

Water Sensitive Planning

An integrated approach towards sustainable urban water system planning in South Africa

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Acknowledgments

“Trust because you are willing to accept a risk, not because it is safe or certain”

-G. Stander-

Sincere thanks to Dr. Juaneé Cilliers, my study supervisor for believing in me and in my academic work. Your support, encouragement and valuable advice in this study were appreciated.

To my parents and my sister for their love, encouragement and support.

Cornell my friend, thank for the fun times that we spent working together.

To God, I truly don't have enough words to express myself with.

Abstract

“Without water, there is no life on the earth; it is the most important of all elements. It must be managed in the best possible way” (Cunningham, 2009). Balanced and self-renewing ecosystems are not new phenomena, developed by earlier civilisations, and still part of our modern cities and societies today. However, the increasing urbanisation, densifications and related urban challenges of the modern urban environment is also increasing the pressure on sustainable resources world-wide. Countries responded to the concept of Integrated Urban Water Management (IUWM) in many different ways; the USA formulated the concept of Low-Impact Development (LID), the UK’s approach was Sustainable Urban Drainage System (SUDS), and New Zealand formulated their approach as Low Impact Urban Design and Development (LIUDD). Aiming to integrate all of the above mentioned approaches Australia developed the concept of Water Sensitive Urban Design (WSUD). WSUD refers to the interdisciplinary cooperation of water management, urban design and landscape planning which considers all parts of the urban water cycle, combines water management functions and urban design approaches and facilitates synergies between ecological, economic, social and cultural sustainability (Wagner, 2010). In the local South African context it is now time for a fundamental paradigm shift to identify and protect sustainable resources, specifically stormwater, not only as a challenge, but a valuable resource playing a critical role in the urban planning and design process and overall sustainability of South Africa’s water resources.

This approach includes the rethinking of the role of layout-planning to direct the desired future of our cities. Water Sensitive Planning (WSP) is introduced by this research, as an initiative to guide current planning and urban design approaches in South African environments, based on the concept of Integrated Urban Water Management (IUWM), with the objective to manage the urban water cycle as a whole, and not as separate entities (Barton, 2009). It bridges gaps between various sectors and provides a platform for trans-disciplinary planning, which is a challenge for sustainable water resources management in South African cities. In order to determine whether South Africa has identified stormwater as a valuable resource, integrated in the urban planning process, the research focused on Potchefstroom’s Local Municipalities approach towards Water Management and Urban Planning. Local policy frameworks such as the Spatial Development Framework (SDF), Integrated Development Plan (IDP) and the Water Service Development Plan (WSDP) were evaluated in an attempt to determine the priority and approach towards integrated water management and spatial planning. Planning recommendations referred to international best practices and case studies from Australia, to guide local South African urban planning and urban design approaches to protect the valuable natural resources in the urban environment, by redefining the current role of layout-planning in a local context, and to direct the desired future and sustainable development in South Africa.

Opsomming

"Sonder water is daar geen lewe op aarde nie; water is die belangrikste natuurlike elemente op aarde en daarom moet dit bestuur word op die beste moontlike manier" (Cunningham, 2009). Gebalenseerde en selfversorgende ekosisteme is nie n nuwe verskynsel nie, ontwikkel deur vroeere beskawings, en is nogsteed deel van vandag se modern stede en gemeenskappe. Egter as gevolg van toeneemende verstedeliking, densifikasie en verwante stedelike uitdagings van die modern stedelike omgewing het die druk op volhoubare hulpbronne eksponesieel verhoog. Dit is tyd om te kyk na n fundamentele paradigmskuif om volhoubare hulpbronne, met spesifieke fokus op storm water, nie net as 'n uitdaging te identifiseer nie, maar as n waardevolle hulpbron wat n kritieke rol in die stedelike beplanning en algehele volhoubaarheid van Suid-Africa speel. Dit sluit die herbedenking van die rol van uitleg-beplanning om die gewenste toekoms van ons stede te rig. Water Sensitiewe Beplanning (WSP) is ingestel as 'n inisiatief om huidige beplanning en stedelike ontwerp benaderings in die moderne stad te lei, gebaseer op die konsep van *Integrated Urban Water Management* (IUWM) wat tot die bestuur van stedelike watersiklus as 'n geheel is, en nie as aparte elemente en nie as 'n aparte entiteite nie (Barton, 2009). Verskillende konsepte het verder ontwikkel vanaf die IUWM konsep, VSA het die konsep van *Low-impact Development* (LID) geformaliseer, Sustainable Urban Drainage Systems (SUDS) was die UK se benadering en die *Low-impact Urban Design and Development* (LIUDD) konsep was ontwikkel deur New-Zealand. Deur n samevatting van die bo genoemde konsepte het Australia *Water Sensitive Urban Design* (WSUD) ontwikkel.

WSUD verwys na die interdisiplinere samevatting van water bestuur en stedelike beplanning wat alle dele van die stedelike watersiklus kombineer om sinergie tussen ekologiese, ekonomiese, sosiale en kulturele volhoubaarheid te skep (Wagner, 2012). WSUD oorbrug die gapings tussen die verskillende sektore en bied 'n platform vir transdisiplinere beplanning, wat as 'n uitdaging in Suid-Africa beskou word. Om te bepaal of Suid-Africa stormwater as n waardevolle hulpbron identifiseer, het die studie Potchefstroom Munisipaliteit se benadering tot water bestuur en stedelike beplanning geondersoek met spesifieke verwysing na die Ruimtelike Ontwikkelingraamwerk (SDF), Geïntegreerde Ontwikkelingsplan (IDP) en die Waterdienste Ontwikkelings Plan (WSDP). Beplanning aanbevelings verwys na internasionale beste praktyke en gevallestudies uit Australië, om plaaslike stedelike beplanning en stedelike ontwerp benaderings te lei om die waardevolle natuurlike hulpbronne te beskerm. Deur herdefiniëring van die huidige rol van die uitleg-beplanning in 'n plaaslike konteks, sal 'n gewenste toekoms en volhoubare ontwikkeling in Suid-Afrika nagesteef word.

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Table of Acronyms

Table 1: Acronyms

BBP	Better planning Practice
BMP	Best Management Practice
CMA	Catchment Management Agency
CNT	Centre for Neighbourhood Technology
CSQA	California Stormwater Quality Association
DBSA	Development Bank South Africa
DPLG	Department of Planning and Local Government
DWA	Department of Water Affairs previously known as Department of Water Affairs and Forestry
GJMC	Greater Johannesburg Metropolitan Council
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
PAI	Population Action International
PIA	Planning Institute of Australia.
PSDF	Potchefstroom Spatial Development Framework
SALGA	South African Local Government Association
SUDS	Sustainable Urban Drainage System
SUDS	Sustainable Urban Drainage System
TARWR	Total actual renewable water resource

UK	United Kingdom
UN	United Nations
UNEP	United Nations Environmental Programme
USA	United States of America
WC/WDM	Water Conservation and Demand Management
WIR	World Resource Institute
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

Source: Own Construction (2012)

Chapter 1: Research theme, design and methods

1.1. Point of departure

Water is perhaps the most important commodity for a community's sustainability and adequate supply of quality water is therefore precious beyond compare (Maser, 1997: 153). Unfortunately the water sector has only had a small impact on decisions that affect the shape and density and planning of South African cities (Fabrizi, 2002). Delivery of water infrastructure and services were added late in the planning process or when cities expanded. Climate change and an ever-expanding population continue to increase demand on the world's freshwater resources and broader environment, and countries around the world are rethinking the way they value, allocate and manage water. Human activities and the intensity of land-use in urban areas are in a direct relationship with the quantitative or qualitative water problems (Huggett et al., 2004: 256). These negative effects of human activities are not always immediately visible. However, when these human impacts finally come to sight (e.g. flooding disaster, serious water pollution), addressing these problems after a long-term of accumulation is extremely costly and in some situation impossible. Flooding, drought and pollution are major obstacles in terms of sustainable urban development. Current institutional arrangements are limited in their ability to address these issues due to a lack of knowledge on how to integrate the nature of water systems and the disintegrated institutional arrangements to manage water related issues (Dent, 2008).

Cities are complex and dynamic systems, with on-going interactions between socio-economic and environmental processes at a local and global scale (Sanchez-Rodriguez, 2002). These systems are being poisoned by rapid urbanisation, and have in effect created a diversity of environmental problems with severe local and global consequences that potentially affect millions of people. Water management is an important consideration for urban development and adds a critical contribution to an ecologically sustainable city. There is a close connection between water management and spatial planning and spatial planning should give proper awareness to surface water bodies relating to spatial location and form. Integrating water management in spatial planning is necessary to obtain the balance between urban development and the water system for sustainable urban environment and future development. However, this view is still a relatively new topic in many developing countries, including South Africa. Australia developed the concept of Water Sensitive Urban Design (WSUD), which contributes to this much needed integrated approach of water management.

This research proposed the integration of the concept of Water Sensitive Planning (WSP) into the local South African context (based on the WSUD best practices) with the objective to initiate a fundamental paradigm shift to identify sustainable resources, specifically in the form of stormwater, as playing a critical role in the urban planning and design process, and overall sustainability of water resources in South Africa. This included the rethinking of the role of layout planning to direct the desired future of the countries sustainability.

Without critical interventions within the next five years, water restrictions and increased interruptions are a distinct possibility (Built, 2011:30). For this reason it is necessary to incorporate WSP into local policies and development plans to address the top priority of creating sustainable cities, by delivering water to people efficiently, economically and equitably. It is important to create a new strategy where the delivery of all urban infrastructure and services are planned through a partnership approach between Urban Planners, the water sector and other sectors together to meet sustainability and liveability objectives set by the community (Binney et al., 2010). Creating a sustainable environment is not an easy task and will require efforts from many professional fields. In this research, the main focus is on the coordination between Urban Planners and Water Managers (local authorities). This integrated approach of Water Sensitive Planning (WSP) will be proposed and evaluated in this study.

1.2. Problem statement

During the last decades the planning context and approaches changed fundamentally. Planning was essentially used as a tool to create a good quality of life for urban citizens by harmonizing the development components in the urban region (Carter, 2007). The notion of sustainable development has recently become more and more important when considering future planning and development. Spatial planning, in this sense, covers many different aspects, including the formulation of policies that influence the future distribution of activities in space and time and contributes an important role in developing strategies and procedures to integrate the use and management of land and water. The current reality is however, that South Africa is running out of usable water resources and that South Africa is not taking adequate measures in terms of stormwater harvesting, which has been regarded as one of the most effecting en practical ways to sustain water availability.

There is no integration between spatial planning and water management approaches in South Africa. The reason why this study has been chosen is due to the worldwide water shortage that is increasing by the day as an effect of rapid urbanization and population growth. Internationally there has been an integrated approach between water managers and spatial planners, by considering layout design approaches that enhances the water services provision, but not in South Africa. This approach needs to be investigated in order to implement it in South African.

1.3. Primary research questions

The integration of the concepts of Spatial Planning and Water Management are essential when considering sustainable development and future planning. In this sense, the primary research questions were captured within three main topics, including: spatial implications; sustainable development; and the integration between Spatial Planning and Water Management.

The primary research questions addressed in this research included the following:

Spatial implications:

1. What is the spatial impact of urban development on surface water systems in the South African context?
2. Can adequate space for surface water be identified and incorporated in the layout and design process?
3. Which spaces are sensitive for surface water management and need an integrated planning approach guided by Urban Planners and Water Managers?

Sustainable development:

4. How does WSP contribute to the sustainable development approach?
5. Which new planning concepts and methods can be used to integrate surface water systems in South Africa?

Integration between Spatial Planning and Water Management

6. Can experience of Australian case studies be helpful for South Africa to find successful ways to integrate surface water management in Spatial Planning and close the gap between these two disciplines?
7. How could the current planning systems in South Africa be reformed in order to integrate sustainable development of surface water management in Urban Planning?
8. How can the institutional co-operation between spatial planning and water management be initiated in the South African context?

1.4. Research aims and objectives

The objective of this research is to rethink the current sustainable development approach in terms of the linkage between Urban Planning and Water Management. This study examines the international approach of WSUD which is defined as the interdisciplinary way in which Urban Planner and Water Managers work together in harmony to promote sustainability of South Africans water resources. It is hoped that the results will contribute to the definition of new values and methods in the current South African planning system by integrating issues of water management and sustainable development.

The theoretical part of the research explored the spatial linkage of water in urban system. Sustainability is known to be the main objective in modern urban planning and was thus used to define the spatial implications of surface water systems. In order to meet future demands it is important to understand the past. Therefore, the theoretical founding also focussed on the water-related problems at the earliest stages of the spatial planning procedures and of advocating a common language shared by Urban Planners and Water Managers.

The theoretical founding and literature research aimed to:

- Capture relevant definitions and the status quo applicable to the research theme.
- Evaluate water management theories and Spatial Planning concepts with regard to the theme of this research.
- Analyse policy and legislative linkages with regard to 'Spatial Planning' and 'Water Management'.
- Identify and evaluate current WSUD approaches.
- Capture international lessons and best practices with regard to sustainable water planning approaches.

The empirical investigation focussed on the feasibility of integrated water management and Spatial Planning through a comparative analysis between South African and Australia planning approaches. The emphasis was placed on problem identification, evaluation of the former planning policy, the urgent reform in the current planning practice based on the new planning system, the development of new planning approaches and cooperation with water management.

The empirical research aimed to:

- Evaluate the current reality and planning approaches applicable to Spatial Planning and Water Management in the Potchefstroom area.
- Present a case study of different international approaches to determine the value and practical implementation of WSUD.
- Conduct a comparative analysis between the South African and Australian approach to Spatial Planning and Water Management
- Evaluate the possibility of an interface between spatial planning and urban water Management, in the local South African environment.
- Integrate the above mentioned and to use it to the advantage of the sustainable water supply for the people of South Africa.

Both theoretical and empirical studies informed the conclusions drawn, and finally lead to the development of a framework of integrated urban and regional planning for water systems and water management, based on sustainability principles and layout and design implication, as captured in the recommendation section.

1.5. Method

The concepts 'water management' and 'spatial planning' were specified in this document as the study aimed to engage with both concepts in integrated development approach. To understand the interconnection between these concepts, the following methods were used in the study:

- Extensive reviews of literature with regard to sustainable development, Spatial Planning and Water Management (as well as the underlying dimensions of water management, theories of Spatial Planning and Water Management and planning approaches) internationally and locally.
- Reviews of international case studies which have implemented WSUD in urban planning concepts and the approaches towards successful implementation.

Structured interviews with experts in the fields of Spatial Planning and Water Management to determine if there is any relationship between these two fields of structural planning and understand the complexities and challenges associated with the different disciplines. Figure 1 illustrates the conceptual model of the research process.

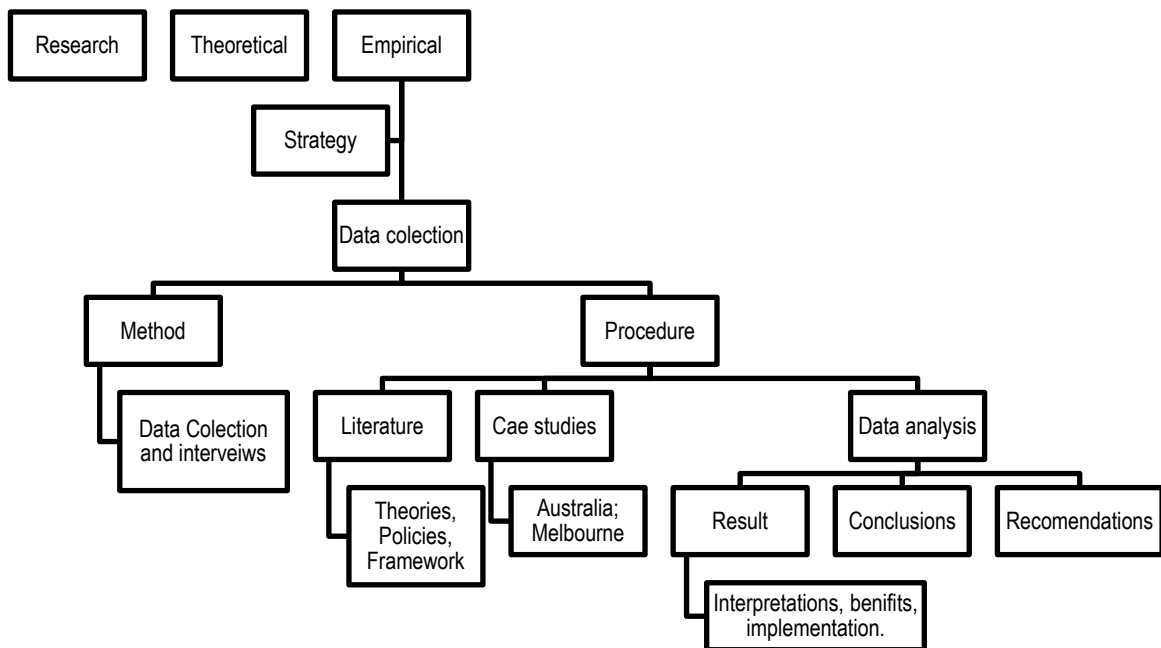


Figure 1: Conceptual model of research progress.
Source: Own Construction (2012).

1.6. Delineation of the study area

Australia is recognised as being the world leader in water management (Langford, 2011). Australia like South Africa has been undergoing major change to its water management since 1994, and while the paths chosen by the two countries differ, both countries have had a range of successes and failures.

Over the last 30 years Australia has developed a strong institutional side together with major technological advances that have helped them manage it, and it is for this reason that countries around the world have turned to Australia for water management solutions. South Africa is in serious need of an integrated approach for creating balanced and self-renewing ecosystems that will form part of the country's modern cities and societies. Therefore, case studies recorded throughout Australia were selected in terms of the successful implementation, long term effects on sustainable urban water development and the overall results documented by the Australian Government. These basic measures narrowed the sample down to 13 specific case studies (Chapter 5).

Local case studies could not be identified due to the new and unexplored nature of WSP in South Africa. This study is the first attempt to integrate urban planning and water management in a local study area. The local study area was undertaken in Potchefstroom, within the Tlokwe Local Municipality, North West Province (South Africa) as the study will indicate that this area is lacking in the attempts to integrate these two concepts. Figure 2 illustrates the location of Melbourne Australia and Figure 3 illustrates the position of Potchefstroom in the North-West Province.



Figure 2: Location of Melbourne
Source: Melbourne Waters (2010)

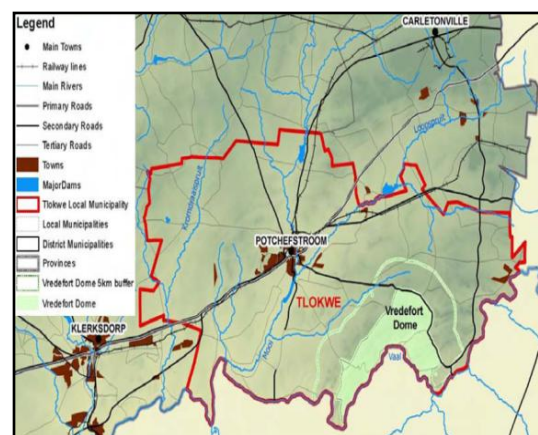


Figure 3: Location of Potchefstroom
Source: Tlokwe Local Municipality (2009)

Within these study areas, the concepts of Spatial Planning and Water Management were evaluated as part of a sustainable development approach, recognizing that other factors also play an important part in sustainable development, but limiting the scope to this specific interface.

1.7. Limitations of the research

The whole range of relevant stakeholders could not be interviewed but focus was placed on a selected group of experts, mainly senior experts on urban planning, water management and environmental protection. Due to the fact that it is the first time that this type of study has been conducted in Potchefstroom, the investigation of the opinions of the public, relevant non-governmental organisations and property owners was not identified as critical. As a result the study lacks an analysis of the views of the wider 'users' of the water bodies, an aspect which needs future study in the future. In order to successfully interpret policy effects of urban development on surface water systems a combination of quantitative and qualitative analysis methods had to be used in this study. The quantitative analysis was limited due to a lack of digital data. Initially the aim of the study was to use GIS spatial analysis tools within the ArcGIS environment to measure the water body reduction and their land use changes and to measure land use changes in riparian buffer zones. The process of doing this was to calculate the amount of water body reduction from 2000 to 2010 (ten year period) and to display it spatially with the use of tools in ArcGIS such as the conversion spatial analysis functions, classification, buffer analysis and visualization. The riparian buffer zones around shallow water bodies had to be defined spatially and the land use changes had to be identified in order to determine the impact of urban development on the spatial water bodies. Furthermore, the study initially aimed to identify the different impervious covers in the urban development areas of Potchefstroom in order to determine if any material that prevents the infiltration of water into the soil, including roads, parking lots, sidewalks, rooftops, and other impermeable surfaces in the urban landscape.

This could unfortunately not be done due to a lack of data from the municipal side. The result of this study would have identified the surface water bodies which have been altered by human activities over the last ten years. The ideal purpose of the investigation would have been to calculate the exact (ha) of shallow and larger water bodies which have been transformed into other types of land use and built-up areas. If these spaces could have been identified the various land use and built up areas affecting the surface water bodies would have been displayed spatially in context of Potchefstroom. This would have been evident to the main issue of sustainable urban development in context to water.

It is contrary to popular beliefs that urban planners do not take surface water bodies and the protection of these natural resources into consideration and furthermore that water managers has not yet considered the positive contribution of stormwater harvesting through accurate urban planning and sustainable design might hold in for the future. For future research there is a need to develop information support systems, (knowledge to systems based scenario) to link spatial issues and water issues. The study is based on the hypothesis that WSP will make an essential contribution to quality of life and should therefore be incorporated in the Urban Water Governance of South Africa to ensure sustainable urban development.

1.8. Outline of thesis

The remainder of this document is structured as follows:

Chapter 2:

This Chapter will explain the characteristics of the natural water systems (hydrological cycle), the water-land relationship and the influence of land use on surface water bodies in urban regions, as a point of departure to integrate the disciplines of Spatial Planning and Water Management. This section will summarize the basic facts about the earth's water resources and further on evaluate South Africa's current water resources in order to understand the status quo and complexities of the local situation.

Chapter 3:

Provides the theoretical background with regards to Spatial Planning and Water Management and will evaluate possible linkages between the two disciplines. Insight into the international best practices and planning approaches, paradigm shifts, design views and South African approach to Spatial Planning and water management will be provided.

Chapter 4:

The international approaches towards sustainable urban water management, spatial consideration, design methods relative to WSP and also the gaps between policy and practice with the aim of bridging these gaps will be discussed in this Chapter in order to develop a conceptual model for an integrated policy approach between Spatial Planning and Water Management.

Chapter 5:

The integrated approach taken by Australia in terms of Spatial Planning and Water Management will be evaluated. Furthermore, specific focus is placed on cases studies based in Melbourne which has incorporated WSUD strategies in their legislations practical and development projects.

Chapter 6:

The setting of the case study in Potchefstroom will be discussed in this chapter, including some general characteristics of the area and the specifics of local planning system and water management approaches.

Chapter 7:

The aim of this research was to explore the water-land relationships of surface water systems that are relevant for Spatial Planning, along with the possible linkage between Spatial Planning and Water Management approaches

through Water Sensitive Planning initiatives. This Chapter summarizes the major findings for each of the research objectives, challenges and questions presented in Chapter 1.

Chapter 8:

By identifying the South Africa's Spatial Planning and water management problems and looking at universal solutions for these problems, WSUD was identified as one of the most sustainable and environmentally friendly approaches that any county could follow for a sustainable contribution towards Spatial Development and Water Management in a three separate implementation levels.

1.9. Definitions

The following are important definitions of applicable terminology that were used in this study. These concepts are implemented within a spatial planning and urban water planning context. These definitions have been formulated to relate to the context of the research theme. It refers to existing policy and legal frameworks applicable to the research.

Table 2: Definitions.

Definitions	
Best Management Practices	This term refers to a broad array of non-structural techniques and engineering structures used to improve the quality of urban stormwater.
Development	A process for improving human well-being through a reallocation of resources that involves some modification of the environment. It addresses basic needs, equity and the redistribution of wealth.
Environmental management	The management of the environmental aspects and elements to enhance the qualities of the natural environment.
Environmental sustainability	Environmentally sustainable activities do not deplete environmental resources faster than they can be regenerated. It is the ability of an activity to continue indefinitely, at current and projected levels.
Green planning	Comprehensive management planning that has the final goal of achieving environmental and economic sustainability.
Green spaces	Land in natural or un-built condition that is proximate and easily accessible to residences and work places; and serves as recreational paths for people; and is protective of natural habitat.
Integrated development	The interrelationship between economic activities and other development dimensions such as social demographic, institutional, infrastructural, financial and environmental aspects.
Land development	The process of building and landscaping land in order to enhance its commercial or social value.
Land-use planning	Planning of human activity to ensure that land is put to optimal use, taking into account the different effects that land-uses can have in relation to social, political, economic and environmental concerns.

Local government	A local authority that is officially responsible for all the public services and facilities in a particular area, whose remit covers an area less than that of the nation, in this study, the municipality.
Master plan	An interpretation of the planning controls and the urban design principles.
Mixed-use development	Mixed-use development locates residential, commercial and industrial land-use in close proximity to one another.
Municipal planning	Planning by municipal government for the more effective management of its functions.
Municipality	An administrative entity with a clearly defined territory and population, governed by the local authorities or local government.
Open space	Undeveloped land.
Public green space	Permanently protected green space in urban areas which, in addition to the attributes associated with green space in general, provides alternative benefits and enhances a more natural, green setting.
Spatial development planning	A participatory process to integrate economic, sectorial, spatial, social, institutional, fiscal and environmental strategies in order to support the optimal allocation of scarce resources between sectors and geographic areas, and across the population, in a manner that promotes sustainable development, equity, and empowerment of poor and marginalised communities and groups.
Spatial integration	Spatial integration is a strategy for doing away with the expensive and exclusionary land-use patterns. It seeks to enhance the efficiency of the city by minimising distances, reducing the costs of development, enhancing social dimensions and increasing the access in the city.
Spatial planning	Gives geographical expression to the economic, social, cultural and ecological policies of society. It is at the same time a scientific discipline, an administrative technique and a policy developed as an interdisciplinary and comprehensive approach directed towards a balanced regional development and the physical organisation of space according to an overall strategy.
Stormwater	Surface water resulting from heavy rain.
Sustainable development	Sustainable development implies economic growth together with the protection of environmental quality, each reinforcing the other. The essence of this form of development is a stable relationship between human activities and the natural world, which does not diminish the prospects for future generations to enjoy a quality of life at least as good as our own.
Urban	A city, town or node of activity. Closely linked to the density of development.
Urban area	Place with a very high population density, compared to the surrounding area.
Urban green space	Public and private open spaces in urban areas, primarily covered by vegetation, which are directly (active or passive recreation) or indirectly (positive influence on the urban environment) available for the users.

Source: Own construction based on the South African Cities Network, 2005; Wolf, 2004; Brundtland Commission, 1987; Baycant-Levent et al., 2005; Wyly, 2010:2; Cemal, 2010; UNEP, 2010.

With these concepts in place, Chapter 2 will start off with a brief explanation of the Earth's water cycle in order to understand why water planning and management is such an important and critical issue to address when considering sustainable development approaches.

Chapter 2: Water for equitable growth and development-

The sustainable development issues

2.1. Introduction

Water is one of the most fundamental and indispensable of all natural resources. It is essential to life and the quality of life, to the environment, food productions, hygiene, industry and power generation (DWAF, 2011). This Chapter will explain the characteristics of the natural water systems (hydrological cycle), the water-land relationship and the influence of land use on surface water bodies in urban regions, as a point of departure to integrate the disciplines of Spatial Planning and Water Management. In order to understand the need for the development of an integrated approach towards water management in spatial development, it is necessary to address the relationship between natural features of surface water systems with human activities in the urban region. This section will summarize the basic facts about the earth's water resources and further on evaluate South Africa's current water resources in order to understand the status quo and complexities of the local situation. Figure 4 captures the conceptual structure of Chapter 2.

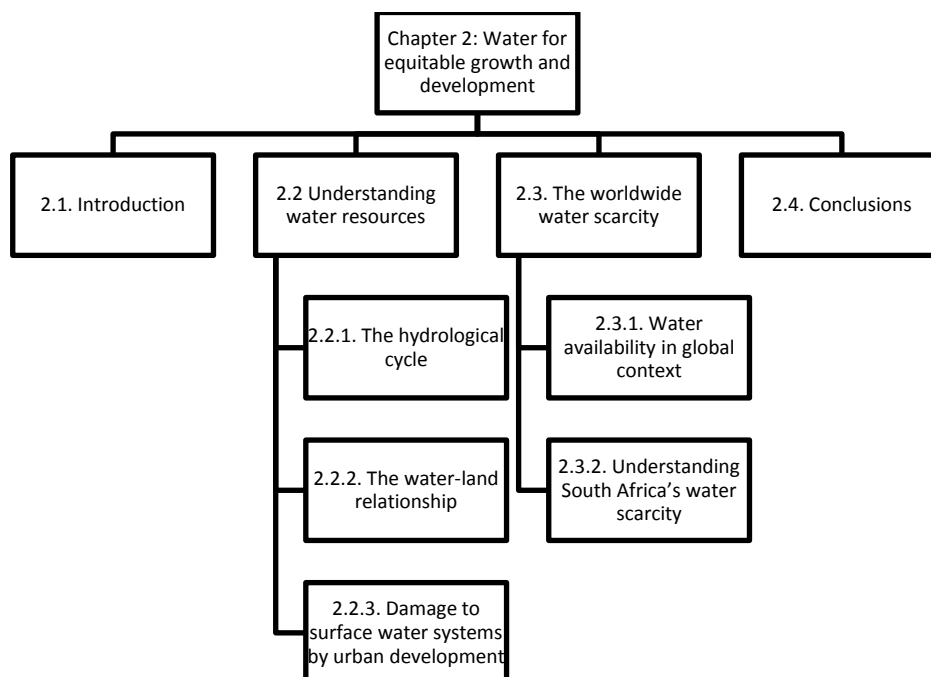


Figure 4: Structure of Chapter 2.
Source: Own creation (2012)

2.2. Understanding water resources

The progress in moving towards sustainable development depends on the ability of ecosystems to support environmental parameters that are vital to human beings (UN, 1992). It is a holistic approach to development that considers all components of the hydrologic system (Harrison, 2012). Urbanization and climate change are major factors placing increased pressure on the water systems. Cities will experience difficulties in efficiently managing scarce and less reliable water resources due to the un-sustainable conventional urban water management systems inherited by previous generations. In order to meet these challenges, there needs to be a paradigm shift (refer to Chapter 3). “Effective water resources management is dependent on all water users and water managers playing their part” (NWRS2, 2012). In this sense, it is important that the hydrological cycle is understood, and how human actions can negatively impact in this cycle.

2.2.1. The hydrological cycle

The National Water Act (No. 36 of 1998) describes water as “...a scarce and unevenly distributed national resource which occurs in many different forms which are all part of a unitary, interdependent cycle”. The hydrologic cycle is described as a continuous movement of water above, on, and below the surface of the earth (Winter, 2002:2). The water on the earth’s surface (surface water) “occurs as streams, lakes and wetlands as well as bays and oceans, it also includes the solid forms of water as snow and ice” (Winter et.al, 2002). The hydrologic cycle (Figure 3) shows the ways in which water moves from one reservoir to another, by way of processes like evaporation, condensation, precipitation, deposition, runoff, infiltration, sublimation, transpiration, melting, and groundwater flow (CSIR, 2009). The oceans supply most of the evaporated water found in the atmosphere, only 91% of it is returned to the ocean basins by way of rainfall, the remaining 9% is transported to areas over landmasses where climatologically factors induce the formation of rain (CIRS, 2009). Figure 3 illustrates that surface water filters into the soil and rocks, slowly replenishing the groundwater, the groundwater naturally overflows, feeding into rivers and wetlands (CIRS, 2009).

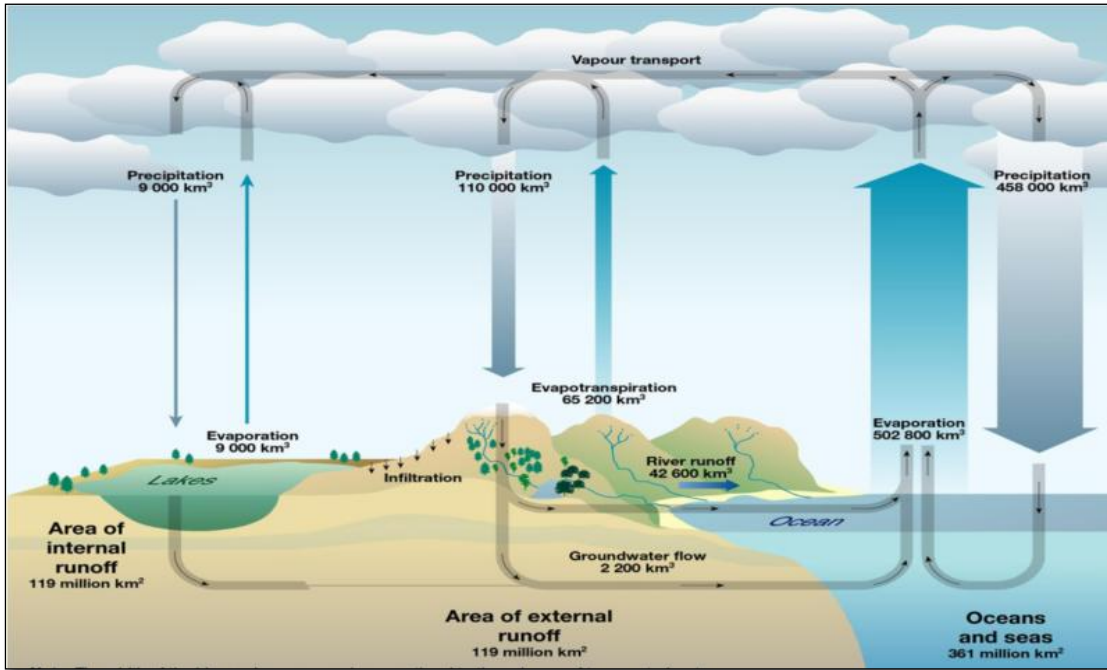


Figure 5: The water cycle
Source: Sarni (2011:31)

2.2.2. The water-land relationship

Rain is highly uneven in specific areas and varies over time. This natural event has its own continuously changing patterns and is beyond human control, in other words water has its own balance status (Pidwirny, 2006). Human interventions to enhance water management include the planning and development of catchment areas, drainage basins, watersheds, surface water bodies and buffer zones, as explained accordingly.

2.2.2.1 Catchments, drainage basins and watersheds

Catchments, drainage basin and watersheds are defined drainage areas of the land-surface that contribute flow to particular edges on the hydrologic network (Sami, 2011). It is an area of land that drains all the streams and rainfall to a common outlet such as the outflow of a reservoir, mouth of a bay, or any point along a stream channel (Perlman, 2012). "All land surfaces, no matter how dry they may be, belong to a drainage basin of some size" (Marsh & Grossa, 2005:260). A drainage basin has a hierarchical network of channels that, in humid areas, hold increasingly larger volumes of water as it moves toward the mouth of the basin that can be shown as stream orders (Figure 6.a). The first order-streams are the most abundant streams in every drainage network (Marsh, 1991:133).

Accordingly, a drainage basin can be ranked as a nested hierarchy (Figure 6.b). The watershed consists of surface water e.g. (lakes, streams, reservoirs, and wetlands) and all the underlying ground water (USGS, 2012). Watersheds are important because the stream-flow and the water quality of a river are affected by things, human-induced or not, happening in the land area "above" the river-outflow point (Perlman, 2012). A watershed (Figure 6.b) exists of three interrelated parts: an upland zone, collection zone and a conveyance zone. The upper zone generates the over flow and the temporary channel flows; the collection zone is the area where runoff from the upland zone accumulates and the a conveyance zone contains the main stream and valley through which water is transferred from the collection zone to higher order channels (Marsh, 1991:138).

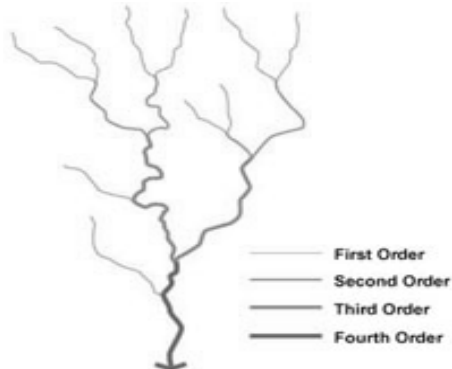

<p>a) Stream order classification according to rank in the drainage network</p> 	<p>A stream's order is its rank:</p> <ul style="list-style-type: none"> • A first-order stream is a channel with no tributaries. • A second-order stream is a channel fed by at least two first-order tributaries. • The joining of two-second order streams forms a third-order stream. <p>Stream ranking continues in this manner until the highest-ordered channel is reached. First and second-order streams are located in the headwater areas of watersheds and typically convey small volumes of water. These lower-order streams are vulnerable to pollution.</p>
<p>b) Illustration of the nested hierarchy of the lower-order basin within a larger drainage basin</p> 	<p>Watersheds, like streams, are ranked according to order. A first-order watershed is drained by a first-order stream, whereas the main channel of a second-order watershed is a second-order stream, and so on for each higher-ordered watershed. A large watershed, therefore, is a nested hierarchy of numerous lower-ordered basins or sub-watersheds.</p>

Figure 6 (a&b): Stream order classification and the nested hierarchy of watershed
 Source: Own construction, based on Marsh (1991:132-134) & Melles, et.al. (2011)

2.2.2.2 Surface water bodies and buffer zones

There is no generally accepted definition for surface water bodies, but the definition given by the European Water Framework Directive (WFD) refers to the concept of wetlands (Rodriguez-Rodriguez & Benavente, 2008). Wetland definition and classification is also confusing, while most people will refer to a “wetland” as a patch of land that develops pools of water after a rain storm, it is certainly not. Wetlands are characterized as having a water table that stands at or near the land surface for a long enough period each year to support aquatic plants, they have unique characteristics that generally distinguish it from other water bodies or landforms based on their water level and on the types of plants that thrive within them (Carpinteria Water District, 2012). The Ramsar Convention 1971 gave a broad international definition of wetland as “areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, or salt including areas of marine water, the depth of which at low tide does not exceed 6 meters” (Ramsar Technical Reports, 2012).

Throughout this research, the aim is to emphasize that surface water bodies, as wetlands, are entitled to have a very high ecological value and that wetlands play a vital role in a healthy and functional ecosystem, and thus sustainable development approaches. Aquatic ecosystems play a key role in maintaining the economic and social security of nations, this includes the preserving biological diversity, providing along with groundwater the integrity of river basins and supporting their normal functioning under conditions of arid climate (Tashkent, 2006). In general there are three groups of surface water systems taking place in urban regions: social and economic functions, natural ecological functions and physical spatial functions (Figure 7). Proper use and protection of these functions are essential for sustainable urban development.

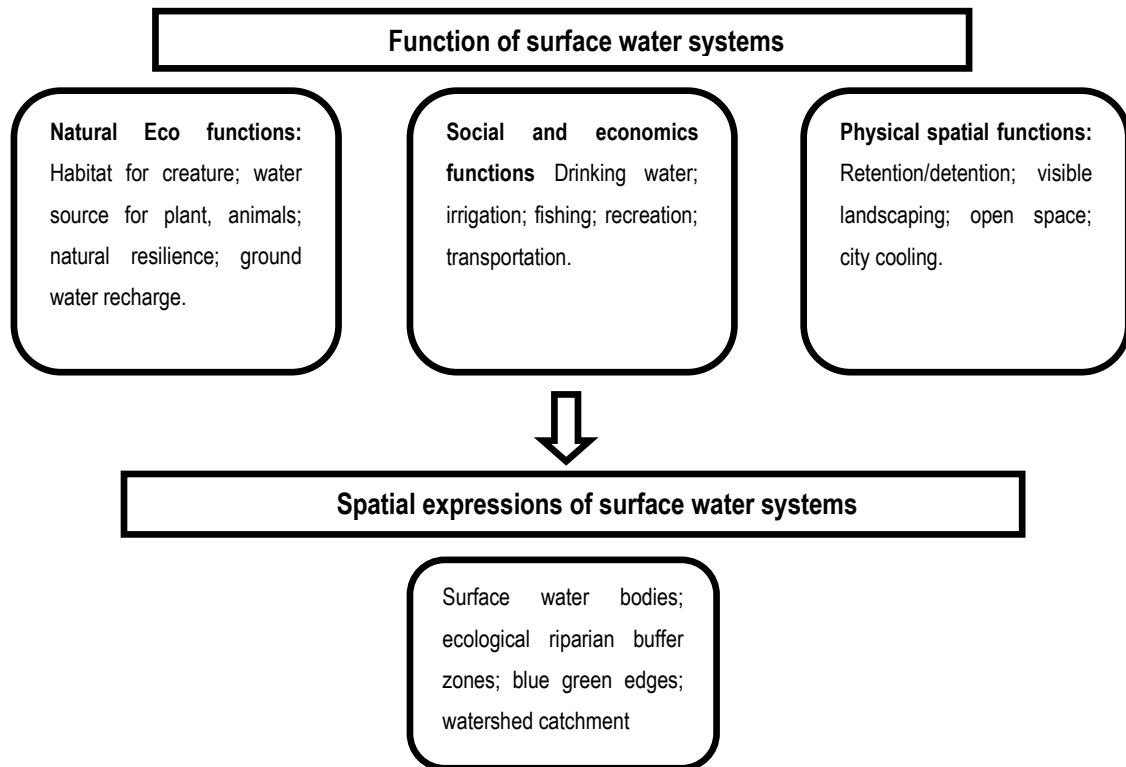


Figure 7: Functions and spatial expression of surface water systems.
 Source: Own construction (2012).

Each zone has different hydrologic behaviour and in turn calls for different development planning and management guidelines. These zones always connect with other urban land use and are therefore not easily define in urban areas (Marsh, 1991:140). It is essential to emphasize the importance of utilizing and providing buffer zones to protect collection areas and streams from development zones. Riparian buffers are vital elements of watersheds, primarily due to their protection of surface and ground water quality from impacts related to human land use. Riparian buffers are vegetated zones of land closest to lakes, streams, and estuaries and it is physically and ecologically related to the aquatic zone (also called conveyance zone by Marsh) and upland zone (Chase, et al. 1997). Preservation and reestablishment of these zones can have many environmental benefits (Hawes & Smith; 2005).

The riparian zone consists of three subzones, different management approaches are needed in each zone. Table 3 explains the characteristics of these three subzones. Riparian buffers forms and important part of the natural environment; they play an essential role in the enhancement and improvement of the spatial quality and identity of both natural and urban areas.

Table 3: Characteristics of different parts in a riparian buffer zone

Riparian buffer zone			
Characteristics	Streamside zone	Middle zone	Outer zone
Function	Protect the physical integrity of the stream ecosystem	Provide distance between upland development and streamside zone	Prevent encroachment and filter backyard runoff
Width	Minimum of 25 ft. plus wetlands and critical habitat	50- 100ft depending on stream order, slope, and 100year floodplain	25-ft minimum setback to structures
Vegetative Target	Undisturbed mature forest; reforest if grass	Managed forest, some clearing allowable	Forest encouraged, but usually turf-grass
Allowable Uses	Very restricted (e.g., flood control, footpaths, etc.)	Restricted (e.g. some Recreational uses, some Stormwater BMPs*, bike paths)	In-restricted (e.g., residential uses, including lawn, garden, compost, yard wastes, most stormwater BMPs*)

Source: Randolph (2004:478).

The status of surface water bodies is thus closely associated with the land-use conditions of riparian buffers zones and watersheds. The section that follows will address the environmental impacts of increased watershed imperviousness as a result of urban development.

2.2.3. Damage to surface water systems by urban development

The urbanization of watersheds increases the imperviousness of land surfaces, alters the density of channels, and diverts much of the surface drainage to underground storm sewers. Where groundwater is over-abstracted or rainwater infiltration is reduced, these dependent ecosystems are negatively impacted (WRC, 2002). Through the development of proper infrastructure, such as dams, water can be stored for future uses instead of running back into the sea. Distillation of seawater is one of the new technologies that can increase the water supply but at this stage the process requires large distillation "machine" and building it would cost a lot of money (Eckhart, 2012). The major driving forces for future change are likely to come from population growth, socio-economic change, climate change and technology change (Water-cycle facts, 2012):

- Increased domestic demands through population growth and smaller households;
- Technological and social attitudes changes;
- Climate change impacts: higher atmospheric CO₂, higher ozone levels, hotter and drier summers and warmer wetter winters would affect natural vegetation, cropping and crop characteristics, and alter runoff and infiltration characteristics;

- Improvements in technology and renewable energy could change the balance between demand management and supply.

The aim of a water-related infrastructure is to supply quality drinking water by draining the runoff flow to the nearest water storage facility in the shortest period of time (EPA, 2012). But there is a major difference between the infrastructure found in a well-developed and unregulated development area. In many cases, the downfall of communities are directly associated with the lack of quality water-related infrastructure (Montgomery, 2009:7). Randolph (2004:373) summarized five main changes of the physical pathways caused by land development and urbanization as:

- Removal of natural vegetation drainage patterns;
- Loss of natural depressions which temporarily store surface water;
- Loss of rainfall absorbing capacity of soil;
- Creation of impervious areas (e.g., rooftops, roads, parking lots, sidewalks, driveways)
- Provision of man-made drainage systems (e.g., storm sewers, channels, detention ponds).

Therefore, although the hydrological cycle consists of the same elements, their proportions in urban area are significantly different. Figure 6 indicates the difference between pre- and post-development runoff. The value of runoff generally increases after urban development.

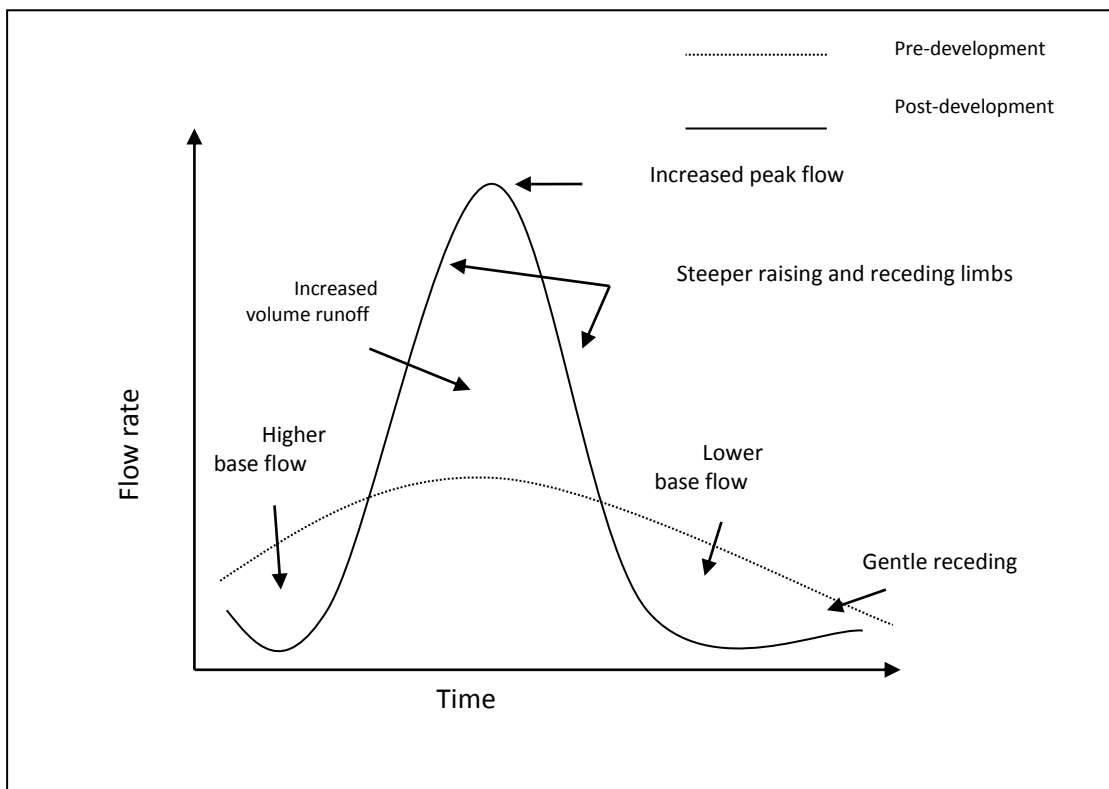


Figure 8: Runoff rate and volume generally increase after urbanization.
Source: Own construction based on Holistic Stormwater Management approach (2012).

After urbanization, runoff carries solids particles from automobile wear and tear, dust and dirt, and winter sand, nutrients from residential fertilizers, metals such zinc, copper, and lead, hydrocarbons leaching from asphalt pavement materials, spilled oils and chemicals, and bacteria from domestic animals (Holistic Stormwater Management approach, 2012). This change of runoff quality and causes a general degradation of water quality in the receiving waters (Table 4).

Table 4: Cause and impacts of urban runoff problems

Urban runoff		
Urban Runoff Problems	Causes	Impacts
Increased flooding	High runoff peak rates due to increased imperviousness	Loss of life and property; economic hardship; non-tangible damages such as anxiety.
Reduced base flow	Reduced groundwater recharge due to increased imperviousness	Recharge is reduced; soil moisture is depleted; decreased exfiltration to rivers; reduced summer low flow in rivers.
Impaired water quality	Polluted runoff from urban areas	Reduced aquatic communities
Channel instability	Change in flow-duration characteristics and sediment loads.	Change in channel form by erosion and deposition.
Impaired habitat	Changes in flows, water quality, and channel form	Reduced terrestrial and aquatic species.
Loss of wetlands	Filling of wetlands for urbanization; altered drainage pathways	Loss of wetland habitats and species.

Source: Holistic Stormwater Management approach (2012).

Figure 9 illustrate the how urban features such as impervious surface associated with different densities of development, will affect the urban runoff. Research by the Centre for Watershed Protection has found that stream quality becomes reluctant when 10% of the stream's watershed is impervious and that an urban stream's ecology is severely impacted when more than 25% of its watershed is impervious (FISRWG, 2012).

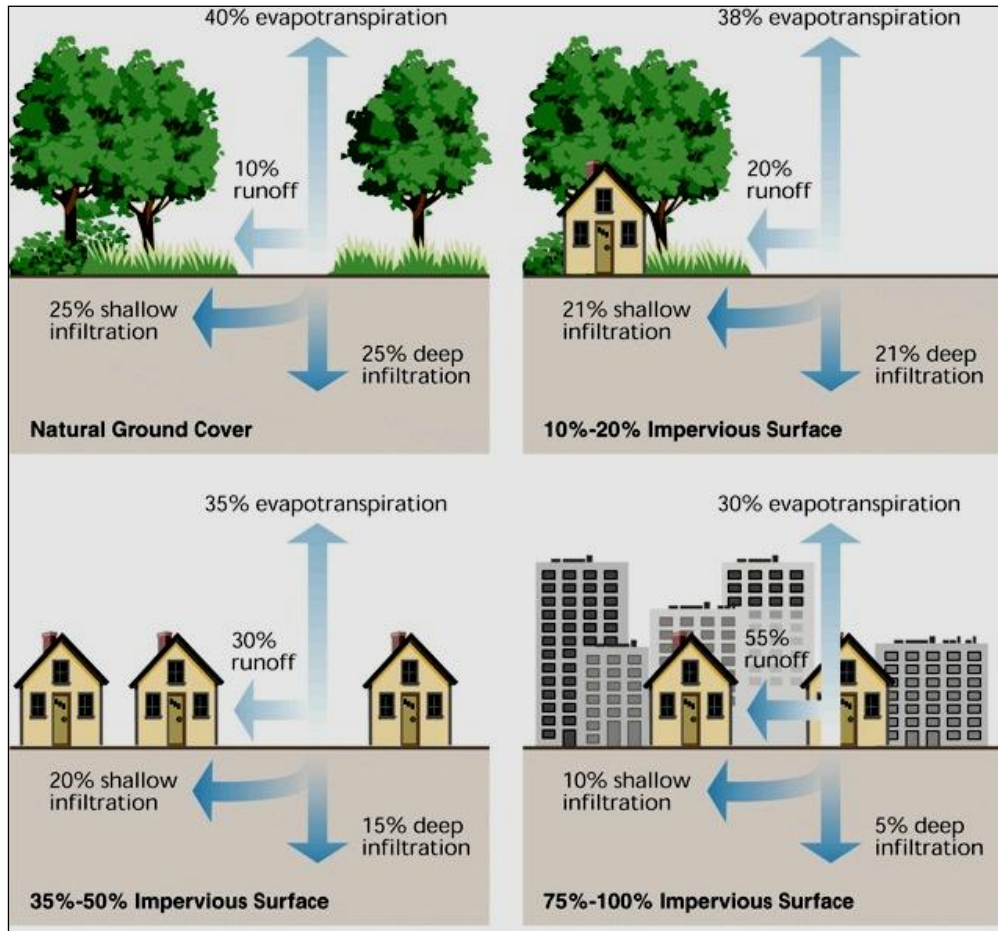


Figure 9: Degrees of Imperviousness and its Effects on Stormwater Runoff
Source: FISRWG (2012)

In addition to the permeability of the catchment, the discharge rate and volume of stormwater runoff from urban surfaces depends on other hydrological factors such as the surface depression storage and antecedent rainfall conditions relating to the wetness of the catchment. The increase in impermeable areas caused by urbanisation has a number of important impacts on the hydrological response from a catchment related to (IWA, 2005):

- Reduce infiltration capacity of catchment surface caused by increasing impervious surface and compaction of soil, which reduces the capacity of the soil to moisture;
- Reduce surface (depression) storage capacity because impervious urban surface are much 'smoother' than natural surfaces;
- Decreased evapotranspiration due to the loss in the natural retention capacity of soil, reduced vegetation wetting and interception by plants.

Water-related problems have always been interrelated with human activities. Generally, too much water in the storm season increases serious flooding risks, and too little water in the dry season causes drought and water shortage. Both of these finally influence the safety and liveability of human life.

Contamination of groundwater by viruses and bacteria has caused a number of disease outbreaks in South Africa, for example at Delmas in 2005 and 2006 (Griesel et al., 2006). The relationship between land and land-use and conditions of water bodies can cause major qualitative and quantitative water problems. Popular believe is that water pollution is caused by pipes dumping toxic industrial waste into a river. Based on the way in which the pollution is discharged, there are two categories of pollution, point source and non-point source. Point source pollution comes from a single source, usually a factory or wastewater treatment plant, pipe or ditch (City and County of Denver, 2012). Point source pollution has largely been controlled by legislation such as the Clean Water Act, which was passed by Congress in 1970. Non-point source pollution represents spatially dispersed sources that come from the cumulative effect of a region's residents going about their everyday activities (City and County of Denver, 2012). In reality, a large amount of water pollution does not come from a single point but from various land use types and land use density. According to the National State of the Environment (SoE) Report land use activities within catchments can result in (SoE Report 2001):

- Dry land salinity that potentially leads to water salinisation;
- Increased soil erosion that is often associated with the transport of sediment and nutrients into waterways;
- Conversion of native vegetation to plantation or crops, which can affect catchment water balances;
- Localised pollution of waters with chemical and biological contaminants from activities (e.g. wastewater discharge and industry);
- Introductions and the spread of exotic plant and animal species that can have varied effects on water quality and quantity, and the aquatic health of inland waters.

As a result, the intensity of land-use in urban areas is in a direct relationship with the quantitative or qualitative water problems. The influence of land-use situation on water quantity problems is described by Randolp (2004) as follow “.....paving and covering the land with impervious surfaces and constructing drainage pipes and lined channels, acts to increase the peak discharge from a given storm event by (a) reducing the amount of water that infiltrates the ground, thus increasing the volume of surface runoff, and (b) increasing the rate at which the runoff accumulates, reducing the hydrograph lag time. Because of impervious surfaces, less water infiltrates the ground, and thus, less is available for ground water contributed base-flow between storms, especially in dry weather periods. As a result, urban streams run faster and higher during storms and often run dry between storms” (Randolph, 2004:373).

Over all, the lack of interface between land use and water quality has places server strain upon both the natural and man maid environments. This is why the water-land process in a watershed needs to be considered as a complete unit. As point out before urban storm water runoff affects water quality, water quantity, habitat and biological resources, public health, and the aesthetic appearance of urban waterways, meaning that the condition of surface land use in the watershed will affect the surface water bodies either in a negative or positive way. In this regard, the status of surface water bodies is closely associated with the land use conditions of riparian buffer zones and watersheds.

Figure 10 summarizes the hydrological cycle and its different characteristics as captured in this section.

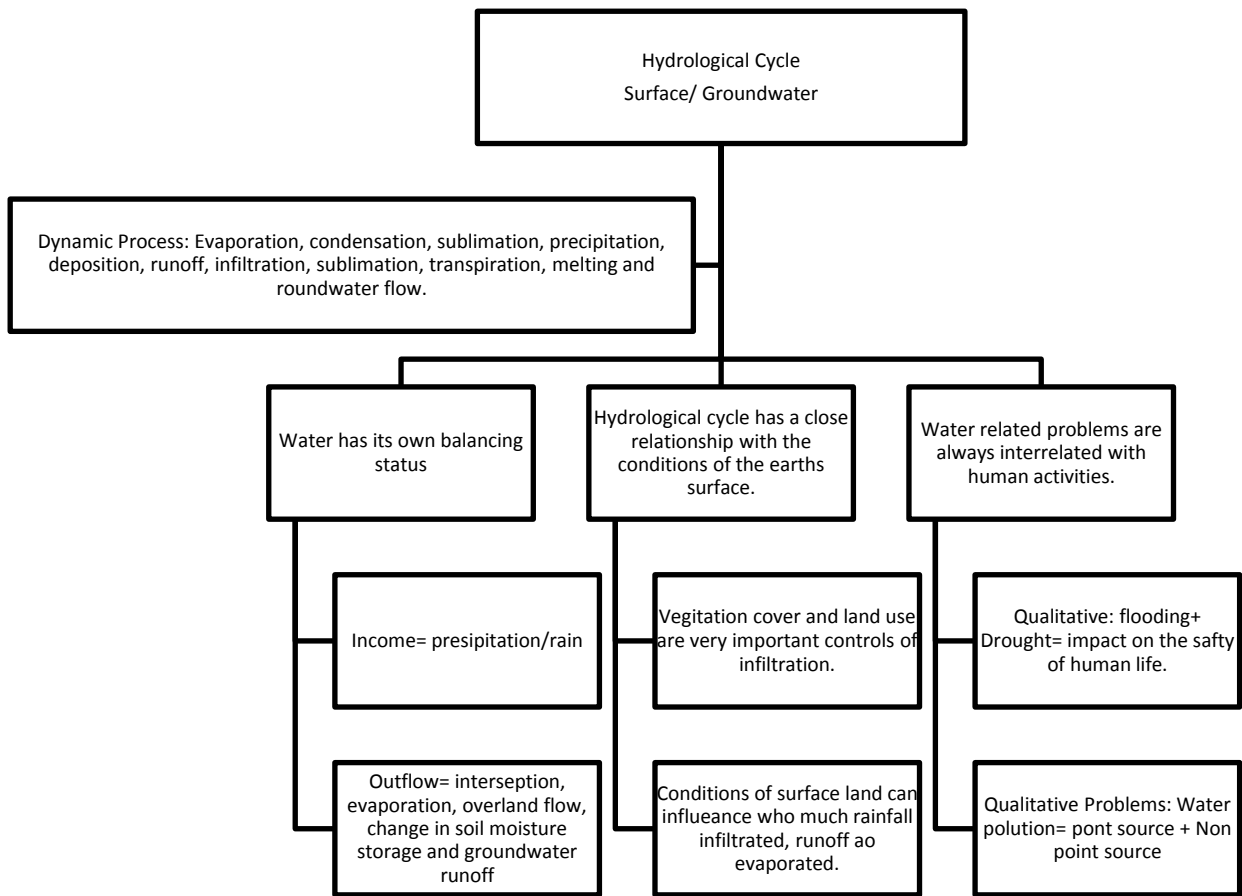


Figure 10: Hydrological characteristics.
Source: Own construction (2012).

2.3. The worldwide water scarcity

Addressing water scarcity is one of the main factors to address in order to solve the water supply problems worldwide. Governments and companies are now addressing water as a strategic issue (IWA, 2009). Exploring some of the facts about water use and scarcity in a global context helps to underpin the current situation of South Africa as well.

2.3.1. Water availability in global context

The world's water resources are estimated at 1.4 billion (thousand million) km³ (Loucks & Gladwell, 1999:12). Table 5 explains that 97.4% of the water in the earth is retained in the oceans, and 2.6% is on land which is divided into 2% in glacial ice caps of Antarctica and Greenland, and only 0.6% in the groundwater, surface water and atmosphere which belong to freshwater (Merrit, 1997:5). This equates to 218 400 km³ of water being available on land for use, and 8 299 200 km³ of water available underground (DWAF, 2004). Only the freshwater can be used as a water resource for humans and other terrestrial organisms.

Table 5: Available water within the world

Water availability					
All Water		All Fresh Water		All easily available surface water	
	%		%		%
Oceans	97.4	Ice Caps and glaciers	76.4	Lakes	52
Fresh Water	2.6	Ground water	22.8	Soil Moisture	38
		Easily accessible surface fresh water	0.6	Atmospheric water vapour	8
				Rivers	1
				Water within living organisms	1

Source: Own construction adapted from Liphadzi (2007:16).

More than one-third of the world's population, estimated at 2.4 billion people, lives in water-stressed regions and 3,6 billion people die each year from water-related disease and 98% of water-related deaths occur in the developing world where 884 million people lack access to safe water supplies (Water.org, 2012). Most of the world's urban growth in the next two decades will be absorbed by cities of the developing world, which are least equipped to deal with rapid urbanization (UNFPA, 2007). This will be particularly notable in Africa and Asia, where the urban population will double between the year 2000 and 2030, making up 81% of urban growth during that period, with harmful consequences if governments do not prepare now for the coming growth (UNDESA, 2007). Most countries struggle with water quality. Pollution-induced quality deterioration not only reduces the benefits of available supply but also leads to a harmful environmental and health hazards. Water-related natural disasters such as floods and droughts are potential threats to human life, both directly and indirectly.

In addition to the human costs, there are also economic losses from crop and property damage. Improving water use efficiency is a promising avenue for supply augmentation in view of the extensiveness of water losses and resource underutilization (NWRS2, 2012).

2.3.2. Understanding South Africa's water scarcity

South Africa is the 30th driest country in the world and has less water per person than countries widely considered to be much drier, such as Namibia and Botswana (NWRS2, 2012:13). Water use and management in South Africa is determined by natural conditions such as climate and rainfall (implying the supply of water) versus development and population growth (implying the need of water). Figure 11 is a summary of the main driving forces that affects South Africa's current water availability. Accordingly the following issues would be explained in greater detail to understand the complexities and realities of South Africa's water provision and usage:

- 2.3.2.1 Water availability
- 2.3.2.2 Environmental dimension and climate change
- 2.3.2.3 Social dimension
- 2.3.2.4 Economic dimension
- 2.3.2.5 Future projections

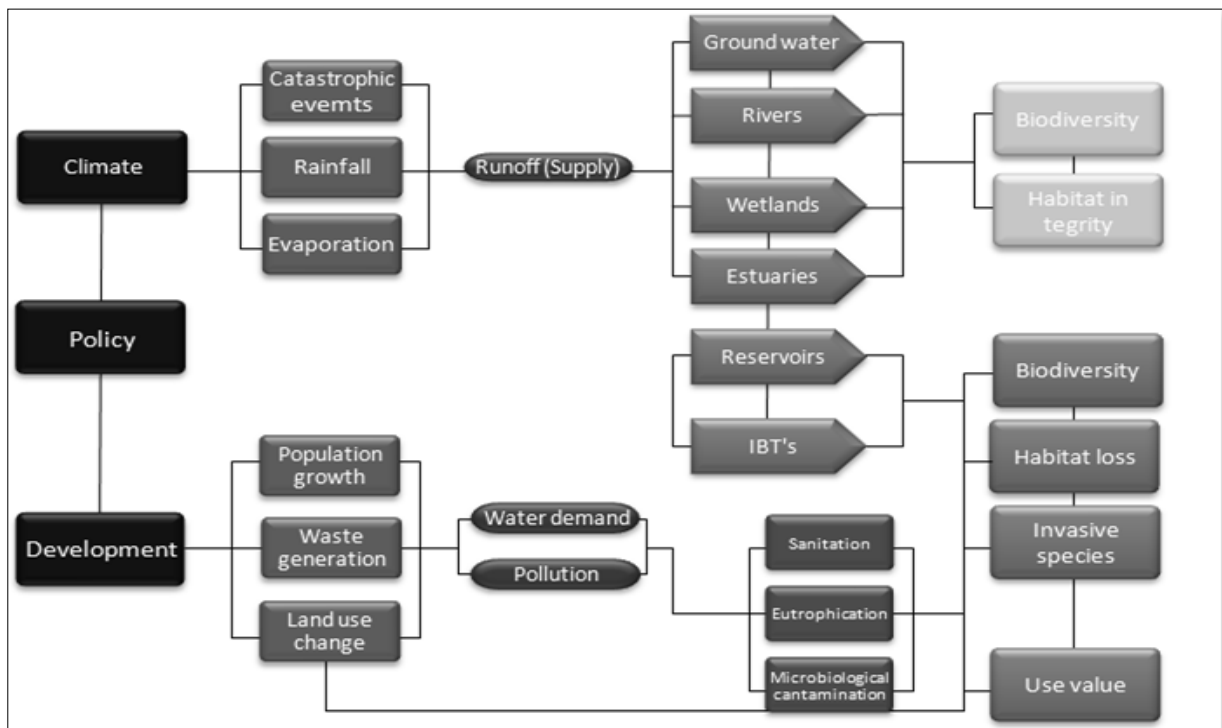


Figure 11: Driving forces effecting freshwater in South Africa.
Source: Own construction (2012) based on Walmsley (2009).

2.3.2.1. *Water availability*

In many parts of the country, South Africa resources have either reached or is fast approaching the point at which all of the financially viable freshwater resources are fully utilised, and truth be told it is the poor and marginalised, under-developed former know as homelands in rural areas that are experiencing water scarcity most intensely. South Africa forms a distinct region, or subcontinent, divided from the rest of Africa by the rivers that mark its northern border. South Africa has no commercially navigable rivers and no significant natural lakes, major rivers in South Africa consists of the Limpopo, that forms the country's natural boundary in the northeast, and the Orange, cuts through the Namib Desert and divides South Africa from Namibia (MyFundi, 2012). The Orange River rises in the Drakensberg Mountains and flows to the west and northwest, draining the highlands of Lesotho before being joined by the Caledon River between the Eastern Cape Province and the Free State (Library of Congress, 2008). Along the coastline are several large lagoons and estuarine lakes, such as Lake Saint Lucia in KwaZulu-Natal (Library of Congress & CIA, 1996). Other large rivers include the Komati; Oliphant's; Molopo; Tugela; Mzimvubu and Breede (DWAF, 2002.a).

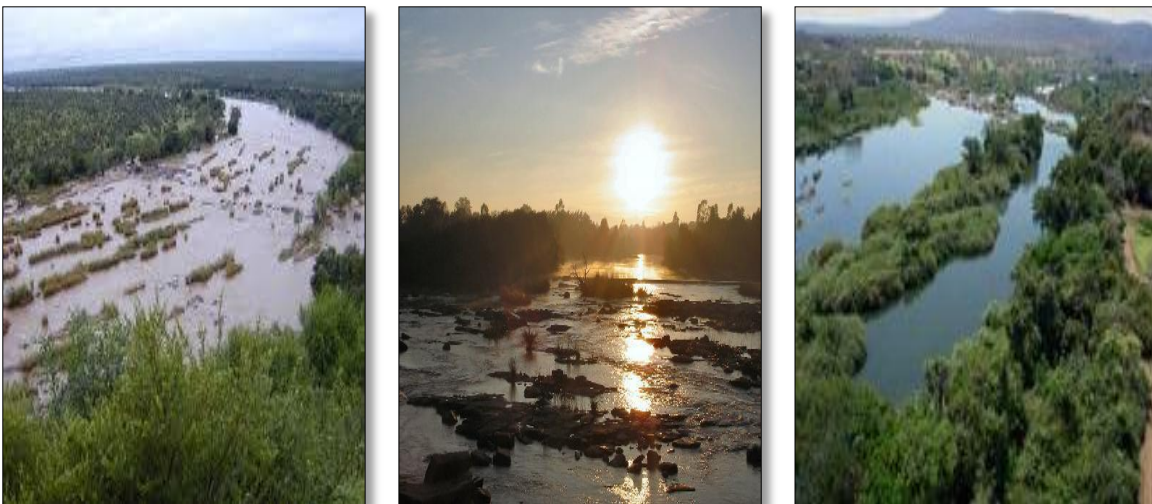


Figure 12: South Africa's rivers.
Source: River of South Africa (2009).

This may be a pretty sight, but the truth is that the rivers throughout South Africa are under intense environmental threat because of a combination of collapsing sewerage works, expanding squatter camps in their catchment areas, and unregulated commercial effluent (Bingwa; 2010). These problems are further escalated by the shortcomings in the management of the dams, which reduces the supply of water we have available and also affects its quality. Build-up of silt, for example, can cause further problems for local councils with regard to the purification of water. As the quality of the water from our water sources deteriorates, it becomes more complex and more expensive to purify this water to make it safe for drinking. A statement given by Gareth Morgan (DA Spokesperson for Environmental Affairs & Tourism) "most municipal sewerage systems in South Africa are 30 to 50 years old. But few councils are doing anything more than Band-Aid maintenance.

A further complication is that councils have been under enormous pressure to expand water and sewerage infrastructure to service previously under-serviced areas” (Morgan, 2008). This has added to the burden on existing infrastructure. One of the major challenges in South Africa is to bring the water to where it is needed. To accomplish this, South Africa has many transfer schemes between rivers within the same catchment and between water management areas. South Africa has 569 dams, with individual capacities exceeding one million cubic metres, have a total capacity of about 32 400 million cubic meters (m³) (CIRS, 2010).

The water balance for the 19 water management areas in the country shows that ten could not fulfil the demand for water in the year 2000 (DWAF, 2004a). This opens up the debate on how many more dams can be built and how much more water can be transferred between river basins to provide enough water for future needs. The government takes measures to guarantee water supply for urban and rural areas such as creating several artificial lakes (primarily for agricultural irrigation), building reservoirs, constructing dikes and water transfers to control flooding and constructing water conservancy and hydropower plants for electricity (Nkondo et al., 2012), still the biggest threat to sustainable water supply in South Africa is not a lack of storage but the contamination of available water resources through pollutions.

2.3.2.2. Environmental dimension and climate change

South Africa’s climate conditions generally range from Mediterranean in the south western corner of the country to temperate in the interior plateau, and subtropical in the northeast. Nearly 91% of South Africa falls within the United Nations' definition of affected dry lands, these are extraordinarily dry areas where the rainfall is low, and the potential evaporation is high (Enviro-Info 2001). Rainfall generally occurs during summer (November through March), although in the southwest, around the Cape of Good Hope, rainfall often occurs in winter (June through August) (Library of Congress & CIA, 1996). Rainfall in the county is highly seasonal and variable, especially in the more arid areas where unpredictable droughts occur. The total surface runoff is only 50,150 m³/annum, with 60% of this arising from only 20% of the land area (DWAF, 2007).

In 2004, the Department of water affairs and forestry estimated that 13.5% of the total volume of groundwater is the only source of portable water for over 300 towns and 65% of South Africa’s population (Woodford et al., 2009). According to Woodford, “the total groundwater use was estimated at some 1 770 Mm³/a, with 64% of that water being used for irrigation purposes in the agricultural sector”, this places the country’s ground-water resources at an estimated 19 000 mm³/a of potentially exploitable groundwater, of which an estimated 10 350 mm³/a is considered utilisable (Woodford et al., 2009). These statistics are alarming when considering the issues of sustainable development.

2.3.2.3. *Social dimension*

The last eighteen years South Africa have witnessed a remarkable transformation not just of the political system leading to freedom of movement but also rapid urbanization caused by the integration of South African capital into the international markets. Economic activity and standard of living are the main drivers of increased water demand. While standard of living is also related to economic growth, the understanding of this relationship is beneficial to the management of water. In the South African context, it is important to understanding that water scarcity is being experienced in different situation by different groups. Rural poor communities experience water scarcity on a daily basis, these communities is also the most vulnerable to droughts and floods.



Figure 13: Pollution in rural communities
Source: S.A Looming water crisis (2011)

Statistics shows that in 1980 only 7.5% of the total population lived in the cities but the figure rose to 9% in 2000 (National Fifth Census, 2001) and 11.5% in 2010 (World Bank Report, 2011). The Population growth (annual %) in South Africa was reported at 1.10 in 2008 (World Bank, 2009), 1.07 in 2009 (World Bank, 2010) and the most recent population growth (annual %) of 1.35 in 2010 (World Bank, 2011). Resulting in a population growth (annual %) rate of 1.17 during 2008 to 2010. The population increased from 40.6-million in 1996 to 44.8-million in 2001 (a growth of 10%). From 2001 to 2011, the population has grown by an additional 12.7% (Census, 2011); this has put an enormous strain on the infrastructure development of South Africa. Globally, most future population growth will take place in cities. This is an important social consideration when planning spatially for adequate water provision.

2.3.2.4. Economic dimension

The reliable supply of water in sufficient quantities and required quality is a crucial input to the economic growth and job creation. Water use in South Africa is dominated by irrigation, which accounts for around 60% of all water used in the country, with municipal domestic a total of 27% (24% urban use and 3% rural). Industries consumes +/- 3% if not part of urban domestic, power generation is accountable for 2%, mining +/- 2.5% and commercial forestry plantations account for a little less than 3% of water used by reducing runoff into rivers and streams (NWRs 2, 2012:18). Irrigated agriculture is the largest single use of water in South Africa (60%) and it has a huge potential socio-economic impact in rural communities. Water is the major limiting factor to the growth of this sector and poor water quality has a negative impact on agricultural exports and associated foreign income. Table 6 summarizes the economic benefits linked to South Africa's water resources.

Table 6: Waters contribution to positive economic growth

Waters contribution to positive economic growth	
Agriculture	<ul style="list-style-type: none"> - Contributes about 3% to the GDP - And 7% to formal employment. - About 8.5 million people dependent on agriculture for employment and income.
Energy Sector	<ul style="list-style-type: none"> - Only uses 2% of water, contributes about 15% to the GDP of South Africa - Creates jobs for 250000 - It generates about 95% of the electricity in S.A. and also exports it to countries in Africa.
Mining Sector	<ul style="list-style-type: none"> - Contributed 8.8% directly and 10% indirectly to the GDP of SA in 2009. - It creates about 1 million direct and indirect jobs. - Target of 140 000 new jobs by 2020 for the mining sector.
Manufacturing Sector	<ul style="list-style-type: none"> - The manufacturing sector contributed 15.5% to the GDP - and 13.3% to jobs in 2009 - A target of 350 000 new jobs for this sector by 2020
Tourism Sector	<ul style="list-style-type: none"> - In 2009, contributed 7% to the GDP and it created 575 000 jobs. - The NGP has set a target of 225 000 new jobs.

Source: Own construction based on GCIS (2011) and NWRs2 (2012)

Almost all of the country's freshwater resources have been fully allocated, while the water quality of these resources has declined due to increased pollution caused by industry, urbanization, afforestation, mining, agriculture and power generation (Ashton et al., 2008).

2.3.2.5. *Future projections for water availability in the near future*

Given the current and anticipated future growth rates of the population and expected trends of socio-economic development, it is highly unlikely that South Africa's water resources will be able to sustain current patterns of water use and waste discharge. Table 7 displays the actual water requirements for 1996 and projected water requirements for 2030 by different water use sectors in South Africa, as compiled from the research of Basson et al., (1997) and the Department of Water Affairs (DWFA, 2002).

Table 7: Water availability for the near future in South Africa

Current and projected water availability for South Africa					
Sector	1996		2030		Volume Increase (%)
	Volume (10(6)m(3)/year)	Sector use (%)	Volume (10(6)m(3)/Year)	Sector use (%)	
Urban and Domestic	2,171	10	6,939	23	220
Mining and industrial	1,598	8	3,380	11	112
Irrigation and Afforestation	12,344	62	15,874	52	29
Environmental	3,932	20	4,225	14	8
Total	20,045	100	30,415	100	52

Source: Own construction, adapted from Basson et al., (1997) & DWFA (2002)

It is expected that South Africa's freshwater resources will be fully depleted and unable to meet the needs of people and industry by the year 2030 (National Committee on Climate Changes, 1998) therefore South Africans must recognise the importance of priority of this possible situation, in order to take the necessary steps to assess current and future demands for water, and plan and manage it accordingly.

2.4. Conclusions

It is evident that, with the continued exploitation and development of water resources to meet growing population and development demands, directive action needs to be taken. In this way water use patterns could be changed and the growth in water requirements slowly decreased.

As previously stated that the conditions of water bodies are affected by land-use, it can clearly be assumed that there is an inter-relationship between land-use and the conditions of water bodies. It is therefore important to understand the hydrologic practice as a dynamic system, so that the capability of fresh water storage or maintenance, runoff mitigation, infiltration and water purification with regards to the relationship of land use conditions can be secured. There is a major issue that traditional stormwater management, the cost of treating water for human consumption increases as our water resources become more polluted. Economic growth implies industrialisation and urbanisation, which will result in further deterioration of water resources. The national water resource Strategy (DWAF, 2004a) calls for “appropriate and timely corrective measures”. Even though water has played a key role in the settlement and initial development of the nation, groundwater is scarce, and there are very different experiences of water scarcity for different groups in South Africa. The challenge for South Africa lies in the efficient and balanced use of water, together with other natural resources, to create an environment conducive to social and economic well-being. As the South African population increases, our water resources face greater pressure.

Social, political and economic activities drive environmental change our modern day-to-day consumption patterns challenge and compromise our water resources. Heavy utilisation of the nation’s water resources and the limited availability of further supplies imply that sustainable water use will require far more efficient water resource utilisation by all sectors. This would include revisiting both low and high benefit water users and arranging possible re-allocations between them. In this sense, the link between Spatial Planning and Water Management should be investigated and enhanced in practice. Chapter 3 will accordingly address and evaluate the interface between Spatial Planning and Water Management from an international perspective and identify possibility to implement such an approach in the local South African environment.

Chapter 3: Spatial Planning and Water Management

3.1. Introduction

Chapter 3 provides the theoretical background with regards to Spatial Planning and Water Management in order to address the challenges and research questions mentioned in Chapter 1, and evaluate possible linkages between the two disciplines. Chapter 3 furthermore provides insight to the international best practices and planning approaches, paradigm shifts, design views and South African approach to Spatial Planning and water management, focussing on the transitional trends and institutional reforms in both fields.

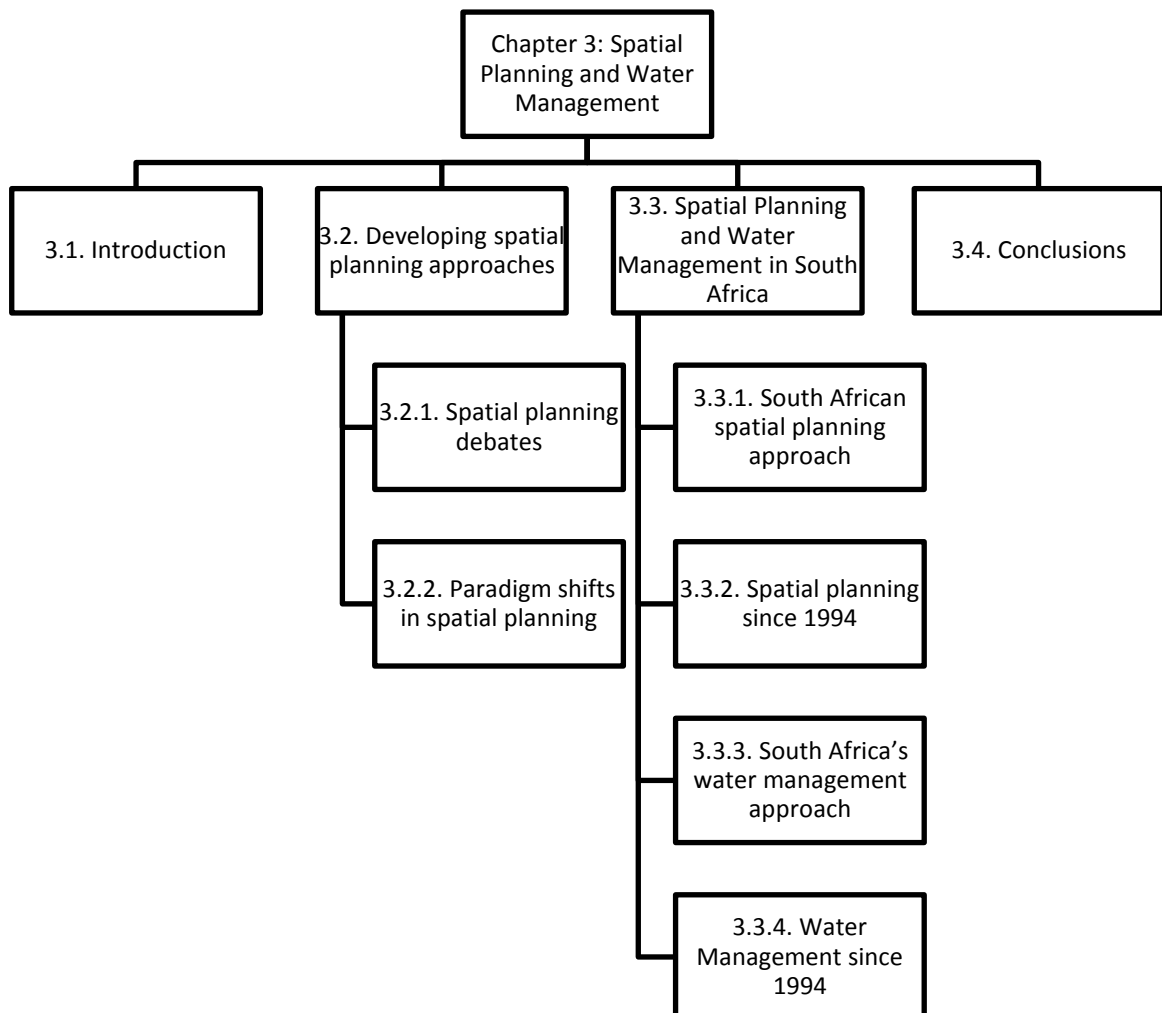


Figure 14: Structure of Chapter 3
Source: Own creation (2012)

3.2. Developing spatial planning approaches

The modern origin of spatial planning lies in the movement for urban reform that arose as a reaction against the disorder of the industrial city in the mid-19th century (Agueda, 2009). With the growing complexity of society in the 19th century, planning became a discipline and profession (Wegener et.al, 2007). Subsequently, urban and regional planning developed as a professional specialization at the beginning of the twentieth century. Planning theory and planning practice has thus evolved with the development of modern society for “the interaction between planning theory, urban change, and planning practice is symbiotic and asynchronous” (Campbell & Fainstein, 2003:12). As a result of these interactions, longstanding debates and disputes developed in the planning field, these debates played the key role in the evolution of planning approaches and planning practice.

3.2.1. Spatial planning debates

Spatial planning is a future-oriented activity that involves the reshaping of the built and natural environment (Pallagst, 2001). The challenge for planning is to ensure the efficient use of limited land resources and to contribute to balanced regional economic development and balanced use of resources, including natural and landscape resources (Hansen, 2008). Spatial planning is also a public sector activity that focuses on the physical environment, because of this physical focus, planning theory has been dominated by design or blueprint approach for a long time (Rydin,1993:1). Knowledge within the planning practice introduces many deferent aspects to the relationship between the physical development with political, social and economic processes. By the early 1970's, it was normal to distinguish between procedural planning theory focusing on planning process from substantive planning theory focusing on the growth and development of cities (Stiftel, 2000:8).

Andreas Faludi, the Dutch planning theorist labelled these two subjects as “theory-of-planning” and “theory-in-planning”, he suggested that “a procedural rather than a substantive theory should be regarded as a proper planning theory” (Faludi, 1973:5). The distinction was and remains controversial; one cannot study process without an understanding of substance, and vice versa. Faludi's viewpoint aroused different standpoints. Franco Archibugi, author of several works in the subject of planning theory and methodology, proposed that besides the theory of/in planning, a theory on planning is necessary, which suggests that there needs to be a connection between procedural and substantive planning. He suggested that planning theory must connect among the different scales, sectors and units of planning (Archibugi, 2004). Beauregard (1990:213) criticized that “planning theorists delved more and more into an abstract process isolated from social conditions and planning practice....few planning theorists concern themselves with the physical city”. Therefore, he proposed a city-centred theory which, as he defined it, “could link structural forces, developmental trends, human intentions and everyday life thereby broadening the scope of planning theory” (Fischler, 2000).

Debates of planning theory have concerned many conflicts between centralization versus decentralization, comprehensive versus incremental planning, top-down versus bottom-up, and planning for people versus planning for place (Campbell & Fainstein, 2003:12). As said before planning theory and practice differ among countries based on their different political, social and environmental backgrounds. The general evolution of planning systems was based on the British experience, as summarized in Table 8. It is however evident, that since the post-war period, planning systems have been subjected to arguments and evolution in planning ideologies or theories.

Table 8: Evolving of the Planning systems based on the United Kingdom (UK) situation.

Planning systems UK						
	From 19 th century to 1910s	1920s – 1940s	1950s – 1960s	1970s	1980s	After 1990s
Economic/ social context	Industrialization and urbanization in the Western countries	Economic Restriction; war; reconstruction	Post-war boom; mixed economy; consensus politics	Economic boom collapses; oil crisis; inner city decline; urban-rural shift	Recessions and restrictions; new technology; collapse of mixed economic consensus.	Economic globalization; environmental concerns; sustainability; informed era.
Key planning issues	Sanitary and public health; good conditions of houses; urban social unrest	Regional unemployment; regionally-based incentives to industrial activities; suburban growth	Rapid development; increasing living standards; multi-faced problems; urban de-concentration	Inner city problems; inequality; excessive substantial growth; environmental problems; complexity and uncertainty	Unemployment; economic development; restructuring development planning	Sustainable development from global recognitions to local actions; city competition capacity; good quality urban environment; climate change.
Planning philosophy	Blueprint-based urban design; environmental determinism; utopian blueprint; technical process of design and drawing	Naive public administration; public sector direction of land use; comprehensive and compulsory planning	Procedural planning theory; the rationale of urban planning theory; system approach	Organization theory; political economy; political sociology	Economic development; land privatization and marketing in urban policy; community participation; institutional approaches	The New Right; the New Left; Liberal political economy; the institutional approach; urban governance
Planning concepts	Garden city, city beautiful movement	Garden city, satellite town; comprehensive, integrative planning; resource allocation for the best use of land	New towns; regional planning; two-tier systems-structure plans and detailed local plans	Negotiation; policy implementation; local politics	Public transport; urban conservation; nature conservation	Sustainable planning; strategic planning; environmental
Planning approaches	Urban design, landscape design.	Comprehensive integrated approach	Planning process model; strategy-led	Environmental policy; development	Public-private partnership; urban	Environmental assessment of project;

			planning	control; urban conservation; countryside policy	development grants; planning as mediation	leverage planning; enterprise zones; urban development corporation; growth management
Planning activities	Architectural profession, sanitary engineering.	Residential development, house-building boom; Regional Planning; Protecting rural areas from unplanned growth	Implementation of new towns program; regional planning; transportation planning	Pollution control; Inner city renewal; housing redevelopment; transport program	Urban regeneration; nature and conservation	Urban regeneration; waterfront renewal schemes, green environment
Legislative activities/ legal framework	The Public Health Act 1848 and 1875; the Nuisance Removal Act 1855; the Sanitary Act 1866; the Housing, Town Planning, etc. Act 1909	The Housing and Town Planning Act 1919; the Town Planning Act 1925; the Town and Country Planning Act 1932 and 1947; the Distribution of Industry Act 1945; the New Town Act 1946; the National Parks and Access to the Countryside Act 1949	The Town Development Act 1952; the Clean Air Act 1956; the Noise Abatement Act 1960; the Industrial Development Act 1966; Land Commission Act 1967; the Transportation Act 1968; the Town and Countryside Planning Act 1968; the Countryside Acts 1967 and 1968	The Town Planning and Country Planning Act 1971; the local Government Act 1972; the Housing Act 1974; the Control of Pollution Act 1974; the Health and Safety at Work Act 1974; the Control of Pollution Act 1974; the Town and Country Amenities Act 1974; the Community Land Act 1975; the Transportation Act 1978; the Inner urban Areas Act 1978; the Transport Act 1978; Ancient Monuments Act 1979	White Paper Lifting the Burden 1985; the Wildlife and Countryside Act 1981; The Derelict Land Act 1982; Countryside Access Charter 1985; the Agriculture Act 1986; water Act 1989; The Housing Act 1988	The 1991 Planning and Compensation Act; the White Paper on the environment; the Citizen's Chapter
Other ideas	Geddes' survey-analysis-plan methodology, Planning should adapt the physical environment	New town; national park; nature reserve; leisure, amenity and wildlife concerns; green belt	Urban heritage protection; pollution control; countryside protection; incremental planning	International Concern with water-dependent areas (i.e. Ramsar Convention on Wetlands in 1976); participative planning	Environmental sensitive areas; "best practicable environmental option" for controlling pollution; water quality control; environmental assessment	

Source: Own construction (2012) based on Hall (1996), Rydin (1993) and Ward (2002).

In this table, it is clear that since the 1990's the spatial planning system has places considerably more attention on the conservation of the environment and economic competition. The planning process has emphasized more and more on good urban governance and more co-operation between professional, political and societal actors (Healey, 1997). South Africa has been using the same approaches to urban development as will be discussed later in this chapter.

3.2.2. *Paradigm shifts in spatial planning*

Paradigm shift is a radical change in the regulating framework, each paradigm shift in the philosophy of science triggers the formation of a new planning philosophy which includes specific (urban) planning theory (Kuhn, 1962). Planning theory determines the accurate scientific method based on the regulating/dominating philosophy of science whereas urban planning theory borrows some concepts and theoretical formulations both from natural and social sciences (Fainstein & Campbell, 1996; Taylor, 1998; Paris, 1982). The utopian blueprint to the rational and systematic approaches and also the shift from the scientific view of planning to a wider combination of scientific and political views is two well know paradigm shifts in the urban planning practice as it made a remarkable contribution to current means of planning. The following views will be discussed to emphasize the paradigm shifts that took place over the years, namely (3.2.2.1) the design-centred view, (3.2.2.2) the systems and rational process view, (3.2.2.3) the collaborative planning approach and (3.2.2.4) the sustainable development approach.

3.2.2.1. *Design-centred view*

The aim of city planning was originally based on the Garden City idea of Ebenezer Howard (1902). Garden Cities of Tomorrow was the second edition title (1902) of Ebenezer Howard's book Tomorrow: A Peaceful Path to Reform (1898), and was perhaps one of the most influential books in the field of urban planning in the past 150 years. Within its pages Howard put forth designs for a "social city" that attempted to bridge between the individualist (capitalist) system of the time and the ideals of socialism that were gaining political impetus, with Trade Unions, Co-operatives and ideas of communal land protection (central to Howard's argument) (Butcher, 2010). According to Fishman (2003) the three foundational figures in planning history was Ebenezer Howard, Frank Lloyd Wright, and Le Corbusier, these three planners looked beyond their own troubled time to a new age each believed was imminent, a new age each laboured to be define and build.

Their concerns thus ranged widely over architecture, urbanism, economics and politics, but their thinking found a focus and an adequate means of expression only in their plans for ideal cities (Fishman, 2003:29). Many developed countries were influenced by their utopian, anti-urban, spatially and expert-oriented way of thinking. Their contribution gave a structured ideal of urban planning theory up until the middle of the twentieth century.

Pre-war planning in Britain was described by Taylor (1998:5-17) as being a physical, design-centred and detailed blueprints leading to planning being expressed as a master plan for urban form, the planning theories were “often similarly preoccupied with visionary plans or designs that showed how the ideal town or city should be spatially organized” (Taylor, 1998:16). However, Jane Jacobs was the first and the best-known critic of the comprehensive modernist approach to urban planning after 1945. Jacobs saw these theories as being utterly at odds with urban realities, and argued that these theories will lead to the destruction of the city as a living community (Jacobs, 1961:25). This traditional planning is targeted at physical results and lacks consideration and understanding of the difference and dynamics of specific urban areas (Ward, 2006). Ultimately the City Beautiful movement demanded an expansive system of parks suited to healthy activities, landscaped boulevards, attractive fountains and outdoor sculptures, and the removal of billboards cluttering the skyline, unfortunately this was too expensive, costing more than the problems it was intended to solve (Bloom & Old, 2007). In Taylor’s words (1998:55) “what planners lacked, and what planning theory had failed to provide, was an adequate empirical understanding of the world they were seeking to manipulate”. Taylor (1998:39-55) summarized several limitations:

- Their physical and design plans ignored the social environment and social network by over-concentration on the physical environment creating an uninformed and misled community.
- The blueprint planning created end-state documents that did not satisfy the changes of continuous development. Planners failed to recognize the changing nature of cities.
- Urban complexity and diversity was neglected without consideration of different interests and values of different people, the normative and utopian ideals exhibited very little desire to address the problems of real-life cities during the plan-making process.

It is important to realize that urban planning cannot consist of a static document because of the constant change in social, economic and environmental characteristics of city. The effect of criticism on the blueprint planning view resulted in a shift to a systems and rational process view of planning.

3.2.2.2. *Systems and rational process view*

It was not until the 1960s when the wider social-economic information and analytic evidence opened their way into the making of plans and planning decisions. The emergence of planning thoughts was two distinct theories: the systems view of cities and the view of planning as a rational process of decision-making (Davoudi, 2006:17). The systems and rational process view of planning was seen as a logical response to the deficiencies of the design-based planning theory when it was realized that using a static way to deal with the dynamic changing problems was not appropriate (Michael, 2002). Emphasis was placed on understanding how cities work by system analysis, this view also initiated the first revolution bringing the interest of science into planning theory. The systems view of planning which was derived from the science of cybernetics, developed by Norbert Wiener in 1948 and was imported into planning by the works of Brian McLoughlin and George Chadwick in the 1960s (Hall, 2002).

Chadwick (1971) clearly explained that such a process view of planning was more about the methods or means of planning, he conceptualized cities and regions as complex systems, or as a spatially-based sub-systems of planning process. The systems and rational process theory of planning suffered another wave of criticism at the end of the 1970s, even though it was the systems view of urban issues and the procedural planning theory that provided a wider scope for spatial planning. Taylor summarized the criticism towards the system and rational process view as (1998:95-109) follow: Firstly, cities had to be accepted as complex systems, planning as a purely technical or scientific work did not develop further to empirically understand the real city. Secondly, there was a false top-down view of planning that defines the planning process as different stages. This view preoccupied the main focus from how plans and policies had to be implemented. Such a rational process model was generally described as “a model of rational decision-making, rather than a model of rational action” (Taylor, 1998:112). Since the 1960s, the focus of planning shifted to focusing more attention on planning theories, specifically social/political issues and the implementation issues in the planning field (Allmendinger, 2002). Planners needed to analyse and understand how cities and regions functioned spatially in economic and social terms. That knowledge was to come from an intellectual revolution which took place in the mid-1950s in urban and regional studies and human geography which led to the ideas that were later imported into planning in the 1960s and had their widest influence on planning thought in the thirist half of the 1970s (Davoudi, 2006,18). Planning theories were redirected to a problem-centred planning approach. This was the basis for developing possible future policies through value judgments and problem-focused analysis. Once again the planning paradigm was shifted on to problem centred research but also to the issues of institutional change and communicative approaches in plan-making and plan implementation.

3.2.2.3. Collaborative planning

Finally, in the 1980's the most significant planning theory to emerge in the last two decades is communicative planning (Alexander, 1997). Collaborative planning took ten years to grow and only two years to write. It was recognized that planning should understand and evaluate governance processes, appoint more interactive public participation and focus on developing qualities of place and territory (Healy, 1990). Communicative planning aimed to create a more democratic form of planning practice and planning theory and there are a number of influences upon the communicative approach. Habermas examines the concept of rationality and its relationship to problems of social action, inter-subjective communication and social-historical change drawing heavily on the writings of George Herbert Mead, Émile Durkheim and Aristotle (Dryzek, 1990). According to Allmendinger (2002), communicative planning is an answer to the dissatisfaction of rational planning. Planning had to be seen as a communicative or collaborative process “is an attempt to find a way forward for planning, to justify its existence and provide a normative basis which it has lacked since the rational comprehensive approaches of the 1970s” (Allmendinger, 2002:206). Even though the advantages of communicative planning were well established, there were some practical problems in using communicative planning.

Communicative planning has been accused of dominating and crowding out other theoretical discourses (Tewdwr-Jones & Allmendinger, 1998), being unconvincing in making the “argument for argument” (Elster, 1998), being culturally imperialistic (Huxley and Yiftachel, 1998), and being ambiguous in its theoretical origins (Ball, 1998). Allmendinger stated that, “Perhaps the most important aspect of planning as a communicative process, its basis upon participative forms of democracy, is taken as read by its proponents without acknowledging a host of practical and theoretical problems associated with this” (Allmendinger, 2002:206). Apart from the criticism about the communicative planning, planning theorists have sought to embrace the communicative perspective as both a validation and prescription for planning as communicative or collaborative trend does offer valuable insights for planning systems. In South Africa, the impact of communicative planning has gained focus in discussions about “meaningful planning”, i.e. “planning that significantly contributes to improving the quality of life of the society for which the planning is undertaken” (Gibbens, 2008). This approach has also been fostered into the South African Planning through the implementation of Integrated Development Planning (IDP) and Spatial Development Frameworks (SDF) in local municipalities. The role of IDP’s and SDF’s is to promote sustainability through the correspondents of local government in order to improve the living conditions of society. These are important communicative planning approaches to determine the quality of interaction and participation from institutional role players.

3.2.2.4. Sustainable development planning approaches

The 1990’s were characterized by the search for increased understanding of the concept and significance of sustainable development. The importance of sustainable development as a basic principle has been widely recognized in the planning field. This was accompanied by accelerating trends towards globalization, particularly with regard to trade and technology (UNEP, 2002). The conviction grew that there were an increasing number of global environmental problems that required international solutions. The planning focus turned to creating a healthy and clean urban environment along with the aim for economic and social development (Table 8). Alternatively, planning has been focused on becoming more knowledge-based, public-participative, problem oriented, communicative and action-oriented (Taylor, 1998; 130-153). The concepts of sustainable development seem to offer a middle way that reconciles environmental priorities with the pressures for economic development at local, national and global levels (Ward, 2002:308). As defined by the report of the World Commission on Environment and Development, sustainable development is “a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations” (WCED, 1987:46). The strategy for sustainable development, adopted in 2001 and amended in 2005, is complemented inter alia by the principle of integrating environmental concerns with European policies which impact on the environment (Europa, 2012).

The European Union's defines sustainable development is as follow "development that meets the needs of the present without compromising the ability of future generations to meet their own needs", it presents a vision of evolution that integrates current and longer-term objectives, and regards social, economic and environmental issues as inseparable and interdependent components of human progress (European Commission, 2012). Within all definitions of sustainable development, three core dimensions are present: development (economic growth), people (social justice) and place (environmental protection), along with three resulting conflicts the property conflict, the resource conflict and the development conflict (Campbell, 2003:435-458). With regards to sustainable development, it is important that planners develop a perspective that cities should be consider as sustainable ecosystems in other word, water sustainability. As Taylor (1998:168) concluded: ".....one of the most important tasks faced by town planning theorist is the development of better theory about the environmental qualities which town planning practice should help bring into being". With the growing interest in sustainable development in planning, planners need to combine both their procedural and their substantive skills and thus become central players in the battle over growth, the environment and social justice in order to achieve a balance in urban regions.

3.3. Spatial Planning and Water Management in South Africa

South Africa has a long history of land-use management legislation. Since 1994 more than 800 policy initiatives, including sustainable development approaches, were incorporated and driven by various government departments with the main aim to re-dress inequality caused by apartheid (Cilliers, 2010). Although sustainable development was initially associated with an enviromental agenda, it had gained strength through its potential to foster transformantion and democratisation (Patel, 2001). However the current realities still suggests of unsustainable fragmented development.

3.3.1. South African spatial planning approach

Since 1652 colonialism formed South Africa's human settlements along racial and class ranks, many sections of the population was excluded from the social, economic and environmental benefits of integrated sustainable urban and rural developments (White Paper on Spatial Planning, 2001). It was not until the early 1950's following the Second Wold War that a political transformation took place due to the fact that mainly British born and educated town planners were brought out to South Africa with a view to introducing British planning ideology, approaches and methods (cross-reference to Table 8) (Forbes, 2011:4). The Berea area of Durban adopted the first formal town planning and zoning scheme in 1953, and only in the 1960's were zoning schemes expended outwards (Forbes, 2011:4).

This led to the formulation of grand apartheid that was essentially a spatial, even geographic, partition attempt, with dire disintegrative spatial consequences (Green paper, 1999). Apartheid planning was integrally linked to “blueprint” or “master plan” as the dominant planning approach (White Paper on Spatial Planning, 2001). The approach was broad in nature, and determined to achieve the desired end state of separate development. This desired end turned into an inflexible representation of the future which required absolute control on the part of planning authorities (White Paper on Spatial Planning, 2001). This planning system, mainly developed to address and support the minority, led to a highly complex and confusing legal planning environment.

3.3.2. Spatial planning since 1994

When South Africa’s first democratically-elected government came into power in 1994 it inherited the fragmented, unequal and incoherent planning systems which developed under apartheid (Bouillon, 2000). There is a considerable array of legislation that controls planning within the geographic boundaries of the Republic of South Africa. Some of the most important are as follows: Constitution of RSA No 108 of 1996; Municipal Systems Act No 32 of 2000; Development Facilitation Act (No 67 of 1995) (DFA); Less Formal Township Establishment Act (No 113) of 1991 and the Planning Acts and Ordinances in the provinces.

The Development Facilitation Act (No 67 of 1995) was a major milestone in the history of urban planning in South Africa as it was the only post-1994 planning law enacted by parliament (**Laros, 2011**). DFA was promulgated as an “interim measure to bridge the gap between the old apartheid era planning laws and a new planning system reflecting the needs and priorities of the democratic South Africa” (DFA, 1995). The DFA thus operates parallel to the existing laws, until such time as they are replaced, as proposed by this White Paper (White Paper on Spatial Planning, 2001).

The Act, however, did not wipe the slate clean with the result that the national and provincial laws relating to planning promulgated before 1994 are still in existence. Other legislation that also affect planning in South Africa include the following: Subdivision of Agricultural Land Act (70 of 1970); National Building Regulation, Act (103 of 1977); Physical Planning Act (125 of 1991); Housing Act (107 of 1997); National Environment Management Act (107 of 1998); National Heritage Resources (Act No 25 of 1999); Promotion of Administrative Justice Act (No 3 of 2000); Planning Professions Act (No 36 of 2002); Social Housing Act of (No 16 of 2008) and the National Land Transport Act (5 of 2009).

Studies done by various researchers highlighted the fact that there was never one holistic policy to guide integrative sustainable development, but that various policies and pieces of legislations captured the idee and dimensions of sustainable development, including the Environment Conservation Act number 73 of 1989, the Development Facilitation Act number 67 of 1995, the Constitution of the Republic of South Africa, Act 108 of 1996, the Urban Development Framework of April 1997, the National Environmental Management Act number 107 of 1998, the Green Paper on Development and Planning of April 1999, the Municipal Systems Act number 32 of 2000, the Land Use Management Bill of 2003 and the National Spatial Development Perspective of 2006. These guiding policies and legislation and their relation to sustainable development are summarised in Table 9.

Table 9: Sustainable development guided by applicable legislation and policies in SA

Sustainable development legislation and policies in SA			
Date	Name	Guide	Relation to sustainable development
1989	Environmental Conservation Act No 73 of 1989.	Legislation	To provide for the effective protection and controlled utilisation of the environment and for matters incidental thereto.
1995	Development Facilitation Act No. 67 of 1995.	Legislation	Facilitates development of settlements, discourages land invasions, promotes efficient and integrated land development, discourages urban sprawl, and makes maximum use of resources.
1996	Constitution of the Republic of South Africa (Act 108 of 1996).	Legislation	The supreme law of the country of South Africa that provides the legal foundation for the existence of the Republic of South Africa sets out the rights and duties of the citizens.
1997	Urban Development Framework. April 1997.	Policy	It provides a positive and common vision of a desired future for South Africa's urban areas in the year 2020. Contains Government's vision for sustainable urban settlements, as well as guidelines and programmes for the achievement of the vision.
1998	National Environmental Management Act (NEMA). No. 107 of 1998	Legislation	The National Environmental Management Act provides co-operative, environmental governance by establishing principles for decision-making on matters affecting the environment, institutions that will promote co-operative governance and procedures for co-ordinating environmental functions; and matters connected therewith.
1999	Green Paper on Development and Planning. April 1999.	Policy	Focus is on co-operative governance between national, provincial and local spheres of government to establish a shared vision.
2000	Municipal Systems Act No 32 of 2000.	Legislation	It is a legislated plan that supersedes all other plans that guide local development, enforced the IDP.

2003	Land Use Management Bill. 2003	Policy	Provides for the uniform regulation of land use management in South Africa, sets principles for spatial planning, land development and land use management, and provides for spatial development frameworks.
2006	National Spatial Development Perspective (NSDP) 2006.	Policy	Ensure economic growth, government spending, future settlement and economic development in main growth centres, informs development plans and support government's national spatial development vision.

Source: Cilliers (2010).

The goals of inclusive and sustainable growth are particularly important for South Africa, and the management of natural resources such as land and water is recognised to contribute to their achievement. However, as the progress of water reforms has demonstrated, the broader democratisation and development process is necessarily shaped by the country's historic development path and the nature of its natural resource endowments. To achieve the global goals of inclusive and sustainable growth, South Africa has to address decades of extensive policy-driven exclusion. The role of water, its management and development provide a new perspective on the policy challenges that the new South Africa has inherited, and the priority to strategies and align Spatial Planning approaches and Water Management approaches in an attempt to build a more prosperous and inclusive society while sustaining the natural environment.

3.3.3. South Africa's water management approach

This section pays particular attention to the reforms that were introduced after the establishment of a democratic government in 1994. Measures were adopted that sought to redress the country's long history of discrimination and to promote inclusion. The reforms also provided for wide-ranging institutional changes, the establishment of a systematic and adaptive planning cycle and the introduction of a process to reallocate water between users in stressed systems where demand outstripped supply. A brief history review of South Africa's approach to water management is given below. Formal water management in South Africa began in the colonial era. In the 17th century, the first civil engineering contract was allowed for a channel to convey water to the Cape Town jetty (Muller, 2011:11). Over the next two centuries, the water requirements of colonial and settler expansion were met without significant state support, intervention or formal administrative framework (DWAF, 2002a). By the mid-19th century, settlement expanded into the immediate interior of the Karoo where the climate is increasingly arid, this had become a formal concern for the colonial government in the Cape and experts were appointed to study the region's water and make recommendations about how best to address water-related problems (Muller, 2011:12). The monograph of Brown (1877) "Water Supply of South Africa" was devoted to an exposition of the history of water management in China.

Brown cited Gustave Wex, an Austrian Hydraulic Engineer and Councillor of State responsible for the regulation of the flow of the Danube, who eulogised China's water management efforts as well deserving of consideration (DWAF, 1986). Brown, concerned about the acute aridity of South Africa's hinterland (writing as he was from the perspective of the Cape), concurred and concluded that South Africa faced similar challenges albeit on a much smaller scale, and would do well to emulate the Chinese approach (Brown, 1877:648). This approach reflected what has been described elsewhere as the 'hydraulic mission', which could equally well describe South Africa's approach to water resource management in the 20th century, which underpinned its economic and social development. Record of any formal water resource management and development is non-existent from the pre-colonial times, but water use and conservation was governed by various communities with strong cultural traditions about the protection of specific water sources (DWAF, 1996). In the 19th century, the urban and industrial development that followed discovery of diamonds and gold introduced a new dynamic into water management (Muller, 2010:11). In 1904 Rand Water, a regional water utility was established under its own statute, preceding by six years the formation of the Union of South Africa.

Shortly after the establishment of the Union government, a national Department of Irrigation was established to coordinate water developments (Muller, 2010:12). Due to rapid urbanisation and industrialisation a new Water Act was passed in 1956, this reform changed the balance of power between riparian owners and other water users. This enabled the country to engage in a major programme of water resource development. The report of the landmark 1970 Commission of Enquiry into Water Matters stated that: The centralized planned management and control of the country's water resources was made possible through fundamental amendments to our legislation passed in 1956, whereby full control over the allocation and use of water in public streams was vested in the State (Commission of Enquiry, 1970:12). These amendments placed in the hands of the Government the instrument for so apportioning the available water resources among various sectors of the economy so that they could make maximum contribution to the development of the country as a whole. In the Republic, development, management and administration of water affairs are now strongly centralized. Only in providing for urban needs and in the distribution of water do local and regional authorities play an important but subsidiary role (Commission of Enquiry, 1970:12).

3.3.4. *Water Management since 1994*

The advent of a democratic government in 1994, which united a country that had previously been separated into racial and ethnic groups as a matter of policy, required fundamental reform in all areas of activity. In water resource management, the objectives of and strategy for this reform were clearly spelt out in a 'Development Vision for Water', which is built on the first democratic government's initial Reconstruction and Development Programme (RDP), (African National Congress, 1993). The vision outlined the competing uses of water and the need to provide for a growing economy while not damaging the resource furthermore it highlighted that the era of continual supply expansion was drawing to a close (African National Congress, 1993).

The challenge of water management in the 21st century is to ensure that the society develops in a way that can function successfully within the constraints of its resource. It is to treat the development, use and protection of our water as a common endeavour in the interests of all, in the spirit of a new patriotism rather than as a series of conflicts between different groups, it is in this spirit that the new water law will be written (DWAF, 1997:16–17). The South African Constitution, Act 108 of 1996, addresses water issued directly and provided the basis for the major changes taking place in the country's water management (Dent). In 1996 South Africa's Cabinet agreed to a set of 'Fundamental Principles and Objectives for a New Water Law in South Africa' proposed by the Minister for Water Affairs and Forestry, Professor Kader Asmal, the principles were then integrated into the 1997 National Water Policy.

Therefore, the following acts and legislations were conducted to support the South African Constitution: National Water Act No. 36 of 1998, National Water Resource Strategy, Guidelines for Water Conservation and Demand Management, Guidelines for Groundwater Resource Management in Water Management Areas, Framework for water Conservation and Demand management, National Climate Change Response Green Paper, Strategic Planning for Water Resources in South Africa- Situational Analysis, The National Environmental Management Act of 1998 (Act 106 of 1998). These guiding policies and legislation and their relation to sustainable water development are summarised in Table 10: The literature review will only focus on urban areas and towns for the sake of the study.

Table 10: Guiding policies and legislation and their relation to sustainable water development in South Africa

Guiding policies and legislation for water management	
National Water resource Act No. 36 of 1998	Aims to protection of the quality of water resources to ensure sustainability of the nation's water resources. Catchment Management Agency (CMA) must be in place to manage the water resource quality and quantity, this includes also water-use licensing for quantity control; re-use of wastewater by irrigation and intentional recharge of an aquifer.
National Water Resource Strategy (NWRS)	Implementation framework for the management of water resources in South Africa. Includes the protection of water resources, water conservation and re-use of wastewater and water demand management.
Guidelines for Water Conservation and Demand Management	Guideline such as leak detection, water-efficient application, management of the metering system, tariff structures. Emphasis was placed on the removal of alien vegetation as it would increase the water availability in river catchments. The guidelines are also strictly followed by the Department of Water Affairs' and Working for Water programme (SA, 2004a:2)
Guidelines Groundwater Resource Management in Water Management Areas	Aims to reduce water losses by creating more vegetated surfaces and soakaways in order to maintain groundwater recharge. This is one of the closest guidelines to WSUD, it recognizes that with early planning, a framework is provided to developers, government and industry to create a secure infrastructure (SA, 2004b:5).
Water Conservation and Demand Management Framework	Addresses issues such as need to reduce water losses to an optimum economic level, control water demand and maximum utilisation of already available infrastructure. The framework is aimed to provide local authority managers with guidance so that they can recognise the shortcomings of the authority.

Water for Growth and Development.	Sets out the challenges faced by the government and the water sector in ensuring that water is used optimally in support of sustainable and pro-poor growth and development. It generally confirms the objectives and focus of the White Paper on a National Water Policy for South Africa (DWAF, 1997), the National Water Act (NWA) and the NWRS.
National Climate Change Response Green Paper	Aims to address the impact of climate change on water resources by monitoring the CMAs at all levels of government. 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).
Strategic Plan: A Situation Analysis 2009	Initiated Water Reconciliation Strategy Studies for large metropolitan areas to determine aspects of current water availability, water use, and future demands (SA, 2009:6). The results of the studies were addresses in the National Spatial Development Plan. These results are also used to better inform municipal managers to help them execute the Water Services Development Plans and Integrated Development Plans more effectively.
The National Environmental Management Act of 1998 (Act 106 of 1998)	An overarching legislation relating to the protection and management of the environment. This law requires regular state of environment reporting in which the Department of Water Affairs and Forestry reports on the state of rivers report and progress report regarding aquatic ecosystems such as wetlands and estuaries.

Source: White Paper (1997).

These legislations and strategies play an important role in our current successes regarding water management, but there is however, also a need to localize water management issues to increase stakeholder engagement and support for resolution strategies. Currently, South Africa strategic framework for water resource management is recognised as being modern and impressive. Its policy, administrative and legislative is considered to be a great strength in the development of South Africa's water supply and resource management (Kasrils, 2003). But still, with the current situation of climate change, Integrated Urban Water Management with specific focus on stormwater harvesting has to be considered as integrated into current legislative frameworks and policies.

3.4. Conclusions

The on-going development of different kinds of planning theories and practices should be seen as a corresponding action that balances each other to some extent from different angles. Planning is exercised at different levels of government from national to local level, and within different sectors. At the local level the physical form and principle of good design remains a necessary and significant consideration for city planning. The concept of systems and rational process views of planning plays an important role at a broader and more strategic level of planning. Collaborative and participatory planning helps planners to move towards a common understanding about problems, objectives and alternatives so as to achieve good quality of urban environments. In order to achieve sustainable development it is necessary to involve the global environmental problems in the local levels of development concerns.

Spatial organization requires public participation and communication, relating to the theory that planning needs to be more open, negotiable and integrated. Combining the sustainable development principle and collaborative planning approach could however offer a new mode for problem-centred and procedural approaches in the planning practice. In this sense, water issues are spatially relevant, therefore the Water Affair Bureau and the Urban Planning Bureau needs to cooperate and coordinate their efforts. The evaluation of South Africa's relevant Spatial Planning and Water Management legislations illustrated that it are in line with the international sustainable development approaches, however, still lacking to address the need to implement future uses of stormwater harvesting in urban areas, along with the lack of an integrated approach. Chapter 4 will contribute to the much needed approach of an integrated urban water management system by evaluating the international best-practice approaches that has been taken to insure sustainable stormwater management.

Chapter 4: Water Sensitive Planning- Integrating Water Management in Spatial Planning approaches.

4.1. Introduction

Chapter 2 stated that South Africa is a water-stressed country and is facing increasing challenges in providing basic services, such as water services, to its people. South Africa has high development aims while rapid urbanization is straining the social and environmental sustainability of urban areas. The studies concern lies in the fact that most of South Africa's surface water resources are fully accounted for, and the fact that South Africa is still following a strict linear approach to water resource usage (extracting water from the natural environment, transporting it to the consumer, and ultimately discharging it into natural water ways downstream) (Chapter 3). Water planning and management policies and legislation are currently not integrated in Spatial Planning approaches, emphasizing the fact that the paradigm shift towards Water Sensitive Planning (WSP) has not yet been allocated in South Africa, as in the case of Australia and many other international countries. Chapter 4 will discuss the international approaches towards sustainable urban water management, spatial consideration, design methods relative to WSP and also discusses the gaps between policy and practice with the aim of bridging these gaps through the conceptual model development of an integrated policy approach between Spatial Planning and Water Management. Figure 13 captures the conceptual framework for Chapter 4.

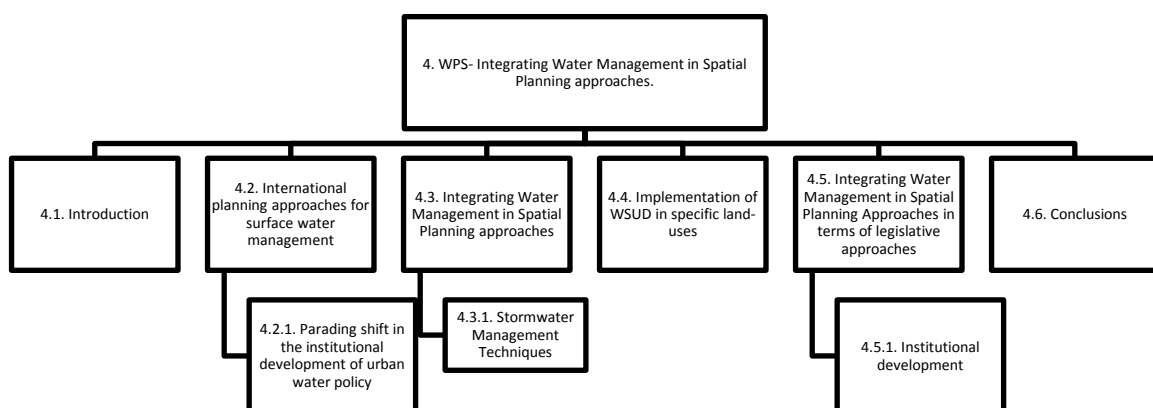


Figure 15: Structure of Chapter 4
Source: Own construction (2012)

4.2. International planning approaches for surface water management

Internationally policy makers argued that water-use needs to be directly associated with the protection of ecosystems (Frankemark & Rockstrom, 2005). Hall indicated that the central point of urban and regional planning concerns the spatial impact of many different kinds of problems and with the spatial coordination of many different policies in the urban region (Hall, 2002). One of the main objectives of spatial planning is to ensure that the utilization of land resources is planned and implemented in an organized manner to meet the needs of present and future generation without deteriorating the quality of space. Land use change and environmental quality are closely related, and the nature and location of development can significantly influence both the generation and resolution of environmental problems. This places spatial planning, which provides a framework for regulating the development and use of land, in a strong position to affect water quantity and quality issues (Carter, 2007).

Spatial planning needs to address the challenge of protecting the natural resources where possible, by developing suitable technologies to repair the natural system which has been damaged due to high density of population and uncontrolled infrastructure development in urban areas. Spatial planning, in this sense, thus needs to include environmental issues (such as water management) as a critical part of the planning process in order to adhere to the objective of sustainable development.

4.2.1. Parading shift in the institutional development of urban water policy

Spatial planning and urban water management often have different approaches to deal with the surface water bodies, management of stormwater, wastewater and water supply. Reason being, Spatial Planning considers water affairs as being part of the basic infrastructure and pay more attention to the urban land use development, while urban water management focuses on the engineering techniques to satisfy urban demand. In order to bridge the gap between these two fields (Spatial Planning and Water Management) it is necessary to identify the spatial needs for the water system in it. The study therefore aimed to identify sustainable development approaches to address the growing concern of the status of the natural water cycle and ecological systems in urban regions, in an attempt to strengthen the paradigm shift towards integrated and sustainable planning approaches.

Surface water management requirements has been undergoing significant changes, moving away from traditional conveyance-oriented drainage and treatment technology towards corresponding improvements and innovations in land-use practices. Accordingly the conveyance-orientated and storage-orientated management approach will be discussed.

4.2.1.1. Traditional conveyance-oriented stormwater management

The problem of stormwater is related to the type of drainage employed to convey rain water and waste from urban areas (MSMA, 2008:6). Urban planning focuses on the abstraction of more water and providing hygienic sanitation in a centralised urban system, which includes the water supply system, sanitation and drainage (Mitchell, 2006:590) diverting waste water away from human habitat. This is also referred to as the traditional conveyance-oriented approach of stormwater management. The objective of the fast traditional conveyance-oriented approach is to convey stormwater from the urban areas as fast as possible, typically to the nearest receiving water body in order to minimize damage and disruption within the collection area (McCuen et al. 1983:10).

The conveyance-orientated flood control measures did not improve the water quality, and they were harmful to the natural habitat. Moreover, Parkinson and Mark (2005:33-34) criticized that this approach focuses too much on technical solutions in a fragmented manner and tends to address problems after they occur, they also pass the flood control problems downstream with little attempt in advance to prevent or mitigate the problems in the collection areas. In Chapter 2 (Figure 6) shows the negative effects of post-development in terms of the traditional conveyance-orientated stormwater management. Recognizing the shortcomings of the traditional conveyance-orientated approach in the 1970s resulted in a shift to the storage-oriented approach (Niemczynowicz, 1999) with a focus on detention, retention and recharge.

4.2.1.2. Best Management Practices (BMPs) storage-oriented approach

Since the 1990's, so called Best Management Practices (BMPs) have been discussed and used in USA to control the pollution of urban runoff and protect the receiving waters to which the runoff drains (Roesner et al., 2001; Strecker et al., 2001; Perez-Pedini et al., 2005; Zhen et al., 2006). BMPs was further defined by Strecher et al. (2001) as a "device, practice, or method for removing, reducing, retarding, or preventing targeted storm water runoff quantity, constituents, pollutants, and contaminants from reaching receiving waters". Perez-Pedini et al. (2005) concluded that examples of BMPs include infiltration trenches, pervious pavement, grass swales, buffer strips, detention, retention, and bio-retention basins, which are further classified as infiltration based BMPs and storage-based BMPs. Furthermore, there are two other kinds of BMP classification: Structural and non-structural BMPs (Horner et al., 2008).

The term structural BMPs, often referred to as "Treatment BMPs," is designed to trap and detain runoff to settle or filter out the constituents before it enters receiving waters. In contrast with non-structural BMPs, structural measures include some engineering design and construction. Non-structural BMPs are management measures that prevent degradation of water resources by preventing pollution at the source, rather than treating polluted runoff (Richard et al, 2008). BMPs have to engage technological, economic, and institutional considerations compatible with environmental quality goals in order to be effective and practicable.

In other words BMPs are innovative, dynamic and improved environmental protection techniques, measures or structural controls that are used to manage something in the most environmentally responsible manner. Adopting principles of integrated BMPs will prevent or reduce the movement of sediment, nutrient, pesticides and other pollutants from the land to surface or ground water (Abbas & Fares; 2009). BMPs help to protect the environment and preserve good water quality. Low-impact development (LID), Sustainable Drainage Systems (SuDS) and Water Sensitive Urban Design (WSUD) are some relevant examples of BMPs and the theme of research and will be summarized accordingly.

Low-impact development (LID)

The concept of Low-impact development (LID) originated in Canada and the United States to describe a land planning and engineering design approach to managing stormwater runoff. LID is an approach to land-use and development practices that attempt to manage stormwater (ideally at the source or as close as possible) by mimicking natural conditions as much as possible emphasizes conservation and use of on-site natural features to protect water quality (Prince George's County, 1999). This approach implements engineered small-scale hydrologic controls to replicate the pre-development hydrologic regime of watersheds through infiltrating, filtering, storing, evaporating, and detaining runoff close to its source. The hydrologic tools used in LID design mainly include (Prince George's County, 1999; 3-11):

- Preserving and protecting environmentally sensitive site features such as riparian areas, stream buffers, floodplains, woodlands, wetlands, conservation zones, valuable trees, steep slopes and highly permeable and erosive soils
- Reducing land surface distortion by preserving more trees or meadows;
- Maintaining time of concentration of peak runoff by lengthening flow paths.

Green rooftops, rain gardens or bio-retention, sidewalk storage, swales, vegetated buffers and strips, infiltration trenches, and permeable pavements are some of the techniques used to accomplish LID in practice. Through the above research conducted on BMP and LID approaches, it would be save to say that BMP and LID clearly forms part of a new paradigm shift in context to surface water management. Coffman (2002) stated that “they both emphasize the making of onsite multi-functional, multi-beneficial and optimized treatment so as to allow the developed area to retain a better hydrologic regime in a watershed.”

Sustainable urban Drainage Systems (SuDS) - storage orientated approach

“Sustainable Drainage Systems (SuDS) offer an alternative approach to conveyance-orientated drainage practices by attempting to manage surface water drainage systems holistically in line with the ideals of sustainable development” (WSUD SA, 2012). This is achieved through a number of sequential interventions in the form of a ‘treatment train’ in order to mimic the natural hydrological cycle.

The storage-oriented approach provides for the temporary storage of storm-water runoff at or near the point of origin, with subsequent slow release to downstream storm sewers or channels, minimizing damage and disruption both within and downstream from the site (Walesh, 1989). It is important to understand that SuDS generally embrace a number of options that are arranged in a treatment train. This helps to improve the efficiency and resilience of the system. In other words, stormwater is managed through a series of unit process collectively known as a treatment trains. There are three key stages in the treatment train (source control, local control and regional control), each having slightly different combinations of SuDS options to control the stormwater.

Water Sensitive Urban Design (WSUD)

Based on the principles of BMP's and concepts of LID and SuDS, Water Sensitive Urban Design (WSUD), a concept developed in Australia (WBM, 2009). WSUD is an approach which integrates the management of all water resources and the total water cycle into the urban development process (DPLG, 2009:3). The concept provides the basis for a holistic approach to stormwater management using techniques that are capable of delivering a wide range of beneficial outcomes at both the regional and local levels. WSUD entails the integration of Spatial Planning and utilisation of best practices in terms of water management to achieve the objectives of sustainable drainage systems for urban areas. Spatial Planning thus provides the pro-active element in the process to facilitate the utilisation of best-practices in terms of stormwater management techniques.

4.3. Integrating Water Management in Spatial Planning approaches by means of water sensitive urban design (WSUD)

Iwona Wagner (Switch urban water, 2010) defined Water Sensitive Urban Design (WSUD) as the integration of urban water cycle management with Spatial Planning, which considers all parts of the urban water cycle. WSUD promotes the integration of stormwater, water supply and wastewater management at the early stages of urban planning to ensure that best practice water cycle management is applied in order to facilitate synergies between ecological, economic, social and cultural sustainability (Wollongong Development Control Plan, 2009). It also bridges gaps between various sectors and provides a platform for trans-disciplinarily interactions, which is a great challenge for sustainable water resources management in cities. Carmon et al. (1997) suggested that water sensitive urban planning and design has the potential to be viable technically, economically and socially, therefore it can contribute to sustainable development. Water Sensitive Urban Design (WSUD) is a sustainable way of managing urban water to reduce the environmental impact of development and to protect the natural hydrological regime. WSUD aims to:

- Protect and enhance our natural water systems;
- Reduce flood risk and divert water from stormwater through on-site water storage, maximising areas where water can enter the ground and using water more efficiently;

- Reduce demand for potable water from our dams improve the quality of water discharged from urban development into the ground and environment prevent erosion;
- Enhance aesthetic and recreational opportunities.

The 'Handbook of Water Sensitive Planning and Design' in (France, 2002), presents the history of water as a design and planning element in landscape architecture and describes new interpretations of water management. Throughout the book emphasis is placed on the importance of the paradigm shift, focussing not only on water management but also on planning and design. Applying these appropriate measures in urban development, will create efficient water resources and minimise demand on the reticulated water supply system. In order to incorporate WSUD successfully into urban development, a range of important stakeholders needs to be included, namely: (WSUD.org, 2012):

- Regional planning commissions
- Municipalities
- Transportation Departments
- Government agencies and utilities
- Land developers
- Stormwater designers
- Engineers
- Environmental organization
- Economic developers
- Commercial developers
- Builders and homeowners

These stakeholders, together, create a strategy to implement Water Management in the Spatial Planning approaches. WSUD objectives are primarily focussed on two issues, namely water conservation and stormwater management:

- a) Water conservation: Reducing and reuse of water by mulching; using drought tolerant plants; reducing areas of lawn; designing water efficient irrigation systems (e.g. dripper rather than spray irrigation); designing non-irrigated landscapes; incorporating permeable / porous pavements; directing water towards garden beds; installing rain water tanks to capture roof water for irrigation or toilet flushing.
- b) Stormwater Management: Storing water on site, maximising areas where water can enter the ground and improving the quality of water discharged into the stormwater system and local water courses. This may be achieved by incorporating storm water quality treatment infrastructure such as rain gardens (bioretention swales and bioretention basins); vegetated swales; sand filters; infiltration systems; rooftop gardens; wetlands and sediment basins on larger sites; and minimising the use of pesticides, herbicides and artificial fertilisers.

As stated, water is one of the important elements for urban planning and design to retain natural and cultural diversity, to create high quality urban space, and to entertain urban citizens, all of which implies spatial consideration (Melbourne Water, 2010). These water spatial issues may only be tackled when they are explicitly integrated into a spatial planning process. The aims, objectives and principles of WSUD are summarized in Table 11.

Table 11: Objective, aims and principles of WSUD

WSUD Approach		
Objectives	Aims	Principles
Functionality and Operational Issues	To change decision makers' perception:	✓ Stormwater must be seen as an economically valuable resource indispensable in modern town planning, urban design and sustainable decision making process and not as a constraint.
	Developing tools:	✓ Minimize the drainage infrastructure cost of the development.
	Add value while minimizing development costs:	✓ For efficient incorporation of stormwater management and water bodies into the decision making process in IUWM and urban planning, for improvement of urban water systems and quality of life, assuring economics of the management and sustainable solutions under conditions of progressive urbanization and growing cities.
Natural Function and Amenity	Protect natural systems:	✓ Protect and enhance natural water systems within urban developments. Promoting and protecting natural waterways as assets allows them to function more effectively and supports the ecosystems that rely on them.
Water Supply and Wastewater	Integrate stormwater treatment into the landscape:	✓ Use stormwater in the landscape by incorporating multiple use corridors that maximize the visual and recreational amenity of developments. The natural stormwater drainage system can be utilized for its aesthetic qualities within parklands and walking paths, making use of natural topography such as creek lines and ponding areas.
Water Quality	Protect water quality:	✓ Improve the quality of water draining from urban developments into receiving environment. Through filtration and retention, water draining from urban developments can be treated to remove pollutants close to their source.
Water Quantity – Hydrologic Management	Reduce runoff and peak flows:	✓ Reduce peak flows from urban development by local detention measures and minimizing impervious areas.

Source: Melbourne Waters (2009)

Chapter 2, started off with a brief description of the earth natural hydrological cycle and the ways in which the water cycle has its own balancing status in the natural environment. The movement of water through this man-made infrastructure is known as the urban water cycle. In order to link water management and Spatial Planning, the study identified three major components in the urban water cycle including (SWITCH, 2012), namely Portable water supply;

Stormwater management; and Waste water management. These three components of the urban water cycle form a general network and manage the flow of water throughout the urban built environment. The study will focus mainly on stormwater management, considering the international approaches which have redirected spatial planning to consider new and innovative ways towards stormwater harvesting. Accordingly the techniques to manage stormwater will be discussed, as part of the WSUD approach:

4.3.1. Stormwater Management Techniques

There are various international recognised stormwater management techniques. For the purposes of this research, some of the relevant techniques were captured, linked to the WSUD approach, and is presented accordingly:

Sediment Basins

A sediment basin is a temporary basin formed by excavation or by constructing an embankment so that sediment-laden runoff is temporarily detained under quiescent conditions, allowing sediment to settle out before the runoff is discharged (QASQA, 2005) (refer to Figure 16).

Swales and Buffer Strips

CIRIA (2009) initiatives describe swales and buffered strips as vegetated surface features that drain water evenly off impermeable areas. Swales are long shallow channels whilst filter strips are gently sloping areas of ground both provide opportunities for slow conveyance and infiltration (CIRIA, 2009). Grassed buffer strips are filter strips that slows the runoff velocities and allowing sediment and other pollutants to settle and by providing some infiltration into underlying soils (CASQA, 2005) (refer to Figure 16).



Figure 16: Swale and buffered strips
Source: Water Sensitive Urban Design (2012).

Table 12 summarises the advantages and limitations of swales and buffered strips as a stormwater management technique.

Table 12: Swales and Buffered strips advantages and limitations

Swales & Buffered strips	
Advantages	Limitations
Vegetated swales are normally less expensive and more aesthetically pleasing than kerbs and their associated concrete- and stone-lined channels.	Swales normally require a larger land area than conventional kerb and channel drainage systems
The ponding that results from the runoff from adjacent impermeable areas is often completely infiltrated <i>in-situ</i> using swales,	Swales have very limited removal capabilities for soluble pollutants and fine sediment
Swales retain particulate pollutants as close to the source as possible.	Swales are impractical on properties that have a relatively steep topography.
Swales generally reduce stormwater runoff volumes and delay runoff peak flows.	Standing water in swales has the potential to result in the breeding of mosquitoes and the generation of foul odours.
The installation and maintenance costs for buffered strips are relatively low.	If they are not properly maintained, failure is likely to occur more quickly with swales than with most other SuDS options.
Buffered strips generally trap the pollutants close to source.	Buffered strips have minimal stormwater runoff storage capacity and are not very good at treating high velocity flows.

Source: Owen et al., (2008) & Stabenfeldt (1996)

Bio-retention areas

Bio-retention is a way of managing stormwater by filtering it through plants and soil in a way that mimics nature. It includes rain gardens, bio-retention swales, stormwater planters and tree pits (Auckland Council, 2010). Bio-retention incorporates a series of small stormwater management interventions such as sand beds, grassed strips for infiltration, temporary ponding areas, mulch layers and a diverse variety of plant species (Alderete, 2005). Normally they would be found in the median strip of divided roads, adjoining roadways, between residential plots, in car parks and in parkland areas (Melbourne Water, 2004), as illustrated in Figure 17. Table 13 summarises the advantages and limitations of bio retention areas as a stormwater management technique.



Figure 17: Bio-retention Areas.
Source: Water Sensitive Urban Design (2012).

Table 13 summarises the advantages and limitations of Bio-retentions as stormwater management technique.

Table 13: Bio retention Areas Advantages/Limitations

Bio retention Areas	
Advantages	Limitations
Bio-retention areas are effective at the removal of most stormwater runoff pollutants Due to their flexible application characteristics, bio-retention areas are easily incorporated into a wide variety of landscapes;	Bioretention areas are normally impractical in areas with steep or persistently undulating slopes;
Stormwater runoff rates, volumes and flood peaks are effectively attenuated with the correct use of bio-retention areas;	Bioretention areas are not suited to areas where the water tables are shallower than 1.8 m (Endicott & Walker, 2007);
Bio-retention areas are generally satisfactory as a retrofit options; and	Bio-retention areas require frequent maintenance to remain aesthetically appealing;
Bio-retention areas can be made aesthetically pleasing.	If there is poor housekeeping in the adjacent areas then there is an increased chance of clogging; and

Source: Melbourne Water (2004) & Alderete (2005).

Wetlands

Ponds and wetlands provide habitat for fish, birds and other wildlife it consist of marshy areas of open water and aquatic vegetation (Dalton et al., 2009). Stormwater wetlands are man-made systems designed to copy the natural wetlands (Smith et al., 2006). They are most commonly used as regional controls although may be used on a local scale in the form of pocket wetlands (Waters, 2006) (Refer to Figure 18).



Figure 18: Constructed Wetlands.
Source: Water Sensitive Urban Design (2012).

Table 14 summarises the advantages and limitations of wetlands as a stormwater management technique.

Table14: Wetlands Advantages/Limitations.

Wetlands	
Advantages	Limitations
Constructed wetlands perform significantly better in the removal of pollutants from stormwater runoff than other regional controls of equal volume;	Constructed wetlands could potentially attract mosquitoes;
Constructed wetlands that are effectively incorporated into the urban landscape of neighbouring residences have the potential to add great aesthetic value to those properties provided there is an appropriate level of maintenance;	Constructed wetlands are limited to application on relatively flat land, as they become costly to incorporate on steep and potentially unstable slopes;
Small aquaculture wetlands have the ability to produce various kinds of food (Hobart City Council, 2006); and	Constructed wetlands may require supplementary water during long dry periods; and
Constructed wetlands can be retrofitted into existing 'flood retarding basins' (Environment Protection Authority – Melbourne Water Corporation, 1999).	Wind action can cause the re-suspension of organic solids where the water is shallow, potentially resulting in adverse changes in the soil chemistry.

Source: Dalton et al., (2009), Robert Bray Associates (2007), Smith et al., (2006) & Waters (2006).

Infiltration Trenches

Infiltration trenches are excavated trenches filled with rock void forming material, designed to detain runoff and enable subsequent infiltration to the surrounding soils, usually not more than 24 hours (Belan, 2004). They reduce surface detained and allowed runoff volumes by providing a pathway for treated water to recharge local aquifers (Jonasson, 2008) (Refer to Figure 18).



Figure 19: Infiltration trenches surrounding car parks
 Source: Water Sensitive Urban Design (2012)

Table 15 summarises the advantages and limitations infiltration trenches as a stormwater management technique.

Table 15: Infiltration Trenches Advantages/ Limitations

Infiltration Trenches	
Advantages	Limitations
Infiltration trenches increase stormwater infiltration and corresponding groundwater recharge;	Infiltration trenches are not appropriate on unstable or uneven land, or on steep slopes;
Infiltration trenches decrease the frequency and extent of flooding;	
Infiltration trenches are particularly effective in removing suspended particulates from stormwater	They are restricted to areas with permeable soils.
Due to their relatively narrow cross section, infiltration trenches can be utilised in most urban areas, including brown-field or retrofit sites.	

Source: Belan, (2004)

Permeable Pavements

Pervious pavement is designed to allow percolation or infiltration of stormwater through the surface into the sub-layers and/or underlying strata (Lake Superior stream; 2009). There are many alternatives for the load-bearing surface material including: gravel, specially designed concrete block pavers (CBP), stone chip, brick pavers, porous concrete and porous asphalt (Cammeray, 2006).



Figure 20: Permeable Pavements
Source: Water Sensitive Urban Design of the Sydney Region (2011)

Table 16 summarises the advantages and limitations of permeable pavement strips as a stormwater management technique.

Table 16: Permeable Pavements Advantages/ Limitations

Permeable Pavements	
Advantages	Limitations
Permeable pavements reduce stormwater discharges rates and volumes from impervious areas	The pollutant removal ability of permeable pavements is significantly lower than most other SuDS options
Permeable pavements increase the 'usable' area on specified developments by utilising, roadways, driveways and parking lots as stormwater drainage areas	Permeable pavements should not be constructed over fill materials, as these soils could fail when saturated
Stormwater runoff stored in permeable pavements can be used to recharge the groundwater table and for several domestic purposes Lined permeable pavement systems can be utilised where foundation or soil conditions limit infiltration processes	If managed incorrectly, there is a great potential for clogging by fine sediment, which significantly reduces the effectiveness of the specified system

Source: Owen et al. (2008)

Retention ponds

Retention ponds and wetland is in many ways the same, both have permanent pools of water but they differ in size and vegetation covers (Campbell, 2001). Retention Ponds are designed to detain and treat runoff for the same period of time as detention ponds (24-72 hrs.) (Campbell, 2001 & Hague, 2007).



Figure 21: Retention Ponds.
 Source: Lakeside Design service (2012).

Table 17 summarises the advantages and limitations of retention ponds as a stormwater management technique.

Table 17: Retention Ponds.

Retention Ponds	
Advantages	Limitations
The incorporation of retention ponds into the natural landscape provides amenity and biodiversity benefits and can also be used for recreational purposes where adequate supervision is available;	The permanent open pool of water creates health and safety concerns and therefore requires social impact considerations at the design stage
Retention ponds generally have the capacity to remove a wide range of common stormwater runoff pollutants;	The permanent open pool of water could display floating debris and scum.
Retention ponds are one of the most cost-effective SuDS options;	Retention ponds are normally restricted to sites with shallow slopes;
Retention ponds often have high community acceptability (Endicott & Walker, 2003, Woods-Ballard, <i>et al.</i> , 2007); and	Retention ponds require a base flow or the addition of supplementary water to maintain a specified permanent water line; and
Stormwater runoff that is captured in retention ponds can be reused for secondary domestic purposes and for various irrigation requirements.	Retention ponds normally require relatively large footprints and may be impractical in dense urban areas

Source: Campbell (2001) & Hague (2007).

Detention ponds

Detention ponds or detention basins are designed to store stormwater runoff for a relatively short period of time (24-72 hrs.) (Hussain et al., 2012). Detention ponds have been commonly used in South Africa alongside conventional systems to prevent flooding (McWhirter; 2004) (Refer to figure 22).



Figure 22: Detention Ponds.
Source: Ken-Mark-Turf (2012).

Table 18 summarises the advantages and limitations of detention ponds as a stormwater management technique.

Table 18: Detention ponds Advantages/Limitations

Detention ponds	
Advantages	Limitations
They are able to temporarily store large volumes of stormwater thus attenuating downstream flood peaks	Detention ponds are not very good at removing dissolved pollutants and fine material;
Detention ponds are relatively inexpensive to construct and easy to maintain;	They are most effective at or near their design flow; their efficacy drops off quite rapidly with very low or high flows;
Detention ponds may serve multiple purposes during drier seasons, particularly recreational purposes such as sports fields, play parks or commons;	The floors of detention ponds can become swampy for some time after major rainfall;
If managed regularly, detention ponds can add aesthetic value to adjoining residential properties as well as presenting fewer safety hazards than wet ponds due to the absence of a permanent pool of water.	Detention ponds are not very suitable in areas with a relatively high water table, or where the soil is very coarse, and there is a risk of groundwater contamination (Hobart City Council, 2006, Taylor, 2003).

Source: Hussain et al., (2012) & McWhirter (2004).

Green Roofs

Green roofs/roof gardens and vegetative roof covers is an important source control for stormwater runoff (Greenstone, 2009). Green roofs are also known as rooftop gardens, vegetated roof covers, living roofs, eco-roofs and nature roofs. Green roofs are a series of layers on top of built structures, consisting of vegetation, growing medium and a range of drainage and protective layers (McIntosh, 2010). Green roofs have additional benefits in the form of insulation and amenity value.



Figure 23: Green Roofs.
Source: Roof-Rocket (2012).

Table 19 summarises the advantages and limitations of green roofs as a stormwater management technique.

Table 19: Green roofs Advantages/ Limitations.

Green roofs	
Advantages	Limitations
Green roofs may be established on both existing and new buildings.	The implementation phase for green roofs requires experienced professionals.
The insulation characteristics of green roofs help to regulate building temperatures with consequent savings of energy.	Green roofs are generally more costly than conventional roof-runoff.
Green roofs can significantly improve amenity and biodiversity where they are implemented.	Green roofs may only be used on steep roofs.

Source: Greenstone (2009), Rickards (2006), USEPA (2007).

Soakaways

Soakaways are excavated pits, normally square or circular in shape, packed with coarse aggregate or other porous media (Owen et al., 2008). Soakaways are more likely to be used in source rather than local controls in order to manage the runoff from residential houses. This is used for temporary storage of stormwater runoff which later infiltrated into the ground (Environment Agency, 1999). Table 20 summarises the advantages and limitations of soakaways as a stormwater management technique.

Table 20: Soakaways Advantages/ Limitations.

Soakaways	
Advantages	Disadvantages
Soakaways can handle relatively high volumes of groundwater recharge	Soakaways are not suitable in areas where infiltrating water would negatively impose on adjacent structural foundations or adversely affect existing drainage characteristics
Soakaways significantly decrease both the runoff volume and rate	Soakaways cannot be used where the ground water table is near the surface
Soakaways are particularly effective in removing particulate and suspended stormwater runoff pollutants.	Sub-drain piping systems must be utilised when Soakaways are implemented in very fine silt and clay stratum because of the low infiltration rates

Source: Atlantis (2010), Environment Agency (1999), Owen et al., (2008).

Other stormwater management techniques to consider include but are not limited to:

Gross pollutant traps

Gross Pollutant Traps, or GPTs, are devices used to prevent large items polluting waterways. They are used in stormwater drains, urban wetlands, airports, beach fronts, industrial plants, flood plains and other locations. They generally collect larger items from the water, such as take away containers, leaves, bottles and plastic bags. Smaller pollutants, such as dirt, chemicals, heavy metals and bacteria are not collected directly by the GPTs (Stormwater Systems, 2009).

Bio-retention Basin

Bio-retention basin is a system that provides efficient treatment of stormwater through fine filtration, extended detention and some biological uptake (WSUD Engineering Procedures for Stormwater Management in Southern Tasmania, 2005, 1). High flows are either diverted away from the basin or are discharged into an overflow structure. Bio-retention basins are typically associated within small areas of land with residential usage or with parking lots where the islands become visually pleasing stormwater treatment centres (Lake Superior stream; 2011).

Sand Filters

Sand filters typically comprise three separate chambers, respectively with sedimentation, sand filtration and overflow roles. The sedimentation chamber removes gross pollutants and medium to coarse sediments. The sand filter chamber then removes much of the medium to coarse sediment as well as some of the finer particulate and dissolved pollutants. Regular maintenance of a sand filter is required to prevent a crust forming on the surface which decreases the infiltration capacity (JSCWSC, 2009). These stormwater management techniques are not a new phenomenon in the Water Planning and Management discipline. However, the implementation of these techniques should also be integrated in the Spatial Planning approaches and layout and design of urban environments. The implementation and design of WSUD approaches will be discussed in this sense.

4.4. Implementation of WSUD in specific land-uses

The scope of implementation of WSUD approaches is subjective to the specific land-uses applicable to a specific area. For purposes of this research, the following land-uses were included:

- 4.4.1 Single residential development
- 4.4.2 Residential sub-divisions
- 4.4.3 Residential multi-unit development
- 4.4.4 Streetscape development
- 4.4.5 Vehicle parking area development
- 4.4.6 Commercial and industrial site development
- 4.4.7 Public open spaces
- 4.4.8 Opportunities for retrofitting

Specific WSUD guidelines were determined for each of these land-uses. The following implementation techniques were summarised based on the WSUD technical manual (2010).

4.4.1. Single Residential Development

A single residential development refers to a dwelling on an individual allotment. Example WSUD objectives and common techniques for single residential developments are summarized below:

Table 21: Single Residential Development

Single Residential Development	
Objectives	Common Techniques
Maintain availability of water during restrictions	Demand reduction including water efficient fittings and appliances
Maximise the efficient use of rainwater and mains water	Landscaping (throughout various chapters, but predominantly
Assist maintenance of garden / landscaping;	Rain water tanks
Ensure water supply for fire protection	Green roofs
Reduce flood risk	Infiltration systems
Reduce greenhouse gas emissions	Permeous pavements
Improve biodiversity	Wastewater reuse
Prevent erosion	
Improve water quality	

Source: WSUD technical manual 2010.

Figure 24 explains the overall strategy for a typical suburban home. The rainwater tanks will provide water for outdoor water uses and indoor (toilet flushing, washing machine) usage, while water efficient fittings reduce mains water consumption elsewhere. Rainwater can also overflow into infiltration (or retention) trench. Runoff from paths, driveways and lawns is directed to garden areas (i.e. rain garden), where the excess runoff can be directed to the retention trench or to the street drainage system.

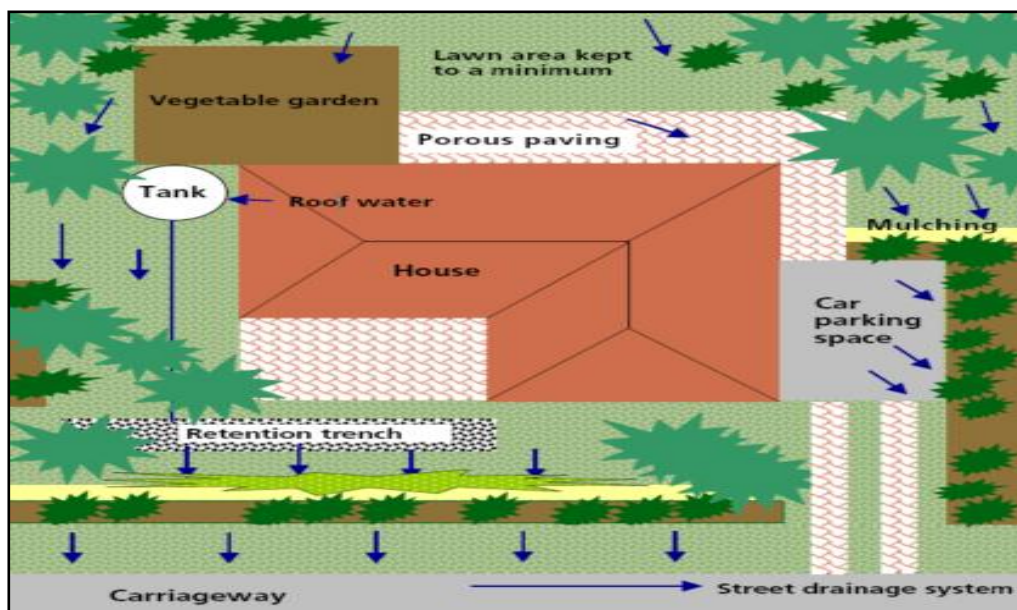


Figure 24: Example of an Overall WSUD Strategy for a Typical Suburban Dwelling.
Source: LHC CREMS (2002).

4.4.2. Residential Subdivision

A residential subdivision refers to an area with numerous dwellings on individual allotments. Example WSUD objectives and common techniques for a residential subdivision development are summarized below:

Table 22: Residential Subdivision.

Residential Subdivision	
Objectives	Common Techniques
Integrate natural and/or existing site topographical features into the subdivision design	Landscaping
Maximise use of natural and/or existing features for multiple use	Rainwater tanks
Minimise capital and maintenance costs per household for municipal infrastructure	Previous pavements
Maximise amount of public open space	Gross pollutant traps
Maximise opportunity to direct runoff into the ground or water body	Bioretention systems
Maintain availability of water during restrictions	Swale and buffer strips
Maximise efficient use of water	Sedimentation basins
Assist maintenance of garden	Constructed wetlands
Maximise development amenity	Wastewater reuse
Ensure water supply for fire protection	
Reduce flood risk; prevent erosion	

Source: WSUD technical manual 2010.

For successful outcomes it is necessary for these measures to be carefully designed as part of an overall strategy that considers local site conditions, development scale and layout. WSUD facilitates the use of smaller, more compact housing lots adjacent to open space areas that typically have high amenity value. This allows greater community access to open space, improving social connectivity and interaction.

At the subdivision scale, sustainable stormwater management includes conveyance controls such as grass swales and bioretention swales, water sensitive road design and natural waterways, and storage methods such as open ponds or covered tanks, constructed wetlands and aquifer recharge. These storage methods offer opportunities to utilise stormwater for irrigation of parklands, sporting fields and for cluster housing groups thus reducing the importation of water and the subsequent transmission costs and associated greenhouse gas emissions.

4.4.3. Residential Multi-unit Development

Residential multi-unit development refers to developments such as: high rise residential units; retirement villages; aged accommodation; townhouses; and single storey units. In most of these types of development, residential water demand is similar to a typical household with the exclusion of garden irrigation. Example WSUD objectives and techniques for a residential multi-unit development are summarized below:

Table 23: Residential Multi-unit Development.

Residential Multi-unit Development	
Objectives	Common Techniques
Integrate natural and/or existing site topographical features into the development design	Demand reduction including water efficient fittings and appliances
Maximise use of natural and/or existing features for multiple use;	Landscaping
Minimise capital and maintenance costs per household for infrastructure;	Rainwater tanks
Maximise amount of public open space;	Rain gardens
Maximise opportunity to direct runoff into the ground or water body	Green roofs
Maintain availability of water during restrictions;	Infiltration systems
Maximise efficient use of water	Pervious pavements
Assist maintenance of garden / landscaping	Gross Pollutant traps
Ensure water supply for bushfire protection	Bioretention systems
Reduce flood risk, prevent erosion	Wastewater reuse
Improve water quality, reduce greenhouse gas emissions	Siphonic roof water systems

Source: WSUD technical manual 2010.

Any combination of the techniques (i.e. rainwater tanks, pervious paving, filtration/infiltration devices, landscape practices) listed above can be very effective at achieving the objectives for multi-unit developments. Figure 25 below shows a possible overall strategy for a multi-unit development.

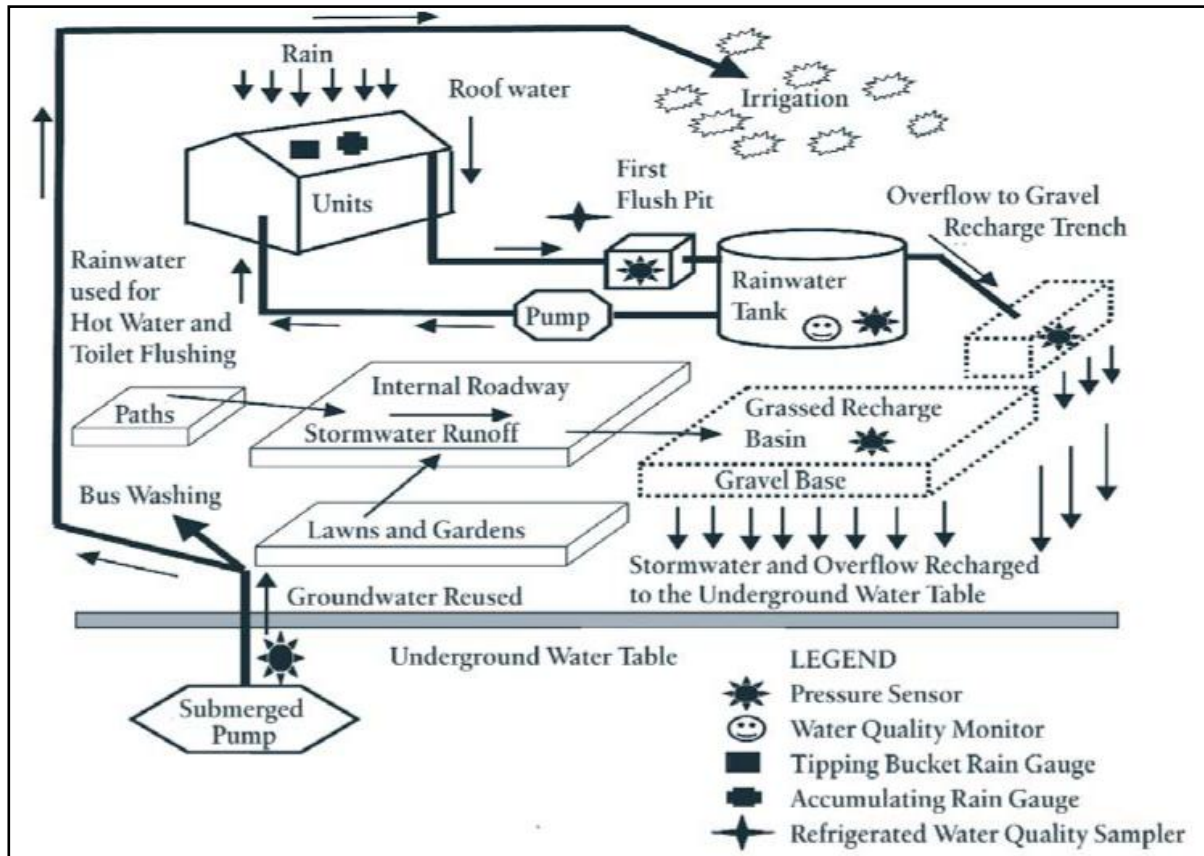


Figure 25: Schematic of a WSUD Multi-unit Layout Utilising Groundwater Recharge and Stormwater Reuse. Source: Hobart City Council (2006).

4.4.4. Streetscape Development

Roads account for a significant percentage of the overall impervious hard surfaces created within a typical development and therefore can significantly change the way water is transported through an area and the volume of runoff that is generated. These areas also generate water borne pollutants that can adversely impact on receiving waterway health (e.g. fine sediments, metals and hydrocarbons). Consequently, it is important to mitigate the impact of runoff generated from road surfaces. Road alignments and streetscapes should be carefully planned to incorporate some degree of treatment. WSUD drainage elements can be used to collect attenuates, convey and treat the runoff before discharge to receiving waterways.

No single street layout will be appropriate for all development and it is largely dependent on topography, density of development and traffic volume. Areas of low traffic volume (i.e. local access streets) may have the greatest flexibility in design alternatives. The following techniques are commonly used in WSUD strategies for streetscape development. These techniques can assist in achieving mains use reduction, water quality and water quantity targets. Example WSUD objectives and techniques for a streetscape development include:

Table 24: Streetscape development

Streetscape Development	
Objectives	Common Techniques
Integrate natural and/or existing site topographical features into the development design	Landscaping
Maximise use of natural and/or existing features for multiple use;	Infiltration systems
Minimise capital and maintenance costs for infrastructure;	Previous pavements
Maximise opportunity to direct runoff into the ground or water body	Gross pollutant traps
Maximise efficient use of water;	Bioretention systems
Assist maintenance of landscaping;	Swales and buffer strips
Reduce flood risk; prevent erosion	Sedimentation basins

Source: WSUD technical manual 2010.

A WSUD streetscape integrates road layout, vehicular and pedestrian requirements with water management needs. It uses design measures such as maximising pervious areas, local stormwater detention (and retention) in road reserves and managed landscaping. Any combination of the techniques (i.e. pervious paving, filtration/infiltration devices, landscape practices) listed above can be very effective at achieving the objectives and targets for streetscape design. For maximum effectiveness, these measures need to be carefully designed as part of an overall strategy that considers local site conditions. Figure 26 shows a possible overall strategy for streetscape development and Figure 27 shows an example of alternative verge design and incorporation of WSUD features.

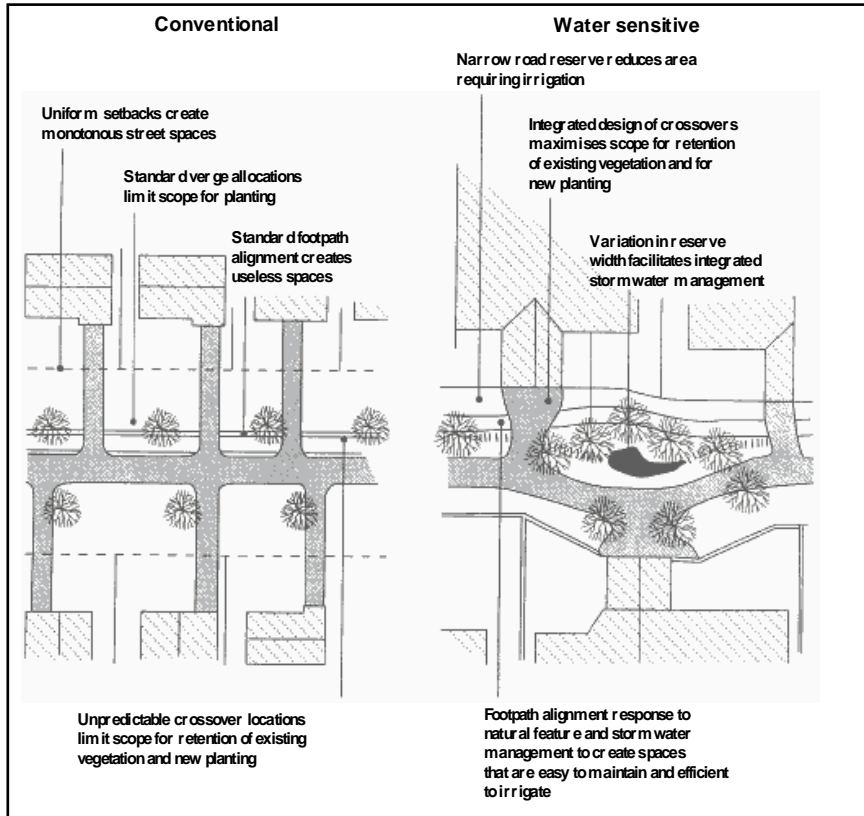


Figure 26: Conventional versus Water Sensitive Road Layout.
Source: CSIRO (1999).

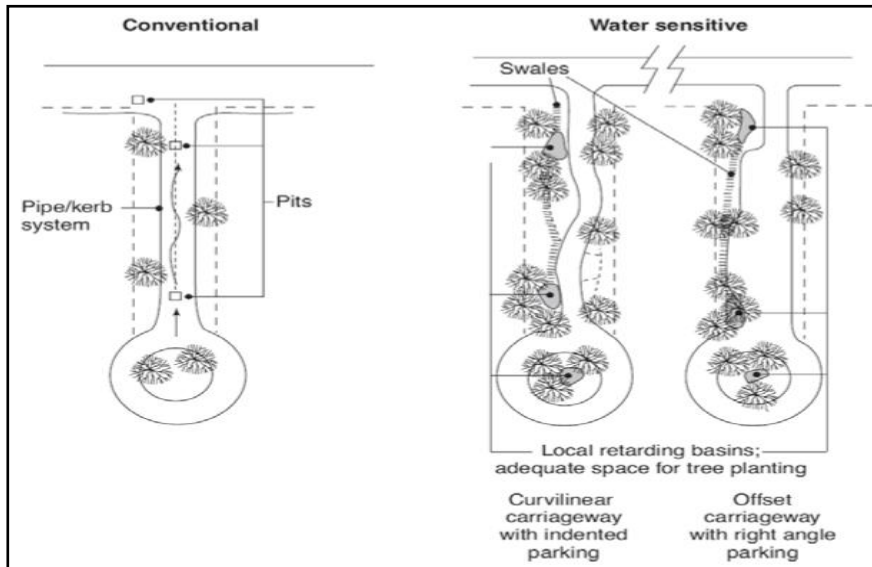


Figure 27: Verges Design and Maintenance
Source: CSIRO (1999)

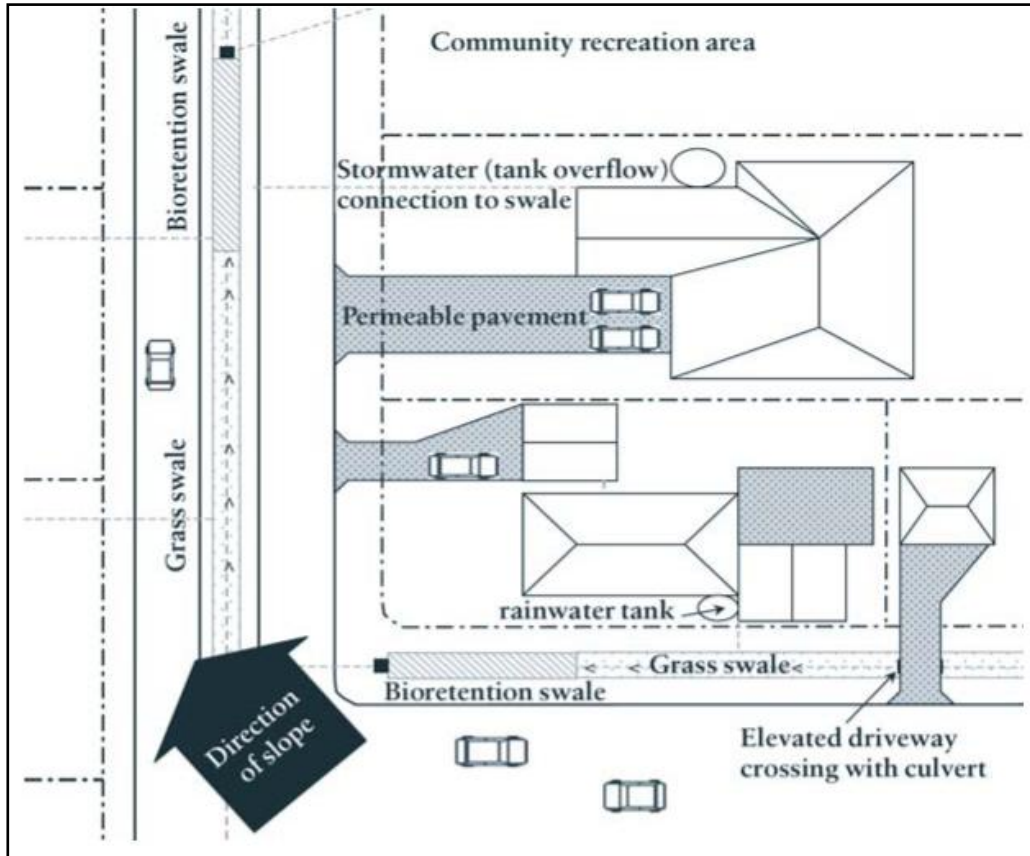


Figure 28: Diagram of Water Sensitive Residential Streetscape Showing Bioretention Swale Street Drainage. Source: Hobart City Council (2006).

4.4.5. Vehicle Parking Area Development

Vehicle parking areas include small scale to large scale car parks. While vehicle parking areas can be large generators of polluted runoff, creative design options can minimise the extent of impervious surfaces in parking areas and subsequent impacts on downstream water bodies.

Example WSUD objectives and techniques for vehicle parking area development are summarized below:

Table 25: Vehicle Parking Area Development

Vehicle Parking Area Development	
Objectives	Common techniques
Integrate natural and/or existing site topographical features into the vehicle parking area design;	Landscaping
Minimise capital and maintenance costs;	Rain gardens
Maximise opportunity to direct runoff into the ground or water body	Infiltration systems
Maintain availability of water during restrictions;	Pervious pavements
Maximise efficient use of water;	Gross pollutant traps
Assist maintenance of landscaping;	Bioretention systems
Achieve high amenity;	Swales and buffer strips
Reduce flood risk; improve water quality; Prevent erosion;	Sedimentation basins
Improve vehicle parking facility aesthetics	Constructed wetlands

Source: WSUD technical manual 2010.

It is desirable to incorporate various WSUD measures in the design of vehicle parking areas. Water sensitive vehicle parking areas are best achieved on sites that are relatively flat to gently sloping, with soils suitable for infiltration (e.g. sandy soils). It is essential that overflow paths for major storms are identified and that these conform to established standards. Gently sloping grassed areas or recessed basins can be incorporated in vehicle parking areas. These may be used to pond water to allow filtration of pollutants and the deposition of sediment. This is commonly accomplished by incorporating specifically designed or modified inlet structures that permit the temporary storage of runoff.

4.4.6. Commercial and Industrial Sites

The commercial sector goes beyond offices to include retailing centres, markets, schools, universities, hospitals and event venues. Figure 29 shows a possible overall strategy for industrial or commercial developments. Commercial and industrial sites can reduce water demand through efficient toilets and appliances. The WSUD objectives and techniques for commercial and industrial sites are summarized below:

Table 26: Commercial or Industrial Development

Commercial or Industrial Development	
Objectives	Common techniques
Integrate natural and/or existing site topographical features into the development design	Demand reduction
Maximise use of natural and/or existing features;	Landscaping, rain garden
Minimise capital and maintenance costs for service infrastructure;	Pervious pavements
Maximise amount of open space for employee use;	Bioretention systems
Maximise opportunity to direct runoff into the ground or water body	Swales and buffer strips
Maintain availability of water supply during restrictions;	Sedimentation basins
Maximise efficient use of water (including reuse);	Constructed wetlands
Ensure water supply for fire protection (where appropriate);	Wastewater reuse
Reduce flood risk; prevent erosion;	Siphonic roof water systems
Reduce peak discharges downstream;	Green roofs
Improve water quality; Improve biodiversity; and Improve aesthetics.	Infiltration systems

Source: WSUD technical manual 2010

Buildings with large catchment areas can harvest rainwater which can be utilised for toilet flushing and irrigation; as such sites often have large garden areas. Runoff can also be harvested from large car park areas. Other opportunities for industrial sites include multiple uses of water within a manufacturing site, the use of treated wastewater for process cooling applications and harvesting runoff for on-site use.

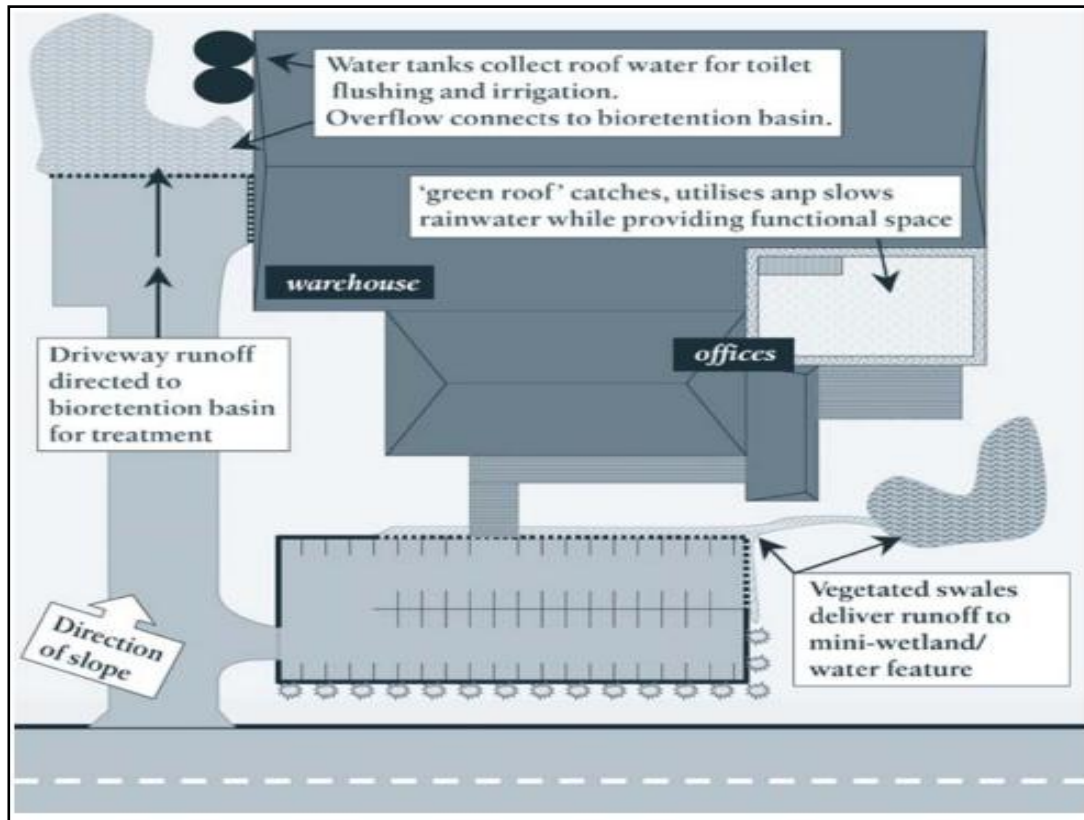


Figure 29: Industrial or Commercial Site Layout Example Incorporating WSUD Measures
Source: Hobart City Council (2006)

4.4.7. Public Open Space

The integration of stormwater management initiatives as components of the open space system contributes to open space outcomes by increasing the physical area of general open space and green elements within a community, enhancing terrestrial and aquatic habitat diversity, and recreational and educational opportunities. The open space system should be developed with the aim of establishing a network of natural features and compatible land uses that will act as a green network throughout the development. The WSUD objectives and techniques for open space networks sites are summarized below:

Table 27: Open Space Networks.

Open Space Network	
Objectives	Common techniques
Align public open space along natural drainage lines;	Incorporation of waterways and wetlands within parks as ecological and/or recreational features;
Utilise public open spaces to provide links between public and private areas and community activity nodes.	Integration of playfields within the basin of a dry detention basin;
Protect/enhance areas containing natural water features (such as creeks and wetlands) and other environmental values by locating them within public open spaces; and	Design of subsurface storage and/or infiltration systems beneath playfields within parks or school yards; and
	Development of gardens within open space areas such as bioretention systems.

Source: WSUD technical manual 2010.

Figure 30 compares examples of public open space provision within a conventional urban design layout and a WSUD layout. It shows how stormwater conveyance and treatments systems can become visual focus points of developments.

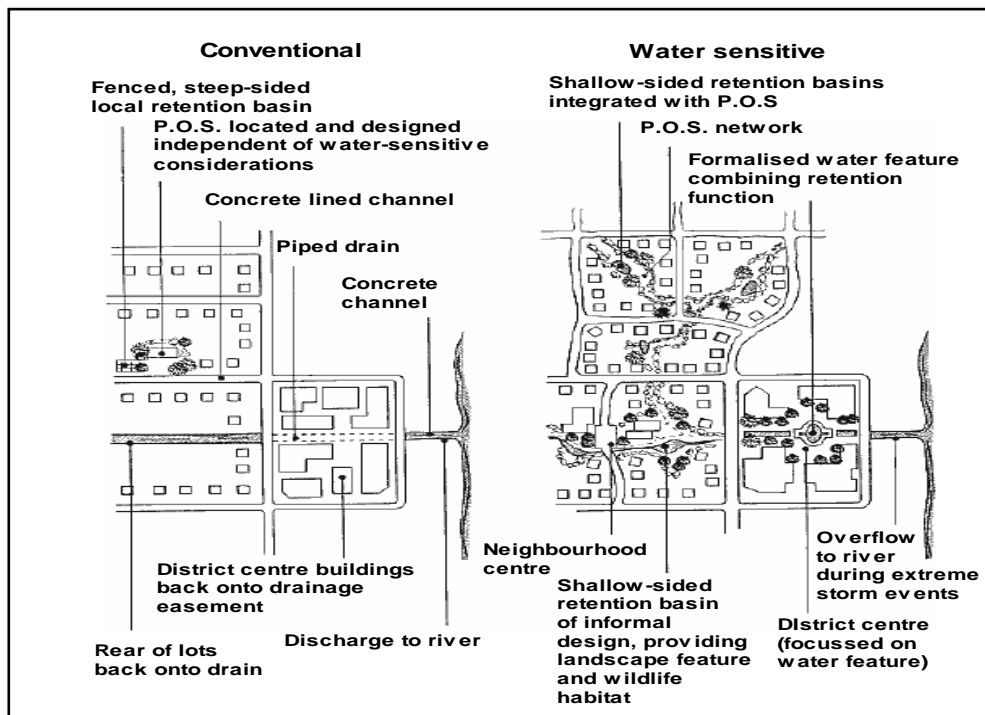


Figure 30: Conventional Urban Layout versus WSUD Urban Layout
Source: CSIRO (1999)

When public open spaces include waterways it is usually preferable to emphasise natural channel systems rather than engineered solutions. Modifications to catchments contributing to each waterway occur due to urbanisation.

This affects natural processes which occur including stream flows and sedimentary processes (sediment nature, delivery rate and transportation). Streams seek to achieve their own dynamic equilibrium, and seek further to adjust, repair and sustain themselves according to their modified environments. Therefore, over time, urban streams respond to a change in catchment conditions and hydrologic response by attempting to modify channel dimensions, and become subject to bed and bank erosion.

4.4.8. Opportunities for Retrofitting

Retrofitting is the process of installing or undertaking additional water management devices or approaches in an existing developed area. Retrofitting can include both structural techniques and non-structural techniques. The WSUD objectives and techniques for retrofitting are summarized below:

Table 28: Retrofitting.

Retrofitting	
Objectives	Common techniques
Reduce flood risk;	Maximising opportunities for capture and use of rainfall on site by techniques such as installing rainwater tanks and directing overflow to infiltration systems;
Improve public health and safety;	Changing gardening practices;
Improve water quality;	Replacing impervious paving with pervious paving;
Restore and conserve environmental condition;	Redirecting/disconnecting stormwater pipes to rain gardens;
Create more attractive and liveable neighbourhoods;	Demand reduction through installation of water efficient fixtures and fittings
Enhance the cultural values of the urban water landscape;	Removing kerbs from some sections of roads, such as where road runoff can flow into adjacent parkland;
Improve use of open space and enhance recreational opportunities;	Installing infiltration devices within roadways/road reserves;
Improve community environmental awareness;	Replacing impervious paving with pervious paving.
Increase cost effectiveness;	Rehabilitating open urban drains or removing sections of subsurface pipes and allowing surface flow through swales;
Demonstrate best management practices; and	The removal of 'gross' pollutants from the system through the relatively straight forward installation of gross pollutant traps, trash baskets in existing side entry pits and retrofitting of side entry pits to grated pits.
Utilise alternative water sources to reduce importation of water supplies	

Source: WSUD technical manual 2010.

Another area of retrofitting opportunity lies in the performance improvement of retarding basins to improve water quality, as well as retardation of discharge. Wetland treatments can be constructed within retarding basins with no reduction of their effective volume, but to provide improved water quality outflows, as well as improving the aesthetics and landscape amenity of some of these structures. In addition to the features shown in residential subdivision, multi-unit development, streetscape development and commercial and industrial sites WSUD offers opportunities for:

- Narrow driveways to maximise the pervious area;
- Integrating the design of driveways to maximise scope for retention of existing vegetation and for new plantings;
- Variation in driveway widths to facilitate integrated stormwater management and substantial plantings;
- Footpaths integrated with driveways which respond to natural features and stormwater management to create spaces that are easy to maintain and efficient to irrigate;
- Pervious paving for driveways and parking areas;
- Common trenching and closer alignment of services to improve scope for reduced disturbance and trenching to retain existing vegetation and plant new vegetation;
- Appropriate landscape practices that include the selection of species to reduce water demand;
- Water efficient fixtures and appliances;
- Community scale wastewater capture, treatment and reuse.

Opportunities exist for incorporating WSUD measures in roadways by diverting the flow from the road to a treatment system:

- Traditional road features such as medians, traffic calming bays, street trees and car parking nodes designed to be lower than the road level to collect runoff from the road;
- Kerb and channel can be replaced with swales;
- Street trees can be retrofitted into stormwater treatment bioretention planter boxes whereby stormwater is diverted into the planter box and filtered through a sandy loam prior to discharge to the stormwater systems; and
- Medians and traffic calming bays can be retrofitted as bioretention systems.

The combination of appropriate water sensitive urban designs are further developed in the case studies presented in Chapter 4, with specific reference to the implementation costs and water savings benefits. By implementing these WSUD principles in Water management and Spatial planning legislations can make a significant contribution to lowering the water demand and increase in the water supply and quality.

4.5. Integrating Water Management in Spatial Planning Approaches in terms of legislative approaches

The worldwide priority of sustainable urban development and water management will increase the needed response in terms of environmental and legislative plans. WSP is believed to be the key linkage between providing an inclusive approach to Spatial Planning and Water Management, helping to overcome the challenges of delivering more sustainable developments within a changing climate. Water cycle studies, development in partnership between Water Managers, Urban Planning and local planning authorities, is necessary to determine the timing, location and requirement of sustainable water infrastructure and integrate it within the local planning framework. Such an integrative framework should be given structure in terms of adequate policies and legislations, supported by a comprehensive institutional development plan.

4.5.1. Institutional development

Organization is defined as a social structure of people with accepted roles, managed to meet a need or to pursue collective goals on a continuing basis (SmartDraw, 2012), while institution is regarded as “stable, valued, recurring patterns of behaviour” (Franks, 1999) or “enduring regularities of human action in situations structured by rules, norms, and shared strategies, as well as the physical world” (Crawford & Ostrom, 1995). Institutional development is defined as “the creation or reinforcement of a network of organisations to effectively generate, allocate and use human, material and financial resources to attain specific objectives on a sustainable basis” (IDOS, 2011). Either way, institutional development has been advocated both in spatial planning (Healey, 1999) and water management (Franks, 1999) for involving more inclusionary approaches to integrative policy. From institutional development point of view, the integrated of water-space policy has to be rooted in the social context or social networks consecutively to gain the support and cooperation of the public. Water-spatial issues rest with general public awareness as well as good urban governance concerning political and administrative elements. As reviewed by Healey (1997) “spatial planning is a field of public policy” creating the idea that the quality of space depends significantly on local capacities for managing various clashes of urban activities. According to Healey (1997:200), spatial planning cannot function apart from the world of economic activities, social life and the natural environment and suggest that the institutional capacity building in governance should provide a “soft infrastructure” of relation-building through which sufficient consensus building and mutual learning can occur and a “hard infrastructure” of a structure of challenges to constrain and modify dominant centres of power. Through-out this research, the focus was placed on water provision, quality and management, as a precious element and sector which has a wide coverage in the urban region. Integration of surface water in Spatial Planning requires a broader societal framework, implying a need for significant changes to existing administrative systems concerning water, land, and related resources. The challenges of integrating Spatial Planning and Water Sensitive Planning are numerous, and vary between cities and countries.

Problems concerning Spatial Planning and Water Management should however also be taken into consideration in such an integrative approach. Problems concerning Spatial Planning and Water Management include, but are not limited to the following:

- Most main metropolitan areas and industrial growth centres have developed around mineral deposit and harbour sites, and are situated far from river courses. This leads to intensive water management, particularly in areas of spreading metropolitan growth. As urban regions continue to engulf villages, small cities, and whole countryside, coordination of the land dedicated to reservoirs, highways, and recreation becomes imperative.
- Water problems are concentrated in urban areas and in addition municipal and industrial water supply, recreation, and the preservation of the visual values of water in the environment will increasingly dominate water management considerations.
- Problem of coordinating water management and urban planning in the area of public policy. This implies an increase demand for greater local participation in national water management. This follows naturally from the increasing recognition of urban values and the impact of river management schemes upon urban land use (Binney et al., 2010).

The integration of Spatial Planning and water management functions is vital element in addressing these problems and ensuring the successful transition to a sustainable city. This shift in emphasis from “service development” to “water management” is a major factor in tying water development conditions ever tighter to the integrated processes of urban planning. Hoch (2000:21) recognised that “plans are more likely to be successfully implemented when they are based on shared beliefs, especially beliefs that are acquired through efforts to build consensus”, meaning that integrating water systems in spatial planning requires a paradigm shift that planners need to use consensus building strategies to improve collaboration among citizens and interest groups. Klein (200:430-438) identified 10 consensus-building principles including: “(1) involve interest as early as possible; (2) tailor the process; (3) be inclusive; (4) identify and nurture shared interest; (5) share credible information; (6) provide impartial and collaborative leadership; (7) consider using professional help; (8) maintain momentum; (9) validate results; and (10) involve the media.” There are deferent approaches towards policy development to guide such an integrative approach.

This research referred to two kinds of approaches ‘reactive’ and ‘proactive’, or ‘sectorial’ and ‘integrated’ approaches. The definitions of a reactive policy approach are given as “the developed in response to a concern, problem, or emergency. It is designed to remedy problems that already exist. Reactive policy development often happens more quickly than proactive policy, as the problems can be pressing or even urgent. Reactive policy debate centres mostly on whether or not a certain policy mechanism is the best way to handle a situation, not whether or not the situation will ever become a problem” (Robinson et al., 2012). Proactive policy is definitions as “deliberately chosen and often designed to prevent a concern, problem, or emergency from occurring” (Robinson et al., 2012).

Reactive approaches need a large amount of investment to correct the prior damage. The sectorial policy undertakes the problems within a single department, while integrated policy emphasizes the early involvement and substantive consideration among different departments, but measures taken by the integrated approaches advocate more support in the formulation of development plans and projects than sectional approaches (UN, 2010). Figure 31 shows four groups of policy and approaches by the combination of these two trends: (I) Reactive-sectional; (II) Proactive-sectional; (III) Reactive-integrated; and (IV) Proactive-integrated.

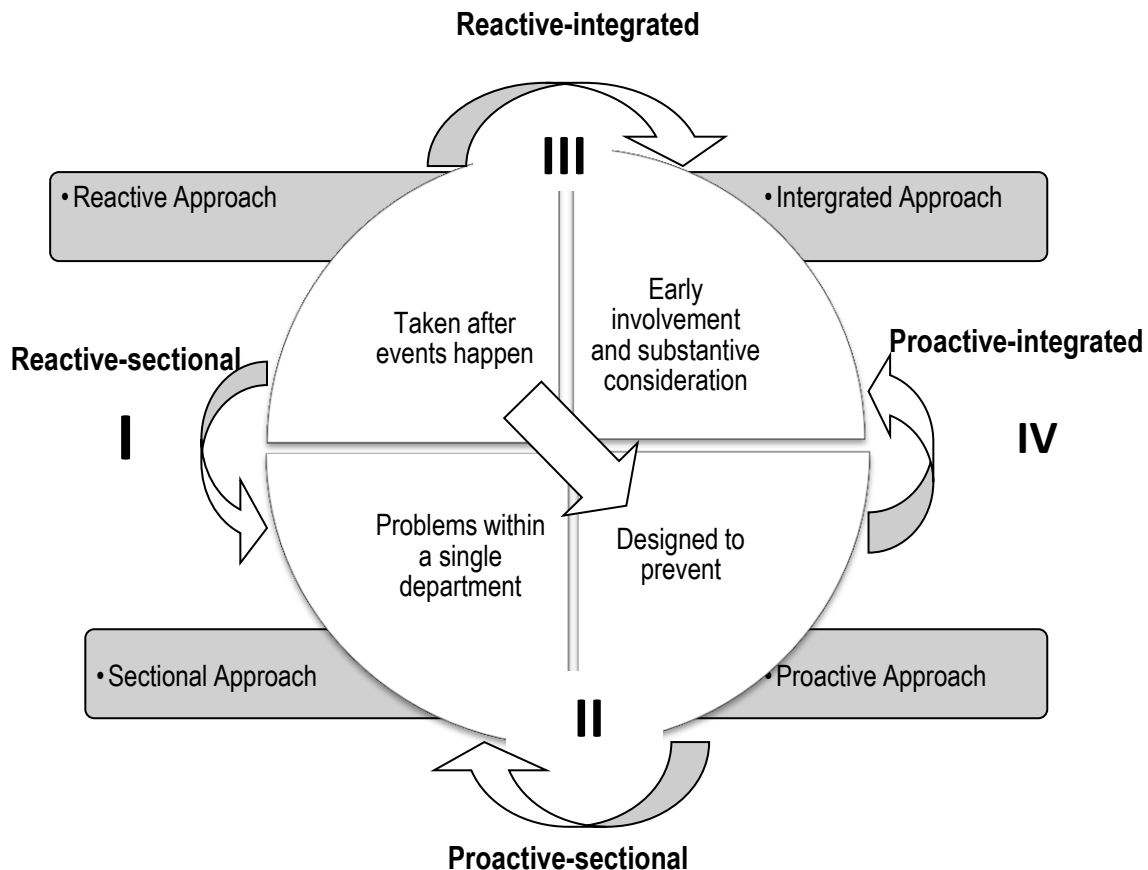


Figure 31: Conceptual model for approach options
Source: Own construction (2012)

Note that the negative effects of human activities spread far beyond their locality into larger areas. These effects normally make reactive-sectional (I) approach dominant in the field of water management and spatial planning spheres, the problem with this approach is that when problems occur, it is always too late to make up a deficiency. A proactive-integrated (IV) policy approaches need to be promoted in order to gain enough capacity to manage and preserve the space for water along with spatial requirement of urban development. Chapter 5 captures an example of such a proactive-integrated policy approach, where WSUD guidelines form part of Australian legislation, linked to Spatial Planning approaches.

4.6. Conclusions

Throughout this Chapter it has been established that there is a strong relationship between the water systems and land-use and that human activities have a direct effect on the quality of urban waters. Water and land has long been studied as separate figures, because water management and land-use planning (as part of spatial planning) were (traditionally) dominated by different expertise and disciplines. The importance to focus on the integration approach of different stakeholders in practice to ensure sustainable development with regards to land-water management in the urban region is gaining importance to enhance the multi-dimensional (and integrated) planning approaches. Embedding sustainable development at the centre of the planning system means the pursuit of good quality of space by linking economic and social development with physical or spatial management. It is essential to engage surface water system in the planning contents and integrate surface water management in the Spatial Planning process in order to create sustainable urban region and living environment. The techniques and design guidelines captured in this Chapter should be included the Spatial Planning processes, focussing on an integrative, holistic planning and design approach.

Chapter 5: International case study – Australia (Melbourne)

5.1. Introduction

Australia has suffered a history of extreme drought and unseasonal flood conditions which has forced Australia to develop new and innovative ways through which they are able to survive these climate change effects. Australia is now known to be the world leader in water management. Urban planning (and planning for water management) is undertaken at all levels of Government in Australia. However, the Federal Government is playing an increasing part in setting policy as part of an overall response to developing climate adaptation and mitigation strategies. The local government has also been engaging with the community to make decisions on urban planning designs that help to promote social cohesion. Chapter 5 will evaluate the integrated approach taken by Australia in terms of Spatial Planning and Water Management. Furthermore, specifies focus is places on cases studies based in Melbourne which has incorporated WSUD strategies in there legislations practical and development projects.

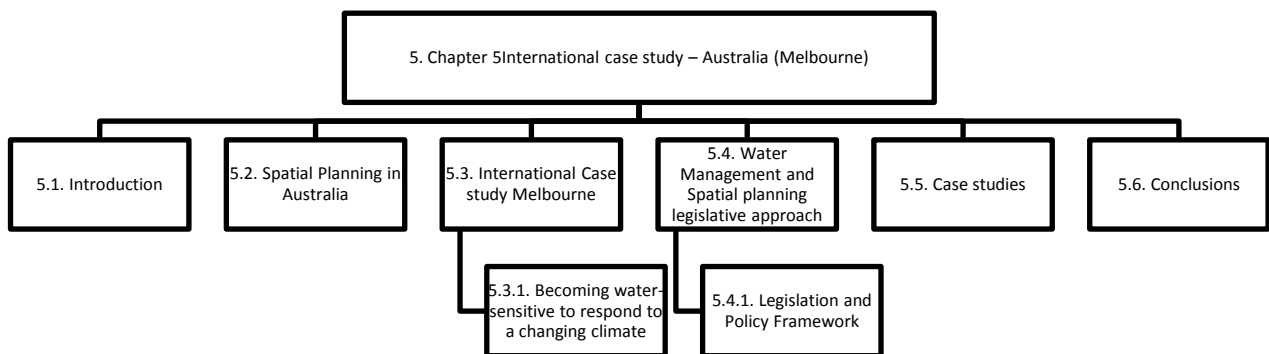


Figure 32: Structure of Chapter 5
Source: Own construction

5.2. Spatial Planning in Australia

Spatial planning in Australia made its first appearance in the early phases of the Colonial era (Troy, 1995:15). In the 19th century, Australia becoming one of the most highly urbanized nations in the world when rapid colonial expansion and economic growth took place (Steele & Gleeson, 2010:305). Early town planners focused on the orderly planning of cities, improving urban health, efficiency and the aesthetics as it was known to be the international urban reform movements (Toon & Falk 2003:4).

Australia had a long period of post war economic growth which forced the Federal and State governments to develop metropolitan plans to address the negative aspects associated with urban growth (Yiftachel 1989:29). The first Federal Department of Urban and Regional Development were established in the early 1970's as the government became directly involved in urban policy (Freestone 2007:79). Today, Spatial Planning in Australia is represented by the Planning Institute of Australia, with a significant body of legislation where urban planning activities are codified in the law, and case law guiding planning principles and decisions (Williams, 2007:9). The Federal Government plays a leading role through the regulation of development on areas that are of national environmental significance. Australia's Federal Government started with the strategic guidance and policies firstly with the Whitlam Labour Government in the early 1970s, the Building Better Cities Program of the mid 1990s and, most recently, with the release of a National Urban Policy in 2011 (Freestone 2007:87) overarching goals is to make the city more productive and sustainable. Australia's need for sustainable development is rapidly increasing due to the changing trends in rainfall patterns, extreme weather conditions, population growth and urban development (Major Cities Unit, 2012).

5.3. International Case study Melbourne

In 1803, the first settlement in the State of Victoria occurred in the coastal hamlet of Sorrento, but the community suffered from limited supplies of fresh water and the settlement was short lived (Parks Victoria, 2003). In 1835, Melbourne was established on the lower stretches of the Yarra River which provided more secure supplies of water, since this time, water has continued to shape Melbourne's community and city form (Eidelson, 2000). The city itself continues to be centred on the Yarra River. Today Melbourne is the capital of the state of Victoria in south eastern Australia and also the second most densely inhabited and fastest growing city in Australia (Australian Demographic Statistics, 2012). It is also recognised as a liveable city and in 2011 was placed second in world rankings of most liveable cities by the Economist Intelligence Unit (Economist Intelligence Unit, 2011). Melbourne is a diverse and cosmopolitan city, unfortunately Melbourne is already experiencing the changes in climate that are predicted for 2030 and 2050 in which the water sector will suffer the most in (SWITCH, 2011). This shock of this reality has forced the city to focus on new ways to build resilience to cope with further insecurities in climate change. Melbourne is doing this by challenging long held planning assumptions about the source of its water and the planning of the city itself (SWITCH, 2011).

The City of Melbourne and the C40 Cities Climate Leadership Group announced that Melbourne will lead a new global network on Sustainable Urban Development (City of Melbourne, 2012). "The C40 is a network of the world's megacities taking action to reduce greenhouse gas emissions. With a unique set of assets, the C40 works with participating cities to address climate risks and impacts locally and globally" (C40 Cities, 2011). C40 Network will enable allow Melbourne to share key ideas so that countries such as South Africa can embark on similar efforts.

This will include delivering of on-the-ground, practical solutions associated with the challenges of urban development (Doyle, 2012). This new paradigm looks to match traditional centralised water supply, sewerage and drainage systems with decentralised schemes that capture and reuse non-traditional water sources such as urban stormwater (Clearwater, 2012). This approach is being integrated into planning of new urban development's to maximise effectiveness. These approaches will be discussed in the following section in order to achieve possible outcomes that can be incorporated into South Africa.

5.3.1. Becoming water-sensitive to respond to a changing climate

Melbourne is a relatively young city that is growing rapidly, over the past century and a half Melbourne has grown from a city of a few hundred thousand people to over 3.5 million people (CSIRO, 2005). It is estimated that by 2030 Melbourne's population will increase by one million. Furthermore, Melbourne is known to have a temperate climate with cool winters and warm-hot summers, it receives only 50% of the rainfall of other Australian cities (Ewert, 2012). Annual rainfall varies from 600 millimetres to the west of Melbourne to more than 1,400 millimetres in the east of the city and varies greatly between years with temperatures that vary between 10 and 16°C across the region (Melbourne Waters, 2012). The south eastern region of Australia, which includes Melbourne, experienced an extended drought from 1997 to 2010. This drought occurred during the warmest decade on record in Australia (Bureau of Meteorology, 2010). In order to maintain sustainability, Melbourne has been lifting attentions to create a model for large-scale urban communities that will reduce greenhouse gasses in order to grow in ways that are environmentally sustainable and economically viable (City of Melbourne, 2012). A major issue that is expected to happen as a result of climate change is the reduction in rainfall, which undoubtedly has a direct impact on the city's water supply depends (Melbourne Waters, 2012). In response the city has diversified its water supply system with a large desalination plant as well as other local scale reuse schemes to make use of the water that falls within the city itself. The water sector has learnt that implementing these types of schemes relies heavily on collaboration with both the community and other sectors that are responsible for planning the city (Bambrick et al., 2011).

5.4. Water Management and Spatial planning legislative approach

Melbourne is represented in the International Water Association's Cities of the Future programme (Binney et al.; 2010) and is being used as a case study for the European Union PREPARED program which is developing advanced strategies to the meet the challenges presented by climate change. Water Sensitive Urban Design (WSUD) and the principles of sustainable water management are supported by the Commonwealth, Victorian and local Governments. This section covers the main legislation and policy tools related to WSUD principles and associated targets set by Council. It also includes a list of relevant codes, standards and guidelines from EPA Victoria and Standards Australia.

5.4.1. Legislation and Policy Framework

The following table captures all the relevant policies and legislation applicable to water planning and management in Australia, and especially Melbourne. It reveals wider policy and legislative frameworks, as well as specific policies and legislation applicable to the urban planning discipline.

Table 29: Government legislations and policy framework

Federal Government legislation and policy framework	
The National Water Initiative (NWI)	The NWI is Australia's blueprint for national water reform. The NWI expected outcomes are "better and more efficient management of water in urban environments, for example through the increased use of recycled water and stormwater".
Melbourne 2030 – planning for sustainable growth	Melbourne 2030 is a 30-year plan to manage growth and change across metropolitan Melbourne and the surrounding region.
Local Government Act 1989	The Local Government Act 1989 gives Victorian Councils the power to create local laws to assist in delivering democratic, efficient and effective local government. Particular reference to the protection of stormwater is contained within the Environment Local Law 1999 and the Activities Local Law 1999.
Planning and Environment Act 1987	The Planning and Environment Act 1987 provides a "framework for planning the use, development and protection of land in Melbourne in the present and long term.
Think Water Act Water	The Think water Act is a strategy for sustainable water resource management. It provides long-term guidance for the management of ACT water resources. Key objectives of the strategy are the introduction of WSUD. Think water, act water has been tabled in the legislative Assembly as the Water Resources Management Plan under the Water Resources Act.
National Capital Plan	The National Capital Plan provides a general policy framework for land use and planning in the Territory, and more specifically guides the planning, design and development of areas of the Territory that have been identified as having national capital importance (Designated Areas). The WSUD code addresses objectives of the National Capital Plan.
Territory Plan	The ACT's planning legislation sets out the provisions for permitting, maintaining or changing land use in the Territory and prescribes the object of the Territory Plan, which guides planning at a Territory level. The Plan sets out broad principles which will guide development and manage change over the next 10-15 years. It sets out strategies in respect to sustainable development, integrated land and water based planning, and environment and high quality design.
Spatial Development Plan	The Spatial Development Plan is the Territory's key strategic planning document for directing and managing urban growth and change. It puts in place a framework that encourages and facilitates population growth and seeks to ensure that we can sustainably provide for this community of the future. The Spatial Plan includes the objective to "create and establish a built form and city layout that minimises resource consumption, including water and energy use"
Environment Protection Act	The Environment Protection Act 1997 (the Act) provides for the protection of the environment. The Territory Plan sets the permitted uses for waters in the ACT and their catchments according to the predominant water use or environmental value. The three types of water use are conservation; water supply; and drainage and open space.

<p>Water Resources Act</p>	<p>Control of all water use in the Territory is vested with the Territory. This means that a licence to take water is required to use groundwater, water from streams, rivers and dams. However, there are some exceptions, so if a component of WSUD involves the taking of water from a pond/wetland/dam, there is a need to check the requirement for a licence.</p>
<p>Policy relevant to Urban Planners</p>	
<p>State Planning Policy Framework</p>	<p>The State Planning Policy Framework provides a context for spatial planning and decision making by planning and responsible authorities.</p> <p>The clauses related to WSUD principles include:</p> <ul style="list-style-type: none"> - Clause 11.01 – net community benefit and sustainable development - Clause 11.03 – adopt a best practice environmental management and risk management approach - Clause 12.07 – manage water resources, reduce the impact of stormwater on bays and catchments using stormwater management (Melbourne 2030) - Clause 14.01 ‘Settlement’ – “Decision making by planning and responsible authorities must be consistent with any relevant requirements of State environment protection policies as varied from time to time, including the Air Environment, Waters of Victoria and specific catchment policies...” - Clause 15.01 – decision-making to be consistent with SEPP (Waters of Victoria and specific catchment policies) - Clauses 15.01 and 18.09 – consideration of Urban Stormwater Best Practice Environmental Management Guidelines.
<p>The Municipal Strategic Statement (MSS)</p>	<p>The MSS is a statement of the key strategic planning, land use and development objectives for municipalities. The Metropolitan Strategy sets objective for water management in two policies:</p> <ul style="list-style-type: none"> - Policy 7.1- “ensures that water resources are managed in a sustainable way”. It sets out broad objectives on how to achieve this including the promotion of water efficiency practices and adopting guidelines to encourage the use of alternative water sources such as rainwater tanks and water recycling. - Policy 7.4- “reduces the impact of stormwater on bays and catchments”. Water sensitive urban design and groundwater management are promoted in this policy.
<p>Clause 54 and 55 for residential development</p>	<p>Clause 54.03-4 and 55.03-4 set permeability objectives and standards to reduce the impact of increased stormwater runoff on the drainage system and to facilitate on site stormwater filtration through the design and use of open and permeable spaces.</p>
<p>Clause 56 for residential subdivisions</p>	<p>Clause 56.07 of the State Planning Policy requires new residential subdivisions of two lots or more to meet best practice water flow and treatment requirements and incorporate integrated water management principles. The specific objectives of Clause 56.07-4 are to:</p> <ul style="list-style-type: none"> - Minimise damage to properties and inconvenience to residents from urban run-off - Ensure that the street operates adequately during major storm events and provides for public safety - Minimise increases in stormwater run-off and protect the environmental values and physical characteristics of receiving waters from degradation by urban run-off. - Meet current best practice performance objectives for stormwater quality, as outlined in the Urban Stormwater: Best Practice Environmental Management Guidelines (Victorian Stormwater Committee 1999) as amended - Ensure that flows downstream of the subdivision site are restricted to predevelopment levels unless increased flows are approved by the relevant drainage authority and there are no detrimental downstream impacts.
<p>Yarra River Action Plan</p>	<p>The Yarra River Action Plan was launched by the Victorian Government in 2006 and outlines:</p> <ul style="list-style-type: none"> - Projects that will meet the challenge of managing water quality in the Yarra River over the

	<p>long-term</p> <ul style="list-style-type: none"> - How the Government will protect and improve the health and amenity of the Yarra - How the community can get involved in the process.
Victorian River Health Strategy (VRHS)	<p>The Victorian River Health Strategy (VRHS) was released in August 2002. It outlines the Government's long-term direction for the management of Victoria's rivers. It provides:</p> <ul style="list-style-type: none"> - A clear vision for the management of rivers in Victoria - Comprehensive policy direction on issues affecting river health - A blueprint for integrating all our efforts on rivers and for ensuring that we get the most effective river health benefits for the effort and resources invested.
Drainage Plan 2004-2009	<p>The Drainage Plan sets out the management of Council's stormwater drainage assets, specifically with the development and maintenance of the infrastructure and measures to improve stormwater quality.</p>
Parks Water Management Plan	<p>A Parks Water Management Plan has recently been completed. It provide a policy and action framework for sustainable water management in parks around the themes of landscape adaptation, water efficiency, open space usage, alternative sources and offset opportunities.</p>

Source: Own construction based on Melbourne Waters (2010).

In terms of the captured legislative and policy frameworks (refer to previous table), the following goals were determined for Melbourne, as milestones to measure the success of the applicable policies and implementation thereof.

Table 30: Implementation goals

Legislation and Policy Framework goals by 2020	
Water conservation	<ul style="list-style-type: none"> - 40% reduction in water consumption per resident by 2020 - 50% reduction in water consumption per employee by 2020 - 90% reduction in total water consumption by Council by 2020
Stormwater management: non-Council land	<ul style="list-style-type: none"> - 20% reduction in total suspended solids (TSS) by 2020 - 25% reduction in total phosphorus (TP) by 2020 - 40% reduction in total nitrogen (TN) by 2020 - 30% reduction in litter by 2020
Stormwater management: Council land	<ul style="list-style-type: none"> - 20% reduction in total suspended solids (TSS) by 2020 - 15% reduction in total phosphorus (TP) by 2020 - 30% reduction in total nitrogen (TN) by 2020 - 30% reduction in litter by 2020
Alternative water source targets	<ul style="list-style-type: none"> - 30% of Council's water needs to be sourced from alternative water by 2020 - 9% of non-Council water needs to be sourced from alternative water by 2020.
Wastewater Reduction Target	<ul style="list-style-type: none"> - 30% reduction in wastewater across the municipality by 2020
Groundwater Quality Target	<ul style="list-style-type: none"> - Where groundwater needs to be re-injected to prevent land subsidence, it needs to be of equal or better quality to the water in the aquifer.
Zero Net Emissions by	<p>The City of Melbourne has recently updated its Zero Net Emissions by 2020 – A roadmap to a</p>

2020 – Update 2008	climate neutral city strategy. The strategy seeks to become carbon neutral through: <ul style="list-style-type: none"> - Sustainable building design - Greening the power supply - Offsets.
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Source: Own Construction (2012) based on Melbourne Waters (2010).

5.5. Case studies

13 specific case studies were included: Kardinia Park and Grinter Park, Eastern Park Stormwater Harvesting, Glenferrie Road Climber Pits, Tanderrum Way Streetscape Upgrade, The Boulevard Estate, Darling Street Stormwater Harvesting Project, Were Street Raingardens, Russells Creek Growth Corridor, Langtree Mall Tree Pits and Royal Park Stormwater wetland and Reuse Scheme. These case studies were included to illustrate the current reality in terms of Water Planning and Management in Australia and to be used in a best-practice comparative analysis. The specific case studies are summarised accordingly.

5.5.1. Kardinia Park and Grinter Park (Miller, 2012)

The City of Greater Geelong has embarked upon a number of stormwater harvesting projects to reduce the City's potable water use and maintain green open space and recreational assets.

Kardinia Park

Karina Park's stormwater harvesting system diverts stormwater runoff from a 30ha area of Newtown and from nearby roofs and playing fields into a new underground storage tank (refer to Figure 33). Water is drawn from this storage tank and used to irrigate the AFL ground's playing surface and other surrounding ovals. The underground storage cells have been constructed to allow bus parking on the ground surface, making effective use of high value open space.

Water is captured from:

- The streets and carparks of 30 Hectares of Geelong;
- The roofs and playing surface of Skilled Stadium;
- Pool backwash from Kardinia Aquatic Centre.

It is estimated that the storage volume will irrigate 90% of the demand; saving 13 million litres of drinking water per year.



Figure 33: Kardinia Park, construction of underground storage tanks
Source: Clearwater (2012)

Grinter Reserve

Grinter Reserve was identified as one of the City's largest users of water (refer to Figure 34). Grinter Reserve diverted 200ha of the residential suburb's stormwater from a conventional drainage system into a constructed wetland in Grinter Reserve. The primary goal was to secure a reliable alternative water source to irrigate the playing fields at Grinter Reserve, to 'drought proof' the sporting facilities and provide appropriate quality water to other assets within the Reserve.

Water is captured from:

- Stormwater from the whole suburb of Whittington and part of St. Albans Park;
- Stormwater from Splashdowns roof, car park and Grinter Reserve;
- Pool Backwash from Splashdown Aquatic Centre.

It is estimated that the storage volume will irrigate 100% of the demand; saving 20 million litres of drinking water per year.



Figure 34: Grinter wetland planning
Source: Clearwater (2012)

Project results

Kardinia Park and Grinter Park has eliminated all potable water use on the sports fields and provide additional water for irrigation thereby increasing the potential for new facilities to be established and encourage the local community to become physically active and socially connected. Grinter Reserve has been transformed into an attractive, social and educational precinct including walking paths, interpretation signage and improved habitat for local indigenous flora and fauna.

5.5.2. Eastern Park Stormwater Harvesting- City of Greater Geelong (Muller, 2012)

The Botanic Gardens is an important natural and cultural resource for the community. The overriding objective was to reduce the Botanic Gardens reliance on potable water and allow the use of 'fit for purpose' water to irrigate the gardens and support tree establishment. A gross pollutant trap, rock filled sediment pond and sand filters captures all litter down to 5mm in size prior to the water entering the storage basin.

Water is captured from:

- Stormwater from a 47 hectare suburban area in East Geelong;
- Stormwater from Splashdowns roof, car park and Grinter Reserve.

It was found that the new 7000m² storage dam holds up to 4 million litres of; providing 90% of the 30 million litres of potable water used in the Botanic Gardens each year.



Figure 35: Pathway runs around lake and temporary fence in place while planting establishes
Source: Clearwater (2012)

Project results

The project has reduced concentration and pollutant loads to Corio Bay. Additionally the water storage dam has provided additional benefits of flora and fauna biodiversity in the area, adding to the visual amenity of the area. The project led to enhanced community wellbeing and amenity through the provision of a walking path around the dam which will connect to the Eastern Park Circuit pathway and promote recreation.

5.5.3. Glenferrie Road Climber Pits (City of Boroondara, 2012)

The City of Boroondara has undertaken an innovative project to treat stormwater and improve the streetscape amenity along Glenferrie Road which is a high profile shopping strip with limited room for traditional style street trees and planting in Hawthorn: Six climber frames located over bio-retention pits ('climber pits') were custom-designed and installed on the footpath to treat urban stormwater (refer to Figure 36 and 37)

Water is captured from:

- Stormwater from by six climber frames located over bio-retention pits.

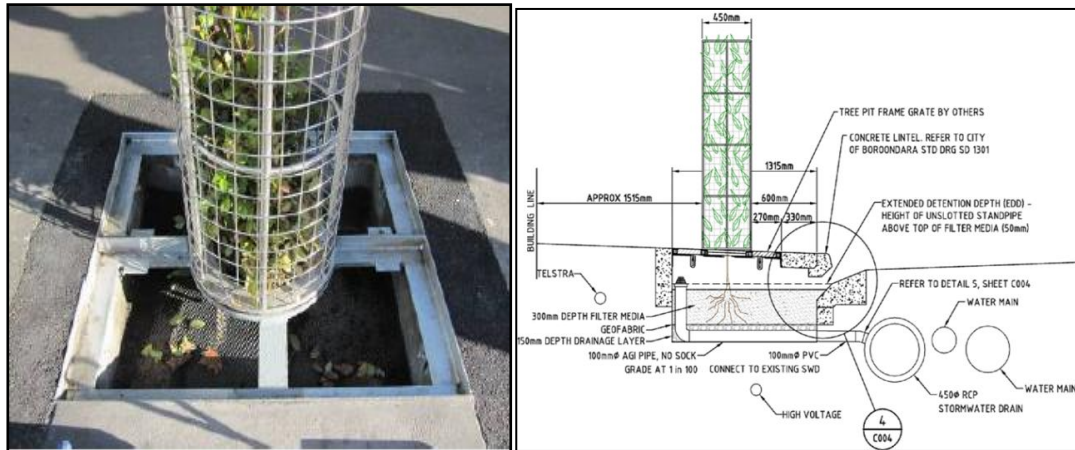


Figure 36: Base of climber pit Cross-section of climber frame and bio-retention pit
 Source: Clearwater (2012)



Figure 37: Climbing plants thriving in pit integration into the streetscape
 Source: Clearwater (2012)

Project results

Climber pits treat the road runoff before it gets discharged into the conventional drainage system it takes up less room, and that they do not have the spreading canopy of a traditional street tree. This allows climber frames to be located in more constrained streetscapes where existing underground services and overhead roof canopies can often limit street greening opportunities.

5.5.4. Tanderrum Way Streetscape Upgrade- Hume City Council (Wilson, 2012)

Tanderrum Way is located within the Broadmeadows Activities Area (refer to Figure 38). Incorporating WSUD into the development has made The Boulevard one of the most sought after new residential areas.

The inverted road profile facilitates the central collection of stormwater and allows the conveyance of larger floods. The Water Sensitive Urban Design (WSUD) features of this project include an inverted road profile which collects and drains stormwater to the centre of the road rather than to the standard side kerb and channel.

Water is captured from:

- A linear bio-retention swale;
- A conveyance system with 200m² permeable pavers;
- There are additional over 250m² of rain gardens in 25 locations.

This approach deliver a high level of public amenity, it is an example of best practice sustainability and stormwater management.



Figure 38: Tanderrum Way Streetscape Upgrade
Source: Wilson (2012)

Project results

This project generated a strong sense of place and community pride through an innovative public place design through best practice stormwater management to both improve stormwater runoff quality and reduce peak flows. The upgrade of Tanderrum Way produced a public space that generates a strong sense of place and civic pride. Innovative design elements allow the street to prioritise pedestrian traffic over vehicular movements without compromising the safety of either. The inverted road profile not only allows the collection of stormwater in the centre of the road, but also facilitates the conveyance of larger floods.

5.5.5. The Boulevard Estate (Clearwater, 2012)

The Boulevard Estate is a new residential community in Shepparton. Water Sensitive Urban Design (WSUD) has been incorporated in the design for the streets and the open spaces in accordance with established best practice.

This development provides Shepparton with a standout new residential community with significant landscape amenity to the streets and open spaces.

Water is captured from:

- Swale integrated into the main entry road;
- Non-traditional drainage infrastructure such as flush kerbs, gravel drainage layers over slotted subsurface pipes and elevated grated pits;
- A wetland running through the linear park treats the stormwater runoff from the Estate.

This approach ensured low flow rain events are retained locally to reduce downstream effects; and that the wetland operates at different stages of the development.



Figure 39: Curb sits flush with road Wetland design
Source: Clearwater (2012)

Project results

Incorporating WSUD into the development has made The Boulevard one of the most sought after new residential estates, providing the community with new recreational and open space amenity. The entire development site (approximately 280 lots when complete) has been designed to alter the floodway characteristics allowing the development site to be above the floodway and the flood path in a defined, excavated depression.

5.5.6. Darling Street Stormwater Harvesting Project (Pfleidere, 2012)

The Darling Street Stormwater Harvesting project in East Melbourne is an innovative stormwater harvesting project that provides treated stormwater to irrigate neighbouring parks and tree medians, including Darling Square (Figure 40), Powlett Reserve and medians in Grey, Simpson, Powlett and Albert streets.

The project took advantage of a local streetscape upgrade to trial a new stormwater harvesting technology that requires infrastructure to be installed below ground.

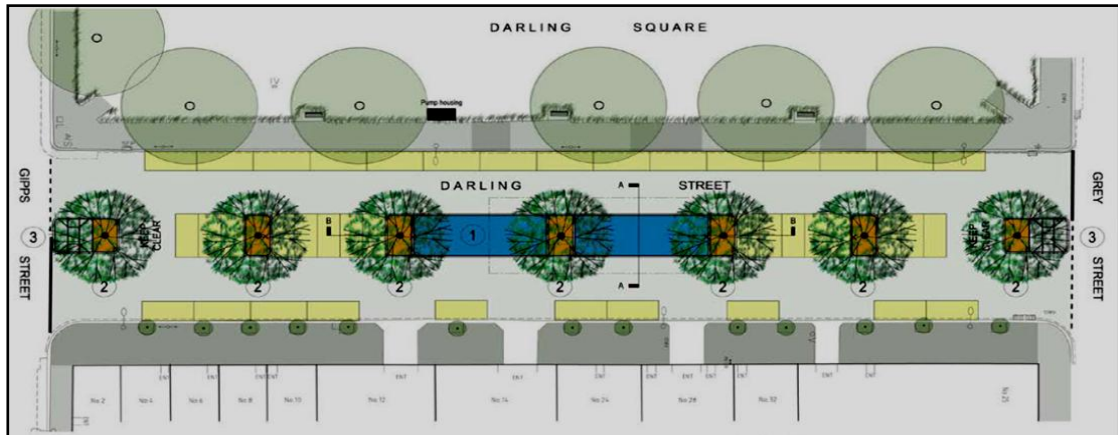


Figure 40: Conceptual layout plan of Darling Street
 Source: Pflidere (2012)

Water is captured from:

- The project harvests stormwater from two nearby existing drains ;
- Water then runs through Gross Pollutant Trap (GPT) and a sedimentation chamber before being stored in underground tanks;
- Pumps then convey the stormwater to the above-ground bio filtration systems for treatment.

This project has lowered the portable water demand; it has improved stormwater quality; and provided a range of social, environmental and economic benefits.



Figure 41: Biofilter median strip on Darling Street underground storage tank during construction
 Source: Pflidere (2012)

Project results

This project achieved environmental benefits through the reduction of runoff volumes entering downstream water bodies delivering an enhanced public realm for the community. It has met the best practice for stormwater pollutant reduction and also reduces stormwater runoff volumes into the local waterways. The project provides increased landscape amenity and mitigation of the urban heat island effect.

5.5.7. Were Street Raingardens (Milkins, 2012)

In 2009, Banyule City Council commenced a streetscape upgrade near the entrance to the Montmorency train station, a previously large asphalt expanse. The upgrade provided an opportunity to improve the public amenity of the area through the delivery of one of Banyule's first Water Sensitive Urban Design (WSUD) assets. The project is located directly in line with the main pedestrian entry for the Montmorency train station, a boardwalk was installed over the raingarden to facilitate pedestrian movement (refer to Figure 42).

Water is captured from:

- Separate rain-garden systems, totalling a treatment area of 120m²;
- The different levels add to the aesthetics of the system but also improve the water quality treatment level;
- Inflows into the rain-gardens include catchment-wide runoff and direct street runoff;

This approach was found to facilitate movement and access in this high activity area used by pedestrians; commuters and vehicles. It introduced a reduction in peak flows; decrease in pollutant loads entering the Plenty River; and enhanced the sense of place.



Figure 42: Raingardens in Were street
Source: Milkins (2012)

Project Results

This project provides stormwater treatment that meets best practice guidelines as directed in the Council's Environmental Sustainability Policy. It also provides an enhanced setting and engaging space for the community in a location that is Montmorency's key focus for retail and transport activities.

5.5.8. Russells Creek Growth Corridor

Wannon Water's Roof Water Harvesting project collects roof runoff from houses within an estate. The size of the demonstration area changed through the life of the project from an initial 142 lot subdivision with retirement village to three subdivisions involving 273 lots. These lots are located in a growth corridor that will eventually grow to over 3000 lots and as such there is potential for the roof water harvesting scheme to be extended as development in the growth corridor continues.

Water is captured from:

- Roof runoff is diverted away from the surface stormwater system via a separate collector pipe;
- Roof water then flows into a 2250 m trunk water mains and approximately 4400 m of smaller diameter collection mains within the new development area.

Project results

This approach produce drinking water; and rain-garden systems; whilst elimination greenhouse gas. The risk of contamination is minimised. This project provides the whole community of Russells Creek with water.

5.5.9. Langtree Mall Tree Pits- Mildura Rural City Council (Clearwater, 2012)

The redesign of the Langtree Mall commenced in 2008 with the implementation of the Central Business District Plan. The project involved upgrading the main pedestrian mall providing an opportunity to incorporate WSUD. Broad community engagement through the CBD planning process and the Mall Concept Design showed a desire for a new and improved pavement surface with existing streetscape clutter removed. Community consultation early in the design process resulted in the mall not only achieving its sustainability objectives but created a multi-use space that is safe and flexible for community events including the Country Music Festival.

Water is captured from:

- The 26 tree pits and approximately 12.6m²per tree of permeable paving installed;
- The tree pits allow for treatment of stormwater and passive irrigation to the root zones when it rains (refer to Figure 43 and 44)

This case study illustrated the provision of shade, low maintenance, addresses stormwater quality issues and efficient uses water. It furthermore provided a range of social and environmental benefits.

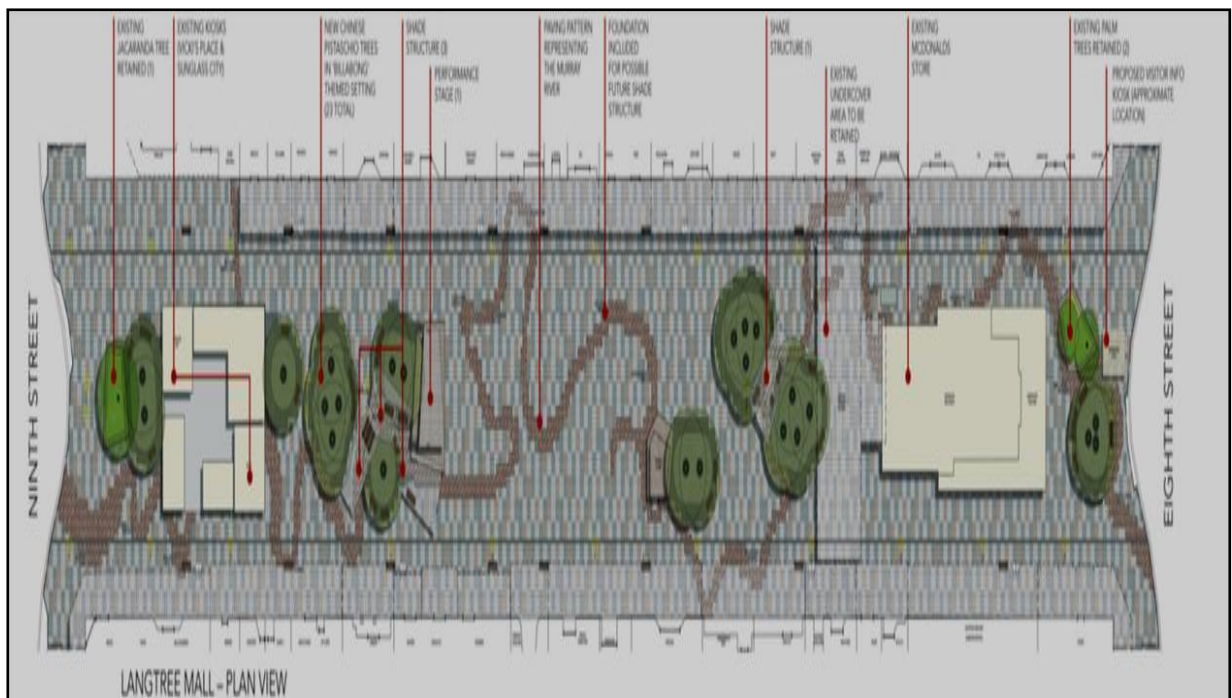


Figure 43: Conceptual layout plan of Langtree Mall tree pits.
Source: Clearwater (2012)



Figure 44: Langtree Mall tree pits.
Source: Clearwater (2012)

Project results

The installation of a significant number of advanced trees as well as an architecturally designed ‘outdoor room’ shade structure has contributed to the overall aesthetics and functionality of the mall. The inclusion of permeable paving into the design ensures that surface flows in a rain event are captured, allowing for passive irrigation of the trees through the root zone.

5.5.10. Royal Park Stormwater wetland and Reuse Scheme (Pfleidere, 2009)

Hidden at the “back” of Royal Park, yet only 4 km from Melbourne’s CBD, the Royal Park wetland system is a project that demonstrates the “City as a catchment” model in action. The project utilised the opportunities of under-utilised land, slope, large catchment a suitable demand and politics, to create a landmark stormwater treatment and reuse system. The Royal Park wetlands provide locals with a quiet place to enjoy the pleasures of nature while also giving the City of Melbourne a valuable resource in this uncertain changing climate.

Water is filtered through:

- Bio-retention swales;
- Raingardens.

This case study illustrated the provision of shade, low maintenance, addresses stormwater quality issues and efficient uses water. It furthermore provided a range of social and environmental benefits.



Figure 45: Boroondara City Belmont Park
Source: Pfleidere (2009)

Project results

This project has improved the quality of stormwater that enters the Yarra River from this site.

5.5.11. Comparative analysis

Table 31 summarizes the case studies presented in this Chapter and the WSUD strategies, along with the contribution to the best-practice strategies.

Table 31: Summary of case studies

Summary of case studies		
Case studies	WSUD Strategies	Best-practice results
Kardinia Park and Grinter Park	<ul style="list-style-type: none"> - Stormwater harvesting; - Roof water harvesting; - Underground storage detention; - Constructed wetlands. 	<ul style="list-style-type: none"> - Reduced the portable water demand. - Re-use water for irrigation purposes - Successful delivery of a high quality, attractive and viable neighbouring centres, with a sense of local identity
Eastern Park Stormwater Harvesting	<ul style="list-style-type: none"> - Gross pollutant traps; - Rock filled sediment ponds; - Sand filters; - Storage basins. 	<ul style="list-style-type: none"> - Ecologically sustainable development with hydrological balance. - Reduction of contamination. - Additional benefits to fauna and flora biodiversity. - Enhanced community well-being and amenity of open spaces.
Glenferrie Road Climber Pits	<ul style="list-style-type: none"> - Urban stormwater harvesting; - Bio-retention pits; - Urban design principles. 	<ul style="list-style-type: none"> - Successful integration of environmental sustainability into the major streetscape to a high level of public domain. - Reduction in peak flow runoff. - Successful contribution to the long term viability of the urban street trees.
Tanderrum Way Streetscape Upgrade	<ul style="list-style-type: none"> - Linear bio-retention swales. - Infiltration systems; - Stormwater treatment; 	<ul style="list-style-type: none"> - Integration with public art, landscaping and scenic amenity. Reduced stormwater runoff and improved quality. Generates a sense of place and civic pride. Pedestrian safety and improved traffic flow.
The Boulevard Estate	<ul style="list-style-type: none"> - Constructed Wetlands; - Swale; - Bufferstrips; - Wastewater management. 	<ul style="list-style-type: none"> - Provides the community with new recreational and open spaces. Designed to alter the floodway to so that development sites are above floodway. Successful model more integrated urban water management.
Darling Street	<ul style="list-style-type: none"> - Stormwater 	<ul style="list-style-type: none"> - Local streetscape upgrade integrated with new stormwater approaches.

Stormwater Harvesting Project	<ul style="list-style-type: none"> - harvesting; - Gross pollutant traps; - Bio-filters; 	<ul style="list-style-type: none"> - Proved to have a range of social, environmental and economic benefits. - Lowered the portable water demand. - Increased landscape amenity and mitigation of the urban heat island effects. Sustainable interception of stormwater pollutants with infiltration and absorption systems.
Were Street Raingardens	<ul style="list-style-type: none"> - Separate rain garden systems; - Infiltration systems; - Stormwater treatment. 	<ul style="list-style-type: none"> - Sustainable intercept of stormwater pollutants with non-conventional infiltration system. - Facilitates movement and access in high activity areas uses by pedestrians. Enhance visual amenity of the site - Integration between WSUD and systems and the road upgrade requirements. - Improved the stormwater quality before discharging it into the Plenty River.
Russells Creek Growth Corridor	<ul style="list-style-type: none"> - Roof runoff; 	<ul style="list-style-type: none"> - Reduced the portable water demand. - Re-use water for irrigation purposes - Successful delivery of water to a complete neighbourhood.
Langtree Mall Tree Pits	<ul style="list-style-type: none"> - Bio-retaining street pits; - Permeable paving. 	<ul style="list-style-type: none"> - Contributes to the overall aesthetics and functionality of the mall. - Insurance of rainwater harvesting for water reuse. Create a clear sense of place.
Royal Park Stormwater wetland and Reuse Scheme	<ul style="list-style-type: none"> - Bio-retention swales; - Raingardens. 	<ul style="list-style-type: none"> - Provides the local community a quiet place to enjoy and also offers a range of social, environmental and economic benefits. - Low maintained way to address stormwater maintenance. - Sustainable interception of stormwater pollutants with the infiltration and absorption systems. Improved the quality of water before it enters the Yarra River.

Source: Own construction (2012)

Through these case studies it is made clear that Melbourne has adapted to the climate change challenges by taking action in terms of water efficient education and demand management programmes; centralizing reservoir network with a desalination plant and by creating new recycled water and stormwater reuse schemes to support reduction in water demands (Melbourne Water, 2012). As a result, water consumption has fallen and supply capacity has both risen and diversified.

Table 32: Melbourne's reduction in water demand

Melbourne's reduction in water demand		
	Historical	Current
Total Annual Demand	433 GL	356 GL
Rainfall dependant, centralised potable sources	1,812 GL	1,812 GL
Rainfall independent, centralised potable sources	-	150 GL
Decentralised, non-potable sources	-	73 GL
Total System Capacity	1,812 GL	2,035 GL

Source: Melbourne Waters (2012).

Other environmental benefits that accoutred as a result of excellent water management include:

- Waste discharge from the sewers and drainage has been reduced.
- There has been a reduction in the load of nitrogen discharged to Melbourne's marine environment.
- More than 25% of the city's sewerage is being treated and recycled.
- The Yarra River 17 billion litre of extra water that is used to sustain the ecosystem.
- Melbourne has 270 community groups protection there water and the environment.
- In the last five years the condition of the rivers has risen from 13 to 46% in terms of water quality (Melbourne Water, 2012).

Melbourne is in this case the best possible city that could have been chosen for the evaluation of case studies as it shows remarkable results in terms being more resilient in reducing its water usage, increasing its water resources, improved the condition of the natural environment the connected engagement with the its community.

5.6. Conclusions

It is evident that the city shape and form can and will alter the water needs of the city either in a positive or negative way. Throughout this Chapter emphasis was placed on the leading role of Spatial Planning in context of sustainable water management. Melbourne has grown into a resilient city though there actions of integrating water and urban planning by introducing non-structural and structural options for achieving their water objectives (refer to case studies captured). Melbourne's Federal Government legislation and policy framework in terms of Water Management and Spatial Planning are highly advanced and could be considered as a leading example for developed and developing countries around the world. Chapter 6 will evaluate the local case study, Potchefstroom, in terms of its Spatial Planning and Water Management approaches, comparing these international approaches and identifying possibilities to implement such approaches into the local context.

Chapter 6: Local case study: South Africa (Potchefstroom)

6.1. Introduction

The setting of the case study in Potchefstroom will be discussed in this chapter, including some general characteristics of the area and the specifics of local planning system and water management approaches. Surveys were conducted (via means of interviews) with local authorities including urban planners, water managers at municipal and national departments as well as private consultants currently practicing in Potchefstroom and Pretoria area. The questioners (Appendix A) used for the interviews aimed to determine the deferent views towards sustainable urban water planning from these various stakeholders. Figure 46 captures the conceptual framework of Chapter 6.

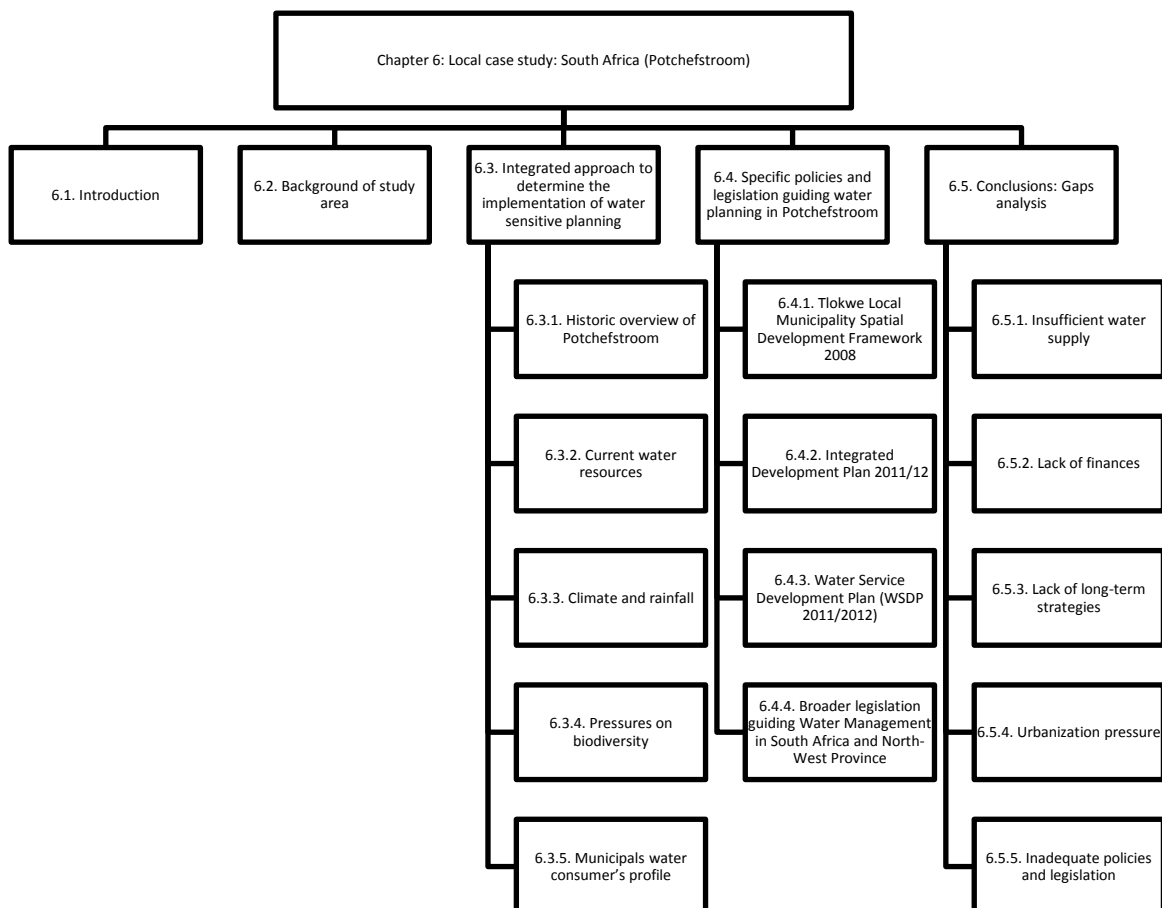


Figure 46: Structure of Chapter 6.
Source: Own Construction (2012)

6.2. Background of study area

For purposes of this research, Potchefstroom was selected as the local case study, located within the Tlokwe Local Municipality (TLM). Potchefstroom is the main urban area of the Tlokwe Local Municipality (TLM), and one of the fastest growing and investment areas within the North West Province and one of the leading local municipalities in South Africa, when measured in terms of a sustainability-focus (NW DACERD, 2009:12). Potchefstroom was also chosen based on its green-city development approach. Since 1842, Potchefstroom's main source of water supply is gathered from the Mooi River Catchment (Van der Walt et al., 2009).

Potchefstroom is situated downstream of the current environmental crises on the West Rand and Fare West Rand (Live Times, 2011). Unfortunately surface water bodies are widely distributed across these plains and includes challenge of dealing with aspects such as acid mine drainage (AMD), closure of mines, and naturally re-watered gold mines which have a negative effect on the Wonderfontein Spruit (upstream tributary of the Mooi Rivier), as well as the underground located groundwater aquifers and springs in the dolomite landscape (Annandale & Nealer, 2011). Furthermore, recent changes in land use and the increase in the demand of water users in Potchefstroom have left the Mooi River catchment with major water management challenges. Figure 47 illustrates the location of the study area.

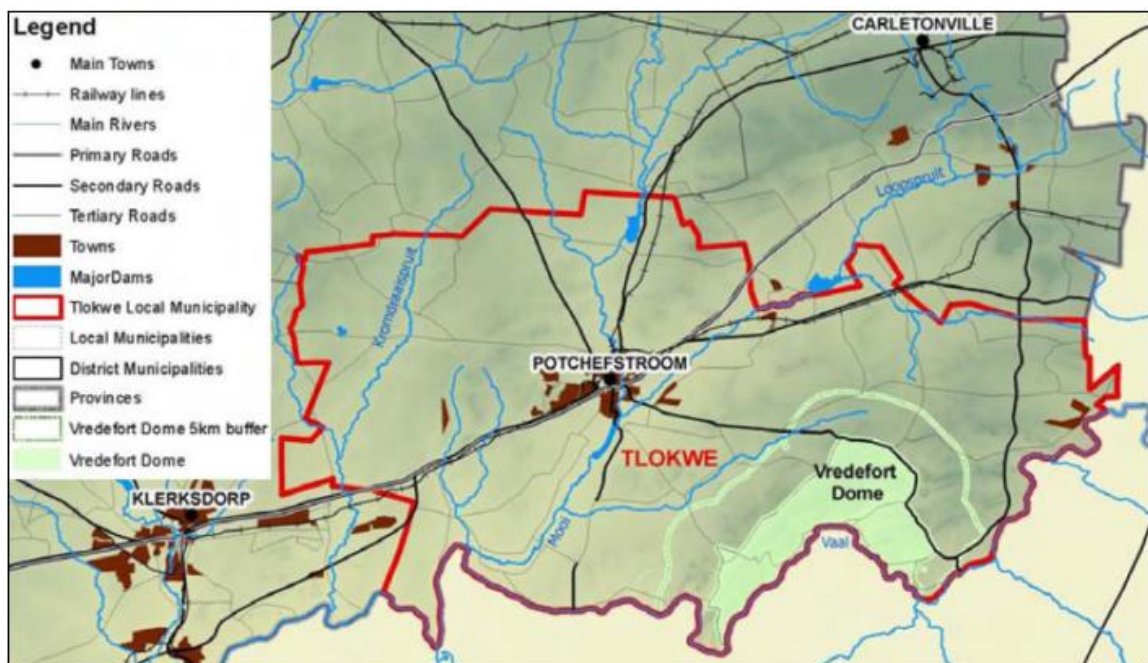


Figure 47: Location of the study area.
Source: NW DACERD (2009:11).

The TLM covers an area of 2673 km² which includes the following areas: Potchefstroom, Ikageng, Mohadin and Promosa; as well as rural villages and commercial farming areas (NW DACERD 2009:12). Table 33 displays the main land use categories in the Tlokwe Municipality (Tlokwe Local Municipality, 2008).

Table 33: Land-cover categories in Tlokwe City Municipality

Land cover categories in Tlokwe City Municipality	
Land Use Category	% Coverage
Cultivated temporary/ commercial dry land	20,3%
Cultivated temporary/ commercial irrigated	0.64%
Forest and woodland	5.19%
Forest plantations	0.45%
Improved grassland	0.04%
Mines & quarries	0.15%
Thicket & bush land	3.28%
Unimproved grass land	66.15%
Urban/ built up land	3.52%
Water bodies	0.24%
Wetlands	0.05%
TOTAL	100%

Source: Tlokwe Local Municipality (2008:15).

Figure 48 illustrates that the greater Tlokwe municipal area is predominantly characterised by 66% unimproved grass lands.

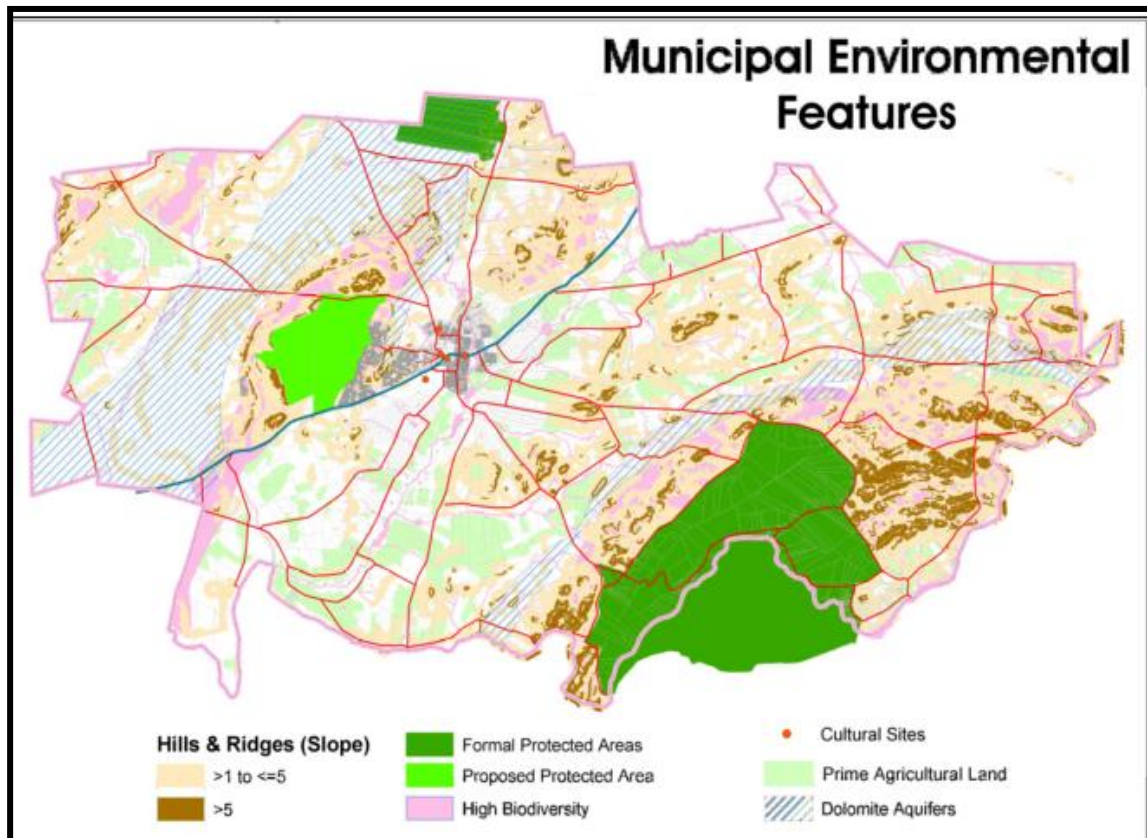


Figure 48: Municipal environmental features
Source: Tlokwe Local Municipality (2008)

Various researchers have proved that there is a very important economic and social value of environmental water (CSIRO, 2012). The Tlokwe (TLM) has been awarded with the Blue Drop Status since 2010 (Tlokwe City Council, 2012). However, With expanding pressures for urban development, the local government and local communities will have to realise that ordinary water management systems needs to evolve in order to balance the ever growing demand of water supply in urban areas. The objective of the Rio declaration, appropriate to the North West provincial is to “make certain that adequate supplies of water of good quality is maintained for the entire population...demand integrated water resources planning and management” (Howard et al., 2010).

The integration of water resource planning must consider all types of inter-related freshwater bodies. Potchefstroom is committed to becoming a “green city”, in 2002 it was selected as one of the model cities at the World Summit on Sustainable Development held in Johannesburg in 2002 (Tlokwe Local Municipality, 2009a:48). Potchefstroom has great development potential in terms of sustainability, and therefore chosen as case study. The study intends to develop new and innovative ways in which Potchefstroom can create water catchment within the urban environment and at the same time be less dependent on the Mooi river catchment. In order to understand the Potchefstroom structures and development problems a comprehensive description of historical and recent developments processes is given below.

6.3. Integrated approach to determine the implementation of water sensitive planning

In order to determine whether it is possible to implement an integrated approach between Spatial Planning and Water Management in a local South African context, it is necessary to investigate certain aspects that contribute to the characteristics of Potchefstroom urban environment. This includes a brief Historic overview of Potchefstroom.

6.3.1. Historic overview of Potchefstroom

The Mooi River played an important ecological and historic role in the development of the town (NW DACERD 2009:8). The North West Spatial Structure is the product of a region that was initially occupied by various African people, later on inhabitants were resettled due to white people that started to move into the area (NW SDF, 2005:6). According to Jenkins (1939), the Mooi River was said to be founded by Andries Hendrik Potgieter during 1835 in the surrounding areas of Potchefstroom, and in 1838 the first little town in the area (called Mooiriviersdorp) was established on the western bank of the Mooi River on several farms in the neighbourhood of Oude Dorp. The area was located on a triangular flat wetland (vlei) with “shallow soil on top of lime- and ouklop rock formations and with black elephant rock (dolomite) scattered on the sides” (Potgieter, 2010). During 1840, it became impassable to initiate further settling in Oude Dorp due to heavy rainfall and a wet-land type (geologically underlain by dolomite) physical terrain (Bardenhorst, 1938:11). The Oude Dorp area became heavily flooded, and in 1841 it was decided to move the town approximately 10km downstream in an attempt to get off the muddy soil and underlying dolomite bedrock (Annandale, 2011). This new and current location was established in 1841 and named Potchefstroom (Jenkins, 1971:104).

Property stands was measured out prior to the resettlement of the inhabitants and alongside the streets there were dug furrows built to transport water from the Mooi River to each and every house of the town, this approach was classified as being much more user-friendly (Bardenhorst, 1938:102). In 1866, a newspaper article was published in the De Argus with concerns being lifted about the urban conditions “...in a shameful state we cannot deny, witness our water furrows and streets, which make it dangerous to anyone to be out after sunset and this leads us to the subject we have in view...” (Bardenhorst, 1938:102). In 1908 the construction of the Potchefstroom Dam (earlier known as Lakeside Dam) took place to meet the town residents’ water needs and to act as recreation resort (Herald, 2012). In 1924 the Town Council decided to build the first water purifying system (3.4 Mℓ/day) and by 1926 the town had its first piped water (Kleinhans, 1985:7), this potable water purification system has continuously been upgraded to currently produce 33.6 Mℓ/day (Annandale, 2011). By 1959, a bigger dam (Boskop Dam) with cemented water-transporting canals was built. It was necessary to construct cemented canals to prevent the water to surface into the soil and underlying dolomite rock (Herald, 1958). Furthermore, in order to manage the surface water in the Mooi River valley more effectively, the upstream located Klerkskraal Dam and its western and eastern banks’ cement canals were completed in 1971 (DEAT, 1983).

6.3.2. Current water resources

The province falls within four Water Management Agencies (WMA) namely Lower Vaal, Middle Vaal, Upper Vaal and the Crocodile Marico (PWSP, 2011). The three biggest surface water dams in the Tlokwe region in which the water is collected and stored includes the (DWAf, 1999):

- Klerkskraal Dam (full capacity of 8 million m³),
- Boskop Dam (21 million m³) and
- Potchefstroom Dam (2 million m³)

Tlokwe forms part of the Upper Vaal WMA as indicated in Figure 49.

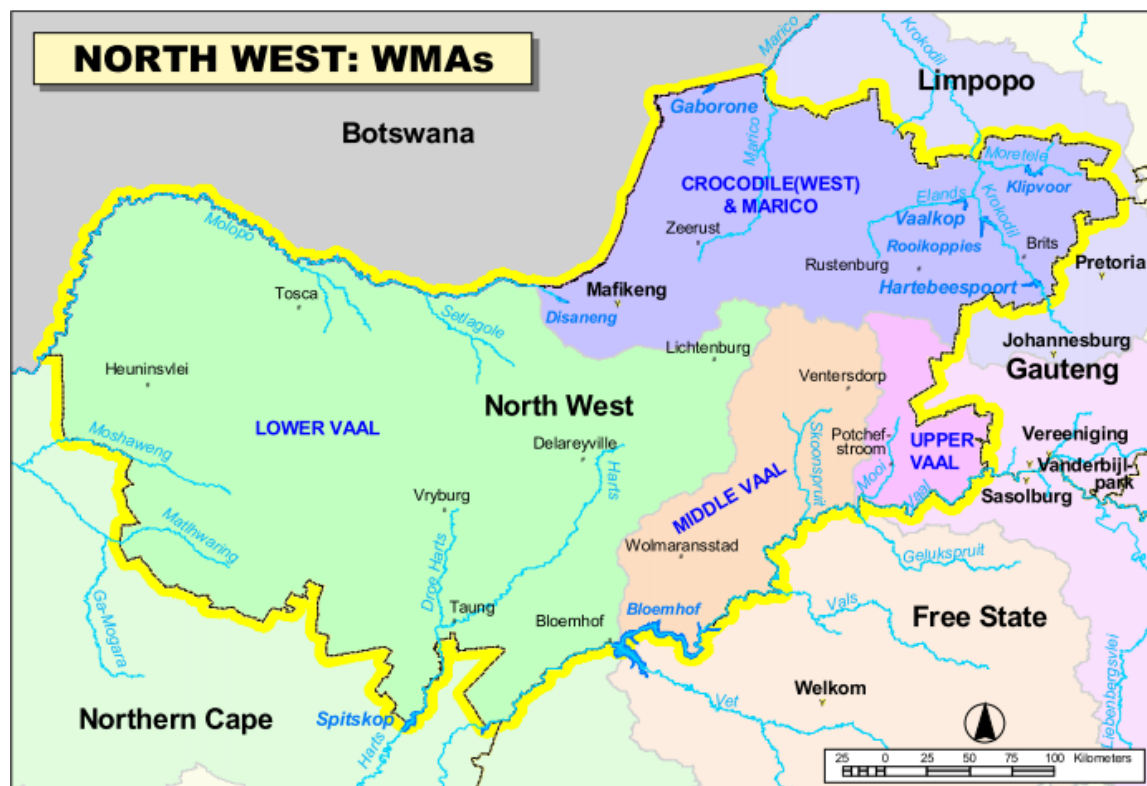


Figure 49: North West WMA's
Source: WSDP (2011/12:8)

DWAf remains responsible for catchment management whilst Catchment Management Agencies and Local Level Water User Associations are also being established (WSDP, 2011/2:12). Other major bulk portable water providers in the North West Province include Rand Water, Botshelo Water, Sedibeng Water, Magalies Water and Midvaal Water (PWSP, 2011/12:13). In addition the surface water allocated from the Mooi River that acts as the main water supply for Potchefstroom, the study will also address the 0.24% waterbodies and 0.05% wetlands. However, the study is mainly based on the urban water cycle and the impacts of urban development on water resources thus, will the environmental features not be discussed in detail.

All wetland areas are classified as high biodiversity areas that should be legally protected. The Mooi River surface water catchment consisting of the Mooi River from the north and the Wonderfontein Spruit from the northeast as well as groundwater from springs in the dolomite landscape, these catchments it has been the main source of drinking water for Potchefstroom's (DWAF, 2002). The Northern fringe of the Vredefort Dome and the central and western proportion of the municipal area, is underlined by dolomite aquifers that requires active management to ensure long-term sustainability of both quality and quantity (NW DACERD 2009:55). After a safety inspection on the Boskop Dam was completed, the report stated that the "dam is founded on a fairly complex geology consistent of a quartzite ridge, shale, lava, dolomite limestone, a number of faults and a diabase dyke" (DWAF, 1999). The same report also states that approximately 75% of the catchment area consists of dolomite and due to the high permeability of the area it can have a major effect on the size of a flood that may accrue in these areas. Areas where water levels fluctuate is particularly vulnerable to develop sinkholes. (NW DACERD 2009:55). Karst refers to landscapes that have evolved into cavities, sinkholes, subsurface aquatic environments and caves (Durant & Peinke, 2008). Karst play a critical role in the channelling and general subsurface movement of water, Tlokwe area houses part of a large karst system that extends as far as Limpopo and Mpumalanga provinces (NW DACERD; 2009:55). Groundwater management is required to ensure a reliable and sustainable groundwater resource to infrastructure development. The groundwater in the TLM area is limited therefore; proper site selection for infrastructure development from a groundwater perspective is needed. The risk of over exploitation of aquifers is insignificantly low due to the extensive surface area of the TLM area and the amount of recharge available from each of the quaternary catchments (NW DACERD; 2009:58).

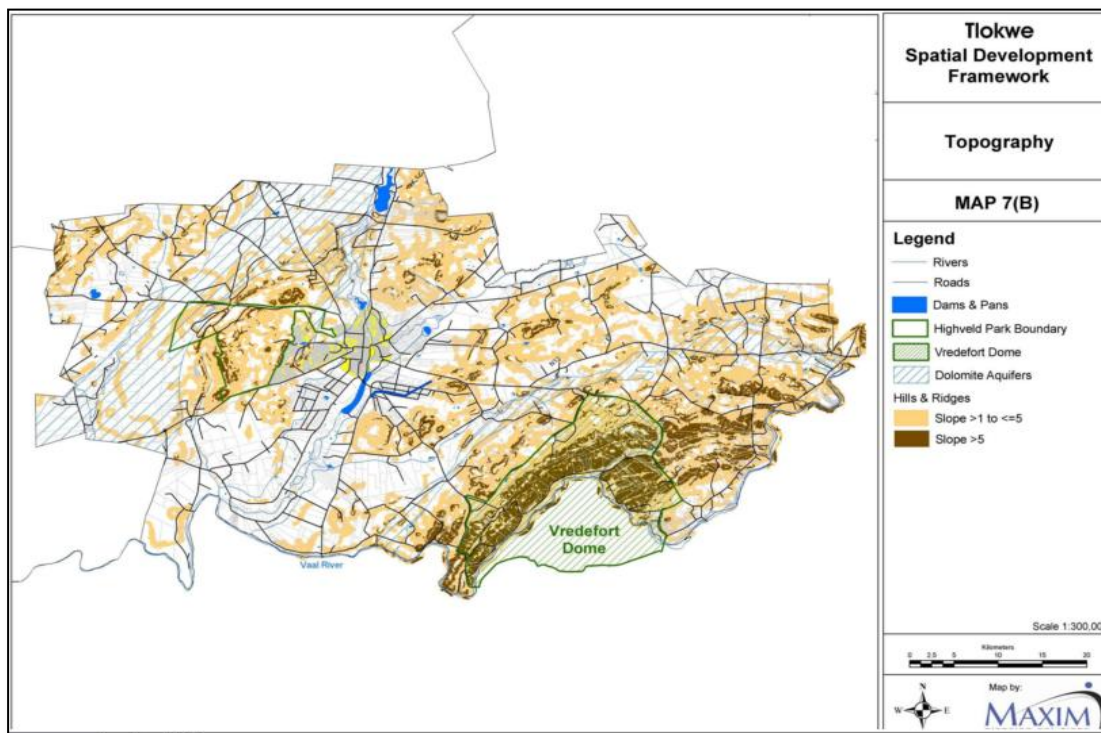


Figure 50: Topography of TLM.
Source: Tlokwe Local Municipality (2008:19).

6.3.3. Climate and rainfall

According to the Weather Bureau of South Africa the western region of the North West Province receives less than 300mm per annum, while the central region receives around 550mm p.a., and the eastern and south-eastern region (Potchefstroom) receives over 600mm per annum (Union of South Africa, 1958). Lynch et al. (2001) reported high annual rainfall variability at Potchefstroom (North West province, South Africa) with a coefficient of variation of 26% for rainfall recorded over 74 years. The Province is also characterized as being very hot in summer (daily average high temperatures of 32°C in January) and mild too cold in winter (average daily minimum in July is 0.9°C) (Villiers & Mangola, 2010). The actual extreme daily maximum for this region was recorded during January in Potchefstroom, and reached 39, 2°C.

Table 34: Temperature, precipitation and humidity levels for select weather stations in the North West Province

Temperature, precipitation and humidity levels							
Stations:	Mean Temperatures (°c)		Precipitation (Mm)			Mean Relative Humidity (%)	
	Jan.	Jul.	Mean	High	Low	Jan.	June.
Potchefstroom	29,1	0,3	625	980	365	71	36

Source: South African Weather Bureau (2012)

6.3.4. Pressures on biodiversity

Poverty, equity, redistribution of wealth and wealth creation are the main drivers of South Africa's goal to improve human well-being, this is also achieved generally at the expense of urban nature conservation. The pressures of urban employment can be directly related to the increase of squatting and informal settlements along the urban fringe, which contributes to habitat fragmentation and sprawling of cities (NW DACERD; 2009:33). Some of the specific urban development factors that are directly related to the state of water resources in Potchefstroom include the following (PWSP, 2011/12):

1. Unregulated settlement patterns causes:
 - Increasing pressures on basic services in rural areas.
 - Major issue of water quality due to high urban densities
 - Urban sprawl especially on high priority agricultural and biodiversity land;
2. Agriculture:
 - Various small dams and rivers in the area are being polluted
 - Groundwater is under-utilized but also limited
 - Improper use of biodiversity offsets in development planning;

- Un-registered waste dumps.
3. Infrastructure development:
- Poor water catchment management
 - Vaal River system provide bulk water services meaning that water is transported from far and using high pumping elevations
 - Impacts on the environment include water pollution and land degradation, altering river flow processes, flooding and displacement of people.

Due to South Africa's unpredictable rainfall, high evaporation rates and low conversion of rainfall to runoff, South Africa is a water stressed country, where demand is fast approaching available supply; this is undoubtedly the case in Potchefstroom as well.

6.3.5. Municipals water consumer's profile

Population growth, increasing living standards and migrating to urban areas places immense pressure on the environment due to the increase in demand for water resources. The urbanization and intensity of land use in the urban core is very high, small rural settlements such as Klipdrift, Boskop, Schoemansdrift, Venterskroon and Lindequesdrift are situated along the major highway routes and consist mainly of informal housing with poor infrastructure and socio-economic conditions (NW DACERD 2009:2). Large scale residential, industrial and commercial development are further leading to optimal infrastructure development, or overloading of existing infrastructure (NW DACERD; 2009:15). In 2007, the total population in the Tlokwe municipality was 120 055 and a 9.9% increase in households or dwellings has been identified in the area from 2001 to 2007 (Statistics South Africa, 2007). Table 35 summarizes the demographic profile of Potchefstroom.

Table 35: Demographic Profile of Potchefstroom, 1996-2003

Demographic profile of Potchefstroom								
	1996	1997	1998	1999	2000	2001	2002	2003
Total Population	176,788	179,151	181,413	183,584	185,674	187,695	189,661	191,499
Annual Population Growth		1.34%	1.26%	1.20%	1.14%	1.09%	1.05%	0.97%
Number of households	42,658	43,927	45,245	47,180	47,800	48,710	50,167	51,261
Population density (number of people per km²)	45.65	46.26	46.84	47.4	47.94	48.46	48.97	49.45
Urbanization rate (% of people living in urban areas)	85.00%	86.40%	87.70%	89.20%	89.80%	87.30%	88.20%	89.50%

Source: Tlokwe IDP (2011:12).

Tlokwe had a positive outcome as there was an increase in the water service delivery from 30.2% in 2001 to 62.6% in 2007 for piped water inside a dwelling (Statistics South Africa, 2007). Water remains a concern in all local municipalities and Tlokwe is no exception. A major reality that faces Tlokwe municipality is the fact that there is a lack of sufficient waste/ refuse disposal, which contributes to the polluted environment and burning of wastes on communal and individual dumps (NW DACERD; 6). Access to basic services is summarized in the Table 36:

Table 36: Potchefstroom Water Services Profile.

Potchefstroom Water Services Profile	
Potchefstroom Municipality	Access (%)
Basic water supply	98.00
Basic sanitation	74.00
Access to free water and sanitation services	100

Source: Tlokwe IDP (2011).

According to the Spatial development framework the urban environment of Potchefstroom is divided into four major land-uses including residential, industrial, educational and open space developments. The actual land uses found in the municipality are indicated in Figure 51:

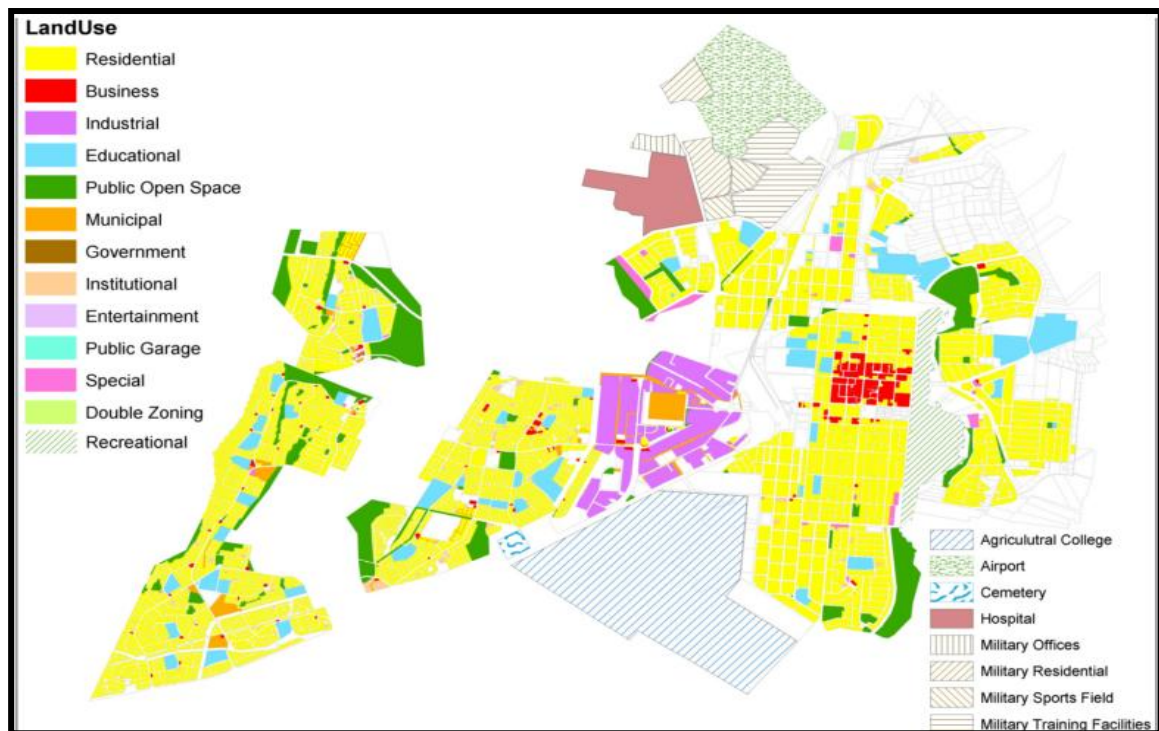


Figure 51: Actual land in Potchefstroom.
Source: Tlokwe Local Municipality (2008).

Most new developments in Potchefstroom are due to take place in the eastern side of the urban area where $\pm 10\,333$ stands are now in a process of establishment. These stands are mainly for the medium to higher income groups, in the West side of the urban area approximately 7 783 residential stands will be established for the lower income groups which will extend beyond Ikageng (Tolkwe Local Municipality; 2008:16). The SDF indicated that the funding for bulk service delivery in the eastern (N12) area is under major restriction (NW DACERD; 2009:23), this is an important factor to consider in term of the study as the implementation of WSUD can be one of many positive outcomes for this popular mixed land use development area. Figure 52 displays the proposed development areas as indicated from 2011.

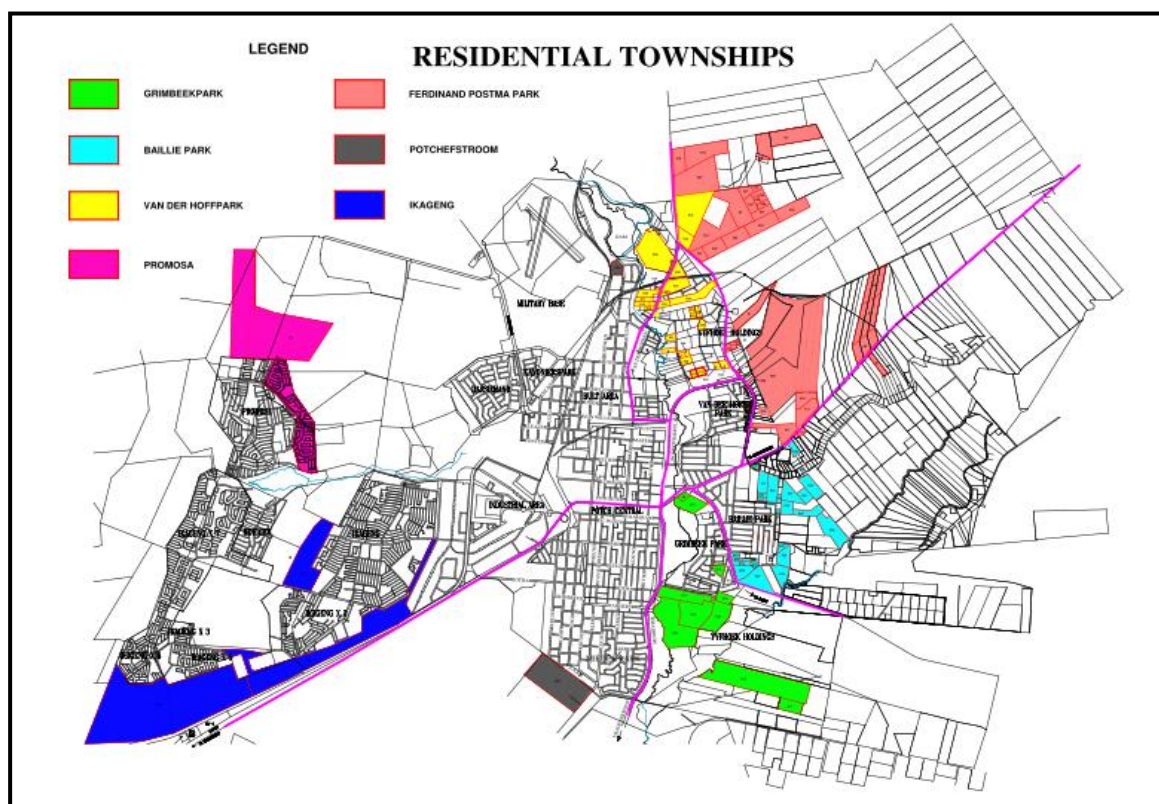


Figure 52: Proposed New development areas in Tlokwe
Source: Local Municipality (2012)

This increasing urbanization is one of the main threats to the natural environment in and around cities in the North West Province. Up until recent realities Potchefstroom has not experienced extreme drought conditions which could have caused the local municipality to suffer from short-term water shortages. In general municipality respond to these effects with short-term strategies as a coping mechanism to meet domestic demand (Mukheibir, 2005:8). In order to address short-term water shortage it is necessary for the municipality to adopt long-term strategies. A major problem effecting the implementation of effective conservation-orientated policies is due to the fact that there is a lack of data to be use by urban planning management (Cilliers et al, 2004).

It seems as if South Africa has a sound range of conservation legislation for the natural environment within urban development in South Africa although, application and interpretation of the legislation is left to local government, who usually neglect these requirements (Cilliers et al, 2004). The following section will discuss the policy approach that is currently in place to minimize the harmful effect of urbanization on the natural environment, specifically water bodies. This section aims to evaluate possible WSUD principles that have been addressed throughout the international local policies and legislations, including stormwater quality and quantity management, demand reduction techniques and the re-use of water. The evaluation of local policies and scope are limited to the Spatial Development Framework 2008; Integrated Development Framework 2008, Intergrated Development Framework Draft 2011/2016; and the Water Service Development Plan as they have a direct impact on the urban development and water management in Potchefstroom.

6.4. Specific policies and legislation guiding water planning in Potchefstroom

In order to consider possibilities to implement WSUD or WSP in the local Potchefstroom context, the newest Local Municipality Spatial Development Framework (SDF), Integrated Development Plan (IDP) and Water Services Development Plan were evaluated to determine the current approach to Spatial Planning and Water Management in the local area, and identify possible linkages between the two disciplines in terms of the policy and legislative frameworks.

6.4.1. Tlokwe Local Municipality Spatial Development Framework 2008

The Tlokwe Local Municipality Spatial Development Framework (LM SDF) was revised during 2008, as a revision of the 2002 SDF and as part of the broader Integrated Development Plan (IDP) process (Tlokwe Local Municipality, 2008:6). The revised SDF aimed to address new guidelines for Spatial Planning, identify spatial constraints and opportunities from various sectoral and geographic perspectives to guide the future development of the region (Tlokwe Local Municipality, 2008:6). The spatial objectives of the SDF were to enhance sustainable development which involved the protection, sustainable use and management of the environment; proper land use management and cost-effective provision of services (NW DACERD, 2009; 27). The SDF proposed to do this by identifying the urban build-up areas as low, moderate, high and very high ecological value, wetland are classified as very high ecological value and it is prohibited to development (Tlokwe Local Municipality, 2008:15). Figure 53 illustrates the ecological sensitive areas in the TML.

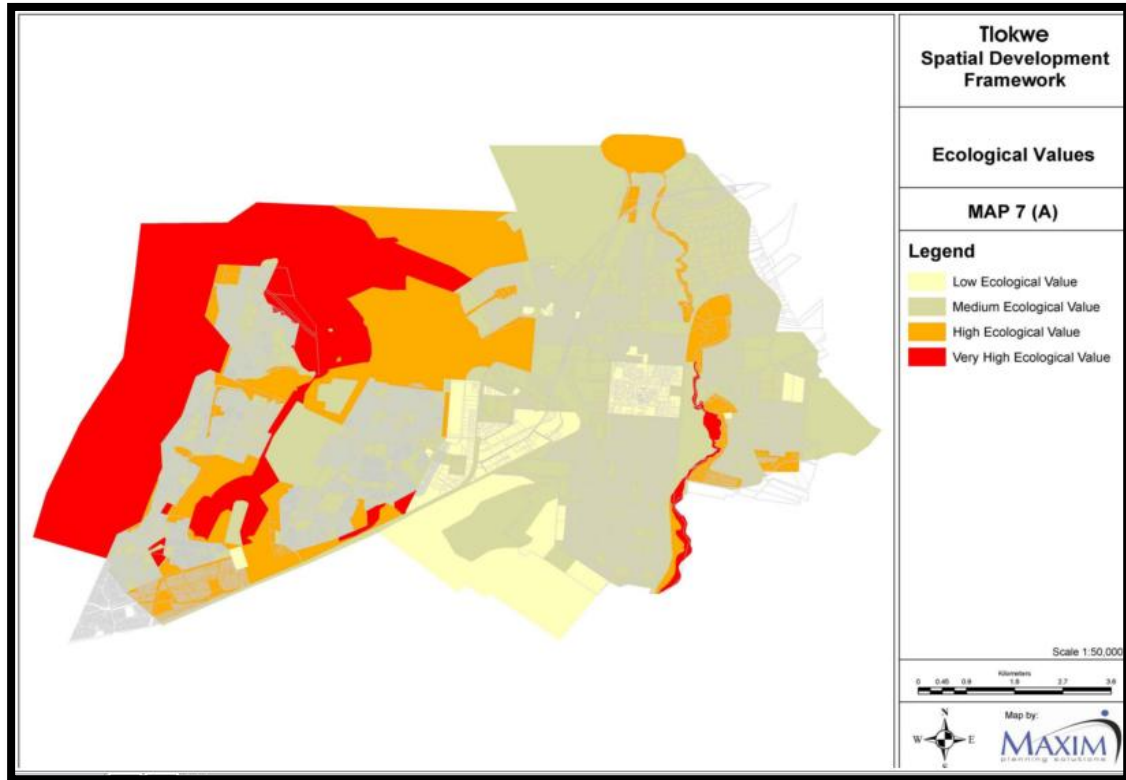


Figure 53: Ecological values of TLM urban build-up areas
 Source: Tlokwe Local Municipality (2008:18)

The SDF placed emphasis on the redevelopment of the primary regional node which included the revitalisation of the CBD (Tlokwe Local Municipality, 2008:47). The Spatial Development Framework identified four primary intervention zones including urban area, a development area, an urban fringe and the rural hinterland (NW DACERD, 28). Table 37 addresses the intervention activities.

Table 37: Planning interventions for Tlokwe.

Planning interventions for Tlokwe	
Planning Zone	Interventions
Urban built up-areas	Densification and integration
	Urban infill
	Upgrading and maintenance of services
	Urban renewal
	Protection of environmental sensitive areas
Urban Edge (development area)	Planning and provision of bulk service for new development
	New township establishment and provision of housing

	Integration of environmental sensitive areas within the municipal open space system
Urban Fringe (Traditional Zone)	Protection of environment sensitive areas as well as high potential agricultural land
	Stimulation of local economic development
	New township development to be considered on merit provided that the municipality will not be responsible for the funding of bulk and external services
	Proper land use management on agricultural holdings and small farm portions
Rural Hinterland	Protection of environmental sensitive areas (Vredefort Dome, Highveld National Park, Boskop dam Nature Reserve and potential protected areas)
	Protection of high potential agricultural land and the promotion of sustainable agricultural projects
	Proper land use and environmental management relating to eco-estates, equestrian developments, country-estate and business development and rural settlements
	Provision of much needed social facilities to the rural population

Source: NW DACERD (2009:28).

Figure 54 is a spatial indication of the intervention zones.

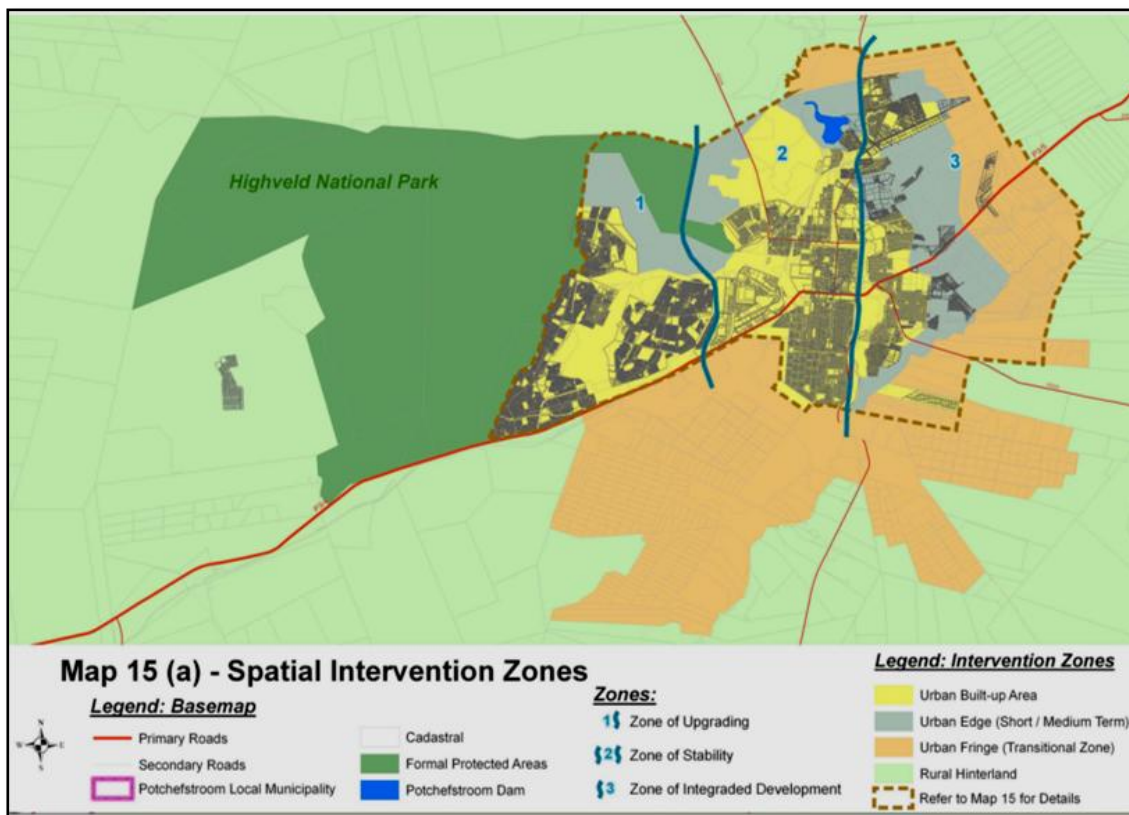


Figure 54: Spatial intervention zones.
Source: Tlokwe Local Municipality (2008: 53).

In order to address the objective of the SDF conceptual elements were developed to guide the spatial development framework, two specific programs that needs to be addressed is the Housing Development Program and the Municipal Open Space System (MOSS). The Housing development program was initiated to integrate land, housing and infrastructure programmes. It mentioned that water borne sanitation can only be provided after the completion of the water network (Tlokwe Local Municipality, 2008: 58). This is one of the measure that has been taken to address sanitation issues and waste water management. Furthermore the SDF (Tlokwe Local Municipality, 2008: 59) identifies the following areas with regards to municipal open space system in the urban areas: “The municipal open space system (MOSS) is intended to function as a series of interconnected parks, open spaces and natural areas which collectively serve as recreation, environmental, functional and historical corridors and areas. Degradation of natural systems or open spaces must not be permitted as a motivation for urban development. These areas should be rehabilitated, thereby raising the quality and amenity value of the open space and contributing to the functioning of the system as a whole. In support of national guiding principles and best practices, an open space network has been delineated that connects all the major areas of the urban area. These park areas are mainly based on the flood plains of the Mooi River and smaller streams, and also take cognizance of areas of high biodiversity and hills and ridges. This open space network also includes...sports, recreational and protected areas.”

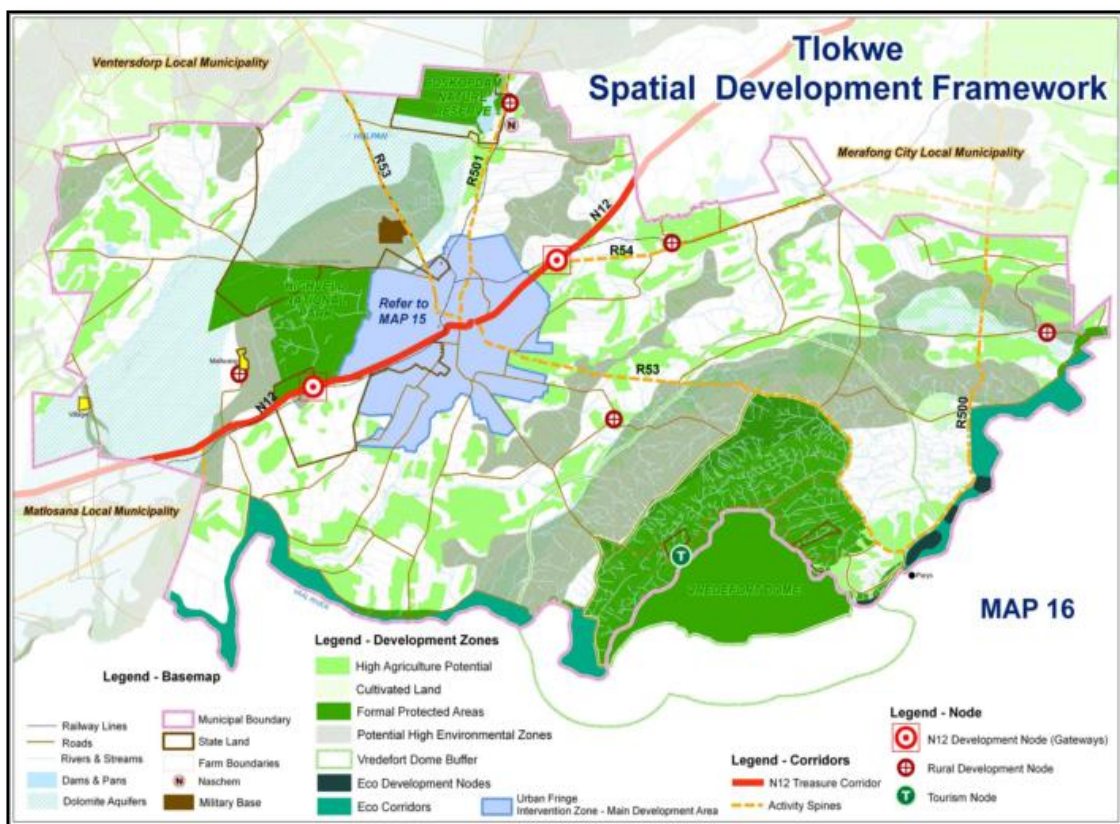


Figure 55: Tlokwe Spatial Development Framework
Source: Tlokwe Local Municipality (2008)

Protection of Environmentally Sensitive Areas (Tlokwe Local Municipality, 2008:61) included the protected areas as well as potential protected areas such as sensitive ecological areas with a rich biodiversity as well as other natural features such as the dolomite aquifers and cultural heritage sites. Basic development conditions (Tlokwe Local Municipality, 2008:72) mentioned that non-ferrous or plastic piping must be used for all water related underground services, waterborne sanitation services must be flexible to prevent breakage or leaking of pipes. Surrounding ground water should slope away from buildings and be taken within all rainwater channels to prevent the formulation of pools after rain and that all structure must be surrounded by an apron in order to remove water from the immediate area of the foundation. The SDF further recommended that: "Due to the fact that this is a very popular area for eco-developments a precinct plan needs to be formulated for this area, focusing on detail environmental, spatial and infrastructure planning" (Tlokwe Local Municipality, 2008:65).

Table 38: Summary of municipal environmental planning issues

Summary of municipal environmental planning issues			
Aspects	Key issues	Treats and constraints	Opportunities
Environmental management	Sustainability	<ul style="list-style-type: none"> - Social economic development pressures 	<ul style="list-style-type: none"> - Energy and resource efficient profile. - Establishment of the Environmental Management Unit - Green procurement policy - International profile
	Water	<ul style="list-style-type: none"> - Water service development plan not yet finalized - Dolomite aquifers 	<ul style="list-style-type: none"> - Sensitive environmental associated with development
Open space planning	MOSS	<ul style="list-style-type: none"> - Degradation - Fragmentation - Uncertainty in planning open space for ecological functioning - Scale of open spaces knowledge and planning - Source data for sensitive classification 	<ul style="list-style-type: none"> - Land use management Policy for the urban portion of the Mooi River. - SDF Planning.
Land use	Estates	<ul style="list-style-type: none"> - Exclusivity - Impacts - Development pressures - Illegal private resorts 	<ul style="list-style-type: none"> - Better resource protection of ecological features.
	Residential	<ul style="list-style-type: none"> - Encroachment on ridges in the west - Disregard of sensitivity of river in urban core 	<ul style="list-style-type: none"> - Quality urban environments.

Source: NW DACERD (2009:37).

To summarize: The formalization of a spatial rationale for the North West Province was based on the Strategic Environmental Assessment process, the national spatial guidelines (NSDP), provincial guidelines for SDF's in the Land Use Management Bill, 2002, and the conceptual framework.

The current Tlokwe Local Municipality SDF does not make account for the protection and management of biodiversity, habitats ground- and surface waters and the natural and cultural heritage, but sadly this is not addressed in a site design manner, in other words there are no guidelines on how to protect these areas. It is also mentioned in the NW SDF that the quantity and quality of water in the North West Province has been declining and that there is a need for a pro-active water management plan to develop their full potential (NW SDF,64). Furthermore, the NW SDF identified areas with medium economic growth potential (Greater Taung, Mamusa, Ditsobotla and Naledi) which is also in need for a pro-active planning approach for water management where the DWAF and the Catchment Management Authorities will have to work together in order to facilitate sustainable development in these areas. However, there is no indication that stormwater harvesting (which is considered as an energy efficient practice of urban and rural areas) is to be implemented as a development opportunity in Potchefstroom. Furthermore, the SDF does mention that development should be concentrated within the existing areas but unfortunately developments are subjected to neither rainwater harvesting nor the installation of water savings devices, which could lead to an exceptional contribution of water supply. No consideration is given to greywater recycling as an alternative water resource. Thus, although the SDF does mention some critical Water Management issues, there is no clear linkage between Spatial Planning and Water Management approaches within the SDF.

6.4.2. *Integrated Development Plan 2011/12*

The Integrated Development Plan stated that the “environmental assets and scarce natural resources need to be well protected and properly enhanced on a continuous basis. We need to continue with the enhancement of the quality and quantity of our water resources” (IDP, 2011/12:8). Tlokwe City Council has undertaken an assessment of its capital infrastructure requirements infrastructure, stating the following needed extensions:

- Bulk sanitation infrastructure: Extension of waste water treatment plant by 22 Ml/day
- Bulk water: Extension of water treatment plant by 30 Ml/day
- Water connections: Number of Installation new water connections
- Roads & storm water: Construction of roads and storm water 261 km

The following environmental initiatives (aligned to NEMA and Local Agenda 21 principles) were identified in the IDP for Tlokwe: the establishment of an Environmental Management Unit in Council; Appointment of service providers in November 2006 for the compilation of a Water Services Development Plan; Provision of road and storm water infrastructure in terms of available funding; Incorporation of proclaimed natural areas and sensitive biodiversity areas into the Spatial Development Framework and a Land Use Management Policy for the urban portion of the Mooi River. The IDP stated that certain sections are affected by lack of shortage water, poor maintenance of provided water stand pipes and insufficient underground water supply (IDP, 2011/16:117).

The IDP also mentioned that a detailed upgrading plan of the water purification and sewerage works will be submitted to Council during the 2011/2012 financial year. A tariff increase of 6% from 1 July 2011 for water was proposed and could be regarded as a demand reduction approach to water management. A summary of the proposed tariffs for households (residential) and non-residential captured in Table 39 (IDP, 2011/12:157):

Table 39: Proposed Water Tariffs.

Proposed Water Tariffs		
Category	Current Tariffs 2010/11	Proposed Tariffs 2011/12
Residential	Rand per kl	Rand per kl
(i) 7 to 16 kℓ per 30-day period	4.09	4.34
(ii) 17 to 36 kℓ per 30-day period	4.31	4.57
(iii) 37 to 56 kℓ per 30-day period	4.54	4.81
(iv) 57 to 80 kℓ per 30-day period	4.76	5.05
(v) More than 80 kℓ per 30-day period:	5.13	5.44
Non residential		
(i) 0 – 5 000 kℓ per 30-day period	4.54	4.81
(ii) More than 5 000 kℓ per 30-day period	4.09	4.34
(iii) Agricultural Holdings over 6 kℓ	5.68	6.02

Source: IDP (2011/12:157)

For 2011/12 an amount of R88.1 million was appropriated for the development of infrastructure which represents 73.9% of the total capital budget, roads and stormwater infrastructure receives R30.7 million (25.8%). Furthermore the refurbishment and renewal of Water Networks was budgeted at R 1.9 million and the backlog eradication of Roads and Stormwater Drainage at R 21.2 million (IDP, 2011/12:165). To summarize: In Chapter 2, Section 2.8 (Sustainable Environmental Management and Public Safety) of the IDP 2009/10, mention is made of the creation of a Cities against Climate Change Program with focus on energy and resource efficiency projects in order to promote 'green' buildings (Tlokwe Local Municipality, 2009/10:27). The assessment indicates that the current infrastructure regarding the water purification and sewerage works is unlikely to sustain its long-term ability to supply clean water and to clean the sewerage to be released in the Mooi River. Consultants for the Water Services Delivery Plan (WSDP) were appointed the DIP in December 2009 with the financial support of DWAF (Tlokwe IDP, 2011/12:67). Section E.3.1. The Strategic Direction of Council in the Tlokwe IDP (2011/12) ensured continuous alignment of the SDF with other sector plans and development policies pertaining to transportation, LED, environmental protection,

water provision and disaster management (Tlokwe IDP, 2011/12:90). Integrated Development Plans including Water Services Development Plans should be aligned in order to strengthen the integrated development approach.

6.4.3. Water Service Development Plan (WSDP 2011/2012)

The WSDP analysis results of January 2006 indicated that most WSDPs are not useful as strategic planning tools as they do not address backlogs sufficiently, and because the financial modelling of the plans is poor. The WSDPs are also not frequently updated for quality improvement and status review (WSDP; 2011/2012). Summary of general major gaps includes limited stakeholder involvement, limited focus on sanitation issues, no info on overall holistic and strategic planning, no financial modelling information, lack of information to support data in tables, lack of associated maps and lack of detailed planning for rural areas (WSDP; 2011/2012). The Department of Water Affairs and Forestry fulfils the primary role of regulating and supporting WSAs in the provision of water services. The following resolutions were made by the WSDP 2011/2011:

- Integration of planning at all levels and across sectors
 - Include a chapter on water in the PGDS
 - Integrate IDP and WSDP processes
 - Integrate water resources and water services planning
 - Create closer links between and amongst all planning structures
- Efficient use and protection of water resources
 - Develop effective water quality monitoring systems and support municipalities to adhere
 - Develop an integrated pollution and waste management strategy
 - Finalise catchment management strategies for all four water management areas
 - Ensure greater involvement of municipalities within water management institutions – CMAs & WUAs
- Addressing water and sanitation backlogs
 - Conduct a full backlog study on water and sanitation to serve as common reference
- Provide hands-on support to municipalities
 - Mobilise more resources for municipalities
 - Develop and support municipal action and/or capacity development plans
- Improve sector collaboration
 - Ensure greater involvement of councillors in forums
 - Link sector forums and the provincial intergovernmental structures
 - Implement provincial sector plan integrating water resources and cross-cutting issues
 - Develop a provincial capacity building plan

Water Service Development Plans highlighted the following issues:

- Water supply
 - Need for bulk infrastructure to support retail water supply systems
 - Adequacy of current water resources infrastructure to cope with increased water use demand
 - Extension of retail infrastructure to address new settlements versus addressing backlogs
 - Operation and maintenance of existing infrastructures
 - Water loss management
 - Water quality management
- Sanitation
 - Bulk infrastructure in areas where water-borne systems replace buckets
 - Responsibilities regarding institutional sanitation and stock watering
 - Operation and maintenance
 - Upgrading of sewage treatment works
 - Pollution control

The following table summarizes the objectives of the WSDP 2011/2012 for the North-West Province.

Table 40: Objectives of WSDP.

Objectives of WSDP	
Objectives	Methods to follow
Access to basic and sustainable water services	Reduce the water and sanitation backlog to less than 5% in the next five years
	Fast-track the bucket eradication programme to achieve the 2007 target
	Increase implementation capacity in all areas of the project cycle
	Improve and align water services information management
	Strengthen intergovernmental and integrated planning
Sustainable water services	Strengthen systems for management of drinking water quality
	Fast-track the finalisation of water services provider mechanisms
	Complete the transfer of assets to Water Services Authorities
	Improve water loss and demand management systems at local level
	Improve the management of new and existing water services infrastructure
	Increase access to free basic water and sanitation for the poor
Integrated water resources management	Increase understanding of water resource management issues amongst all water users

	Increase availability of water resources to support economic and domestic usage
	Improve the management of water resources at catchment and local levels
Sustainable water services institutions	Increase capacity of water service authorities to assume their constitutional functions through targeted, strategic and coordinated support
	Increase capacity of water service providers to provide sustainable water services
	Increase capacity of DWAF as a sector leader to ensure effective sector regulation at provincial level
Effective intergovernmental relations and collaboration	Strengthen collaboration all provincial sector stakeholders
	Strengthen links between the provincial and local government intergovernmental structures
Strong provincial water sector	Increase required technical and associated skills to support sector initiatives
	Increase the usage of appropriate technology in the provision of water services and management of water resources
	Increase participation of women in the provision and management of water
	Increase the participation of civil society organisations in the provision and management of water

Source: Own construction based on WSDP (2011/2012).

6.4.4. Broader legislation guiding Water Management in South Africa and North-West Province

Policy and legislation such as the National Water Act (Act 36 of 1998) is central to the management of water resources from national to catchment level. Legislation therefore influences the pressures, state, impacts and responses pertaining to the water resources (Walmsley et al. 1999).

Table 41: Broader legislation guiding water management in South Africa and North-West Province

Broader legislation guiding water management in South Africa and North-West Province	
Act/Guideline/Policy	Description
White Paper on Environmental Management Policy	<p>The goals of this policy are:</p> <ul style="list-style-type: none"> - Effective institutional framework and legislation - Sustainable resource use and impact management, - Holistic and integrated planning, - Participation and partnerships in environmental governance, - Empowerment and environmental education, and - Information management and international co-operation.

<p>White Paper on the Conservation and Sustainable use of SA Biological Diversity (GN 1095, 28 July 1997)</p>	<p>The goals of this policy are inter alia:</p> <ul style="list-style-type: none"> - Sustainability, - Minimising impact on biological diversity, - Application of the precautionary principle, and - Ensuring that benefits from use of resources serves the national interest.
<p>White Paper on Integrated Pollution and Waste Management for South Africa. (GN 227, 17 March 2000)</p>	<p>The vision for this policy is to develop and maintain an integrated pollution and waste management system that contributes to sustainable development and measurable improvement of the quality of life, by harnessing the energy and commitment of all South Africans for the effective prevention, minimisation and control of pollution and waste.</p>
<p>General Policy in terms of the Environment Conservation Act 73 of 1989 (GN 51, 21 Jan 1994)</p>	<p>This policy has amongst its aims:</p> <ul style="list-style-type: none"> - Environmental rights for all, - Sustainable use of resources, - The maintenance of natural systems, - Sustainable development, and - The establishment of a partnership between the state and the community (including private sector, industry and the international community) to pursue environmental goals.
<p>White Paper: A Minerals and Mining Policy for South Africa (GN 2359 20 October 1998)</p>	<p>This policy strives to facilitate the establishment of a balance between a cost effective and competitive mining industry and the imperative to protect the environment. The Policy calls for inter alia:</p> <ul style="list-style-type: none"> - The employment of environmentally competent staff in government, - A co-ordinated and integrated environmental management approach to the planning, management and use of all natural resources, - Increased public involvement, and - On-going research into environmental management and pollution control.
<p>Minerals Act 50 of 1991</p>	<p>Sections 38 and 39 of this Act require the holder of a mining authorisation to compile and submit an Environmental Management Programme Report, and undertake rehabilitation of the land surface. The Regulation describes the required processes for environmental management on the site, pecuniary provision in terms of the EMP, performance assessment and monitoring of the provisions of the EMP.</p>
<p>National Water Act (36 of 1998)</p>	<p>This Act makes provision for the sustainable and equitable protection, use, development, conservation, and management and control of water resources. Reg 704 relates to the use of water for mining and associated activities. Any person intending to open a new mine must notify DWAF not less than 14 days before commencement of the activity, submit their EMP, notify them of cessation of activity and report any emergency incident (or potential incident) relating to water to DWAF.</p>
<p>National Environmental Management Act (107 of 1998)</p>	<p>This Act deals with the prevention and remediation of soil erosion, stocking rates and prohibits the destruction of wetlands. NEMA also deals with Integrated Environmental Management (IEM) - including:</p> <ul style="list-style-type: none"> - Identification, prediction and evaluation of the actual and potential impacts on the environment; - Risks, consequences and alternatives and options for mitigation of activities; monitoring and management of environmental impacts, and the effectiveness of the implementation of mitigating measures.
<p>Water Services Act (Act 108 of 1997)</p>	<p>Is chiefly concerned with the provision of water supply and sanitation to the people of South Africa</p>

Source: Own construction (2012)

6.5. Conclusions: Gaps analysis

From the case study evaluation and interviews with various professionals (Annexure A) in the planning field the following gap analysis were identified in terms of planning for water management in Potchefstroom. Gaps include but are not limited to:

6.5.1. Insufficient water supply

The water supply indicates that Tlokwe Local Municipality has no external sources of water (bulk services). The town of Potchefstroom has one integrated water service system with household's metered connections and water borne sanitation systems in place. In the rural areas underground water source supply the settlements and little is known with regards to the possible impact of contamination from VIP's. It is evident that the current abstraction is fairly more than the licensed abstraction indicating that the water supply is not being managed and regulated in a secure manner.

Table 42: Availability water supply status

Availability water supply status			
Water source	Number of Sources	Current Abstraction (MI/Day)	Licensed abstraction (MI/Day)
Groundwater	2	1	0
Surface water	1	38.36	20
External Sources	0	0	0
Water returned to resources	1	21	16.425
Recycled Water	0	-	-

Source: WSDP (2012)

6.5.2. Lack of finances

Limited capital funding is available with R400 000.00 being spent on water and sanitation services in the last financial year. Funding of the refurbishment/ replacement of existing infrastructure is urgently required. There were no indications that the budget has funding for the repair of pipe works, leading to an enormous amount of water that waste away.

The operations and maintenance budget for water service is coming under increasing pressures as services are being expanded to customers base at the higher service level to customers unable to pay and requiring full subsidisation. Water tariffs are still relatively low and free basic services are rendered to indigents in the town of Potchefstroom who are receiving pressurised households water supply and water borne sanitation service levels. Scope does exist for raising of tariffs for ensuring that services can be accommodated but tariff modelling is required to ensure the extent of cross subsidisation is correctly managed.

6.5.3. Lack of long-term strategies

By implementing long-term strategies the municipality would be able and ready with adaptation responses; this includes the supply and demand side water management strategies.

- Supply side- A Water Service Development Plan and also groundwater resource plan, municipality would know how much resources are available at current and future stage.
- Demand side- Awareness campaigns, water restrictions, and the re-use of greywater, water tariff changes and the changes in sanitation systems can be encouraged (Mukheibir, 2005).

6.5.4. Urbanization pressure

Population growth trends in the area should be considered more comprehensively in order to plan for the longer term water demand. The impact of the growing student-population also needs to be considered, along with the associated housing provision and development pressures. An increase in the population exerts pressure on the environmental quality and quantity of the water resource through greater demand as well as the discharge of used water through sewerage and other effluents.

6.5.5. Inadequate policies and legislation

The Tlokwe municipality needs to create an enabling legislative environment for the successful implementation of water resource management projects, or rather, WSP activities. Table 43 summarizes the gaps that need to be addressed in Potchefstroom, based on the comparative analysis between Potchefstroom and Melbourne Australia. These gaps will be addressed in the Chapter 8 as part of the recommendations for the study.

Table 43: Comparative analysis

Comparative analysis NW vs. Melbourne		
	Australia, Melbourne	North-West Province, Potchefstroom
Integrative policies	YES	NO
Sustainable development approaches	YES	NO
Responding to climate change	YES	YES
Responding to water management	YES	NO
Legislative framework to support water management	YES	NO
Goals to measure implementation and success	YES	YES
Successful case studies of integrated Spatial Planning and Water Management approaches	YES	NO
Identified techniques for stormwater management	YES	NO
Design approaches in terms of different land-uses	YES	NO

Source: Own Construction (2012).

From Table 43 it is evident that the local approach to integrative planning needs to bridge the gaps between Spatial Planning approaches and Water Management approaches. Although some critical issues of Water Management are mentioned in guiding Spatial Planning legislation and policies frameworks, no actual implementation guidelines, techniques or requirements exists. Chapter 7 will elaborate on these findings.

Chapter 7: Conclusions and Discussion

7.1. Introduction

The aim of this research was to explore the water-land relationships of surface water systems that are relevant for Spatial Planning, along with the possible linkage between Spatial Planning and Water Management approaches through Water Sensitive Planning initiatives. This Chapter summarizes the major findings for each of the research objectives, challenges and questions presented in Chapter 1.

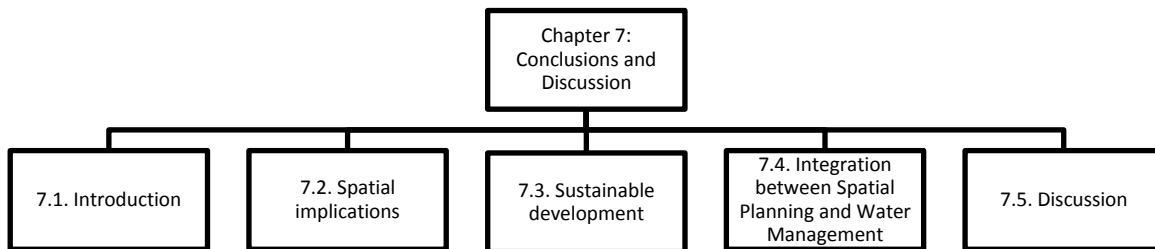


Figure 56: Structure of Chapter 7
Source: Own construction (2012)

7.2. Spatial implications

- 1) What is the spatial impact of urban development on surface water systems in the South African context?

The earth's water supply will always remain constant, but unfortunately humans are able of altering the cycle which is known as the fixed supply of water, creating an imbalance which has a direct effect on the quantity and quality of natural water resources available to current and future generations. In South Africa, human activities have had major negative effects on water systems in urban region. Population increases, rising living standards, and industrial and economic growth have placed greater demands on the country's natural environment. Given South Africa's population size and the current phase of massive urbanization, keeping natural water systems intact will require new measure of water management. Chapters 2 and 4 illustrated significant negative effects on riparian zones, complete reclamation and pollution due to rapid urban development. Although since 1998, a variety of policy and legislative initiatives (Chapter 3) were formulated for Spatial Planning and Water Management irrespectively, these two sectors are still not integrated and interlinked in practice.

The findings of this research revealed that in order to effectively reduce the negative impacts of urban development, it is necessary to include the spatial expression of water systems in the designing of spatial plans, visions and programmes, in particular under the circumstances of rapid urban land expansion in South Africa.

2) Can adequate space for surface water be identified and incorporated in the layout and design process?

In Chapter 4, spatial considerations for surface water management identified three types of spaces for urban water areas, namely (1) space for detention/retention facilities (Dalton, 2010), (2) space for riparian corridors or buffer zones (Hayes, 2000), and (3) landuse for water space in the watershed (Silva & Williams, 2001). These spaces should be recognized as the link between Spatial Planning and Water Management in terms of land-use, and should be defined and protected accordingly. Spatial Planning should consider these water related land-uses and include it into the overall spatial organization. Water Management practice should accordingly consider the spatial implications in all applicable technical measures. Once again, it is a vices versa responsibility from both disciplines, Spatial Planners and Water Managers should make a combined effort towards a paradigm shift of sustainable and integrated development, in order to protect these water spaces and future urban areas. Space for surface water can, and should be identified, and captured in the adequate policies and development plans (SDFs, IDPs) in order to ensure the enforcement and protection of these sensitive spaces and land-uses. The objectives should accordingly be incorporated in the layout and design process, by means of technical requirements, site-specific development and land-use specifications.

3) Which spaces are sensitive for surface water management and need an integrated planning approach guided by Urban Planners and Water Managers?

The protection of surface water bodies, reserving riparian buffer zones and carefully considering the land-use within the watershed is essential in order to maintain healthy aquatic ecosystems. As discussed in Chapters 2 and 4, surface water forms part of the ecological systems and it is a matter of serious concern today. Surface water is a vital component of the natural and environmental quality of the region within the watershed. Therefore, land-use in the watershed should be intensely regulated due to the close relationship between land-use and the status of surface water bodies. Surface water systems as open space in the city is beneficial for urban spatial quality, as it does not only offers great economic value and environmental quality, but also contributes to urban land value, and the marketability of the city, which in this matter may attract potential investors.

7.3. Sustainable development:

- 4) How does WSP contribute to sustainable development?

The concept of sustainable development is grounded on an integrated approach between environmental, social and economic considerations. The WSP initiative also furthers the concept of integrated planning and development, as it aims to link Spatial Planning and Water Management approaches. These two approaches cannot be planned in isolation, when considering the objectives of sustainable planning and development. Chapter 2 investigated the direct relationship between spatial planning and the water land relationship between these two concepts as a result Chapter 4 investigated the significant changes that surface water management is undergoing, moving away from traditional conveyance-oriented drainage and treatment technology towards corresponding improvements and innovations in land-use practices. WPS is the link toward the new storage-orientated management of surface water in urban areas to insure sustainability in South African cities.

- 5) Which new planning concepts and methods can be used to integrate surface water systems in the current Spatial Planning approaches in South Africa?

Sustainable surface water systems is a component of integrated water resource management and requires balance and maintenance of system resilience within the context of natural and human development processes. In practice it is the process of binding multiple stakeholders with deferent viewpoints in order to determine how water should best be managed. In order to decide if a water system is sustainable, various economic, social and ecological considerations must be considered. Chapter 4 indicated that principles of water sensitive planning (WSP) needs to be considered as new spatial concepts and methods for water systems in spatial planning. WSP is to be implemented as part of all future developments, including greenfield and redevelopment projects and, as opportunities arise, in established urban areas. Examples of these principles are: reducing the impervious area within the catchments or watershed areas, identifying and protection of surface water bodies and wetlands as important elements for urban spatial structures, and buffer zones and riparian corridors as part of the urban green structures. It is also important to include and plan for multi-functional land-uses which will help to control the water problems, as well as to improve the quality of space of urban areas. The surface water systems should be more carefully considered both at strategic level and at local action level.

7.4. Integration between Spatial Planning and Water Management

- 6) Can experience of Australian case studies be helpful for South Africa to find successful ways to integrate surface water management in Spatial Planning and close the gap between these two disciplines?

The evaluation of Melbourne's (Australia) spatial water policy, illustrated that the traditional end-of-pipe techniques were not adequate enough to deal with water-related problems on its own. It was concluded that by defining how, where and when new development occurs, the planning system can play an important supporting role in promoting water conservation. "It would be desirable, for example, if planning strategies, Development Plans, and development assessment included the principles of the water conservation hierarchy – avoid, reduce, reuse, recycle, and discharge, where necessary, in an environmentally responsible manner" (PIA, 2012). This study has demonstrated that it is possible to solve some of the water problems and minimise the negative impacts of human-related land-uses on the water system with co-operation of sectoral authorities and agencies through innovative approaches for Spatial Planning and Water Management. It is essential for statutory planning documents at the regional and local level not to be in conflict, but supportive of the various water conservation measures. Water sensitive urban design was introduced in Chapter 4, with the aim of bringing together Spatial Planning and Water Management by 'making space for water' to create the opportunity for protection of both the water system and an adequate level of spatial quality. The Australian spatial water policy offers an example for a new perspective that requires innovation in the planning process, institutional reform, new planning methods, and especially the organization of negotiation and cooperation between different stakeholders.

- 7) How could the current planning systems in South Africa be reformed in order to integrate sustainable development of surface water management in Spatial Planning?

Urban development places an enormous amount of pressure on the quantity and quality of water resources by the ever-increasing land uses which limits the potential for infiltration and groundwater recharge and increases the volumes of stormwater run-off (Chapter 2). If urban expansion and land development had no harmful impact on surface water systems, it would imply that there are no imperfections in the spatial planning process. Unfortunately, as demonstrated throughout the study, surface water systems are being harmed due to urban and land development, and this reality emphasises the need for a WSP approach to be incorporated in the spatial planning process of South Africa. In Chapter 4, the study referred to a proactive approach that should be considered. This will not change the fact that Spatial Planning and management of water systems should be guided at strategic level while it operates at a local level, but the proactive approach may lead to a more integrated spatial planning model as discussed in Chapter 4. The study argues that this proactive approach may lead to a more innovative and effective approach to Spatial Planning and Water Management in an integrated manner. In Australia (Chapter 5) the essential role of surface water systems is recognized in urban spatial policy-making processes. Unfortunately in South Africa, policies have up to date not yet addressed the value of the surface water system as truly important. The current

planning systems in South Africa would, however, only be reformed, once all policy-makers and local authorities grasp the importance and consequences associated with water planning and management.

8) How can the institutional co-operation between Spatial Planning and Water Management are initiated in the South African context.

The relationship between nature and urban space is gaining importance in the local South African environment, but not to the extent of sustainable development. . Local planning authorities and the water management agencies in South Africa needs to tackle the issues of surface water problems in a sustainable way, addressing the issues of institutional compartmentalisation. As emphasized in this research, consideration of surface water management as an integral component in Spatial Planning needs to be addressed in terms of (1) planning content, implying new planning knowledge, concepts, and aims leading to pursuing other spatial forms of urbanization, and (2) the planning process itself, which includes acceptance of and support for spatial water policy and its implementation, as well as participation of stakeholders, the public and decision makers to raise awareness and organize commitment. Institutional segmentation has to be broken down to remove barriers for cooperation. The adequate Spatial Planning and Water Management policies and legislations needs to be aligned to strengthen each other, and not function in isolation as the current practice reveals. Ultimately there needs to be a national policy, focussing on a comprehensive and integrated approach to guide coordination and integration of Spatial Planning and Water Management objectives.

7.5. Discussion

Throughout the research it was evident that separate departments of national, regional and local governments manage Spatial Planning and Water Management in South Africa. The intent of the research was to evaluate international conceptual approaches to integrate the planning and management of these two disciplines, and develop a concept to be implemented in the local environment to address the current fragmented planning approaches. Because of the rapid social, economic and urban development taking place in South Africa, the implementation of a “clean-break” will be a difficult task. However, a context-sensitive approach between Spatial Planning and Water Management was explored in this research in order to broaden the necessity of Water Sensitive Planning in South Africa. The concept of WSP was proposed as a relevant initiative to integrate the approaches of Spatial Planning and Water Management, based on the challenges and uniqueness of the local South African environment. The WSP approach was development based on the WSUD approach and comparative analysis of the Australian case studies (presented in Chapter 5). The following table captures the core objectives of the WSP approach, as structured from the theoretical investigations, empirical findings and best-practice analysis.

Table 44: Core objectives of the WSP approach

Core objectives of the WSP approach		
WSP approach as initiative to implement in SA	As captured from theoretical investigation	As captured from empirical investigation
Focus on sustainability	The world's water resources are being heavily consumed resulting in a limited future availability of useable water. This has placed pressure nationally and internationally on all sectors to employ sustainable water resource management. Embedding sustainable development at the centre of the planning system means the pursuit of good quality of space by linking economic and social development with physical or spatial management. It is essential to engage surface water systems in the planning contents and integrate surface water management in planning process in order to create a sustainable urban region.	Case studies illustrated a sustainable result in terms of water management, specifically stormwater management by use of non-conventional stormwater harvesting approaches and layout site design techniques that mimics the natural environment as far as possible. The international case study of Australia illustrates a remarkable water saving and also changing environment in terms of community participation of sustainable urban development (Chapter 5). This is an importance driving force for the implementation of WSP in South Africa as it is stated in Chapter 2 that the water availability in South Africa is also on the verge of being classified as being unsustainable.
Integrating Water Management and Spatial Planning.	There is a strong relationship between the water systems and land-use and human activities have a direct effect on the quality of urban waters. Water and land has long been studied as separate figures, because water management and land-use planning (as part of Spatial Planning) were (traditionally) dominated by different expertise and disciplines. In theory it is suggested that Water Managers and Spatial Planners must work closely together to in a water land relationship to identifying catchments, drainage basins and watersheds, surface water bodies and buffer zones to reduce the damage to surface water systems by urban development.	The WSUD approach links the two concepts by integrating stormwater, water supply and wastewater management at the early stages of urban planning to ensure that best practice water cycle management is applied in order to facilitate synergies between ecological, economic, social and cultural sustainability. It also bridges gaps between various sectors and provides a platform for trans-disciplinary interactions which includes legislation on National level, planning schemes on Municipal level and site-design techniques on Local level.
Participatory approach	At the local level the physical form and principle of good design remains a necessary and significant consideration for Spatial Planning. In order to achieve sustainable development it is necessary to involve the national environmental problems in the local levels of development concerns. Water Affairs Bureau and the Urban Planning Bureau needs to cooperate and coordinate their efforts.	The cases studies that were evaluated in this study (Chapter 5), displayed a range of successful implementations of WSUD that was initiated by Spatial Planners and Water Managers together with local municipal decision-makers. This is the integrated approach that is so desperately needed in South Africa.
Legislative approach	The evaluation of South Africa's relevant Spatial Planning and Water Management legislations illustrated that they are in line with the international sustainable development approaches, however, still lacking to address the need to implement future uses of stormwater harvesting in urban areas, along with the lack of an integrated approach. These techniques and design guidelines were captured in study and should be included the Spatial Planning processes, focussing on an integrative, holistic planning and design approach.	WSUD illustrates the possibilities to enforce such integrated legislation approaches if it is considered and implemented at all levels of Planning. WSP in terms of the South African context can be addressed at National Level by including a WSP legislation that will be relevant to all stakeholders. Australia has a range of legislations that addresses WSUD. As mentioned in Chapter 6, the WSDP is in need of integrated water management legislation, which in this sense seems relevant to employ WSP in South Africa's legislations.

<p>Design guidelines</p>	<p>A landscape can be divided into individual drainage basins, each of which contains all the elements of drainage systems that contribute water to one particular stream. Preserving these natural filter traps in the watershed are important measures which should be integrated into Spatial Planning and Water Management it also needs to be more actual, implementable and measureable. Policies and legislation should be related to a site-scale design, implemented in a practical way as illustrated in chapter 4 and 5.</p>	<p>Chapter 4 elaborated on the specific land-use requirements and the implementation and design of WSUD in specific land-uses which includes single residential development, residential subdivision, residential multi-unit development, streetscape development, vehicle parking area development, commercial and Industrial sites and public open space. The implementation of WUDS must be address in these zones with a planning toolkit to facilitate planners and water managers. The technical guideline which forms part of WSUD toolkit was address in chapter 4.</p>
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Source: Own construction (2012)

From the theoretical investigation and empirical findings it was conclude that WSP can be proposed as a relevant solution to adhere to the current fragmented planning in South Africa in terms of Water Management and Spatial Planning. This recommendation will be discussed in more detail in the next chapter.

Chapter 8: Recommendations

8.1. Introduction

The propose of the research was to identify new initiations towards sustainable urban development and water management that could be implemented in the local South African planning approaches, in an integrated manner. By identifying the South Africa's Spatial Planning and Water Management problems and evaluating universal solutions for these problems, it was concluded that WSUD is one of the most sustainable and environmentally friendly approaches that can address these problems, focussing on a sustainable contribution towards water development and water management in a short, medium and long term period. The WSP approach was identified as a possible solution to address the South African challenges of fragmented planning and an approach to link current Spatial Planning and Water Management approaches. The WSP approach was based on the WSUD approach, but customised for the local environment of South Africa. Accordingly, specific planning recommendations will be discussed to address the mentioned challenges.

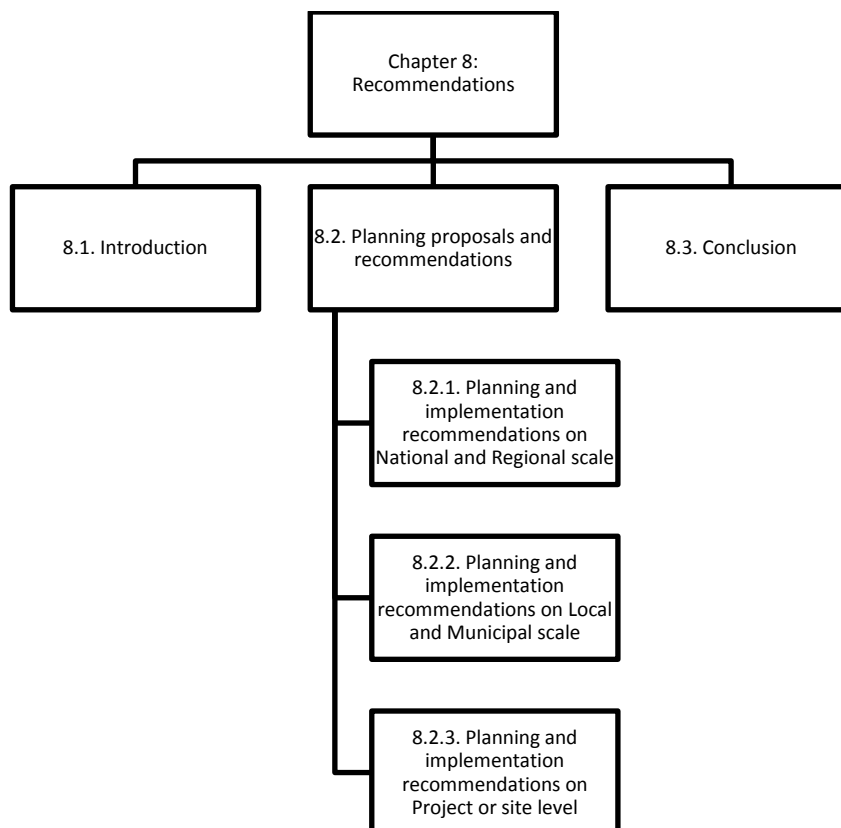
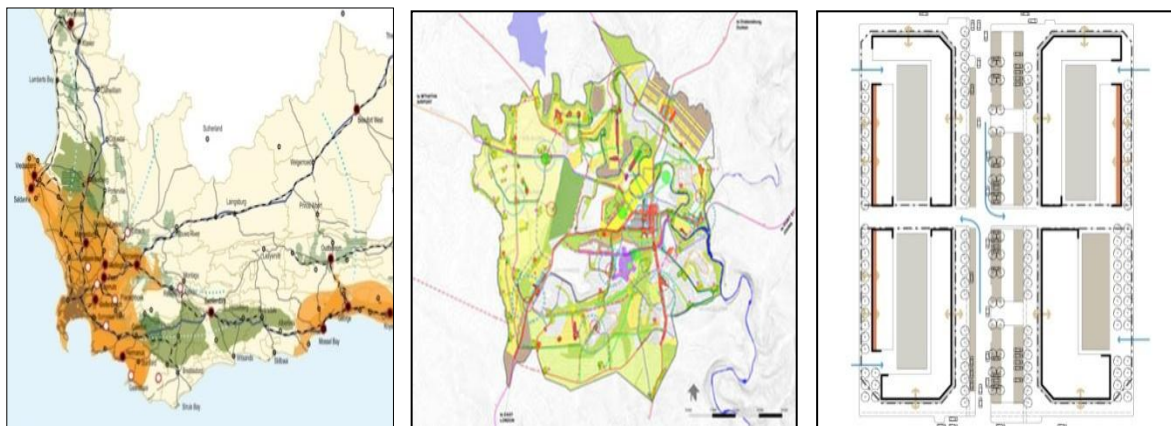


Figure 57: Structure of Chapter 8.
Source: Own constructions (2012).

8.2. Planning proposals and recommendations

WSP is recommended as the possible solution to address South Africa's current challenges in terms of Spatial Planning and Water Management. WSP serves to protect the the water quality in urban areas with the objective to support sustainable urban development and to meet the need of the local communities. It is an intergrated approach that will be used mainly by Urban Planners and Water Managers in close cosideration to protect natural water systems by using sustainable site design tegniques such as stream buffers, bioswales, raingardens, reducing hard surfaces my mimicing the natural inviroment as far as possible. The implementation of the proposed WSP approach will be discussed in terms of the various scales of planning, from large scale to small scale, each with different objectives. The scales of planning were also linked to the levels of government, namely (1) National and Regional where the focus is placed on regional planning control measures, (2) Local or Municipal level where the focus is on local control measures and (3) Project level where the focus is on source control. In this sense, the deferent spatial consideration of surface water systems, from strategic level (i.e. master planning, land use planning) to action level (i.e. on-site design), was incorporated and implemented as part of the integrated WSP approach. These relevant scales/levels applicable to the planning recommendations of this research thus include (refer to Figure 58):

- 8.2.1 National and Regional scale / Regional controls
- 8.2.2 Local and Municipal scale / Local controls
- 8.2.3 Project or site-level / Source Control



National and Regional scale → Local and Municipal scale → Project or site level

Figure 58: Deferent scale of WPS implementation.
Source: Own constructions (2012).

To insure successful integration of Spatial Planning and Water Management within these different levels and scales, South Africa needs to develop a shared and practical vision between Urban Planners, Water Managers and partnering stakeholders which have the capacity, willingness and tools to adopt the new approach of integrated, sustainable development. It is important that WSP is addressed and implemented at each of the identified scales; otherwise the approach will not achieve the incremental evolution in development practices needed to fully transition to water sensitive development approach. The proposed implementation of the WSP approach on each of the scales will be discussed accordingly.

Planning and implementation recommendations on National and Regional scale (Regional controls)

The Department of Water Affairs and Forestry (DWAF) should work closely with the South African Planning Commission, Department of Human Settlement and the Urban Development Institute of South Africa, together with other relevant stakeholders, to set the priorities for future land and water planning in South Africa. The guiding departments should be committed to deliver advice on water management issues in order to facilitate the land-use planning process in a timely manner and in co-ordination with other agencies. On National level South Africa needs to develop:

- A framework to guide integrated land and water management; supported by technical guidance for better urban water management;
- Include WSP within the guiding policies and legislation applicable to national and regional level, such as the IDPs and SDFs.
- Develop guidelines for preparing local water management strategies to inform local planning schemes, amendments or local structures plans;

Sustainable development of South Africa's water systems should be seen as the main aim for implementing WSP. By incorporating these principles and green landscape techniques of WSP will result in less storm water run-off, a reduction of the heat island effect that is typical of urban development, a reduction of pollution and sedimentation, decreased energy expenditures, and will help control warming of local water ways. WSP, along with its trans-disciplinary and integrated approach, will, in the South Africa's context, bring new issues into the local planning system, including new claims for policy attention, new problem areas, new criteria of plan alternatives and adoption, new data collection and information analysis, new concepts of spatial organization and urban design and new cooperation demands for implementation in existing administrative authorities. WSP must be implemented in the national South African planning approach, in order to integrate Water Planning and Management approaches and current Spatial Planning processes.

Chapter 2 elaborated on the characteristics of the South African environment and gave an indication of the importance of preparing and implementing new water legislation to guide future planning and sustainable

development. South Africa's current realities include overloaded sewerage system, poor access for maintenance, poor sanitation, low water pressure, extremely high density, poor access and services, tributaries blocked and polluted, informal settlements below flood line, pollution of river and many other problems. WSP can be used to address these issues, as illustrated in the table below, a summary of the potential application processes suitable specifically for South Africa's water situation and the benefits that WSP could provide in terms of South Africa's looming water crisis and fragmented planning approaches.

Table 45: Implementation of WSP as part of a Sustainable Development approach for South Africa

Implementing WSP in South Africa		
South-Africa's current reality issues.	Potential applications	WSP principles to be included.
Environmental dimension and natural conditions		
Climate change.	- Wastewater management and infiltration systems	- Reduces surface flows - Groundwater recharge
Low rainfall.	- Rain water tanks. - Rain Gardens - Green Roofs	- Portable Water storage for household uses.
Flooding.	- Bioretention systems	- Fine and soluble pollutants removal, including nitrogen and phosphorus - Streetscape amenity - Frequent flood retardation - Wildlife habitat
High evaporation rates.	- Vegetated swales - Wetlands	- Medium and fine particulate removal, including phosphorus removal - Streetscape amenity - Wildlife habitat - Community asset - Medium to fine particulate and soluble pollutant removal, including nitrogen and phosphorus
Low availability of run-off.	- Siphonic Roofwater Systems.	- Medium and fine particulate removal, including phosphorus removal - Rapid filtration prior to storage and reuse
Social dimension.		
Rapid population growth.	- Demand reduction	- Water limitation.
Need for development.	- Buffer strips	- Pre-treatment of runoff for sediment removal - Streetscape amenity
Water demand.	- Sediment basins	- Coarse sediment capture - Temporary installation - Pre-treatment for other measures
Pollution.	- Gross pollutant traps (GPTs)	- Reduces litter and debris, including organic matter - Can reduce sediment - Pre-treatment for other measures
Management of water resources		

Management of dams.	- Construction and Establishments	- Management of the construction site for minimising erosion and sediment
Poor maintenance water and sewerage systems.	- Monitoring Objectives and Effective Maintenance	- Ensure that WSP elements are actually constructed to specification
Approach taken by relevant authorities.	- Detailed WSUD Guidance Material.	- Implementation of WSP guidance material into all new developments for water sustainability and use sage.

Source: Own construction (2012)

At Regional scale planning areas are defined by political or geographic boundaries that can encompass multiple watersheds, cities and towns. It is important to include a trans-disciplinary planning approach (engaging a variety of stakeholders) to define region-wide development concerns, prescribe regional strategies and coordinate local actions. These agencies may also include regional transportation planning agencies and regional economic development corporations. The planning and implementation of WSP on regional level should be included in the current and future Spatial Development Frameworks (SDFs) and Integrated Development Plans (IDPs), in order to guide local scale planning and enforce the integrated approach between Water Management and Spatial Planning. The SDFs and IDPs should not only mention the critical water management issues (as currently captured), but provide insight on the future development visions in terms of Water Management and Spatial Planning, identifying adequate space and land-use to support such an approach, and set guidelines as to how it can be implemented.

Planning and implementation recommendations on Local and Municipal scale (Local controls)

The proposed implementation of WSP on a Local or Municipal level in South Africa was informed by the international best-practice approaches as captured in this research (cross-reference to Chapter 4). It was evident that in order to structure an integrated WSP approach on local level, three aspects needed to be addressed:

1. The need for interaction between Spatial Planning and Water Management plans in order to ensure that land-use plans do not contradict water goals and that water planning also takes broader landscape-related aspects into account;
2. The need to integrate water-planning-goals into all sectoral policies. This may be addressed by implementing impact assessment procedures for projects, plans and programmes that may have an impact on water resources and quality.
3. Consider elements and procedures that are common to several pieces of legislations (e.g. management plans, monitoring measures, public participation) and that could benefit from common databases, spatial information systems, and methods of communication.

With this in mind, a framework was created to address the challenges of integrated planning and WSP on a local level. This framework is summarised in Table 46, followed by the discussing and interpretation thereof.

Table 46: Framework to addressing challenges

Framework for integrated planning on local level		
Challenges →	Vision →	Strategies for action
- Creating a driver for change	- Liveability and sustainability	- Preparing for change
- Recognising the changing values of water services	- The many values of water	- Determine the value of water
- Overcoming the institutional divide	- Trans-disciplinary planning	- Complex water management objectives into urban development decisions
- Making it happen	- Adaptive and collaborate water sector	- Build a network of smarter, more active industries.

Source: Own creation (2012) based on IWA Cities of the Future Program (2010).

Each of these challenges listed in Table 46 will be discussed accordingly, addressing the visions and suggested strategies and actions to progress, in terms of integrating water planning and current Spatial Planning approaches and processes on a local and municipal level.

8.2.1.1. Creating a driver for change

Cities debate about the broad definition of sustainability, and planning at strategic level should cover a wide range of objectives. It is important to embody water-space or water-land issues among them. Urban Planners and Water Managers need to work together at the outset of plan-making processes to offer better information and new theories to emphasize the importance of keeping and protecting specific space for water. Public participation and consensus building needs to be encouraged in the planning process, the analysis and formulation of space for water based on the local context needs the public involvement and motivation. It is important to achieve the professional agreement between Urban Planners and Water Managers at first, and more importantly to ensure that all other stakeholders have an understanding of, access to, and involvement with management practices.

It is necessary to create a collaborative planning processes aimed at strengthening and mobilizing social networks to support the initiatives, requirements and incentives of water sensitive planning and design which can stimulate household, communities, cities to take appropriate behaviours (refer to Chapter 3). The following table captures certain suggested actions to create a driver for change and to implement WSP on a local level.

Table 47: Creating a driver for change.

Suggested actions to progress	<ul style="list-style-type: none"> • Simplify the vision, definitions and measures of a sustainable city.
	<ul style="list-style-type: none"> • Location selection and preservation framework have to be put forward with the consideration of water systems in the contents of strategy. Develop a city wide urban planning framework that establishes minimum liveability standards.
	<ul style="list-style-type: none"> • Ensure that integrated planning includes all stakeholders and provides outcomes for these areas.
	<ul style="list-style-type: none"> • Create a framework to assess planning options based on full lifecycle sustainability assessment
	<ul style="list-style-type: none"> • Develop resource accounts of the city's assets, resources, open spaces and biodiversity based on the principles of "urban metabolism".

Source: Own creation (2012) based on IWA Cities of the Future Program (2010).

8.2.1.2. Recognising the changing values of water services

Water services around the world are expanding from the traditional water and sanitation services into broader fields linked with the improvement of liveability in cities. It is no longer a need to plan for water usage, it is a necessity. The incorporation of WSP principles in the planning system requires the development of new spatial concepts for water systems which better reflect natural hydrological processes. In this regard, the watershed or catchment could be a useful spatial unit to take into account when considering the reduction of impervious area in land-use planning. Existing surface water bodies and wetlands can be used as important elements for urban spatial structure and thus need to be preserved, conserved or restored as far as possible.

Buffer zones or riparian corridors need to be included in urban afforestation and the green system. A trans-disciplinary approach is needed to identify water-related spaces and include (and protect) these spaces in the Spatial Planning processes, in order to control water problems and improve the quality of space. The following table captures certain suggested actions to ensure the recognition of the changing values of water services on a local level and to implement WSP accordingly.

Table 48: Changing values of water services

Suggested actions to progress	<ul style="list-style-type: none"> Clarify the definitions and principles of integrated water management.
	<ul style="list-style-type: none"> Framework to assess water management options (including centralised, decentralised, water efficiency, market based and WSUD options).
	<ul style="list-style-type: none"> Clarify roles and responsibilities for integrated water management.
	<ul style="list-style-type: none"> Investigate new sources within the city based on WSUD principles.
	<ul style="list-style-type: none"> Management framework covering risks, planning and decision making for an integrated water management portfolio.
	<ul style="list-style-type: none"> Review urban planning provisions to ensure they create opportunities for new WSUD.
	<ul style="list-style-type: none"> Urban planning integrates objectives of multiple sectors.
	<ul style="list-style-type: none"> Maximise the ability of water infrastructure to provide multiple community benefits.
	<ul style="list-style-type: none"> Utilise the water sector's technical expertise to define and communicate with the community on the concept of 'fit for purpose' water based on different water qualities.

Source: Own Construction (2012), based on IWA Cities of the future program (2010).

8.2.1.3. Overcoming the institutional divides

The water sector provides a specific service to cities, and is one of many essential services considered by Urban Planners when creating a new layout or development plan. However, although Urban Planners use the data and information as received from the water sector, it is not always interpreted correctly or to the full extent, and the planning and management of the water and water-spaces thus function in isolation. There is a need for the Spatial Planning and water sectors to work together to incorporate the increasingly complex water management objectives into urban development decisions. The utilization of information support systems is a precondition to reach consensus among the different interests and stakeholders during the plan-making process. The information about the landscape features and water quantity and quality records is helpful to raise awareness and understand the problems, to reach the consensus of planning goals and finally solve the problems co-operatively. Advocating water sensitive planning and design is beneficial to water systems as well as to urban development in the watershed. A trans-disciplinary planning approach should be followed when planning for water sensitive areas. The following table captures certain suggested actions minimise the institution divides and to implement WSP on a local level.

Table 49: Institutional divides

Suggested actions to progress	<ul style="list-style-type: none"> • Provide customer and industry-focused information on the economic, social and environmental costs associated with different water supply choices.
	<ul style="list-style-type: none"> • Create a water pricing strategy that is flexible and adaptive, linked to the availability of the resource.
	<ul style="list-style-type: none"> • Continue to build on community and stakeholder trust in the water sector
	<ul style="list-style-type: none"> • Investigate the potential to further develop water markets that might eventually provide greater choice for consumers.

Source: Own Construction (2012), Based on IWA Cities of the future program (2010)

8.2.1.4. Making it happen

Finally, the water sector faces the challenge of influencing Spatial Planning decisions at an early stage in central, regional and local governments. More implementation-orientated methods will be helpful to mitigate the negative effects of urban development on hydrologic regimes. It requires that planning at the strategic level concerns not only the long term vision but also the short term action, offering an open, democratic, participative environment for plan-making and plan implementation. At this level, it is essential to consider hydrology in the planning framework to identify sensitive water spaces and integrate them in shaping spatial form and the multi-functional landscape. Land use principles are advanced and grounded on water spatial concepts. Cost effective on-site design is encouraged to preserve the hydrologic functions of the landscape. The following table captures certain suggested actions to “make WSP happen” on a local level.

Table 50: Making it happen.

Suggested actions to progress	<ul style="list-style-type: none"> • Define the role of government and the private sector in the provision of water services (planning and policy versus service delivery decision-making).
	<ul style="list-style-type: none"> • Review best ways to engage local communities and the development industry in planning and decision making.
	<ul style="list-style-type: none"> • Develop a metropolitan integrated management plan that has objectives and outcomes across multiple sectors.
	<ul style="list-style-type: none"> • Identify any unnecessary financial and regulatory barriers that might restrict competition in the water sector.
	<ul style="list-style-type: none"> • Build the capacity of the community, industry and government to make informed choices that test, prove, demonstrate and deliver integrated water management.
	<ul style="list-style-type: none"> • Develop the mechanisms to identify the risks of integrated water options and ways to mitigate them.



Source: Own Construction (2012), Based on IWA Cities of the future program (2010).

The best way to integrate Spatial Planning and Water Management is to create a general vision of a sustainable future in which the challenges that have been addressed will be understood across these various planning sectors and among the different stakeholders. A shared vision can be developed by facilitating an interactive discussion between the many sectors that are, in isolation, developing their own visions for a water sensitive future on the one hand, and a spatial plan on the other hand. In this sense, one of the aims of the WSP approach is to develop a common language for sustainability and to create networks across these sectors and bridge the current gaps between Spatial Planning and Water Management approaches.

Planning and implementation recommendations on Project or site level (Source Control)



Detailed development guidelines are needed on the project or site-level in order to guide WSP and ensure the successful implementation thereof. This includes zoning ordinances, subdivision and land-use regulations and other planning tools needed to involve more specific issues such as the designation and protection of water sensitive areas, regulations of development density and onsite layout requirements for minimizing imperviousness. Integrating WPS into the site design requires integrating its principles into site master planning. This will optimize the interface between Spatial Planning and Water Management in practice, but also contribute to land-use efficiency, pedestrian and vehicular circulation and access, natural resource preservation and protection, parking, utilities, runoff management, recreation and landscaping. WSP planning principles should set project goals such as creating green space connectivity and similar non-structural stormwater controls and minimizing impervious surface, while design techniques include specific details such as where road widths can be minimized and where pervious pavements are needed. Accordingly, certain WSP design techniques were identified, based on the Australian best-practice case studies, and proposed for the Potchefstroom area (Chapter 6) to be implemented on a site-scale level. These planning proposals are captured in the following tables:

Table 51: Tanderrum Way versus Lekele Street

<p>Case studies</p>	<p><u>Tanderrum Way, Broadmeado (Australia)</u></p> 	<p><u>Lekele street, Potchefstroom (South Africa)</u></p> 
<p>Description</p>	<p>Tanderrum Way is the acts as the access point to a Secondary College and it connects to an existing street accessing Council Offices and the Broadmeadows train station. Cross reference to Chapter 5.5.4.</p>	<p>Lekele street is known as main street in Ikageng, Potchefstroom, it is heavily utilized by motor and pedestrian traffic.</p>
<p>Current reality</p>	<p>Tanderrum Way has an inverted road profile which collects and drains stormwater to the centre of the road rather than to the standard side kerb and channel</p>	<p>Lekele street along with many other similar main streets in Potchefstroom offers an opportunity to deliver a high level of public amenity as well as best practice sustainability and stormwater management also the creation of a public space that generates a strong sense of place and civic pride.</p>
<p>Design techniques</p>	<p>Already implemented:</p> <ul style="list-style-type: none"> - WSUD site design measure include: - A linear bio-retention swale; - A conveyance system with 200m² permeable pavers; - There are additional over 250m² of rain gardens in 25 locations. 	<p>To be implemented based on international example:</p> <ul style="list-style-type: none"> - WSP design techniques to include: - Bio- retention swales - Permeable pavements - Rain gardens
<p>Result</p>	<p>These layout design techniques allow the street to prioritise pedestrian traffic over vehicular movements without compromising the safety of either. The inverted road profile allows the collection of stormwater in the centre of the road and also facilitates the conveyance of larger floods waters. Additional stormwater runoff from footpaths can also be directed to garden beds for passive irrigation of trees and vegetation, reducing the water demand in public areas.</p>	



Source: Own construction (2012)

Table 52: Eastern Park Stormwater Harvesting versus Ikageng community Park.

<p>Case studies</p>	<p><u>Eastern Park Stormwater Harvesting (Australia)</u></p> 	<p><u>Ikageng community Park, Potchefstroom (South Africa)</u></p> 
<p>Description</p>	<p>The Botanic Gardens is an important natural and cultural resource for the community. Chapter 5.5.2</p>	<p>Ikageng community Park is situated alongside Lekele street, and functions as a space for relaxation. Unfortunately this area suffers from heavy waste pollution and it lacks a sense of place.</p>
<p>Current reality</p>	<p>Stormwater from a 47 hectare suburban area in East Geelong has now been diverted into the new storage dam within Eastern Park instead of flowing, untreated, out to Corio Bay. The new 7000m² storage dam has replaced a sporting oval (historically a manmade lake) adjacent to the Gardens.</p>	<p>The Ikageng Community Park along with many other similar parks in Potchefstroom offers an opportunity to act as a stormwater harvesting project in urban area by diverting the parks into new storage dams, instead of flowing, untreated as runoff water. This will also reduce the resilience on potable water and also reduced the playability on irrigations.</p>
<p>Design techniques</p>	<p>Already implemented:</p> <ul style="list-style-type: none"> - WSUD site design measure include: - A gross pollutant trap, - rock filled sediment pond and - sand filters captures all litter down to 5mm in size prior to the water entering the storage basin - A linear bio-retention swale; 	<p>To be implemented based on international example:</p> <ul style="list-style-type: none"> - WSP design techniques to include: - Constructed wetlands - Linear bio-retention swales
<p>Result</p>	<p>The construction of a botanic garden will engage a number of community activities were delivered to raise and enhanced community wellbeing and amenity through the provision of a walking path around the dam which will connect to the a variety of residential areas. These layout design techniques allow the park to features as a social benefit for the community.</p>	

Source: Own construction (2012).

Table 53: Langtree Mall Tree Pit versus Kerkstreet Street.

<p>Case studies</p>	<p><u>Langtree Mall Tree Pit (Australia)</u></p> 	<p><u>Kerkstreet street, “Wandelaan” Potchefstroom (South Africa)</u></p> 
<p>Description</p>	<p>The project involved upgrading the main pedestrian mall providing an opportunity to incorporate Water Sensitive Urban Design (WSUD). The capture and use of water in this project was identified as a priority at the very early stages of the design process. Chapter 5.5.9</p>	<p>“Wandelaan” is a popular street in Potchefstroom and offers a variety of shop alongside the street way. It is heavily utilized by pedestrian and vehicle traffic.</p>
<p>Current reality</p>	<p>The 26 tree pits and approximately 12.6m² per tree of permeable paving installed into this busy streetscape provide amenity and additional shade to the overall design of the pedestrian mall. The tree pits allow for treatment of stormwater and passive irrigation to the root zones when it rains.</p>	<p>Wandelaan offer opportunity for the implementation of various WSP techniques which will provide multiple benefits for the community, creating an engaging open Space and improving stormwater.</p>
<p>Design techniques</p>	<p>Already implemented:</p> <p>WSUD site design measure include:</p> <ul style="list-style-type: none"> - A linear bio-retention swale; - A conveyance system with 200m² permeable pavers; - There are additional over 250m² of rain gardens in 25 locations. 	<p>To be implemented based on international example:</p> <p>WSP design techniques to include:</p> <ul style="list-style-type: none"> - Bio-retention swales - Permeable pavers.
<p>Result</p>	<p>The installation of a significant number of advanced trees as well as an architecturally designed ‘outdoor room’ shade structure has contributed to the overall aesthetics and functionality of the mall. The inclusion of permeable paving into the design ensures that surface flows in a rain event are captured, allowing for passive irrigation of the trees through the root zone.</p>	

Source: Own Construction. (2012).

From the comparative analysis it is evident that there is scope to implement WSP design techniques on a site-level. This will, however, be subjective to good management and good governance support structures. These techniques can form part of the current layout and design standards as captured in the Redbook (CSIR, 2007). Urban Planners need to be aware of the importance of planning for water sensitive areas, and understand the possible design techniques that can be used to strengthen the WSP approach through Spatial Planning processes.

8.3. Conclusion

WSP is proposed as a possible solution to address the current water management problems in South Africa, through an integrated planning approach which link the Water Management and Spatial Planning disciplines. The WSP approach is based on the Australian WSUD approach which is proven to be successful in practice. For successful implementation in South Africa, WSP needs to be implemented on all planning scales and government levels as described above. This integrated approach needs to be enforced from a National perspective through guiding legislation, guided on a Regional level through the SDFs and IDPs, incorporated in the Local level in terms of the Local Municipality Planning Scheme and implemented on a site-level by means of design techniques. Figure 59 illustrates the possible implementation WSP on all levels of governance in South Africa.

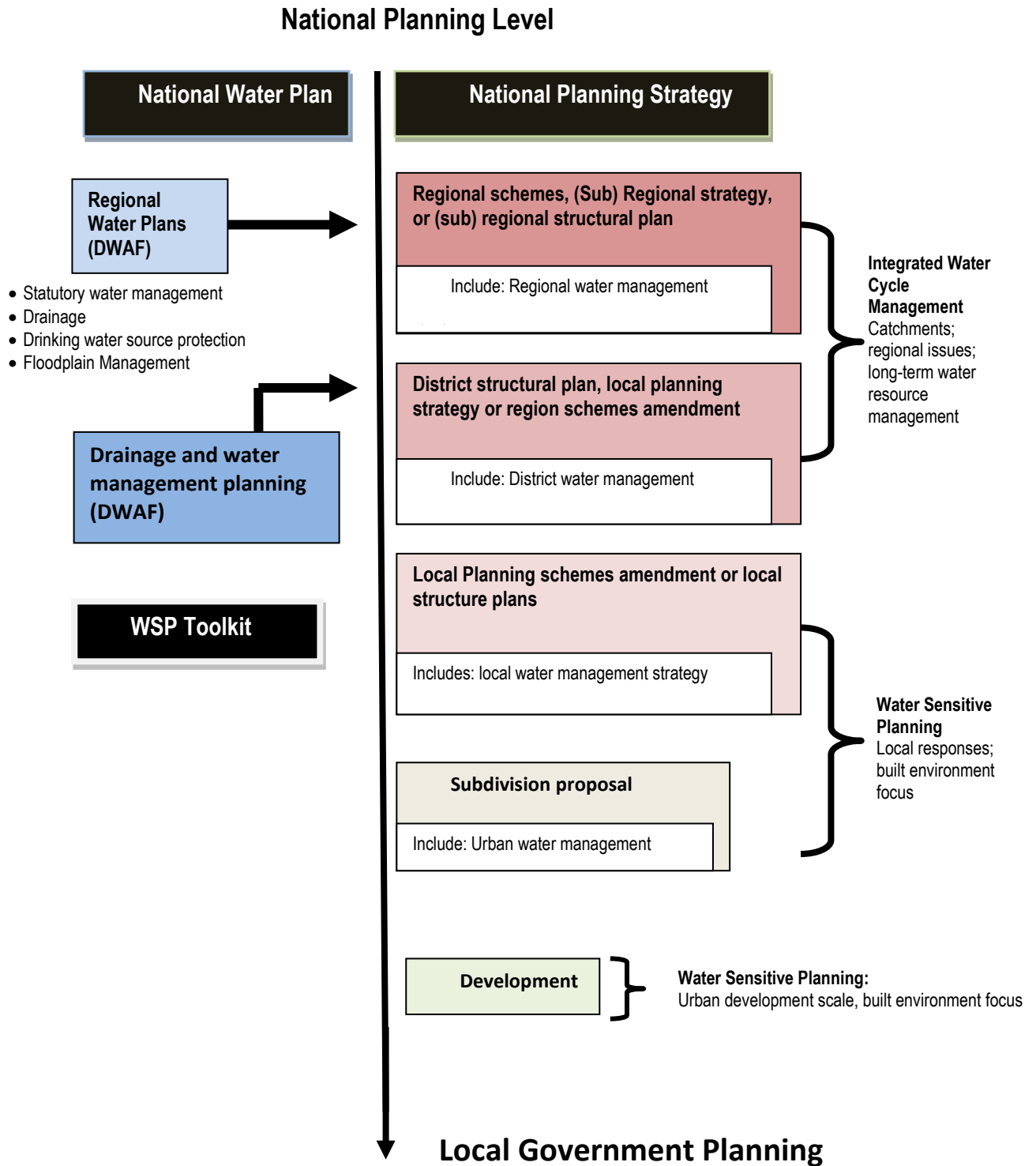


Figure 59: Implementation of WSP in South Africa. Source: Own construction (2012).

WSP is a trans-disciplinary approach and need to incorporate various stakeholders on each of the proposed levels of implementation. It is an integrated approach and needs to be aligned in all planning and policy goals. It is a practical approach to bridge current Water Management and Spatial Planning approaches and thus needs to be strengthening by adequate planning and design tools. These issues are addressed and captured in Table 54.

Table 54: Trans-disciplinary and integrated WSP approach in South Africa

Trans-disciplinary and integrated WSP approach			
Planning scale	Stakeholders	Planning and Policy goals	Planning and Design tools
National/ Regional level	<ul style="list-style-type: none"> - Environmental organizations - Regional Planning commissions. - Water Managers - Rural networks - Transportation departments - Multiple municipalities 	<ul style="list-style-type: none"> - Transit systems - Large-scale parks, contiguous trails and vegetated corridors - National and state regulatory compliances - Watershed planning - Solid waste management 	<ul style="list-style-type: none"> - Landscape and land use modelling - Urban Planners - Systems for Urban Stormwater Treatment and analysis - Economic developers - Professional stormwater modellers
Municipal/Local level	<ul style="list-style-type: none"> - Municipalities - Urban Planners - Water Managers - Economic developers - Environmental organizers - Developers - Builders and consultants 	<ul style="list-style-type: none"> - Jurisdiction planning - Infill and redevelopment - Policy development - Flood control - Plan review criteria 	<ul style="list-style-type: none"> - Modelling programs - Stream buffer ordinance - Stormwater regulations - Zoning specification - Water quality criteria for new development and retrofit projects
Project or site level	<ul style="list-style-type: none"> - Municipalities - Urban Planners - Water Managers - Communities and homeowner - Designers - Engineers - Consultants 	<ul style="list-style-type: none"> - Desirable home and work facilities and structures - Sustainable site designs - Pocket parks - Contiguous buffers - General overall sense of community 	<ul style="list-style-type: none"> - Project site reconnaissance - Design techniques - Stormwater Management Model - Best management practice selection and design

Source: Own Construction (2012)

Though the empirical research (Chapter 6) it was indicate that South Africa has enabling environments for the implementation of WSP activity. Focus must be redirected to the decision-makers and their ability to sustain water resources, by obtaining greater water resources, since the pressure on the municipality to provide services are escalating out of hand and specifically Potchefstroom will not be able to keep up with the current water demand pressures in the next 5 year (Interview, Nel.B).

This is why WSP must be implemented at three different scales as indicated. In order to actively benefit from WSP in the South African context it would be suggested that planning on national level could incorporate WSP legislation, SDF's and IDP's on regional level must be equipped with a WSP Toolkit, together with municipal Schemes and Zoning requirement. Referring to the title of the study, Water Sensitive Planning: An integrated approach toward sustainable urban water system planning in South Africa, it is believed that the study has successfully linked the theoretical and empirical findings. Furthermore, the proposals mentioned in the study will be addressed in a PhD study to commence next year, based on the findings of this research.

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Appendix A

Appendix A:

Interview questions for South African experts.

Interview questions for Spatial Planners.

Interviews were conducted with various stakeholders whom hold a respected position in the industry of urban planning and water management. Table 55 summarises the level of expertise of the individuals whom participated in the survey.

Table 55: Interview Participants.

Participant	Position of expertise
BCK Nell	Water Quality Monitoring- Tlokwe City Council
L. Carson:	Department Infrastructure- Tlowke City Council
A. Venter	Water managers and private water licensing consultant Potchefstroom.
S. Villiers	Town and Regional Planner – Tlokwe City Council
C. Heimann	Executive Manager ISRDP at National Department of Provincial and Local Government

The study did not feel the need for a community survey as the approach towards integrating urban planning and water management is still a new concept in South Africa.

Interview questions for South African experts

Interview questions for urban planners in Potchefstroom

1. What kinds of categories is the surface water in Potchefstroom classified based on planning standard?
2. Which kinds of water-problems are being faced by urban planning in recent years?
3. What kind of work has urban planning department done to deal with the present water-related problems?
4. Has the research on hydrologic effects of land use been done before?
5. How is the cooperation of urban planners and water managers to define 'blue', 'green' and 'grey' lines and what are the major obstacles for the implementation?
6. What are the major responsibilities of urban planners to deal with water-related problems?
7. How do the urban information systems support for the water-related problems analysis and what are the major achievement and barriers?

Interview questions for water managers in Potchefstroom

1. What kind of work has water affair department done for tackling water-related problems?
2. Has the research on hydrologic effects of land use been done before?
3. What is the role of water affair department in the lake protection in Potchefstroom? What are the obstacles for implementation?
4. How is the process of institutional reform in Potchefstroom and what are the effects of it?
5. What are the comments and suggestions on the cooperation with urban planning department?
6. How is the process of the construction of spatial information system on water system? What are the achievement and obstacles for using it to support the analysis on water-related problems?

Interview questions for South African experts

Conceptual and Practical aspects

1. What are the major problems of surface water and how it is related to spatial policy and land use planning in South Africa?
2. What are the main functions of surface water in the South African spatial planning policy and how does 'giving space for water' insert as a primary principle in land use planning at national, provincial and local levels?
3. From 1850 to 1940, the amount of water surface had greatly decreased when water lost its regulating role in the design of urban development.
 - a. What is the main water problem raised from this transformation?
 - b. From spatial planning perspective, what are the lessons which could be learned from this experience?
4. After 1970s, there is the renewed interrelationship among urban planning, landscape design and hydraulic engineering. 'Giving space for water' becomes a primary principle of South African spatial policy. Moreover, it implicates the creation of new water bodies.
 - a. What kind of benefits has the new spatial concept brought about on the relationship between urban development and water?
 - b. Where and how is the new water body located and created? What are the conflicts for such an approach?
 - c. Is the space-for-water policy being relaxed now because of local/regional opposition?
5. What are the major problems concerning the river cities in the South African? How can urban network planning be useful for conflict reduction of space for urbanization and space for river?

Procedure aspects

6. During the planning authorized, what kind of process should spatial planning follow when involving 'space for water' issues in?
7. Which organizations play the important role of the decision-making?
8. How are conflicts between surface water management and land use (especially for urban development) resolved?
9. Which organization play the major role in the implementing the spatial planning policy concerning the space for water and to what extent can they play?
10. What is the percentage and respective purpose of the financial support for the surface water management at national, provincial and local level?
11. What is the effect in recent years?
12. What is the role of the various levels of government in managing the relationship between surface water and land management (national, provincial and local)?
13. Are the roles and responsibilities clearly defined?

Information aspects

14. Are the risk calculation models necessary for spatial plan-making for the river cities in the South Africa?
15. Is the development of spatial scenarios for surface water management an important instrument in South Africa?
16. What organizations have a leading role in the development of spatial scenarios and how is the participation of other organizations with complementary or conflicting mandates arranged?
17. What are the current gaps in knowledge in relation to the interface between surface water management and urban development (land use) that are now being addressed or should be addressed by research?