet flushing. If industrial wastewater were to be mixed with domestic wastewater, the resulting treated water would in turn be too polluted to be re-used since the nutrients from the domestic wastewater would be contaminated by the industrial wastewater; the treatment of industrial waste on-site would thus reduce the need for treatment plants to treat large volumes of highly polluted water along with domestic wastewater in the municipal system. Lastly, using a separate stormwater system would put less water in the wastewater system, and rainwater would be used as a natural resource when it is allowed to infiltrate and fill up groundwater levels (Butler & Parkinson, 1997:59).

To deal with the quality of polluted water certain SUDS activities are suggested. Currently, urban run-off from streets is captured by the stormwater system, accumulating pollutants and waste which can be hazardous to the receiving environment. One solution to this problem is that the stormwater system be designed with grit and oil separators as a first treatment step, to catch solid waste and oil (Shutes et al, 1997:20). These separators or interceptors serve a dual purpose: the solid waste and sediments accumulate at the bottom of the storage chamber, but the oil on the other hand rises to the top, ready to be collected (Shutes et al, 1997:20). A second step in the treatment process is the construction of wetlands and ponds. Wetlands have the ability to remove pollutants if clay soil and proper deep-rooted vegetation is used, and the ponds allow for maximum detention of polluted water, giving enough time for plants to take up pollutants naturally (Shutes et al, 1997:21). By using both the separators and the wetlands, more pollutants are removed from the stormwater system and the water can thus be used as a resource. The pre-treatment of stormwater before it enters the wetland is of equal importance as its passage through the wetland itself, and further treatments after the wetland stage are recommended if available space allows for an extra lagoon (Shutes et al, 1997:24).

### 2.3.4 Low-Impact Urban Design and Development (LIUDD)

Low impact urban design and development (LIUDD) is unique to New Zealand and the concept evolved from the original concept of LID – initiated in the USA – as mentioned above, and LIUDD principles have grown since the 1990s (van Roon & van Roon, 2005:2). In 2003 the Centre for Urban Ecosystem Sustainability (CUES), a partnership between the University of Auckland and Landcare Research New Zealand Ltd., obtained funding from the Foundation for Research, Science and Technology (FRST) to make LIUDD practice possible in New Zealand. LIUDD's first principle is to work within the cycles of nature and minimise the ecological footprint. LIUDD ethos incorporates some of the tenets of the Maori people: when development designs are initiated, the natural cycle which distributes water, soil and energy is kept in mind, and the river catchments are used as a starting framework. Therefore the recycling of water, wastes, material and energy is promoted, as well as innovation in infrastructure and technology, and waste discharge into sensitive environments is prevented (van Roon & van Roon, 2005:6). The second principle is that LIUDD aims to choose development sites based on minimising ecological impact. This means that only the least ecologically, culturally and visually sensitive areas should be chosen for building developments. The cost of developments should also be taken into consideration if comparisons are made between conventional infrastructure and ecosystem services provided by nature (van Roon & van Roon, 2005:6). The waste generated by development should be minimised as well, and the promotion of local resources, materials and labour should be emphasised (van Roon & van Roon, 2005:7). The third principle encourages the use of alternative forms of development so that the natural landscape should be kept intact, and also to ensure the efficient use of infrastructure. Accordingly, stormwater should be channelled properly to enhance groundwater recharge, and the use of water for sewage removal not encouraged, thus reducing infrastructure needs (van Roon & van Roon, 2005:8). Rainwater tanks and greywater use however is promoted. Implementing LIUDD is potentially feasible in wide-open spaces to accommodate stormwater technologies, sewage treatment, the storage of reclaimed water, and the enhancement of indigenous biodiversity, but it can also be implemented in high-density areas as well. LIUDD involves development in potable water, stormwater, and wastewater – known as all “three waters” (Van Roon, 2007:438).

The Centre for Urban Ecosystem Sustainability (CUES) established a task force to investigate how well LIUDD was being implemented since it began in 2003. This task force also had to oversee the development of LIUDD guidelines at government level and in the private construction/development sector (van Roon, Dixon & van Roon, 2005: 2). Plans to start with LIUDD implementation were made on various levels, and the government of New Zealand first responded with strategic plans, whereby the councils communicated with the residents in the community regarding their urban development, to keep them informed before actual physical work was scheduled (van Roon, Dixon & van Roon, 2005:11). Here, the physical work of new development is determined via the structure plans, and is used as a tool to involve the community further in the development process; this is known as the “neighbourhood plans”. Lastly the Integrated Catchment Management Plan (ICMP) can be initiated, whereby the community, with the water resource management professionals, decide on how to manage the catchment and ensure the urban environment is being incorporated into part of the water cycle (van Roon, Dixon & van Roon, 2005:12).

The uptake of LIUDD is limited since Auckland’s city council still lacks data on biodiversity and the cost of implementation, and there seems to be limited information on how to evaluate water cycle management options. The council also feels that LIUDD would be a threat to revenue accumulation since water demand will reduce, as will the need to have wastewater systems. Developers also do not seem too keen on LIUDD since it does not seem profitable, and developers claim that the council is not providing sufficient incentive to implement LIUDD. Private developers still have to learn more about the concept, and the demand from consumers for this type of design is just not there. The community at large is unaware of LIUDD and its benefits, and the running cost of such new developments is not clear (Eason et al, 2004:10).

### 2.3.5 Water Sensitive Urban Design (WSUD)

Similar to the American Low-impact Development (LID), Sustainable Urban Drainage Systems (SUDS) from the UK, and Low-Impact Urban Design and Development (LIUDD) from New Zealand, Australia initiated Water Sensitive Urban Design (WSUD) in the 1990s. The term was coined by a group at Murdoch University in Perth, Western Australia (Fane, 2005: 28). The reason for serious urban water management changes came in the early 1990s when two major Australian urban river systems, the Murray-Darling and Hawkesbury-Nepean basins, became unsustainable through negative environmental impacts. Land use practices, diversion of water for irrigation, and nutrient discharge from stormwater and reclaimed water, all impacted upon these two urban river basins. Since serious environmental stress was detected in the rivers, especially when assessing the water quality, improved urban water management was planned, also to accommodate the projection of population growth before the environment would deteriorate further (Anderson, 1996:38).

Improved urban water management resulted in WSUD for Australia’s urban areas. WSUD provides guidelines which give consideration to water in the natural environment and improve infrastructure design, preferably during the pre-development stages. The design approach can be used on various scales from smaller developments (one house) to large city-scale urban development. WSUD can be implemented in new developments, existing cities and brownfield sites to promote the clustering of land uses (Donofrio et al, 2009:182). WSUD is however focused not only on the stormwater system, like LID, but all water flows are considered a resource. The reason for this is that all water flows, from potable water to stormwater and wastewater, have an impact on the natural and built environment (McAlister, 2007:8).

According to Donofrio et al (2009:180-181) key principles of WSUD include:

- “Protection of natural systems within the city

- Protecting the water quality,
- Maximising re-use of water,
- Reduce potable water demand via water conservation and overall system efficiency,
- Creation of functional landscapes (e.g. recreational spaces) in the city which in turn actually treat stormwater quality and promote infiltration of water and thus reduce urban run-off and the need to manage it"

The feasibility of WSUD implementation has to be accepted first, and the construction sector is one sector that has to show a change to such new design. Construction cost plays a major part when developers decide on building, either according to WSUD or the conventional system design, and not maintenance costs or the life cycle of the system (Boubli & Kassim, 2003:1). The use of various WSUD techniques however can determine how costly a development would be. A case study compared a conventional development with a development using elements of WSUD, in the urban area of Sydney, North West. Cost comparisons showed that it was cheaper to put in rainwater tanks, permeable pavements and storage tanks than the conventional On-site Stormwater Detention system (OSD). The OSD system is a stormwater collection system where stormwater is collected by conventional drains, paving and pipes, which convey stormwater to underground storage tanks at the end of the street. The quality of the water in the OSD system is questionable and end-of-line water quality devices have to be installed as well (Boubli & Kassim, 2003:6). The authors state that, in their opinion, the cost of buying products for WSUD techniques will decrease when the demand and competition for these products increases (Boubli & Kassim, 2003:16). Smaller pipes are needed and water quality treatments are less costly than treatment within conventional systems. Also, the overall cost for larger developments will decrease, as more space is available to install rainwater tanks, for example, and the greater the number of uses for the water (gardening, toilet flushing, etc.) the greater the benefit and savings. Variation in techniques would however be the ideal WSUD (Boubli & Kassim, 2003:16**).**

In order for WSUD to work as part of IUWM, various independent activities have to be identified. In the following section these activities will be explained. First to be discussed are those WSUD activities which can be employed either in collaboration with each other or in isolation to be ultimately water sensitive in an urban area. These activities include stormwater/drainage management, re-use of water, demand reduction techniques and greenroof installation. The four activities are defined and case studies from Australia are showcased. Secondly, impediments experienced in the implementation of WSUD in Australia will be examined.

## 2.4 WSUD ACTIVITIES

### 2.4.1. Drainage/Stormwater management

Stormwater is seen as a water resource of great value. Usage can range from the retention of stormwater for filtration into acquirers for later use, to the filling of wetlands and lakes for recreational use. Hence the quantity and quality of water being received by the stormwater system need to be managed. The quality of stormwater can be treated in different ways; this will be discussed first and the management of quantity second.

#### 2.4.1.1 Management of the quality of stormwater

In order to keep stormwater clean various practices can be initiated such as buffer strips, constructed of wetlands used as treatment control. Two types of treatment can be followed to be more effective in treating stormwater. A primary treatment option can be to channel water via a bio-filtration system of bio-retention swales, with grass and other vegetation, for infiltration into the underlying gravel-filled trench (Lloyd, Wong & Porter, 2002:3). These bio-retention swales are depressed areas in the landscape designed to accept infiltration of stormwater, or move stormwater to a collection point. Water then flows first through the vegetation into a gravel-filled trench. Ideally, the drainage of stormwater should however not be managed in isolation, but the solid waste stream should also be managed accordingly, as part of the primary treatment. The reason for this is that gross pollutants (mainly paper, plastics, and garden waste) are transported by the stormwater system into the receiving waters such as rivers and estuaries and can threaten the aquatic environment (Allison, Chiew & McMahon, 1997:1). To curb gross pollutants from entering the aquatic environment, stormwater systems around urban areas in Australia are installed with various types of trappings. Trappings are designed with chambers, racks, screens, etc., that strain the solid waste/gross pollutant which can be removed later on by the maintenance teams. Six trappings are commonly used around the cities; the efficiency of trappings is determined by good maintenance and the volume of waste the trappings catch. If less waste is caught it means waste is going through to receiving aquatic environments and, if trappings are not maintained, waste can break down and create more pollutants (Allison, Chiew & McMahon, 1997:7).

The conventional manner in which stormwater and waste are managed as individual aspects of the urban environment are challenged and an integrated approach was needed. Integrated Waste Management (IWM) was defined by the United Nations Environmental Programme (UNEP) in 1996 as a framework for designing and implementing new waste management systems and for analysing and optimising existing systems. This framework emphasises that by tackling waste streams (solid, wastewater/aqueous and atmospheric wastes) individually, more waste will accumulate around the world. Hence the problem of solid waste should be approached in an integrated manner (Seadon, 2006:1328). A good example of a working solid waste reduction scheme can be seen in a programme begun by the Australian Capital Territory (ACT) government; in 1996 they aimed to have zero waste by 2010. By 2004 the government had achieved a 70% diversion of its solid waste. Solid waste accumulation was reduced by having a resource recovery centre that stored recycled material until it could be sold for revenue (Seadon, 2006:1330). The involvement of society however is of utmost importance to enable such big initiatives to work (Seadon, 2006:1331).

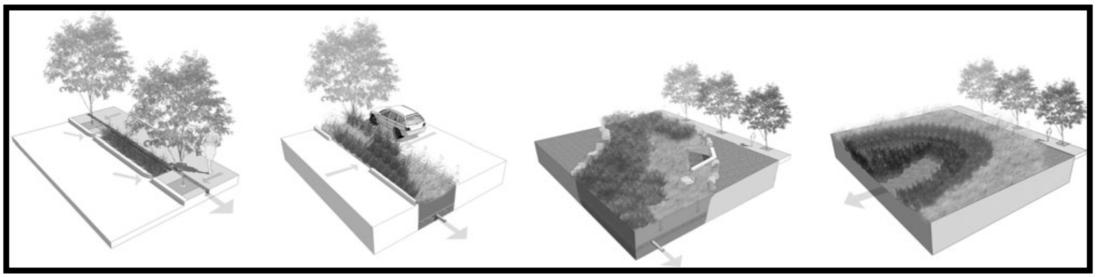
The secondary treatment option involves a series of wetland systems also known as a “treatment train”. This line of treatment ensures that sedimentation and pollutants do not accumulate in one space but get spread out and treated along the water-way by the bio-filters (Lloyd, Wong & Porter, 2002:4). The treatment train is viable since no single stormwater treatment measure can manage flow of water as well as remove all pollutants. Hence a collection of wetland systems is promoted (Lloyd, Wong & Porter, 2002:2). These bio-filtering treatment areas however do need regular monitoring, maintenance and acceptance from the surrounding communities in order to work (Lloyd, Wong & Porter, 2002:5).

#### 2.4.1.2 Management of the quantity of stormwater

The quantity of water and pollutants entering the stormwater system can be managed in four different ways. Firstly, better irrigation systems with rain sensors -that stop irrigating when it rains- are recommended so that no extra water will be running into the stormwater system (Donofrio, et al, 2009:182). A second option can be the installation of a rainwater harvesting tank that receives rainwater from the roof gutters (roof run-off) and stores it for later use. This practice has been practised in rural Australia for a long time but urban dwellers need to take up the use of tanks as well, because of current drought conditions, and not only for stormwater management (Tam, Tam & Zeng, 2010:178). The third suggestion is drought-tolerant landscaping practices. Drought-tolerant landscaping reduces irrigation run-off. These first three practices, known as "source control elements" do not only reduce the quantity of water entering the stormwater system but also prevent pollutants from entering water bodies and groundwater (Donofrio, et al, 2009: 182). Fourthly, it is recommended that retained (stored) water be released slowly into the ground to recharge groundwater (McAlister, 2007:8). Stormwater can be collected in gravel "pipes" that direct the water to aquifer recharge points and during the dry months the groundwater can be used for filling up ponds to be used as water recreational spaces (Newman, 2001,96). Rainwater tank benefits stretch from aiding stormwater management (roof run-off storage), to the re-use of water, and as a water-demand management tool; it can be used as the latter since potable water would no longer be used for irrigation or toilet flushing etc.

Various WSUD projects have been implemented and tested in different cities and towns around Australia. Projects have even been established in new housing developments and at the neighbourhood level to move away from the well-known centralised urban infrastructure system. Many projects aim to provide services on a localised level to prevent the uptake of space in urban areas. One of the earlier case studies is a housing development of 27 houses called Figtree Place in Newcastle, New South Wales. The development was built on an old bus station site and the impervious areas had to be removed to provide an infiltration area for rainwater. Investigation was carried out to see if stormwater storage could be a possible on-site water supply, and to what use the potential supply could be put. The investigation concluded that stormwater storage and use would be viable for the new development. It was decided that the stormwater would be used for toilet flushing and providing hot water to households, as well as for irrigation and washing the buses (Coombes, Argue & Kuczera, 1999:336). Nineteen household yards received an underground rainwater tank. Trenches receive the overflow of the water tanks to ensure groundwater gets recharged. All run-off from paved areas was guided towards a Detention Basin Recharge Area where water could accumulate and later seep into the unconfined aquifer (Coombes, Argue & Kuczera, 1999:336). Seven households, however, made use of the conventional stormwater system, but also had roof rainwater tanks (Coombes, Argue & Kuczera, 1999:337). The rainwater tank stored the water to be used for toilet flushing and hot water; a pump in the tank ensured that if there were not enough rainwater in the tank the toilet and geyser would automatically connect to the main water supply. During the evaluation of the new WSUD development it was found that most bacterial contaminants that are present in the rainwater tank died in the geyser when water was heated at between 55˚C and 63˚C. Many structural faults were discovered with the rainwater tanks but with better tanks and maintenance the rainwater tanks, along with the use of the geyser to heat the water, created a perfect combination. However, residents also received signage on the hot water taps that hot water could not be used for human consumption (Coombes, Argue & Kuczera, 1999:340). Compared to conventional developments, water saving at Figtree Place is estimated to be at 60%, irrigation also being taken into consideration. In the household around 45% water savings were made because of the use of water from the rainwater tank. Reduction in construction cost was also noticed but better and improved plans for such development would yield higher savings. Twenty-six surveys were done with the residents of Figtree Place. Ninety-five percent of survey participants accepted the use of rainwater for toilet flushing, hot water, washing clothes and even cooking (Coombes, Argue & Kuczera, 1999:341). Seventy percent of survey participants even indicated that they would not have a problem with drinking rainwater. It has been established that the WSUD concept is popular with communities and construction industry professionals (Coombes, Argue & Kuczera, 1999:341).

In 2002 the Sydney region launched a project to revive river channels and ensure better stormwater management. Three councils, the Marrickville, Canterbury and Strathfield Councils, began a joint initiative called "Riverlife" to restore the Cooks River. Catchment planning processes along with educational activities ensured that the river can now be used for water sports and recreation. In collaboration with the Monash University the councils created a Master Plan for stormwater management called the Model for Urban Stormwater Improvement Conceptualisation (MUSIC). This model ensures that the communities can model unique stormwater measures for water retention systems, water quality targets and potential water usage. The model also allows for assessment of implemented measures (Beatley & Newman, 2009).



**Source:** Donofrio, et al (2009:182)

**Figure 2.1:** Stormwater treatment types

Better water quality and quantity management was not the only outcome of the stormwater management component of WSUD, but aquatic environment protection and landscape amenity improved as well. Street design and landscape can be made aesthetically pleasing, while a service is being provided by the vegetation. The layout of the stormwater scheme should match the landscape characteristics but still promote Best Management Practices (BMPs) whereby the collection, treatment, storage or re-use function of a stormwater scheme is possible. Run-off can be reduced by having fewer impervious pavements; the natural water systems can be enhanced by incorporating the treatment train as well as adding value to the visual aspects of a development (Lloyd, Wong & Porter, 2002:1). This means that, during rainfall, stormwater flows into the primary treatment process, which can include the gross pollutant trappings and the bio-filtration swales, and then through the treatment train where it is treated optimally. A possible layout or design of treatment types which include buffer strips, bio-retention basins, bio-swales, and constructed wetlands is illustrated in Figure 2.1.

### 2.4.2 Re-use of water

WSUD does not only focus on stormwater. The flow of potable water and wastewater is also being considered. Though they can be re-used separately, often stormwater and wastewater can be re-used in conjunction with each other. An option for Australians is to choose to be connected to a “reticulated recycled water supply”, supplied by government. This system provides recycled water for non-potable use only as an alternative source of water via a pipeline with a tap for each user who opted to use it (McAlister, 2007:16). A second option is the aforementioned rainwater harvesting tank which allows for the re-use of water for non-potable purposes. As described earlier, the re-use of stormwater via rainwater harvesting tanks can satisfy homeowners’ non-potable needs such as flushing of toilets, doing laundry and watering the garden (Speers & Mitchell, 2000:1).

Wastewater on the other hand, first needs to be treated to an acceptable level in order to be re-used. The issue often not only starts with the treatment of wastewater but with what type of sanitation is being provided. If the wastewater system could demand less potable water, e.g., by not using potable water for toilet flushing, the first problem is already solved. For this reason various other sanitation services are being promoted, called “localised sanitation management”; they include septic tank systems, aerobic treatments and composting toilets, used mostly on a small scale by homeowners (Newman, 2001:96). In Australia small-bore sewer systems are popular whereby a household has an interceptor tank connected to a small-bore sewer. The interceptor tank receives all the gross solids first, and then the sewage flows into the small-bore sewer. This means that less water can be used when flushing the toilet since the pipes connecting to the interceptor tank do not need to make use of gravity to function. From the small-bore sewer the sewage can then continue through a connection to a larger Waste Water Treatment Works, or be removed by other services (Little, 2004:141). According to Little (2004:142) for a house connection that has a water consumption of 165 litres/person/day, the return flow is 132 litres/per person/day. For a yard or standpipe water consumption of 35 to 50 litres/per person/day, the return flow is 40 litres/per person/day (Little, 2004:142).

More high-tech systems can involve UV disinfection but there are even more natural systems such as wetland systems or solar aquatic systems. In solar aquatic systems wastewater gets treated on site (at home) with aqua culture hydroponics in passive solar greenhouses; various water flora and fauna are used to filter water naturally through different stages (Miller, 2004:483). Conventional wastewater treatment works are costly to build and maintain, and often receive too much wastewater to cope with. In such instances overflow needs to be managed before the receiving environment bears the brunt of it. Transferring wastewater under pressure or vacuum could be the solution; this option does not require a large reticulation network because more waste material is transported and less water is needed for flushing (Speers & Mitchell, 2000:1).

If localised sanitation is not possible and wastewater has to go to a Waste Water Treatment Works (WWTW) the treated effluent can still be of use, e.g., public recreational open spaces can be irrigated with the treated wastewater (Speers & Mitchell, 2000:4).

Re-use of stormwater and treated wastewater is well established in Australian cities, because urban areas are connected to the Water Reclamation and Management Scheme (WRAMS). One example is of Newington Village, which used to be the athletes’ village for the Olympic Stadium. The Sydney Olympic Park was designed to be a leader of its kind when it came to the re-use of water (Beatley & Newman, 2009). First of all, the roof of the stadium is connected to a rainwater harvesting tank under the sports field. Water collected in the tank is used for irrigation of the field and surrounding gardens. The second major reclamation activity is that Newington Village itself is linked to the WRAMS system, whereby treated wastewater and stormwater is re-used for toilet flushing and irrigation. It is estimated that 40% of the reclaimed water is used for toilet flushing in both the village and the Olympic Park and 60% if used for irrigation and operational wash-down of spaces. WRAMS and other activities save 850 million litres of drinking water a year (Beatley & Newman, 2009).

Industrial water reclamation projects are not unheard of such as the Eraring Power Station near Sydney, which recycles wastewater from a WWTW. At the power station the treated wastewater is treated even further to a purified state, to be used in the boiler for steam-powered turbines. This recycled water conserves about 1.2 $Mm^3$ of potable water a year (Anderson, 2003:4). In the mining industry water can also be recycled to be used for cooling, washing of material, etc. On an industrial level the re-use of water can have a major positive impact on river health because fewer pollutants enter the rivers when water is re-used, rather than discharged into the municipal wastewater system or receiving rivers. The re-use of water can ensure that aquatic life in rivers is not negatively affected and river aesthetics can improve, because water is treated for re-use. Waterways can be used for recreational purposes and downstream users of the river water have a lower cost when treating water further (Anderson, 2003:7). On the supply side urban potable water supply schemes can save costs because fewer infrastructures are needed to provide more water supplies. Less storage infrastructure, such as dams, is needed because less water needs to be supplied. On the wastewater management side, costs can be saved because less discharge pump stations and pipelines will be needed to carry wastewater away. A second saving will be made when less water needs to be treated to remove pollutants, because industries that use reclaimed water can treat wastewater themselves (Anderson, 2003:8).

### 2.4.3 Demand Reduction Techniques

Water Demand Management or Potable Water Demand Reduction Techniques, as it is also known, goes hand in hand with all other conservation techniques. Management initiatives include both the demand and supply side of water management, involving the retrofitting of appliances but also the "fit-for-purpose" approach, which emphasises the use of potential alternative sources of water and minimises the use of potable water (McAlister, 2007:8). The retrofitting of appliances can include putting in low-flow tap fittings, low-flush or dual-flush toilets and even installing irrigation systems that can be controlled electronically (Newman, 2001:95).

The use of water-efficient appliances such as dishwashers designed to save water is highly recommended. Potable Water Demand Reduction Techniques however are not a new concept in Australia, which had a programme initiated in 1976 (Hipkins, 2007:2). The programme had a total sprinkler ban and a "user pay" method of charging for potable water. It was more than successful, with the Water Authority making less money; the programme had to shift to a "service charge" whereby the allocation of water was guaranteed. This shift however made water demand rise again. On the other hand, water conservation and demand management practices contribute to groundwater over-use, since there was a belief that less reticulated water would then be used. Currently, sprinkler bans on alternate days, water-wise rebate programmes for retrofitting and the promotion of boreholes in household gardens have borne fruit. Extra measures are being considered such as borehole registration and metering, charging industrial water users, total sprinkler bans, and charging domestic users the "true cost" of water (Hipkins, 2007:5).

According to the Australian guidelines (AU, 2001:5) an effective water demand management strategy, specific to urban water use ensures that:

- "Water use is reduced (both peak and average demands)
- Reduced water leaks/loss
- Reduced wastewater flows
- Improved financial performance through delaying of new infrastructure development and reduced operational cost
- Better awareness of consumers of the environmental and financial value of water."

These guidelines mandate service providers to create Water Demand Management Plans which detail their audit reports, water consumption reports, meter accuracy reports and Water-wise business plans (AU, 2001:5). WDM is also a management issue that has to be implemented from the beginning of infrastructure lifespan until it is replaced. Since infrastructure is an asset to a water services provider, the financial costs have to be considered. The guidelines stipulate that Least Cost Planning is a principle whereby WDM is integrated into the infrastructure planning phase, to establish whether new infrastructure is needed or not. These principles ensure that WDM programmes are successfully implemented before the construction of a new building, making sure that the cost of the new building can be compared to the savings of the WDM programmes. The operational phase can also be positively affected by WDM programmes, because through these programmes, problems can be picked up and solved, such as altering the pressure in the water reticulation system to improve service delivery (AU, 2001:5). Lastly, when infrastructure has to be replaced through WDM programmes there might be no need to replace assets or new low-capacity assets can be implemented (AU, 2001:6).

The Australian guidelines also indicated that water demand strategies can be divided into two types: water demand reduction strategy, and the supply rationalisation strategy (AU, 2001:6).

Water demand reduction strategies include:

- “Volumetric charging: (cost is charged according to the volume of water used)
- Education campaigns
- Water use restrictions
- Installation and retrofitting of water saving devices
- Best practice irrigation water management”

Supply rationalisation strategies

- “Customer metering
- Water loss reduction
- Leakage detection and repairs
- Reducing seepage and evaporation losses in dam storage and irrigation systems
- Accurate metering
- Pressure reduction
- Effluent re-use”

The Government of Southern Australia (GSA) has a plan for their water future based on failed and successful programmes implemented over the years, focusing on the city of Adelaide (GSA, 2009:16). Various programmes include the Water Efficiency Labelling Scheme (WELS) whereby the installation of rainwater tanks is regulated and checks are made on newly built homes to ensure that homes have water savings devices. Water-use devices like toilets have to meet the minimum requirement set by WELS. The WELS programme is influenced by the H2OME Rebate Scheme, which enables new homeowners to afford the WELS chosen devices. Furthermore, households in Australia do not have to bear the full cost of retrofitting their homes with water saving devices because this is subsidised by the H2OME Rebate Scheme, as well as other rebate schemes introduced by the government (GSA, 2009:105). In 2009 the government enhanced the H2OME Rebate Scheme with added rebates for hot water reticulators, garden goods, and pool covers. As part of the imposed water restrictions, pool owners first have to have a pool cover before they are permitted to fill a pool in Southern Australia (GSA, 2009:106).

Educational programmes play an important role in how communities receive water demand initiatives. One such programme is the National Water Initiative, launched by the government of South Australia (GSA, 2009:108). This introduced the “Smart Bill” in 2009, a quarterly bill that shows customers how much water they use daily, with comparisons of other households of similar size. Schools also benefit from programmes such as Waterwatch, Frog Census, WaterCare and the Australian Sustainable Schools Initiative (AuSSI), with a Learning Centre created in 2009 as well (GSA, 2009:108).

For the industrial and government water-user component, the city of Adelaide performed water audits on businesses that use more than 50 ML/year via their Business Water Saver Program in 2007. Each of these businesses had to create a water efficient plan in their areas of operation, and the programme also assisted industries in fulfilling their Trade Water Effluent Improvement programme requirements. (GSA, 2009:110). Government buildings were also targeted to make sure these buildings save water in the future. In Adelaide the use of water to maintain public space is estimated at 13% of the main supply, hence the Code of Practice for Irrigated Public Open Space (IPOS) was introduced (GSA, 2009:111). IPOS provides reporting tools and models to implement best practice irrigation management in open spaces such as sports fields. Fifty-six percent of councils indicated that they have implemented IPOS, with water savings of 30% (GSA, 2009:111). It was recorded between 2005 and 2006 that Adelaide had fewer water losses than any other city in the country, through a water reticulation network leakage programme. To improve on this record the city started to work on an $8 million leak-detection project (GSA, 2009:111).

Consumer behaviour towards water restrictions and tariff changes is also important to consider in urban planning. A survey was conducted in Sydney to investigate consumer behaviour, and the majority of respondents were in favour of different pricing strategies. Respondents believed that high-volume consumers should pay high tariffs, and those who can keep their consumption below average should be rewarded. Even though respondents felt that these two different pricing strategies might be an option, the majority also felt that higher tariffs should not necessarily be the option to promote water conservation (Troy & Randolph, 2006:69). With regard to water restriction, respondents were aware of restrictions but did not know their duration or purpose, and were not sure what they involved (Troy & Randolph, 2006:78). Respondents felt that restrictions are needed to reduce water use but also felt that because there is a lack of enforcement for violations, water demand would never decrease. Responses indicated that restrictions made people more aware of their water consumption and had an impact on some people’s lives, especially on those who live in a house rather than an apartment (Troy & Randolph, 2006:81). The survey established that consumers are more concerned with the price they have to pay for water rather than the volume of water they consume. The volume of water in kilolitres on the water bills was too difficult to comprehend, however if respondents’ water use were compared to other household consumption, consumers became embarrassed if their household used more water than one of smaller or similar size (Troy & Randolph, 2006:77).

### 2.4.4 Greenroofs/rooftop gardens

A greenroof is a specially designed roof planted with vegetation via a substrate, a layer of growing medium that supports the plants, which varies in depth from 20 to 30cm. Many environmental benefits can be incurred from installing a greenroof. The structural needs for the roofing system would include waterproofing, root barriers, and insulation underlying the medium or substrate layer (Thomas & Thomas, 2003:6). The greenroof substrate or medium needs to be lightweight, stable (chemically and physically) and able to hold water and nutrients for the plants. The European greenroof industry uses crushed bricks and roof tiles, etc., but these are too difficult and expensive to access in Australia. According to Williams, Rayner & Raynor (2010:3) furnace bottom ash from coal-fired electric power plants could be used in Australia, but currently substrate for potting or nursery containers, such as pine bark, is used instead. Various drought-resistant plants which grow naturally in Australia are ideal for the garden but the substrate needs to be specialised first. More research on the topic is thus needed to help the industry develop (Williams, Rayner & Raynor, 2010:5).

Two types of rooftop gardens or greenroofs are being promoted in Australia. The first, and more maintenance-free rooftop garden, is the “Extensive Greenroof” that often consists of drought-resistant plants (desert species) that thus need little or no irrigation. The second type is the “Intensive Greenroof”, which needs more care from professionals because often a bigger plant selection is used and more maintenance is required (Thomas & Thomas, 2003:6). Both rooftop gardens however need a membrane underneath to ensure plant roots and moisture does not penetrate the roof. The membrane should also be able to keep the water on the roof well enough to fit the purpose of being a garden. A third type of greenroof is the “Vertical Garden”, the chief benefit and purpose of which is to insulate buildings (Thomas & Thomas, 2003:8).

The first two rooftop gardens however have many more benefits. Water conservation benefits include improved stormwater management, as these greenroofs absorb and hold rainwater and filter sediments and heavy metals from the water; on a larger scale, less water ends up in the stormwater system and authorities thus have less water to divert, which in turn reduces the cost of building and maintaining a stormwater system. Studies have shown that a substantial percentage of rainwater along with dissolved pollutants such as heavy metals; copper, lead and cadmium can be retained by greenroofs in high rainfall areas (Thomas & Thomas, 2003:15). Other benefits include better insulation for buildings, which in turn means less energy use, hence lower greenhouse gas emissions. These gardens can also serve as aesthetic improvement in urban areas as well as increasing property prices (Thomas & Thomas, 2003:17). The authors, Thomas & Thomas (2003:8) indicated that older developments in the country would not be so difficult to retrofit or upgrade, but the ideal option would be for the Australian government to ensure new developments implement changes to infrastructure planning, and install rooftop gardens. Impediments, however, include community ignorance, government reluctance to support projects, and the need for researchers and professionals to increase their knowledge of rooftop gardens/greenroofs (Thomas & Thomas, 2003:23). However, greenroofs are not only seen as positive for stormwater management but might also be useful to help reduce the impact of climate change. Low density vegetated areas act as heat sinks and is 5˚ C cooler than heavily built areas. Hence rooftop gardens are being promoted as part of denser, greener, more sustainable, water sensitive cities, along with parking areas being grassed, and the preservation of existing trees. Greenroof development should thus not be done in isolation, and land-use practices revised, so that land is rezoned for lower density residential development (Hipkins, 2007:8)**.**

Australian greenroof development projects encounter many problems, largely because Australia has to rely on studies done in other countries where the temperature, rainfall, available substrates and vegetation used for the roofs differ to their own. Intensive greenroofs in the country include various parking areas at prominent buildings such as the University of Melbourne, Melbourne Cricket Ground, Brisbane’s South Bank Parklands, and the National Gallery of Victoria (Williams, Rayner & Raynor, 2010:2). Many apartment blocks and hotels created these gardens as recreational spaces for their residents like Melbourne’s Crown Casino and the M Central apartments in Sydney. Office-block developers also incorporate the roof garden to be more “green” such as the examples at the Department of Primary Industries at Queenscliff, and Council House 2 in Melbourne (Williams, Rayner & Raynor, 2010:2). Many of these intensive greenroofs have trees and grass as vegetation. An experimental un-irrigated extensive greenroof, however, is situated at the University of Melbourne and an irrigated example on a toilet block at Elisabeth Bay in Sydney (Williams, Rayner & Raynor, 2010:2).

Excitement about greenroofs is starting to develop amongst architects and developers, aiming to be more “green” in their buildings; climatologists are advocating these roofs to reduce heat loss and use of electricity for air-conditioning, etc., and policy makers are also becoming aware of the benefits of greenroofs with regard to WSUD and urban biodiversity habitats (Williams, Rayner & Raynor, 2010:2). The financial benefits however need to be reflected first before the greenroof industry can grow or building guidelines can be changed by urban planners (Williams, Rayner & Raynor, 2010:2). From the viewpoint of WSUD, captured stormwater or recycled greywater has to be used for those greenroofs that need irrigation; choosing plants suited to the climate would be ideal, otherwise it would be counter-productive if more potable water were to be used for irrigation purposes (Williams, Rayner & Raynor, 2010:5).

## 2.5 IMPEDIMENTS OF WSUD IMPLEMENTATION

WSUD has encountered many impediments in Australia since the 1990s. According to Lloyd, Wong and Chesterfield (2001:302) these fall into four categories: the first is the regulatory framework in Australia. The regulatory environment in many state institutions is too fragmented, with responsibilities for water supply, groundwater, stormwater and wastewater often split within or between organisations. Local government often feels that they have a lack of expertise to implement or even asses WSUD projects. Principles, standards, frameworks and guidelines are still needed on a local, on-site and regional level (Lloyd, Wong & Chesterfield, 2001:304). The facilitation of integrated management of water has also been hindered by lack of political will, poor community participation and organisational commitment (Brown, 2004:1). Organisations involved in WSUD are often not driven by IUWM but rather by achieving a minimal level of regulatory compliance with State Government obligations. Often junior staff gets tasked with obtaining and ensuring that the organisations comply with regulations (Brown, 2004:6). If an organisation however has a champion to push and promote IUWM, the collaboration with the engineering, environmental and planning departments in the organisation becomes a priority, but community participation is often forgotten (Brown, 2004:8).

The second category of impediments is the technology and design of certain items used for WSUD. Although the appreciation of the “treatment train” approach (using more than one treatment process to treat polluted water) has been positive, its implementation however was not as positive. Because of the technicality and variety of WSUD techniques, many interested parties do not have access to proper information on how to implement them (Lloyd, Wong & Chesterfield, 2001:305). This leads to poor execution of design, especially under bad construction practices. However, the issue can be solved if different professionals can be involved in the projects to ensure that all aspects (the natural environment, the economy and the community) of the design are covered (Lloyd, Wong & Chesterfield, 2001:305).

The third category is the assessment of WSUD and the cost of its implementation, hence the importance of modelling both cost and assessment (Lloyd, Wong & Chesterfield, 2001:306). If modelling is done properly to keep in mind external costs (environment and quality of life) as well as capital cost, then by comparison the environmental cost of conventional urban design should be much greater. External costs are however much more difficult to calculate – and because costs are so difficult to calculate it is proposed that a model-toolkit is created to assess a number of urban designs that would provide different economic scenarios for each site-specific constraint (Lloyd, Wong & Chesterfield, 2001:307). Cost implications in establishing, for example, a stormwater system or other WSUD activity after development has been completed becomes problematic. The cost is perceived to be much higher if the maintenance of a system is taken into consideration as well. However the integrated approach of WSUD has gained support over the traditional “conveyance-orientated” approach, because development costs are reduced, water pollution is minimised, and the hydrological environments are not being disturbed as much as they were in the past during the establishment of buildings (McAlister, 2007:8). But even if new infrastructure with separate greywater and wastewater (sewage) systems along with pressure reduction techniques can be implemented, the cost would be similar to a conventional system. If, however, one keeps in mind how the separation of stormwater from the sewage system would put less pressure on the sewage system, as well as improve efficiency, it would produce an overall positive outcome (Speers & Mitchell, 2000:4).

The last impediment category is the marketing and overall acceptance of WSUD activities by the community. The reason for this is that developers create water features, such as wetlands and ponds, to attract buyers but are not considering the long-term sustainability of such structures. The beneficial use of water features is often lost because of lack of proper planning and lack of proper engineering and scientific design principles. These water features often become full of litter and sand, algal blooms become a problem and they often get infested with weeds and mosquitoes (Lloyd, Wong & Chesterfield, 2001:307).

The necessary transformation from conventional urban planning to a more water-sensitive urban planning requires the establishment of a new culture across various organisations, professions, and tiers of government (Brown & Clarke, 2007:1). Because the technological changes are difficult to implement and many governments lack the will to manage urban water effectively across many sectors, the implementation of WSUD will remain a challenge. Change in policy frameworks, new skills and knowledge, and rewards and penalties are clearly still required (Brown & Clarke, 2007:56).

With IUWM being portrayed across the world by various concepts, comparisons can be made as illustrated in Table 2.1 below. Concepts include, as mentioned before, Low-impact Development (LID) initiated in the USA, Sustainable Urban Drainage System (SUDS) started in the UK, Low-impact Urban Design and Development (LIUDD) implemented in New Zealand and lastly Water Sensitive Urban Design (WSUD) started in Australia.

**Table 2.1:** Comparisons of IUWM concepts

| LID | SUDS | LIUDD | WSUD |
|---|---|---|---|
| • Stormwater quantity management via implementation of rainwater harvesting tanks, greenroofs and pervious pavements. | • Stormwater quantity management via separation of stormwater system from sewage system;<br>• Stormwater quality management via solid waste management and constructed wetlands. | • Stormwater quantity management via rainwater harvesting and pervious pavements;<br>• Re-use of water via greywater re-use and reclamation of treated wastewater. | • Stormwater quantity management via rainwater harvesting, water-wise gardening, pervious pavements, etc.<br>• Stormwater quality management via solid waste management and constructed wetlands;<br>• Demand Reduction Techniques via retrofitting of appliances, leakage detection and fixing, water use restrictions, pressure reduction , awareness campaign, etc.;<br>• Re-use of water via fit for purpose water use, reclamation of treated wastewater and localised sanitation;<br>• Greenroof installation linked to stormwater quantity management. |
| **LID** | **SUDS** | **LIUDD** | **WSUD** |
| <u>Positive</u><br>• the natural state of an area is kept intact;<br>• beautification of an area.<br><br><u>Negative</u><br>• homeowners prefer | <u>Positive</u><br>• Less pressure on the sewage system if stormwater system is separate;<br>• beautification of an area. | <u>Positive</u><br>• the natural state of an area is kept intact;<br>• beautification of an area.<br><br><u>Negative</u><br>• The community, private | <u>Positive</u><br>• Well documented research; Various/diverse activities to implement;<br>• Activities can be done in combination on household level to city |

| | | | |
|---|---|---|---|
| wider streets and paved areas;<br>• not preferred on contaminated land;<br>• proper education needed to ensure maintenance. | Negative<br>• Will not be sustainable if community is not on board. | developers and council is not well informed and prepared;<br>• Demand for the design is low. | level.<br>Negative<br>• Maintenance of developments not kept;<br>• The community, private developers and council is still getting accustomed to WSUD |

## 2.6 THE SOUTH AFRICAN LEGISLATIVE SITUATION

In order for WSUD implementation to occur, guidelines have to be set to aid the different spheres of government in their role of delivering services to the broader community. For this purpose the last section in the literature review covers relevant literature in the South African legislative framework that would create an enabling environment for the conceptualisation and implementation of WSUD, by checking for any legislation with WSUD principles or directives. As described earlier, the WSUD principles identified by Donofrio et al (2009:180-181) include:

- “Protection of natural systems within the city
- Protecting the water quality,
- Maximising re-use of water,
- Reducing potable water demand via water conservation and overall system efficiency,
- Creating functional landscapes (e.g. recreational spaces) in the city which in turn actually treat stormwater quality and promote infiltration of water and thus reduce urban run-off and the need to manage it.”

These principles were used as a yardstick during the search in the legislation documents.

South Africa operates within three spheres of government: national, provincial and local/municipal. The country’s legislative framework emphasises, via the Constitution, that local government (municipalities) is that sphere of government with the right and executive authority to administer local government matters such as water and sanitation services; these are limited to potable water supply and wastewater management. Local government legislation/strategies, specific to the case study area of the George municipality, will be discussed further in Chapter 4 of this study. National and provincial governments must support local government via legislation and other means so that local government can exercise their power and function. National and provincial government cannot intervene in local government functions, and provincial government can only play a supervisory role (Hollingworth et al, 2011:13). National and provincial government legislation will be discussed in the following paragraphs of this literature review.

There are seven key pieces of legislation to be examined. The first to be discussed, critical to the endurance of sustainable water resource management, is the ‘National Water Act No. 36 of 1998’, which guides all other legislation subsequent to its promulgation – the second piece of legislation is the ‘National Water Resources Strategy’, a consequent mandate of the National Water Act of 1998. The third piece of regulatory material to be considered is the ‘Guidelines for Water Conservation and Demand Management’, which suggests possible implementation ideas to water management institutions. The fourth document is the ‘Guidelines Groundwater Resource Management in Water Management Areas’ which explicitly mentions WSUD in several paragraphs. Document five in the discussion is the ‘Framework for Water Conservation and Demand Management’, created by the South African Local Government Association (SALGA) to govern the manner in which local authorities manage water demand and conserve water resources. The sixth important guideline to be discussed is the ‘National Climate Change Response Green Paper’ gazetted in 2010 which is the second document to mention WSUD explicitly. The last document is a strategic piece of material with regard to the whole country’s water situation, called the ‘Strategic Planning for Water Resources in South Africa – A Situation Analysis’ of 2009. The Strategic Plan stipulates the DWA’s strategies for five years, from 2009 until 2014. In the context of the literature review however, the Situation Analysis of 2009 will be discussed, which analyses and summarises important issues in the water sector. For the purpose of the literature review, however, the focus is only on urban areas and towns.

### 2.6.1 National Water Act No. 36 of 1998

The National Water Act No. 36 of 1998 (NWA) stipulates that in order for a water resource to be protected at a local level, such as the catchment level, a Catchment Management Agency (CMA) has to be established to manage the water resource quality, quantity, development of the resource and its conservation. Control over the resource is exercised by the issuing of water-use licensing, so that the abstraction of water does not disturb the Reserve. Water-use charges are set where a river might be used for waste discharge, and data monitoring is done regularly (SA, 1998:24). The re-use of wastewater is deemed a controlled activity – wastewater must be safe for the natural environment before its release can be permitted. Re-use of wastewater in the Act includes irrigation and intentional recharge of an aquifer (SA, 1998:54). With regard to conservation of water resources the Act stipulates that water use charges can be altered to enable water resource management to conserve water (SA, 1998:70). In the case of water stress, water demand management can be enforced via compulsory licensing of water use, if the prevailing use of water needs to be reviewed. Water uses which can be instructed to undergo compulsory licensing include; water use for a controlled activity, discharging of wastewater into a water source, storing of water, water used for recreation, etc. (SA, 1998:60). The Act does not mention any regulatory guidelines on stormwater management.

### 2.6.2 National Water Resource Strategy

The National Water Resource Strategy (2004) (NWRS) encompasses regulations mentioned in the Water Services Act No. 108 of 1997, and the National Water Act No. 36 of 1998. The NWRS stipulates similar guidelines as mentioned above regarding the CMAs' responsibility of protecting water sources, re-use of wastewater and Water Conservation and Water Demand Management. One added water resource management practice which is mentioned in the NWRS is that basic sanitation facilities should be designed to protect water resources and not pollute them (SA, 2004c:11). The NWRS created the National Water Resource Classification System as a yardstick measurement of water quality. This system classifies a water resource such as a river according to the uses of that river. The classes range from: Natural, Moderately Used, Heavily Used and lastly, Unacceptably Degraded Resource (SA, 2004c:57). By classifying a certain resource, water management institutions such as a CMA can then decide what action to take to remedy problems, if any. In the NWRS mention is made of the Water Services Act which specifies the quality of wastewater and the manner in which it is discharged, before it enters a water body for disposal via licence and general authorisations (SA, 2004c). An additional requirement from the NWRS is that industrial discharge into the sewerage system is also controlled in order to ensure that the quality of the discharge is not harmful to the environment and that the sewerage system can handle the amount of added industrial wastewater. The most relevant strategies that have to be in place include: strategies on the protection of water resources, better water-use strategies (mostly via licensing), water conservation and demand management strategies, and water pricing strategies (SA, 2004c). In the case of the drought conditions, a disaster management plan should be in place. Strategies have to be enacted by responsible public departments and service providers.

### 2.6.3 Guidelines for Water Conservation and Demand Management

Water conservation and demand management is currently put into practice following the 'Guidelines for Water Conservation and Water Demand Management' in both Water Management Areas and the Water Services Sector. These guidelines are provided in three volumes. The first volume regulates action of the Catchment Management Agencies (CMA); the second provides guidelines for undertaking a WC/WDM Situation Assessment and the Development of a Business Plan within the Water Services Sector. The third volume focuses on educational campaigns and institutional management (SA, 2004a). Various activities are mentioned in the guideline such as leak detection, management of the metering system, water-efficient appliances, tariff structures, etc. (SA, 2004a:69). In Volume 1 the guidelines stipulate what water services institutions such as Catchment Management Agencies (CMAs) have to keep in mind when creating their own implementation strategies. Implementation strategies should dictate what the agriculture, mining, industry and other sectors should include in their water management plans to show how water is being conserved via simple tools, such as a checklist (SA, 2004a:3). One important aspect of Volume 3 is the emphasis on the removal of alien vegetation to increase available water in river catchments. Since alien vegetation requires more water its removal would increase water availability in river catchments. The guidelines detail how this should be done and the Department of Water Affairs' Working for Water programme follow these same guidelines (SA, 2004a:2).

### 2.6.4 Guidelines Groundwater Resource Management in Water Management Areas

The Guidelines Groundwater Resources Management in Water Management Areas is one of two documents which mention WSUD explicitly. The guidelines state that WSUD aims to reduce water losses by creating more vegetated surfaces and soakaways in order to maintain groundwater recharge. WSUD should, according to the guidelines, be recognised early in the land-use planning process. With early planning, a framework is provided to developers, government and industry to create an ecologically sound infrastructure. The guidelines claim that WSUD can generate new opportunities for the creation of efficient systems, avoiding the need for infrastructure and increasing the value of properties (SA, 2004b:5).

### 2.6.5 Water Conservation and Demand Management Framework

An additional water conservation and demand management framework has been created by the South African Local Government Association (SALGA) specifically to guide local government/municipalities. Since WSAs/municipalities struggle to improve their management of water resources, SALGA designed the framework to address important issues: the level of service provided (continuity & pressure of supply), the need to reduce water losses to an optimum economic level, the need to control water demand, maximum utilisation of already available infrastructure, and efficiency in the use of human and financial resources (SA, s.a.). The framework is aimed to provide local authority managers with guidance so that they can recognise the shortcomings of the authority. Most importantly SALGA created tabular checklists in the framework whereby the WSAs see if they do in fact need to address these issues (SA, s.a.). The first checklist is a "relevance" checklist whereby the WSA assesses whether the framework designed by SALGA is relevant to their needs; if it is, then the WSA needs the framework guidelines in order to improve. Secondly, data checklists were also created for all technical data, social data, and financial data. Third, situation assessment checklists were created in the framework to make it easier for WSAs to assess their current situation. Situation assessments include, for example, the authorities' water storage capacities, their water treatment situation (cost & quality), how well their WC/WDM practices are doing, their water losses, etc. (SA, s.a.). Not only does the framework include checklists but also a layout of an Implementation Plan from the start-up phase, along with "long-term on-going activities". The last document to help WSAs to implement WC/WDM is a guide format for the Annual Report on WC/WDM. All of the above were created for WSAs to implement WC/WDM according to a structured layout **(**SA, s.a.).

### 2.6.6 National Climate Change Response Green Paper

The Minister of the Department of Water and Environmental Affairs invited members of the public to comment on the Green Paper. The Green Paper is a national attempt to remedy the country's impact on the global environment, since South Africa is a contributor to global climate change through the economy's dependence on fossil fuels (SA, 2010:4). Because South Africa is also vulnerable to the impact of climate change, the government recognised that there is a need for short-term prioritising of adaptation interventions in the three key sectors of water, agriculture and health (SA, 2010:6). For this literature review the focus is on the water sector since it is "arguably the primary medium through which climate change impacts will be felt by people, ecosystems and economies" (SA, 2010:7). The South African Government aims to address the impact of climate change on water resources by accelerating the process of establishing CMAs and strengthening their regulation and monitoring at all levels of government. It is significant that the Green Paper states that the re-use of wastewater at municipal level will be prioritised, and if wastewater cannot be re-used more investment will be put into high-quality treatment of water if it is to be discharged back into the environment (SA, 2010:9). The establishment of household rainwater harvesting incentive programme is also an aim of the government, as well as maintenance and renewal programmes for water resource infrastructure (SA, 2010:10). The removal of alien vegetation is administered via the Working for Water programme, since more water becomes available in river catchments when alien vegetation is removed. The government aims to accelerate programmes like this as well as the Working for Wetlands and Working for Fire programmes, which aim to protect vulnerable ecosystems (SA, 2010:22). For more urban-specific measures, the South African government also aims to address challenges by encouraging and developing Water Sensitive Urban Design. This would provide a means to capture water in the urban environment and minimise pollution and disturbance by making sure that stormwater is treated as a water resource which is not to be discarded. This Green Paper is thus the second document which mentions WSUD explicitly (SA, 2010:26).

**2.6.7 Strategic Plan: A Situation Analysis 2009**

According to the Situation Analysis 2009, Water Reconciliation Strategy Studies were initiated for large metropolitan areas – of which the town of George was one – to determine aspects of current water availability, water use, and future requirements for water, and how these three topics can be reconciled through different strategies (SA, 2009:6). The goals of the studies were to develop future scenarios, to investigate all possible water resources which could be added to current resources, to investigate and recommend how demand for water can be reconciled with currently available supply, and the creation of a system to monitor and update these strategies. Target areas for the reconciliation studies were identified as primary growth areas in the National Spatial Development Plan. The studies conducted on metropolitan areas were taken to their specific Strategy Steering Committee (SSC) which will meet and recommend annually monitoring strategies. This is being done to maintain a 25-year planning outlook (SA, 2009:8).

The studies concluded that in the chosen metropolitan areas WC/WDM activities should be implemented as soon as possible by WSAs/municipalities. Secondly, the re-use of water as a potential source of water for coastal cities is to be recommended; however in some inland areas the re-use of water has become a necessity. Groundwater has also been identified as a resource. The quest for more surface water resources and more inter-basin transfer schemes has to play a role in reconciling supply and demand for current and future situations (SA, 2009:8).

The Western Cape Water Supply System Reconciliation Strategy Study was completed in 2007, after nationwide studies were initiated in 2005. The situation after 2007 can be summarised as follows: the Strategy Steering Committee (SSC) was formed in 2007 and is active; WC/WDM activities have been put in place and the 2011 estimate of demand exceeding supply has been moved to 2013, and the re-use of water will only be assessed in the 2010/11 financial year (SA, 2009:27). With more of a focus on the supply of water, the current situation includes feasibility studies (also for the financial year 2010/11) for the use of the Table Mountain Aquifer, using already completed drilling pilot studies: six surface water feasibility studies had already been executed in 2008. Not many achievements have been listed in the Situation Analysis of 2009, because most supply-orientated studies (boreholes, surface water studies) started later than planned. The spilling of poorly treated wastewater still goes on and Water Demand Management activities in towns outside of Cape Town, in the Western Cape, are not as successful (SA, 2009:28).

Plans for the future in the Situation Analysis make mention of “All Towns Reconciliation Strategy Studies”, that will provide reconciliation strategies for those towns not covered by the studies in metropolitan areas. Every town and village has to be assessed to determine water resource availability (SA, 2009:9). These studies would determine sources of water supply and better inform municipal managers to help them execute the Water Services Development Plans and Integrated Development Plans more effectively. The studies would aim to investigate the water requirements of a town, resource management options, source development options (groundwater, surface water, return flows and re-use) and reconcile demand and supply. WC/WDM measures would also play a key role. Water quality and the state of water services infrastructure will be another aspect to examine. Solutions will be recommended specifically to address infrastructure and capacity problems in towns. This All Towns Reconciliation Strategy Study is aimed to be completed over the next three years, from the adoption of this document (SA, 2009:9).

South Africa has numerous acts of legislation that set the path for better water resource management, especially in urban areas. With the current situation of climate change, Integrated Urban Water

Management has to be considered. Having looked at the legislation, it seems as if the country guided these endeavours. However by doing this thesis, one has now to discover if any of these plans and strategies has been implemented to an urban planning/designing level, to comply with the theme of WSUD. The implementation of legislation fits in well with a conclusion by Gunnel (2009:18) which emphasised that simply reducing negative impacts by a certain percentage is not going to solve the world's environmental problems, though it can certainly help it to become standard practice.

## 2.7 CONCLUSION

The literature review reveals how unsustainable conventional urban water management system became, which gave rise to a response. The response across the globe came in the form of a concept called Integrated Urban Water Management (IUWM). IUWM is the initial concept that eventually resulted in the formulation of Water Sensitive Urban Design (WSUD) in Australia. Outside of Australia, IUWM resulted in Low-Impact Development (LID) in the United States of America, Sustainable Urban Drainage System (SUDS) in the United Kingdom and Low Impact Urban Design and Development (LIUDD) in New Zealand. The literature review focused mainly on WSUD since the primary objective of the study is to determine the type and extent of WSUD activities implemented by the George municipality. The history of WSUD is discussed as well as those various WSUD activities which can be implemented. WSUD was not applied without problem in Australia; hence the impediments to WSUD implementation in Australia were also discussed. Lastly, a detailed description of South Africa's water management legislation was given, to identify which legislative documents incorporate WSUD principles. In conclusion, Speers & Mitchell (2000:3) and Newman (2001:96) mention that WSUD techniques/activities work more effectively if a whole combination of measures is implemented for each unique situation. However, Newman (2001:99) adds that multi-centred cities are emerging because of the economy – but the question remains, whether water management can also be de-centralised with a multiple-site approach, even though the technology seems to be available. In southern Africa however, the implementation of Demand Reduction Techniques or, rather, Water Conservation and Water Demand Management on a local municipality scale is hampered by a lack of human and financial resources, and the focus on water resource augmentation as only a short-term option. The benefits of these techniques need to be emphasised along with national support to maintain the smooth running of the activities (Mwendera et al, 2003:769).

The case study area chosen for the study is the George municipality. To provide a clear context, more background on the municipality is given in the next chapter.

# CHAPTER 3: STUDY AREA

## 3.1 BACKGROUND

"Dry with an abundance of sunshine", as described by Burger (2008:7), South Africa receives on average 452mm of rainfall annually, significantly below the world average of 860mm. Furthermore, where dams are particularly vulnerable to excessive evaporation, this evaporation often exceeds rainfall (Davies & Day, 1998:30).

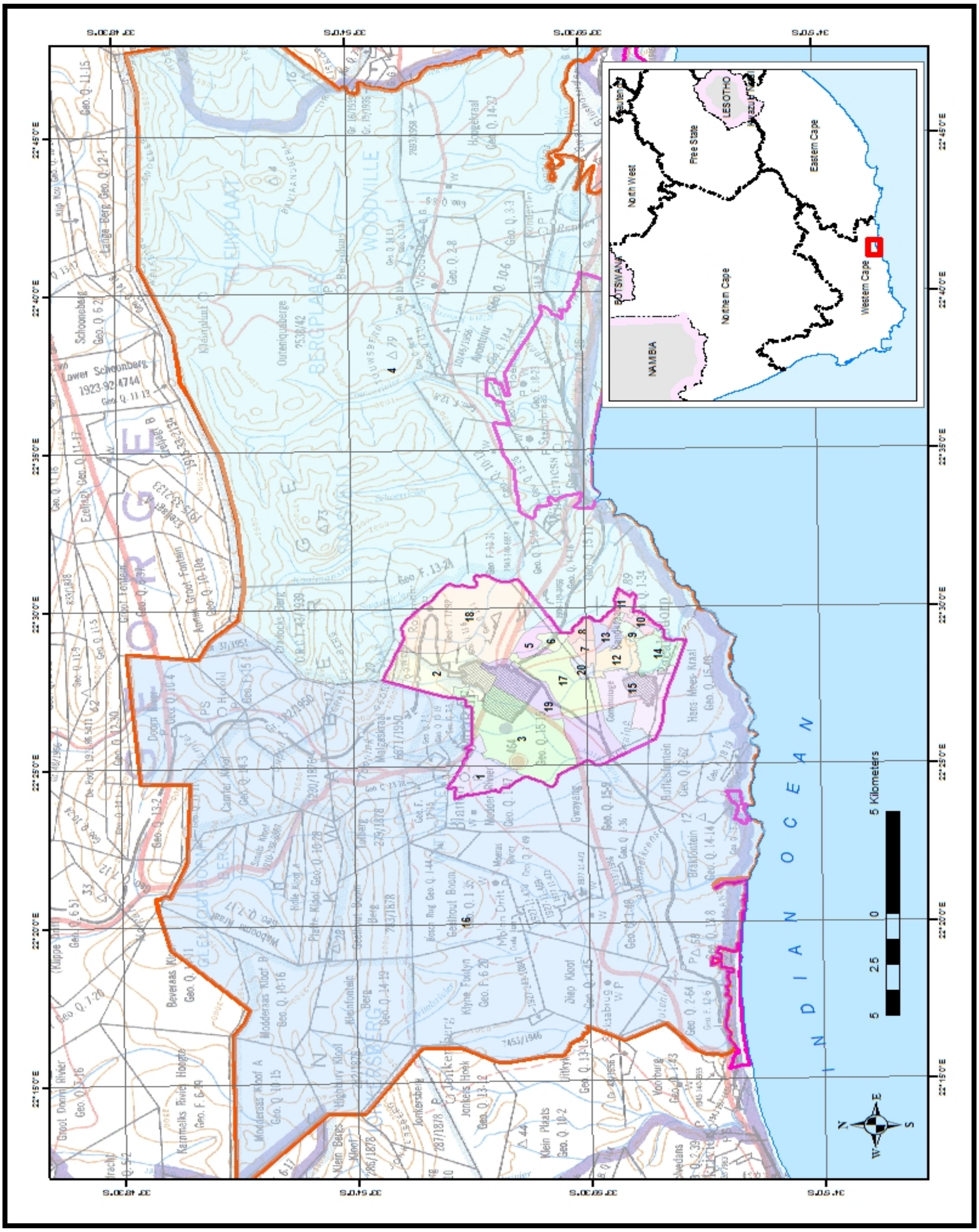
Australia has similar longitudinal ranges to South Africa, with mostly arid to semi-arid conditions (Pereira, Cordery & Iacovides 2009). Australia is "the driest continent" with 80% of its population living in areas that receive less than 600mm of rain annually (Beatley & Newman, 2009:4). In addition, much like South Africa, Australia is primarily subject to a rate of evaporation greater than rainfall (Dallman, 1998). To implement WSUD, the cities of Australia first had to experience drought to seek an alternative to the conventional urban system, which was unsustainable at best. With its progressive legislation, South Africa can implement alternatives before it too suffers what Australia is already experiencing. The municipality of George with its surrounding urban areas of Pacaltsdorp and Wilderness will be investigated. The George municipality was declared a drought disaster area in November 2009, along with many others in the Eden district (Province of Western Cape 2009). The drought is a cause for concern since the municipality is not seen as a water-deficient municipality, as described in the George Spatial Development Framework (GSDF) Volume 2 (George Local Municipality, 2008:44). On the other hand the Reconciliation Study completed in 2007 indicated that the George municipality, along with other municipalities in the district, had their water resource management under control, but that seasonal influxes of tourists during summer months put pressure on the systems due to the lack of adequate water storage facilities such as dams. Since the municipalities in the district have inadequate water storage facilities, the pressure of seasonal demand was seen as a probable cause of deficits (SA, 2009:9). The case study is thus relevant since the municipality was alerted to the issue of probable water deficits.

This chapter first considers how the George municipality is structured. The urban structure of the municipality is examined by emphasising the layout of spatial development in the town. Secondly, the chapter details the climate and rainfall of the town. This is followed by the water resources discussion to assess where the water comes from and where wastewater ends up. Since water services are provided for domestic use, the water consumer profile is also detailed, with mention made of commercial and industrial uses as well. Lastly the soil conditions of the area are discussed in order to explore the options for stormwater quantity and quality management, through channelling stormwater into the soil or wetlands as part of groundwater recharge or stormwater treatment.

### 3.2 GEORGE URBAN FORM

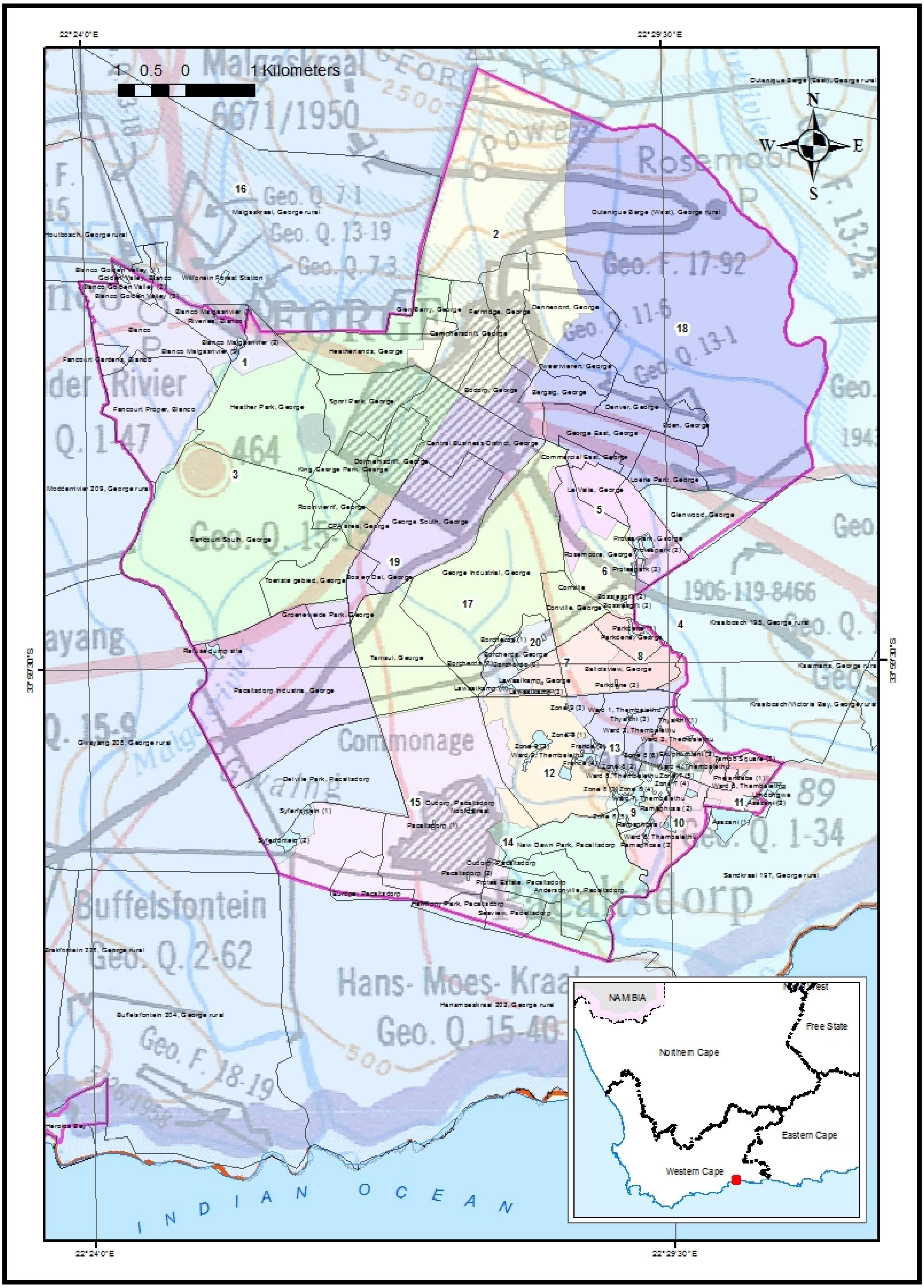
The town of George can be classified almost as a significant urban service centre out of 21 key urban areas in South Africa. This definition is determined by the Geographic Value Added Product (GVA). The GVA is the amount that the town contributes economically to the country's wellbeing. If the GVA requirement of between R4.5 and R9 billion GVA per annum were lowered, George could be classified as such, as mentioned in the State of the Cities Report Chapter 2 (SACN, 2006:14). In Volume 1 of the George Spatial Development Framework (GSDF) mention is made of how the diversity of industrial activities strengthens the economic environment of the town, as does the position of the town along the Cape Town to Port Elizabeth coastal axis, the Mossel Bay to Plettenberg Bay Garden Route axis, and the N9/N12 coast-to-inland axis. The town provides services to the Southern Cape, Little Karoo and Central Karoo because of its accessible location. As well as being a coastal economic hub, the town and surrounding areas benefit also from the growing tourism industry. George has progressed from an "Upward Transitional" position to that of "Secondary Core" type in the national system; it is therefore no longer secondary (secondary town) to the main cores (George Local Municipality, 2008:22).

The urban form of George has been influenced by "Segregated (apartheid) planning" and "Modernist planning". These two forces created a "Dispersed City" which was worsened by the segregation of social groups. Apartheid urban planning created physical separation between communities, e.g., the use of the N2 separating the urban areas of George and Pacaltsdorp. The "Modernist planning" form ensured that land uses were separated and dispersed; the low-income residential areas are situated on the cheaper land on the periphery of the town and the middle income and high incomes area are also decentralised. Services thus have to be provided over long distances which meant without public transport the poor suffered. The lack of land use integration became unsustainable as specified in Volume 1 of the municipality's Spatial Development Framework (George Local Municipality, 2008:33). The town of George received municipality status in 1837 and is currently the administrative hub of the Garden Route Area. The municipal area of George includes the city of George, the coastal resorts of Wilderness, Heroldsbay, Victoria Bay and rural areas such as Rondevlei and stretches to about 1,068km$^2$ (Auditor General 2009:15). See Figure 3.1 illustrating George municipality wards as well as Figure 3.2 a closer look at the urban layout of George with its various suburbs.




**Source:** Van Niekerk (2011, pers com)

**Figure: 3.1:** George municipality wards map



**Source:** Van Niekerk( 2011, pers com)

**Figure: 3.2**: George suburbs map

## 3.3 CLIMATE AND RAINFALL

George enjoys a mild coastal climate, with a small difference between minimum and maximum temperatures. The town experiences hot humid summers (mean of 25º Celsius) and cool rainy winters with an average temperature of 13º Celsius. The town falls within a “uniform rainfall zone” because it receives rainfall throughout the year. The average annual rainfall is 866mm with high rainfall during the months of March and April, and September and October (George Local Municipality, 2008:18). The case study area however has been experiencing a 1 in 130-year drought since 2009 (Gunning, 2009). Records in the area indicate that from January to December 2009 it received 100mm less rainfall than in 1946, the lowest recorded rainfall for the same period (Mooiman, 2010, pers com). A drought is defined as a kind of natural hazard which is worsened by the growth in water demand, but it is very complex to define what type of drought occurs at a particular time (Mishra & Singh, 2010:205). The definition that is deemed most suitable for the drought experienced by the case study area is called a meteorological drought. Meteorological drought is defined as a lack of precipitation over an area for a period of time. This means the drought indicates a precipitation deficit with respect to the average values, and monthly rainfall data is often needed to determine this type of drought. Other studies use the duration and intensity in relation to cumulative/collective precipitation shortages (Mishra & Singh, 2010: 206).

Globally, scientific discussions revolved around the Intergovernmental Panel on Climate Change (IPCC) through its four assessments. The IPCC urges water managers to begin ‘‘a systematic re-examination of engineering design criteria, operating rules, contingency plans and water allocation policies’’ and states with high confidence that ‘‘water demand management and institutional adaptation are the primary components for increased system flexibility to meet the uncertainties of climate change’’ (Mukheibir, 2010:1035). Academics and policy makers started shifting discussions to address the adaptation strategies of countries as a response to Climate Change impact, whereas politicians the world over discussed the mitigation of the emission of greenhouse gases. The aim of all of these discourses is to reach national and regional level, however, the problem is that the resources and capacity at local level to deal with the implementation and operational issues are not always considered (Mukheibir, 2010: 1035).

The National Climate Change Response Green Paper recognises that if international action is not taken to reduce global temperature South Africa will suffer potentially catastrophic consequences.

Predictions indicate that by mid-century the coast of South Africa will warm by 1º C (one degree Celsius) and the interior by 2º to 3º C. By 2020 the coast is predicted to become 3º to 4º C warmer and the interior by 6º C. Some parts of the country will become drier, with a reduction in the availability of water, which would in turn affect human health, agriculture, and the environment (SA, 2010:5). Extreme weather events such as severe floods and droughts and even a rise in sea level are also predicted. However increased $CO_2$ concentrations measured at the Global Atmosphere Watch station at Cape Point indicate climate change impacts can already be observed in South Africa. The sea level is already rising by 1.87mm per year in the west coast and by 1.47mm at the south coast, and by 2.74mm on the east coast. Surface air temperatures and frost days have been observed to have changed with statistical significance since 1950 across the country, and are consistent with and often surpass the rate of mean global temperature rise. An increase in the outbreaks of fires has been recorded in the winter rainfall biomes of the country, as well as an increase in precipitation in the south-west of the country (SA, 2010:5). The south-western part of the country has Mediterranean climatic conditions, with mild and moderate rainy winters and long, hot and dry summers (Miller, 2004:134). During summer months the winter rainfall biomes are drier and are more susceptible to fire since the dead wood of vegetation become more flammable (Dallman, 1998, 10).

The variability of the climate in the George municipality is a concern, since flooding was experienced just prior to the drought in the years 2006 to 2008 (Auditor General 2009:10). For this reason, the concerns voiced on climate change issues need to be addressed by the municipality. There is a link between climate variability and climate change. Climate variability is evident when a local municipality's water resources are affected by periodic droughts which leave the municipality with short-term water shortages. The municipality then responds with short-term strategies as a coping mechanism to meet domestic demand (Mukheibir, 2005:8). This is the same response given by the George local municipality in this study. Strategies of the George municipality are further discussed in Chapter 4 of this study. With climate change on the other hand, the frequency of droughts will increase which in turn would lead to frequent water shortages in local municipalities. In order for the municipality to cope with their vulnerability to frequent droughts long-term strategies need to be promulgated. By having both short-term and long-term strategies the municipality would be ready with adaptation responses (Mukheibir, 2005:9). Two areas of adaptation strategies for local municipalities are supply and demand side management strategies. The supply side management can include measures such as the Water Services Development Plan -which will be discussed in Chapter 4-

and also groundwater resource planning. By planning for the supply side, the municipality would know what resources are available, how and when surface water and groundwater can be used in conjunction and making sure that artificial groundwater recharge is put into operation. On the demand side the municipality can cater for water restrictions, water tariff changes, changes in sanitation systems, awareness campaigns, and the re-use of greywater (Mukheibir, 2005).

## 3.4 WATER RESOURCES

The George municipal area is being supplied with water from the Garden Route dam in the Swart River. The dam has a registered use of 30 Ml/day and extra extraction of 7.3 Ml/day is permitted from the Kaaimans River. The Touws River is also a small source of water to the town of George. The old George area of Heroldsbay, Pacaltsdorp and Thembalethu is supplied by eleven reservoirs and two water towers. The present water supply provides water to the old George area as well as the more recently incorporated locales of Wilderness, Wilderness Heights, Hoekwil, Kraaibosch, Kleinkrantz and Victoria Bay, as detailed in the GSDF Volume 2. Two Water Treatment Plants (WTPs) treat raw water for the town (George Local Municipality, 2008:43). According to the GSDF, urban areas are defined as higher density residential areas, areas of commercial/industrial concentrations, and open space systems. The municipality regulates the urban areas via guidelines that stipulate that an urban edge is necessary to prevent urban sprawl and ensure services can be provided to all (George Local Municipality, 2008: 61). The guidelines also mention the water demand of urban areas that should not burden the water supply, but according to the SDF the average annual growth rate of water demand that can be expected up to 2030, has been estimated at about 6% for the George area (George Local Municipality, 2008:45).

The George area has the Wilderness Lakes but these have been affected by stormwater contamination and poor urban development and the municipality has created Lake Buffer Zones. Various guidelines from the municipality regulate further development near the lakes and estuaries. High density development is promoted and existing developments are required to use solar power, recycle greywater and make use of rainwater harvesting (George Local Municipality, 2008:59).

George municipality has two large Waste Water Treatment Works namely the Gwaing WWTW and the Outeniqua WWTW, as well as smaller WWTWs, at Kleinkrantz, Herolds Bay and Breakwater Bay/The Brink WWTWs. Privately owned WWTWs also opened in the town of George, namely the

Oubaai and Saasveld WWTWs (Nel, 2010, pers com). None of the sludge from the WWTW's can be used for composting, owing to its iron content and variable acidity and alkalinity; also it is disposed of on-site and not at the landfill site (George Local Municipality, 2008:46).

## 3.5 MUNICIPAL WATER CONSUMER PROFILE

The urban environment of George has been divided into four major land uses. The first is the Central Business District (CBD), which still functions as a vibrant commercial hub. The second is the decentralised commercial nodes, e.g., the Garden Route Mall, east of George. The third land use is the industrial area, also central to the town. The last urban land use of the municipality is for residential areas, which are still highly segregated on the basis of income, race and proximity to urban utilities and opportunities. Residential areas are clustered around the CBD with high income communities further away but the poorer\low income communities the furthest to the south and south-eastern side, as the SDF states in Volume 1 (George Local Municipality, 2008:27). A detailed water services level table per ward is illustrated in Appendix A. Table A.1.

Based on the population profile projections for George, the population grew to 194,044 residents in 2009, an annual growth rate of 4.6%, calculated by the draft George Spatial Development Framework (George Local Municipality, 2009a:6). According to Stats SA however George's population grew by 0.1% in previous years, but a full census in 2011 will provide clear figures (George Local Municipality, 2009a:5). With this population the town is thus classified as a "large town" with a population of between 25,000 and 250,000 as mentioned in Chapter 2 of the State of Cities report (SACN, 2006:12).

## 3.6 SOIL CONDITIONS

One of the objectives is to investigate how the existing stormwater system network is mapped out, in order to observe whether stormwater drains empty into areas where groundwater retention and ultimately recharge would be possible, or if such areas could sustain constructed wetlands for beautification and water quality treatment. For these reasons the soil types of the municipality will be examined.

Firstly, groundwater forms part of the hydrological cycle of the earth and since there is more pressure on surface water, groundwater can be seen as a regular and reliable source (Newson, 1994:5).

Groundwater recharge is characterised as a slow process in the hydrological cycle and contributes to 30% of the global water supply, more than the surface water supply (Newson, 1994:5). Because of the flux (flow movement) of water between the surface and the ground and the impact of human activities on this flux, the storage of water in the ground is considered important to this study; this can be influenced by human activities such as wetland drainage, river-flood protection or impoundment of water, which alters the seasonal and short-term nature of water storage in the ground (Newson, 1994:9).

Groundwater retention and recharge is aimed at conserving water for future use. Groundwater retention/recharge works on the principle that water percolates/seeps deeply into the ground as far as the soil can accept. Groundwater recharge methods are used to conserve excess water from floods, for example, for future use (Manning, 1987:112). Soils and rock determine the nature and extent of groundwater storage (Gregory & Walling, 1973:59). Soil is defined as the upper few feet (to a depth of 1.5m/5ft) near the surface where the roots occupy the ground (Manning, 1987:87).

First of all, George soil has one characteristic that stands out which could mean that groundwater retention is a potential water resource management option. The catchment area around the rivers and low-lying lakes in George comprise of Aeolian sands. Aeolian sand is characterised by unconsolidated material, which does not include cementing materials in the porous spaces (porosity) and thus leaves the soil permeable, or free to absorb water (Gregory & Walling, 1973:61). Permeability is thus the property of porous material, such as sand, that allows water to flow through it. Water flows more readily through sand (open voids) than through clay (Manning, 1987:68). Clay on the other hand is characterised as material that does not allow infiltration, as pores often swell tightly together when it becomes hydrated (Manning, 1987:70).

The area is also distinguished by mountains from the Table Mountain Group, which is characterised by the hard, white and soft quartzitic sandstone and Malmesbury Formation strata, composed of quartzites, phyllites and schists, situated above the lakes. The soils from the Table Mountain Group sandstone have poor water retention properties (SA, s.a.). However, schist is an indurated/cemented material which has fewer porous spaces, and thus would not allow water to permeate into these soils (Gregory & Walling, 1973: 61).

## 3.7 CONCLUSION

The case study of the George municipality needed to be put in context and the chapter began with a look at the structure of the George municipality urban area, emphasising the significance of the town and the role it plays in the Eden district. Secondly the chapter elaborated on the climatic conditions and rainfall patterns of the town; since the town falls in a “uniform rainfall zone” and has a mild coastal climate, the drought was a considerable phenomenon and the issues of Climate Change was touched upon. The climate and rainfall section was followed by the water resources discussion to demonstrate resource abstraction and wastewater management. Then the water consumer profile was considered with mention of commercial and industrial uses as well. Since stormwater management is part of WSUD activities, the soil conditions of the area were discussed in the last section of the chapter.

The legislative environment of the National government was elaborated upon in the literature review, but local government which consists of municipalities has to have their own legislation to govern each municipality, hence the need to showcase what legislation guides the George municipality, and this will be discussed in the next chapter.

# CHAPTER 4: MUNICIPALITY LEGISLATIVE RESPONSE

## 4.1 INTRODUCTION

This chapter deals with the identification of actions taken by the George municipality to be more water sensitive in their water resource management processes; it meets part of the second and the fourth objectives of the study by identifying various strategies and plans promulgated by the municipality, before the drought, as a response to the drought and for the future. The strategies, bylaws and plans created by the municipality are identified to demonstrate that an enabling environment was created for proper implementation. These documents reflect what plans the municipality made to manage water resources before the municipality had to manage a drought situation, as well as those promulgated during the drought to manage the disaster, and only a single document reflects future plans. Before the drought the municipality promulgated the George Spatial Development Framework of 2008, the Integrated Development Plan of 2009/10, and the Water Services Development Plan of 2009/10. All three documents specify general plans for water demand management with no emphasis on chronic lack of water but cautionary measures instead. During the drought however the municipality had to act rapidly with the drought situation in order to provide water to the town, and responded with strategy documents such as the Drought Status Report at the beginning of 2010, as well as their Drought Management Policy, a Water Demand Management Strategy, and a Water Services Bylaw. Future plans however are only laid down in the Water Services Development Plan of 2010/11.

## 4.2 IDENTIFIED MUNICIPAL STRATEGIES & PLANS

### 4.2.1 Prior to the drought

#### 4.2.1.1 George Spatial Development Framework (GSDF) 2008

In Volume 1 of the George Spatial Development Framework (GSDF), along with projects to obtain more water resources mention is made of the use of recycled water from wastewater treatment plants (George Local Municipality, 2008:33). In Volume 2 of the document mention is made of the Environmental Impact Assessment (EIA) commissioned for the use of treated effluent from the Outeniqua WWTW which will go to the Garden Route dam and provide an extra 11 Ml/per day. The use of effluent from the Gwaing WWTW is seen as an option for the future. The use of treated effluent is promoted by the municipality for the irrigation of golf courses (George Local Municipality, 2008: 46). The harvesting of stormwater is mentioned as an energy efficient practice as part of rural development opportunities, and not as part of urban development (George Local Municipality, 2008, 55). For the future the GSDF does mention that future developments should be concentrated within existing areas of development and should be subject to rainwater harvesting and installation of water saving devices as mentioned in Volume 2 of the document (George Local Municipality, 2008, 59). Investigation into greywater recycling as an alternative water source is considered, should water demand exceed supply, and the design of environmentally friendly closed wastewater treatment systems for domestic effluent, and reduction in wastewater flow is also discussed (George Local Municipality, 2008, 70). To summarise, the GSDF stresses the need for certain measures: the use of treated effluent from WWTWs not only for irrigation but also for filling the Garden Route dam; the harvesting of stormwater; the recycling of greywater; the installation of water-saving devices, and possibly the design of a closed wastewater treatment system for domestic effluent.

#### 4.2.1.2 Integrated Development Plan 2009/10

In Chapter 3 of the IDP 2009/10 mention is made of the creation of a climate change strategy with aims to do a water-wise campaign as a summary of the Provincial Growth and Development Strategy (George Local Municipality, 2009/10d:44). More detailed endeavours of the municipality are mentioned in Chapter 4 of the IDP as Key Performance Areas with the municipality aiming to repair 98% of pipes burst in 2009 to 2011, and replace 800 water meters each year. Quality management of the stormwater system is mentioned as well, with the municipality aiming to clean only 10% of manholes of debris for the period 2009 to 2011 (George Local Municipality, 2009/10d:69). Cleaning of wards however receives a budget of R275,000, for each ward for each year between 2009 and 2011 (George Local Municipality, 2009/10d:72). The provision of water tanks was budgeted for, with an annual amount of R500,000 for 2009 to 2011, in Ward 4 (Wilderness, Touwsranten and Glenwood) and Ward 16 (Harolds Bay, Dellville Park, Geelhoutboom, Herold, Ou Baai, Waboomskraal, and Sinksabrug) – which it can be assumed is to be used for capturing rainwater (George Local Municipality, 2009/10d:71). To summarise; the IDP document mentions a water-wise campaign; aims to repair 98% of burst pipes; clean only 10% of manholes; the cleaning of wards receives a substantial budget each year and rainwater tank installation is provided in only two wards.

#### 4.2.1.3 Water Services Development Plan 2009/10

The municipality adopted the WSDP of 2009/10 with a Water Demand Management Strategy, identifying various measures to be implemented (Nel, 2010. pers com). These include; the implementation of a new water cost and pricing strategy; the introduction of a leakage management programme; the launching of a socio-political programme; the promotion of water conservation products and the re-use of wastewater. The implementation procedure of the Water Demand Management strategy aims to start the process based on the lowest unit cost of measures and the time and effort it would take to introduce. Implementation will start with addressing water use and waste at the municipal properties and recording the subsequent savings, the initiation of a WC/WDM communication campaign, and thirdly conducting a financial analysis and implementing the proposed tariffs. Other activities include; the design and implementation of a water loss management programme; focusing on large water users to encourage re-use of wastewater in their practices; and lastly, leading by example to encourage residential water users to plant water-wise gardens and install dual flush/low flow toilets. One important aspect of a WSDP is to mention future bylaws planned by the municipality; the bylaw discussed is the Water and Sanitation Services Bylaw in draft form, which will only address service levels but say nothing of water conservation measures. To summarise, the WSDP highlighted WC/WDM as an activity to be implemented for the year 2009 to 2010.

### 4.2.2. During the drought

#### 4.2.2.1 Drought status report (January 2010)

As a response to the drought in the year 2010 the municipality published a status report which states that investigations into future water resource supply were complete by April 2007, and that Water Demand Management was one of the supply options as well as the use of treated effluent (Mooiman, 2010, pers com). A third option mentioned in the document is that the municipality considered enforcing the compulsory installation of rainwater harvesting tanks for new developments, upon developers applying for building permission, even though the municipality could not afford to subsidise the installations. The document highlights the tight restrictions that have been in place since 2009 and the intensification of the awareness campaign since the second half of 2009. The municipality offices however did not wait on the campaign but led by example, initiating various activities at the municipal offices. For example high-volume water consumers were contacted to indicate that their water could be restricted by the municipality if high consumption continued; public toilets received hippo bags/bricks in the cisterns; staff in tourist accommodation and prisons etc. were educated about water saving as well as municipal staff members, and taps and showers on the beaches were disconnected. To summarise, the status report highlighted many activities that had been implemented already in 2009.

#### 4.2.2.2 Drought management policy

The drought management policy was approved by the municipal council so that such a policy would be in place to cope with future drought situations, during periods of low rainfall or a drop in water resources (Mooiman, 2010, pers com). Situation coping mechanisms grow more strict the worse the situation becomes, and are based on several criteria: the level of the Garden Route dam, the Malgas pumping scheme’s permitting a decrease in pumping-volume, and other pumping schemes being utilised optimally. The first indicator to receive a response is the dam falling between 60% and 45% capacity; the response would be WC/WDM measures such as leakage detection, water restrictions, awareness campaigns, etc., and a violations report service would also be made available. If the dam is at 45%, all WC/WDM measures have to be followed, but the municipality would be able to provide the free basic water allowance (6kl/month) to indigent households only. The greater the drop in dam levels the stricter WC/WDM become with penalties for high-volume consumers. However no mention is made of treated affluent use, stormwater management or greenroof installation.

#### 4.2.2.3 Water demand management strategy

The strategy indicates demand management measures taken in the past which include: pipe and leakage repairs, pressure management, an alien invasive plant removal programme, public awareness, bulk meter installation, a block tariff system, indigenous gardening promotion, and many more (Mooiman, 2010, pers com). For the future the strategy stipulates the installation of water meters for each dwelling, retrofitting water-saving appliances, installing rainwater harvesting tanks on all new developments, installing bulk water meters and monitoring bulk pipelines. Greywater re-use is not promoted in this strategy since effluent will be treated to potable standards.

#### 4.2.2.4 Water Services Bylaw to limit or restrict the use of water

The bylaw states only what course the law will take in the case of restrictions being violated (Mooiman, 2010, pers com). Restrictions on water use do not allow any water for irrigation; if irrigation has to be done; specific times of day are allotted. Mention is made of automatic flushing urinals to be disconnected but no mention is made of projects and water conservation measures.

### 4.2.3 After the drought

#### 4.2.3.1 Water Services Development Plan 2010/11

The WSDP 2010/11 stipulates the same water demand management activities as the WSDP 2009/10. What is different is that the 2010/11 document mentions private water demand management options, such as the promotion of private property owners to install greywater systems, but these are expensive and might give cause for health concerns (Mashicila, 2010, pers com). One option for the municipality to consider is the installation of a dual reticulation system, where the extra system carries treated effluent or salty groundwater to households to be used for non-potable purposes such as toilet flushing, laundry and gardening. The document does highlight that this might only be feasible to install when new developments are built (Mashicila, 2010, pers com). For the future the municipality is also considering taking a project for the re-use of effluent to the second phase, as Phase 1 is already in place (Mashicila, 2010, pers com).

## 4.3 CONCLUSION

The George municipality needed to create an enabling legislative environment for the successful implementation of water resource management projects, or rather, WSUD activities. Documents promulgated before the drought included the George Spatial Development Framework of 2008, Integrated Development Plan of 2009/10, and the Water Services Development Plan 2009/10. All three documents stipulate general plans for water demand management. The drought however forced the municipality to provide water and deal with the demand, therefore the Drought Status Report, the Drought Management Policy, a Water Demand Management Strategy, and a Water Services Bylaw was created. Future plans are however specified only in the Water Services Development Plan of 2010/11. Only eight of those WSUD activities identified in the study period were implemented: emergency water tariffs, revised water restrictions, the initiation of an awareness campaign, general localised sanitation services, leakage detection and fixing, as well as the treatment and re-use of wastewater. The management of stormwater quality and quantity was also identified as part of the eight WSUD activities in this study. An analysis of these activities to investigate their impact on water consumption will be discussed in the following chapter.

# CHAPTER 5: MUNICIPALITY WSUD ACTIVITIES ANALYSIS

## 5.1 INTRODUCTION

In order to analyse to what extent the WSUD activities made an impact on water consumption, three types of data/info will be used to compare findings, and will be briefly described beforehand. Firstly, the bulk water meter data will indicate a reduction or increase of bulk water use in a given suburb. Secondly, debtors' data will indicate consumption on a more localised level per sub-ID (which is lower than the suburb's) and even per individual water meter. Bulk water meter data is the data recorded by bulk meters in the Engineering Department of the municipality. Debtors' data is the water consumer data from the municipality Finance Department, which indicate the volume of water used by consumers, per water meter on a property. Lastly, the information that will indicate if the municipality really made a difference in their water consumption patterns is in the Eden Water Crisis Reports. These reports were compiled by the Eden District Municipality to monitor the local municipalities' response to drought project implementation. By investigating these reports it will indicate either that the municipality reported accurate or inaccurate information regarding water consumption levels – since the bulk water data and the debtors' data might indicate otherwise.

The data/info mentioned above will be used to compare the extent of project/activity implementation by investigating eight examples of projects initiated by the municipality for which data was received from the Engineering Department. The eight examples include; implementation of emergency water tariffs, and revised water restrictions, the initiation of an awareness campaign, general localised sanitation services, leakage detection and fixing, as well as the treatment and re-use of wastewater. The last two out of the eight examples are projects/activities concerned with the management of stormwater quality and quantity management.

## 5.2 WSUD ACTIVITY ANALYSIS

### 5.2.1 Data to correlate the extent of WSUD activities

#### 5.2.1.1 Bulk water data - January 2008- December 2010

Bulk water data was obtained from the Engineering Department of the George municipality for 35 bulk meters (May, 2011, pers com). Data captured by the municipality from bulk water meters in the different suburbs from January 2008 to December 2010 was used. The data reflect only the volume of water measured at the bulk water meters but correlations can be drawn between the bulk water data and the debtors' data. Not all meters will be of relevance as data are only needed for suburbs where WSUD activity was implemented. Data will assist in determining how much water has been used by the domestic, commercial, and industrial sector. Readings took place on a weekly basis (May, 2010, pers com), but one impediment to clear data collection was the inconsistency of these readings. Often readings were not done – one can only assume that either teams did not go out to do readings, and values might have been estimated, or that a meter might have been broken and had to be replaced, the fault discovered only after a while. For this reason readings often stop abruptly and start again with zero, after a meter was fixed. Spatial data received from a consultancy firm (Kv3) which provides strategic support to the municipality, often indicate a bulk meter on the map, but the data list would not show meters. Often data were not captured because certain meters were considered offline – or there was simply no explanation given as to why no readings were taken. Furthermore, data for certain bulk meters at one point were extremely high but suddenly showed an extremely low water usage, as in the case of the three Fancourt Golf Course bulk meters, detailed in Appendix C.

#### 5.2.1.2 Debtors' data – January 2008-June 2011

Debtors' data is the data collected and managed by the Finance department of the municipality. Data was collected personally from the Finance Department, (see Appendix B for the official letter used to gain a visit to the municipality). This data reflects the water accounts per user, and indicates the actual meter reading (i.e., previous reading and new reading) as well as consumption values from month to month. See Figure 5.1 for an example of debtors' data. Consumption is calculated using the difference between the previous reading and the new reading. In the context of the data provided, water consumption is chosen as a means to measure the impact of a WSUD activity since actual meter readings would only show increases from month to month but not fluctuations from month to month. Consumption values would thus indicate an increase in the actual meter reading increases or a decrease in the actual meter reading increases from month to month. These fluctuations in consumption can indicate a change in a water account. Data were analysed while keeping this in mind.

**Table 5.1:** Debtors' data example

Suburb : START : END : ZZZZZ
Billing Cycle : START : 2010-01 END : 2011-06
Service Type : W
Consumption in excess of :

Suburb 35

| Debtor's Account No. | Name of Debtor | Subgrp | Billing Period | Previous Reading | New Reading | Meter Factor | Consumption | Erf No. | Subdiv |
|---|---|---|---|---|---|---|---|---|---|
| Site Address: 158 PROGRESS STREET | | | | | | | | | |
| 28700200102 | TOETSTERREIN | I/DOM | 2011-03 | 4285.000 | 4298.000 | 1.000000 | 13.000 | 00000464 | 00000 |
| Site Address: 158 PROGRESS STREET | | | | | | | | | |
| 28700200102 | TOETSTERREIN | I/DOM | 2011-04 | 4298.000 | 4308.000 | 1.000000 | 10.000 | 00000464 | 00000 |
| Site Address: 158 PROGRESS STREET | | | | | | | | | |
| 28700200102 | TOETSTERREIN | I/DOM | 2011-05 | 4308.000 | 4321.000 | 1.000000 | 13.000 | 00000464 | 00000 |
| Site Address: 158 PROGRESS STREET | | | | | | | | | |
| 28700200102 | TOETSTERREIN | I/DOM | 2011-06 | 4321.000 | 4343.000 | 1.000000 | 22.000 | 00000464 | 00000 |

**Source:** George municipality finance department

The data of the debtors are not reflected per suburb but rather by sub-IDs, whereby a suburb is divided into specific numbers. Sub-IDs had to be identified using the street names reflected in the data. Sixty-five sub-IDs were identified in the municipality and available data of sub-IDs start from January 2008 to June 2011, a total of 42 months. The number of sub-IDs in a suburb is not consistent, and the number of debtors per sub-ID is not consistent either. Data received from the Finance Department had to be converted from Microsoft Notepad to Microsoft Excel spreadsheets. However not all debtors' data will be of relevance, but only those debtors' data identified in the implemented WSUD activity specified during the study period, and this will follow in this chapter. The data are sorted according to water account numbers since the account number is a constant factor. The one variable factor is the erf number of a property. Different situations that have been reflected by the debtors' data needed to be taken into consideration:

- Each debtor is assigned an account number which is linked to a person, a business or industrial company. The account number stays the same but the erf linked to the water account can change since debtors move from erf to erf.
- On the other hand account numbers can be linked to more than one erf, which can suggest that the debtor owns more than one property and thus pays for water consumption at two erven.

- Another aspect to consider is that more than one meter can also be installed on one erf with more than one debtor paying for the water consumption. An example of such a situation can be where a church has a crèche on its erf, and the church pays for water consumed at the church building, but the crèche owner or tenant pays for water consumed at the crèche's building.
- More than one meter can also be installed on one erf with one account holder (debtor) as well, which means that one person pays for two meters on one property. This can happen on business premises with different buildings but one owner of those buildings or it can be a house with a garage with living quarters which can be rented out to a tenant.
- One impediment to mention is that sometimes an account holder's data is not complete. Often volumes recorded on the water account stop abruptly. The assumption is that the water meter was faulty and had to be replaced hence the reading had to start from zero again, as in the case of the bulk water meters mentioned before. Data were often also missing from debtor's records and in that case the debtor's account was not used for data analysis.
- During the data analysis/sorting process it was recognised that the data were sorted according to the different document types. For example indigent consumers were recorded according to a data document type named INDIG, high volume consumers as TOPCO and business as BUS, etc. Sorting the various debtors according to these documents was helpful in the analysis process.

In order to make sense of the data, only reliable account numbers per WSUD activity can be used to ensure consistency from January 2008 to June 2011. In the end various assumptions can be drawn out of the data which include;

- Consumption (kilolitres) per debtor/account holder
- Consumption (kilolitres) of a sub-ID
- Comparisons can be made between two or more sub-IDs
- The extent of WSUD activity implementation can be tracked by using a timeframe from before an activity, the start of an activity, to the end of available data
- A correlation between the bulk water data and the debtors' data identified in the sub-IDs if bulk meter data is available for the specific suburb

### 5.2.1.3 Eden Water Crisis Management Progress Reports and Water Supply Status Reports: January 2010 to February 2011

The Eden Water Crisis Reports were and still are monitoring tools compiled by the Eden District Municipality. They indicate the progress of local municipalities, with regard to rainfall patterns, water supply (dam levels) and demand of water during and immediately after the drought period. Local municipalities and the district municipality are monitored by the Western Cape Region's Department of Water Affairs (DWA). The significance of these reports is that they represent what has been reported to the Eden district municipality by the local municipalities. Reports claim to indicate what percentage of water has been saved by introducing various WSUD activities, but they were sporadically compiled, hence not all the months of 2010 will be reflected in analysis. The reported reduction in water consumption is summarised in Table 5.2 below. The municipality aimed to reduce consumption to 15kl/household per month.

**Table 5.2: Eden Water Crisis/Supply Reports**

| Name of Report | Date of Report | Supply risk rating | Average daily consumption and daily consumption per person reduction |
|---|---|---|---|
| Eden District Municipality Water Crisis Management Progress Reports | 15 January 2010 | High Risk: less than 3 months of water supply in storage. | • From 35.6 Ml/day in December 2008 to 25.1 Ml/day during December 2009, a reduction of 30%.<br>• Daily consumption per person measured in December 2008 and 2009 has decreased from about 200 to140 litre/person/day. |
| Eden District Municipality Water Crisis Management Progress Reports | 12 February 2010 | High Risk: less than 3 months of water supply in storage. | • From 35.67 Ml/day in January 2009 to 22.92 Ml/day during January 2010, a reduction of 36%.<br>• Daily consumption per person measured in January 2009 and 2010 has decreased from about 198 to 127 litre/person/day. |

| | | | |
|---|---|---|---|
| Eden District Municipality Water Crisis Management Progress Reports | 05 March 2010 | Medium Risk: 3 to 6 months of water supply in storage. | • From 43.096 Ml/day in February 2009 to 24.514 Ml/day during February 2010, an excellent reduction of 43%.<br>• Daily consumption per person measured in February 2009 and 2010 has decreased from about 238 to 136 litre/person/day. |
| **Name of Report** | **Date of Report** | **Supply risk rating** | **Average daily consumption and daily consumption per person reduction** |
| Eden District Municipality Water Crisis Management Progress Reports | 08 April 2010 | Medium Risk: 3 to 6 months of water supply in storage. | Not included |
| Eden District Municipality Water Crisis Management Progress Reports | 07 May 2010 | Medium Risk: 3 to 6 months of water supply in storage. | • From 34.545 Ml/day in April 2008 to 22.026 Ml/day during April 2010, an excellent reduction of 36%.<br>• Daily consumption per person measured in April 2008 and 2010 has decreased from about 192 to 122 litre/person/day. |
| Eden District Municipality Water Crisis Management Progress Reports | 05 July 2010 | Low Risk: more than 6 months of water supply in storage. | • From 32.82 Ml/day in June 2008 to 22.01 Ml/day during June 2010, an excellent reduction of 33%.<br>• Daily consumption per person measured in May 2008 and 2010 respectively, has decreased from about 182 to 123 litre/person/day. |
| Eden District Municipality Water Crisis Management Progress Reports | 31 October 2010 | Low Risk with Sustainability indicator: sustainable water supply of more than 12 months. | • From 33.63 Ml/day in October 2008 to 22.08 Ml/day during October 2010, an excellent reduction of 35%.<br>• Daily consumption per person measured in 2008 and 2010 respectively, has decreased from about 187 to 123 litre/person/day |
| Eden District Municipality Water Supply Status Report | 31 December 2010 | Sustainability indicator: sustainable water supply of more | Not included |

| | | | |
|---|---|---|---|
| | | than 12 months. | |
| Eden District Municipality Water Supply Status Report | 28 February 2011 | Sustainability indicator: sustainable water supply of more than 12 months. | Not included |

**Source:** Summers (2010, pers com)

Water consumption data of 2010 was compared with data from previous years (2008 & 2009) and not month to month in 2010. The summary above shows consumption decreased per month in comparison to the years before. According to the Water Crisis Reports the George municipality was already in low risk in July 2010 with more than 6 months' water supply in storage. WSUD activities still continued past this date however as will be discussed further in this chapter.

### 5.2.2. Implemented WSUD activities

#### 5.2.2.1 Emergency water tariffs from 27 November 2009 to 27 December 2010

The tariff returned to normal on 27 December 2010 (George Local Municipality, 2011). The tariffs were imposed on the whole town, domestic, commercial and industrial water use sector. The emergency tariff structure was published on the municipality website during the drought months from 2009 and during 2010, as illustrated in Table 5.3 below. Analysis of the impact of tariff changes on consumption will follow after the restriction section of 5.2.2.2.

**Table 5.3: Emergency Tariff structure**

| **Consumption per month** | **Domestic Tariff Indigent Households** | **Domestic Tariff code (1401)** | **Industries/Businesses (with consumption < 100kl / day) Tariff code (1402)** |
|---|---|---|---|
| 0 – 6 kl | **Free** | **R 7,30 / kl** | **R 10,95/ kl** |
| > 6 – 15 kl | **R7.30/kl** | **R 10,95 / kl** | **R 10,95/ kl** |
| > 15 – 30 kl | R 16,80 / kl | R 16,80 / kl | R 16,80 / kl |
| > 30 – 50 kl | R 30,30 / kl | R 30,30 / kl | R 30,30 / kl |
| > 50 kl | R 60,00 / kl | R 60,00 / kl | R 60,00 / kl |

**Source:** George Local Municipality (2009b)

#### 5.2.2.2 Revised Water Restrictions since 07 December 2009 to 25 November 2010

Water restrictions were enforced in the George municipality from 07 December 2009 (George Local Municipality, 2009c). In a meeting on 25 November 2010 the municipality council decided to ease restrictions since the area had received some rainfall (George Local Municipality, 2011). Restriction of water use included prohibition of the watering of gardens and sport fields using potable water; car-washing was banned, although some exemptions were granted, especially for businesses. The cleaning of hard surfaces with water and the filling of swimming pools were also prohibited. Private water supplies, such as borehole water could be used for the above mentioned purposes, but otherwise restriction violations were punished with a fine or imprisonment.

The emergency tariffs and restrictions were imposed on the whole town of George, Pacaltsdorp and Wilderness. In order to examine the extent of these activities high income suburbs was compared with the lower income suburbs. As shown in Table 5.4 below, the wards have been sorted and ranked according to an income bracket of between R1 and R1600 per month. The assumption is that the ward that has the lowest percentage of residents for this income bracket (R1-1600) represents the wealthiest wards, and the wards with the highest percentage of that bracket represent the poorest wards. In an attempt to analyse the impact that WSUD has had on actual water usage behaviour, the three highest ranked wards (wards 3, 2 and 18 – higher income) were compared with the three lowest ranked (or ranked to be the poorest) wards, wards 13, 9 and 11. All of these poorest wards fall within the Thembalethu area which presents a problem. According to the debtors' data, these wards fall within sub-IDs 40, 41 and 42. To complicate matters, these sub-IDs also contain the debtors' data of wards 10 (ranked 17$^{th}$) and 12 (ranked 11$^{th}$). For the high income wards, four sub-IDs were identified, namely sub-IDs 7,2,19 and 25, and are represented as follows:

- Ward 2
  - Suburb: Bo-Dorp
  - Number of debtors for the purpose of analysis: 129
  - Sub-ID 2
- Ward 2
  - Suburb: Denneoord
  - Number of water users for the purpose of analysis: 251
  - Sub-ID 25
- Ward 3
  - Suburb: Dormehls Drift

- Number of water users for the purpose of analysis: 49
- Sub-ID 7

- Ward 18
    - Suburb: Loerie Park
    - Number of debtors for the purpose of analysis: 250
    - Sub-ID 19

All indigent water consumers were excluded from these sub-IDs' debtors' data, to ensure that poorer consumers were not part of the high income ward. To solve the problem of having too many different debtors in the three poorest sub-IDs (40, 41 and 42) with approximately 160,000 lines of data, which might not be relevant, the procedures below were followed:

A decision was made to include only debtors who were marked as indigent, since they fall into the three poorest wards (as indicated by the code/file name INDIG). The number of debtors for this exercise was found to be 4410, of which only 2621 (or 59%) were found to be consistent over the 42 month period. Sub-ID 41 was excluded because it represents only 12 indigent water account holders.

Since four sub-IDs will be used from the highest income category, data was randomly selected from sub-ID 40 (which represents 2543 consistent users) and arranged into three separate groups for the purpose of analysis. The data groups are thus described as follows:

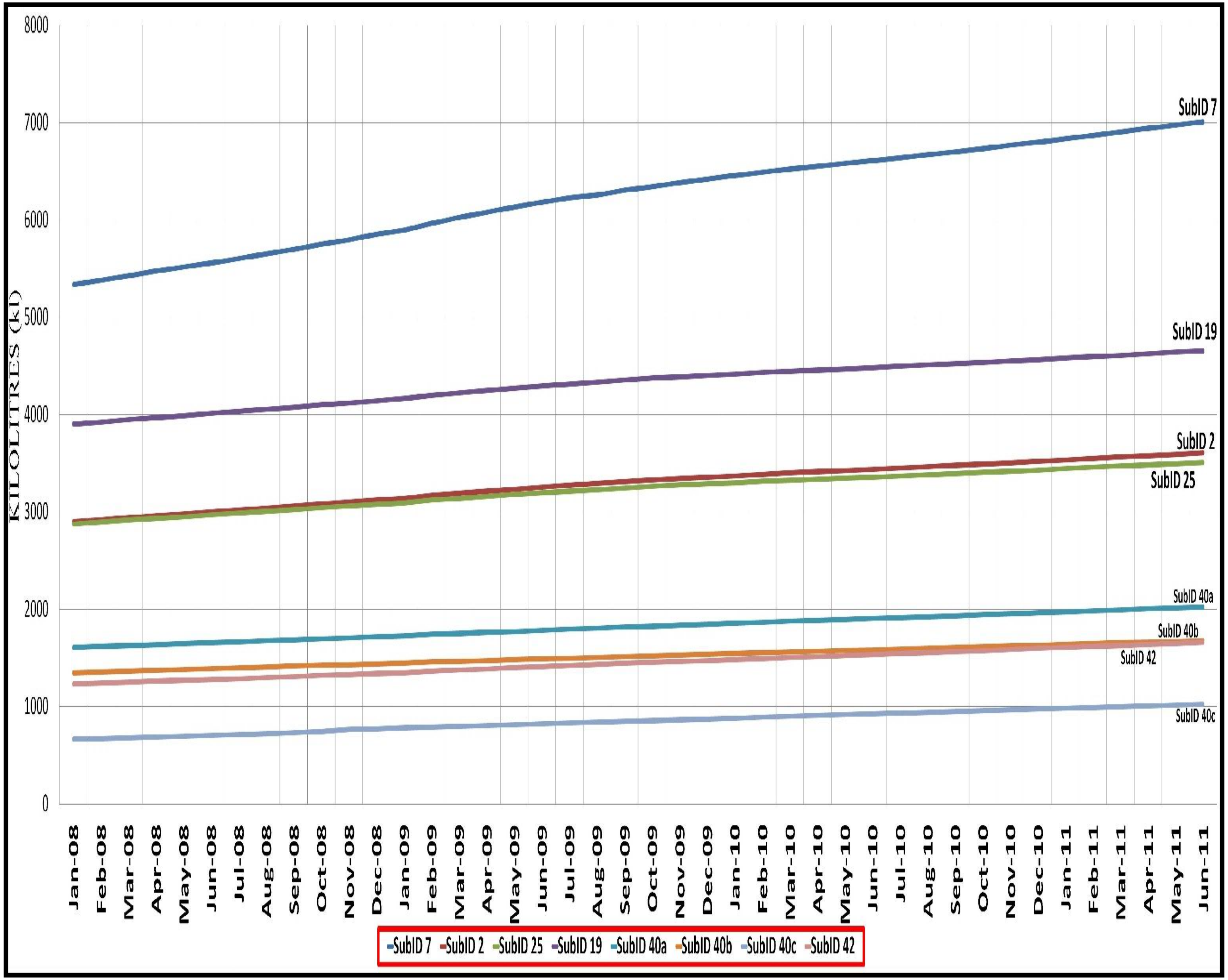
- Sub-ID 40a
    - Number of debtors for the purpose of analysis: 140
- Sub-ID 40b
    - Number of debtors for the purpose of analysis: 187
- Sub-ID 40c
    - Number of debtors for the purpose of analysis: 177
- Sub-ID 42
    - Number of debtors for the purpose of analysis: 53

**Table 5.4: Water consumption profile**

| | | | GENDER | | EMPLOYMENT | | | HOUSING | | | INCOME | | | | Piping | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rank (R1 - R1600) | Ward | Population Total | Male | Female | Paid Employee | Unemployed | Self Employed | Formal Housing | Informal dwellingin backyard | Informal dwelling not in backyard | No Income | R1 - R1600 | R1601- 12800 | R12801 - R25600+ | Piped in Dwelling | Piped in Yard | Piped Community Strand <200m | Piped Community Strand >200m |
| 1 | 3 | 6101.15 | 49.34 | 50.51 | 35.03 | 0.54 | 11.43 | 99.63 | 0.37 | 0 | 0.74 | 1.84 | 28.15 | 8.15 | 98.89 | 0.37 | 0.37 | 0 |
| 2 | 2 | 5662.34 | 47.81 | 52.19 | 31.03 | 55.17 | 9.66 | 98.8 | 0.8 | 0.4 | 1.59 | 5.58 | 66.93 | 12.75 | 97.61 | 0.8 | 0.4 | 0 |
| 3 | 18 | 6610.67 | 49.25 | 50.75 | 25.21 | 57.14 | 13.28 | 98.99 | 0 | 0.37 | 1.11 | 5.91 | 48.72 | 19.93 | 98.89 | 0.37 | 0.74 | 0 |
| 4 | 19 | 8682.11 | 49.83 | 50.17 | 39.05 | 48.7 | 9.22 | 97.67 | 1.66 | 0 | 2.66 | 6.97 | 63.12 | 20.6 | 98.67 | 0.66 | 0 | 0 |
| 5 | 5 | 6278.19 | 47.42 | 52.58 | 52.49 | 52.49 | 1.66 | 87.31 | 4.48 | 7.84 | 2.99 | 19.04 | 47.77 | 4.1 | 84.33 | 7.84 | 6.72 | 1.12 |
| 6 | 15 | 7606.73 | 45.8 | 54.2 | 46.69 | 47.95 | 1.74 | 83.49 | 4.78 | 11.74 | 0.87 | 26.52 | 56.53 | 10.87 | 76.52 | 10.87 | 11.3 | 0.87 |
| 7 | 16 | 9753.79 | 58.63 | 50.34 | 48.84 | 41.28 | 5.23 | 80.16 | 2.35 | 16.45 | 2.09 | 32.37 | 43.07 | 13.84 | 53.79 | 6.01 | 11.49 | 1.83 |
| 8 | 1 | 5454 | 45.65 | 54.35 | 43.86 | 45.15 | 1.55 | 83.23 | 3.87 | 12.9 | 2.26 | 38.38 | 27.42 | 0.97 | 78.39 | 15.16 | 3.87 | 2.26 |
| 9 | 4 | 9436.32 | 50.05 | 49.95 | 39.24 | 51.16 | 3.49 | 68.46 | 1.68 | 29.19 | 5.03 | 45.97 | 42.29 | 2.02 | 54.03 | 9.73 | 21.81 | 8.05 |
| 10 | 6 | 7536.81 | 45.51 | 54.23 | 45.8 | 48.02 | 1.63 | 88.81 | 9.75 | 1.44 | 4.33 | 46.57 | 39.71 | 0 | 83.03 | 11.19 | 4.69 | 0.72 |
| 11 | 12 | 7619.17 | 49.32 | 50.63 | 43.69 | 47.53 | 2.21 | 85.22 | 1.54 | 12.86 | 4.22 | 51.44 | 29.94 | 0.96 | 58.93 | 29.75 | 7.87 | 1.54 |
| 12 | 17 | 5255 | 47.06 | 52.94 | 42.37 | 55.07 | 0 | 87.4 | 6.11 | 3.82 | 1.53 | 53.44 | 44.66 | 0 | 87.79 | 8.78 | 2.29 | 0 |
| 13 | 8 | 6184.6 | 48.55 | 51.45 | 37.48 | 52.9 | 0.86 | 82.07 | 1.99 | 15.94 | 1.2 | 56.57 | 41.83 | 0 | 79.68 | 4.78 | 7.97 | 6.77 |
| 14 | 7 | 6661.4 | 47.71 | 52.29 | 41.99 | 50.61 | 1.33 | 87.41 | 8.15 | 4.07 | 4.44 | 58.52 | 29.26 | 0.74 | 66.3 | 31.48 | 1.11 | 0 |
| 15 | 14 | 8987.18 | 46.44 | 53.56 | 36.07 | 58.2 | 1.39 | 97.63 | 0.4 | 1.98 | 4.35 | 64.82 | 30.05 | 0 | 97.23 | 0.79 | 0.79 | 0 |
| 16 | 20 | 6099 | 46.76 | 53.24 | 35.73 | 60.33 | 0.95 | 84.46 | 2.39 | 12.75 | 4.78 | 65.33 | 28.29 | 0 | 69.72 | 19.52 | 9.37 | 0.8 |
| 17 | 10 | 5276.7 | 47.77 | 50.78 | 37.37 | 56.09 | 1.84 | 83.23 | 3.87 | 12.9 | 6.84 | 78.7 | 13.69 | 0.38 | 44.11 | 31.56 | 6.84 | 17.49 |
| 18 | 13 | 5683.42 | 47.38 | 52.41 | 33.7 | 57.21 | 1.72 | 59.59 | 0 | 38.78 | 0.82 | 80.41 | 18.77 | 0 | 45.31 | 41.63 | 3.67 | 3.67 |
| 19 | 9 | 4434 | 47.52 | 52.03 | 34.35 | 58.16 | 1.36 | 60 | 1.3 | 38.26 | 4.35 | 82.17 | 13.48 | 0 | 39.13 | 35.65 | 11.3 | 12.17 |
| 20 | 11 | 6082.41 | 49.08 | 50.83 | 36.38 | 56.78 | 2.01 | 54.64 | 1.43 | 43.21 | 1.79 | 86.43 | 11.07 | 0 | 33.57 | 35.71 | 17.86 | 11.79 |

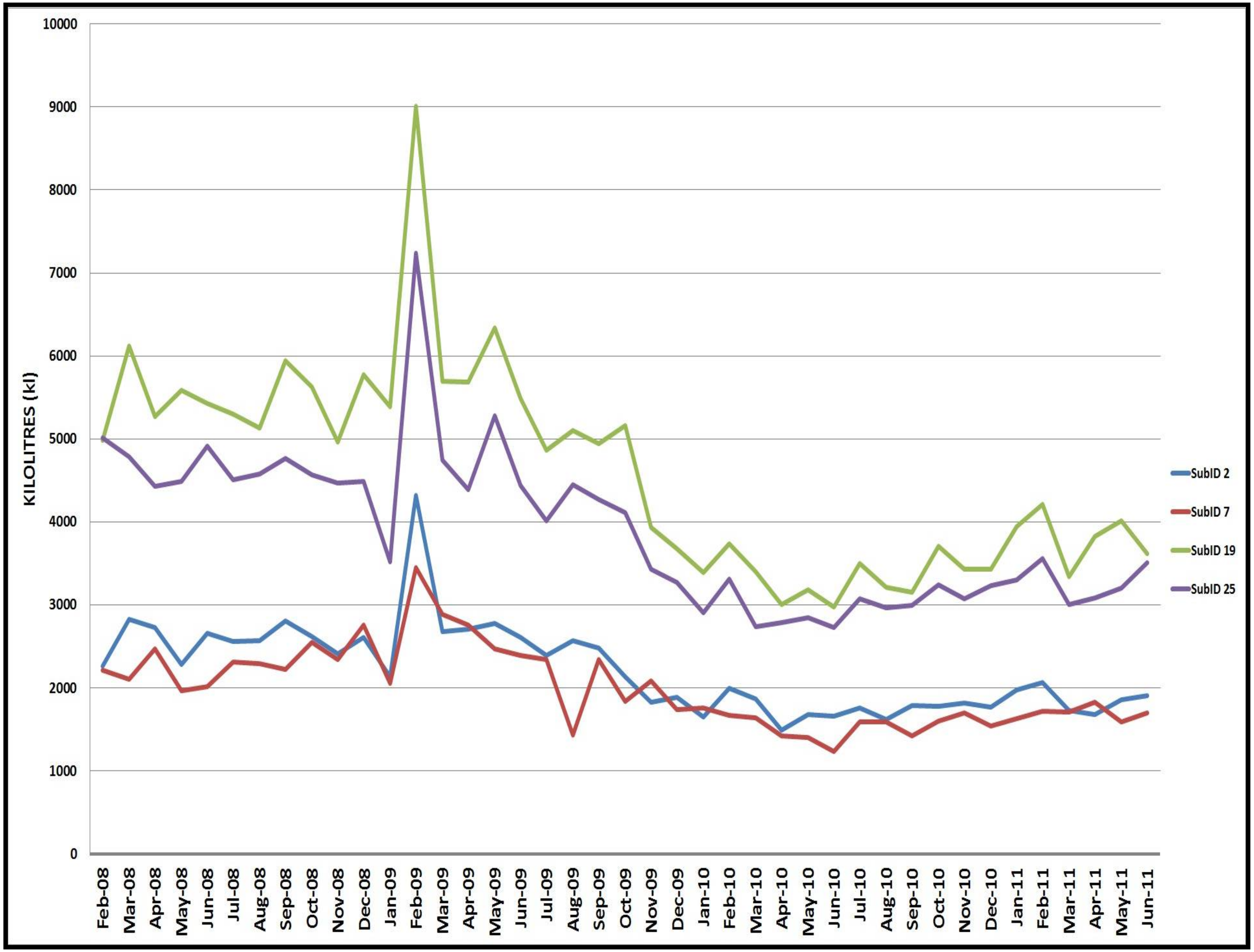
Three sets of calculations and graphs were generated with:

- Average actual water usage: the new readings for each analysis group was added and then divided by the number of water account holders for each group, which gave the average water account usage (water usage per account holder) for each group.
- The consumption value (old reading minus new reading) per group, per month was generated for each group. If consumption is negative, then it means that there has been a decrease in water being used. If the consumption is positive, then it means that there is an increase in water being used. Furthermore, if, for example, water usage increases (positive consumption) in February and March, but the consumption for March is greater than consumption for February, it means that the increase in the water being used for March is greater than the increase for water used in February. To put it another way, consumption increases at an increasing rate.
- The percentage increases were generated for the months of September, October, November and December during the years 2008, 2009 and 2010. This was done adding the consumption values (for each suburb and/or group) for each month and then dividing it by the sum of the actual water usage (for each suburb and/or group) for each previous month, and multiplying by 100.




**Source**: George municipality finance department

**Figure 5.1:** All sub-IDs average actual water usage comparisons




Source: **George municipality finance department**

**Figure 5.2**: Consumption value for high income sub-IDs

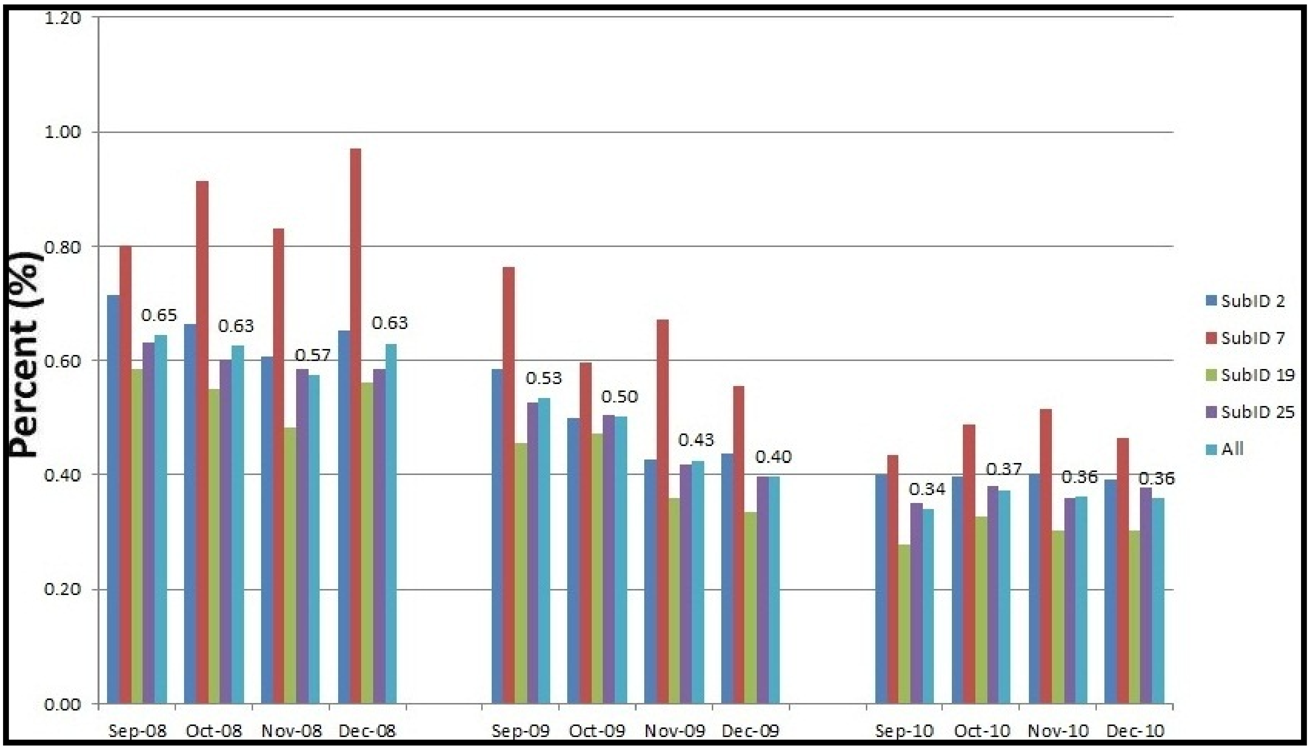
The findings are:

- Average actual water usage for all sub-IDs: The higher income sub-IDs (2, 7, 19 and 25) used more water than the poorer sub-IDs as seen of Figure 5.1.
    - The consumption values for the high income users generated in Figure 5.2 above suggest that there may have been a decline in water usage during and after the month of October 2009, when the awareness campaign began. The tariff changes and restrictions came into effect in November 2009 and December 2009 respectively. A reduction in consumption can be seen for those three months, and the decline seems to come to an end in the month of June 2010 after which an increase is apparent. The Eden Water Crisis report for July 2010 does mention that the municipality was already in Low Risk in the drought period, with more than six months' supply of water (Summers, 2010 pers com).
- The percentage increases: a new bar chart was generated by using the percentage increases from one month to the next, using the months of September, October, November and December. The actual numbers and the accompanying graph are displayed below in Table 5.5.

**Table 5.5:** Percentage values high income sub-IDs

| 3 | | Sep-08 | Oct-08 | Nov-08 | Dec-08 | Sep-09 | Oct-09 | Nov-09 | Dec-09 | Sep-10 | Oct-10 | Nov-10 | Dec-10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | SubID 2 | 0.71 | 0.66 | 0.61 | 0.65 | 0.58 | 0.50 | 0.43 | 0.44 | 0.40 | 0.40 | 0.40 | 0.39 |
| 5 | SubID 7 | 0.80 | 0.92 | 0.83 | 0.97 | 0.76 | 0.60 | 0.67 | 0.56 | 0.44 | 0.49 | 0.52 | 0.46 |
| 6 | SubID 19 | 0.59 | 0.55 | 0.48 | 0.56 | 0.46 | 0.47 | 0.36 | 0.33 | 0.28 | 0.33 | 0.30 | 0.30 |
| 7 | SubID 25 | 0.63 | 0.60 | 0.58 | 0.58 | 0.53 | 0.50 | 0.42 | 0.40 | 0.35 | 0.38 | 0.36 | 0.38 |
| 8 | All | 0.65 | 0.63 | 0.57 | 0.63 | 0.53 | 0.50 | 0.43 | 0.40 | 0.34 | 0.37 | 0.36 | 0.36 |

**Source:** George municipality finance department




**Source:** George municipality finance department
**Figure 5.3:** Percentage values high income sub-IDs

Figure 5.3 shows a bar chart with the percentage increases (as calculated in table 5.5.). The bar labelled 'All' is the total percentage increase for the four sub-IDs in the high income wards. Similar to the consumption value graph in Figure 5.2 once again, it is significant that the 2009 period is characterised by consecutive decreases, as opposed to the water usage patterns of 2008 and 2010. This could suggest that the three measures (tariffs, restrictions and awareness) did have an impact on water usage behaviour for a short period.

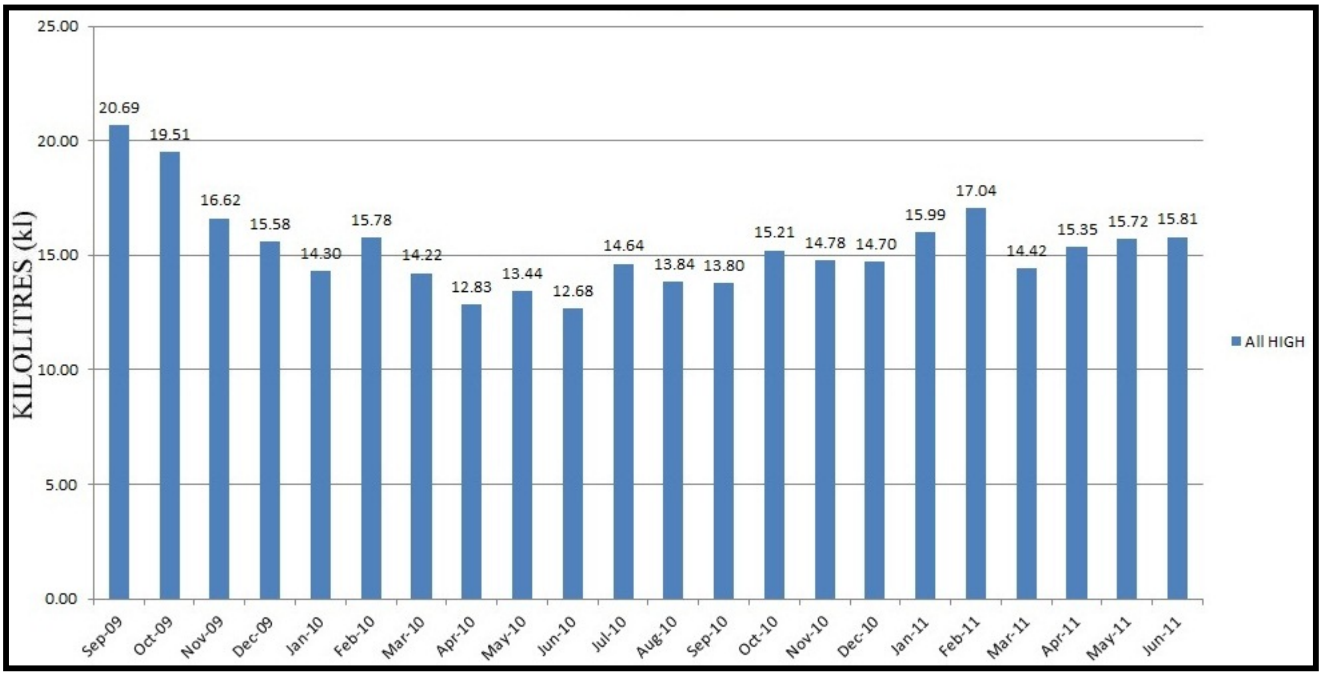
The Eden Water Crisis Report indicated that there was a 43% decrease in water consumption in February 2010 compared to February 2009 (Summers, 2010, pers com). With similar comparisons of all the percentage values for the high income sub-IDs (sub-IDs 2, 7, 19, and 25) it was discovered that those sub-IDs actually show a 55% decrease as seen in Table 5.6.

**Table 5.6:** Percentage decrease high income sub-IDs

| | |
|---|---|
| Feb-09 | 24020 |
| Feb-10 | 10712 |
| Difference | 13308 |
| % decrease | 55.40383 |

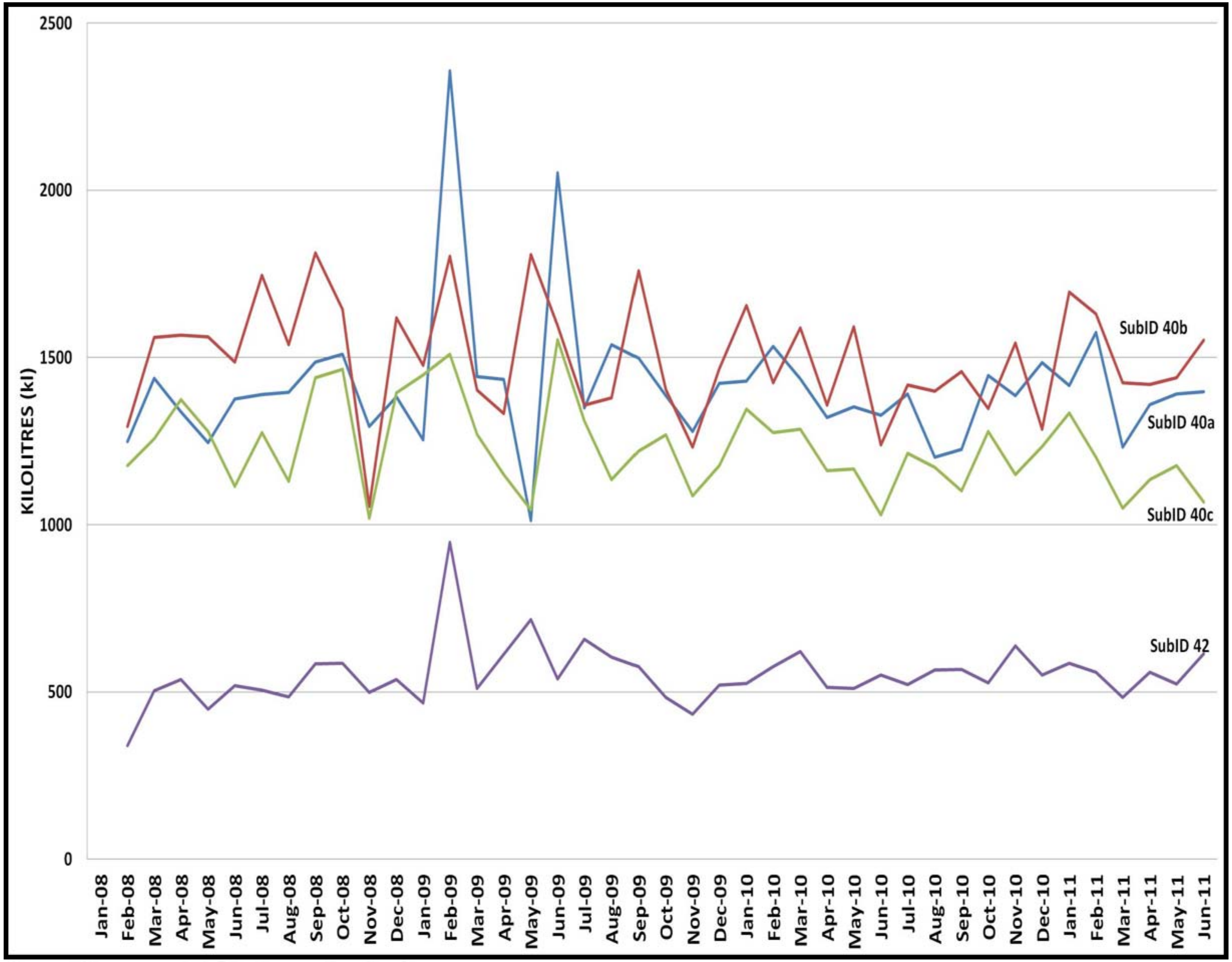
**Source:** George municipality finance department

The municipality aimed to reduce consumption of households by 15kl/household per month (Summers, 2010, pers com). By using the debtors' data for all four sub-IDs (high income) from the month of September, 2009 to June 2011, the average consumption values were generated and are shown in the graph in Figure 5.4. According to the results, the municipality managed to attain these results. Furthermore, the graph below suggests that there have been significant decreases since October 2009, up until June 2010 – after which it seems to be the case that consumption increased above 15kl.




**Source:** George municipality finance department
**Figure 5.4:** All high income sub-IDs average decreases

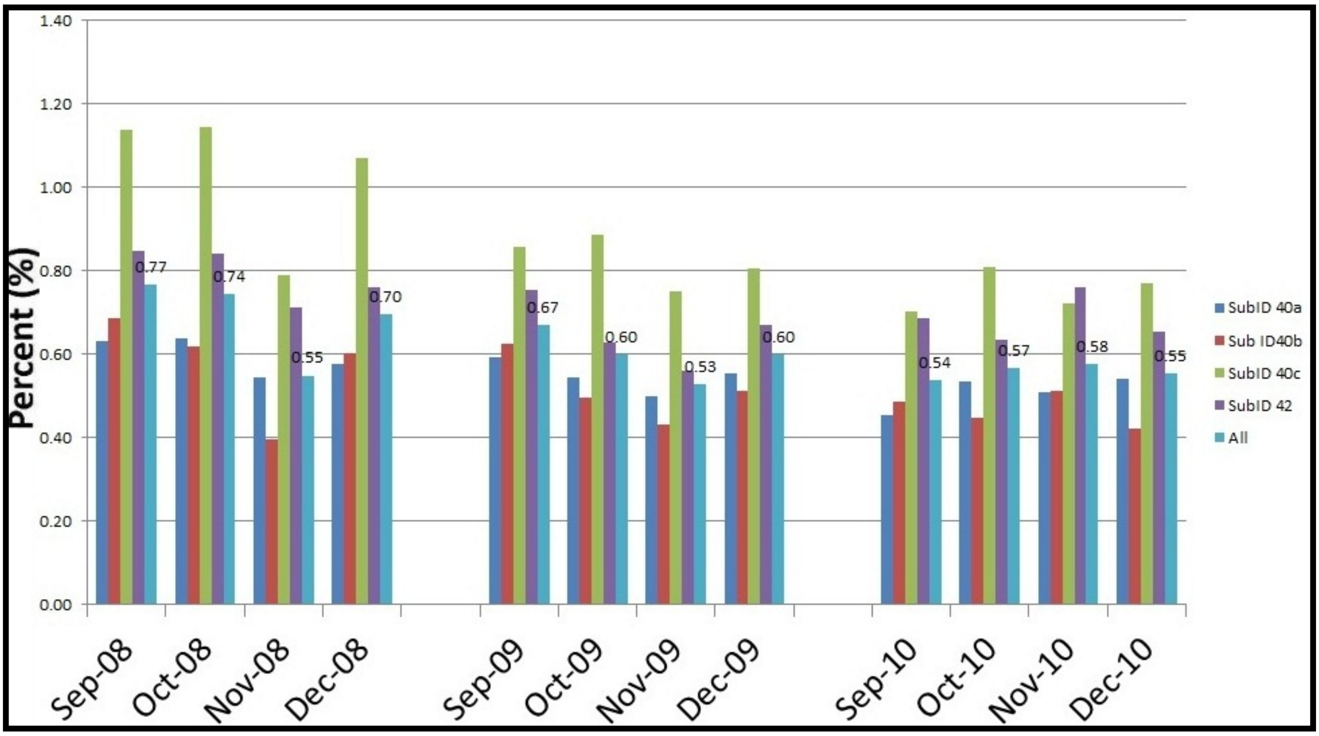
The consumption values for the low income households (sub-ID 40 and 42) generate the following graph in Figure 5.5. Unlike the high income graph that shows a pattern, this graph seems to indicate that consumption remained constant and was not affected by the municipality's interventions.




**Source:** George municipality finance department

**Figure 5.5: Consumption value for low income sub-ID**

The second approach to a percentage increase was used to generate the bar chart in Figure 5.6. The bar chart does not provide an answer as to whether the three WSUD activities (tariff changes, restrictions and the awareness campaign) had an effect on the behaviour of water users in the low income sub-IDs. It merely suggests that the water consumption of 2010 is following the same monthly pattern of 2008.




**Source:** George municipality finance department

**Figure 5.6:** Percentage values low income sub-IDs

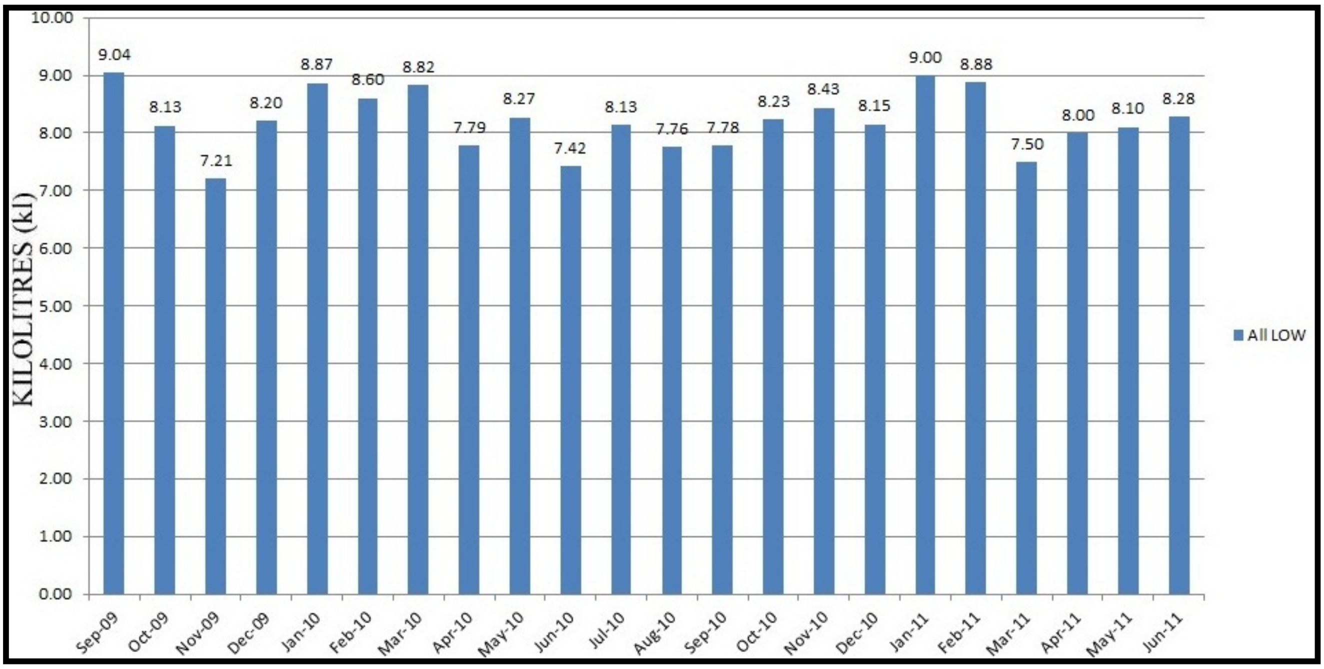
To test the municipality's claims of having reduced water consumption by 44% when comparing the months of February 2009 and February 2010, the same calculations as used with the high income sub-IDs were applied. It was concluded that the municipality missed its target, and only reduced water consumption by 27%. The calculation is as follows:

**Table 5.7:** Percentage decrease low income sub-IDs

| | |
|---|---|
| Feb-09 | 6617 |
| Feb-10 | 4809 |
| Difference | 1808 |
| % decrease | 27.32 |

**Source:** George municipality finance department

Lastly, to see if consumption had been reduced to 15kl, the graph in Figure 5.7 was generated, using the average consumption values. In addition to showing that water consumption had always been below 15kl, it also confirms that the municipality's interventions had no significant impact on the water consumption of users in these low income areas. It also suggests that no interventions are needed in low income areas.




**Source:** George municipality finance department
**Figure 5.7:** All low income sub-IDs average decreases

In summary the three WSUD activities (tariff changes, restrictions and the awareness campaign) might have had a short-term effect on water consumption with a reduction in water consumption increase from October 2009 to June 2010 in the high-income wards. The consumption values started increasing again in July 2010 once the municipality announced in the Eden Water Crisis Report that they were at low risk during the drought. In the low-income wards however the effect of the WSUD activities cannot be seen since these areas already used far less than the targeted 15kl reduction. The lower income areas do not seem to need intervention.

### 5.2.2.3 Awareness campaign since October 2009 till January 2011

The George municipality initiated an awareness campaign in October 2009 with the help of an expert, Ms Diane McGown to provide full support to the campaign and to the managers, Ms Mooiman and Mr Basson from the Engineering department (McGown, 2011, pers com). Before assistance was called in, the community received weekly updates about the dam levels via notice boards in town. The Eden District Disaster Management manager, Mr Otto felt there was a need for an awareness campaign since there was no response from the public to make any changes. A general awareness campaign was launched by the task team created for the whole Eden region's towns hit by the drought. Billboards were set up at the main entrances of the towns and streetlamp posters were put up, similar to the one illustrate in Figure 5.8.

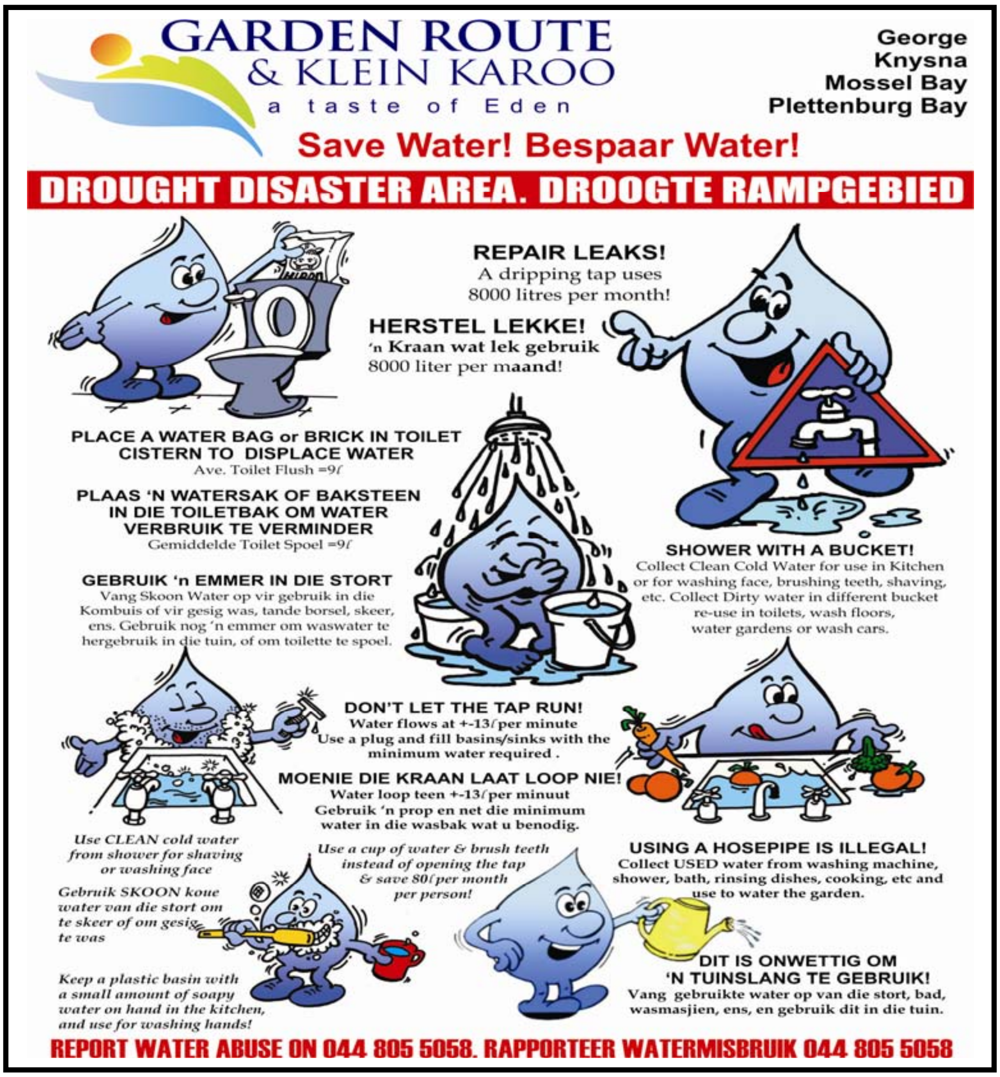

**Source:** McGown (2011, pers com)

**Figure 5.8:** Water scarce area poster

Local radio ran a radio campaign and a water conservation jingle was created by Ms McGown and two young men from the local township of Thembalethu. This jingle played on the radio as well as at the municipality switchboard for callers placed on hold. Twice a week interviews were held on the radio with different Eden district local municipalities' staff members with regard to the water situation. Water saving tips were also given by Ms McGown every Friday via the radio. The newspaper campaign was run in the following newspapers, *Die Son*, the *George Herald* and *Die Burger* for six months and banner strips were designed by the Eden District municipality communication department (McGown, 2011, pers com). The whole awareness campaign ended in January 2011 when the drought was officially over (McGown, 2011, pers com).

Additional awareness activities included an exhibition stand with water-saving devices showcased at the Garden Route mall as well as displaying the Water Augmentation Plan for a week on an information board. This information board included info on how the municipality will abstract more water. After the board was situated at the mall it was then moved to local public libraries for a month at each library. A PowerPoint presentation was created by Ms McGown about the municipality's role in water conservation and how people can help save water during the drought. It was presented to municipality staff members who in turn went out to wards in the municipality to talk to community members for four nights a week for six weeks. Community members could raise concerns and questions. This presentation was done at most primary and high schools as well. The McDonalds fast food restaurant in George provided an incentive (cash prise) to a school with the greatest consumption reduction of water-use over three months; the best water-saving tip from a learner also earned him/her a free meal voucher every week, the winner also published in the local newspaper. The school with the most water-saving tips over the three months also received a cash prize from the restaurant.

A George Task Team was set up, consisting of senior managers, disaster management, and the engineering and accounting departments. With regard to the awareness campaign this task team initiated roadblocks during the holiday period (December) where leaflets were handed out; the fire department had a Santa Clause and played the water conservation jingle with messages in the townships (McGown, 2011, pers com). An example of a leaflet is illustrated by Figure 5.9.




**Source:** McGown (2011, pers com)

**Figure: 5.9:** Water saving tips leaflet

The response to the awareness campaign during the drought period was put into action by the town's residents. These efforts were often published in the *George Herald* online. One response published in January 2010 was from the Oubaai Golf Estate and Spa that installed its own WWTW that treats the estate's sewage, and the treated wastewater is in turn used to irrigate the gardens and golfing greens. In addition to capturing all the wastewater and treating it themselves, the estate also drains the water that runs off the golf course back into the WWTW via underground pipes to be treated again. Irrigation dams are also filled with stormwater on the estate (Lourens, 2010).

The Fancourt Golf Estate on the other hand produces their own magazine and published their own activities regarding water conservation on their premises in an article on 26 May 2010 (Scott, 2010, pers com). The environmental management team of the estate followed a two-step approach, whereby the hotel and housing developments were retrofitted and water used for irrigation is managed efficiently for the garden and golf course. Retrofitting of appliances included installing dual flush toilets, low-flow showerheads and insulated hot-water pipes to prevent heat loss. The new housing developments are built without outside municipal taps and indigenous gardening is promoted. Housing units are designed to allow rainwater run-off (stormwater quantity management) to accumulate in one central catchment dam which in turn is used for irrigation. The golf course itself is irrigated via a central electronic system named the Rainbird System with a weather station which measures the rainfall, wind speed, wind direction and temperature. The data captured in this system calculates water gained via rainfall and water lost via evaporation. In turn the golf course manager can then decide how much water will be used for irrigating the golf course, even via his mobile phone. Irrigation of the golf course ceases when seven millimetres of rainfall has been recorded at a local weather station. Hotel guests were also reminded to conserve water by taking short showers instead of baths, and linen is washed only on request and not every day, as per usual. Staff members were trained in using water optimally and a competition was held to give an incentive for water conservation ideas (Scott, 2010, pers com). A future idea for better irrigation is in the pipeline, which includes the use of ozonated water which would make plants healthier and less thirsty. A school of thought around ozonated water for irrigation implies that since ozone is a disinfectant it will destroy bacteria, fungi and micro-organisms that infect plants. Pesticides and other chemical then will not be needed. The concept further suggests that the greater amount of oxygen delivered to the roots would encourage growth and reduces water consumption (Scott, 2010, pers com).

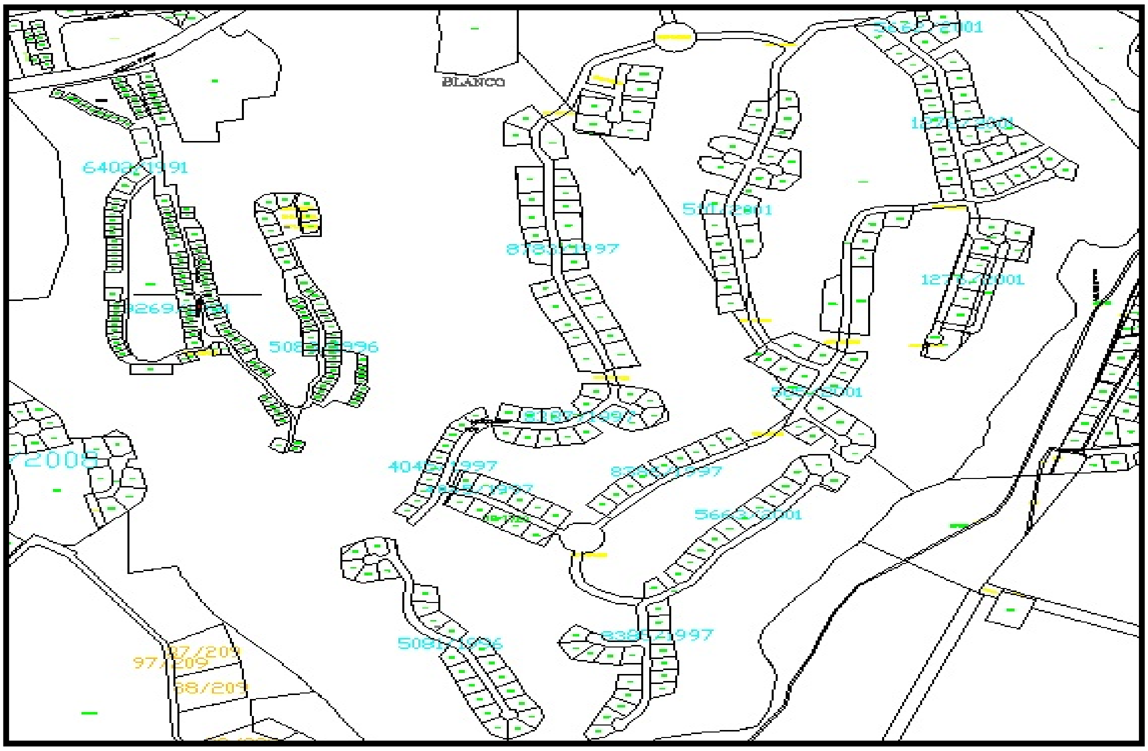
The actions of the estate could also be accredited to a Record of Decision taken by the provincial Department of Environmental Affairs and Development Planning (DEADP) which stipulated that the estate should install rainwater harvesting tanks for new residential developments on their premises. The document also specifies that stormwater should be guided to a space of storage for recycling purposes for irrigation from a centrally controlled irrigation system (Swanepoel, 2010, pers com).

Upon analysis of the debtors' data for this WSUD activity (awareness campaign) in Fancourt Golf Estate, it was discovered that two sets of data can be retrieved from the debtors' data. Firstly water users in sub-ID 37 and secondly, water usage registered under the name of Fancourt's holding company, Plattner Golf (PTY) LTD was of relevance to the Fancourt analysis. Sub-ID 37 was identified as the Fancourt estate which includes the golf course and buildings situated on the estate as well as the buildings housing the holding company, as seen in Figure 5.10. The entire Fancourt Golf Estate, or rather sub-ID 37, falls within the red circle on the image. Individual buildings are visible on the image along the bends of the road as white shapes. These white shapes represent individual erven and thus debtor's/water accounts.


**Source:** http://maps.google.co.za

**Figure 5.10:** Fancourt Golf Estate map

Spatial data for the erven was sourced from the Department of Rural Development and Land Affairs. This was needed to ensure that the correct erf numbers were identified properly, as seen in Figure 5.11 where erven are represented by the green dots.

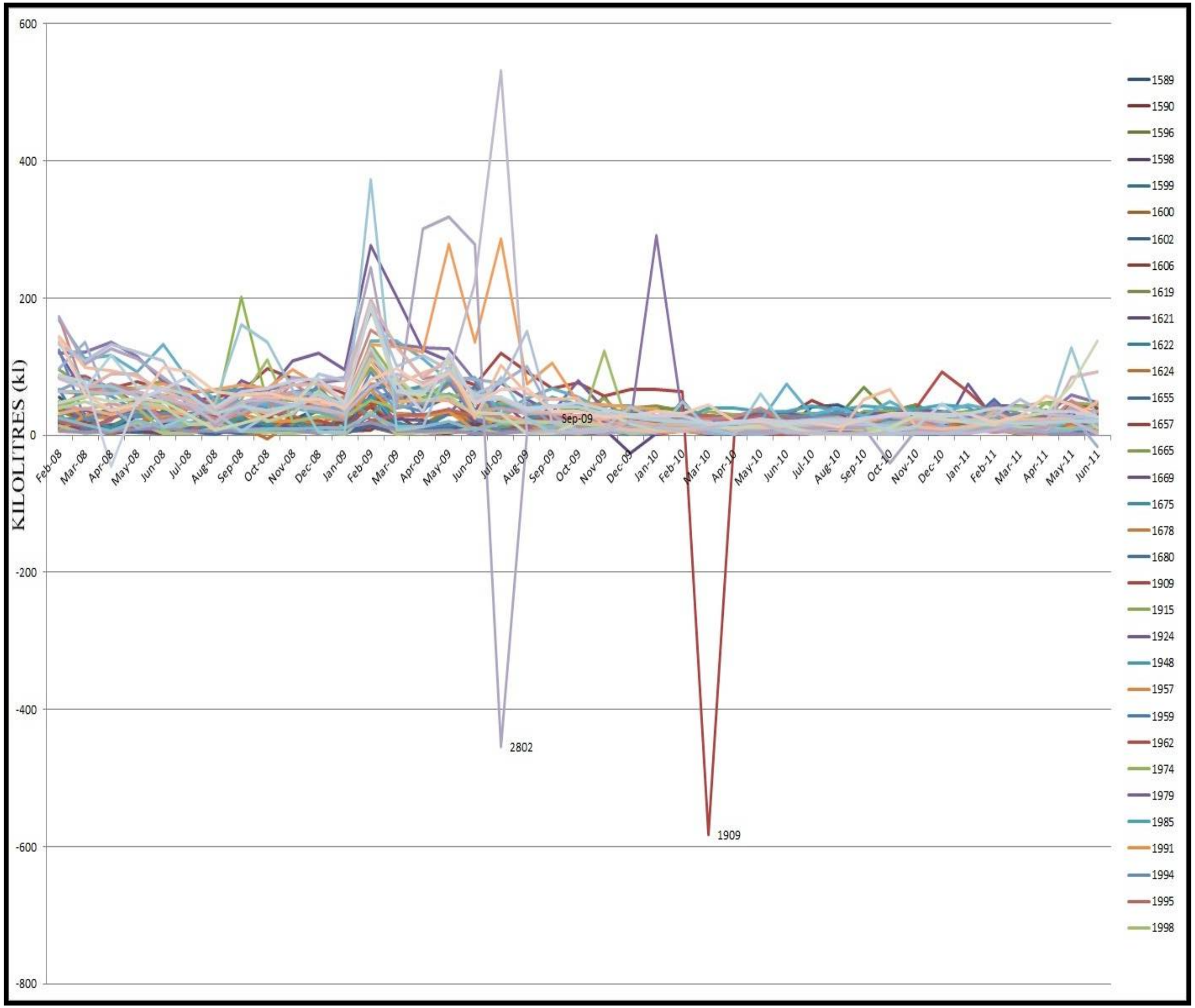


**Source: Van Niekerk (2011: pers com)**

**Figure: 5.11:** Fancourt Golf Estate erf number map

Sub-ID 37 has 215 individual erven but only 53 (24% of all erven) are utilised for the purpose of determining the impact of the awareness campaign. These erven were targeted because they appear in the debtors' data across all 42 months (from January 2008 to June 2011) and provide consistent data. The debtors' data of these 53 erven does not include the holding company's debtors' data; the holding company's data will be analysed separately. The purpose of this is to distinguish between the water consumption of the holding company and those debtors who reside on the estate.

Consistency in the data depended on debtors' data not reflecting unusual patterns of use. An example of data inconsistency is illustrated by Figure 5.12 which shows a sudden decline in July 2009 for the erf number 2802. This decline is several times greater than increases before and after July. Not only is the consumption value dropping to a very sudden low volume but the data for 2802 was also captured incorrectly. Every new month has to reflect the previous month's "new reading" as its "previous reading"; the previous reading for July (the reading that reflects the water usage or rather the new reading value for June) is not correct. The previous reading for July is written as 6434kl but should have been 6952kl. This is illustrated below in Table 5.8 with details for erf number 2802 in yellow.




**Source:** George municipality finance department

**Figure 5.12:** Fancourt debtor's inconsistencies

**Table: 5.8:** Erf 2802 debtors' data inconsistency

**Source:** George municipality finance department

| | | | | | | Jun-09 | | | | | | | Jul-09 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | | | Debtors Accoun | Name of D | Subgroup | Previous I | New Reac | Meter Fac | Consump | Erf Numbe | Subsidy | | Previous I | New Reac | Meter Fac | Consump | Erf Numbe | Subsidy |
| 37 | Site Address: | 2 BRASSIE LANE | 1001573805 | PRESHNU | I/DOM | 2674 | 2758 | 1 | 84 | 2027 | 1 | | 2758 | 2789 | 1 | 31 | 2027 | 1 |
| 38 | Site Address: | 5 BRASSIE LANE | 1001400819 | CELSUM 1 | I/DOM | 6062 | 6198 | 1 | 136 | 2030 | 1 | | 6198 | 6485 | 1 | 287 | 2030 | 1 |
| 39 | Site Address: | 11 BRASSIE LANE | 1001278469 | LOGOPRO | I/DOM | 6487 | 6518 | 1 | 31 | 2034 | 1 | | 6518 | 6544 | 1 | 26 | 2034 | 1 |
| 40 | Site Address: | 10 BRASSIE LANE | 1001285111 RJ | HEINRICH | I/DOM | 6812 | 6838 | 1 | 26 | 2035 | 1 | | 6838 | 6866 | 1 | 28 | 2035 | 1 |
| 41 | Site Address: | 2 FANCOURT STREET | 1001819231 | GANIK IN\ | ACB | 989 | 999 | 1 | 10 | 2046 | 1 | | 999 | 1001 | 1 | 2 | 2046 | 1 |
| 42 | Site Address: | 16 FANCOURT STREET | 34820570102 | LODGE 83 | I/DOM | 1371 | 1374 | 1 | 3 | 2057 | 1 | | 1374 | 1376 | 1 | 2 | 2057 | 1 |
| 43 | Site Address: | 14 FANCOURT STREET | 34820590100 | LODGE 83 | I/DOM | 1699 | 1707 | 1 | 8 | 2059 | 1 | | 1707 | 1724 | 1 | 17 | 2059 | 1 |
| 44 | Site Address: | 4 NIBLICK CLOSE | 34821190105 | GRENVILL | I/DOM | 3729 | 3761 | 1 | 32 | 2119 | 1 | | 3761 | 3792 | 1 | 31 | 2119 | 1 |
| 45 | Site Address: | 2 GREENSIDE CLOSE | 1001707013 | ASSOCIATI | I/DOM | 4265 | 4346 | 1 | 81 | 2286 | 1 | | 4346 | 4423 | 1 | 77 | 2286 | 1 |
| 46 | Site Address: | 1 CHIP CLOSE | 1001653691 W. | WILLEM K | I/DOM | 4365 | 4400 | 1 | 35 | 2334 | 1 | | 4400 | 4440 | 1 | 40 | 2334 | 1 |
| 47 | Site Address: | 1 STYMIE CLOSE | 1001364559 | SAGITTARI | I/DOM | 4303 | 4331 | 1 | 28 | 2797 | 1 | | 4331 | 4351 | 1 | 20 | 2797 | 1 |
| 48 | Site Address: | 1 PUTTER CLOSE BLANCO | 1001390600 KJ | MERCER | I/DOM | 6673 | 6952 | 1 | 279 | 2802 | 1 | | 6434 | 6498 | 1 | 64 | 2802 | 1 |
| 49 | Site Address: | 2 LOFTER CLOSE | 1001366252 | VILLA VIA. | I/DOM | 5892 | 5921 | 1 | 29 | 2806 | 1 | | 5921 | 6005 | 1 | 84 | 2806 | 1 |
| 50 | Site Address: | 4 LOFTER CLOSE | 1001701134 PR | F&P LAND | ACB | 7415 | 7440 | 1 | 25 | 2807 | 1 | | 7440 | 7542 | 1 | 102 | 2807 | 1 |
| 51 | Site Address: | 12 GREENSIDE DRIVE FANCO | 1001533184 AB | BEACH | I/DOM | 6569 | 6630 | 1 | 61 | 2836 | 1 | | 6630 | 6707 | 1 | 77 | 2836 | 1 |
| 52 | Site Address: | 11 GREENSIDE DRIVE FANCO | 1001403757 MI | &CP MUR | I/DOM | 5805 | 5859 | 1 | 54 | 2837 | 1 | | 5859 | 5911 | 1 | 52 | 2837 | 1 |

Another example of inconsistency is the issue of missing data. For the debtor on erf 1588 as seen in Table 5.9 displayed in yellow, the month of August is missing thus affecting the consumption values. Since September's previous reading is reflected as July's new reading the data is not reliable and cannot be used for analysis.

**Table: 5.9:** Erf 1588 debtors' data inconsistency

| 1 | Debtors Accour | Name of Debto | Subgroup | Billing pe | Previous I | New Reac | Meter Fac | Consumpt | Erf Numb | Subsidy | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 1001450649 | LODGE 601 FAN | I/DOM | Jan-08 | 3945 | 3968 | 1 | 23 | 1588 | 1 | | Site Addres |
| 3 | 1001450649 | LODGE 601 FAN | I/DOM | Feb-08 | 3968 | 3987 | 1 | 19 | 1588 | 1 | | Site Addres |
| 4 | 1001450649 | LODGE 601 FAN | I/DOM | Mar-08 | 3987 | 4018 | 1 | 31 | 1588 | 1 | | Site Addres |
| 5 | 1001450649 | LODGE 601 FAN | I/DOM | Apr-08 | 4018 | 4059 | 1 | 41 | 1588 | 1 | | Site Addres |
| 6 | 1001450649 | LODGE 601 FAN | I/DOM | May-08 | 4059 | 4091 | 1 | 32 | 1588 | 1 | | Site Addres |
| 7 | 1001450649 | LODGE 601 FAN | I/DOM | Jun-08 | 4091 | 4110 | 1 | 19 | 1588 | 1 | | Site Addres |
| 8 | 1001450649 | LODGE 601 FAN | I/DOM | Jul-08 | 4110 | 4144 | 1 | 34 | 1588 | 1 | | Site Addres |
| 9 | 1001450649 | LODGE 601 FAN | I/DOM | Aug-08 | 4144 | 4178 | 1 | 34 | 1588 | 1 | | Site Addres |
| 10 | 1001450649 | LODGE 601 FAN | I/DOM | Sep-08 | 4178 | 4189 | 1 | 11 | 1588 | 1 | | Site Addres |
| 11 | 1001450649 | LODGE 601 FAN | I/DOM | Oct-08 | 4189 | 4200 | 1 | 11 | 1588 | 1 | | Site Addres |
| 12 | 1001450649 | LODGE 601 FAN | I/DOM | Nov-08 | 4200 | 4237 | 1 | 37 | 1588 | 1 | | Site Addres |
| 13 | 1001450649 | LODGE 601 FAN | I/DOM | Dec-08 | 4237 | 4294 | 1 | 57 | 1588 | 1 | | Site Addres |
| 14 | 1001450649 | LODGE 601 FAN | I/DOM | Jan-09 | 4294 | 4308 | 1 | 14 | 1588 | 1 | | Site Addres |
| 15 | 1001450649 | LODGE 601 FAN | I/DOM | Feb-09 | 4308 | 4356 | 1 | 48 | 1588 | 1 | | Site Addres |
| 16 | 1001450649 | LODGE 601 FAN | I/DOM | Mar-09 | 4356 | 4403 | 1 | 47 | 1588 | 1 | | Site Addres |
| 17 | 1001450649 | LODGE 601 FAN | I/DOM | Apr-09 | 4403 | 4437 | 1 | 34 | 1588 | 1 | | Site Addres |
| 18 | 1001450649 | LODGE 601 FAN | I/DOM | May-09 | 4437 | 4483 | 1 | 46 | 1588 | 1 | | Site Addres |
| 19 | 1001450649 | LODGE 601 FAN | I/DOM | Jun-09 | 4483 | 4484 | 1 | 1 | 1588 | 1 | | Site Addres |
| 20 | 1001450649 | LODGE 601 FAN | I/DOM | Jul-09 | 4484 | 4515 | 1 | 31 | 1588 | 1 | | Site Addres |
| 21 | 1001450649 | LODGE 601 FAN | I/DOM | Sep-09 | 4515 | 4518 | 1 | 3 | 1588 | 1 | | Site Addres |
| 22 | 1001450649 | LODGE 601 FAN | I/DOM | Oct-09 | 4518 | 4538 | 1 | 20 | 1588 | 1 | | Site Addres |
| 23 | 1001450649 | LODGE 601 FAN | I/DOM | Nov-09 | 4538 | 4558 | 1 | 20 | 1588 | 1 | | Site Addres |
| 24 | 1001450649 | LODGE 601 FAN | I/DOM | Dec-09 | 4524 | 4527 | 1 | 3 | 1588 | 1 | | Site Addres |
| 25 | 1001450649 | LODGE 601 FAN | I/DOM | Jan-10 | 4527 | 4543 | 1 | 16 | 1588 | 1 | | Site Addres |
| 26 | 1001450649 | LODGE 601 FAN | I/DOM | Feb-10 | 4543 | 4554 | 1 | 11 | 1588 | 1 | | Site Addres |
| 27 | 1001450649 | LODGE 601 FAN | I/DOM | Mar-10 | 4554 | 4568 | 1 | 14 | 1588 | 1 | | Site Addres |
| 28 | 1001450649 | LODGE 601 FAN | I/DOM | Apr-10 | 4568 | 4590 | 1 | 22 | 1588 | 1 | | Site Addres |
| 29 | 1001450649 | LODGE 601 FAN | I/DOM | May-10 | 4590 | 4595 | 1 | 5 | 1588 | 1 | | Site Addres |

Sheet2 Sheet3 37 plattner 37 37 missing 37 erf move extraction complete analyses data 37

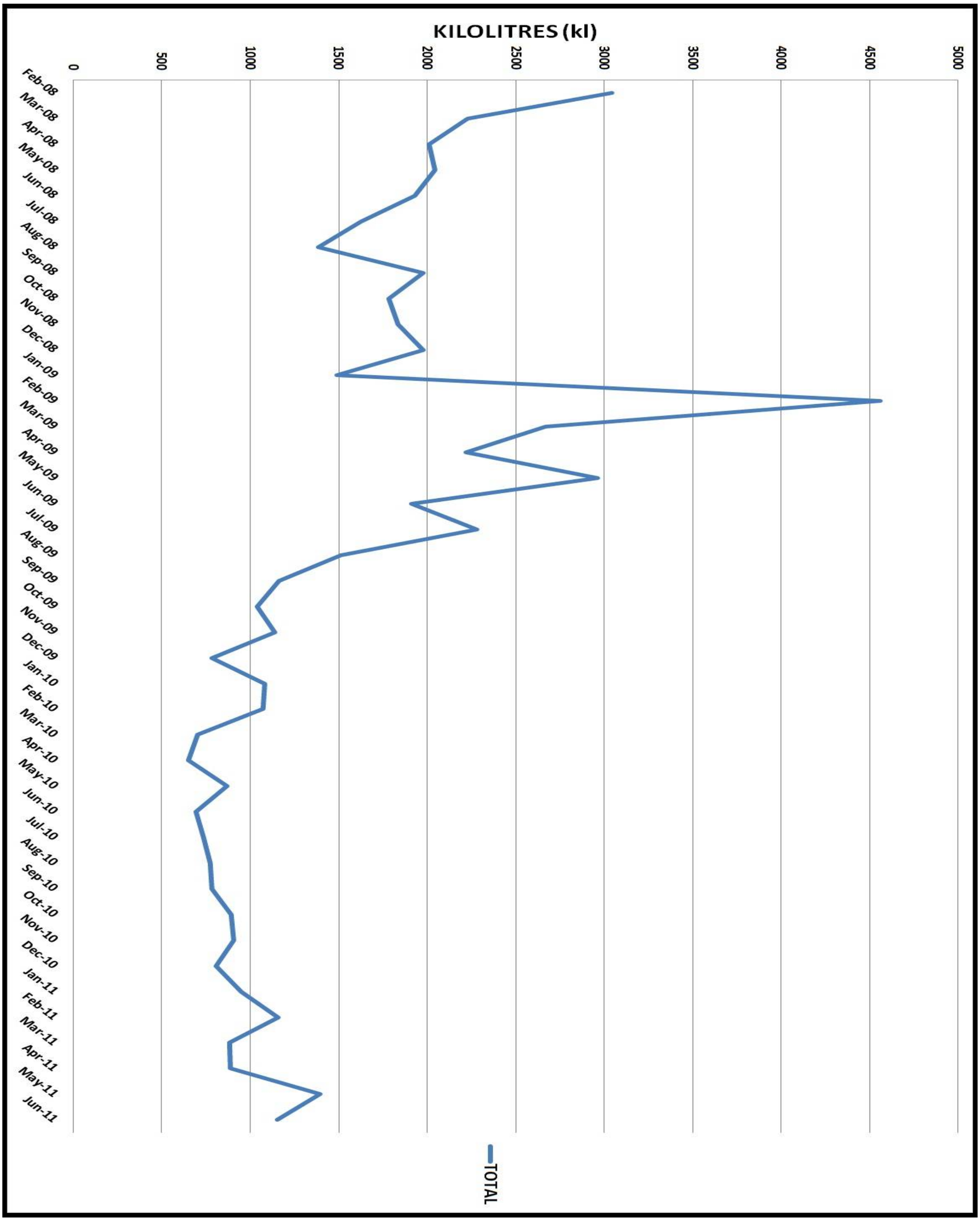
**Source:** George municipality finance department

As mentioned before sub-ID 37 has been identified as the Fancourt Golf Estate debtors' data with 215 individual erven, but only 53 erven (24% of total erven) utilised for the purpose of determining the impact of the awareness campaign. Figure 5.13 displays the monthly total of consumption for the 53 erven chosen for analysis.

The municipality's awareness campaign started in October 2009 and the estate wrote the article on their water conservation efforts in May 2010; however the awareness campaign of the municipality cannot get credit for the downward trend of water consumption in the 53 erven on the Fancourt Golf Estate, since consumption had already followed a downward trend from March 2009 after a sharp upward trend in February 2009. The decline after February might be due to the reduction in water use when tourists leave George after their summer holiday.

However, one significant observation can be made using Figure 5.13, which is that from July 2010, consumption starts to increase, which means that Fancourt's attempts to create awareness via their magazine article also had no impact on water usage in the estate.

Fancourt's holding company, Plattner Golf (PTY) LTD has also been identified as a debtor on the estate along with the other erven identified in sub-ID 37. The holding company's debtors' data with all its water accounts was separated from the other debtors in sub-ID 37 in order to distinguish the consumption values of the holding company from the other residences on the premises. Table 5.10 illustrates how the holding company's debtors' data is reflected.




**Source:** George municipality finance department

**Figure 5.13:** Fancourt 53 erven total water consumption (Jan 2008- June 2011)

| Debtors Accoun | Name of Debtors | Subgroup | Billing per | Previous R | New Read | Meter Fac | Consumpt | Erf Numb | Subsidy | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 34816760300 | PLATTNER GOLF PTY LTD | I/DOM | Jun-10 | 1616 | 1618 | 1 | 2 | 1676 | 1 | Site Address: | FANCOURT STREET |
| 34816760300 | PLATTNER GOLF PTY LTD | I/DOM | Jul-10 | 1618 | 1625 | 1 | 7 | 1676 | 1 | Site Address: | FANCOURT STREET |
| 34816760300 | PLATTNER GOLF PTY LTD | I/DOM | Aug-10 | 1625 | 1630 | 1 | 5 | 1676 | 1 | Site Address: | FANCOURT STREET |
| 34816760300 | PLATTNER GOLF PTY LTD | I/DOM | Sep-10 | 1630 | 1631 | 1 | 1 | 1676 | 1 | Site Address: | FANCOURT STREET |
| 34816760300 | PLATTNER GOLF PTY LTD | I/DOM | Oct-10 | 1631 | 1632 | 1 | 1 | 1676 | 1 | Site Address: | FANCOURT STREET |
| 34816760300 | PLATTNER GOLF PTY LTD | I/DOM | Nov-10 | 1632 | 1637 | 1 | 5 | 1676 | 1 | Site Address: | FANCOURT STREET |
| 34816760300 | PLATTNER GOLF PTY LTD | I/DOM | Dec-10 | 1637 | 1641 | 1 | 4 | 1676 | 1 | Site Address: | FANCOURT STREET |
| 34816760300 | PLATTNER GOLF PTY LTD | I/DOM | Jan-11 | 1641 | 1665 | 1 | 24 | 1676 | 1 | Site Address: | FANCOURT STREET |
| 34816760300 | PLATTNER GOLF PTY LTD | I/DOM | Feb-11 | 1665 | 1674 | 1 | 9 | 1676 | 1 | Site Address: | FANCOURT STREET |
| 34816760300 | PLATTNER GOLF PTY LTD | I/DOM | Mar-11 | 1674 | 1678 | 1 | 4 | 1676 | 1 | Site Address: | FANCOURT STREET |
| 34816760300 | PLATTNER GOLF PTY LTD | I/DOM | Apr-11 | 1678 | 1691 | 1 | 13 | 1676 | 1 | Site Address: | FANCOURT STREET |
| 34816760300 | PLATTNER GOLF PTY LTD | I/DOM | May-11 | 1691 | 1700 | 1 | 9 | 1676 | 1 | Site Address: | FANCOURT STREET |
| 34816760300 | PLATTNER GOLF PTY LTD | I/DOM | Jun-11 | 1700 | 1704 | 1 | 4 | 1676 | 1 | Site Address: | FANCOURT STREET |
| | | | | | | | | | | | |
| 34002750306 | PLATTNER GOLF PTY LTD | BUS | Jan-08 | 272187 | 273647 | 1 | 1460 | 1720 | 1 | Site Address: | BIRDIE LANE |
| 34002750306 | PLATTNER GOLF PTY LTD | BUS | Mar-08 | 273647 | 290228 | 1 | 16581 | 1720 | 1 | Site Address: | BIRDIE LANE |
| 34002750306 | PLATTNER GOLF PTY LTD | BUS | Apr-08 | 290228 | 293556 | 1 | 3328 | 1720 | 1 | Site Address: | BIRDIE LANE |
| 34002750306 | PLATTNER GOLF PTY LTD | BUS | May-08 | 293556 | 319693 | 1 | 26137 | 1720 | 1 | Site Address: | BIRDIE LANE |
| 34002750306 | PLATTNER GOLF PTY LTD | BUS | Oct-08 | 319693 | 319724 | 1 | 31 | 1720 | 1 | Site Address: | BIRDIE LANE |
| 34002750306 | PLATTNER GOLF PTY LTD | BUS | Nov-08 | 319724 | 328834 | 1 | 9110 | 1720 | 1 | Site Address: | BIRDIE LANE |
| 34002750306 | PLATTNER GOLF PTY LTD | BUS | Apr-10 | 379699 | 386259 | 1 | 6560 | 1720 | 1 | Site Address: | BIRDIE LANE |
| 34002750306 | PLATTNER GOLF PTY LTD | BUS | Jul-10 | 328834 | 331126 | 1 | 2292 | 1720 | 1 | Site Address: | BIRDIE LANE |
| 34002750306 | PLATTNER GOLF PTY LTD | BUS | Aug-10 | 331126 | 333536 | 1 | 2410 | 1720 | 1 | Site Address: | BIRDIE LANE |
| 34002750306 | PLATTNER GOLF PTY LTD | BUS | Sep-10 | 333536 | 335916 | 1 | 2380 | 1720 | 1 | Site Address: | BIRDIE LANE |
| 34002750306 | PLATTNER GOLF PTY LTD | BUS | Oct-10 | 335916 | 338416 | 1 | 2500 | 1720 | 1 | Site Address: | BIRDIE LANE |
| 34002750306 | PLATTNER GOLF PTY LTD | BUS | Nov-10 | 338416 | 341192 | 1 | 2776 | 1720 | 1 | Site Address: | BIRDIE LANE |
| 34002750306 | PLATTNER GOLF PTY LTD | BUS | Dec-10 | 341192 | 344192 | 1 | 3000 | 1720 | 1 | Site Address: | BIRDIE LANE |
| 34002750306 | PLATTNER GOLF PTY LTD | BUS | Jan-11 | 344192 | 347782 | 1 | 3590 | 1720 | 1 | Site Address: | BIRDIE LANE |

34 | 34 Plattner | Sheet2 | Sheet3 | 37 plattner | 37 plattner analyses | 37 | 37 missing | 37 erf move | ex

**Source:** George municipality finance department

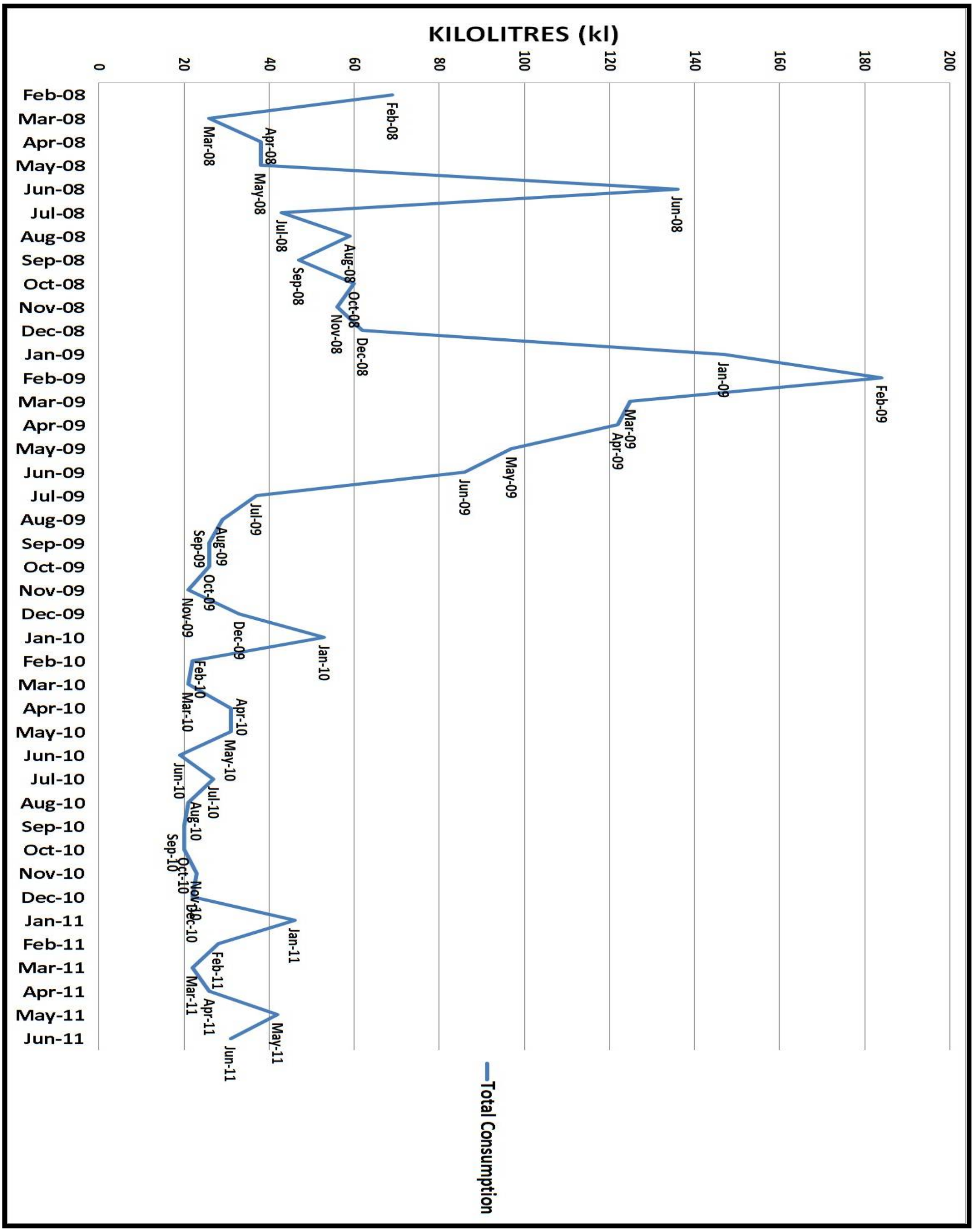
Fourteen individual water meters were identified that were registered under the name Plattner Golf (PTY) LTD but only three meters could be taken for data analysis processes, as it was more consistent than the others. Inconsistencies can be seen in an example where consumption values were not captured, illustrated in Table 5.11.

**Table: 5.11:** Plattner Golf (PTY) LTD debtors' data inconsistencies

| Account # | Erf # | Feb-10 | Mar-10 | Apr-10 | May-10 | Jun-10 | Jul-10 | Aug-10 |
|---|---|---|---|---|---|---|---|---|
| 34816760300 | 1676 | 1586 | 1591 | 1605 | 1616 | 1618 | 1625 | 1630 |
| 34002750306 | 1720 | | | 386259 | | | 331126 | 333536 |
| 35710830317 | 1720 | | | | | | | |
| 35710830317 | 1720 | 5836 | 6828 | 7510 | 7971 | 8544 | 8982 | 9380 |
| 35710830317 | 1720 | 494497 | 496491 | 498612 | 499612 | 499753 | | |
| 35710830317 | 1720 | | | | | | 400 | 1064 |
| 1001286758 | 1970 | 6715 | | | | | | |
| 1001286796 | 2038 | 2034 | | | | | | |
| 1001286796 | 2038 | | | 1999 | 2005 | 2006 | | |
| 1001470726 | 2285 | 4672 | 4679 | 4683 | 4687 | | 4690 | 4695 |
| 1001470740 | 2287 | 4829 | 4832 | 4839 | 4847 | 4855 | 4864 | 4870 |
| 1001403812 | 2843 | 5534 | 5535 | | | | 5538 | 5545 |
| 1001774831 | 3004 | | 3309 | | 3314 | | 3319 | 3395 |
| 1001352895 | 19955 | 864 | 877 | 887 | 899 | 908 | 919 | 929 |

**Source:** George municipality finance department

The three consistent meters are used for the analysis and the monthly consumption totals are reflected in Figure 5.14. The first result shown in the figure is that the graph shows similar consumption patterns as in Figure 5.13 of the 53 erven identified in sub-ID 37. Secondly, the graph in Figure 5.14 indicates that despite the awareness-raising article in the Fancourt magazine of May 2010 the water consumption still increased from July 2010. Water consumption patterns indicate that water consumption in 2011 (January- June) was even higher than the same months in 2010, even after all of the awareness-raising and water conservation efforts initiated by the Fancourt environmental management team. The holding company meters do not reflect any reduction in water consumption.




**Source:** George municipality finance department

**Figure 5.14:** Three Flatiner Golf (PTY) LTD monthly consumption totals

In an attempt either to disqualify or prove the positive impact the awareness campaign had on water consumption on the Fancourt Golf Estate, three bulk meters which service the Fancourt area were identified. However as seen in Appendix C the bulk meters readings are highly irregular with extreme high consumption and sudden low consumption values, and thus could not be utilised for impact measurement.

On the subject of the municipality's awareness campaign another article printed in the *George Herald* described how a local businessman began to conserve water. The owner of the Loerie Bakery in the George CBD installed his own rainwater harvesting tanks (ten tanks with a capacity of 24,000 litres) in January and saved the municipality 55,000 litres of water per month. The tanks were connected to the building's toilet system so water was used for flushing as well as washing bread crates and vehicles. The owner installed the whole system himself and the cost came to R18, 000 which he sees as an investment, since he saves R1, 000 a month which goes towards paying of his investment over only 18 months. The same system is installed at the owner's home where rainwater is used for toilet flushing, laundry, and the garden and fish pond, which resulted in his household of five using only 6,000 litres per month. This 6kl is exactly the volume of water provided per month according to law as free basic water (SA, 2004c:76). Therefore the owner is saving money at home as well. The owner commented to the newspaper that he thinks the municipality should lead by example and also install rainwater harvesting tanks for use in municipal buildings (Schoonraad, 2010b).

The municipal website updated users about the dam levels and various other water conservation tips. The water wastage hotline number continuously reminded website users about their responsibility to report leaking pipes and water wastage by community members as illustrated in Figure 5.15.


**Source:** [www.george.org.za](http://www.george.org.za)

**Figure 5.15:** Municipality website drought update

The extent of leakage detection and fixing as a WSUD activity will be discussed further in this chapter.

**5.2.2.4 Localised sanitation services since 04 January till 01 December 2010**

The Water Services officer in the municipality Engineering Department provided data on localised sanitation services provided by the municipality (Michaels, 2011, pers com). The George municipality still provides localised sanitation services whereby sewage is removed manually from septic tanks by a sucking-tanker service (known as a honey sucker) since toilet facilities are not connected to the sewage system. This service was provided before the drought and before 2008 – the time from which debtors' data was available – but analysis was made from 2008 for 42 months, as mentioned earlier. Localised sanitation is deemed part of WSUD under the re-use of water category, since less water is needed to transport sewage to a designated WWTW.

The data provided by the Engineering Department recorded services provided from January 2010 to December 2010. For the purpose of data analysis data from January 2010 was selected. The data consisted of debtors' names receiving the service. Only 16 names could be utilised for data analysis purposes since many names had to be discarded for the following reasons:

- Addresses that did not exist
- Names of debtors that did not exist
- Names of businesses that did exist, but were difficult to locate (on maps) due to either:
    - the names of the businesses and the names of debtors being different or
    - the names of these businesses being absent from the debtors' data provided by the municipality
- there is a change of ownership of a specific erf (property) during the 42 months being analysed and hence does not show consistency

The localised sanitation service is provided in Wilderness, a suburb in Ward 4. Because the services have been provided from before 2008, changes in water consumption values would not be noticeable, as it is such a short period (42 months) for analysis. The suburb of Wilderness will be thus compared to other suburbs which do not receive the service, to determine whether localised sanitation service provisions make a difference in water consumption values when compared to those which do not receive the service.

In Table 5.4 the wards have been ranked according to the income bracket of residents who earn between R1 and R1600. The numbers in the graph represent the ward population percentage per income. The assumption is that the ward that has the lowest percentage of residents for this income bracket (R1-1600) represents the wealthiest ward and the wards with a higher percentage of that bracket represent the poorest wards. Wilderness is ward 4, the 9th richest (or 12th poorest) ward of the 20 wards (based on the aforesaid assumption). The three top-ranked wards (wealthiest) include wards 3, 2 and 18. Wilderness will thus be compared to ward 2, 3 and 18. These three wards were selected for analysis in three other WSUD activities (tariff changes, restrictions and awareness campaign) as well. It should be kept in mind that wards are divided into suburbs and suburbs are divided into sub-IDs in the debtors' data database. Sub-IDs were chosen randomly.

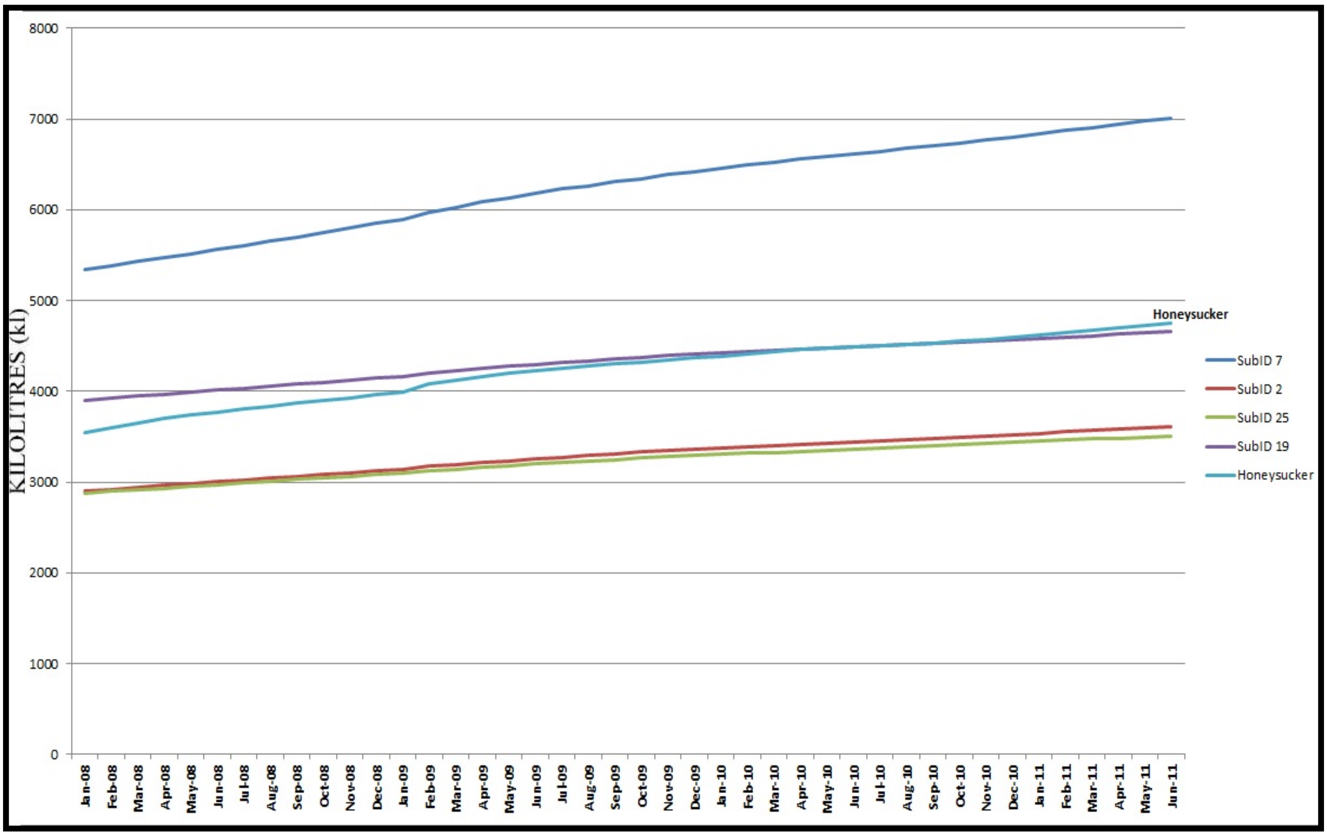
The methodology of analysis is as follows:

- Ward 2
    - Suburb: Bo-Dorp
    - Number of debtors for the purpose of analysis: 129
    - Sub-ID 2
- Ward 2
    - Suburb: Denneoord
    - Number of water users for the purpose of analysis: 251
    - Sub-ID 25
- Ward 3
    - Suburb: Dormehls Drift
    - Number of water users for the purpose of analysis: 49
    - Sub-ID 7
- Ward 18
    - Suburb: Loerie Park
    - Number of debtors for the purpose of analysis: 250
    - Sub-ID 19

The inconsistency in the totals of debtors in a sub-ID used for data analysis is due to the fact that sub-IDs do not have similar numbers of debtors in them, and debtors' data in the sub-IDs are not consistent for the 42 months. As explained before only consistent debtors' data with the full amounts of 42 months were used for analysis. For the purpose of analysis, the average consumption percentage increase per sub-ID, per month was calculated and the following percentage values were generated:

- Wilderness: 0.71% / month
- Dormehls Drift (Sub ID 7): 0.67% / month
- Bodorp (Sub ID 2): 0.53% / month
- Denneoord (Sub ID 25): 0.49% / month
- Loerie Park (Sub ID 19): 0.43% / month

For the purpose of strengthening analysis, a graph is generated in Figure 5.16 to show average water usage (total New Reading divided by the number of debtors). Wilderness is represented by the line titled, Honeysucker.




**Source:** George municipality finance department

**Figure: 5.16:** Localised sanitation comparison average water use

It should be noted that, without employing statistical analysis, it is difficult to derive a viable analysis from the data above. It should therefore be mentioned that the data above should only be used for the purpose of providing a starting point from which a much more in-depth study can be initiated. It would then be advisable for a researcher with skills in statistical analyses to add more substance to the research by applying statistical calculations.

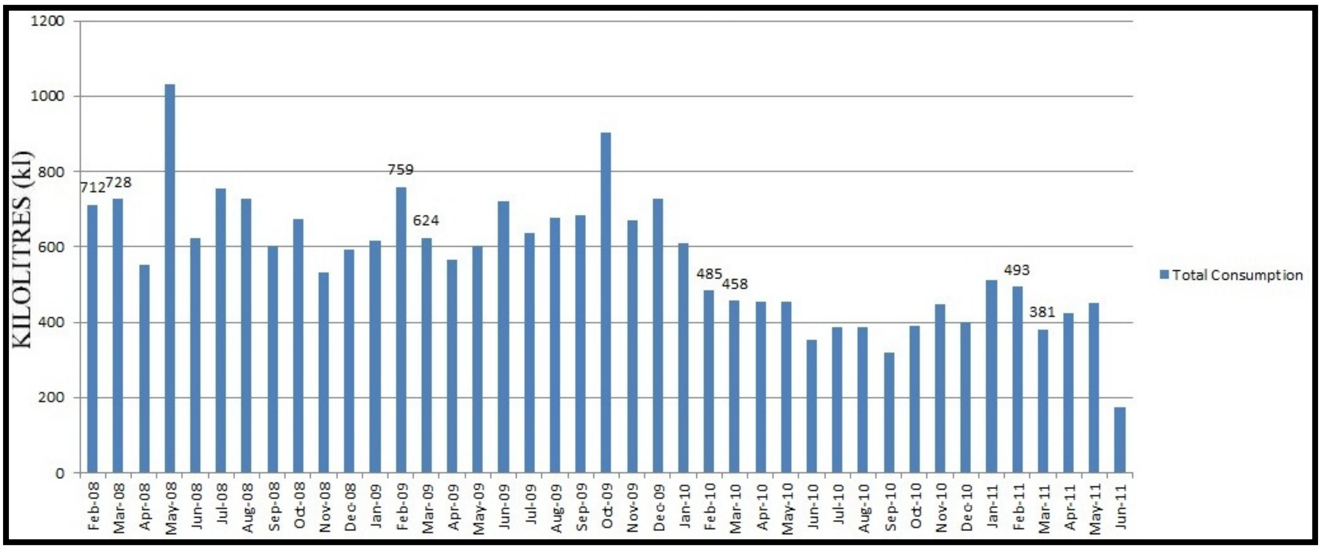
The following observations can be made:

The percentage increase in the water usage of those users using the localised sanitation service is much higher than the three suburbs being used for comparison. The percentage increase per month for Wilderness is 0.71%. This could suggest that the service does not encourage positive water conservation behaviour in water users. The graph (average use) suggests that the service does not reduce the amount of water being used. In fact, it may even suggest that it might require more water to remain functional in case the septic tank becomes dry. This is illustrated by the figure where the Loerie Park (sub-ID 19) begins (in February 2008) by using more water than the Wilderness (Honeysucker) water consumers. In 2010 however, localised sanitation users started using more water (average water usage per property) in 2010 than three of the other suburbs. It can be observed that sub-ID 7 (Dormehls Drift) which falls in the highest income ward (ward 3) still uses more water on average than any of the others.

#### 5.2.2.5 Leakage detection and fixing in indigent and high consumer households from 04 January 2010 to 29 October 2010

The Water Services Officer in the municipality provided data (a complaints report list) on leakage detection and fixing services provided by the municipality (Michaels, 2011, pers com). The municipality began fixing leaks for free, especially at registered indigent households. Visits were made to households and homeowners were informed about their high water consumption, and often the municipality fixed leaks, though households that could afford it paid for it themselves. The municipality also planned to penalise high-volume consumers who continued with high consumption even during the water restriction period. The *George Herald* online published an article on the restriction devices bought by the municipality to install at high-volume consumers' households, and the first suburb targeted was Heather Park (Schoonraad, 2010a). The restriction devices were not installed, because the municipality first had to follow certain procedures to enable their installation at these residences, which took some time. By the time these procedures had been followed the drought in the municipality was under control and there seemed no need to install the restriction devices. However, since water restrictions were lifted (from November 2010), water use has increased yet again at the same high-volume consumer residences; because they use over 15kl per month they were identified as the target group for restriction device installation (Micheals, 2011, pers com).

Upon analysis of the debtors' data for the WSUD activity of leakage detection and fixing, it was discovered that on the data list provided by the municipality a distinction was made between indigent households, and non-indigent high-volume consumers. For the purpose of the data analysis process, 20 names of debtors from each group were chosen from the month of January 2010. January 2010 was the month when leakage detection and fixing was initiated. The purpose of this process was to track the consumption changes before the date of leakage fixing (January 2010) and after. In the indigent group it was discovered that all the complaints came from sub-ID 60 which falls in the suburb of Parkdene. Only ten debtors' names deemed to be valid since other debtors' data were inconsistent with missing data and readings showing unusual decline of consumption as seen in the other debtors' data analysis earlier in the chapter. In the high-volume consumer group it was discovered that consumers identified on the complaints list resided in various sub-IDs and not in just one. Similar problems occurred with the inconsistent and missing data; therefore only fourteen debtors' names could be used. In total 24 debtors could be identified with valid data which was consistent. In Figure 5.17 the total consumption of each debtor (all 24) is presented from February 2008 (reflects consumption value derived from January 2008) to June 2011. Each value in this bar chart reflects the difference in water usage per kilolitre from month to month. For example, the chart below reflects a consumption value of 728 for the month of March, 2008. During the month of February 2008, the total amount of water used was equal to 43,890kl and the total amount of water used in March was 44,602kl. The difference between these two values is 712, meaning that in March water use increased by 712kl. Therefore the consumption value for the month of February 2008 was 712kl. This then indicated that the increase in water usage was greater in March than in February.




**Source:** George municipality finance department

**Figure 5.17:** Leakage detection analysis total consumption

As part of data analysis for this WSUD activity, changes in water consumption were measured for the period before January 2010 and after. It was discovered that the total consumption values (of the 24 debtors) was higher in December 2009 than in January 2010. After the fixing was done, consumption values indicated a decrease in the consumption values.

- Dec-09 – 728kl
- Jan-10 – 611kl
- Feb-10 – 485kl
- Mar-10 – 458kl
- Apr-10 – 454kl

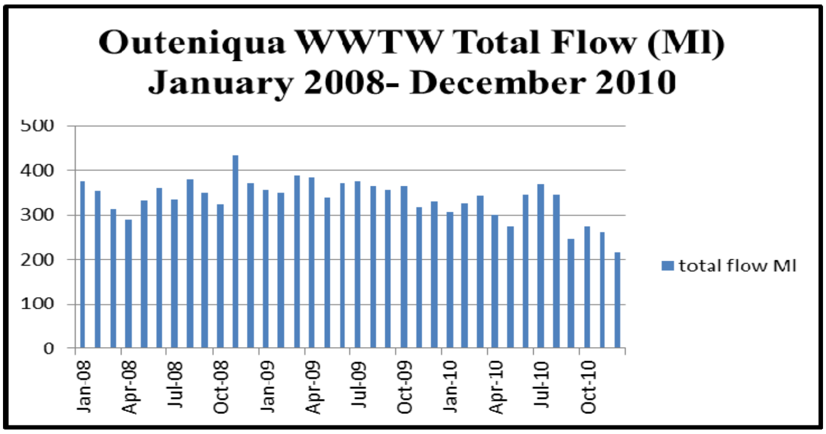
Even though Figure 5.17 indicates fluctuation in water levels, the decreases in consumption in 2010 after January are still lower than the same months for the years before, for the same months. Since January 2010 total consumption values for the 24 debtors are still under the 600kl mark as seen on Figure 5.17

### 5.2.2.6 Treated wastewater re-use project- Evaluation Report (In operation since 04 August 2010)

The engineer at the regional Department of Water Affairs responsible for the monitoring of infrastructure projects in regional municipalities provided the report of this particular project

(Mashicila, 2010, pers com). Once the area was declared a disaster area in November 2009, the municipality had to react to the possibility that the town might not have water after February 2010. Consequently the municipality initiated a back-up plan by treating wastewater to a highly acceptable level (reclamation) and pumped it back into the raw water supply of the Garden Route Dam from the Outeniqua WWTW, one of the WWTWs in the municipality. The project had two phases: Phase 1 was the construction of the ultrafiltration plant which would treat the wastewater, and Phase 2 was the construction of the pump station and pipeline that will be used to pump the treated wastewater into the Garden Route dam (Mashicila, 2010, pers com).

The Outeniqua Wastewater Treatment plant started treating 10Ml of wastewater a day on 4 August 2010. Figure 5.18 illustrates the total wastewater flow at the Outeniqua WWTW from January 2008 to December 2010 in megalitres. This reclamation of highly treated wastewater is the first of its kind in South Africa (Schoonraad, 2010c). However, the commercial re-use (e.g. for irrigation) of treated wastewater at other WWTWs is not considered in the George municipality; the treated wastewater is only used for cleaning purposes on the WWTW sites (Jumart, 2010, pers com).




**Source:** Jumart (2011, pers com)
**Figure 5.18:** Outeniqua WWTW Total Flow (Ml)

By observing the wastewater flow volume of the month of August (inception of the reclamation) for the three years in question, it can be seen that wastewater flows dropped from August 2008 (381 Ml), August 2009 (365 Ml) to August 2010 (347 Ml). Flow however did not reduce to fewer than 200 Ml a month. See Figure 5.18 where, for the year 2010, the wastewater flow is lower by comparison to all other years, even considering the spring and summer months when the town receives an influx of tourists as mentioned in Chapter 3.

#### 5.2.2.7 Stormwater system management (stormwater quality management)

The Water Services officer in the stormwater section provided this information (Quinot, 2010, pers com). In 2010 the maintenance of the stormwater system was done by municipal staff on an ad hoc basis as illustrated in Table 5.12.

**Table 5.12:** Stormwater quality maintenance

| STORMWATER MAINTENANCE : GEORGE MUNICIPALITY | |
|---|---|
| **Period** | **Action** |
| 2004-Dec 2007 | All general maintenance and cleaning of stormwater done by George Municipality staff. Jetting of blocked lines done by contractors. |
| Jan 2008 - Dec 2009 | Tenders were called for 16 local contractors from previously disadvantaged communities to undertake the maintenance of the SW.<br>Their duties included the following:<br>Cleaning of SW channels.<br>Cleaning of catchpits.<br>Cutting grass at SW outlets and waterways.<br>Carting away of debris.<br>This was highly successful with George Municipality winning the Komoso award for this project. |
| Jan 2010 - current | Tenders were called again but contractors not yet appointed due to a shortage of funds.<br>Currently Municipal teams are undertaking the cleaning of SW on an ad hoc basis. |

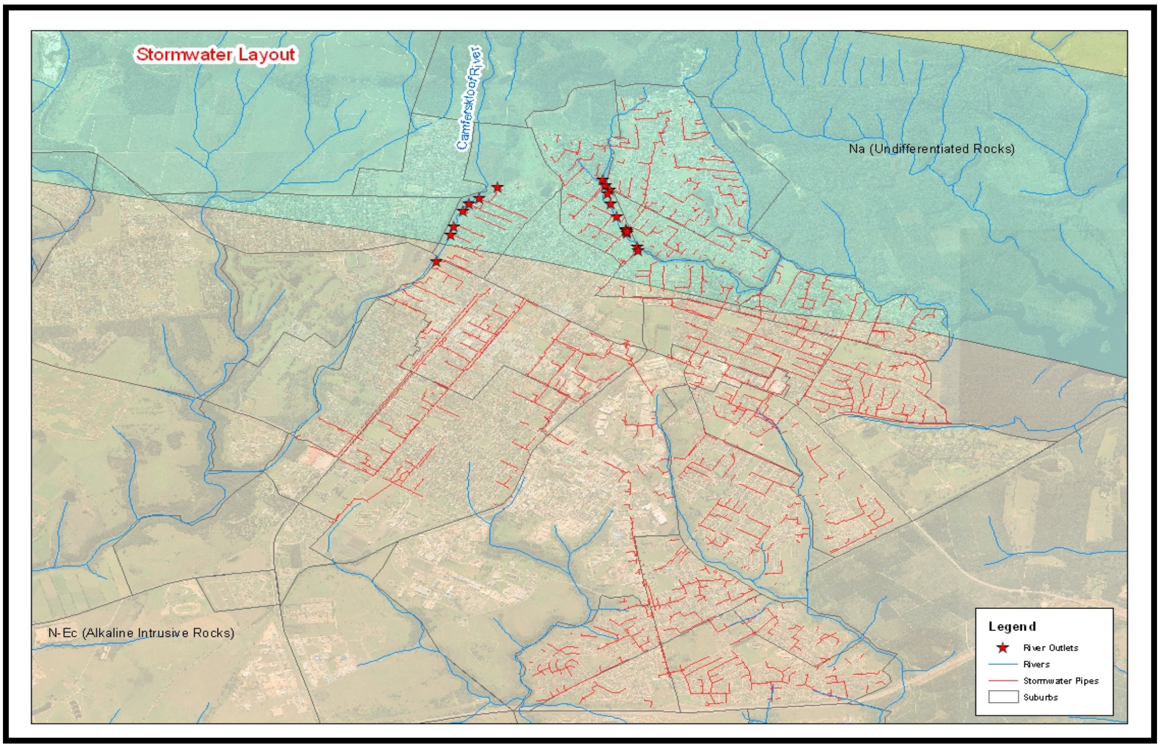
**Source:** Quinot (2010, pers com)

Targeted areas for cleaning are usually the previously disadvantaged communities, as there is greater pollution and blockage of the system in those community areas, and the high unemployment rate can be addressed by employing community members. Cleaning is done at least once a month in each ward, but better maintenance of the stormwater system will be possible once the Stormwater Master Plan is finalised with maps of the stormwater system. The labour-intensive cleaning of the system is done to prevent foreign objects reaching the discharge points, hence cleaning at discharge points is performed as well (Quinot, 2010, pers com). In December 2010 the Executive Mayor Mr Bazil Petrus gave support to the Extended Public Works Programme (EPWP) that is taking place in sixteen areas of George. This programme sees to it that four contractors employ 48 workers to clean the streets of the municipality, as reported on the George municipality website (George Local Municipality, 2011). Even though the cleaning of the streets is labour intensive, it is deemed the best solution for keeping the stormwater system pollution-free. Unemployed community members were chosen to clean the streets with a dedicated municipal staff member to help with timesheets, work planning and payment of labour (George Local Municipality, 2010). As mentioned before the IDP of the financial year of 2009/10 indicates that the cleaning of wards would receive a budget of R275, 000 for each ward for each year between 2009 and 2011 (George Local Municipality, 2009/10d:72). This WSUD activity cannot however be measured by using bulk meter data or debtors' data; therefore the investigation of the impact of stormwater quality management will not be done in this study. The municipality still has to consider stormwater as a resource; hence stormwater quality management is not a priority

**5.2.2.8 Stormwater system management (stormwater quantity management)**

The municipality deemed it fit to initiate a George Stormwater Master Plan in order to have a database and layout of the stormwater system, and the plan was compiled by private consultants from SSI Consulting (Koeglenberg, 2010, pers com). Through the investigations the municipality now knows the limitations of the system, and the infrastructure conditions were compiled as well as a Stormwater Management System (SMS) (George Local Municipality, 2010:1). Consultants were employed to create the plan and provided it for this study (Koeglenberg, 2011, pers com). The scope of the Master Plan study did not however include investigation into new and future developments or pervious pavements as part of the stormwater management system (Koeglenberg, 2010, pers com). The aim of pervious pavements is to guide stormwater towards a groundwater recharge point; the stormwater layout received by the municipality (Figure 5.19) indicated that most stormwater outlets empty into two river courses, and the layout is designed to transport water away from the urban areas, and not to accumulate for recharge.

Therefore stormwater cannot be captured in a constructed wetland or specially designed pervious pavement since the infrastructure does not allow for it. Even though other outlets might exist in open spaces, to identify them as possible groundwater recharge sites is not feasible, since the soil structure does not permit the absorption of large amounts of water without force (Schloms, 2010, pers com). According to Mr Schloms, the sandy topsoil would be saturated too quickly during rainfall and little to no percolation would occur into the underlying clay soil. Wetlands in the environs are also uncommon, since the rivers flow to the sea at too high a velocity and erode too deeply into the landscape to permit the formation of natural wetlands. Constructed wetlands could only be established for beautification and not the treatment of stormwater (stormwater quality management) because they would be too shallow for the purpose (Schloms, 2010, pers com). Since bulk water meter data and debtors’ data cannot be used to quantify the extent of this WSUD activity it will not be tackled in this study.




**Source:** Vivier (2010, pers com)

**Figure 5.19:** George Municipality Stormwater layout

Pervious pavement construction was not a consideration in the recommendations of the Stormwater Master Plan. Also, the soil structure of the town does not allow for proper groundwater recharge, which is prescribed as part of WSUD. Hence without these pavements and suitable soil structure, groundwater recharge would not be viable for the municipality.

## 5.3 CONCLUSION

Proof of only eight WSUD activities could be identified in the George municipality. In order to investigate the impact of these eight activities debtors' data (water account data) and bulk meter data was sourced. By further investigation it was determined that the bulk meter data could not be used to correlate against debtors' data since the bulk meter data were either non-existent or highly irregular. By investigating the Eden Drought Reports it was discovered that the municipality reported throughout the drought period that there was a reduction of water consumption per month during the year 2010. The municipality aimed to reduce consumption to 15kl/household per month.

The eight WSUD activities identified include; the implementation of an emergency tariff structure, water restrictions, an awareness campaign, localised sanitation services, leakage detection and fixing and treated wastewater re-use, as well as stormwater quantity and quality management, which were also part of the eight WSUD activities.

The tariff structure, water restrictions and awareness campaign were implemented in the whole George municipality. The three activities might have had a short-term effect on water consumption with a reduction in the water consumption increase from October 2009 to June 2010 in the high-income wards chosen for analysis. The consumption values started increasing again in July 2010 once the municipality announced that they were at low risk during the drought in the Eden Water Crisis Report. In the low-income wards however the effect of the WSUD activities cannot be assessed since these areas already use far lower than the target 15kl reduction. The lower income areas do not seem to need intervention. An awareness campaign was initiated and various responses from the public to the campaign were published. The Fancourt Golf Estate water consumption was measured for the awareness campaign activity since the estate printed a magazine article during the campaign period, to display their water conservation initiatives. Two debtors' data types were utilised for the analysis of the estate, which is sub-ID 37 and Fancourt's holding company, Plattner Golf (PTY) LTD. The two data types presented similar consumer patterns and it seems the awareness campaign of the municipality cannot receive credit for any water consumption reduction in the estate since water consumption reduced as early as March 2009 before the municipality's awareness campaign of October 2009. On the other hand the magazine article also had no effect on the water consumption of residents on the estate, or even the holding company, with water consumption still increasing after the magazine article of May 2010 (Scott, 2010, pers com). Water consumption for January 2011 to June 2011 is even higher than the consumption for January to June 2010.

The impact of localised sanitation service activity on water consumption cannot be detected. Compared to four other suburbs (which do not receive the service) the service provided in Wilderness did not result in a reduction in water consumption. On average the Wilderness area still consumed more water than three other suburbs; however the highest income suburb of the municipality still used more water than all suburbs in the analysis. If however a percentage increase per month is considered, then Wilderness still increases at a higher rate than all the suburbs in the analysis at about 0.71%.

Leakage detection and fixing shows a decrease in monthly totals out of 24 debtors, since fixing was begun in January 2010, and the totals also seem to be lower in 2010 than 2008 and 2009 for the same months.

In the case of the treated effluent re-use activity, wastewater flows since August 2010, (operation started at the WWTW) did reduce, compared to previous years. Stormwater quantity and quality could not be measured by the debtors' data or bulk water data. However, since the municipality made an effort to create a Stormwater Master Plan the management of stormwater quantity via the stormwater system would be a priority for the municipality, even though there is no consideration for pervious pavements yet. On the matter of stormwater quality, the municipality has cleaned the stormwater system continuously at strategic places since the Mayor of the municipality made it a priority.

WSUD activity implementation had a short-term impact on water consumption patterns in the areas identified. The leakage detection and fixing activity indicated a reduction in consumption patterns and wastewater flows seem to have been reduced, as shown in the re-use of treated effluent activity. Each activity had different impact on water consumption for short periods of time, but water consumption often increased again in the middle of the year of 2010.

The last chapter of this study will summarise all chapters above, and the results of the study aim and objectives. During the study period various hurdles had to be overcome and this will be discussed as well. Contributions to the study will also be mentioned.

# CHAPTER 6: CONCLUSION

## 6.1 INTRODUCTION

This study investigated the extent of Water Sensitive Urban Design activities in the George municipality in the Western Cape Province, South Africa. Water Sensitive Urban Design (WSUD) was the Australian response to the concept of Integrated Urban Water Management (IUWM), a means to deal with unsustainable water resource management in the urban environment.. The unsustainability of water resource management was firstly addressed by IUWM which encapsulated the entire water cycle from rainwater to surface water, groundwater, and wastewater, as part of urban water management and not as separate entities. The initial ideas for IUWM came from the Urban Water Resources Research Council of the American Society of Civil Engineers during the late 1960s and early 1970s (Mitchell, 2006:592). The principles of IUWM emphasise that the whole water cycle needs to be considered when planning urban development. Not only should human needs be taken into consideration but so too should the needs of the natural environment, keeping developments sustainable to benefit the environment, the economy and society, with proper consultation.

Countries around the world responded with their own concepts, such as Australia with Water Sensitive Urban Design, the USA with Low-impact Development (LID) the UK with their Sustainable Urban Drainage System (SUDS) and New Zealand with Low Impact Urban Design and Development (LIUDD). The concept chosen for this study is Australia’s WSUD, to deal with water resource management, as Australian cities experience continuous severe water shortages and dry conditions. The case study area, the George municipality, experienced drought and hence needed a sound water resource management response. Since South Africa has progressive legislation to aid the municipality, the enabling environment already existed to deal with water resource management during dry times. The WSUD approach influenced design and planning from the moment rainwater was captured in dams, treated, and reticulated to consumers, to the point of wastewater re-use as well as stormwater use. Techniques identified as WSUD activities are grouped according to four categories: stormwater management, Demand Reduction Techniques (also known as water demand management), re-use of water and greenroof installation. A number of activities are suggested under these four main WSUD activities. WSUD activities can be implemented on a large scale with suburbs working together, by maintaining a constructed wetland as part of stormwater quality management, or on a small scale, with a household owning a rainwater harvesting tank to capture rainwater for use in gardening or flushing toilets.

This chapter touches on what results were gathered from the study by summarising the six objectives met in coming to the aim of the study. During the study various impediments were encountered and these are elaborated upon in this chapter as well. The last part of the chapter details the contribution of this study to research.

## 6.2 SUMMARY OF RESULTS

### 6.2.1 The aim of the study and Objective One

The aim of the study was to investigate whether the George municipality was implementing WSUD activities, and to what extent these had an impact on water consumption. In order to achieve this aim, the following objectives were met: the first objective was to identify what constituted WSUD activities from Australian literature, which was done in Chapter 2 of this study. Four main activities were identified in the literature namely, stormwater quantity and quality management, Demand Reduction Techniques also known as water demand management, re-use of water and greenroof installation.

Stormwater management is based on the premise that stormwater is a resource and should be treated as such by managing its quantity and quality. Stormwater quantity management includes the installation of rainwater harvesting tanks, pervious pavements for easy groundwater recharge, better irrigation practices to avoid watering plants when it rains, as well as installing water-wise gardens. Stormwater quality management includes the installation of gross pollutant or solid waste trappings which trap waste before it enters the stormwater system. Preventing waste from entering the stormwater system should be first priority with solid-waste management programmes. Quality management can be applied in steps with various treatment processes through constructed wetlands. These wetlands receive the stormwater and clean the water via the natural processes provided by plants in the wetland. Demand Reduction Techniques, or rather water demand management techniques, are diverse and include: the retrofitting of water appliances, water tariff changes, water use restrictions, leakage detection and fixing, etc. Re-use of water as the third type of WSUD activity can include the re-use of treated wastewater, localised sanitation options – which can be used in collaboration with Demand Reduction Techniques – and the use of rainwater and stormwater as separate water reticulation systems for gardening and toilet flushing. Lastly greenroof installation is also a WSUD activity whereby plants are situated on rooftops to capture rainwater to manage its quantity and quality similar to stormwater management.

### 6.2.2 Objective Two

The second objective of the study was to identify WSUD activities by examining the strategies, plans and bylaws of the George municipality in order to determine if the municipality had an enabling environment for WSUD implementation. Three time-spheres were identified wherein possible legislation was passed by the municipality, which included legislation passed prior to the drought, during the drought, and legislation for the future. Prior to the drought the municipality promulgated the George Spatial Development Framework of 2008, Integrated Development Plan of 2009/10, and the Water Services Development Plan of 2009/10. All three documents stipulate general plans for water demand management with no emphasis on actions to be taken when there is a chronic lack of water, but cautionary measures instead. Plans for more water abstraction via extra pumping stations, greywater recycling and wastewater reclamation, water conservation awareness campaign, leak detection and fixing and stormwater system cleaning were mentioned as future water resource development plans for the municipality in these documents before the drought occurred. During the drought the municipality had a rapid response with strategy documents such as the Drought Status Report at the beginning of 2010 as well as the Drought Management Policy, a Water Demand Management Strategy, and a Water Services Bylaw. In these documents the plans mentioned in previous years such as the reclamation of treated wastewater, new pumping stations, water demand management activities such as tariff changes, water restrictions, leakage detection and fixing and the awareness campaign were pushed to be implemented as soon as possible. Future plans however are only stipulated in the Water Services Development Plan of 2010/11 which emphasises that private development projects should encourage the installation of greywater systems which re-use greywater for gardening and toilet flushing. A separate reticulation system which would use treated wastewater or salty groundwater for toilet flushing and other non-potable uses is also promoted in this future document, but only for newer infrastructure development projects. This document also specifies how the reclamation of treated wastewater should be taken to the next phase in the future, since the first phase was already started during the drought at the Outeniqua Waste Water Treatment Works.

The identification of WSUD activities continued by examining WSUD activity project reports and proof of stormwater management initiatives. Documentation of eight diverse WSUD activities were identified: implementation of emergency water tariffs and revised water restrictions, the initiation of an awareness campaign, general localised sanitation services, leakage detection and fixing, as well as the treatment and reuse of wastewater. The last two out of the eight examples are initiatives concerned with the management of stormwater quality and quantity management.

### 6.2.3 Objective Three

The third objective was to compare the extent of the implementation of WSUD activities in the case study area by investigating the following:

- ✓ Bulk water data from each relevant bulk water meter to see the response of the identified WSUD activities on bulk water use
- ✓ Debtors' data for the consumer consumption information which can either correspond to bulk water data or not

The eight WSUD activities were measured by utilising the debtors' data, since the bulk water data provided for the study was incomplete. Debtors' data was obtained from the Finance Department of the George municipality. Debtors' data reflects the water accounts per water user and indicates the actual meter reading (previous reading and new reading) as well as consumption values from month to month. Consumption is calculated as the difference between the previous reading and the new reading. In the context of the data provided, water consumption was chosen as a means to measure the impact of a WSUD activity. Actual meter readings would only show increases from month to month and would not indicate any identifiable patterns in the behaviour of water users. Consumption values would thus make it possible to identify the behaviour of water users since there are identifiable patterns in terms of increases and decreases in consumption. Data is however organised according to sub-IDs. Sub-IDs are identified as follows: wards consist of various suburbs, and suburbs consist of various sub-IDs.

The first WSUD activity identified was the implementation of emergency water tariffs. Tariff changes are grouped under Demand Reduction Techniques or water demand management. The literature illustrated that the majority of consumers interviewed in Sydney, Australia, was in favour of different pricing strategies for water consumption, and that high-volume water consumers should pay for their high consumption, but also that consumers who save water should be rewarded. Even though respondents felt that there should be different pricing strategies the majority also felt that higher tariffs should not necessarily be the option to promote water conservation (Troy & Randolph, 2006:69). But the survey did establish that consumers were more concerned with the price they had to pay for water rather than the volume of water they consumed. The volume of water used in kilolitres per quarter reflected on the water bills were too difficult to comprehend but a reflection of litres used per day was better to understand. When respondents' water use was compared to other household consumption-consumers became embarrassed if their household used more water than a smaller or similar size household (Troy & Randolph, 2006:77).

The municipality implemented revised water restrictions, which are grouped under Demand Reduction Techniques or water demand management. The same survey conducted in Sydney, Australia, indicated that, with regard to water restrictions, respondents were aware of restrictions but did not know how long they would last, nor what purpose they served (Troy & Randolph, 2006:78). Respondents felt that restrictions were needed but without the enforcement of penalties for violations, water demand would never reduce. Restrictions made people more aware of their water consumption and made an impact on some people's lives, especially those who lived in a house rather than an apartment (Troy & Randolph, 2006:81).

An awareness campaign was initiated by the George municipality once the area was declared a drought-stricken area. Awareness campaigns or education campaigns also fall into the group of Demand Reduction Techniques. In the literature it is emphasised that educational programmes should not only be big initiatives at schools or public spaces but they should also be government programmes, like the National Water Initiative launched by the government of South Australia (GSA, 2009:108). This scheme introduced the "Smart Bill" in 2009 which showed customers how much water they used daily with quarterly billing, and also provided comparisons of other households of similar size. This reinforced the results of the Sydney survey mentioned earlier, that the volume of water in kilolitres on water bills was too difficult for consumers to understand and needed to be put in a more simpler or more understandable form – and also demonstrated that consumers would react if their consumption were compared negatively to that of other households (Troy & Randolph, 2006:77). The awareness campaign initiated by the George municipality gained responses from various businesses and individuals; the owner of a bakery saved the municipality 55,000 litres of water a month on his business premises and now at his home uses only 6kl of water per month (the free basic water allowance according to law) having installed rainwater harvesting tanks for toilet flushing and other uses. Fancourt Golf Estate however reported in their monthly magazine about their water conservation efforts but according to the data analysis of their debtor/water accounts (for the holding company and properties on the estate) no difference can be seen in water consumption.

In order to see the extent of three of the activities (tariff changes, restrictions and the awareness campaign) three high-income and three low-income wards were compared. The results show that there was a reduction in water consumption during the implementation of these three activities, thereby suggesting that these three activities did have an impact on water user behaviour. It should be noted however that from July 2010, consumption started to increase at an increasing rate. Since it was announced in July 2010, that the drought was at low risk, it could be argued that these three activities has a short term impact. Over the long term, water users starts to resume their normal water usage behaviour (or wasteful usage behaviour) In the low-income wards however the effect of the WSUD activities cannot be seen since these areas already use far lower than the targeted 15kl reduction. The lower income areas do not seem to need intervention.

The George municipality provides general localised sanitation services which removes sewage from septic tanks at homes and businesses. Localised sanitation services are utilised when it is beneficial for a wastewater system to lessen its demand for potable water, e.g., water used for toilet flushing. Localised sanitation management includes septic tank systems, aerobic treatments and composting toilets, mostly used on a small scale by homeowners (Newman, 2001:96). The option of transferring wastewater under pressure or vacuum to a Waste Water Treatment Works can be a solution as well. This option does not need a large reticulation network because more waste material is transported and less water is needed for flushing (Speers & Mitchell, 2000:1). In Australia small-bore sewer systems are popular whereby a household has an interceptor tank connected to a small-bore sewer, all of which uses less water since the pipes’ connection to the interceptor tank does not need to make use of gravity to function; after sewage passes through the interceptor tank it can then move through the small-bore sewer to a larger Waste Water Treatment Works or be removed by other services (Little, 2004:141). For a house connection that has a water consumption of 165 litres/person/day, the return flow is 132 litres/person/day. For a yard or standpipe water consumption of 35 to 50 litres/per person/day, the return flow is 40 litres/person/day (Little, 2004:142). The George municipality provides the tanker service mostly in the suburb of Wilderness where, compared to four other high-income suburbs, the average percentage increase of water consumption per month is much higher; this means the water consumption of Wilderness still increases month to month faster than the other suburbs in the analysis. The comparisons of the four suburbs with Wilderness were made by taking the average use, and illustrate that localised sanitation services do not encourage water conservation, since the water use is still higher in Wilderness than in the three other suburbs identified. The remaining suburb is the highest-income suburb of the municipality and still has a higher consumption than all of the suburbs used for analysis.

The George municipality initiated leakage detection and fixing programme. An example of positive results from such a programme can be found in the city of Adelaide. The aim was to encourage industries, businesses and government, which use more than 50 Ml/year, to conduct water audits (GSA, 2009:110). Adelaide was deemed the city with the least water losses since its launch of a water reticulation and leakage detection programme between 2005 and 2006, and more money was provided to improve their track record. This shows that money is needed for such programmes, and by starting with plans in strategic sectors like businesses, industries, and government itself, more water will be saved, as it is these sectors which use the largest volumes of water. The George municipality’s leakage detection and fixing programme was initiated in January 2010, and by comparing 24 debtors’ accounts from this month to June 2010 the consumption values show a decrease in monthly totals; the totals also seem to be lower in 2010 than 2008 and 2009 for the same months and remained lower than 600kl a month.

The municipality also implemented a treatment and re-use of wastewater project at one Waste Water Treatment Works in the town. In the literature it is clear that re-use of wastewater and even stormwater use is well established in Australia and it is estimated to save large volumes of potable water, which would have been used for toilet flushing and irrigation. The athlete village for the Sydney Olympic Park is just such an example, where reclaimed water is used to flush toilets and for irrigation. It is estimated that 40% of the reclaimed water is used for toilet flushing in the village and the Olympic Park and 60% if used for irrigation and operational wash-down of spaces. This re-use of water saved 850 million litres of drinking water a year (Beatley & Newman, 2009). The re-use of wastewater does not only save water but because the quality of water after treatment is better, pollutants are not released into the natural environment. If re-use of wastewater were performed on an industrial level the municipality wastewater system would receive less water to cope with. If a river has to receive treated wastewater the aquatic life and river aesthetics would improve, and the cost of treating the water downstream would also decrease (Anderson, 2003:7). If wastewater were re-used there would be no need for further development of supply side-driven infrastructure -such as dams for storage purposes- since water already in the urban water cycle would be used and re-used. Waste Water Treatment Works would also require fewer infrastructure developments since wastewater does not need to be disposed of (Anderson, 2003:8). The municipality initiated the reclamation of treated wastewater from their Outeniqua WWTW and pumped the high quality reclaimed water back into their Garden Route dam to be mixed with raw water. This reclamation of wastewater was the first of its kind in South Africa and 10Ml of wastewater now gets treated every day (Schoonraad, 2010c). However, treated wastewater at other WWTWs does not get used for irrigation but only for cleaning WWTW sites (Jumart, 2010, pers com).

Stormwater quality management was part of the municipality's daily service to keep the stormwater system clean and free from solid waste and to ensure water does not become polluted. The municipality has a labour-intensive programme to clean waste traps and stormwater outlets physically. With fewer pollutants it becomes possible to use stormwater as a water resource. The literature suggests various other options to ensure that the water in the stormwater system does not become polluted; a primary treatment process using solid waste traps can be followed, along with bio-filtration systems, which consist of swales or depressions in the landscape designed to accept the infiltration of stormwater, or move stormwater to a collection point. Water thus flows through the waste traps and the swales which can be filled with vegetation and gravel to treat the water naturally (Lloyd, Wong & Porter, 2002:3). A secondary treatment is the construction of wetlands in a series or, as it is known, a "treatment train". This series of treatments ensures that pollutants do not accumulate in one space but get spread out and treated along the waterway by the bio-filters (Lloyd, Wong & Porter, 2002:4). The soil structure of George however does not allow for deep natural wetlands, but constructed wetlands could be utilised for beautification, though not for stormwater treatment purposes owing to their restricted depth (Schloms, 2010, pers com). The municipality still has to consider stormwater as a resource; for this reason stormwater quality management is not a priority.

Stormwater quantity management in the municipality is considered in the Stormwater Master Plan. This plan was part of a project to obtain data and more research on the existing stormwater system since information was not available. The stormwater system was mapped and the system still allows stormwater to flow into rivers and open spaces, and is not used as a resource; neither was pervious pavement construction a consideration in the recommendations of the Stormwater Master Plan (Koeglenberg, 2011, pers com). The soil structure of the town does not allow for proper groundwater recharge, as prescribed as part of WSUD (Schloms, 2010, pers com). The aim of pervious pavements is to guide stormwater towards a groundwater recharge point, but without these pavements and suitable soil structure, recharge would not be viable for the municipality. However, pervious pavements and groundwater recharge are not the only options for stormwater quantity management, and the promotion of better irrigation systems, rainwater harvesting and water-wise gardening certainly are (Donofrio, et al, 2009: 182).

One thing is for certain, diversity through more than one particular WSUD activity brings better water resource management. Speers and Mitchell (2000:3) say it best by stating that a “dogged adherence to one approach is counterproductive and likely to lead to a reduction rather than an increase in sustainability.”

### 6.2.4 Objective Four

The fourth objective of the study was to identify the future plans of the municipality for new developments and this was done by the identification of only one document, namely the Water Services Development Plan of 2010/11. A short summary of the document’s intentions for the future of water resource management in the George municipality was mentioned earlier, when part of Objective Two was discussed.

### 6.2.5 Objective Five

This was to identify the reason for past implementation or non-implementation of WSUD activities.This study concluded that the George municipality implemented eight diverse WSUD activities, mentioned before in this chapter. During the drought period however a newspaper article stated that the municipality would address the high-volume consumers’ unwillingness to reduce consumption by installing restriction devices on water meters; these restriction devices allow for a limited volume of water to be used per household – if the limit is reached the meter stops, and more water needs to be purchased by the consumer at the municipality (Schoonraad, 2010a). The restriction devices were not installed. The municipality claims that it took time to finalise implementation procedures and the drought was already under control by the time installation could at last occur. However, since the water restriction was lifted in November 2010, water use has increased yet again at the same high-volume consumer residences identified previously, that is, those who use over 15kl per month (Micheals, 2011, pers com). During the study period, staff members completed a checklist to identify which WSUD activities had been implemented by the municipality and in which suburb implementation occurred.

**Table: 6.1:** WSUD activities claimed and proven

| WSUD activity | Responsible person/ municipality department/suburb identified for implementation | Proven activity implementation by study |
|---|---|---|
| 1. Stormwater management | | |
| Quantity | | Proven- Stormwater system management (stormwater quantity management)- Stormwater Master Plan |
| ✓ Rainwater tanks | ✓ Civil Eng Services Henry Jansen Alton Michaels<br>✓ All Suburbs | |
| ✓ No automatic irrigation methods | No Implementation | |
| ✓ Water-wise gardening | ✓ Civil Eng Services/Henry Jansen<br>✓ All Suburbs | |
| ✓ Pervious pavements | No Implementation | |
| ✓ Groundwater retention and recharge | No Implementation | |
| Quality | | |
| Solid waste management only | ✓ Environmental Services/Giel Goosen<br>✓ Civil Eng Services/Jacques Quinot<br>✓ All Suburbs | Proven- Stormwater system management (stormwater quality management)- continuous |
| Constructed wetlands | No Implementation | |
| 2. Demand Reduction Techniques (WC/WDM) | | |
| ✓ Retrofitting with water saving appliances | • Civil Eng Services/Henry Jansen/Alton Michaels<br>• All Suburbs | |
| ✓ Leakage detection and fixing | • Civil Eng Services/Henry Jansen/ Alton Michaels<br>• All Suburbs | Proven- Leakage detection and fixing in indigent and high consumer households from 04 January 2010 to |

| | | |
|---|---|---|
| | | 29 October 2010 |
| 2. Demand Reduction Techniques (WC/WDM) | | |
| ✓ Water use restrictions | • All Suburbs | Proven- Revised Water Restrictions since 07 December 2009 to 25 November 2010 |
| ✓ Suitable tariffs system (charge for volume used) | • Civil Eng Services/Henry Jansen/ Alton Michaels<br>• All Suburbs | Proven -Emergency water tariffs from 27 November 2009 to 27 December 2010 |
| ✓ Accurate metering | • Civil Eng Services/Henry Jansen/ Alton Michaels<br>• All Suburbs | |
| ✓ Pressure reduction programmes | • Civil Eng Services/Henry Jansen/ Alton Michaels<br>• All Suburbs | |
| ✓ Reduction of seepage and evaporation in dam storage and irrigation systems | • Civil Eng Services/Henry Jansen/ Alton Michaels<br>• All Suburbs | |
| ✓ Better irrigation options | No Implementation | |
| ✓ Educational campaigns on environmental and financial value of water | • Civil Eng Services/Henry Jansen/ Alton Michaels<br>• All Suburbs | Proven- Awareness campaign since October 2009 till January 2011 |
| ✓ Reduced wastewater flow | • Civil Eng Services/Henry Jansen/ Alton Michaels<br>• All Suburbs | |
| 3. Re-use of wastewater | | |
| ✓ Fit for purpose use (irrigation, dust settling) | • Civil Eng Services/Henry Jansen/<br>• All Suburbs | |
| 3. Re-use of wastewater | | |
| ✓ Reclamation of treated wastewater | • Civil Eng Services/Henry Jansen/<br>• All Suburbs | Proven- Treated wastewater re-use project- Evaluation Report (In operation since 04 August 2010) |
| ✓ Localised sanitation options (not linked to conventional sewage system): vacuum sanitation systems, septic tanks, composting toilets, etc. | • Civil Eng Services/Henry Jansen/<br>• All Suburbs | Proven- Localised sanitation services since 04 January till 01 December 2010 |
| 4. Greenroof installation | | |
| Installing greenroofs linked to stormwater quantity management | No Implementation | |

**Source:** May (2010, pers com)

According to the checklist in Table 6.1 all WSUD activities had been implemented in all suburbs except greenroof installation, irrigation method changes, pervious pavements, groundwater retention and recharge, and installation of constructed wetlands (May, 2010, pers com). However, as the study concluded in Chapter 5, proof of only eight WSUD activities could be found, as mentioned at the beginning of this section. These activities are also listed in Table 6.1.

No other reasons for non-implementation and even past implementation have been put forward. Since the strategies identified in Chapter 4 indicate that the municipality has an enabling environment for WSUD activity implementation, it must be presumed that there is a lack of human and financial resources to implement and maintain activities mentioned in the literature review, especially for Demand Reduction Techniques. Another factor in the non-implementation of these techniques could also be that the focus of decision-makers is on obtaining greater water resources, since there is pressure on the municipality to provide services, and the benefits of WSUD activity implementation are not always recognised (Mwendera et al, 2003:769).

### 6.2.6 Objective Six

Objective Six was to make recommendations about the possible regulation of WSUD in the George municipality and how this can be applied to other drought-stricken municipalities. Recommendations for future research are also provided.

#### 6.2.6.1 Recommendations to municipality

It would benefit the municipality's water resource management significantly to learn from the efforts they had to undertake in order to obtain sustainable water resources during the drought period. By improving the planning processes the municipality would be prepared for future natural disaster phenomena. The WSDP and the IDP are the primary tools used by the municipality, but plans in these documents are not followed through and, if they were, there is no proof of this, owing to poor record-keeping. Since the drought many strategies, plans and bylaws were created to address the drought but no documents were provided to address the future. This is evident in the collection of documents presented in Chapter 4 of this study. A recommendation is that future documents – be it the new WSDP and IDP or the George Spatial Development Framework – should, for example, stipulate that housing developments have rainwater harvesting tanks and water-saving devices installed before occupation, or even that development should not be approved if WSUD activities are not included in the development plans.

A second recommendation would be that the municipality should look at various WSUD activities and not only Demand Reduction Techniques or Water Conservation and Demand Management just because the legislation is there to guide the organisation. The WSUD activities identified in this study indicate that stormwater quantity and quality management might be another subject to consider, since the municipality made an effort to create a Stormwater Master Plan. The majority of activities identified in the study still however focus on Demand Reduction Techniques or Water Conservation and Demand Management but localised sanitation still needs more emphasis, since various technologies do exist. A suggestion is that the target sector for activity implementation should be less on the poorer domestic water user but rather the high income, high volume domestic user and business, and industry.

A third recommendation is that the municipality's data capturing and record-keeping methods and management should become a priority, as records and data can be utilised to showcase the municipality's progress in not only water conservation but also in sustainable development, climate change responses, socio-economic development, etc. The data system should be user-friendly so that staff members can quantify data, and any errors or problems in data capturing can be red flagged. This would help with the quality control of data and ensure that all consumption values were captured correctly – especially with debtors' data, though bulk water data quality control should also become a priority. As the study has shown, without proper data capturing and record keeping, the municipality cannot significantly prove the impact of activities implemented in the town, as was the case with the bulk meter reading data which was incomplete, and some of the debtors' data which was unreliable.

### 6.2.7 Recommendations for future research

This study emphasises the lack of implemented WSUD activities. However to say that WSUD can be successfully implemented across the country would be premature, as much more research has to be done on its potential. As encountered during the study period it was difficult to source data on WSUD activities due to a lack of records, as in the case of leakage detection and localised sanitation, as well as any information on the water-saving benefits of the specific activities. Investigating the reasons for this lack of data record-keeping could be a potential research topic, or even what could be done to improve it. Proper research on the subject of how a municipality is run on a daily basis and how the administration measures the impact of implemented activities should be carried out, and not just at a theoretical level, since practical implementation is the issue.

One glaring absence in the water-meter data was for communal standpipes and communal toilets. This lack of data shows there is also a major gap in research at local government level. The meter level of communal standpipes and toilets would be useful for information on future housing development. Municipalities could plan better if they had data on how much water the standpipes provide to a certain size of community and, for instance, whether it was acceptable. Better sanitation services could also be planned if the research were available to help the municipality make informed decisions. The sustainability of communal standpipes and toilets would thus be in question.

As mentioned before there is a lack of research on the water-saving benefits of leakage detection and localised sanitation. Often research aims at monetary savings and not water volume savings. More research could be done on consumer behaviour and the impact of seasonal water use as well. For future research the change in consumer behaviour on the average per person or household would also be beneficial to the academic community.

## 6.2 IMPEDIMENTS EXPERIENCED DURING STUDY PERIOD

During the investigation period of the study various impediments were experienced in obtaining data, reports, and communication. The first obstacle was encountered with the initial objective of the study; this was to obtain data from the year 2004 to 2010 to make broader conclusions and see the bigger picture of water resource management changes in the George municipality. However no reports of WSUD activities being implemented in the municipality were available from the Engineering Department for the dates requested. Not even end of year reports for those WSUD activities being implemented were made available for the study. Neither did the municipality website provide access to reports which would be of interest to the public.

Obstacle number two was met when the data which specified WSUD activity implementation was obtained; it gave only recent information (for example only for 2010) and no prior implementation data was available. The data of WSUD activity implementation was also provided in raw format and had to be examined for relevance. No report on the impact of implementation accompanied the raw data, which could have been used to strengthen the value and quality of the data. The assumption is that the municipality engineering staff made an effort to keep records of what was implemented only because the municipality was experiencing drought from late 2009 through 2010 – also that they needed to report to the Department of Water Affairs and the community, because the region had been declared a disaster area, and people and organisations became interested in the progress being made by the municipality.

A third impediment was the difficulty in finding the right department, person or consultancy with the relevant data or reports. The raw data, mentioned previously, had information on the targeted consumers for leakage detection and fixing and localised sanitation, and had to be scrutinised for relevance; this data was obtained from the Engineering Department of the municipality. Information on stormwater quality management was provided by the Road and Stormwater section of the municipality instead; however, this was minimal and no data or reports were available on how and where stormwater quality management was practised. Stormwater quantity management was addressed by the municipality by commissioning a Stormwater Master Plan from a private consultancy firm called SSI Engineering, who provided a draft report for this study, since the municipality had no data or reports of its own. Neither did the municipality have any reports or data on the implementation and success of the emergency water tariffs and revised water restrictions. The municipal website was the only source of information regarding the commencement and termination of both these WSUD activities. For this study it was important to have a start and finish date for a WSUD activity, in order to measure the extent and impact of the activity implementation. One important WSUD activity implemented by the municipality was the awareness-raising campaign during the drought period. However, no report was provided by the municipality for this study but personal communication with the private consultant, who managed the campaign on behalf of the municipality, provided insight on what was done as part of the campaign. Lastly, the treatment and re-use of wastewater WSUD activity resulted in an Inception Report by the municipality, but the Evaluation Report was considered more important for this study; the Evaluation Report was obtained from the director who evaluated the progress of the activity implementation on behalf of the Department of Water Affairs.

In order for this study to investigate the extent of the WSUD activity implementation, data was needed which illustrates consumer water demand. For this purpose debtors' data, as consumer data is known, was obtained from the George municipality Finance Department. The fourth obstacle encountered during data collection was that debtors' data had to be abstracted from the Finance Department's system at the municipality. To abstract the data was problematic since the system had to provide data on all consumers; consequently, the document was too big and had to be converted to a suitable format that could be handled by a normal computer processor. Secondly the data had to be scrutinised since it comprised thousands of pages of data. Data was not arranged in wards or suburbs but rather in sub-IDs. These sub-IDs had to be identified individually first, and this was difficult as the Finance Department did not have schematics or even digital maps of how the sub-IDs are divided. In order to obtain information of how sub-IDs are divided, an internet search had to be done for the street names which were identified in the data, per individual sub-ID. Digital data which can be used for the production of digital maps was obtained from a consultancy firm (Kv3) which produces strategy documents for the municipality, and this data could be used to make maps of how the wards and suburbs overlap, but not likewise for the sub-IDs. In the end the biggest obstacle was to source data that was relevant. Since high consumption values were more valuable it was the most important data for the study. However the first batch of data did not have high consumer data but only data on consumers who use less than 15kl per month. The data that was needed for the study was consumer data for consumers using volumes of water higher than the average household's free 6kl per month. A personal visit to the municipality had to be made once more to obtain the data of high-volume consumers, since high-volume consumers had been identified for leakage detection, Fancourt and Oubaai golf resorts and more. It was discovered also that the debtors' data had many flaws; in the search for debtors with full records it was found often that months of consumer data had not been captured. Since the consumer data reflect water consumption in kilolitres per month, the missing data meant that a consumption pattern could not be established; as a result, a debtor with missing data was not chosen as part of the analysis. A second flaw of the debtors' data was that when consumption values were calculated from month to month it was discovered that the data system calculated the consumption values incorrectly if consumption decreased. If a consumer used less water than the previous month it would not show the correct difference (less than before) but would rather show an increase in that difference. To back up the debtors' data bulk meter data was needed and they were readily available from the Engineering Department.

A fifth obstacle was found during data analysis. Meter readings were often sporadically recorded since meters often break and need to be replaced. The replacement of faulty meters often results in incorrect data being recorded prior to removal and zero recordings during the replacement period. Meter readings hence often start with zero at any random period. Certain meters are not even being recorded in the data by the municipality anymore, e.g., four out of six Thembalethu bulk meters. These four bulk meters were last recorded at the end of 2003. Some bulk meters such as the Oubaai bulk meter are not even measured at all. Spatial data received from the consultancy firm Kv3 were utilised to map the different bulk meters according to the ward where it was situated. This map showed new bulk meters which were not part of the data received by the Engineering Department.

The sixth obstacle was that senior staff members of the Engineering Department passed on the request for data to junior staff members. As observed, this action resulted in late reply to data or information requests. Data and information was also not provided in report form but rather in a raw data format, and junior staff could not answer all questions fully without consulting their seniors.

During the data analysis process the last impediment was to identify the sub-IDs along with the consumer names listed in the WSUD activities, in the debtors' data. It was found that often names of consumers were repeated on the list of homes identified for two WSUD activities, namely the leak detection and localised sanitation. Names were often misspelled and even addresses did not fit consumer names on the activity lists provided by the municipality Engineering Department. WSUD activity lists also mentioned that certain consumers, for example, received the localised sanitation service as early as January 2010 but the debtors' data would show that those consumers only had a debtor's record later in the year. These inconsistencies in Engineering Department record-keeping on implemented WSUD activities made data analysis very difficult. Therefore, only names of consumers that could be found with full debtor records were used for data analysis.

## 6.3 RESEARCH CONTRIBUTION

This study indicates that South Africa has excellent legislation and local municipalities have an ability to respond to disaster phenomena by promulgating strategies. However the implementation of strategies and plans on a local level is lacking and, even if measures are implemented, the recording of their implementation is poor. Not only are records of implemented activities not available, but those records that are available are not easily accessible or consistent. This study also stated that available literature is more about the theoretical concepts which would enable authorities to manage water resources properly, but their implementation is not broadly written about or researched, e.g., research on the benefits of localised sanitation and even leakage detection is lacking, just as there is little study of consumer behaviour and the impact of seasonality on water consumption. It appears that research aims only to mention activities as part of a concept but rarely indicates how much water can be saved when these concepts have been implemented. The benefits can often be illustrated in monetary terms, but what is needed is evidence of the benefits to water resource management.

# REFERENCES


Allison R, Chiew F & McMahon T 1997. *Stormwater gross pollutants*. Industry Report 97/11. Cooperative Research Centre for Catchment Hydrology, Monash University.

Anderson JM 1996. Current water recycling initiatives in Australia: Scenarios for the 21st century. *Water Science and Technology*. 33, 10-11: 37-43.

Anderson J 2003. The environmental benefits of water recycling and re-use. *Water Science and Technology: Water Supply* 3, 4:1-10.

Andoh YG, Faram MG, Stephenson A & Kane AS 2001. A novel integrated system for stormwater management, Paper delivered at the 4th Conference on Innovative Technologies in Urban Drainage 25-27 June 2001, Lyon, France

Auditor General 2009. George Municipality Annual Report 2008/09. Available from: www.george.org.za [Accessed on: 05 September, 2010]

Australia (AU) 2001. Guidelines for Implementing Total Management Planning, Asset Management: Water Demand Management Implementation Guide, Department of Environment and Resource Management (DERM) Queensland. Available from: http://www.derm.qld.gov.au/compliance/wic/pdf/guidelines/tmp/2001_guidelines/implementation/asset_01.pdf [Accessed on 05 May 2011].

Beatley T & Newman P 2009. *Green urbanism down under- Learning from sustainable communities in Australia*. USA: Island Press.

Boubli D & Kassim F 2003. Comparison of Construction Cost for Water Sensitive Urban Design and Conventional Stormwater Design, Available from: www.cardno.com.au [Accessed on 05 March 2010].

Brown R 2004. Local Institutional Development and Organisational Change for Advancing Sustainable Urban Water Features. Keynote Address delivered at the proceedings of the International Conference on Water Sensitive Urban Design: Cities as Catchments 21st- 25th November 2004, Adelaide, Australia.

Brown RR & Clarke JM 2007. *Transition to water sensitive urban design: The story of Melbourne, Australia.* (Report No. 07/1). Facility for Advancing Water
Bio-filtration, Monash University.

Burger D 2008. *SA Yearbook 2007/08*. South Africa: Government Communications and Information System (GCIS). Department of Foreign Affairs.

Butler D & Parkinson J 1997. Towards Sustainable Urban Drainage, *Water and Science Technology*. 35,9:53-63.

Coombes PJ, Argue JR & Kuczera G 1999. Figtree Place: a case study in water sensitive urban development, *Urban Water* 1:335-343.

Coombes PJ & Kuczera G 2002. Integrated Urban Water Cycle Management: Moving towards systems understanding. *University of New Castle*. Available from: http://www.freshwateraction.net/web/d/doc_627.pdf [Accessed on 14 October 2009].

Dallman PR 1998. *Plant life in the world's Mediterranean climates- The Mediterranean Basin, South Africa, Australia, Chile, and California*. Oxford: Oxford University Press.

Davies B & Day J 1998. *Vanishing waters*. Cape Town: UCT Press.

Dietz ME 2007. Low impact development practices: A review of current research and recommendations for future directions. *Water Air Soil Pollution* 186, 351-363

Dietz ME & Clausen JC 2008. Stormwater run-off and export changes with development in a traditional and low impact division. *Journal of Environmental Management* 87, 560-566

Donofrio J, Kuhn Y, McWalter K & Winsor M 2009. Water-Sensitive Urban Design: An Emerging Model in Sustainable Design and Comprehensive Water-Cycle Management. *Environmental Practice* 11, 3:179- 189.

Eason C, Pandey S, Feeney C, van Roon M, Dixon J 2004. Low impact urban design and development: making it mainstream. Paper delivered at 1st International Conference on Sustainability Engineering and Science, Auckland, New Zealand

Falkenmark M & Rockstrom J 2005. *Balancing water for humans and nature- The new approach in ecohydrology*. UK: Earthscan.

Fane SA 2005. Planning for sustainable urban water: Systems-approaches and distributed strategies, Doctoral dissertation. Sydney: University of Technology, Institute for Sustainable Futures.

George Local Municipality 2008. George Spatial Development Framework. Available from: www.george.org.za [Accessed on 11 January 2010]

George Local Municipality 2009a. Profile & Statistics in the George Municipal Area. Available from: www.george.org.za [Accessed on 11 January 2010]

George Local Municipality 2009b. Emergency Tariffs Notice. Available from: www.george.org.za [Accessed on 03 August 2010]

George Local Municipality 2009c. Revised Water Restrictions Notice. Available from: www.george.org.za [Accessed on 03 August 2010]

George Local Municipality 2009/10d. George Municipality Integrated Development Plan. Available from: www.george.org.za [Accessed on 22 July 2010]

George Local Municipality 2010. George Mayor supports labour intensive extended public works programme. Available from: www.george.org.za [Accessed on: 14 January 2011]

George Local Municipality 2011. Change in Emergency Tariff and Restriction Notice. Available from: www.george.org.za [Accessed on 07 June 2011]

Government of Southern Australia (GSA) 2009. *Water for good- A plan to ensure our water future to 2050*. The Office for Water Security: Available from: www.waterforgood.sa.gov.au [Accessed on 01 March 2010]

Gregory KJ & Walling DE 1973. *Drainage basin form and process*: *A geomorphological approach*. New York: Wiley Publishers

Gunnell K 2009. Green Building in South Africa: Emerging Trends, Paper prepared for the Department of Environmental Affairs and Tourism (DEAT). Directorate: Information Management.

Gunning E 2009. Eden District Disaster Area, *News 24 Online*, 12 November 2009, Available from: http://m.news24.com/news24/southafrica/news/eden-district-a-disaster-area-20091112 [Accessed on June 2010]

Hipkins M 2007. Climate Change Impact and Response in Western Australia, Paper delivered at the Planning Institute of Australia National Congress 1 – 4 May 2007, Australia

Hollingworth B, Koch P, Chimuti S, & Malzbender D 2011. An investigation into the water infrastructure development financial allocation pathways in municipalities. Report No. TT 476/10. Water Resource Commission. Available from: www.wrc.org.za [Accessed on 15 June 2011].

Jacobson M 2003. Water Policy and Pricing Timber Plantations in South Africa: Implications for Sustainable Forestry. Paper delivered at the 12th World Forestry Congress, Quebec City Canada. Available from: www.fao.org/docrep/article/wfc/xii/0308-c1.htm [Accessed on 17 March 2010].

Kamara AB & Sally H 2004. Water Management Options for Food Security in South Africa: Scenarios, Simulations and Policy Implications. *Development Southern Africa* 21, 2:365 – 384.

Kothari CR 1985. *Research Methodology: Methods and Techniques*. 1st Edition. New Delhi: Wiley Eastern Limited

Little CJ 2004. A comparison of sewer reticulation system design standards gravity, vacuum and small bore sewers, Paper delivered at the 2004 Water Institute of South Africa (WISA) Biennial Conference 2-6 May 2004, Cape Town, South Africa

Lloyd SD, Wong THF, Chesterfield CJ 2001. Opportunities and Impediments to Water Sensitive Urban Design in Australia, Paper delivered at the 2nd South Pacific Stormwater Conference 27 – 29 June 2001, Auckland, New Zealand

Lloyd SD, Wong THF, Porter B 2002. The planning and construction of an urban stormwater management scheme. *Water Science and Technology* 45, 7:1-10

Lourens P 2010. Oubaai's water dilemma, *The George Herald Online*, 20 January 2010, Available from: www.georgeherald.com: Accessed on: 24 August, 2010

Manning JC 1987. *Applied principles of hydrology*. Ohio: Merril Publishing Company

McAlister T 2007. *National guidelines for evaluating water sensitive urban design (WSUD)*. (Office Report R B16789.001.00.doc). Queensland: BMT WBM Pty Ltd

Miller GT 2004. *Living in the Environment*, 13th ed. Canada: Brooks/Cole.

Mitchell VG 2004. Integrated Urban Water Management, Report of Australian Water Conservation and Reuse Research Program, Joint initiative of CSIRO & AWA

Mitchell VG 2006. Applying Integrated Urban Water Management Concepts: A Review of Australian Experience. *Environmental Management* 37, 5: 589–605.

Mishra AK & Singh VP 2010. A review of drought concepts. *Journal of Hydrology* 391, 202-216.

Mukheibir P 2005. Local water resource management strategies for adaptation to climate induced impact in South Africa. Paper delivered at the Workshop for Rural Development and the Role of Food, Water and Biomass: Opportunities for Development and Climate 14-16 November 2005. Novotel, Dakar

Mukheibir P 2010. Water access, water scarcity and climate change, *Environmental Management* 45: 1027-1039

Mwendera EJ, Hazelton D, Nkhuwa D, Robinson P, Tjijenda K, & Chavula G 2003. Overcoming constraints to the implementation of water demand management in southern Africa. *Physics and Chemistry of the Earth* 28: 761-778

Newman P 2001. Sustainable urban water systems in rich and poor cities-Steps towards a new approach. *Water Science and Technology* 43, 4: 93-99.

Newson M 1994. *Hydrology and the river environment*. Oxford: Claredon Press.

Pereira LS, Cordery I, Iacovides I,  2009. *Coping with water scarcity: addressing the challenges.* Paris: Springer,

Province of Western Cape 2009. *Provincial Gazette.* 20 November, No 6677. Cape Town: Province of Western Cape.

Schoonraad I 2010a. Water Wasters cut down to size, *The George Herald Online,* 26 May 2010, Available from: www.georgeherald.com: Accessed on: 24 August, 2010

Schoonraad I 2010b. George business owner saves water with tanks, *The George Herald Online,* 09 June 2010, Available from: www.georgeherald.com: Accessed on: 09 September, 2010

Schoonraad I 2010c. Effluent re-use in George now reality, *The George Herald Online*, 18 August 2010, Available from: www.georgeherald.com: Accessed on: 23 August 2010

Seadon JK 2006. Integrated Waste Management – Looking beyond the solid waste horison. *Waste Management* 26: 1327–1336.

Shutes RBE, Revitt DM, Mungur AS & Scholes LNL 1997. The Design of Wetland Systems for the Treatment of Urban Run-off. *Water Science and Technology*. 35,5: 19-25.

South Africa (Republic of) s.a. *Framework for water conservation and demand management*. Pretoria: South African Local Government Association (SALGA)

South Africa (Republic of) s.a. About the Cape Metropolitan Area- Terrain, Soils and Geology. Pretoria: Department of Environmental Affairs and Tourism. Available from: http://www.deat.gov.za/Enviro-Info/sote/citysoe/cape/soil_a.htm#Soils: [Accessed on 26 March 2010].

South Africa (Republic) 1998. National Water Act No 36 of 1998. Pretoria: Department of Water Affairs.

South Africa (Republic of) 2004a. *Guidelines for water conservation and water demand management in water management areas and in the water services sector*. Pretoria: Department of Water Affairs.

South Africa (Republic of) 2004b. *Guidelines for groundwater resources management in water management areas.* Pretoria: Department of Water Affairs.

South Africa (Republic of) 2004c. *National water resource strategy (NWRS)*. Pretoria: Department of Water Affairs

South Africa (Republic of) 2009. *Strategic planning for water resources in South Africa- A situation analysis*. (Report No. P RSA000/00/7809). Pretoria: Department of Water Affairs

South Africa (Republic of) 2010 National Climate Change Response Green Paper, *Government Gazette 33801*

South African Cities Network (SACN) 2006. *State of the cities report 2006.* Braamfontein: South African Cities Network. Available from: www.sacities.net [Accessed on 26 March 2010].

Speers A & Mitchell G 2000. Integrated Urban Water Cycle. Paper delivered at the Conference on Water Sensitive Urban Design – Sustainable Drainage Systems for Urban Areas 30-31 August 2000, Melbourne, Australia

Tam VWY, Tam L & Zeng SX 2010. Cost effectiveness and trade-off on the use of rainwater tank: An empirical study in Australian residential decision-making. *Resources, Conservation and Recycling* 54:178–186.

Thomas R & Thomas M 2003. *Green roofs for sustainable cities- Sustainable cities 2025.* (Project no. GR-311003-1). Report delivered to Standing Committee on Environment and Heritage October 2003, House of Representatives, Parliament of Australia.

Troy P & Randolph B 2006. Water Consumption and the Built Environment: A Social and Behavioural Analysis. Research Paper No 5. City Futures Research Centre. New South Wales Government Environmental Trust.

United States of America (USA) 2000. Low Impact Development: A Literature Review. Office Report. Washington DC: Low Impact Development Centre, United States Office of Water, Environmental Protection Agency.

Van Roon M, Dixon J & van Roon H 2005. Reformulating planning tools to promote Low impact urban design and development. Paper delivered at the New Zealand Water and Waste Association 4th South Pacific Conference on Stormwater and Aquatic Resource Protection 4-6 May 2005, Auckland, New Zealand.

Van Roon M & van Roon H 2005. Low impact urban design and development principles for assessment of planning, policy and development outcomes. Working Paper 051. Auckland: Centre for Urban Ecosystem Sustainability. Available from: http://www.landcareresearch.co.nz. [Accessed on 15 June 2011].

Van Roon M 2007. Water localisation and reclamation: Steps towards low impact urban design and development, *Journal of Environmental Management* 83, 437-447

Williams NSG, Rayner JP & Raynor KJ 2010. Green roofs for a wide brown land: Opportunities and barriers for rooftop greening in Australia. *Urban Forestry and Urban Greening*, 1-7

Wong THF 2006. An Overview of Water Sensitive Urban Design Practices in Australia. *Water Practice and Technology* 1, 1:1-8

Wynkoop SE 1999. Low-Impact Development Design Strategies: An Integrated Design Approach, Prepared by: Prince George's County, Maryland, Department of Environmental Resources, Programs and Planning Division.

Zehnder AJB, Yang H & Schertenleib R 2003. Water Issues: the need for action at different levels. *Aquatic Sciences*. 65:1-20

**Personal Communication**

Jumart J (jurie@george.org.za) 2010. RE: Treated effluent reuse. Email to N. Lottering (lotteringn@dwa.gov.za) (23 July).

Jumart J (jurie@george.org.za) 2010. RE: Wastewater flows. Email to N. Lottering (lotteringn@dwa.gov.za) (09 May 2011).

Koeglenberg J (janniek@ssi.co.za) 2011. RE: Stormwater master plan. Email to N. Lottering (lotteringn@dwa.gov.za) (11 January).

Koeglenberg J (janniek@ssi.co.za) 2010. RE: Pervious pavements. Email to N. Lottering (lotteringn@dwa.gov.za) (22 June).

Mashicila S (mashicilas@dwa.gov.za) 2010. RE: Outeniqua WWTW reclamation plant project performance evaluation. Email to N. Lottering (lotteringn@dwa.gov.za) (29 September).

Mashicila S (2010). Engineer, Department of Water Affairs, Bellville, Meeting in November, 2010 about the George municipality WSDP 2010/11

May A (arthur@george.org.za) 2010. RE: Bulk water data questions. Email to N. Lottering (lotteringn@dwa.gov.za) (07 June).

May A (arthur@george.org.za) 2010. RE: WSUD activity table. Email to N. Lottering (lotteringn@dwa.gov.za) (01 September 2010)

May A (Arthur@george.org.za) 2011. RE: Bulk water data. Email to N. Lottering (lotteringn@dwa.gov.za) (02 February).

McGown D (montage@iafrica.com) 2011. RE: George water conservation awareness campaign. Email to N. Lottering (lotteringn@dwa.gov.za) (23 February).

McGown D (montage@iafrica.com) 2011. RE: End of George water conservation awareness campaign. Email to N. Lottering (lotteringn@dwa.gov.za) (14 June).

Michaels, A (alton@george.org.za) 2011. RE: Copy of complaints- leak detection for high water consumers and indigent households and provision of localised sanitation services. Email to N. Lottering (lotteringn@dwa.gov.za) (02 February).

Michaels, A (alton@george.org.za) 2011. RE: Restriction devices. Email to N. Lottering (lotteringn@dwa.gov.za) (19 July).

Mooiman L (Lindsay@george.org.za) 2010. RE: Various plans and strategies to deal with the drought. Email to N. Lottering (lotteringn@dwa.gov.za) (14 January).

Nel C (coenien@ssi.co.za) 2010. RE: WSDP 2009/10. Email to N. Lottering (lotteringn@dwa.gov.za) (04 August).

Quinot J (jacques@george.org.za) 2010. RE: Questions on about the maintenance of the stormwater system. Email to N. Lottering (lotteringn@dwa.gov.za) (31 May).

Quinot J (jacques@george.org.za) 2010. RE: Stormwater system management. Email to N. Lottering (lotteringn@dwa.gov.za) (31 May).

Schloms B 2010. Lecturer, Stellenbosch University, Stellenbosch, Consultation session on 03 August, 2010 about soil characteristics of George.

Scott T (tanas@fancourt.co.za) 2010. RE: Fancourt water conservation initiatives written in their May edition of Fancourt magazine. Email to N. Lottering (lotteringn@dwa.gov.za) (05 July).

Summers R (summersr@dwa.gov.za) 2010. RE: Drought reports. Email to N. Lottering (lotteringn@dwa.gov.za) (22 November).

Swanepoel D 2010. RE: Environmental Authorisation of Fancourt –amendment of extension. Email to N. Lottering (lotteringn@dwa.gov.za) (14 July).

Van Niekerk A (amvanniekerk@ruraldevelopment.gov.za) 2011. RE: Spatial data. Email to N. Lottering (lotteringn@dwa.gov.za) (19 June).

Vivier H(hannahmv@ssi.co.za) 2010. RE: Stormwater network/layout. Email to N. Lottering (lotteringn@dwa.gov.za) (13 July).

# APPENDIX A

**Table A.1** Water services level per ward

| | | GENDER | | EMPLOYMENT | | | HOUSING | | | INCOME | | | | Piping | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ward | Population Total | Male | Female | Paid Employee | Unemployed | Self Employed | Formal Housing | Informal dwellingin backyard | Informal dwelling not in backyard | No Income | R1 - R1600 | R1601- 12800 | R12801 - R25600+ | Piped in Dwelling | Piped in Yard | Piped Community Strand <200m | Piped Community Strand >200m |
| 1 | 5454 | 45.65 | 54.35 | 43.86 | 45.15 | 1.55 | 83.23 | 3.87 | 12.9 | 2.26 | 38.38 | 27.42 | 0.97 | 78.39 | 15.16 | 3.87 | 2.26 |
| 2 | 5662.34 | 47.81 | 52.19 | 31.03 | 55.17 | 9.66 | 98.8 | 0.8 | 0.4 | 1.59 | 5.58 | 66.93 | 12.75 | 97.61 | 0.8 | 0.4 | 0 |
| 3 | 6101.15 | 49.34 | 50.51 | 35.03 | 0.54 | 11.43 | 99.63 | 0.37 | 0 | 0.74 | 1.84 | 28.15 | 8.15 | 98.89 | 0.37 | 0.37 | 0 |
| 4 | 9436.32 | 50.05 | 49.95 | 39.24 | 51.16 | 3.49 | 68.46 | 1.68 | 29.19 | 5.03 | 45.97 | 42.29 | 2.02 | 54.03 | 9.73 | 21.81 | 8.05 |
| 5 | 6278.19 | 47.42 | 52.58 | 52.49 | 52.49 | 1.66 | 87.31 | 4.48 | 7.84 | 2.99 | 19.04 | 47.77 | 4.1 | 84.33 | 7.84 | 6.72 | 1.12 |
| 6 | 7536.81 | 45.51 | 54.23 | 45.8 | 48.02 | 1.63 | 88.81 | 9.75 | 1.44 | 4.33 | 46.57 | 39.71 | 0 | 83.03 | 11.19 | 4.69 | 0.72 |
| 7 | 6661.4 | 47.71 | 52.29 | 41.99 | 50.61 | 1.33 | 87.41 | 8.15 | 4.07 | 4.44 | 58.52 | 29.26 | 0.74 | 66.3 | 31.48 | 1.11 | 0 |
| 8 | 6184.6 | 48.55 | 51.45 | 37.48 | 52.9 | 0.86 | 82.07 | 1.99 | 15.94 | 1.2 | 56.57 | 41.83 | 0 | 79.68 | 4.78 | 7.97 | 6.77 |
| 9 | 4434 | 47.52 | 52.03 | 34.35 | 58.16 | 1.36 | 60 | 1.3 | 38.26 | 4.35 | 82.17 | 13.48 | 0 | 39.13 | 35.65 | 11.3 | 12.17 |
| 10 | 5276.7 | 47.77 | 50.78 | 37.37 | 56.09 | 1.84 | 83.23 | 3.87 | 12.9 | 6.84 | 78.7 | 13.69 | 0.38 | 44.11 | 31.56 | 6.84 | 17.49 |
| 11 | 6082.41 | 49.08 | 50.83 | 36.38 | 56.78 | 2.01 | 54.64 | 1.43 | 43.21 | 1.79 | 86.43 | 11.07 | 0 | 33.57 | 35.71 | 17.86 | 11.79 |
| 12 | 7619.17 | 49.32 | 50.63 | 43.69 | 47.53 | 2.21 | 85.22 | 1.54 | 12.86 | 4.22 | 51.44 | 29.94 | 0.96 | 58.93 | 29.75 | 7.87 | 1.54 |
| 13 | 5683.42 | 47.38 | 52.41 | 33.7 | 57.21 | 1.72 | 59.59 | 0 | 38.78 | 0.82 | 80.41 | 18.77 | 0 | 45.31 | 41.63 | 3.67 | 3.67 |
| 14 | 8987.18 | 46.44 | 53.56 | 36.07 | 58.2 | 1.39 | 97.63 | 0.4 | 1.98 | 4.35 | 64.82 | 30.05 | 0 | 97.23 | 0.79 | 0.79 | 0 |
| 15 | 7606.73 | 45.8 | 54.2 | 46.69 | 47.95 | 1.74 | 83.49 | 4.78 | 11.74 | 0.87 | 26.52 | 56.53 | 10.87 | 76.52 | 10.87 | 11.3 | 0.87 |
| 16 | 9753.79 | 58.63 | 50.34 | 48.84 | 41.28 | 5.23 | 80.16 | 2.35 | 16.45 | 2.09 | 32.37 | 43.07 | 13.84 | 53.79 | 6.01 | 11.49 | 1.83 |
| 17 | 5255 | 47.06 | 52.94 | 42.37 | 55.07 | 0 | 87.4 | 6.11 | 3.82 | 1.53 | 53.44 | 44.66 | 0 | 87.79 | 8.78 | 2.29 | 0 |
| 18 | 6610.67 | 49.25 | 50.75 | 25.21 | 57.14 | 13.28 | 98.99 | 0 | 0.37 | 1.11 | 5.91 | 48.72 | 19.93 | 98.89 | 0.37 | 0.74 | 0 |
| 19 | 8682.11 | 49.83 | 50.17 | 39.05 | 48.7 | 9.22 | 97.67 | 1.66 | 0 | 2.66 | 6.97 | 63.12 | 20.6 | 98.67 | 0.66 | 0 | 0 |
| 20 | 6099 | 46.76 | 53.24 | 35.73 | 60.33 | 0.95 | 84.46 | 2.39 | 12.75 | 4.78 | 65.33 | 28.29 | 0 | 69.72 | 19.52 | 9.37 | 0.8 |

| | |
|---|---|
| ward 1 | BLANCO, FANCOURT GARDENS |
| ward 2 | DENNEOORD, CAMPHERSDRIFT, BO DORP, TWEERIVIEREN |
| ward 3 | HEATHER PARK, HEATHERLANDS, GLEN BARRY, DOHRMELHLSDRIFT, KING GEORGE PARK, ROOIRIVIERRIFT |
| ward 4 | WILDERNESS, TOUWSRANTEN, GLENWOOD |
| ward 5 | LAVALIA, PROTEA PARK, ROSEMOOR, CONVENT GARDEN, PART OF URBANSVILLE |
| ward 6 | URBANSVILLE |
| ward 7 | LAWAAIKAMP, BALLOTSVIEW, MARAISKAMP |
| ward 8 | PARKDENE |
| ward 9 | THEMBALETHU |
| ward 10 | THEMBALETHU |
| ward 11 | THEMBALETHU |
| ward 12 | THEMBALETHU |
| ward 13 | THEMBALETHU |
| ward 14 | PACALTSDORP: NEW DAWN PARK, ANDERSONVILLE, SMARTIES TOWN, SEA VIEW |
| ward 15 | PACALTSDORP: EUROPE, OU PACS, NOORDSTRAAT |
| ward 16 | HAROLDSBAY, DELLVILLE PARK, GEELHOUTBOOM, HEROLD, SINKSABRUG, OU BAAI, WABOOMSKRAAL |
| ward17 | CONVILLE |
| ward 18 | BERGSIG, LOERIE PARK, GENEVA FONTEIN, EDEN, DENVER PARK |
| ward 19 | GEORGE CENTRAL, BOS-EN-DAL, GROENEWEIDE PARK, GEORGE SUID |
| ward 20 | BORCHARDS, HELFTE, LAWAAIKAMP |

**Source:** George Local Municipality (2009/10d)

# APPENDIX B

UNIVERSITEIT·STELLENBOSCH·UNIVERSITY
jou kennisvennoot · your knowledge partner

***Geografie en Omgewingstudie***
***Geography and Environmental Studies***

5-10-2010

George Municipality

To whom it may concern

CONFIDENTIALITY OF DEBTORS DATA: MS N LOTTERING

Ms Lottering is currently enrolled for a MA study in geography at the University of Stellenbosch. In order for her to successfully complete her data collection phase for the study entitled “Towards Water Sensitive Urban Design in urban South Africa - The Case of George municipality” she has to get access to the municipality’s debtors data. She has subscribed to the necessary ethical agreements and protocol in doing her research and should she get access to the said data she will use it for academic purposes only.

A final copy of her study can be made available to the municipality if you are interested in the findings.

Please do not hesitate to contact me should you have any queries regarding this request.

Yours sincerely,

**Figure B.1:** Letter for debtors’ data request

# APPENDIX C

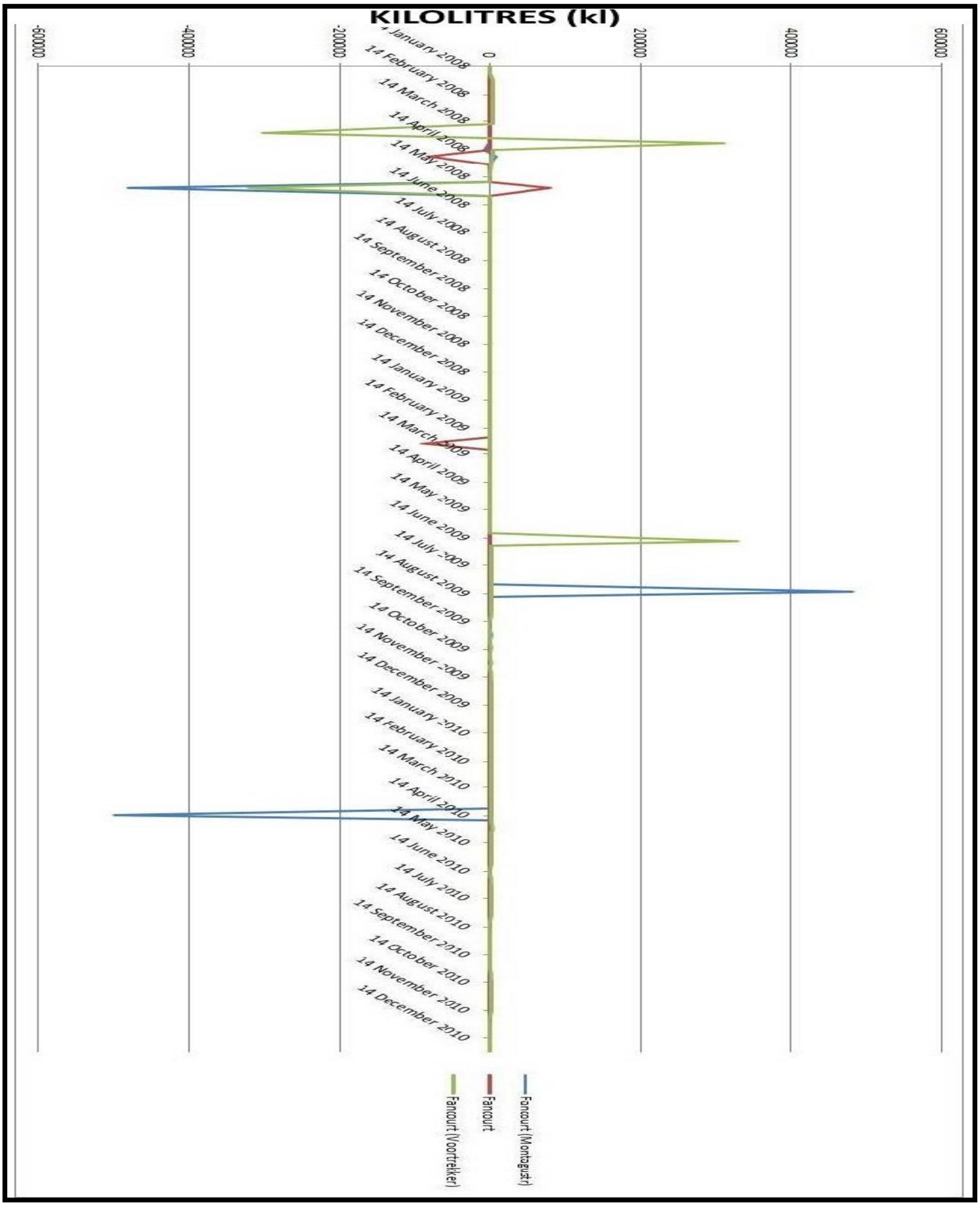



**Figure C1:** Fancourt Bulk Meters