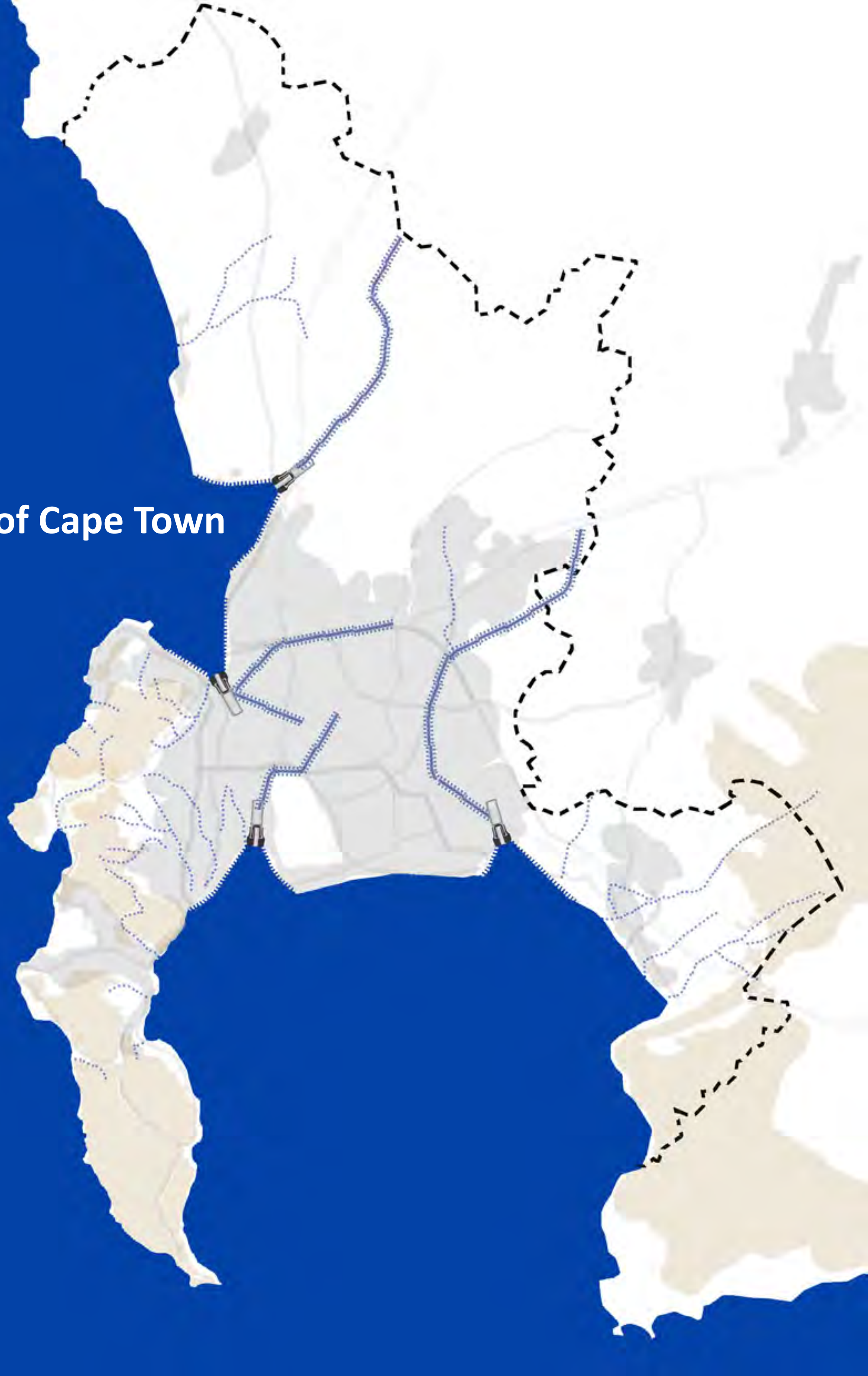
Every Last Drop:
The Role of Spatial Planning in Integrated Urban Water Management in the City of Cape Town

Rebecca Cameron



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Acknowledgements

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My Father's World

- Maltbie D. Babcock, 1901

This is my Father's world,
and to my listening ears
all nature sings, and round me rings
the music of the spheres.
This is my Father's world:
I rest me in the thought
of rocks and trees, of skies and seas;
his hand the wonders wrought.

This is my Father's world,
the birds their carols raise,
the morning light, the lily white,
declare their maker's praise.
This is my Father's world:
he shines in all that's fair;
in the rustling grass I hear him pass;
he speaks to me everywhere.

This is my Father's world.
O let me ne'er forget
that though the wrong seems oft so strong,
God is the ruler yet.
This is my Father's world:
why should my heart be sad?
The Lord is King; let the heavens ring!
God reigns; let the earth be glad!

Abstract

Water is essential to life. However, the current urban water system and environment is degrading freshwater ecosystems, nature's ability to replenish resources and the relationship between people and the environment due to unsustainable consumption and discharge patterns. This is an international phenomenon and in the City of Cape Town, where water is considered a scarce resource, it is particularly urgent and important. This is due to the expected population growth, and an increased water demand as the current services backlog is addressed and living standards increase which when combined with the stresses of Climate Change and the associated future uncertainty make it even more alarming. These issues have direct and indirect implications that are too often hidden from and invisible to the public, especially with regard to the spatial form and structure of the City, which occurs through formal or informal processes of management and investment. While there is a movement towards tackling these issues, through the Integrated Urban Water Management Paradigm, there has been little physical change manifest in urban areas where the source and effects of these problems are so acutely experienced.

This study has therefore sought to understand how spatial planning can be utilised as a tool to aid the transition to a more water-secure future through enabling sectoral integration and spatial co-ordination; where water influences the form and structure of the City. This is based on the premise that freshwater ecosystems and the role and effects of the urban water system are poorly addressed in spatial planning. Strategic Spatial Planning, unlike land use management, is a process of long term future imagining that is well-positioned to address the conflicts and tensions that arise through the implementation of a variety of sectoral policies with competing interests while including the voice of multiple stakeholders. In light of this, this study has undertaken a review of international and local literature to theoretically locate this study. This is followed by a contextual spatial and policy analysis of Cape Town to better understand the key priorities for water and urban development in the area. Using these two as a platform to guide appropriate intervention, a Spatial Development Water Framework (SDWF) has been created to propose a new water and development paradigm in Cape Town. This plan is governed by the principles of reverence, restoration, restraint and responsibility. Through acknowledging the spatial relationships between people, their activities and freshwater ecosystems this SDWF offers the opportunity to promote a more cyclical flow of resource use, the use of ecosystem services for more resilient and less energy dependant infrastructure, increased local subsistence and an improved relationship and connection between people and their water environments. It is through these strategies that it could be possible to transition to an increasingly secure water future in the City of Cape Town for improved social and ecological health, connected communities, shared prosperity and an intelligent water system.

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Chapter One:

Introduction

Context and Significance of this study

Water is essential for life. It is a component of all natural and human systems, whether a pathway or resource (Wilson and Piper, 2010). Water surrounds us in our oceans, polar ice caps, lakes, rivers, aquifers and atmosphere but less than 1% is accessible freshwater available for consumption by humans, plants and animals (NOAA, 2014). As seen in Figure 1.1, while water does exist in a well-known cycle of replenishment, this has been altered by anthropogenic actions which have degraded the water system through misappropriation and pollution (Bahri, 2012). Globally, human activities consume 50% of all renewable and accessible freshwater (EEA, 2009) yet 783 million people are still without access to safe drinking water (UN Water, 2013). As populations continue to grow and rates of urbanisation rise, the direct demand for water is estimated to increase by 19% by 2050 while the indirect demand, through food and energy production, is estimated to increase by over 50% (UN Water, 2013). This escalation in demand is accompanied by an expected reduction in supply as a result of global climate change (Wilson and Piper, 2010). This confluence of events and factors results in water being increasingly recognised as one of the most critically stressed resources on Earth.

As classified by the World Resources Institute, South Africa is currently a water scarce country[1] that is experiencing high water stress (Reig *et al*, 2013), as seen in Figure 1.2. Furthermore, it is not only the availability of water but also access to clean water of acceptable quality which is predicted to be "the single greatest and most urgent development constraint facing South Africa" (Scholes, 2001:51).

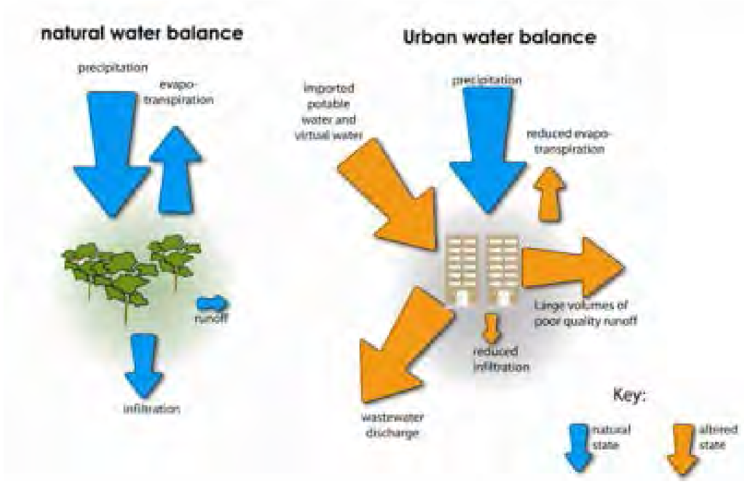


Figure 1.1: A diagram depicting how anthropogenic activities alter the natural water cycle (Healthy Waterways, 2011)

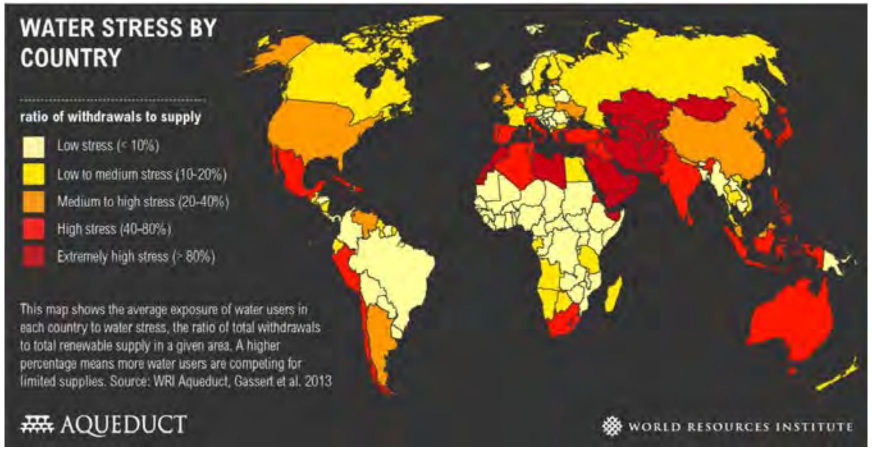


Figure 1.2: A map showing the water stress experienced by countries globally. South Africa is ranked as a high water stress country. (Reig et al, 2013)

1 South Africa has less than 1000m3 of freshwater available annually per person.

Access to safe water and adequate sanitation are the two fundamental requirements for human well-being and dignity. Every person in South Africa has the right of access to clean freshwater as stated by the Bill of Rights enshrined in our Constitution (RSA, 1996). Water is therefore not only relevant to ensuring environmental sustainability but holds relevance to issues of economic equity and social justice too. However, due to the environmental degradation of water sources and sinks, linear water use systems and the unpredictability of future water provision due to climate change, it is uncertain whether this life-giving resource will be available for all to access. This, in turn, could restrain further socio-economic development in South Africa (Jewitt, 2002).

This is further exacerbated in the Western Cape, a province of South Africa, by the increasing population and accompanying land use activities; pollution of water sources; and the high percentage of irrigated crops coupled with the restrained geographical location of water with the region's arid interior. More specifically in the City of Cape Town, the provincial capital of the Western Cape, severe strain is placed upon existing water resources to maintain and increase supply to meet the demand from agriculture, households and industry. This strain is expected to increase as demand is projected to exceed supply by 2019, as seen in Figure 1.3, without factoring in the influence of a changing climate where drier and warmer conditions are predicted (WCPG, 2012). These factors therefore make the City of Cape Town a vital area of study to investigate the journey to an increasingly water secure region.

The use, management and discharge of water from urban systems and human activities therefore have a vital role to play in ensuring water sustainability. In response to this impending crisis, the concept of Integrated

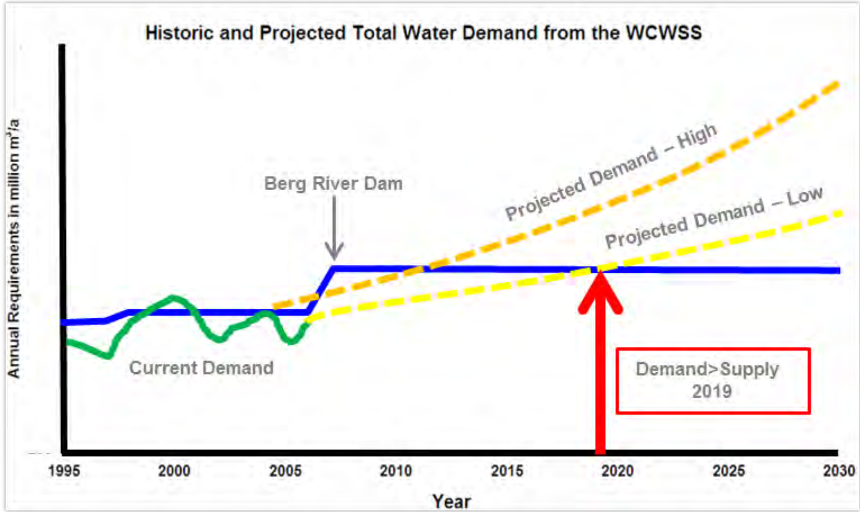


Figure 1.3: Berg Water Management Agent Historic and Projected water demand in comparison to supply (Western Cape Government, 2012: 62)

Water Resource Management (IWRM) has been passionately pursued by organisations such as the World Bank and the United Nations as an alternative approach to conventional water resource management. While there are multiple definitions of IWRM, the most accepted is provided by the Global Water Partnership (2000: 22) who defines it as,

> *"A process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems."*

The aim is to move from the conventional approach where aspects of the natural and urban water cycle are managed in isolation to an approach where they are managed as integrated parts of a cohesive whole. From this, Integrated Urban Water Management (IUWM) has been developed where the scale of implementation is limited to an urban area rather than a river basin, as in IWRM. The principles of IUWM are being applied internationally and in South Africa with the aim of holistically improving the resilience and sustainability of clean water supply and waste water treatment. As stated by Global Water Partnership, IUWM brings together fresh water, wastewater, storm water, and solid waste to enable better management of water quantity and quality (Bahri, 2012). The principles include environmental, economic, social, technical, and political aspects of water management to better align urban water flows with natural water cycles to enable sustainable development and livelihoods for all citizens. While this management framework has been promoted globally since the early 1990's, for more than 20 years now, successful implementation still remains elusive due to a lack of identifiable tools to apply these principles in real ways (Biswas, 2004 and Merrey, 2008).

From this definition, the apparent objective of IUWM is to enable a pathway to improved sustainable development. Currently this buzzword, 'sustainable development', has multiple definitions in different contexts, therefore to go beyond the definition offered by the Brundtland Report[2], Edgar Pieterse (2011:312) provides the following framework for applying it to the context of the Global South:

> *"[Sustainable Development is] a robust conceptual framework [that] must tie together three critical meta domains of urban transition that need to be pursued simultaneously if we are serious about advancing sustainable human settlements and cities. These domains are sustainable infrastructure, the inclusive economy and efficient spatial form, glued by processes of democratic political decision-making."*

In light of this framework, while current IUWM practices in South Africa encourage a rethinking of present infrastructural, economic and governance systems (Mitchell, 2006 and Armitage, 2013) there is minimal discussion with regard to the need to better integrate spatial planning and water management. As stated by Woltjer and Al (2007:212),

> *"the majority of decisions with regard to water management are made without reference to spatial planning issues related to urbanization and population growth, and conversely development and land-use decisions are also made with little consideration of their effects on water systems."*

Therefore, with the competition for access to water expected to become even fiercer between domestic, recreational, agricultural and industrial land users; it is necessary to intervene not only through policy but intentionally through spatial planning too.

More specifically, spatial planning is concerned with "*the problem of coordination or integration of the spatial dimension of sectoral policies through a territorially-based strategy*" (Cullingworth and Nadin, 2006: 91). Spatial planning is therefore considered more complex than land-use planning as it addresses tensions and conflicts between competing policies and users to promote a more rational arrangement of activities and to reconcile policy objectives (UNECE, 2008). With regard to the need to address future water availability and management practices, while enabling sustainable livelihoods; spatial planning comes to the fore as a tool for integration and sectoral collaboration. This is because, as Wilson and Piper (2010:30) put forward,

2 The definition of Sustainable Development provided by the Brundtland Commission in Our Common Future (1987: 427);

> *"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs".*

"*spatial planning has a vital role to play in assisting the process of minimizing conflicts and identifying synergies between mitigation and adaptation through aligning and organizing the spatial consequences of policy decisions*". This is referred to as horizontal integration and, as spatial planning is prevalent in municipal, provincial and national government spheres it also facilitates vertical integration too. This dissertation therefore investigates the use of spatial planning as a tool for the improved integration and implementation of IUWM to enable the transition to an increasingly secure water future.

Philosophical underpinning of Study

Figure 1.4: A diagram representing the nested systems of environment, society and economy resting on the platform of governance (NSSD1, 2011:1)

The philosophical position which underpins this dissertation holds that as water is essential for all life, it fundamentally connects and supports the functioning of the environment, society and the economy. These form part of a nested system of life on earth where the environment is the platform on which society and, in turn, economic structures exist and operate, as seen in Figure 1.4. The relationships that exist within this system require that each smaller system functions within the parameters of the larger system to enable symbiotic resource flows with the aim of creating a more environmentally and socio-economically sustainable region to benefit all citizens and the natural environment. This refers to Systems Theory which seeks to engage with a holistic view of components and the interrelationships among the components in a system (Berkes and Folke, 1991). Often Systems Theory is used within biology to study an ecosystem, however with its application to all of earth, including humans, the biotic and the abiotic; it is a useful lens to begin to comprehend the complex interconnectivity that exists as a web of relationships in the universe. The application of Systems Theory, especially in this time of unprecedented uncertainty, expresses a need for humility before the natural world. Humility means to acknowledge that humans are unable to fully recognise and comprehend all of these relationships and their complexity therefore our actions should display caution and restraint. With regard to human-nature relationships, this theory requires that humans are viewed within, rather than isolated from, ecological and abiotic systems. This has led to the concept of Urban Ecology where cities and towns are viewed as one of the processes that exist within an ecological system. As stated by Marina Alberti (2004; 245);

> *"Urban Ecosystems evolve over time and space as the outcome of dynamic interactions between socio-economic and bio-physical processes operating over multiple scales".*

This definition speaks to the flow of materials between human activities and the natural world highlighting the importance of where resources come from and where waste is going. The impacts of our consumption are therefore more keenly connected to the success of our livelihoods; throwing something away is no longer beyond our borders of care but rather impacts the system we call home. This also acknowledges that the health and well-being of human settlement is embedded within the health and well-being of the local and global environment. Aldo Leopold has framed this concept as the *Land Ethic* which he states (1968: 203);

> *"changes the role of Homo sapiens from conqueror of the land-community to plain member and citizen of it. It implies respect for his fellow-members, and also respect for the community as such"*.

This concept therefore binds human settlement and growth to the limits of the ecological system and, if being exceeded, the urban system is considered unhealthy and unsustainable and therefore must be changed.

Recently, research was undertaken by 28 internationally renowned scientists in 2009 to identify and quantify nine planetary boundaries which if exceeded could result in abrupt and irreversible environmental changes which would irrevocably harm humanity's existence on Earth (Stockholm Resilience Centre, 2014). This is referred to as the Planetary Boundaries and, as seen in Figure 1.5, three of these have been grossly exceeded already, namely biodiversity loss, the nitrogen cycle and climate change, while the others edge ever closer to the advised limit. Currently these relationships are experiencing strain due to the dominance of human activities, such as agriculture, industry and households, and are expected to worsen with increasing uncertainty of future resource availability due to climate change and increased demand from people. Therefore a primary goal of current development planning and initiatives should be to ensure clean water provision and safe access for all of the current population along with enabling those same rights to be experienced by future populations too. This is referred to as intra- and inter-generational equity and equality. Also, as climate change will make it more difficult for these needs of water provision to be met than is currently experienced, greater weighting should be given to the provision of future resources through protecting, restoring and enhancing current water sources and flows. Therefore, it is necessary to employ more holistic, integrated and strategic planning methods to positively intervene in a world of ever-increasing complexity and uncertainty.

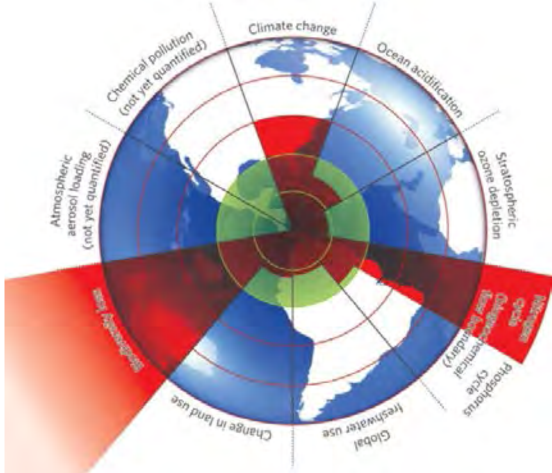


Figure 1.5: A diagram depicting the concept of Planetary Boundaries. Each segment is representative of one of the nine bounadries with green indicating the permissable limit and red indicating the current effect of human activities. As seen, three of the nine boundaries are currently exceeded.(http://theoverthinker.org/wp-content/uploads/2013/10/9-planetary-boundaries.jpg)

Scope of Study

The scope of this dissertation is limited to the anthropocentric water use at the metropolitan scale of the City of Cape Town. While this study recognise the right of the environment to access clean freshwater sources to allow for ongoing system functioning and rejuvenation, the primary focus of this research will be on anthropocentric water use in Cape Town, as the most dominant force that influences resource consumption due to the highly urbanised and sizable population present.

The focus area for this dissertation is the City of Cape Town, as seen in Figure 1.6, which is adjacent to the Stellenbosch and Drakenstein Municipalities which are grouped into the Berg Water Management Area. This scale enables a more holistic view of water usage with the aim of further integration and collaboration across various sectors, professionals and academics, as found in urban planning, civil engineering, urban water management, and national and provincial government water and development departments.

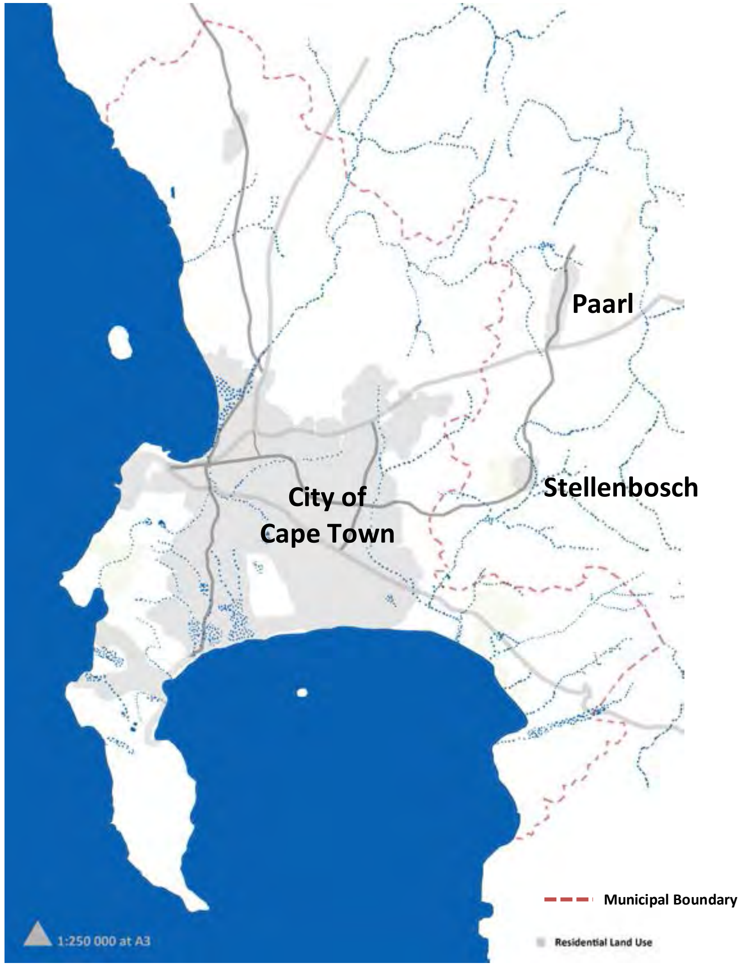


Figure 1.6: A map of the study area, the City of Cape Town, located in the Berg Water Management Area (Author's Own)

The primary and secondary research questions bound the extent of this study. The primary research question is: What is the role of spatial planning in Integrated Urban Water Management in the City of Cape Town?

The secondary questions include:

- What are current international approaches to the integration of spatial planning and urban water management and how applicable are these to the context of the City of Cape Town?
- What spatial planning issues currently impact water management in the City of Cape Town?
- What is the current urban water cycle and capacity in the City of Cape Town and how is this expected to change in the future?
- What water uses and issues currently impact spatial planning in the City of Cape Town?
- What and where are the sources and sinks of water for the City of Cape Town and what are the current or expected spatial planning threats and opportunities to these areas?
- How can spatial planning positively intervene to enable sustainable water management practices?

The research outcome of this dissertation is a Spatial Development Water Framework (SDWF) for 2055 for the City of Cape Town with water efficiency, sustainability and resilience at its core through implementing strategies of restraint, reverence and restoration. This SDWF promotes environmental recovery and enhancement while reducing anthropogenic water use through the implementation of cyclical systems and wise land use decisions. This is to enable responsible enjoyment of the City's freshwater resources to support adequate, satisfied and sustainable livelihoods.

Limitations of Research

There have been a few limitations experienced in this study. The foremost was the time constraint of having only five months to undertake all aspects of research, conceptual development and writing; with the second being a lack of sufficient and current data, especially for smaller non-metropolitan municipalities. This has limited the depth and breadth to which this research could be undertaken. The first constraint this has imposed is the scale of the study. Originally, the study was to consider the urban water cycle in the Cape Town City-region which includes the Drakenstein and Stellenbosch Municipalities; however, due to these limitations, the study has been confined to the City of Cape Town. This does not drastically alter the purpose and outcome of the study as it is focused on the anthropogenic water use of the region, of which Cape Town is the greatest consumer and contributor. However, to holistically engage with IUWM and IWRM it would be more beneficial to study the use and discharge of water in the functional region of the Cape Town City-region. Secondly, these limitations have also affected the analysis phase where the research is based on secondary and tertiary data with minimal opportunity to interview and engage with stakeholders in the process. The lack of stakeholder participation in the development of the SDWF and associated strategies is of concern as it is a fundamental principle of IUWM. This has been addressed, in part, by using a high proportion of government documents in which public participation and analysis of public opinion has already taken place. This limitation is further resolved in the final chapter of this dissertation where further research options are presented to present an understanding of this study as being a single contribution of a greater body of research in this field. Despite these limitations, the scope of this dissertation is sufficient to garner a legitimate investigation into the role of spatial planning in Integrated Urban Water Management.

Structure of Study

The structure of this dissertation is guided by the primary and secondary research questions and is presented in a series of chapters. This dissertation begins with an overview of the methods employed for this investigation and follows, in the second chapter with a thematic review of relevant international and national literature on Integrated Water Resources Management, Integrated Urban Water Management (IUWM), Spatial Planning and the need for integration between these spheres of knowledge and practice. With this review, the current theoretical discourse and context is understood in greater depth and acts as a framework in which to locate the contextual analysis of the City of Cape Town. In the third chapter, a case study is undertaken through the use of a desktop study of national, provincial and municipal policies, plans and documents. The aim of this case study is to determine the flow of water from sources to sinks, water issues that affect the long term sustainability of the region and to identify opportunities and constraints for intervention through the lens of IUWM. This study also includes a review of the current spatial informants across the provincial and municipal spheres of government that impact the region to understand the current state of water discourse within the planning paradigm.

This body of research then acts as a foundation on which to locate the design development of the Spatial Development Water Framework (SDWF) for the City of Cape Town as a vital tool for improved implementation of the principles and practice of IUWM, as captured in the fourth chapter. In this chapter, this dissertation revisits international literature to identify applicable precedent, planning, management and implementation practices, from which lessons can be learned for the benefit of water security in the City of Cape Town. More specifically, the case studies of Lima, Peru and Melbourne, Australia are drawn upon. The intervention is then guided by the concepts of restraint, responsibility, reverence and restoration of water in this metropolitan municipality. The next chapter, Chapter Five, outlines the suggested implementation for the SDWF through identifying the roles and responsibilities of various actors and the phasing layout for action. The final chapter concludes this study and reflects upon the process and lessons learnt. This is accompanied by a brief investigation into further research questions that are ignited from this study as opportunities to advance this field of research.

Methods and Techniques of Research

Research Methods

A research method refers to the process used for gathering information and data. The research methods to be used for this dissertation include both quantitative and qualitative methods. Qualitative methods refer to analysis which is more subjective, interpreted and text or image based while quantitative data is objective, precise and numerically based. Both of these methods have value in this research in order to compile a holistic research base on which to locate the development of a SDWF for the City of Cape Town. When determining the research method(s) most appropriate for a study Yin (2009: 8), as seen in Figure 1.7, suggests that three factors be taken into account; these are the type of research question, the amount of control over events that is required and the whether the research is focussed on contemporary events.

METHOD	(1) Form of Research Question	(2) Requires Control of Behavioral Events?	(3) Focuses on Contemporary Events?
Experiment	how, why?	yes	yes
Survey	who, what, where, how many, how much?	no	yes
Archival Analysis	who, what, where, how many, how much?	no	yes/no
History	how, why?	no	no
Case Study	how, why?	no	yes

Figure 1.7: Table showing applicable research methods as per the required research outcomes. Case Study is highlighted as the relevant research method for this study (Yin, 2009: 8).

Case Study

As mentioned, the primary method used in the research is the case study method. This method is defined as "*an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between the context and phenomenon are not clearly evident*" (Yin, 2009: 18). The case study method allows a researcher to produce context-dependant and value-driven knowledge of a specific area (Flyvbjerg, 2006). As this research is focused on the City of Cape Town it is a valuable research method. This method of research has been identified as the most appropriate for this study's research purposes because the case study inquiry reveals how a varied set of factors interact to create the distinctive environmental, social and economic characteristics of a place and it is useful for acquiring deeper insight into the developmental factors of that location (AAPS, 2009). Moreover, the case study inquiry benefits from the previous development of theoretical propositions to guide data collection and analysis

(Yin, 2009) which further validates the review of literature included in the study as a basis for research. This non-linear research method also suits the design method for the iterative conceptual design development process which requires review and revision as integral to the process. However, the disadvantages of this method include a prejudice against this form of research as there is no strict methodology to be adhered to and can therefore be accused of a lack of academic rigour through presenting somewhat swayed outcomes (Yin, 2009). The researcher however must endeavour to overcome this disadvantage through ensuring an accurate and non-biased representation of all data. Secondly, a case study does not represent a sample but rather expands and generalizes theories; that said it is difficult to generalise from a case study therefore the same research will be required in other places to determine a similar outcome.

Research Techniques

Research techniques differ from research methods in that the latter refers to the process of data collection whereas the former refer to the strategies by which the data is collected. While one research method is employed in this study, there are multiple research techniques used to garner a more holistic and thorough investigation of the study area. The research techniques used for this study include interviews, desktop research, non-participant observations, and data analysis.

Interviews

This technique allows for a more in-depth understanding of the topic through discussion with those directly involved. A semi-structured interview technique was used to allow for some freedom of opinion and adaptation to individual interviewees. The strength of this technique is that interviewees' responses can be transcribed and then used directly in the research for a more well-rounded response to the topic. However, the limitations are that this technique can be time-consuming, the personal bias of the interviewee must be taken into account and the interviewer needs to be aware of and prevent the use of leading questions which could guide a response in a certain direction. These limitations are addressed through research which adheres to a well-constructed time schedule; to be aware of the body language, words and attitudes of the interviewee when responding to questions; to be aware of bias, and to compile a list of questions prior to the interview so that leading questions can be removed.

Desktop Research

This technique is used to undertake a literature review to understand the various theoretical standpoints from contemporary authors on the topics of IWRM and of the integration of spatial planning and IUWM. Another desktop study is undertaken to gather data on the current water flow of the City of Cape Town (location of sources and sinks, threats and capacities) and to analyse the current Urban Water Management Documents and strategies used in and by the City of Cape Town. The strength of this technique is that large amounts of information can be investigated however; the limitations of this technique are that the outcome can be quite self-referential and contain personal bias as this is an individual exercise. This limitation can be addressed through discussion with the researcher's supervisor on the topic and to ensure that there is rigorous justification for response to the research, collecting information from various sources and different theoretical standpoints.

Non-participant Observations

This research technique will have a specific focus on mapping as a tool for analysis. This allows the researcher to spatially locate the analysis to identify overlapping concerns, risks and opportunities in the region. This is especially important as the spatial representation of the analysis will inform the research outcome of the Spatial Development Water Framework.

Data Analysis

Once the data has been collected, interpretation of data is required. This research uses mixed methods for this task by through explanatory interpretations to explain the occurrence of certain phenomena and evaluative interpretations to assess the findings.

Conclusion

Water has integral role in the continued existence of life on Earth. This, combined with the uncertainty facing its future availability due to increased demand, environmental degradation and climate change, increasingly makes water one of the most critically stressed resources. This not only affects direct water consumption but indirect consumption through food and energy production and environmental service provision thereby making water a resource that holds multiple values for a diverse group of stakeholders. Integrated Water Resource Management (IWRM) and later Integrated Urban Water Management (IUWM) therefore gained popularity as a paradigm or framework to engage with this increasing complexity and to better align anthropocentric water use with that of natural systems. This is made possible by viewing all water use as part of a greater system of global water; moving from a sectoral to integrated approach. The key goal of this shift was to promote sustainable development to improve the livelihoods of citizens worldwide. With Edgar Pieterse's critique of sustainable development and its applicability to the Global South, three spheres of focus are proposed for improved implementation of sustainable development imperatives. These include infrastructure, governance and spatial planning. While current IWRM and IUWM frameworks focus on the former two spheres, implementation of this integrated paradigm still remains elusive. This study therefore focuses on the role of spatial planning in IUWM to act as a tool for better implementation, specifically in the City of Cape Town.

Chapter Two:

Literature Review

Introduction

Water is increasingly acknowledged as one the world's most critically stressed resources (Bahri, 2012; UN Water, 2013; and Wilson and Piper, 2010) as a result of increasing demand and decreasing quantity and quality. This can be attributed to population growth, pollution of water sources and sinks, and droughts and floods exacerbated by global climate change. Furthermore, it is increasingly acknowledged that in order to manage water in a sustainable and integrated way that one has to involve multiple stakeholders. These include private and public sector users, the general public and public-private partnerships concerned with provision of water for both sustainable human livelihoods and ecological resilience. Therefore, as stated by Medema *et al* (2008: 1);

> *"It is now widely accepted that complexity, variation, and uncertainty are inherent properties of linked social and natural processes and that natural resource management strategies must somehow reflect these properties in the pursuit of sustainability".*

Consequently new paradigms of water planning, intervention and management have arisen in many parts of the world with the aim of ensuring the provision of water to support sustainable livelihoods, ecological flourishing and biodiversity. This paradigm is referred to as Integrated Water Resource Management (IWRM) when applied at the scale of a river basin, and Integrated Urban Water Management (IUWM) when applied to the scale of a city or an urbanized area. In this study these terms are not used interchangeably. As IWRM was established prior to IUWM, the former is the foundation and acts as a general guide, while the latter puts forward a more specific approach to water management in urban areas where human activities have a larger influence on water systems. To gain greater understanding and insight into the creation, purpose and implementation of this paradigm, this chapter reviews contemporary international and national literature written on the subject of IWRM and IUWM. The literature review explores more general insights to give a broad and overarching theoretical framework in which to locate the more specific water context of the City of Cape Town that is discussed in the next chapter of this study.

This thematic review[1] begins with an overview of current anthropogenic water use patterns along with the historic and the now dominant approach to water management. As identified by various authors of the literature discussed; this review then puts forward the current concerns with this pattern of use and management to give reason and impetus for change. The change suggested is in the form of the new management paradigm of IWRM. This review then engages with the definitions of the term, its inception, interpretations, and methods of application and implementation. With the concept of IWRM being promoted for over 20 years now (Biswas, 2004), there has also arisen a body of literature in which this framework has been critiqued. In this review, the critique is important as it offers the prospect of identifying concerns, failures and opportunities for improvement and strengthening of the IWRM paradigm. This review then moves on to a discussion of spatial planning and the role it has as a tool in contemporary urban planning frameworks. Spatial planning and water planning have a mutually-dependent relationship whether acknowledged or not by different eras of management (Woltjer and Al, 2007; Wilson and Piper, 2010). With this understanding, the literature then guides

[1] A thematic review of literature is guided by common topics of discussion identified in the literature by the author of this study rather than organising the literature chronologically or by the authors' methods. This type of literature review allows for a more in depth discussion of major concepts and ideas current in discourse (The Writing Centre, 2014).

the discussion of integrating spatial planning and IWRM to address the primary critique of the framework which is a lack of implementation. This chapter then concludes with a review of current international approaches to implementing the integration of spatial planning in IWRM and, more specifically, IUWM. This acts as a launching pad from which to engage directly with the case study of the City of Cape Town and its specific water context.

Anthropocentric water use

The use of water and land is dominated by human activities with more than 50% of available land surface converted for the use of agriculture and human infrastructure (Hooke *et al*, 2012) along with the use of 50% of all accessible and available freshwater resources (EEA, 2009). Of this water, 60% is used in agriculture and the remaining 40% being used in urban and industrial areas (UN Water, 2013) which inhabit approximately 6% of all land (Hooke *et al*, 2012). This disproportionate use of water to the land coverage is representative of a wasteful and ecologically illiterate approach towards freshwater ecosystems in society. It is for this reason that this study primarily focuses on anthropogenic water use systems which are currently defined by linear systems of extraction, treatment, consumption and discharge accompanied by high pollution loads (Bahri, 2012).

While anthropogenic water use does not inherently result in environmental degradation, the scale of use, lack of reuse and the use of water as a conduit for waste have negatively affected this delicate relationship. Without human intervention, the water cycle replenishes itself through continuous flow of water from one physical state to another. The ecologies of plants and animals have evolved to become part of this cycle. That is, when water is consumed by plants or animals, firstly the amount of water needed to sustain life has adapted to the climatic condition of that specific context. Furthermore, once water is consumed and discharged, the nutrient load released does not exceed the ecological limitations for filtration and cleansing so that it can be easily reused and recycled (NOAA, 2014). These two characteristics of the water cycle as shown by nature are where human intervention has failed.

The failure of human water systems to link into the water cycle as nature does is further exacerbated in areas of industrial activity and high population densities concentrated on relatively small areas (Niemczynowicz, 1999). These conditions are found in urban areas and, as human settlements have been historically positioned close to water sources such as rivers and coastlines, the proximity of these human activities increases the environmental stress placed on water systems (Jewitt, 2002). Within urban areas this stress is caused by a lack of permeable surface areas which inhibits groundwater recharge and increases the volume and velocity of surface run-off. This in turn increases the flow of stormwater which carries a high solid and liquid pollution load from industrial, domestic and transportation land uses. As Daigger (2011) puts forward, this environmental stress is then exacerbated due to a lack of sufficient pollution-control systems which have degraded local water supplies thereby increasing the scale of the disruption as water is sourced from watersheds far from urban areas. Therefore the aim of urban water management has been developed over time to control and reduce the risk of this disruption to natural water flows.

The Historic Development of Water Management in Urban Areas

The provision of water has guided the development of human settlements throughout time. However, since the industrial revolution, innovations in water technology have enabled settlements to detach from this natural constraint and locate far from water sources (Woltjer and Al, 2007). In urban areas water is used for multiple purposes which include, amongst others; drinking, cleaning, irrigation, recreation and sewage removal. Water management has therefore been essential to urban development to ensure fair and adequate distribution of water, the separation of clean from contaminated water, and the mitigation of water disasters, such as flooding and drought, to promote human health, well-being and dignity. Current dominant water management has approached these tasks by separating the water uses into isolated sectors of management, such as water supply, wastewater and stormwater drainage, with associated functions, such as land use, economic development and environmental affairs, also managed by separate entities (Bahri, 2012). While these are, most often, all dedicated government line departments there is little co-ordinated effort between sectors to ensure the most resource and cost efficient solutions. Another feature of dominant methods of water supply, sewerage and drainage systems is the reliance on large centralised and closed-pipe systems of treatment and discharge (Mitchell, 2006).

The paradigm of water management has shifted and evolved ever more rapidly over the past 200 years since the onset of industrialisation and as Radif (1999) identifies, there have been four dominant eras of water management from the pre-industrial state to the current state. In the pre-Industrial settlement water management was supply driven with the purpose of making water available to users (Savenije and van der Zaag, 2008). In this era, freshwater was predominantly sourced from water bodies as close to the settlement as possible and the environment was considered a user and regulator of the water system with little technological aid. The second era spans from the Industrial Revolution to the 1960's. During this time, the primary aim of water management was to meet the unprecedented level of demand from the rapidly growing population and economy by maximising the volume of water available (Radif, 1999). This occurred by diverting water from new sources that tended to be located far from the users in a settlement. With water considered as a resource to be exploited indefinitely, there was an emphasis on control with an engineering focus that resulted in massive individual infrastructure projects, such as dams, to live up to the mantra of 'predict and provide' (Savenije and van der Zaag, 2008). However, as highlighted by Funke *et al* (2007), this approach began to change in the 1970's in reaction to the technocratic 'top-down' approach which negated the intricate socio-economic and political nature of water, and with the recognition of the limit of resources and the realities of overexploitation due to excessive demand. This socio-political and environmental renaissance affected all resources with a shift from supply-side to demand-side management along with accounting for ecological and social constraints to resource use (Radif, 1999). Especially in water management, Savenije and van der Zaag (2008) note that this shift in approach led to a rise in regional and national planning for more efficient resource provision as opposed to the single project-based approach of earlier decades. The current approach to water management, that includes the IWRM paradigm, has been in existence without much alteration since the early 1990's. This approach seeks to embed water management in issues and policy of socio-economic development, environmental protection and physical planning with an additional focus on public participation and multiple objectives (Savenije and van der Zaag, 2008 and Braga, 2001). A comparison of the historic versus contemporary evolving approach to urban water resource management is seen in Figure 2.1.

	Approach	
Item	Historical	Evolving
Water supply	Remote sources	Local sources
Optimized costs	Infrastructure	Water use, energy consumption
Functions	Single purpose systems for drinking water, storm water, and used water	Multipurpose systems to integrate functions
Configuration	Centralized systems	Hybrid systems (centralized and decentralized components)

Figure 2.1: A table summarizing the comparison between historical and evolving approaches to urban water management (Daigger, 2011: 14)

Only a year after the release of the Brundtland Commission's Report in 1989, this new paradigm also focused on finding ways to manage water to ensure a sustainable future. Sustainability in this sense can be summarised in South Africa's water mandate: *Some, for all, forever* (RSA, 1997). This encapsulates the understanding that water is life not simply matter or material, that water resources are finite, that everyone has the right to a clean and adequate supply of water, and that long term protection and planning of water resources is essential to water security (MacKay, 1999). IWRM is a far more strategic approach to water management that engages with ecosystem-based management which makes the healthy functioning of the ecosystem key to the water system (Radif, 1999) through a holistic engagement of water uses at a river basin level. In *Transitioning to Water Sensitive Cities: Historical, Current and Future Transition States* (2008), Wong *et al* speak to this transition of water management in urban areas as representative of change within the 'hydro-social contract'. This term, as first coined by Lundqvist *et al* in 2001, is defined as (Wong *et al*, 2008: 2);

> *"…the pervading values and often implicit agreements between communities, governments and business on how water should be managed. This contract is shaped by the dominant cultural perspective and historically embedded urban water values, expressed through institutional arrangements and regulatory frameworks, and physically represented through water systems infrastructure".*

Therefore due to the hydro-social contract being influenced by history, culture and society's values, it can only be expected that each country has a different single contract or even a multitude of contracts that represent the relationship between humans and water in that context. Due to this, while there is a move towards the IWRM paradigm mentioned; the earlier paradigms are still in existence today as values and perspectives of water have not yet been changed either by internal or external forces. Braga (2001:582) is optimistic that this will change and that the older systems of management will eventually be substituted by the newer systems that involve multiple objectives and democratic engagement with multiple stakeholders at a river basin level. However, the earlier paradigms are still in existence today and the slow rate of this paradigm shift is causing concern in the face of population growth, increasing rates of urbanisation and climate change.

Concerns with the Consequences of Current Practices of Water Management

As identified in the literature (Mitchell, 2006; Carter, 2007; Wilson and Piper, 2010; and Bahri, 2012), there is a growing concern with the consequences of current practices of water management. This includes the inability of current resource supplies to meet the demand in both quantity and quality; the increased pollution load that discharged water carries; the damage to freshwater ecosystems which leads to a vicious cycle of exponential degradation; and the opening of closed-loop systems through the use of built infrastructure. These are then further exacerbated by the uncertainty and unpredictability of the effects of anthropogenic climate change. Biswas (2004: 248) notes that these concerns and problems are,

> *"becoming increasingly more complex and interconnected with other development-related issues and also with social, economic, environmental, legal, and political factors at local and national levels and sometimes at regional and even international levels".*

It is not that this complexity has only existed in contemporary times rather that it has been possible to ignore and leave dormant until now; a time of such severe affronts to the way in which resources are used that the system has disintegrated thereby revealing its inherent flaws. This means that dealing with water issues in sector-based, single-dimension plans no longer has the ability to approach nor engage with the multi-dimensional issues that have been brought to common awareness today. Biswas (2004) also identifies that these concerns occur at multiple scales and therefore the solutions need to do so too. The scales can be simplified to the local and global scale. The former being concerned with the natural resources base and the visible impacts of human activities, and the latter being concerned with the long-term sustainability and effects of human activities (Conway and Chambers, 1991).

With reference to the local scale of impact, the increase in demand for water is fuelled by population growth, the increasing rate of urbanisation and the extent of physical urban growth (Woltjer and Al, 2007), both individually and concurrently. As populations urbanise and economies grow, there has been a correlating trend of increased per capita water consumption (Wilson and Piper, 2010). Due to seasonal and geographic variability in water availability, roughly 35% of the global population, with the majority in cities, are expected to live in areas of water shortage by 2050 (Knight, 1998 in Niemczynowicz, 1999) even though the rate of population growth is thought to be slowing. The conventional approach has been to continue sourcing water outside of urban areas to reach this demand through constructing reservoirs and dams in river valleys. This has caused both environmental and socio-political concern through ecological disruption and destruction while increasing the competition for finite water resources between urban, peri-urban and rural users. As urban populations increase, the waste output increases too and, as water is a primary conduit of urban waste through sewage and stormwater, the consequences are most noted in the degradation of local, receiving freshwater ecosystems (Mitchell, 2006). This further aggravates water stressed areas as immediate sources are too contaminated for use.

With reference to the global scale of impact, the long term sustainability of human activities is jeopardised by the effects of anthropogenic climate change (Conway and Chambers, 1991). More specifically, in urban areas water has been identified as the main conduit for climate change effects (UN-Water, 2010) and, as recognised by the International Panel on Climate Change in their 4^{th} global assessment in 2007, freshwater hydrology will be among the systems the most affected by climate change (Bahri, 2012). This is likely to occur through flood and drought damage to water and sanitation infrastructure and water ecosystems which will result in a reduced capability to filter and mitigate urban waste products (Wagner and Zalewski, 2009 and Mitchell, 2006). Prior to experiencing the effects of climate change, infrastructure and planning decisions were taken with regard to the concept of 'Stationarity'. Loftus (2011) defines this as "*the assumption that changes in natural systems will not exceed* *what has been seen in historical observation*". While estimations can be made of the effects of climate change, they are ultimately shrouded in a high degree of uncertainty as climate change undermines 'Stationarity' and the ability to predict future climatic events (Bahri, 2012). Hence, the only certainty is the presence of uncertainty and the need for built-in adaptability to cope with the direct and indirect effects of climate change which should now be taken into account when making long term planning decisions.

At both a local and global scale, measures of mitigation against and adaptation to Climate Change must occur simultaneously to reduce the impact of the extreme weather events expected, especially on those living in poverty who are most vulnerable. Mitigation concerns actions taken to reduce the likelihood of a disaster occurring, while adaptation refers to actions which aim to prevent catastrophe if disaster occurs (Lenhart *et al*¸2009). While some measure of short term intervention can aid these actions, both require a long term planning approach to be successful and sustainable.

These concerns at both the local and global scale have rallied a call to identify new ways of managing water in urban areas, such as IWRM, to enable greater ecological restoration and alignment thereby helping to provide an increasingly secure urban water future.

Integrated Water Resource Management

Integrated Water Resource Management (IWRM) encompasses a shift from the dominant approach by moving from isolation to integration; that is to the integration of water-based sectors, water users, and human and environmental water use. More specifically, the IWRM perspective aims to ensure that "*social, economic, environmental and technical dimensions are taken into account in the management and development of water resources*" (Thomas and Durham, 2003: 24). IWRM is an evolving water management paradigm that is implemented within the boundaries of a river basin rather than legislated boundaries, such as municipalities or countries. From this, Integrated Urban Water Management (IUWM) has been developed for implementation within the boundaries of an urban area. In this section the literature for IWRM is reviewed which follows with an evaluation of IUWM.

IWRM as a concept for water management is based upon "*the perception of water as an integral part of the ecosystem, a natural resource and a social and economic good, whose quantity and quality determine the nature of its utilization*" (Radif, 1999: 145). This concept has been in existence since the 1950's with all United Nations Member Countries agreeing upon it as a way forward for water management at the UNESCO International Conference on Water in 1977 (Medema *et al*, 2008). However, as noted by Biswas (2004), the institutions of the time were ill-equipped to implement it and the concept went into obscurity until the early 1990's when there began a search for methods to alter the concerning trajectory of contemporary water management. At this time, international bodies were established with the distinct role of developing, promoting and implementing IWRM within countries around the world; with the most prominent being the Global Water Partnership (GWP), the World Water Council (WWC) and the World Bank. As can be expected in a paradigm of multiple stakeholders and differing contexts, there are many definitions of IWRM; especially with regard to the focus on integration. However with the dominance of the GWP in promoting IWRM, it is their definition which is most widely accepted in the literature reviewed (Medema *et al,* 2008; Bahri, 2012; Savenije and van der Zaag, 2008). IWRM is defined as (GWP, 2000: 22);

> *"a process that promotes the co-ordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems".*

As stated by the GWP, IWRM is based on the 'Dublin Principles' discussed at the International Conference on Water and the Environment in Dublin, 1992 which put forward that (Merrey, 2008; Savenije and van der Zaag, 2008: 294):

1. *Water is a finite, vulnerable and essential resource which should be managed in an integrated manner*
2. *Water resources development and management should be based on a participatory approach, involving all relevant stakeholders*
3. *Women play a central role in the provision, management and safeguarding of water*
4. *Water has an economic value and should be recognised as an economic good, taking into account affordability and equity criteria.*

As evidenced in this definition and the principles on which it is based, Funke *et al* (2007) identified that the two prominent features of IWRM include the call for co-ordination and integration of natural and human systems to promote a balance between resource consumption and protection and, secondly, to redress the current legacy of unequal access to water resources and sanitation that still exists in many countries. To achieve this, the approach of IWRM includes the development of alternative water resources, such as groundwater, desalination, stormwater and waste water; the protection of current water sources to improve quantity and quality; and the implementation of demand management strategies (Thomas and Durham, 2003).

Lewis Jonker (2007) calls for IWRM to be recognised as a framework rather than a process. A process can be defined as *"a systematic series of actions directed to an end of creating a specific outcome"* (Merriam-Webster, 2014) where as a framework is defined as *"a real or conceptual structure intended to serve as a support or guide for the building of something that expands the structure into something useful"* (Rouse, 2005). This distinction is beneficial as IWRM tends to be non-prescriptive due to the lens of context, culture and climate that is applied to the methodology of implementation. Viewing IWRM as a framework therefore allows for a loose and flexible structure where the goals can be set and suitable tools can be determined; rather than prescribing contextually inappropriate tools that inflict further damage and ecological degradation (Jonker, 2007). This supports the conclusion of Medema *et al* (2008: 3) that, "*IWRM is not a state to be achieved, it is a continuous process of balancing and making trade-offs between different goals and views in an informed way".*

In South Africa, the concept of IWRM was adopted early in the 1990's in new policy and legislation which was being drafted after the fall of the Apartheid Regime. This reformed legislation, for the first time since colonisation, granted the right of access to water to every person in South Africa (RSA, 1996 and NWA, 1998). With this, water resources management policy aimed to "*reconcile basic human needs, ensuring access and equity, with economic development and the imperative of ecological integrity, while respecting trans-boundary commitments*" (Van der Zaag, 2005: 868). As noted by Funke *et al* (2007), IWRM is a necessary alternative in South Africa as water is not naturally nor historically distributed equally and participation by relevant stakeholders is essential to ensure appropriate service delivery and to incorporate indigenous knowledge. As is identified in the concept of IWRM, South African Water legislation focuses on issues of infrastructure provision, water pricing and governance; with a specific focus on ensuring the integral role of public participation (NWA, 1998 and DWA, 2013). The diverse range of factors included illustrates the socio-technical transformation required with the implementation of IWRM.

Firstly, with regard to infrastructure, the IWRM encourages a turn from centralized separated systems to decentralised hybrid systems. This includes green infrastructure, which incorporates the restoration and construction of ecological systems to increase or maintain water quantity and quality; used-water reclamation and re-use systems; and potentially even dual-water distribution systems (Daigger, 2011) to enable urban water managers to match appropriate water quality to use. Also, as noted by Wilson and Piper (2010), water infrastructure is typically built to reflect historical predictability of rainfall patterns; however, with increased rainfall event extremes, it is necessary to incorporate the opportunity for incremental change into the design of new infrastructure. Secondly, with regard to water pricing, IWRM intends that it should be used as a tool to implement policies of social equity and discretionary use in accordance with water availability (Wilson and piper, 2010). Water pricing refers to the amount that water management bodies charge users for water supply and water-based services. This can be governed by either private or public entities; with public ownership of water resources in South Africa being maintained by national government as water is envisioned as a public good (DWA, 2002). Alternatives to conventional, non-differentiated water pricing could include that it is representative of water quality thereby encouraging the use or recycled water for non-potable purposes, and seasonal availability thereby influencing user demand patterns according the natural availability of water (Bahri, 2012).

Finally with regard to governance as an essential component of IWRM identified at the Second World Water Forum in 2000 at The Hague, the current water crisis can be attributed to poor and ineffective governance of water systems and resources (Funke *et al,* 2007). Resource governance, as defined by Turton *et al* (2007: 12), is

> ''*the process of informed decision-making that enables trade-offs to be made between competing users of a given resource so as to mitigate conflict, enhance equity, ensure sustainability and hold officials accountable*".

This definition brings to the fore the invested role of multiple stakeholders within the governance of resources in that there are concessions necessary for sustainable and equitable water resource use. With regard to the paradigms of water management mentioned earlier, Turton *et al* (2007) place the five paradigms in relation to the dominant governance approaches, as seen in Figure 2.2. This conceptual diagram indicates the evolution of water management approaches from a highly technocratic, centralised management approach with supply-side options to a more democratic, decentralised management approach with demand-side options. With regard to governance in water planning, Bahri (2012) has put forward a normative model, as seen in Figure 2.3, where water services are co-ordinated and in which the institutional water sphere interacts, rather than integrates, with urban planning and water services with a focus on the same goals of improved quality of life and environmental conservation.

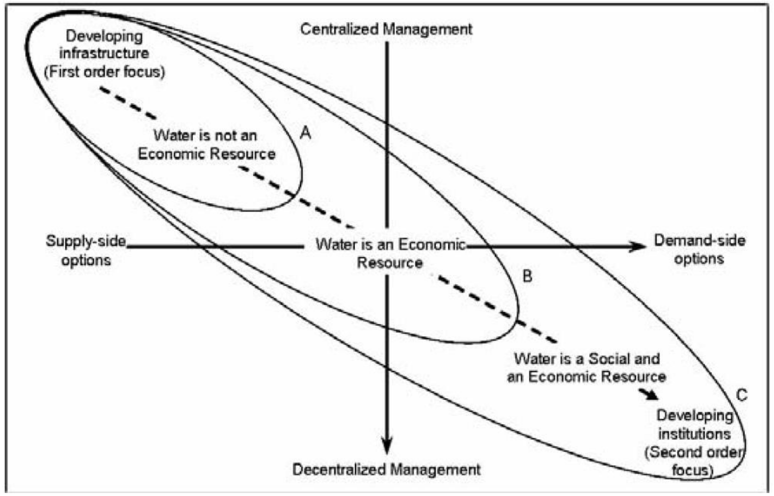


Figure 2.2: A conceptual diagram indicating the relationship of water management paradigms against governance approaches. (Turton *et al*, 2007:5)

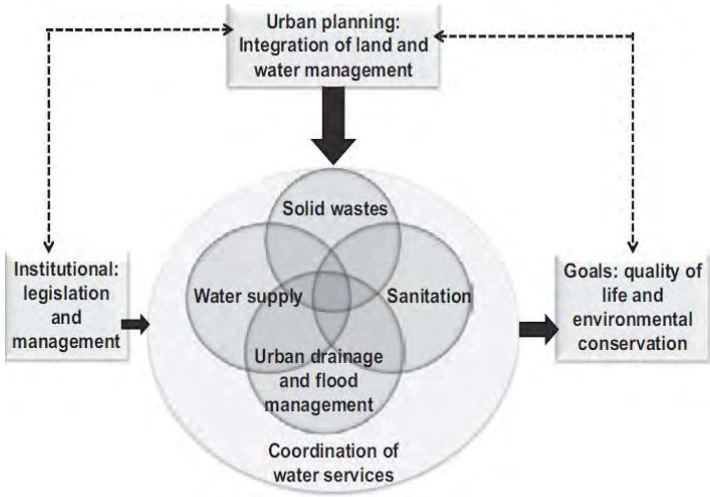


Figure 2.3: A conceptual diagram of the normative water governance approach proposed by Bahri (2012). (Tucci, 2009 in Bahri, 2012: 69)

The South African National Government Department that was placed at the helm of this new management paradigm seems to have been struggling to find the right place to locate itself to fulfil this mandate. This can be evidenced in the number of times the department has changed its name; this includes a move from the Department of Water Affairs and Forestry (- 2009) to The Department of Water Affairs (2009 – 2014) and most recently to the Department of Water and Sanitation (2014 -). This is a simple observation; however it does shed some light into the challenge of transformation in large government institutions to implement IWRM and the more integrated approach.

Within the paradigm of IWRM there are a multitude of diverse factors and actors to be taken into account and heard where urban, peri-urban and rural water users are brought together to ensure a water secure future for the whole river basin. While this larger scale of planning is necessary to engage systematically with anthropogenic water use, as mentioned earlier, urban areas account for a disproportionately large consumption of water resources. This means that specific focus needs to be placed on the complex system of water use in urban areas that have a unique set of opportunities and constraints.

Integrated Urban Water Management

Integrated Urban Water Management (IUWM), which has been in discussion since the late 1990's, holds to the same principles and makes use of similar tools to IWRM with slight modification for the urban context. The move from IWRM at a watershed scale to IUWM at a city scale follows Merrey's call (2008) for a shift from an imposed natural boundary of management to that of the boundaries of a problem; that is a 'problem-shed' perspective. While still retaining the necessary complexity, this means that management can begin with a concrete problem setting, map what is required and viable and then identify the actors involved (Merry, 2008).

While there is less literature specifically on IUWM, the primary proponent is the UNEP (2013: 2) who define it as, *"the practice of managing fresh water, waste water and stormwater as links within the resource management structure, using an urban area as the unit of management".* As evidenced in this definition, the flows of water most influenced by the urban condition, notably waste water and stormwater are of paramount importance for IUWM. This is because they heavily modify the quantity and quality of water in urban freshwater systems, thereby holding the greatest risk and opportunity for water management alternatives. The principles for urban water management as identified by Mitchell (2006:590) require that water management must,

1. Consider all parts of the water cycle, natural and constructed, surface and subsurface, recognising them as an integrated system.

2. Consider all requirements for water, both anthropogenic and ecological.

3. Consider the local context, accounting for environmental, social, cultural, and economic perspectives.

4. Include all stakeholders in planning and decision-making processes.

5. Strive for sustainability, aiming to balance environmental, social, and economic needs in the short, medium, and long term

The implementation of these principles result in a more cyclical and less wasteful water flow, greater citizen participation in water management and increased ecological stability. The difference between current urban water management practices and IUWM can be seen in Figure 2.4.

Past urban water management	Future IUWM
Water and wastewater systems are based on historical rainfall records.	Water and wastewater systems rely on multiple sources of data and techniques that accommodate greater degrees of uncertainty and variability.
Water follows one-way path from supply, to single use, to treatment and disposal.	Water can be reclaimed and reused multiple times, cascading from higher to lower quality.
Stormwater is a nuisance, to be conveyed quickly from urban areas.	Stormwater is a resource to be harvested as a water supply and infiltrated or retained to support aquifers, waterways, and vegetation.
Human waste is nuisance, to be treated and disposed.	Human waste is a resource to be captured, processed, and used as fertiliser.
Linear approaches deploy discrete systems to collect, treat, use, and get rid of water.	Restorative and regenerative approaches offer integrated systems to provide water, energy, and resource recovery linked with land-use design, regulation, and community health.
Demand equals quantity. Infrastructure is determined by the amount of water required or produced by end-users. All supply-side water is treated to potable standards; all wastewater is collected for treatment.	Demand is multifaceted. Infrastructure matches characteristics of water required or produced for end-users in sufficient quantity, quality, and level of reliability.
Gray infrastructure is made of concrete, metal, or plastic.	Green infrastructure includes soil and vegetation as well as concrete, metal, and plastic.
Bigger is better; collection system and treatment plant are centralised.	Small is possible; collection systems and treatment plants may be decentralised.
Standard solutions limit complexity; water infrastructure consists of 'hard system' technologies developed by urban water professionals.	Solutions may be diverse and flexible; management strategies and technologies combine 'hard' and 'soft' systems devised by a broad range of experts.
Utilities track costs alone and focus on accounting.	Utilities evaluate the full array of benefits from investment and technology choices, and focus on value creation.
The standard is a business-as-usual toolkit.	An expanded toolkit of options includes high-tech, low-tech, and natural systems.
Institutions and regulations block innovation.	Institutions and regulations encourage innovation.
Water supply, wastewater, and stormwater systems are physically distinct. Institutional integration occurs by historical accident.	Water supply, wastewater, and stormwater systems are intentionally linked. Physical and institutional integration is sustained through coordinated management.
Collaboration equals public relations. Other agencies and public become involved only when approval of predetermined solution is required.	Collaboration equals engagement. Other agencies and public are actively involved in search for effective solutions.

Sources: Moddemeyer, 2010; Pinkham, 1999.

Figure 2.4: A table indicating the differences between current urban water management practices and Integrated Urban Water Management (Bahri, 2012: 37)

While IWRM includes rural, ecological and urban water use, IUWM predominantly focuses on urban water users and their outputs. An urban context can differ from that of a river basin with regard to the degree to which the area of study has been modified by human use, the intensity of that use and the concentration of waste production. While these three aspects can increase the strain on water management and ecological systems, they can also offer the opportunity for improved systems integration, efficiency and economic viability due to the proximity of systems and the presence of a sufficient support threshold.

Of particular importance in IUWM is the concept of local subsistence as a goal for resource use; that is extraction, consumption and waste outputs. This is because, as stated by Mitchell (2006: 603), when new measures of water management are implemented;

> *"care must be taken not to just shifting the environmental, social, and/or economic dis-benefits of urban water servicing in either time or space. That is, the dis-benefits should not be simply shifted to a new location, such as from a local surface water body to a distant groundwater system, or delayed in time, such as from an immediate negative impact to a slow-building but long-term impact".*

This is especially important to ensure the sustainability of future water management for spatial and generational equity and equality.

The current popularity of both IWRM and IUWM has been attributed to the seemingly holistic response it offers to a world faced with the reductionism of a sectoral approach (Biswas, 2004) while the imperative of sustainability continues to grow more urgent, yet elusive (King, 2009). However as these concepts age, there is growing critique and interrogation due the lack of significant exchange from theory to practice and that there is little change evident in the trajectory of global water resource use. This next section evaluates the literature that offers reasons why this is thought to be the case and what needs to change.

An evaluation of the critique of IWRM and IUWM

The critique of IWRM and IUWM is becoming more mainstream with previous advocates of the concept now stating that it is ill-advised to uncritically accept the current definition of IWRM as it is ''*narrow, incomplete and unchallenging*'' (Gyawali et al., 2006 in Funke *et al,* 2007: 1238; Biswas, 2004; and Merrey, 2008). The literature reviewed has identified two main critiques which are believed to have resulted in the lack or little implementation of IWRM globally. These include that the definition is too broad and vague with its origins too focused in the discourse of the Global North and that the ambiguous task of integration has led to paralysis in practice.

Firstly, as already noted, the most common definition of IWRM is that put forward by the GWP (2000:22) where it is,

> *"a process that promotes the co-ordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems".*

However, this definition is critiqued as being packed with popular buzzwords which give little guidance to the implementation and assessment of IWRM initiatives. While van der Zaag (2005) believes that this gives space for innovation and creativity, Biswas (2004) breaks down this definition into its component parts to critically evaluate the lack of identifiable purpose, audience and methodology. From this he determines that the vagueness of the concept thwarts practice thereby resulting in little discernible impact of the IWRM paradigm up until now. Biswas rebukes the water management community at large for falsely identifying IWRM practices as this ambiguity in the definition is a likely proponent of the popularity of IWRM as water management can continue as 'business-as-usual' while claiming to follow this latest paradigm. Due this critique, Jonker (2007: 1262) puts forward an alternative definition which simply states that,

"IWRM is a framework within which to manage people's activities in such a manner that it improves their livelihoods without disrupting the water cycle".

This definition, without the use of buzzwords encapsulates the essence of IWRM; that human activities are to be governed and constrained by the boundaries enforced by ecological stability. This definition also engages with another critique of IWRM that it does not hold the developmental agenda so integral to ensuring sustainable livelihoods in the Global South. Due to the fact that IWRM is predominantly a paradigm of the Global North, when transplanted to areas of the Global South it is ill-suited as it assumes a stable political environment in which decision-making takes place and it does not directly address the existence of large scale generational poverty and a lack of infrastructure (Allan, 2003 and Funke *et al*, 2007). Merrey (2008) identifies this in the fact that demand management and cost recovery are central to the practice of IWRM however they can hardly be the priority if there are large numbers of people without water access and water resources remain under- and un-developed as is the case in many countries in the Global South. He therefore calls for a 'Livelihoods-based IWRM' paradigm to ensure the centrality of developing water resources for health and productivity benefits to reduce poverty. Other obstacles to implementing IWRM in the Global South include a lack of sufficient funds to finance the necessary infrastructure upgrades and water resources development projects; a lack of an appropriate institutional framework for water management; and the need to increase social awareness in caring for urban water resources (Braga, 2001). While these concerns highlighted are quite generalised across the Global South, it is essential that they are factored in to IWRM paradigms to ensure the long term sustainability of water management practices through interplay with local conditions and characteristics (Funke *et al,* 2007). This could lead to a more labour-intensive approach where jobs are created through the restoration and preservation of environmental service providers rather than the more technical and mechanised solutions favoured in the Global North.

With regard to the second main critique of the current IWRM paradigm, it is centred on the ambiguity of what is meant by 'integration' has resulted in a paralysis in practice. Biswas (2004) has identified 35 sets of issues which a variety of authors on IWRM identify as what is meant to be integrated under IWRM; ranging from policies, impacts, technologies, water outputs and objectives. This broad expectation of the purpose of integration in IWRM has resulted in a lack of conceptual clarity which is hampering the implementation of IWRM, especially in South Africa (Jonker, 2007). The most popular understanding of IWRM relates to the integration of water management institutions with other functions, such as agriculture and land use, however these can become so such cumbersome bureaucratic entities that they are even further away from achieving the goals of IWRM especially in countries that do not have the financial, human and institutional resources to support the efficiency of large government departments (Merrey, 2008). It is for this reason that Biswas (2004) promotes an alternative to integration being the close collaboration, co-operation and co-ordination between institutions. This would also help to create a more holistic response to IWRM as water management agents could then co-ordinate responses and objectives across other resource sectors, such as energy and food, whose use and sustainability are inherently linked to a water secure future.

The complexity of integration also brings to the fore the lack of tools promoted through IWRM to facilitate holistic responses to climate change and resource insecurity. With regard to the contextual realities of achieving sustainable development in the Global South, Edgar Pieterse (2011) puts forward a framework that is intended to draw together four key overarching spheres of transition in urban areas that must be engaged with concurrently to further sustainable livelihoods and resilient cities. The four spheres of this framework include sustainable infrastructure, the inclusive economy and efficient spatial form; brought together by processes of democratic governance. In the literature there is much discussion with regard to infrastructure, the economic value of water and governance issues relating to IWRM. However there is little mention of the change in spatial form necessary in urban areas for the implementation of IWRM for a sustainable water future. I believe this to be an oversight in IWRM as the tool of spatial planning offers the opportunity to use of space and place, not institutions and governance, as the facilitator of integration across diverse spheres and with multiple stakeholders. The following section investigates spatial planning as a tool for this integration and the role it could play in improving the implementation of the IUWM paradigm for more water efficient and secure urban development.

Spatial Planning and its role as a facilitator of integration in the IUWM Framework

Spatial planning can be broadly defined as *"the practices that influence the distribution of activities in space"* (Woltjer and Al, 2007: 1). This process involves multiple actors and stakeholders who work at a variety of scales to shape the world and its landscapes to best fit human purposes. Historically, the role of implementing spatial planning has been designated to government and their town and regional planners; however more recently, with democracy evolving and the strengthening of civil society, there are an increasing number of actors involved in shaping our environment, either formally or informally. Spatial planning is more complex than simple land-use regulations as it addresses conflicts, tensions and contradictions among sector-based policies and practices (UN, 2008) especially where multiple demands are placed on increasingly scarce land resources in urban areas. As identified by Carter (2007: 331), land is envisioned as a means;

> *"to encourage social progress and welfare through, for example, providing housing or services such as schools and hospitals; to promote economic growth, such as industrial estates and transport infrastructure; and to provide space for the natural environment for reasons including biodiversity conservation and the maintenance of natural floodplains".*

Spatial Planning is therefore essential as a tool to facilitate the balance of these agendas to enable sustainable development and livelihoods. With this in mind, the United Nations (2008: vii) therefore defines Spatial Planning as,

> *"a key instrument for establishing long-term, sustainable frameworks for social, territorial and economic development both within and*

> *between countries. Its primary role is to enhance the integration between sectors such as housing, transport, energy and industry and to improve national and local systems of urban and rural development, also taking into account environmental consideration".*

This definition brings to the fore the role of spatial planning as an integrator amongst sectors to improve social well-being while being a custodian of environmental sustainability considerations within the built environment. This is a holistic activity that integrates environmental, social and economic considerations across many human activities that results in plans that include policies on energy, transport, water and tourism, for example (Carter, 2007). Spatial Planning is therefore uniquely positioned for the task of enabling better integration in IUWM as it focuses on the spatial relationships of multiple policy agendas and is by nature a tool for the integration of sectors to appropriately address the complexities of the urban condition (Albrechts *et al*, 2003) while preventing the duplication of efforts by actors involved. Furthermore, with the threat of Climate Change becoming more common place in everyday lives, especially those living in poverty who are most vulnerable, Woltjer and Al (2007) call for greater co-ordination of mitigation and adaptation efforts with the use of spatial planning. This territorially-based strategy articulates a vision for an area with an emphasis on the quality of place to guide public and private investment (Albrechts *et al*, 2003).

This is especially relevant in South Africa where spatial planning was used as a tool for the implementation of Apartheid policies of racial segregation, both nationally and within urban areas. Unfortunately these have become ingrained into the spatial fabric of urban areas in South Africa and therefore still govern the development of cities today. Thus, spatial planning must now be used to enable equitable redress for a more sustainable growth future. However, it must be noted that it is not spatial planning itself which will result in the improvement of a community but rather the inclusion and will of all stakeholders in combination with a sound framework for action which will facilitate a transparent and achievable change in urban areas (UN, 2008).

As noted, spatial planning is a tool used to engage with multiple policy agendas implemented in a specific place that result in conflicts in space and time. The outcome of spatial planning is therefore to mediate how land is used which is integral to the promotion of environmental sustainability because, as highlighted by Owens and Cowell (2002: 5), *"changes in land use are linked to environmental change through a multiplicity of direct, indirect, sometimes cumulative and often uncertain effects"*. Furthermore, as Carter (2007) notes, due to the nature of spatial planning relating to both human and natural environments through the practice of shaping space, it also has the ability to influence the relationship between the two. This could occur through influencing the type and location of developments to reduce the generation of pollution near ecologically sensitive areas, addressing issues across multiple spatial scales and sectors, and involving multiple stakeholders so conflicts can be discussed and resolved (Carter, 2007). This reflects the socio-economic influences on natural resources such as water (Blowers, 2000) and how spatial planning takes knowledge and transfers it to application (Opdam *et al,* 2002).

More specifically, with regard to the relationship between urban water and spatial planning, Woltjer and Al (2007) identify four linkages between water and land, or place. These are that water pollution is created on land and transferred to waterways; that urban development is encouraged or constrained by the lack or presence of water; that dense urban developments with a lack of pervious surfaces can cause flooding; and that land uses such as agriculture and industry can pollute and deplete groundwater, rivers and wetlands. To reiterate this, Jewitt (2002) notes that the water passing through a catchment is highly sensitive to its land use and therefore it is necessary for IWRM and IUWM to consider the management of land as critical to the success of water resource systems. However, water issues still remain disconnected from broader urban planning processes as the dominant practice, mainly in countries of the Global South, is still associated with the modernist principles of the design of physical human settlements and land-use schemes where infrastructure remains strictly within the role of an engineer (Bahri, 2012). It is therefore important to engage with proactive planning practices by reintegrating urban water planning, spatial planning and infrastructure planning so as to prevent water resource problems which could restrict socio-economic development activities and ecological opportunities in the future (Carter, 2007 and Niemczynowicz, 1999). This is because, as Funke *et al* (2007: 1244) highlight, "*if IUWM is not implemented successfully in the planning stage then there is little hope of achieving integrated management in practice*". This review of the body of literature concerning spatial planning and the critique of the current IWRM framework seems to encourage greater integration of urban spatial and water planning to establish holistic and sustainable responses to the complexity of urban water futures under climate change and increasing population pressures. The following section continues with a review of the proposed and current approaches in the literature to this suggested integration.

The use of Spatial Planning as a tool within the IUWM Framework

As mentioned, there is a need to include the natural system as a dimension of the human system (Kidd and Shaw, 2007) to allow for more holistic responses to climate change and population pressures on increasingly scarce resources, one of which being water. As noted by Wilson and Piper (2010),

> *"the need for closer integration of planning for water and spatial planning is now recognised but routes to achieve this are still to be developed [which constitutes] a significant area of research".*

From the literature reviewed, four approaches to integrating spatial planning and IUWM have been identified. This includes a model of transitional water strategies by Woltjer and Al (2007) and Wong *et al* (2008); Water Sensitive Planning as proposed by Carmon and Shamir (2010) including a call for the visible inclusion of water in cities by Goranson (1993); Water Neutral Development by Wilson and Piper (2010) and mechanisms of change as put forward by Carter (2007). It is hoped that an evaluation of these diverse approaches will enable the development of an appropriate framework and spatial plan for a water secure future in the City of Cape Town, as discussed in later chapters.

Firstly, as a broad outline to map the future development of water and spatial planning in urban areas Woltjer and Al (2007), in the context of the Netherlands, put forward four approaches to urban water management which indicate a shift in the overall hydro-social contract. The first stage mentioned is the conventional approach where there is public management of water quality and quantity; secondly, there is spatial planning where water is integrated into broader policy-making; thirdly, there is strategic water planning where water management is made to be more socially and politically important; and finally, a 'New Water Culture' where water is a source of social coherence, participation and new cultural identities (Woltjer and Al, 2007). It is noted that this transition is becoming evident in cities in the Netherlands, such as Rotterdam where infrastructure and new developments focus on the centrality of water as part of the urban fabric and identity of the city, both as heritage and the site of current and future social cohesion (de Graaf and van der Brugge, 2010). This model of transition is expanded upon by Wong *et al* (2008), with the concept of 'Water Sensitive Cities' in the Australian context. As seen in Figure 2.5, the transition of water management approaches is accompanied by socio-political drivers and service delivery functions which increase in complexity and sustainability from the 'Water Supply City' to the 'Water Sensitive City'. This model resulted from observations and research of the development of Australian cities and it is acknowledged that while presented as a linear path, there have been occasions of non-linear progression (Wong *et al*, 2008).

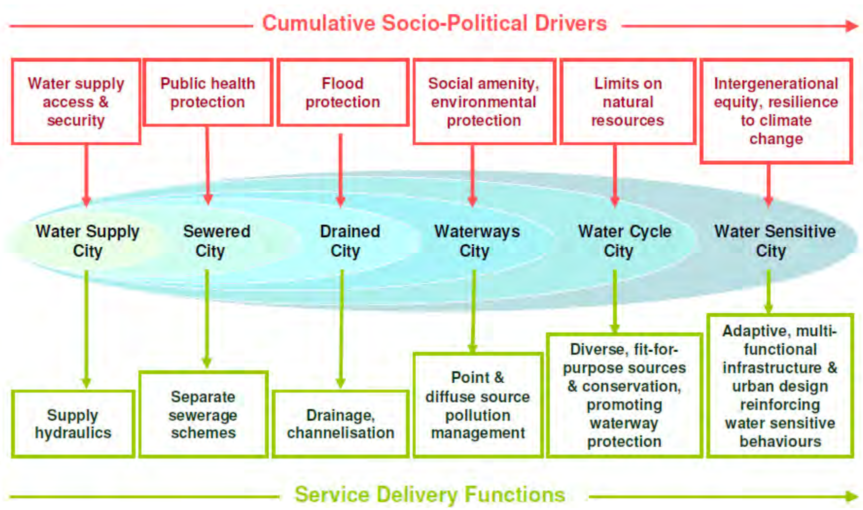


Figure 2.5: The model of transition in urban water management as proposed by Wong *et al* (2008: 5)

In the South African context, with the presence of both formal and informal settlements, this transition to water sensitive settlements is envisioned by Armitage *et al* (2014) as a bringing together the two servicing approaches to meet the developmental needs through new water sensitive systems while retrofitting existing systems. This is seen in Figure 2.6.

These models represent an evolution of water management approaches from that of being singular and secular to improved integration and awareness of water in the urban condition. In both of these approaches spatial planning is a strategic and fundamental tool used to achieve the transition to a 'New Water Culture' or a 'Water Sensitive City'. This would inevitably see a change in the urban layout of the city as water governs developments and the creation of public space. While the end goals suggested may be utopian, at least moving towards these ideals could help secure an increasingly secure water future.

As a more pragmatic approach to a water-secure future through integrating urban water and spatial planning, Carmon and Shamir (2010) in the context of Israel, promote the establishment of 'Water Sensitive Planning'. The aim is to promote sustainable development and construction with the goals of (Carmon and Shamir, 2010: 181),

> *"Improving the planned environment for its users, augmenting water resources and improving their quality, reducing the negative impacts of stormwater, preserving ecosystems and achieving all this in a cost-effective way and with involvement of citizens".*

While this does little to acknowledge the inevitable conflict management necessary in the process of development, this concept does promote implementable principles which would transform urban layout and form to be more ecologically sound by acknowledging natural water systems and flow.

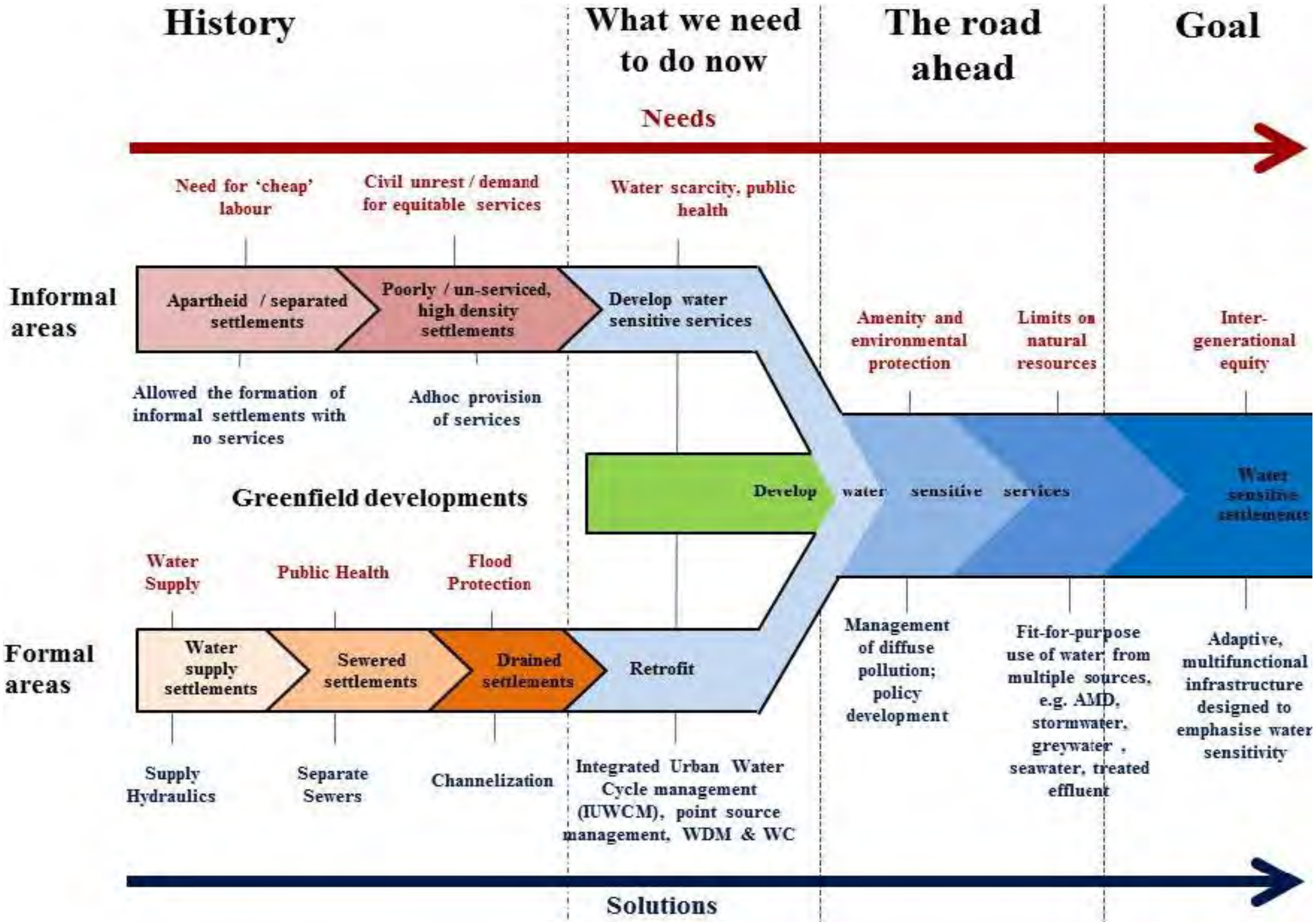


Figure 2.6: The model of transition in urban water management in South Africa as proposed by Armitage *et al* (2014: 25)

These principles include the promotion of minimizing runoff, discharge and pollutant load in urban areas to pre-development levels. This could be accomplished through higher density development; reducing the area of roads and parking lots through mixed land use; decentralised water management structures; and placing open spaces and roads in accordance with the natural hydro-geographic layout of an area to mimic the predevelopment water flow (Carmon and Shamir, 2010).

When implemented within an urban area, these principles would allow water to not only be a resource for consumption or waste removal but also an opportunity for recreation, visual relief and urban cooling. The prospect of these moments being created in the city is of particular importance to spatial planning practitioners who motivate for urban place-making along with principles for long-term and large scale infrastructure. Christer Goranson describes this in the following words (Goransson, 1993 *in* Niemczynowicz, 1999: 6):

> *"[The] contrast between so living, soft and organic water and so strict and rigid environment of a city, gives a fascinating combination that contributes an additional dimension to the city. If the water that comes to the city could be made to stand still for a moment, or to be visible on the surface, the city environment would be enriched and bring pleasure to all our senses".*

Similar to 'Water Sensitive Planning' is the concept of 'Water Neutral Development' as promoted by Wilson and Piper (2010) when responding to the English and Dutch experience. This responds to both the sustainability and climate change agenda as a call for development to not lead to an increase in total water demand and where the ecological functions of water are a foundation of spatial planning decisions (Wilson and Piper, 2010). This is applicable at both a single site and regional scale with it being essential to recognise that more space is needed for water on land; for example to provide permanent or temporary water storage to mimic ecological processes.

Finally Carter (2007), in England, offers three mechanisms for more effective inclusion of environmental considerations in spatial planning. This is based on the premise that (Baker Associates, 2005: 20 *in* Carter, 2007: 332),

> *"there is wide recognition that the water environment is increasingly challenged by the effects of development, and since the management of development is the role of the land use planning system, it is important that sufficient connection is made between the water environment and the planning system".*

These three mechanisms include, firstly, spatial plan preparations to set out a broad strategic framework at a regional level to guide the consideration of water at a local level; to create buffer zones around water bodies to reduce pollutant load and protect habitats; and to regulate the development and use of land. Secondly, with regard to developmental control which governs how local authorities permit or refuse proposals for development or land use change, there needs to be an overall guiding framework within higher planning spheres of provincial and national government. The third mechanism references the application of planning techniques where Carter (2007) suggests that Strategic Environmental Assessments and stakeholder participation are essential to strengthening the decision-making process and the long-term sustainability of strategies and implementation. This occurs through increasing the democratic legitimacy of planning authorities and building consensus. These three mechanisms encourage integration between urban water and spatial planning through a focus on the changes necessary in the planning processes and authorities. This is indicative of a belief in the cohesive nature of spatial planning as an existing tool, with amendments rather than an overhaul of systems. This more incremental approach would fare better, especially in countries of the Global South, as the change required can be implemented after or along with a corresponding change in institutional, financial and human capacity.

These four approaches evaluated have been extracted from a broad body of literature to represent the range of socio-political and biophysical contexts in which solutions to integrating urban water planning and spatial planning are being sought. While the contexts differ there are commonalities between these approaches as evidenced in similar calls to move to a more democratic, multi-stakeholder governance approach where urban development and land use is governed by the presence or lack of water. This is with the aim of moving to a more sustainable urban form which encourages and promotes a water secure and resilient city.

Conclusion

Water is life. People, their livelihoods and nature are dependent upon sufficient access to clean, freshwater sources; however, through technological innovation the relationship between humans and the source of their resources has been severed. With less than 1% of water on earth suitable and accessible for consumption found in the earth's rivers, lakes and dams; this can be considered a scarce resource especially in the face of global anthropogenic climate change and increasing population stresses. While water is not the only resource under severe pressure from these occurrences; it is expected that as temperatures rise due to climate change, global freshwater ecosystems which are a lifeline for survival on earth, will be the most affected through drought and floods. This is further exacerbated through the continued misuse and mismanagement of water resources in human activities through excessive pollutant loads being expelled in waterways from cities and the disruption of the replenishing system through the natural water cycle due to the expanse of impervious surfaces that cover urban areas. In summary, there is less water available for use as populations rise and climate change causes drought and the little water that is left is being heavily polluted thereby damaging the resilience of ecological systems and human health. Historic and current water management practices are identified as having been largely detrimental to ecological systems and functioning and are paralysed in the face of future uncertainties. With a global realisation of this, a new paradigm of water management has evolved, that is Integrated Water Resource Management at a river basin scale and Integrated Urban Water Management at a city scale. These new paradigms aim to promote sustainability, equity and equality of water resources through the improved integration of the largely sectoral approach to water management solutions. There have been strong global proponents of these new paradigms over the last 20 years; yet, there is little evidence of implementation and a growing critique. This critique has firstly identified that the greatest hindrances to current IUWM strategies lie in the definition being broad and vague with its origins too focused in the discourse of the Global North and, secondly, that the ambiguous task of integration has led to paralysis in practice. As proposed in this review, spatial planning is a tool inherently suited for the purposes of integration of diverse sectors and policy agendas and, consequently, should be incorporated into the arsenal of IUWM, along with the already existing guidance on infrastructure, governance and economic viability. This is not a new proposal even though it is not yet common practice. This review therefore summarises four primary approaches to integrating spatial planning and IUWM to enable more sustainable urban form with specific regard to a water secure city. From this, it is evident that there is a call to move to a more democratic, multi-stakeholder governance approach where urban development and land use is governed by the presence or lack of water to presence and prioritise water, our lifeline, in urban areas. Likewise, as stated by Carter (2007: 339);

> *"ultimately, the 'spirit' of the IUWM goes beyond the achievement of good water status and requires an evolution in the relationship between human societies and the water environment, something that spatial planning processes have the potential to help stimulate"*

This thematic review of international and national literature has evaluated current anthropogenic water uses and the development of dominant water management practices as a foundation to understanding the impetus for change as the formation of the IWRM and IUWM paradigms. The critique of these paradigms from the literature identified concerns, failures and opportunities for strengthening and improvement. This was then used as a platform on which to base the proposal for the integration of spatial planning into IUWM to improve implementation and thereby aim to ensure urban water security. With the evaluation of current approaches to this integration, this review has provided a conceptual point of departure from which to begin the contextual analysis of the case study; that is the City of Cape Town, to better understand the opportunities and constraints present to the creation of a water-secure, resilient and life-giving city for all its citizens.

Chapter Three:

Contextual Analysis

"Water, thou hast no taste, no colour, no odour; canst not be defined, art relished while ever mysterious. Not necessary to life, but rather life itself, thou fillest us with a gratification that exceeds the delight of the senses."
- Antoine de Saint-Exupery (1900-1944), Wind, Sand and Stars, 1939: 156

Introduction

Water varies greatly in quantity, quality and physical state depending on the climate, latitude and anthropogenic modification of a place; from ice and snow in the Polar Regions to heavy rainfall in tropical regions and little to no water in desert regions. The natural, and now modified, presence of water in an area impacts the rate of consumption, the pattern of resource use, and the water management strategies applicable. Therefore, this makes the study of context vitally important to intervening in an area for a more water secure future.

This study has so far undertaken a literature review which has laid out a theoretical context for intervention. This chapter now carries out a contextual analysis for the City of Cape Town to understand the current state and trends with regard to water quality and quantity along with the opportunities for and risks to a sustainable, healthy and abundant water future. As this study is focused on the role of spatial planning as a tool in Integrated Urban Water Management (IUWM), this analysis, as far as possible, is translated spatially through the use of maps. While this analysis has been limited to desktop research and policy review, it relies heavily on the public participation and primary data collection of a variety of national, provincial and municipal documents along with other academic research

The national vision held by the South African Department of Water Affairs and Sanitation is that "Water is life. Respect it, Conserve it, Enjoy it" (DWS, 2014). To elaborate on this, the following level of service provision and water use is envisioned for all South Africans (CoCT, 2008 (a): 1):

> *"All people living in South Africa have access to adequate, safe, appropriate and affordable water and sanitation services, use water wisely and practise safe sanitation. Water supply and sanitation services are sustainable and are provided by effective and efficient institutions that are accountable and responsive to those whom they serve. Water is used effectively, efficiently and sustainably in order to reduce poverty, improve human health and promote economic development. Water and wastewater are managed in an environmentally responsible and sustainable manner".*

This chapter provides an indication of whether this vision is being achieved and indicates the concerns and shortcomings of the current urban water system. To locate the study, this chapter begins with an overview of the relevant national, provincial and municipal policies, strategies and spatial informants, and the water management within each of these spheres. It then continues with a summary of the bio-physical and socio-economic context of the City of Cape Town. This chapter then moves to a specific analysis of water in the city. The primary focus of this section is on anthropogenic water use due to the high level of modification and consumption that has resulted from human activities in the metropolitan region. The structure of this section follows the flow of water from source to outflow, as seen in Figure 3.1, which includes a Material Flow Analysis of anthropogenic water use in the city to understand the sources, sinks and users of water. Using this as a guide, the following topics are discussed to provide a holistic picture of the use and discharge of water in the City of Cape Town; these include sources of water supply, bulk services for the

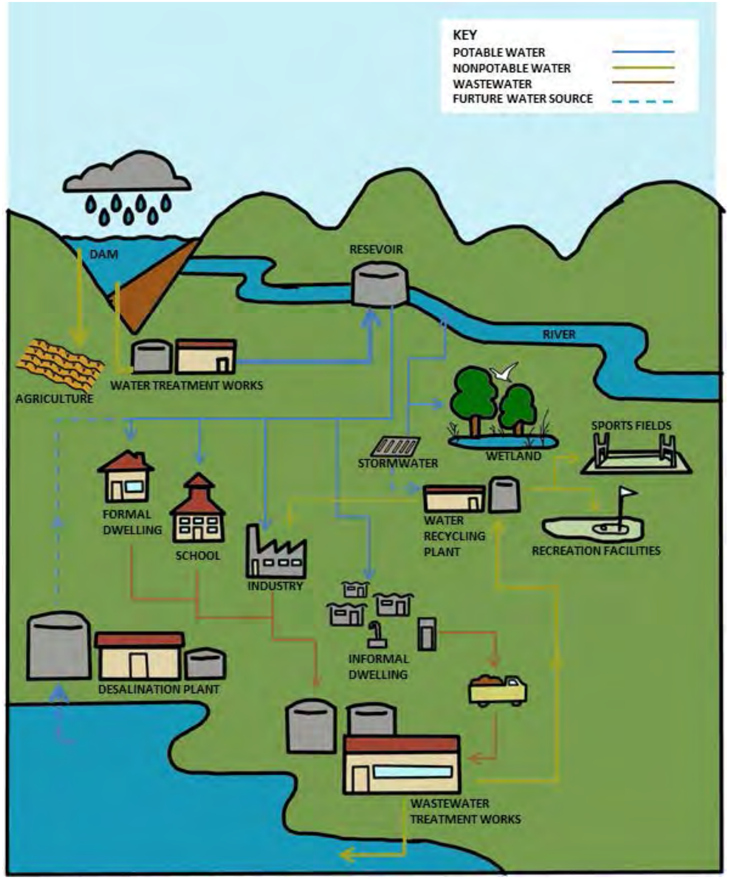


Figure 3.1: Diagram showing the urban water flow (Author's Own from UCT, 2012: 14, altered and adapted from Power House Museum – the managed water cycle (http://www.powerhousemuseum.com/ecologic/files/2011/11/Managed-Water-cycle.pdf)

provision for water, the uses of water, stormwater, and bulk services provision for waste water treatment. Of great importance are the projections of water and sanitation demand which are influenced by the impacts of climate change, urban growth, and population growth and consumption across the region. While the natural environment is the foundation of our livelihoods and therefore is most likely to be affected by our (mis)use of water; this analysis also looks at the relationship between both social and economic issues and the presence and use of water in the City. This is further analysed through the lens of sustainability using a framework for evaluation developed by Kevin Winter, a geographer involved in the Urban Water Group at the University of Cape Town, (Winter, 2010) and updated with the most recent data available. This evaluation gives a snapshot of the degree to which current water use and management systems are sustainable and projects a vision for the desired state of water in the City. Following from this, the opportunities for and constraints to water sources and sinks are identified to compile a list of key issues and priorities for water in the City of Cape Town. This chapter concludes with a spatial representation of these key issues and opportunities and constraints to use as a foundation for intervention in the following chapters.

Links to Current Policies and Strategies: National, Provincial and Municipal Government

In this section of the chapter, various policies, plans and strategies are analysed to gain a better understanding of the broader-scale operating context and issues regarding water use and management in the City of Cape Town.

In South Africa, the Constitution lays out the presence of three spheres, rather than tiers, of government; that is National, Provincial and Municipal, which are to work together to progressively achieve the rights of all those who live in South Africa (RSA, 1996). While there still remains a loose hierarchy, based on the spatial extent of governance, there are specific functions dedicated to each sphere. The following plans, policies and strategies are representative of either those which relate to one another in a hierarchy or those that cover the functions delegated to that sphere of governance, as seen in Figure 3.2. The policies discussed engage with issues of water security in terms of the environment, society and the economy.

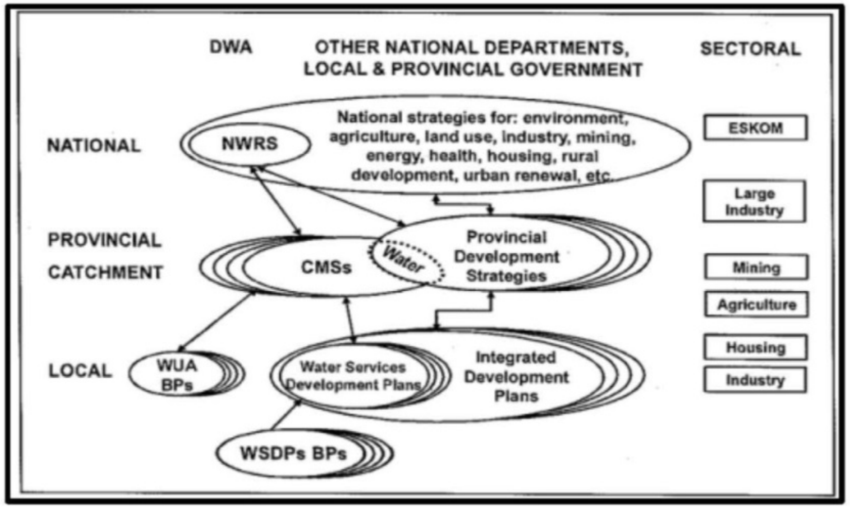


Figure 3.2: Diagram indicating the 'interaction' of institutional plans and strategies across the institutional scales (WCPG, 2011: 32)

The summary provided is framed by a similar undertaking by the Western Cape Government (2012) in the 'Sustainable Water Management Plan' and by Pithey *et al* (2007) for the Sustainability Institute in 'Water and Sanitation in City of Cape Town'. As national plans, policies, strategies tend to be broader and applicable to the whole country; the summary will begin with these, followed by the relevant documents for the Western Cape Provincial Government and then the City of Cape Town Metropolitan Municipality. Another sphere for consideration is the river catchment scale. The City of Cape Town falls within the Berg River Catchment however, there is no policy or strategy at this scale as yet because the Water Management Agent has not been officially established (DWAF, 2007).

To begin with, an international perspective of water and its management is provided through understanding the relevant Millennium Development Goals (MDGs). These goals were proposed by the United Nations and agreed to by all member countries in 2000 and have targets set to be achieved by 2015 (UN, 2014). The goals range from eradicating extreme poverty to improving health, environmental sustainability, education and gender equality. With regard to water specifically, *Goal 7C* is '*To ensure environmental sustainability: Halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation*' (UN, 2014). This goal has been achieved five years ahead of schedule however there are still a large number of people without access to sufficient water supply and sanitation, which is 748 million and 2.5 billion respectively. This goal has however been criticised for not engaging with environmentally sustainability more holistically through addressing infrastructure and agriculture (Deneulin, 2009 and FAO, 2002). These goals offer a yard stick by which to measure the performance of a nation in meeting the development needs for all citizens. Though these have been criticised for lacking strong indicators for equality within countries and that it is mechanism to introduce local change through external motivation which could result in unsustainable long-term approaches (Deneulin, 2009 and Marglin, 2008). The attitude towards water that is presented in the MDGs follows the conventional anthropocentric approach. This is where water is a resource to be used by people and for their activities with little concern over the availability of water for ecological flourishing.

To start with national government, the relevant documents include the Constitution, the National Development Plan (NDP), the Medium-term Strategic Framework 2014 – 2019, the National Water Act (NWA), the National Water Resources Strategy (NWRS) and the National Strategy for Sustainable Development (NSSD1). With regard to the Provincial sphere of government the relevant documents are the Western Cape Government Provincial Strategic

Objectives (PSO), the Western Cape Infrastructure Framework (WCIF), the Western Cape Water Supply System Reconciliation Strategy (WSSRS), the Western Cape Climate Change Response Strategy and Action Plan, the Sustainable Water Management Plan - 'The Water Plan', the Land Use Planning Act (LUPA), and the Western Cape Provincial Spatial Development Framework (PSDF). Finally, the relevant municipal documents are the City of Cape Town Integrated Development Plan (IDP) 2013/2014, the City of Cape Town Water Services Development Plan (WSDP), City of Cape Town Integrated Metropolitan Environmental Policy (IEMP), the Cape Town Spatial Development Framework (SDF) and other sector-specific policies; concerning urban stormwater and river corridor management to name a few.

The analysis of the policies, as seen in Annexure A, follows a framework for each document that includes identifying the relevant sphere of government, the year it was released or enacted, the vision put forward for the area in question, the aim of the document, the key principles to abide by, relevant text or reference to water and the environment in the document and whether this is spatially interpreted. This has helped to generate a succinct and comparable analysis of a large and varied set of policies, plans and strategies.

From this analysis it is evident that there is a plethora of plans, strategies and policies that address the way in which human activities are to interact with nature, land and precious water resources in South Africa. The plans and strategies discussed have been generated with the aim of translating the relevant policies into actions. Several key points can be drawn out from the documents analysed. Firstly, all the documents take an anthropocentric view on the use of nature as a resource to be used for human development and flourishing with a secondary focus on protecting nature for its own sake. This approach is found in the formative documents for the environment and water in South Africa; the Constitution of 1996 and NEMA of 1998, which are adhered to by all subsequent policies and plans. Secondly, while there are a variety of principles employed across the documents three principles are common; these include equity, equality and sustainability so that resources benefit current and future generations. In line with these is the Precautionary Principle; that is the principle of least regret where there is a focus of the mitigation of any harmful effects, whether known or unknown. Thirdly, in these documents water is envisioned as an economic asset, along with other natural resources, to alleviate poverty through sufficient access to enable improved livelihoods. However, this approach is of concern as it simplifies the relationship between humans and water to only the need of consumption; thereby negating the spiritual, aesthetic and cultural relationships possible between humans and a primary life source. Fourthly, Climate Change is mentioned throughout the documents as a key consideration to the use and conservation of natural resources, especially water in an increasingly drying climate in South Africa. This links to enacting of the Precautionary Principle where climate change is leading to a more uncertain and insecure resource future. In light of this, it interesting to note that throughout the documents, other than the latest municipal plans where Water Sensitive Urban design (WSUD) is suggested for implementation, there is still a focus on large-scale, centralized infrastructure to reconcile water supply and demand. This approach can lead to inflexible and vulnerable infrastructure projects which, once built, are unable to adapt to changing climatic conditions thereby potentially creating white elephants and an insecure water supply system. Furthermore, there is concern noted with regard to the silo-based approach to management and implementation that has been practiced. While institutional integration of line departments is not evidenced in the documents, as is proposed in IWRM; greater co-ordination between departments is encouraged in the planning and implementation of projects and strategies. The final key point identified through this analysis of policies, plans and strategies is with regard to the spatial nature of these documents. It is only in the later documents, from 2012 onwards, that the spatial implications of resource use and the resource implications of land use are considered. Furthermore, only 4 out of the 18 documents reviewed offer a direct spatial interpretation of the strategies and actions proposed, with two of these being spatial development frameworks.

In the City of Cape Town, the foremost document that currently guides development and change in the urban water system is the Water Service Development Plan (WSDP) which forms part of the Integrated Development Plan for the City. The vision that guides this document is *"to be a beacon in Africa for the provision of Water and Sanitation services"* with the purpose of this document to *"acknowledge the progress made so far by the municipal Water and Sanitation Department and to identify the critical challenges remaining*" (CoCT(b), 2012: 5). There are six principles employed to enable this vision which include integrity, respect, customer focus, trust, transparency and professional. The primary focus of this document is to engage with ways to reduce and eliminate the backlog of service provision in the City while improving the maintenance and upgrading of aging bulk infrastructure. There is desire to implement environmentally sustainable interventions, however there is little mention of moving away from conventional water management approaches other than the prospect of increasing the reuse of wastewater effluent for industrial water users. In this document, the strategies proposed are aligned with the objectives of the IDP but there is no mention of the spatial alignment of proposals with the City's SDF. There is also still a strong sectoral approach to the interventions proposed which lie only within the ambit of the Water Services Department even though it is understood that the actions of other departments affect the urban water system in the City. Finally, the language utilised in this document reflects the shift from being citizens with rights to customers in a capitalist system of consumption which negates the influence of those who do not have the financial capital to pay for service delivery. This is particularly precarious in the socio-economic context of Cape Town where a relatively large proportion of the population relies on the provision of free services.

As discussed in the previous chapter, resource consumption, management and discharge are affected by and have an effect on a location and can therefore be bound by spatial relationships. These relationships can be complex and to improve co-ordination it could be beneficial to not only align projects and strategies institutionally, but spatially too. A spatial representation of strategies also helps to co-ordinate actions across sectors of resource management, such as energy, food and solid waste, to engage holistically with more sustainable solutions.

More specifically, the spatial development frameworks are designed to guide public and private investment so that the vision of the region can be achieved. The vision put forward by the Provincial Spatial Development Framework (PSDF) is to enable *"socially just communities and settlements in the Western Cape through a sustainable development path*" (WCPG, 2012: 3-1). The principles enacted to achieve this vision include Ecological integrity, the health of the Planet; Social equity the situation of the People; and Economic efficiency, the attainment of Prosperity (WCPG, 2012: 2-1). This framework aims to redirect the historical development trajectory of urban sprawl, environmental recklessness and inequality (WCPG, 2012). The PSDF provides an analysis of all towns in the province to understand their socio-economic needs and potential, along with the identification of development corridors and tourism routes to be enhanced and maintained, as seen in Figure 3.3. More precisely, with regard to water in the Western Cape, the PSDF acknowledges concern over the increasing water scarcity on the west coast from Cape Town to Saldanha especially as this area holds the greatest socio-economic development and growth pressure.

Figure 3.3: The Western Cape's Provincial Spatial Development Framework (WCPG, 2009: 8-5)

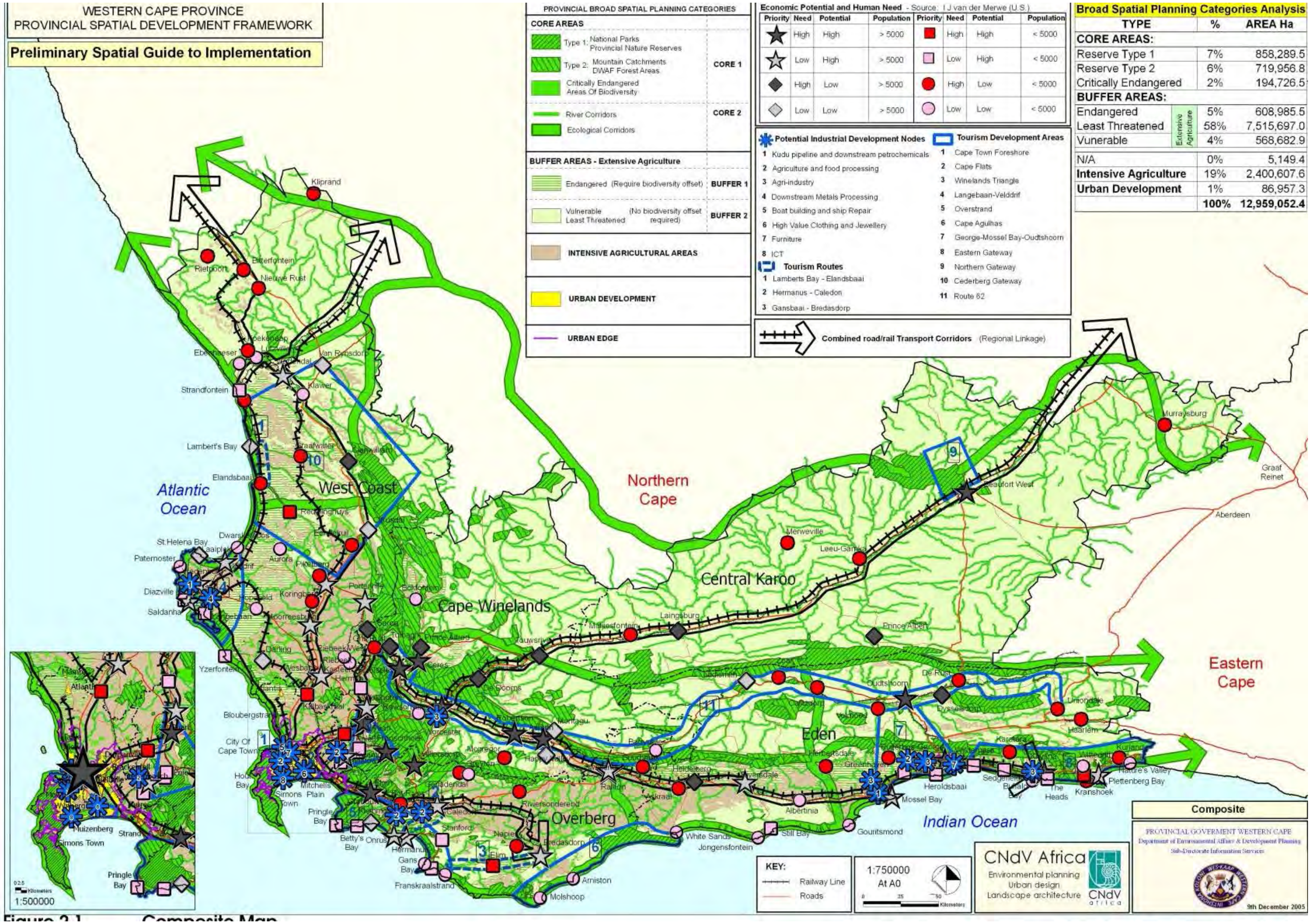


Figure 3.1 Composite Map

In this document, water is conceptualised as a resource for human consumption within the following objectives:

- Objective 1: Align the future settlement pattern of the Province with areas of economic potential and the location of environmental resources.
- Objective 2: Deliver human development programs and basic needs programs wherever they are required.
- Objective 3: Strategically invest scarce public resources where they will generate the highest socio-economic returns.
- Objective 9: Minimise consumption of scarce environmental resources

The PSDF presents a spatial vision of the Western Cape as an area dominated by environmental concern with preference given to Critical Biodiversity Areas as the primary spatial structuring element across the province and with the City of Cape Town as the principal metropolitan area. The plan reinforces the socio-economic and spatial dominance of the City of Cape Town within the region with secondary areas being identified as Saldanha, Mossel Bay - George, Stellenbosch – Paarl and Hermanus.

Following from this, the SDF for the City of Cape Town looks inward to identify key priorities for the city while acknowledging the strong inter-dependent relationships with the rest of the region and surrounding provinces in South Africa. The 2040 vision for the City of Cape Town is to (CoCT(a), 2012: 9);

> *"turn Cape Town into one of the world's greatest cities in which to live and learn, work, invest and discover – a place of possibility and innovation, with a diverse urban community and all the opportunities*

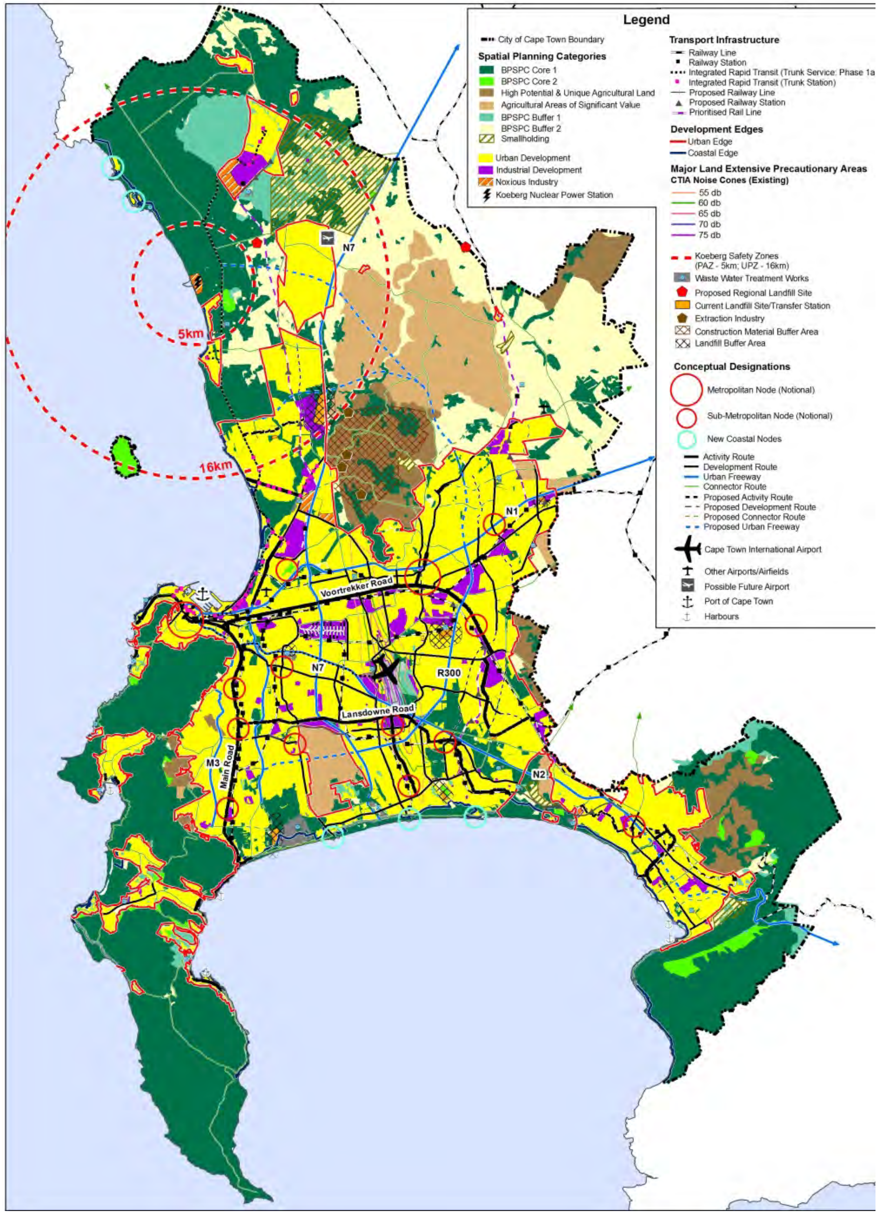


Figure 3.4: City of Cape Town Spatial Development Framework (CoCT(a), 2012: 85)

and amenities of city life, within a natural environment that supports economic vibrancy and inspires a sense of belonging in all".

The primary principles to enable this vision are that the public good should prevail over private interests, to work harmoniously with nature, equity and equality, and urban efficiency. As seen in Figure 3.4, these are spatially translated through the identification of activity and development routes with a hierarchy of nodes, such as Voortrekker Road, Main Road and Lansdowne Road, and the inclusion of an urban edge to strategically concentrate economic development and densify these urban areas. Land use is also an important element in the SDF with industrial and agricultural land of significant value identified along with residential, commercial and biodiversity land uses.

More specifically with regard to water, the SDF speaks of creating a balance between urban development and environmental protection through reducing the impact of development on freshwater ecologies. This is proposed to be implemented at the spatial scale of the District SDF through the incorporation of WSUD principles so that development decisions do not negatively affect high productivity aquifers, rivers and wetlands (CoCT(a), 2012). The SDF puts forward a strong development vision for the City of Cape Town which aims to strategically intervene to promote spatial equity and improved livelihoods for citizens. However, as evident in the final SDF map, the spatial and visual presence of water is subservient to the economic and social imperatives in the City of Cape Town.

Water in South Africa, the Western Cape and the Berg River Water Management Area

South Africa is considered to be a water-stressed country with a low Water Poverty Index (WPI), as seen in Figure 3.5. The WPI includes measures of "*access to water; water quality, quantity and variability; water uses, capacity for water management; and environmental aspects*" (Sullivan *et al*, 2003: 189).

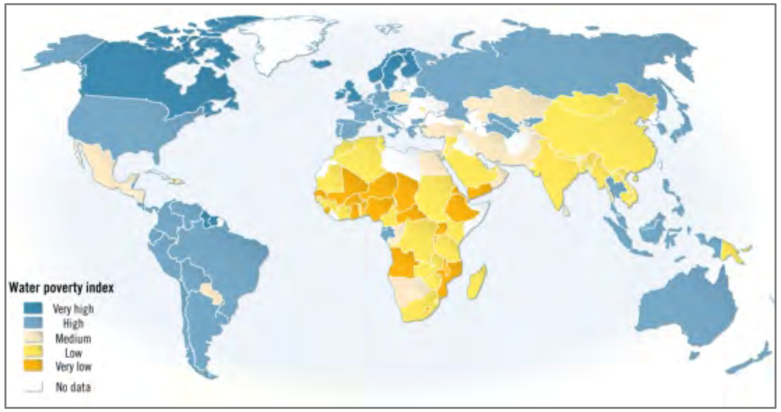


Figure 3.5: A map of the world showing the Water Poverty Index for each country (Ahlenius, 2005). South Africa has a Low Water Poverty Index Rating.

This is due to both climatic and anthropogenic reasons. South Africa is the 30th driest country in the world with low rainfall and a warm climate that increases evaporation which, when accompanied by a relatively large population compared to other countries in the SADC region, results in a low per capita quantity of available water (DWA, 2013). Of this low rainfall, only 9% is runoff to be utilised while the remaining 91% either infiltrates the ground or is evaporated (Winter, 2010). The diverse topography and climate of South Africa, from high-lying mountains to low coastal plains; from arid to sub-tropical regions, results in a highly varied rainfall pattern across the country with 60% of rivers arising from only 20% of the land (DWA, 2013). This makes water and the land that captures rainfall a scarce and valuable resource.

South Africa relies primarily on surface water resources with groundwater being used for some agricultural irrigation. Due to this over reliance on surface water resources, most of the economically available water yield in South Africa is developed and utilised; with two thirds of the Mean Annual Rainfall (MAR) stored in dams (DWA, 2013). Groundwater is therefore increasingly being recognised as an important and viable alternative source of water for human consumption, especially in urban areas where demand is high. Along with water quantity, water quality in South Africa is also a national concern as 60% of river ecosystem types and 65% of wetlands are threatened; with 25% and 48% being critically endangered, respectively (DWA, 2013). This is indicative of a dire disruption to the natural water cycle thereby undermining national water security.

There are a number of concerns and challenges regarding water at a national scale in South Africa; these include security of supply, environmental degradation and resource pollution (DWA, 2013). To address these concerns across a varied set of topography and climatic conditions, the National Department of Water and Sanitation has divided the country into nine water resource planning areas that follow the ecological borders of watersheds, as seen in Figure 3.6. These are known as Water Management Areas (WMAs) and the Western Cape is made up of two WMAs. Each of these WMAs is supposed to have a Catchment Management Authority who makes decisions regarding water allocations and management in that area and is made up of a variety of stakeholders. It is important to note that the legislated provincial and municipal boundaries do not coincide with the boundaries of the CMAs therefore making co-ordination and implementation difficult with multiple stakeholders adhering to different provincial and municipal policies and by-laws.

As access to water is a human right enshrined in the Constitution, there is a direct imperative to ensure that this scarce resource is distributed in such a way as to provide for the basic needs of all citizens irrespective of where they live in South Africa. To give effect to this a Basic Human Needs Reserve (BHNR), along with an Ecological Reserve (ER) to promote a well-functioning environmental system, is required by the National Water Act of 1998 to be enforced on all water resources in all WMAs (RSA, 1998). The BHNR dictates that each person should receive 25 litres of water per day for drinking, cooking and washing. The ER requires that at least 25% of the national MAR should remain in rivers, although this percentage differs according to the biophysical context of each river system (DWA, 2013). While the BHNR is effective in almost all municipalities, only the Breede-Overberg CMA in the Western Cape has implemented an ER for the river (DWAF, 2003).

Figure 3.6: A map showing all 9 Water Management Areas in South Africa (DWA, 2013)

As seen in Figure 3.7, the allocation of water is undertaken predominantly by National Government with later stage allocations undertaken by the relevant CMA. This national allocation methodology requires that the BHNR and the ER are of first priority, with secondary priority given to international obligations, inter-basin transfers, future water use and strategic water use. After which, if there is still available water it can be considered for new allocations.

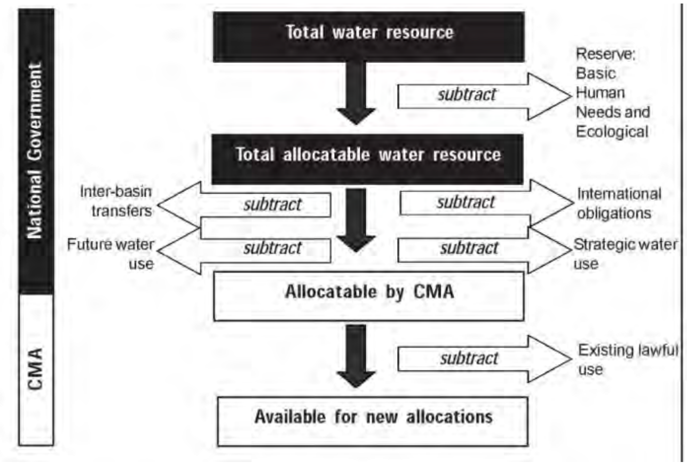


Figure 3.7: A diagram indicating how water is allocated within and out of South Africa and the institutions involved (Sguazzin et al, 2003: 9)

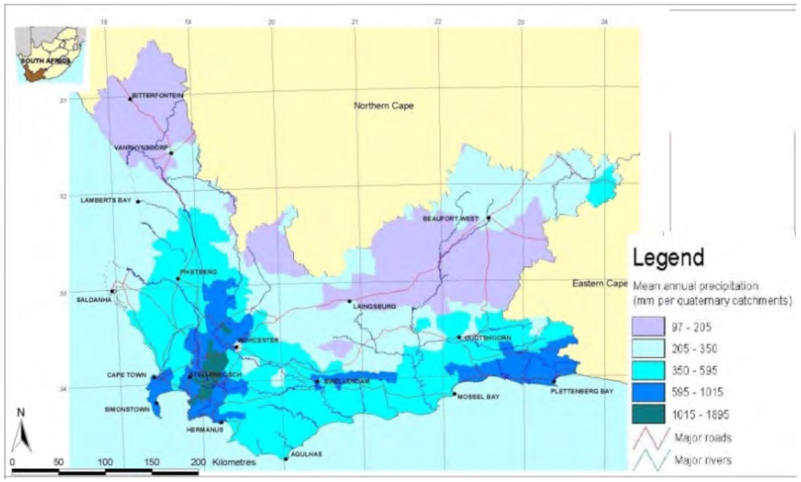


Figure 3.8: A map indicating the Western Cape's average rainfall in quantity and location (Cape Water Solutions, 2013)

More specifically, in the Western Cape rainfall varies spatially and seasonally from the semi-arid west coast to the high-lying Boland Mountain Range to the temperature southern coast. Cape Town receives a relatively high rainfall and is in close proximity to areas of the highest rainfall in the Western Cape, as seen in Figure 3.8. This makes contextual-based water management essential to sustainable water use leading to a secure water future.

Climate change in the Western Cape and the City of Cape Town is expected to result in decreasing water availability and a shorter rainfall season with an increased severity in extremes, such as storms and flooding. Accompanying this, temperatures will be warmer with increased wind speeds leading to increased rates of evaporation in dams and rivers (WCPG, 2011). This is predicted to lead to a greater frequency in the presence of droughts and pests, increased fire danger and soil erosion, and increased energy consumption to pump and clean water from further afield. Water is therefore acknowledged as a key sector in the short to medium term that requires the implementation of climate change adaptation and mitigation responses (WCPG, 2011).

The Berg WMA, as seen in Figure 3.9, has a single primary river which is the Berg River which flows from the Boland Mountains in the South East to Saldanha Bay in the North West. With the warm, dry summers and cool, wet winters this Mediterranean climate supports both irrigated, intensive agriculture, such as vineyards, and dryland, extensive agriculture, such as wheat. The primary urban area in the Berg WMA is the City of Cape Town with secondary towns being Stellenbosch, Paarl and Saldanha. Due to the high expense and resource needs to transport water far distances, as is in nature, each region's activities should be adapted to the amount of water available within that region As seen in Figure 3.10, the Berg WMA differs from other

WMAs in the Western Cape in its consumption profile in that over 50% of water is used in urban areas with the City of Cape Town as the major user (Berg et al, 2007). This is interesting to note as in the Berg WMA, urban land use occupies less than 20% of the area, as seen in Figure 3.9, therefore indicating a lack of ecological alignment in urban water resource system.

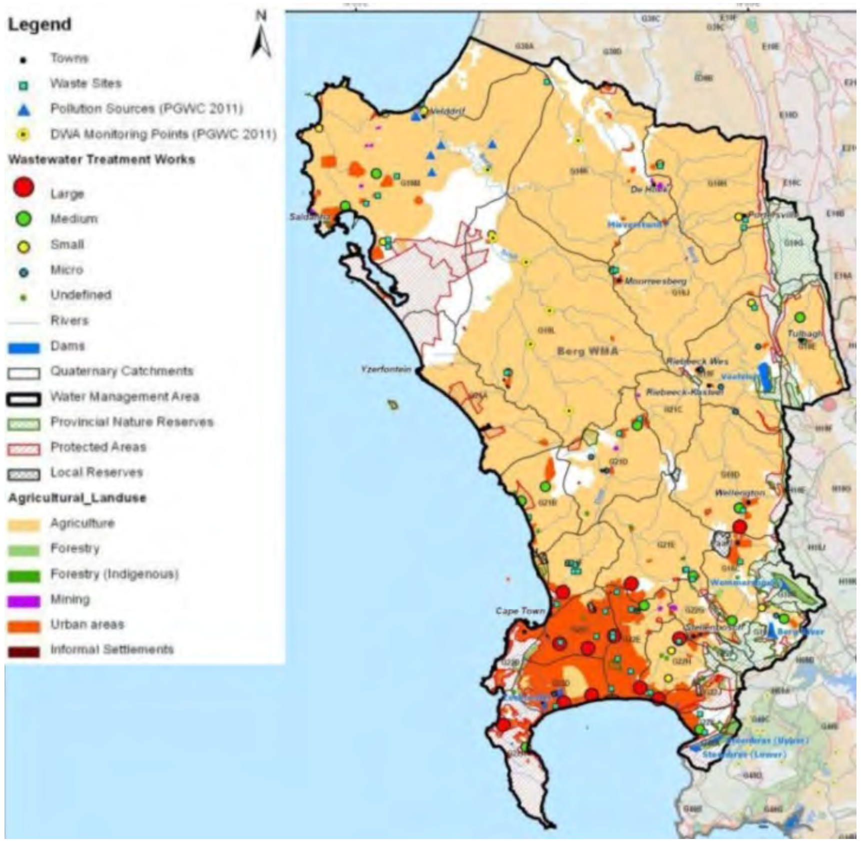


Figure 3.9: Land Use in the Berg WMA (WCPG, 2011: 313). Dark orange is indicative of urban development with Cape Town present in the South West.

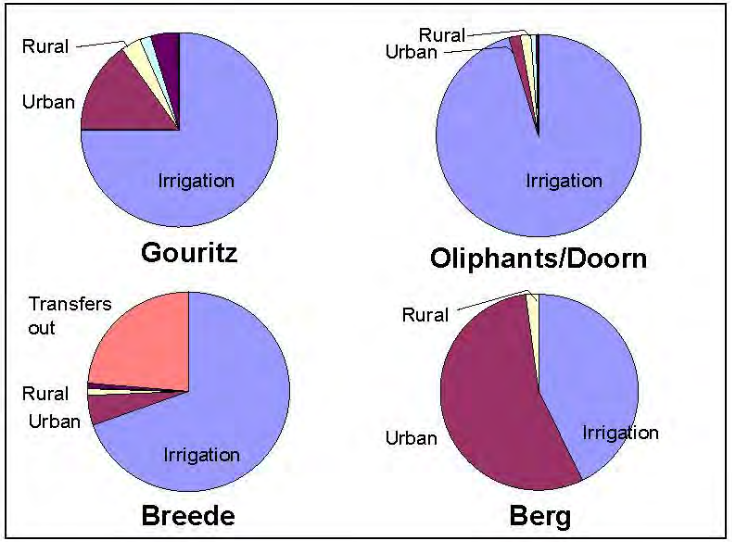


Figure 3.10: A comparison of water use in each of the Western Cape's four WMAs (WCPG, 2011: 332). The Berg WMA is dominated by urban water use.

Analysis of Water in the City of Cape Town

As the spatial focus area of this study is the City of Cape Town, this section offers an overview of the bio-physical and socio-economic conditions and trends of the municipality to understand the local biological and human influences on the urban water system and hydrological system. This is followed by a more in-depth analysis of water supply, consumption and output of the city. The aim of this section is to provide a quantitative and qualitative foundation of research to understand the context-specific priorities, concerns and opportunities for a water secure future in Cape Town which will guide strategic intervention in the next chapter of this study.

Biophysical Analysis

The City of Cape Town is located on the south west coast of South Africa in the Western Cape Province, as seen in Figure 3.11. Known internationally for the Table Mountain Range, the beaches on the Atlantic and Indian Ocean coastlines, and the Cape Floral Kingdom; Cape Town is also host to unique grasslands on the lowlands of the coastal plain, known as the Cape Flats[1], and a diverse network of rivers and wetlands which are a haven for plant life and animals and provide a natural infrastructure to support the city (CoCT(c), 2012). It is for this reason that the Khoi originally named this area *Camissa* which means 'Place of Sweet Waters' (Boraine, 2010). This has resulted in the City of Cape Town being a global urban biodiversity hotspot without parallel; thereby placing international responsibility on the municipality, the Provincial Government and the National Government to ensure adequate protection and conservation (CoCT(b), 2008).

Overall, the City of Cape Town's environmental well-being is improving slightly with the '2012 State of the Environment Report' for the municipality indicating that water use, freshwater quality, air quality and solid waste are improving; invasive species, access to natural green space, waste water, energy use and carbon are stable with biodiversity and coastal water quality declining since 2009 (CoCT(c), 2012). With regard to water resources, this is a promising report showing hopeful trends however, as biodiversity and coastal water quality are both indicators of the overall health of a system, there are still concerns with regard to the urban water system in Cape Town.

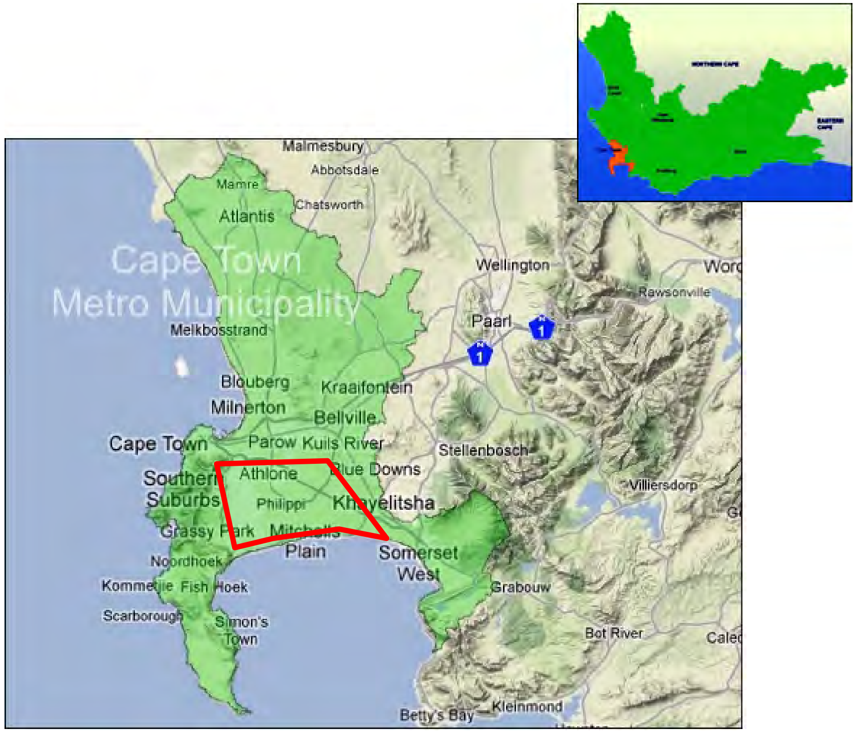


Figure 3.11: A map indicating the location and boundary of the City of Cape Town. The Cape Flats is outlined in red (http://www.westerncape.gov.za/image/2012/10/cape_town_metro_map.jpg)

The metropolitan municipality covers a total area 2461 km^2 (StatsSA, 2011). The Mediterranean climate provides rainfall throughout the year but mostly in the cooler winter months. The total MAR for Cape Town is 379Mm^3/a (CoCT, 2005).The rainfall is largely brought in by the North Westerly wind, the dominant winter wind, while the strong South Easterly wind brings dry air in summer. This results in wetter areas around Table Mountain Range with drier conditions on the Cape Flats (CoCT, 2005). The network of rivers and wetlands which transports and captures this rainfall is vital to the ecological functioning of this region; especially on the drier Cape Flats which has few rivers as it is a

[1] The Cape Flats has historically been under-conserved and has experienced sprawl due to Apartheid planning policies

dune system. The main rivers in the City of Cape Town are the Lotus, Soet, Bokramspruit, Hout Bay, Mosselbank, Sir Lowry's Pass, Salt, Diep, Elsieskraal, Black, Eerste/Kuils, Silvermine, Schusters and Lourens Rivers with their respective tributaries. The main wetlands or 'vleis' in the City of Cape Town are Little Princessvlei, Milnerton Lagoon, Princessvlei, Rondevlei, Langevlei, Zoarvlei, Zandvlei, Westlake Wetland, Glencairnvlei, Die Oog, Rietvlei and Wildevoelvlei. A detailed map of the location of these can be seen in Annexure B. While a number of these are used for recreational purposes, unfortunately, the majority of these rivers and wetlands are highly modified, degraded and polluted with high levels of alien vegetation and siltation (Pithey *et al,* 2007).

As mentioned the City of Cape Town is located within the Cape Floral Kingdom, the most diverse in the world, therefore making protection of biodiversity of high priority. Ensuring the preservation of biodiversity in the indigenous fynbos vegetation of Cape Town also protects and conserves water resources, as fynbos has evolved to this climate and therefore does not consume a lot of water and provides a highly suited soil retention system for steep mountain slopes to prevent soil loss and siltation of rivers. It is therefore of great concern that there has been such a severe loss of vegetation and biodiversity in the City of Cape Town due to urban development and agricultural expansion, as seen in Figures 3.12 and 3.13 where each colour represents a different type of vegetation and the white represents a lack of the indigenous vegetation.

The current Biodiversity Network for the City of Cape Town, which is presented and incorporated in the SDF, includes these remaining areas of indigenous vegetation in the city within a web of systems that aims to create linkages with the formally protected areas of indigenous vegetation, such as Table Mountain National Park, where possible. The hope is that with greater connectivity, the vegetation will have a greater likelihood of flourishing. It is important to note that while some of these critical biodiversity areas coincide with the main rivers and wetlands due to their associated vegetation, there are some hydrological systems which remain unconsidered and under-conserved.

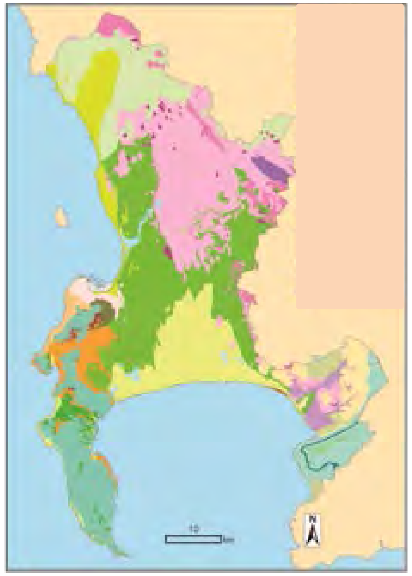


Figure 3.12: Historical extent of natural vegetation in City of Cape Town (CoCT(c), 2012: 17)

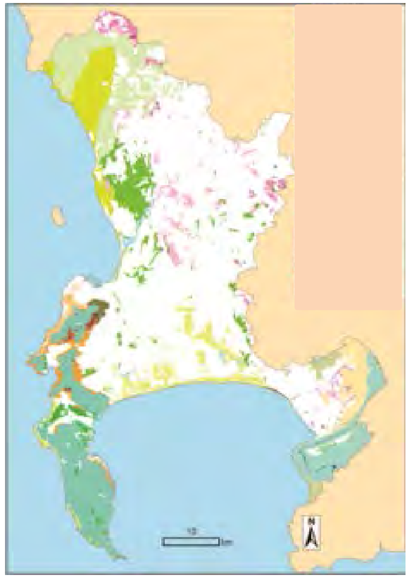


Figure 3.13: Current extent of natural vegetation in City of Cape Town (CoCT(c), 2012: 18)

Due to the close proximity of urban development, especially informal housing, and natural boundaries, such as mountain ranges, the coastline and rivers combined with strong climatic variances; the City of Cape Town is exposed to various natural risks which are most often exacerbated by inappropriate urban development. As seen in Figure 3.14, this includes fires (informal settlement one in red dots), floods (blue) and the threat of sea level rise due to global warming (ranges from green, yellow then orange) with those in poverty, living mostly on the Cape Flats, experiencing the greatest vulnerability.

The varied bio-physical conditions of the City of Cape Town creates a diversity in flora, fauna and hydrological systems which is an asset that must be preserved not only for ecological functioning but to aid an improved resilience in the livelihoods of citizens.

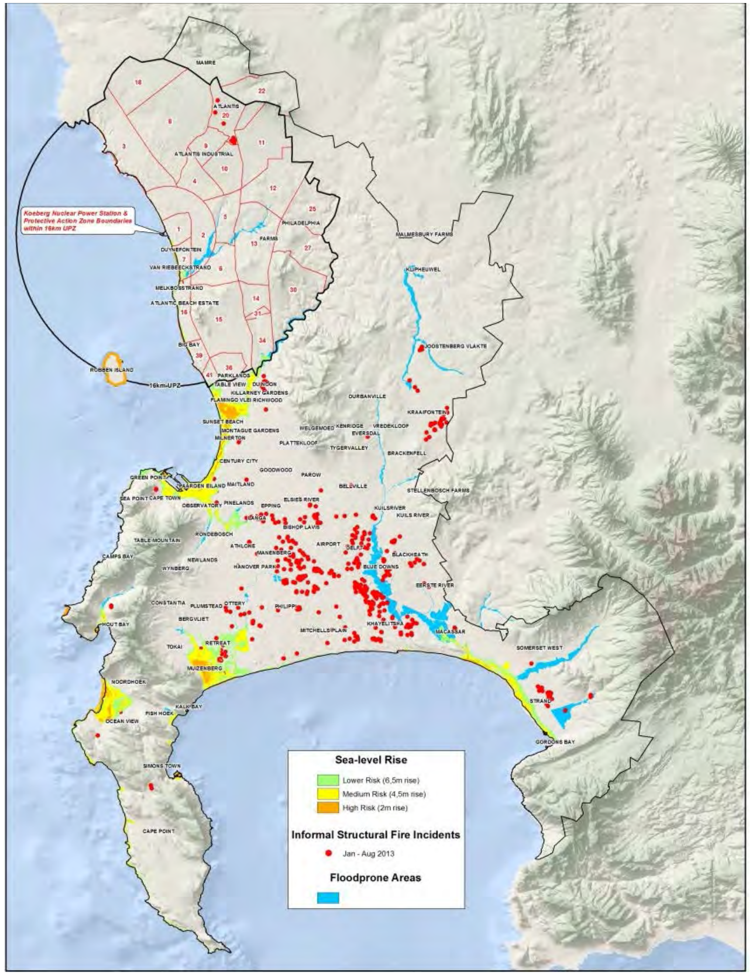


Figure 3.14: A map indicating the risks and areas of vulnerability (fire, flood and sea level rise) in the City of Cape Town with a magnified view of the Cape Flats as the area of greatest vulnerability (CoCT, 2013)

Current and Future Land Use

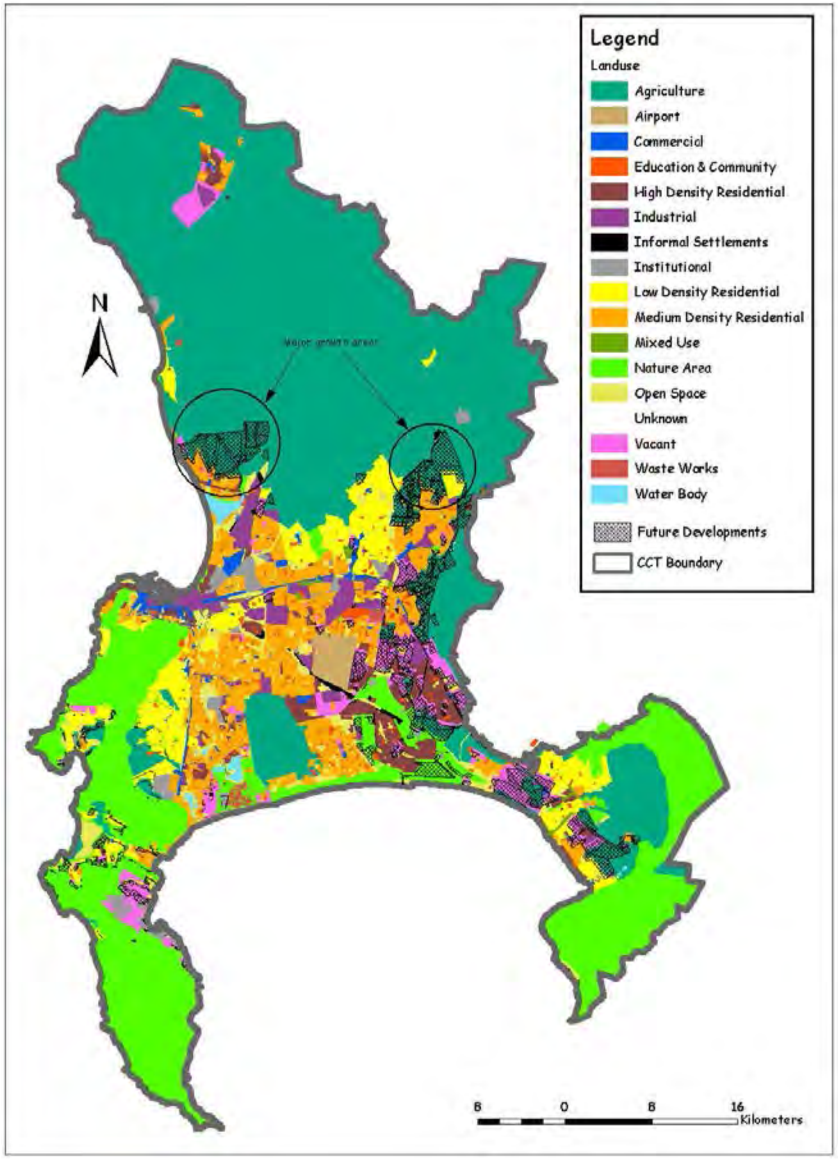


Figure 3.15: A map indicating the current and potential land use in the City of Cape Town (CoCT(a), 2008: 65)

Land use denotes how human activities are modifying the land. In the City of Cape Town, the primary land uses are medium and low density residential; commercial; industrial; agriculture; and conservation, as seen in Figure 3.15. The location of human activity in Cape Town is dictated by the topography with a concentration of habitation on the Cape Flats. Three key environmental considerations of land use are urban sprawl, access to green open space and the location of vacant land that is available for potential development. As seen in Figure 3.16, the threat of urban sprawl is being experienced as development spreads from the Northern central city, the Bellville area, northwards and eastwards, following major transport routes such as the N7, N1 and N2.

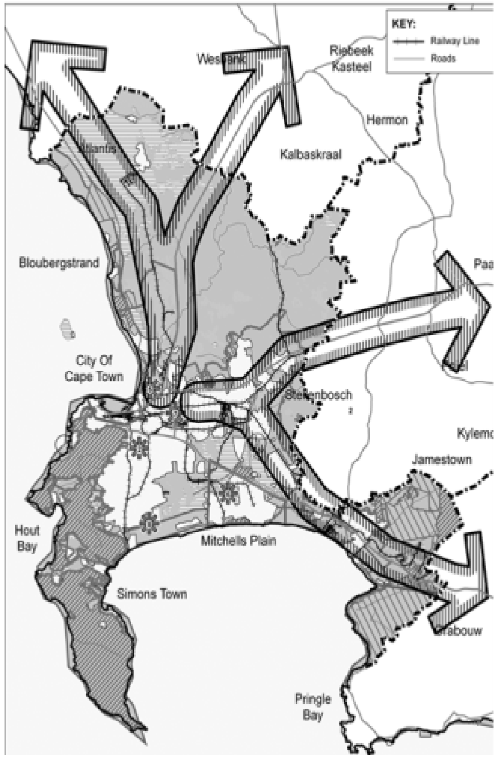


Figure 3.16: City of Cape Town urban sprawl threats (WCPG, 2009: 104)

This trend of sprawl has resulted in a 40% increase in the spatial footprint of Cape Town since 1985 (Armitage *et al*, 2009). As urban development continues to spread rather than compact, the cost of the provision of services is expected to rise with new infrastructure needed to serve areas further away. This is especially concerning with regard to water as with longer distances there is a greater opportunity for water loss through leaks. To counter this, the current SDF proposes an Urban Edge to bound urban development and spread. However, this precautionary measure has been overstepped to allow for a new, large scale urban development on the West Coast known as WesCape which is particualrly questionable with regard to urban water security. Secondly, the need for access to green open space that is of a good quality and is safe is necessary for the health and well-being of citizens and biological life support systems. It can also help citizens to reconnect and develop a relationship with their natural surroundings, as Cape Town is so well-known for. However, the Cape Flats has a deficiency of access to healthy, quality green space with prime access available to low density residential areas along the mountain ranges to the west and east of the City (CoCT(a), 2012). Finally, with regard to vacant land that is available for potential development, while there are a few land parcels within the city which are mainly around the airport, the majority of available land is on the periphery (CoCT(a), 2012). This could be a concern with regard to the provision of services related to urban sprawl.

Socio-economic Analysis and Trends

The City of Cape Town is the second most populous city in South Africa and is the most densely populated and urbanised municipality in the Western Cape and Berg WMA. It has a total population of 3 740 026 which is 64% of the Western Cape's total population (StatsSA, 2011). The population is predicted to

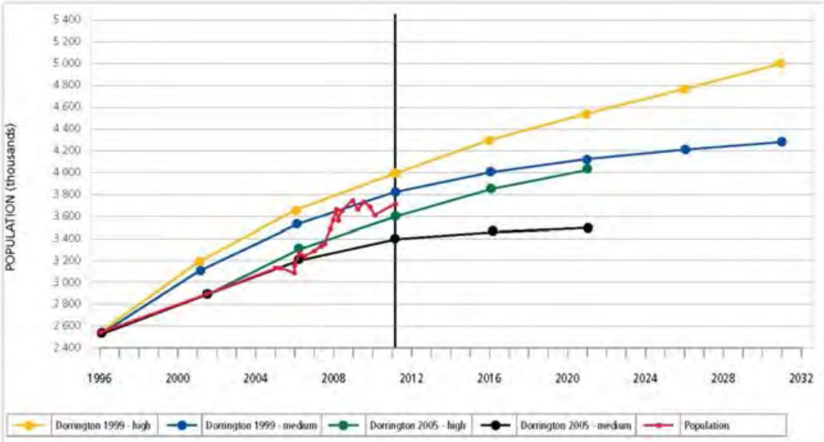


Figure 3.17: A Graph showing high and medium predictions for future population growth for the City of Cape Town from 1996 to 2030 (CoCT(a), 2012)

Key Socio-economic Statistics	2001 Census	2011 Census	Trend (2001 - 2011)
Total population	2892243	3740026	22.67%
Young (0-14)	26,6%	24,8%	Small Decrease
Working Age (15-64)	69,6%	69,6%	Stable
Elderly (65+)	5%	5,5%	Small Increase
Dependency ratio	46,3%	43,6	Small Decrease
Sex ratio	92,4	95,9	Small Increase
Annual Growth rate	2.40%	2,57%	Small Increase
Population density	no data	1530 persons/km2	
Unemployment rate	29,2%	23,9%	Large Decrease
Youth unemployment rate	36,8%	31,9%	Large Decrease
No schooling aged 20+	4,3%	1,8%	Large Decrease
Higher education aged 20+	12,8%	16,6%	Large Increase
Matric aged 20+	25,9%	29,8%	Small Increase
Number of households	759,485	1,068,573	Large Increase
Number of Agricultural households	no data	34,383	
Average household size	3,7	3,3	Small Decrease
Female headed households	35,7%	38,2%	Small Increase
Formal dwellings	78,9%	78,4%	Stable
Housing owned/paying off	60,7%	54,2%	Small Decrease
Flush toilet connected to sewerage	85,4%	88,2%	Small Increase
Weekly refuse removal	94,3%	94,3%	Stable
Piped water inside dwelling	69,4%	75%	Small Increase
Electricity for lighting	88,8%	94%	Small Increase

Figure 3.18: A table indicating the trends in key socio-economic statistics from 2001 to 2011 (compiled and analysed by author with original data from StatsSA, 2011)

be approximately 4.2 million by 2030 based on moderate assumptions, as seen in Figure 3.17 (CoCT(a), 2012). The table in Figure 3.18 is a summary of key population statistics for Cape Town. The trends between 2001 and 2011 to be noted are that the annual population growth rate has increased slightly; there has been a decrease in the unemployment rate; there has been a large increase in the number of households while the number of formal households has remained stable which means growth is predominantly happening in the informal sector; and there has been an increase in the number of households with access to a flush toilet connected to sewerage and access to piped water inside the dwelling. However, there still exists a backlog which if not addressed will continue to grow with the growing population.

Spatially, Cape Town still predominantly remains trapped within the Apartheid spatial structure of racial segregation, as seen in Figure 3.19, as there is little residential racial integration. Informal settlements are areas of need in the city as these hold the greatest backlogs in service provision and high rates of unemployment and, as seen in Figure 3.20, the informal settlements of Cape Town are mostly located on the Cape Flats.

Cape Town has a service-based metropolitan economy that is driven by small, medium and micro-enterprises which account for 50% of the city's economic output. This diverse economy's three biggest sectors are finance, insurance, property and business services; manufacturing; and wholesale and retail trade, catering and accommodation (CoCT, 2014). As agricultural production is decreasing, there is a push towards enabling growth in the tourism sector (UCT, 2013). This however is questionable as the small-scale agriculture prevalent in Cape Town is labour intensive while tourism is highly seasonal and is a supporting industry. Overall, this output is 10.58% of the South African Gross

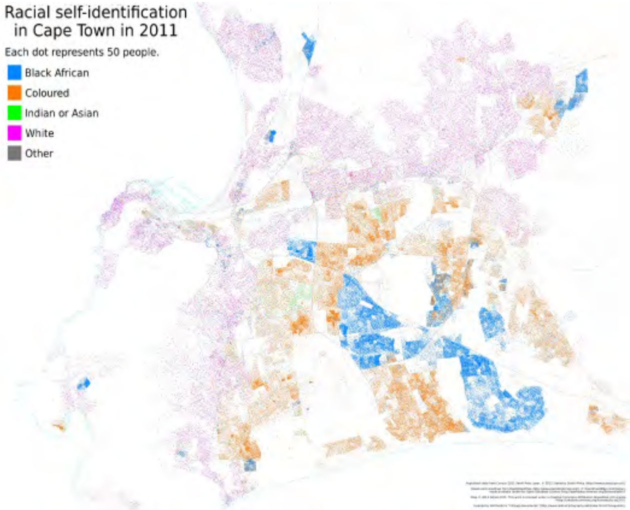


Figure 3.19 (Top): A map indicating the racial distribution and density of the residential areas in the City of Cape Town (Frith, 2012)

Figure 3.20 (above): Map indicating the location of informal settlements, shown in red, in the City of Cape Town (Rodrique et al, 2006: 7)

Domestic Product (GDP) and 71.1% of the Western Cape's GDP (CoCT, 2014). This places Cape Town in an important position economically as a regional hub for the economy which offers local and global inter-connections. The annual economic growth rate has been an average of 4%, which falls below the 6% that is required to reduce unemployment (CoCT, 2014). However, about 14% of the population having no income while the largest annual income bracket is R19 600 – R38 200, which is a monthly income of between R1633 and R3183 which is below the 2011 Poverty line (StatsSA, 2011). This means that a minority, rather than the majority of citizens, is grossly benefitting from the economy resulting in a highly unequal economic state. Therefore to enable a more spatially equal economic growth, the City's SDF proposes a concentration of new economic activities on the Cape Flats (CoCT(a),2012).

Anthropogenic water use

The following section will focus on water in the City of Cape Town with specific reference to anthropogenic water use which is defined as water used by humans and in activities related to human livelihoods and recreation. This focus is justified by the dominance of human activity in the City of Cape Town that has modified the land and flow of resources and is the primary culprit of pollution and nutrients which damage the natural hydrological cycle. This section will examine the urban water cycle through looking at the sources and management of water, the use of water and the discharge of water once treated. This section will conclude with a comparison of the existing and desired state of the water and sanitation services system in Cape Town to determine its current level of sustainability.

The annual water use in Cape Town is 310 Million cubic metres (Mm^3) with the trend of water use over the last 15 years shown in Figure 3.21 (CoCT(c), 2012).

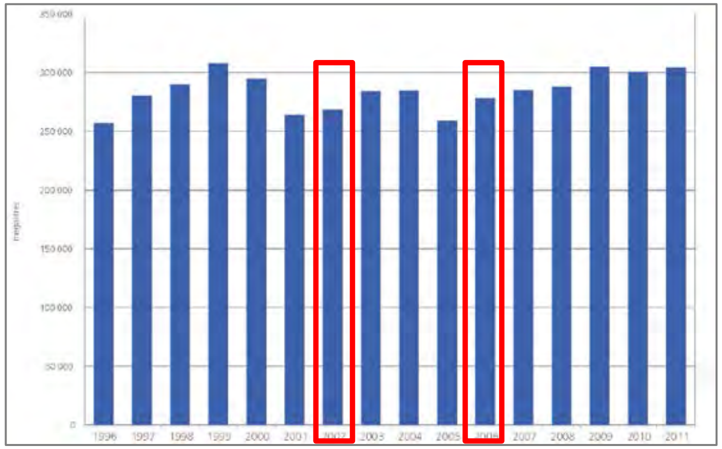


Figure 3.21: Total Annual water use from 1996 to 2011 in the City of Cape Town with years of water restriction indicated in red (CoCT(C), 2012: 33)

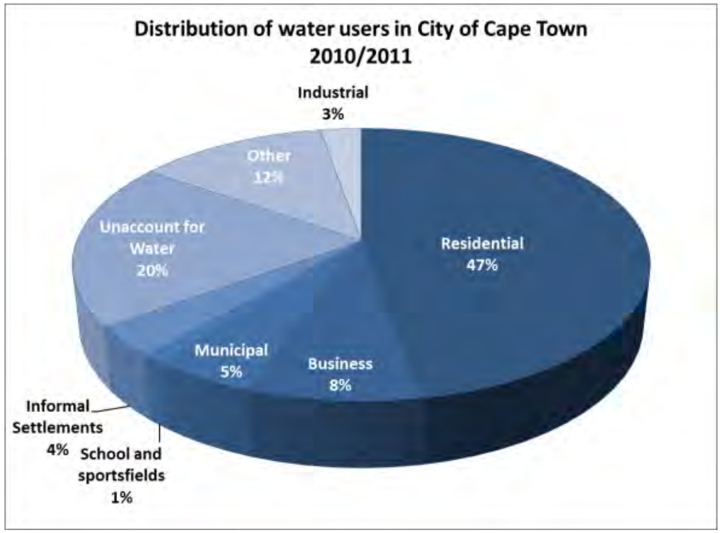


Figure 3.22: The percentage distribution of water users and consumers in the City of Cape Town 2010/2011 (from author with original data from CoCT(c), 2012)

This trend depicts the attitude towards water use in the City of Cape Town; where in 2001 and 2005 water restrictions were imposed resulting in a sudden and large reduction in consumption. However, once these restrictions were lifted, water use returned to previous levels. This shows that while restrictions have a short-term positive effect on the use of water, they do little to transform the long-term attitudes and behaviours of water users. To elaborate on this, the terminology used to represent a need to reduce water consumption, such as 'restrictions', frames the need for behavioural change in in the negative; a necessary inconvenience. Alternatively, there is a need to promote an understanding of the scarcity of water and the need for humility and reservation in resource consumption before the uncertainty of a changing climate.

The primary water users, as seen in Figure 3.22, are Formal Residential Consumers, Business and the Municipality. 'Unaccounted for water' is included in this data set as, although it is not a specific consumer, through unmetered connections and water leaks it accounts for 18-20% of all water used (CoCT(c), 2012). To understand the flow of this water from source to sink, this study has undertaken a Material Flow Analysis of Anthropogenic Water in the City of Cape Town.

Material Flow Analysis of Water in the City of Cape Town

A Material Flow Analysis is an industrial analysis methodology which, when applied to a metropolitan context, is concerned with quantifying the flow of resources from the natural environment into the anthroposphere, identifying the processes which use those resources and the resource outputs from those processes back into the natural environment (Hendriks et al, 2000). The MFA for water in the City of Cape Town developed in this study is seen in Figure 3.23.

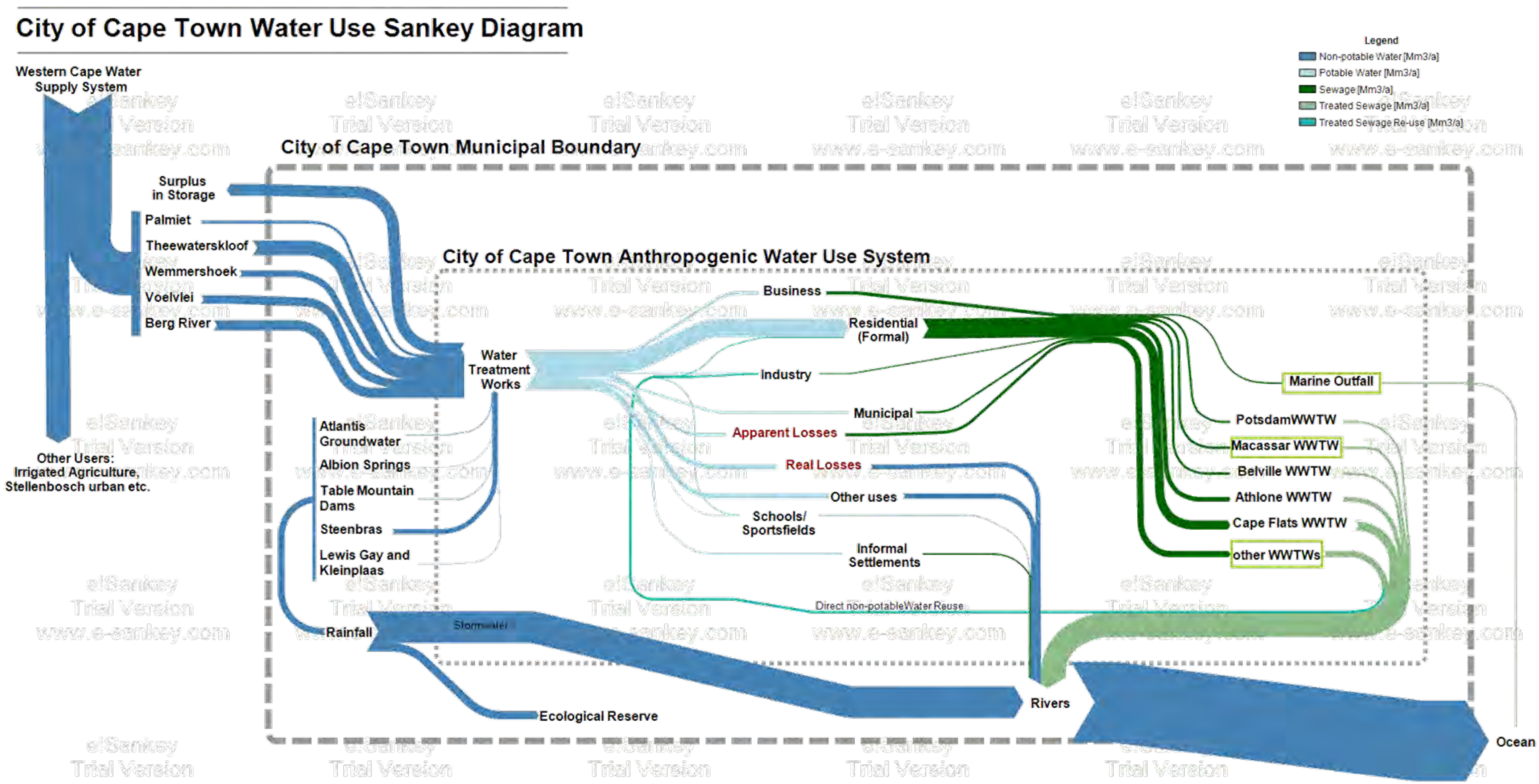


Figure 3.23: A Material Flow Sankey Diagram for the anthropogenic water system in the City of Cape Town. A larger version is available in Annexure C.

(from author, with data from: WCPG, 2011; CoCT, 2005; CoCT(c), 2012; CoCT(b), 2012;DWA, 2013, WCPG, 2012)

An MFA is a flow diagram made up of processes and arrows of flow, which is read from left to right. While the processes are named, the arrows of flow follow a key to represent the quantity and quality of water. The size of the arrow of flow is proportionally indicative of the quantity of water that flows from one process to one another. The colour of the arrows indicates the quality of the water flow; this includes non-potable, potable, sewage, treated sewage, and treated sewage for reuse. This is important to represent as, to intervene in an urban water cycle, both quantity and quality of water must be considered and used appropriately to move towards a more efficient and sustainable water system. The boundaries depicted in the MFA are representative of the systems analysed. Firstly, the larger rectangle is the City of Cape Town's physical municipal boundary, therefore the processes indicated outside of this rectangle occur outside of the municipal spatial boundary and those indicated within the rectangle occur within the boundary. The second boundary indicated in this MFA is that of the anthropogenic system in the City of Cape Town. This means that all processes which are a direct result of human intervention into the hydrological system, such as water treatment, consumption and waste water treatment, are included within this smaller rectangle. With regard to stormwater, as it is rainwater which is channelled through a human-built network of drainage but is not utilised as a water source, it enters and then leaves the anthropogenic boundary unchanged.

Overall, this MFA indicates a picture of linear water flow where outsourced water supply is relied upon as the primary water source; potable water is used for all purposes whether necessary or not; and very little water is reused. The subsequent analysis of the current state and trends of the urban water system in Cape Town will follow this flow of water from source to discharge as indicated in the MFA diagram.

Sources of Water Supply, Water Source Management and Bulk Water Service Provision

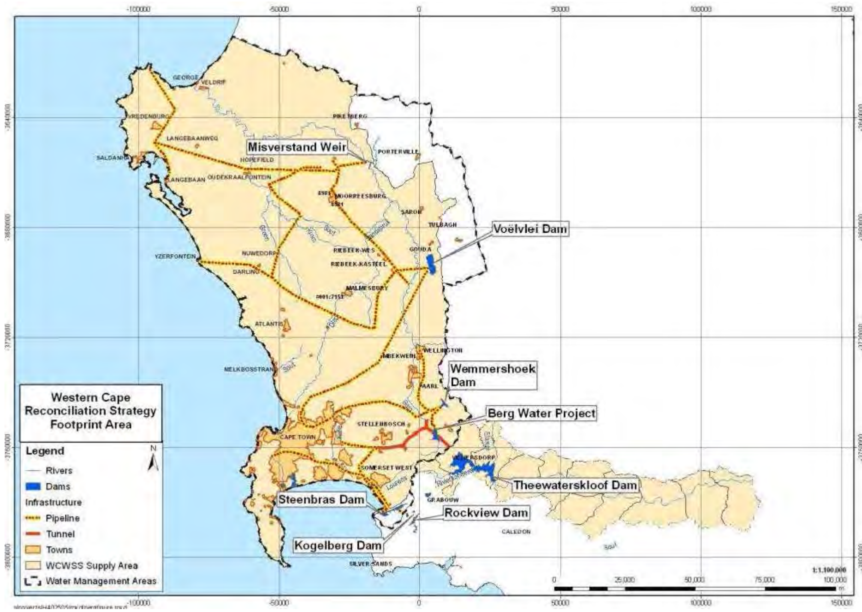


Figure 3.24: Map of the Western Cape Water Supply System (CoCT(b), 2012: 2)

The Western Cape Water Supply System (WCWSS) provides the City of Cape Town with water throughout the year. The physical extent of this system is seen in Figure 3.24. The current total water yield in this system is 556 Mm³/a (CoCT(b), 2012). Of this bulk untreated water supplied, 98.5% is sourced from surface water such as rivers and dams, while 1.5% is sourced from groundwater (CoCT(b), 2012). This system is managed and operated by DWS, Eskom and the City of Cape Town. While the majority of water in this system is utilised by the City of Cape Town, that is 398Mm³/a (CoCT(b), 2012), it also supplies water to urban users in Stellenbosch, Paarl and other towns in the Berg WMA and is used for irrigation of crops. This means that an unconstrained increase in demand for water from the City of Cape Town would negatively affect the availability of water for surrounding towns and agriculture, which could result in a vicious cycle of food insecurity and economic instability in the region.

The water for the WCWSS water is sourced from rivers and dams both within and outside of Cape Town's municipal boundary. The sources of water outside of the boundary make up 85% of total supply and include Theewaterskloof, Voëlvlei, Palmiet, the Berg River and Wemmershoek (CoCT(b), 2012). The remaining 15% is obtained from dams and sources within the municipal boundaries; this includes the Steenbras Dams, Lewis Gay and Kleinplaats Dams, Table Mountain Dams, Albion Springs, and the Atlantis Groundwater Scheme (CoCT(b), 2012). The proportionate contributions from each source are seen in Figure 3.25. It is then transported through a large reticulation network to water treatment plants around the city, as seen in Figure 3.26.

As noted ground water sources makes up a small percentage of overall water supply. In the City of Cape Town, the town of Atlantis in the north relies on the Silwerstroom and Witsands Aquifers where treated waste water is pumped into the aquifers and, through indirect reuse[2], is pumped into the potable water system which has placed these aquifers under high stress (CoCT(c), 2012). Groundwater is also the primary water source for non-potable water used for irrigation of agriculture in the Philippi Horticultural Area (PHA) which has placed the western side of the Cape Flats Aquifer under stress (WCPG, 2011). This stress is representative of unsustainable water use as extraction is outstripping recharge.

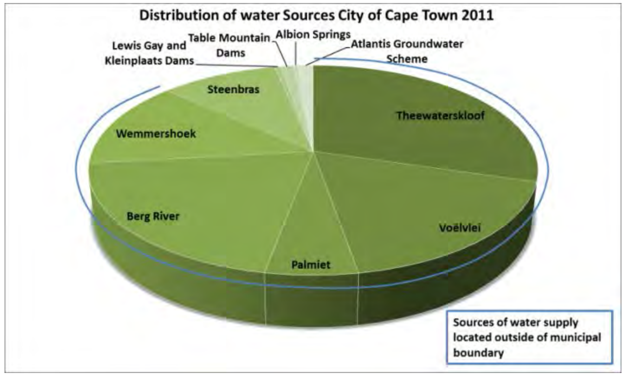


Figure 3.25: Proportionate distribution of water supplied from various sources to the City of Cape Town (from author with original data from CoCT(b), 2012: 2.152)

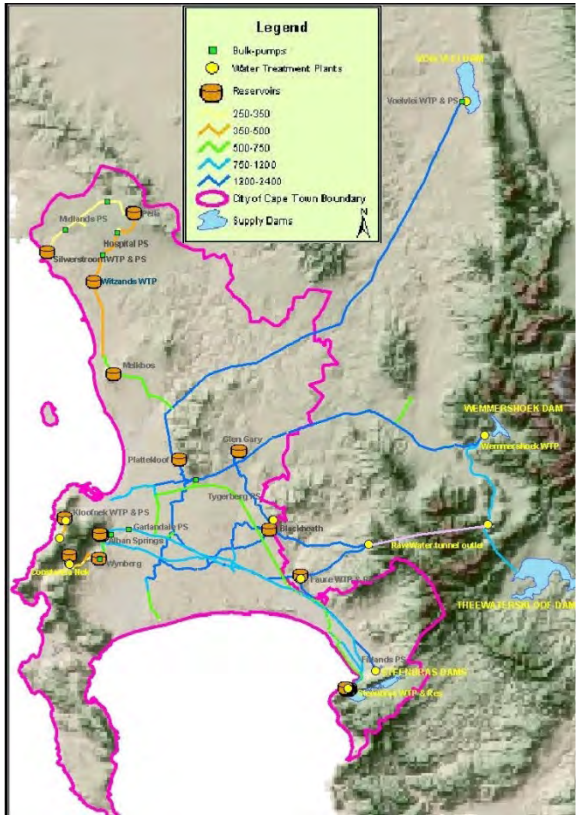


Figure 3.26: The main components of the bulk water supply Infrastructure in the City of Cape Town (CoCT(a), 2008: 155)

[2] "Indirect potable reuse is the augmentation of a drinking water source (surface or groundwater) with reclaimed (recycled) water followed by an environmental buffer that precedes normal drinking water treatment. This differs from direct potable reuse which is the introduction of recycled (reclaimed) water directly into a potable water distribution system downstream of a water treatment plant" (Chalmers, 2011: 5)

While there is currently a 98Mm³/a surplus in water supply from the WCWSS for the City of Cape Town, it is expected that demand will outstrip supply by 2019, even with successful Water Conservation and Water Demand Management (WC/WDM), after which new sources of water will be required (WCPG, 2011), as seen in Figure 3.27. To provide a plan to reconcile the supply of water with the demand for water in the city, there are a variety of proposals presented in the Western Cape Water Reconciliation Strategy which include, as listed from the most immediate to delayed interventions, raising Voelvlei Dam wall; abstracting water from the Table Mountain Group Aquifer; the large scale reuse of water, raising the Lower Steenbras Dam wall, abstracting water from the Cape Flats Aquifer; and finally desalination. The phasing of these has been considered with regard to social and economic feasibility.

With specific mention of the Cape Flats Aquifer, this is a viable water source which offers the potential to meet up to two thirds of the basic water needs, that is 18Mm³/a, in the City of Cape Town (Adelana and Xu, 2006). While the aquifer still is of an acceptable quality to utilise, it is becoming increasingly polluted (Adelana and Xu, 2006). This is due to the use of land above the aquifer and adjacent to the rivers which recharge the aquifer. This includes concentrated industry which leaks a variety of chemicals; wastewater treatment works which can leak untreated human waste and high levels of nitrates; landfill sites which can leak toxic materials from batteries and other waste; cemeteries which release toxins from decomposing bodies; informal settlements which are often characterized by little to no sanitation services and the infiltration of pesticides from the Philippi Agricultural Area (Giljam and Waldron, 2002). This illustrates the direct spatial relationship between land use and water source pollution therefore calling for a more water-literate and integrated spatial planning approach to allow for the use of urban water sources.

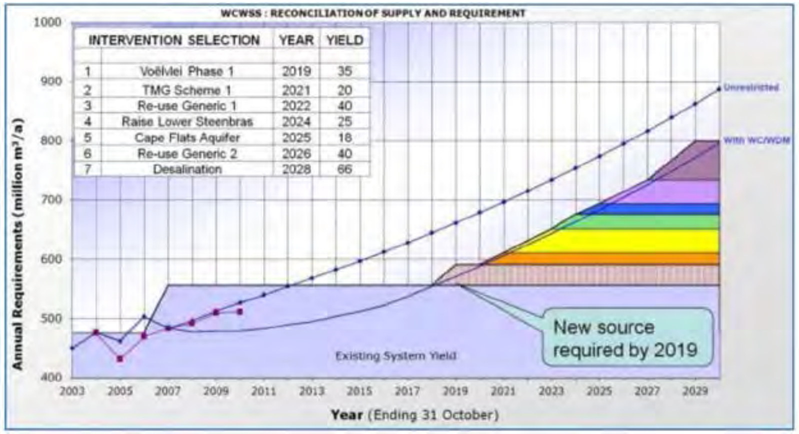


Figure 3.27: A graph indicating the current water use and supply, the expected date that demand will outstrip supply and the subsequent Western Cape Water Reconciliation Strategy to enable water security into the future (WCPG, 2011: 235)

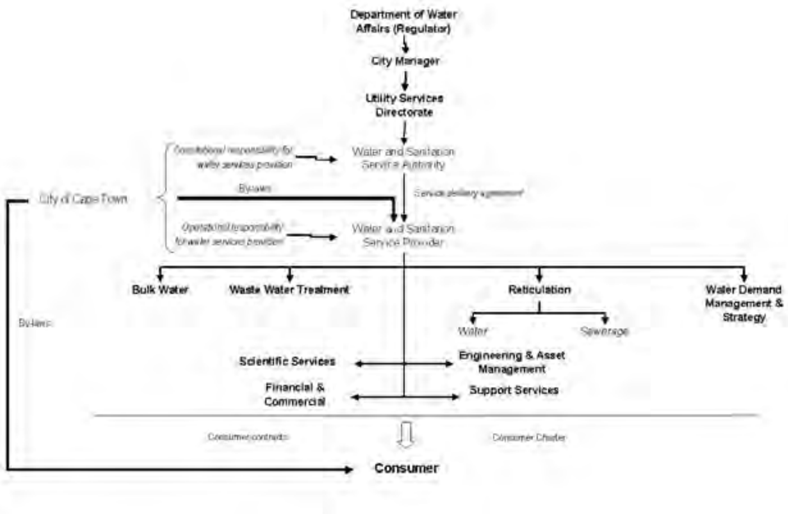


Figure 3.28: Water services institutional and governance arrangement diagram for the City of Cape Town (CoCT(c), 2012: 46)

The management of water in the City follows from that initiated by the DWS at a national and provincial level. The institutional arrangement of this relationship from DWS to the City to the consumer is seen in Figure 3.28. The City of Cape Town manages all water sources within the municipal boundary and the Wemmershoek Dam while DWS manages the rest.

Uses of Water in the City of Cape Town

From these dams, rivers and aquifers water is used as both potable and non-potable water. Potable water has been formally treated in a water treatment plant and is suitable for human consumption and non-potable water is untreated or less treated water that is only fit for activities with indirect or no human consumption. In total, per capita water consumption in the city has decreased over the last 15 years, as seen in Figure 3.29, which is indicative of the success of WC/WDM strategies that have been implemented. However, it is important to note this graph is an average across the city which hides the discrepancies of water use due to socio-economic factors and seasonal variations due to the presence of hot, dry summers where water demand is far higher than in the cool, wet winters.

In the City of Cape Town, the most common water used is potable water with the largest consumer being the formal residential sector, as seen in Figure 3.22 and 3.23. Of this sector, the largest water user is domestic single residential followed by informal households and then back yard dwellers (CoCT(b), 2012), as seen in Figure 3.30. The city aims to reduce current total water use from 310 Mm^3/a to 290 Mm^3/a with a daily per capita use from 220 litres/day to 180 litres/day by 2017 (CoCT(c), 2012) which could help push back the need for alternative water supply sources to 2026 (Winter, 2010).

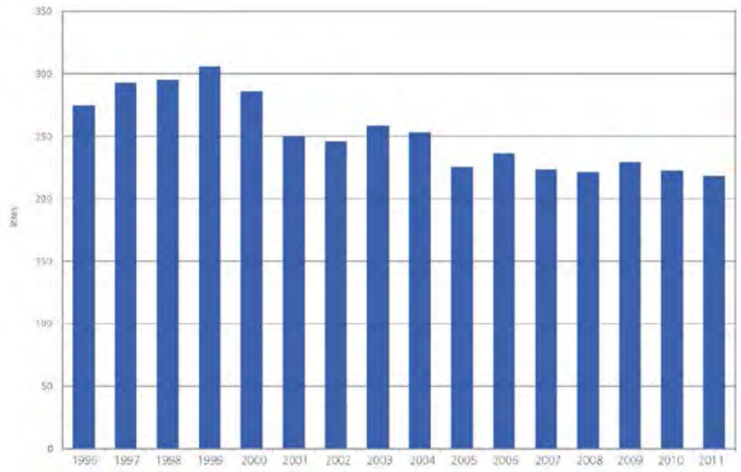


Figure 3.29: Daily per capita water use City of Cape Town 1996 – 2011 (CoCT(c), 2012: 34)

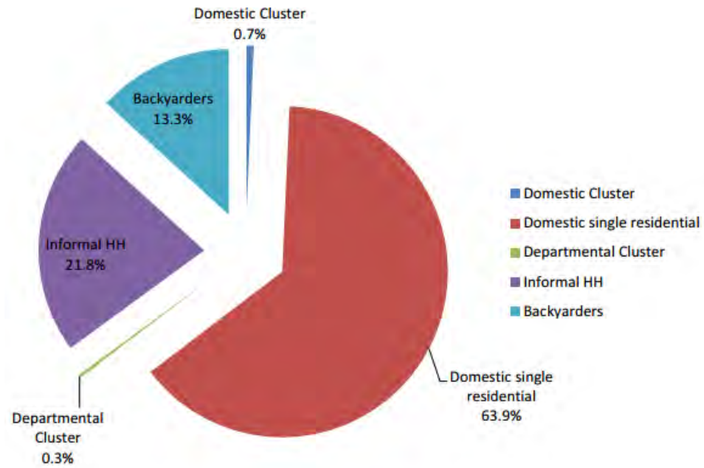


Figure 3.30: Breakdown of residential consumers in the City of Cape Town – December 2011 (CoCT(b), 2012: 28)

Within the formal residential sector, water is used predominantly for toilet flushing, showering/bathing and clothes washing (Jacobs *et al,* 2005). This is the case for both high income and low income households. However these users groups differ as higher income earners are more likely to use up to 38%

of their total water use for the irrigation of domestic gardens, as seen in Figure 3.31. This means that, respectively, 58% and 73% of potable water used in high and low income earning households can be substituted for non-potable water or make use of water reuse strategies.

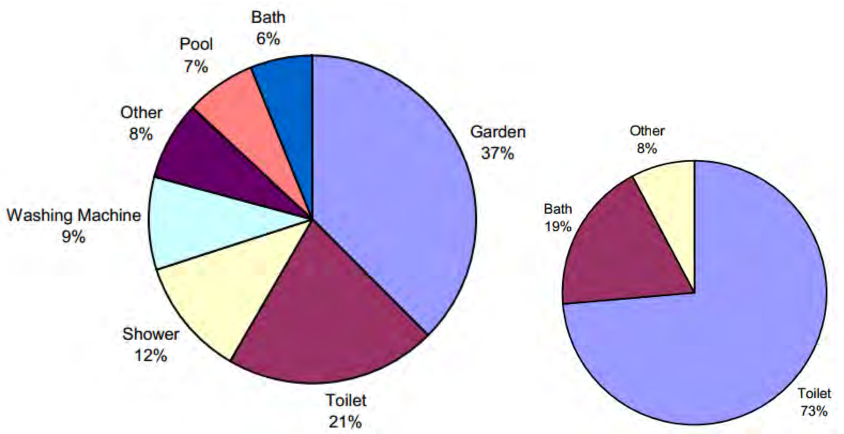


Figure 3.31: Diagrams indicating the distribution of water used in high income (left) and low income (right) households (Jacobs *et al,* 2005: 7). The diagrams are proportionately sized, with high income households using almost 2.5 times more water than low income households.

With the growing housing challenge in Cape Town, there are an increasing number of informal settlements and backyard dwellers for which there still remains a service delivery backlog. While the backlog is decreasing, as of January 2012, 99% of households in Cape Town had sufficient access to water supply with the remaining 1%, that is 14 511 households, all located in informal settlements (CoCT(b), 2012). While almost all formal households have a metered connection to the water supply system within the dwelling, those living in informal settlements are currently sharing one standpipe with a single tap that is within 100m of their household between 27 other households (CoCT(b), 2012). Along with the high usage requirements placed on a single tap, the lack of maintenance also results in the creation of cesspools and unhealthy conditions surrounding what is most often the only available water source (Pan, 2011). With regard to the provision of sanitation in the city, 88% of households have sufficient service provision, which means that there is a current backlog of 80 364 households. Currently all formal households have access to a flush toilet with almost all being connected to the sewerage system. However, only 59% of informal settlements have access to sanitation services (CoCT(b), 2012).

Flush toilets throughout the city utilise potable water which raises concern over the sustainability of the formal sanitation sector, especially with impending increases in use along with the rollout of housing. The majority of sanitation provision in informal settlements is water-free through the use of chemical toilets and pit latrines. However, as these services are shared between almost 6 households (CoCT(b), 2012), the lack of maintenance can leave them in an unsanitary and unsafe condition (Pan, 2011) thereby making them undesirable to inhabitants. This can result in many households relying on the bucket system or open defecation which leads to further hazardous conditions in the household and surrounding areas (CoCT(b), 2012).

This has resulted in many service delivery protests as residents are dissatisfied with the level of service provided (CoCT(b), 2012) and while this is understandable on the part of residents, there are many service delivery obstacles facing the City; these include a lack of financial capital the legal prohibition of providing services on private land and ill-suited land for settlement with high water tables or located on old land fill sites.

Water Pricing

Although not a direct spatial element of the urban water system, water pricing represents the economic value of this resource and the attitude towards water in a municipality. In Cape Town there is a domestic stepped tariff structure for water and sanitation that is pro-poor and addresses the needs of indigent households. The City currently aims to provide all citizens with 50 litres of free water per day; this is twice the national standard and meets international standards set by the World Health Organisation. This comes to a total of 6 kilolitres (kl) of free water per household of 4 people with an additional 4.5kl of free water for low income households (CoCT(c), 2012). This policy also includes the removal of 4.2kl of sewage per month and a 10kl allowance for subsistence farmers. Beyond this, water is charged for, with residential users being charged half of what industrial and commercial users, who are not subject to a stepped tariff, are charged (CoCT, 2013). This stepped tariff is beneficial as it invokes an ethos of the more you use, the more you pay. However, Colvin of the Freshwater Programme at WWF, says that this is not enough as the water tariff is too low for high income earners who are paying relatively little for a source of reliable, drinking quality water while those in poverty are paying an inordinate cost, either in monetary terms or in terms of labour or the burden of disease (Alfreds, 2013). From this it is then interesting to note that those high income earners are the same user group who consume the greatest amount of water which represents the undervalued nature of water in Cape Town.

Unaccounted for Water

Unaccounted for water (UAW) is defined as (World Bank, 2013);

> *"the difference between the quantity of water supplied to a city's network and the metered quantity of water used by the customers. UFW has two components: (a) physical losses due to leakage from pipes, and (b) administrative losses due to illegal connections and under registration of water meters".*

In Cape Town, UAW accounts for 18% of all water use, indicated in Figure 3.23 as real and apparent water losses (CoCT(b), 2012). While 38% of this is due to illegal connections, the remaining 62% is due to leaks (CoCT(b), 2012). This is indicative of the insufficient budget and capacity given to the maintenance and upgrading of old, failing infrastructure. The City aims to reduce UAW to 15% by 2017. Even so, as the availability of water decreases and demand increases, this area of wasteful water use will need to be addressed further.

Stormwater in the City of Cape Town

As mentioned, Cape Town receives precipitation throughout the year with high levels of rainfall during the winter months. In total the city receives approximately 379 Mm^3/a of MAR and, with an estimated 67.5 Mm^3/a of this necessary for the Ecological Reserve (CoCT, 2005). The city could therefore meet a large proportion of its water needs from sources within the municipality, taking account of seasonal variation, if stormwater was harvested (Armitage and Carden, 2014). This rainfall is transported through a network of rivers, open channels and pipes which is then discharged into the city's rivers and the ocean. This system is separate from the sewerage system so as to prevent an overflow of sewage during periods of heavy rainfall. Land use impacts water sources both directly and indirectly (WCPG, 2011). In areas of high urban development stormwater carries high pollution loads from roads with toxic liquids, solid waste and dirt being transported, most often, into canalised rivers that have little natural filtration capabilities. This is seen in Figure 3.32 which indicates the correlation of land use and river and wetland quality in the City of Cape Town. The state of the rivers and wetlands as shown in Figure 3.32 is derived from analysis undertaken by the City of Cape Town in

2005 for the 'State of the Rivers Report' and in 2012 for the 'State of the Environment Report'.

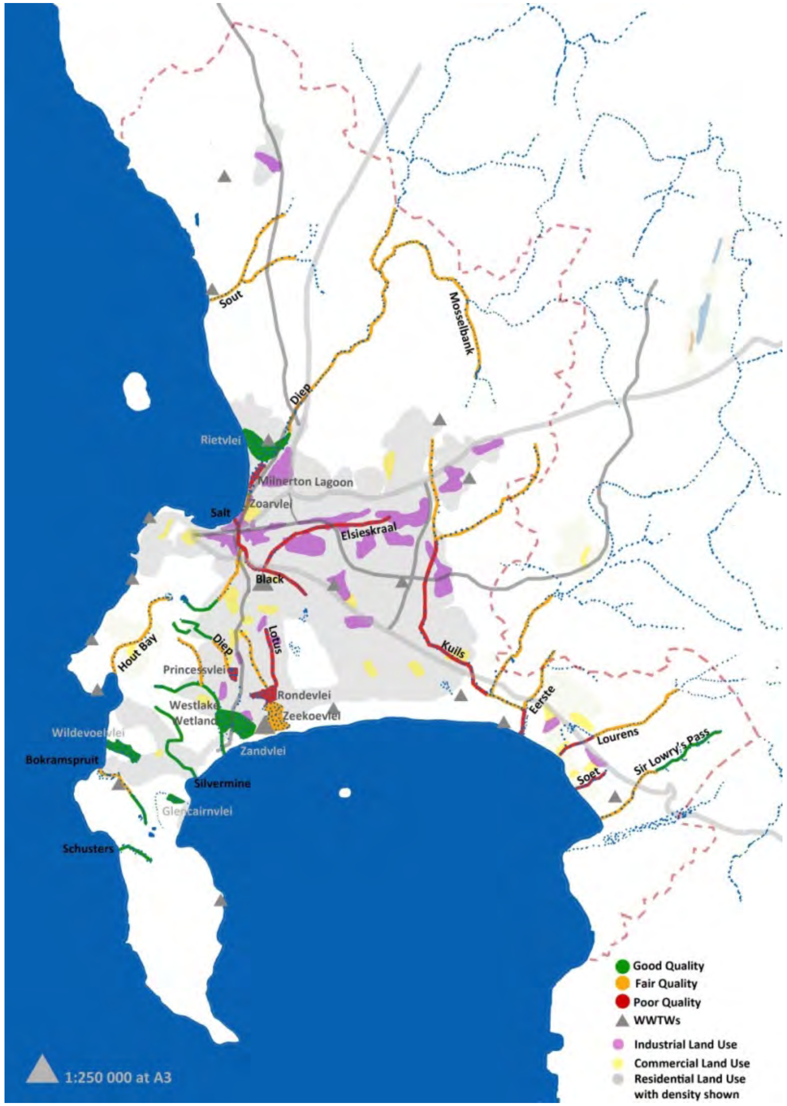


Figure 3.32: A Map indicating the correlation between water quality in rivers and wetlands with the use of land surround hydrological systems (from author with data from CoCT(c), 2012: 39)

This, along with the discharge from wastewater treatment plants as discussed later, has led to degraded rivers and wetlands, which are important water sinks within the city. This pollution load and level of degradation is noted to increase as the rivers flow downstream (WCPG, 2012). While water quality in rivers and wetlands has increased from 2009, only 3/14 major rivers and 7/13 major wetlands are compliant with public health regulations (CoCT(c), 2012). In Figures 3.33 and 3.34, the stark contrast in the quality of freshwater ecologies is shown when comparing the Liesbeek River, indicated as a green river, and the Sout River, indicated as a red river.

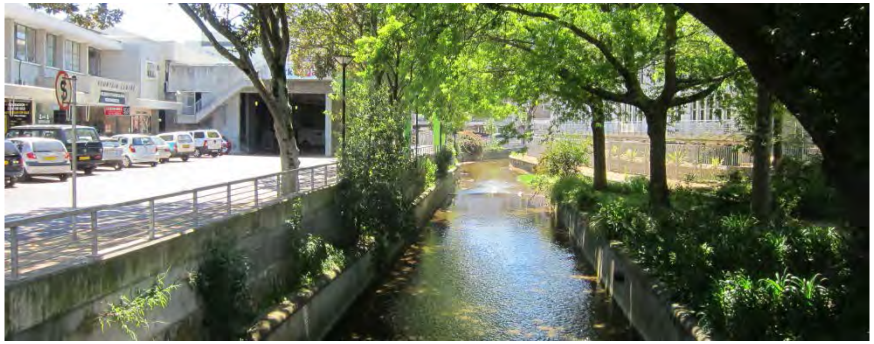


Figure 3.33: A photograph of the Liesbeek River (Author's Own)

Figure 3.34: A photograph of the Sout River (Google Earth, 2014)

Along with the social and economic impacts of insufficient service provision in informal settlements, there are significant environmental consequences too. In the City of Cape Town, informal settlements have the greatest impact on stormwater quality with Joe Slovo, Nonqubela, Sweet Home Farm and Khayelitsha being the areas of highest risk to water quality (WCPG, 2011). This is due to poor drainage which leads to flooding and contamination of water points and rivers through grey and black water combining; poor sanitation; and a lack of weekly refuse removal (Pan, 2011). A secondary contributor to a high pollution load in freshwater systems in Cape Town is industry. While there is little heavy industry in the metropolitan area, there is still a concern over untreated industrial effluent that enters either the sewerage or river network, due to the low pH levels and high heavy metal content of this effluent (CoCT(b), 2014). The City of Cape Town aims to have aquatic systems that fulfil both public and ecological health requirements with buffers to protect the receiving environment from polluted runoff (CoCT(c), 2012).

This vision is currently evident in only a few hydrological systems in the city which means that there is much to be done to improve the current situation to make this vision become reality.

Bulk Services Provision for Waste Water Treatment

Waste water is discharged from domestic, commercial and industrial outlets; which include toilets, kitchens, showers and factory outflows, amongst others, and is contaminated with a variety of physical and biological pollutants which enters the sewerage system. In the City of Cape Town approximately 60% of all water used in channelled to numerous Waste Water Treatment Works (WWTWs) around the city. The city has 26 WWTWs, three of which are marine outfalls while the rest release effluent into nearby rivers in the City thereby not returning water to the river from which the water was originally sourced (CoCT(c), 2012).

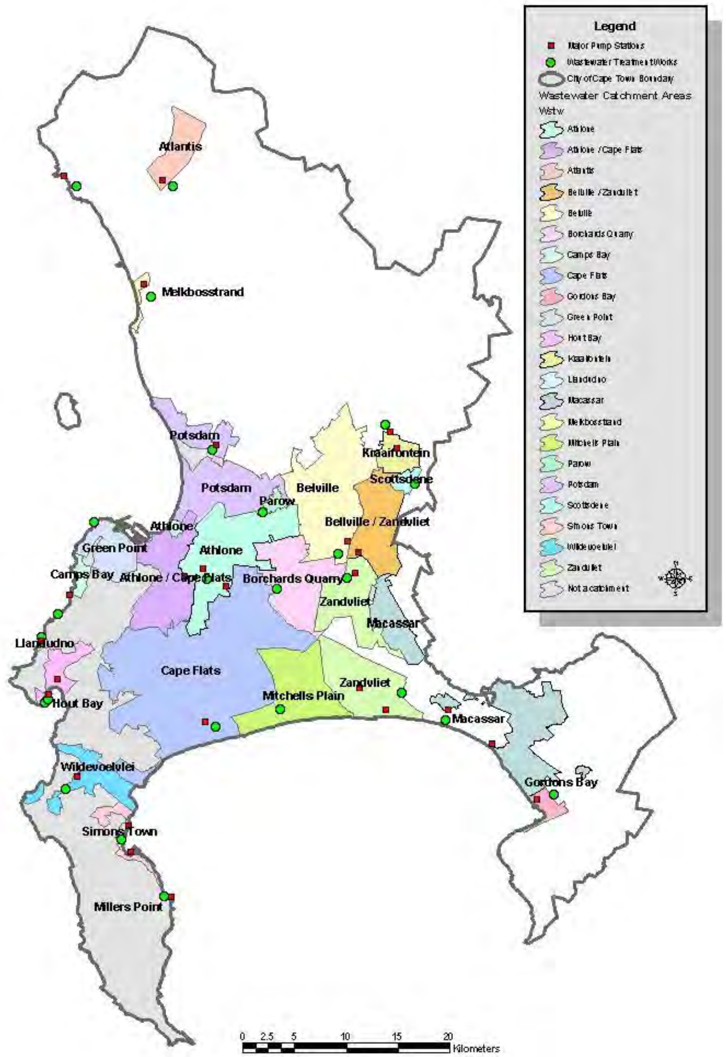


Figure 3.35: Main components of the Wastewater Treatment System (WWTWs and service areas) in the City of Cape Town (CoCT(a), 2008: 156)

The Kuils/Eerste River receives effluent from 6 WWTWs; Black/Salt River receives effluent from 2 WWTWs; and Diepriver, which flows into Rietvlei, receives effluent from Potsdam WWTW (WCPG, 2012). This has resulted in minimal seasonal variation in these urban rivers thereby disrupting ecological systems. Each WWTW is located within an area of the city from which it receives sewage, as seen in Figure 3.35. The WWTWs in Cape Town vary in size and capacity therefore, as indicated in Figure 3.23, the two largest WWTWs, Athlone and the Cape Flats, receive 50% of all sewage in the city with only 10% being received by the 18 smaller WWTWs in the city.

The quality of water released from these WWTWs is integral to future water security. To evaluate whether water quality is of a sufficient level, the City of Cape Town is subject to the National DWS Green Drop Assessments on an inter-annual basis. The last assessment undertaken in 2013 shows that, overall, there has been a slight improvement however Bellville WWTW has worsening compliance levels with Athlone, Mitchell's Plain, Kraaifontein, Zandvliet and Borcherds Quarry having the lowest compliance. All marine outfalls, Macassar WWTW and a few other smaller WWTWs have achieved Green Drop Status; making it 11 out of 26 in total (DWA, 2012).

The effluent from WWTWs such as waste water and the by-products of bio-solids are a valuable resource which is currently under-utilised in the City of Cape Town. Firstly, with regard to bio-solids, activated sludge is used in agriculture and primary sludge is used for compost however most is deposited in landfills (CoCT(c), 2012). Therefore the City of Cape Town has begun a bio-solids beneficiation project to evaluate how to improve the management and resource potential of this material (CoCT(c), 2012).

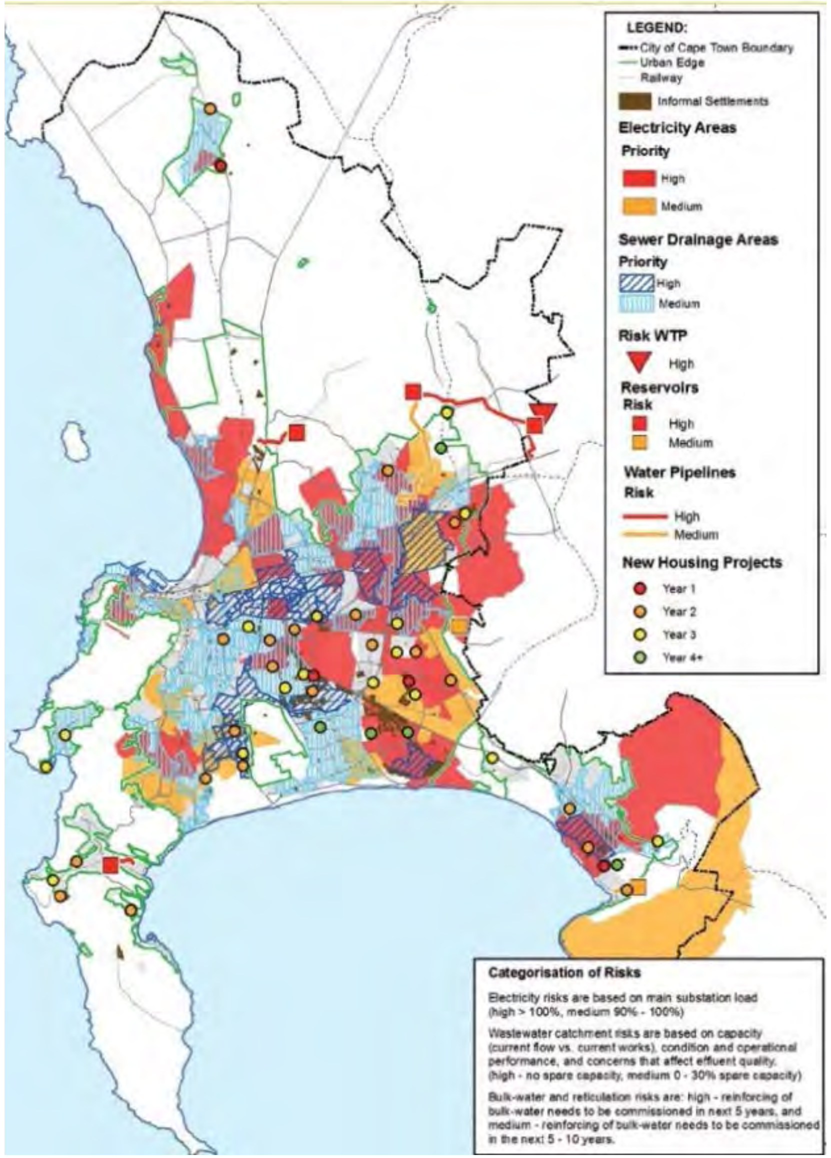


Figure 3.36: A map indicating the areas of greatest infrastructure risk – electricity, Sewer drainage, water treatment plants, reservoirs, water pipelines – overlaid with areas identified for new housing projects in the City of Cape Town (CoCT(a), 2012: 92).

Secondly, with regard to the reuse of waste water, there has been an almost 100% increase in use of treated effluent, mainly for industrial purposes and the irrigation of sports grounds (CoCT(c), 2012). While there are still social and religious objections to the reuse of waste water as a potable water source, this water source is increasingly being considered by urban water managers as water shortages will be more frequent and severe in the face of climate change (WCPG, 2011).

The need to upgrade existing infrastructure alongside the demand for new infrastructure for water and sanitation services has put strain on the existing infrastructure, therefore leading to the increased unsustainability of supply, consumption and discharge in the City of Cape Town.

As seen in Figure 3.36 there are areas of risk especially for the provision of sewerage capacity, with high risk areas being Ottery; Hanover Park; Nyanga; Philippi; between the N1 and Voortrekker Road to Bellville; Brackenfell; Harare in Khayelitsha; and Strand. Furthermore, there are large sections of the city which are experiencing a medium level of risk with regard to sewer drainage which, if not addressed, will soon become areas of high priority as fully serviced populations increase with the new housing projects in these areas. To transfer

this into action, Figure 3.37 has been generated as a map to indicate the required interventions with regard to both water and sanitation services bulk infrastructure. As this map indicates, the majority of new demand is on the periphery of the city where urban development is spreading, whereas maintenance is the priority in the more central urban areas. This is therefore representative of a direct relationship between sprawl and the provision of new, costly infrastructure.

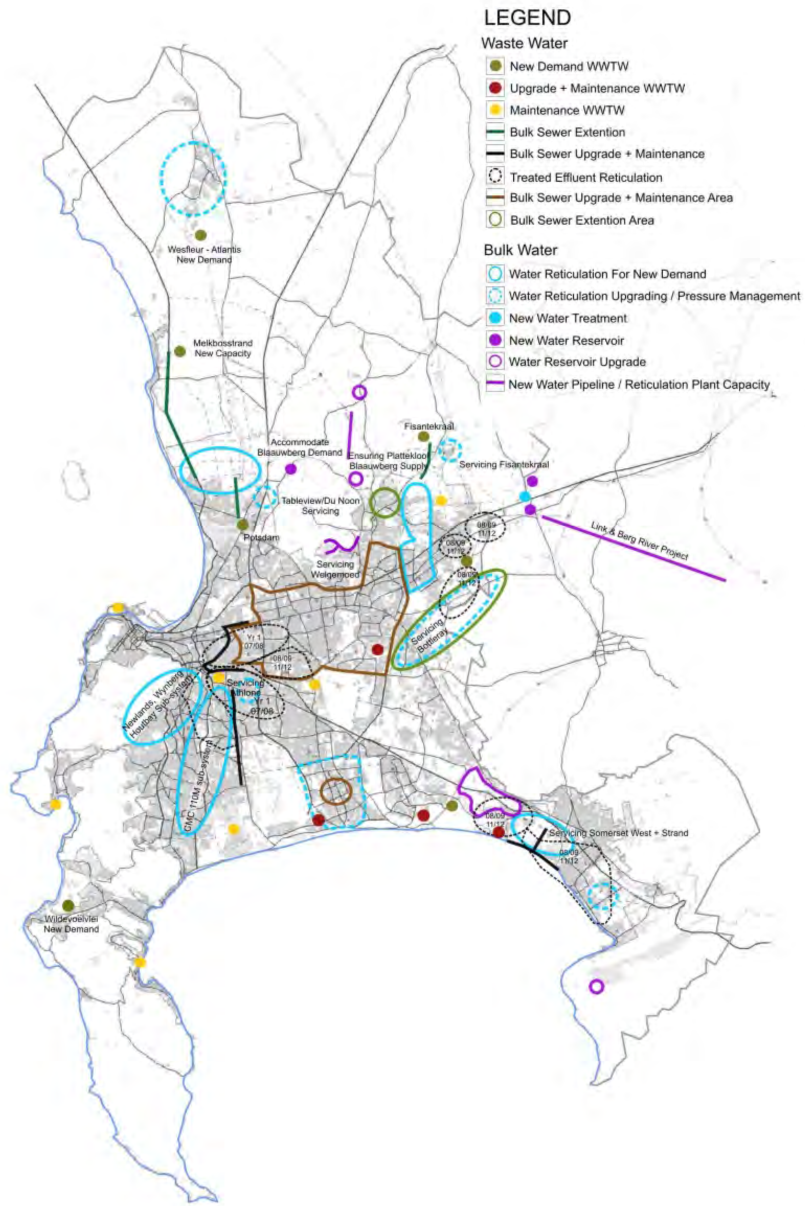


Figure 3.37: Water services priority areas in the City of Cape Town (CoCT(b), 2012)

The Sustainability of the Urban Water Cycle in the City of Cape Town

Sustainability and sustainable development has multiple definitions. For the purposes of this analysis the it is defined as (Goodland and Daly, 2006 in Armitage *et al*, 2009: 2),

> *"the process through which specific targets are set, actions planned and strategies implemented in order to deliver on current needs in a manner that is responsive to the earth's capacity to replace 'used' resources and absorb 'generated' wastes, being conscious of the needs of future generations"*.

Overall, Cape Town has been described as being on a path of weak sustainability which, as identified by Armitage et al (2009) implies that there exists an *"inherently inefficient method of crisis management which is unlikely to create long-term environmental sustainability".* To remedy this, it is necessary to have a strong focus on citizens and their well-being as a direct outcome of well-managed resources and long term planning (Armitage *et al,* 2009).

To summarise this analysis, a framework for sustainability proposed by Kevin Winter in *Sustaining Cape Town* (2010) and in Armitage *et al* (2009) has been edited and extended for the purposes of this study on the urban water system in Cape Town. The framework therefore identifies five components of sustainability; that is Social, Economic, Environment, Political and Institutional; each with their own criteria and subsequent indicators. The most recent available data has been included as evidence of current practice which is compared to a 40 year vision for the desired practice in Cape Town. This desired practice is premised on the international trends and my own beliefs about how the urban water system should be. The full analysis is shown in Annexure D. This is a qualitative assessment of the state of each indicator and criteria which offers an overview of the sustainability of the urban water system. As seen in Figure 3.36, the social, economic and political components are currently in a 'Fair' level of sustainability, while the environmental and institutional components are currently in a 'Poor' level of sustainability.

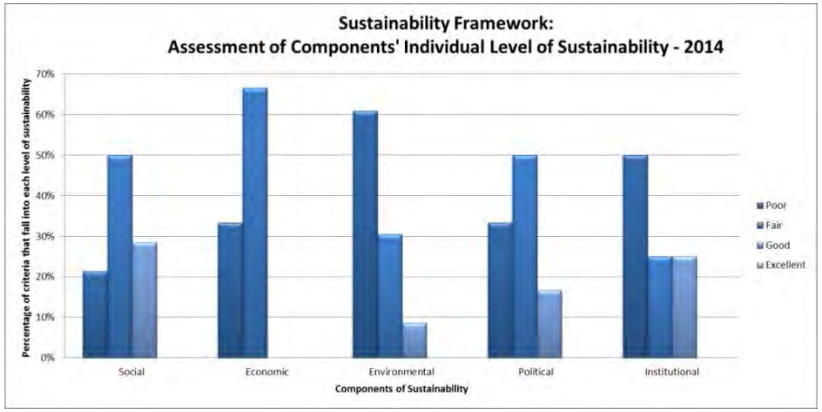


Figure 3.36: A summary of the Level of Sustainability for each component of analysis (Author, 2014)

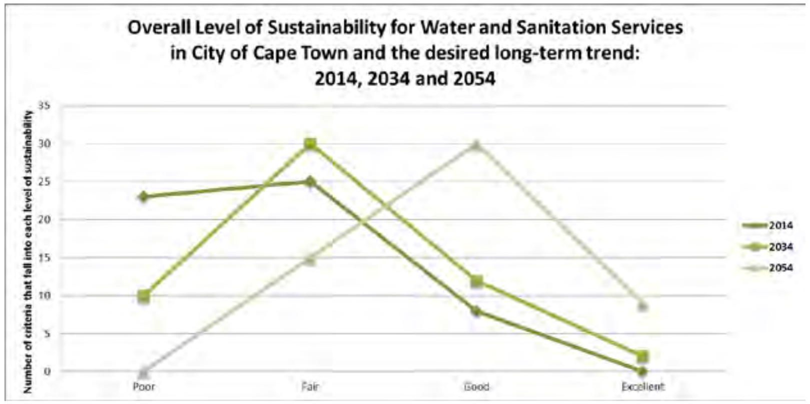


Figure 3.37: A graph showing the number of compatibilities for each level of sustainability and indicating the desired progression of the overall level of sustainability for the urban water system in Cape Town from 2014 to 2054 (Author, 2014)

This is of concern because, as presented earlier, the environment is the foundation upon which the society and the economy are based alongside a strong governance system. Therefore, in order to enable sustainable livelihoods through appropriate socio-economic development, ecological functioning and flourishing is vital as the source of breath and the quencher of hunger and thirst. This analysis therefore clearly indicates that the City of Cape Town must realign the urban water system services with ecological systems to enable a more sustainable water future. This desired trend is evidenced in Figure 3.37 where the overall Level of Sustainability shifts from 'Poor/Fair' to 'Good' over the next 40 years. The following section will look at the key priorities for the urban water system in Cape Town that must be addressed achieve an improved level of sustainability over the next 40 years.

Opportunities for and Risks to the Urban Water System in Cape Town

The map of the opportunities for the urban water system in the City of Cape Town, as seen in Figure 3.38, and the map of the Constraints and Risks for the urban water system in the City of Cape Town, as seen in Figure 3.39, are each a synthesis of the relevant analysis undertaken to form a foundation of intervention into the municipal area. The opportunities and constraints have been identified with regard to environmental, social and economic factors.

The opportunities include the urban edge, the presence of protected parks and reserves; the presence of high performing WWTWs with extra capacity; the presence of WWTWs which have the capability and capacity for treated effluent reuse; the availability of groundwater due to low current stress; and good quality of water in certain rivers and wetlands.

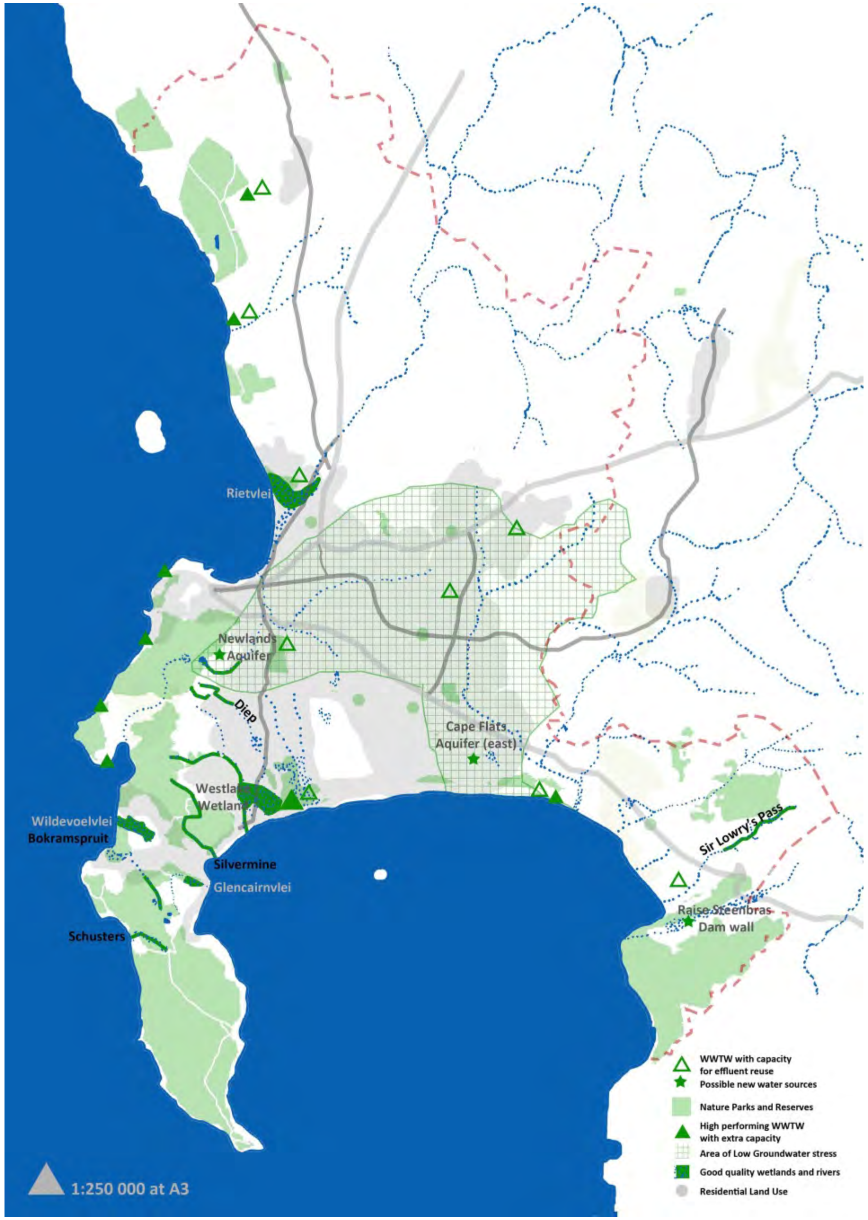


Figure 3.38: A map of the Opportunities for the Urban Water System in Cape Town (Author's own)

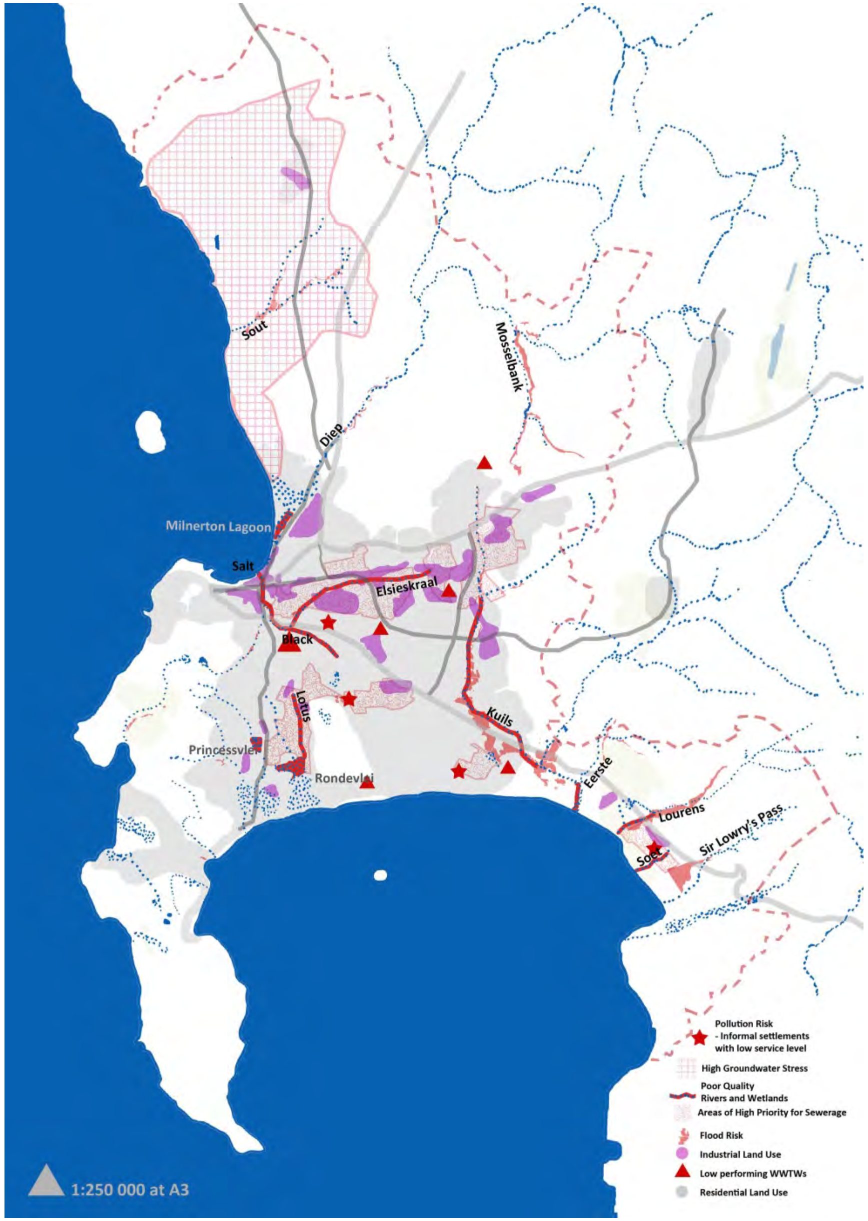


Figure 3.39: A map of the constraints and risks to the Urban Water System in Cape Town (Author's own)

From this map a series of trends can be identified. Firstly, there are a number of rivers and wetlands that still have good water quality which have the more immediate potential as a water source for the city. A relatively large portion of the municipality is dedicated to parks and reserves which offers a place of sanctuary, restoration and renewal for flora, fauna and citizens. However, it must be acknowledged these protected areas are predominantly located on the mountainous areas. This gives preference to the conservation of mountain fynbos varieties over the coastal plain and grassland varieties. The majority of the parks and reserves and all the good quality rivers and wetlands are on the periphery of the city furthest from the higher density formal and informal settlements and movement routes. This could potentially lead to an aggregated positive response where all aspects of the water system gain increased resilience and environmental stability from the agglomeration of water system opportunities. Secondly, the potential for reuse of treated effluent form WWTW is dispersed across the city in multiple WWTWs. This offers the potential for decentralised district opportunities for reuse thereby closing the urban water cycle within a smaller geographic area. Thirdly, the opportunity for groundwater use is beneficially located where the highest density of the population lives therefore reducing the distance of water transportation and in turn reducing the construction and maintenance costs of the reticulation system. Finally, from this map it is evident that there are opportunities for a more efficient, resilient and secure urban water system in the City of Cape Town which can be preserved and enhanced for increased benefit to the city.

The constraints and risks include the high pollution load from industrial areas and low serviced informal settlements near waterways; high groundwater stress surrounding Atlantis; the poor water quality in certain rivers and wetlands; areas of low sewage drainage capacity and flood risk.

From this map a number of trends can be identified. Firstly, the majority of risks and constraints are present on the Cape Flats with an apparent correlation between land use and water quality in rivers. There also seems to be a clustering of diverse risks and constraints in certain areas of Cape Town; such as along Voortrekker Road, to the west of the PHA, along the Milnerton coastline and in Strand. This therefore increases the complexity of these risks and constraints and the solutions necessary.

These constraints and risks threaten the overall security of Cape Town's urban water system and therefore must be addressed as a matter of priority in order to enable a process of shifting to a more sustainable urban water management model.

Key Issues and Priorities for Water in the City of Cape Town

From this analysis, the following key issues for the urban water system in the City of Cape Town have been identified as necessary areas of priority action:

1) Reduced Resource Availability
    a. Climate Change - redefining resource flow
    b. Pollution of sources and sinks
    c. Over-reliance on external sources
2) Increasing vulnerability
    a. Climate Change – increasing severe weather events: Flood and Drought
    b. Population growth
    c. Water and Sanitation Services provision backlog
    d. High levels of poverty, unemployment and inequality
3) Infrastructure
    a. Climate Change – lack of resilience
    b. Enables a linear resource flow
    c. Aging, centralised and sectoral system
    d. Lack of capacity for necessary growth and development
4) Relationship between people and nature
    a. The negative relationship between urban development and hydrological systems in the city
    b. Lower income households have poor access to good quality green open space

Each of these will require action from a diverse network of actors, from government to civil society and from private companies to individual citizens. There is also an opportunity within each of these priorities to engage more holistically and envision solutions to address more than one problem, thereby pooling resources and capacity for a faster response time and more comprehensive community engagement.

Conclusion

This analysis has provided an overview of the urban water system in the City of Cape Town. To understand the broader influences on this system; policies, plans and strategies from national, provincial and municipal spheres of government were reviewed along followed by an analysis of the current state of water in South Africa, the Western Cape and the Berg WMA. From this it is understood that South Africa is a water scarce country and there is a plethora of policies to manage the relationship between human activities and the use of natural resources, especially water. This anthropocentric view on water as a socio-economic resource put greater importance on the distribution of water, not only for environmental functioning and the continuation of meeting current water demands, but also to address issues of equality and equity for socio-economic redress throughout South Africa. Within the Western Cape the City of Cape Town is a prominent economic and development node thereby making it one of the largest consumers of resources. This propels the focus of this study as changing how the urban water system functions in Cape Town will therefore influence the water security trajectory of the region.

This is followed by a more specific analysis of the City of Cape Town with an overview of the biophysical, socio-economic and land use conditions present. From this, the diversity of circumstances in Cape Town comes to the fore; from the variance in natural surroundings to that of social and economic inequalities. All this creates a frame through which to understand the current urban water system and how it functions. Water is a precious resource which must be conserved and managed appropriately to ensure an increasingly sustainable and equitable water future. Climate change is causing a reduction in annual precipitation with an increase in the severity of droughts and storm events. Therefore resilience to these elements must be cultivated through the stewardship of resources and land. As acknowledged in this analysis, land use has a direct and indirect effect on water resources; at source, through urban flow and discharge. The level of sustainability of the urban water system in Cape Town was then assessed to be in a 'Poor' state and to enable the projection of a future desired state; as a basis for a vision of the urban water system in 40 years. From this, and in combination with the analysis, a list of the key issues and priorities are identified as a foundation for intervention in the coming chapter.

Chapter Four:

Spatial Development Water Framework for the City of Cape Town 2055

Water is life

By Rebecca Cameron

Water is life, our being, our soul.

Life-giver,

flowing through the city as through our veins.

Facing our rivers, turning towards wetlands

we reconnect

to care, to rest, to repent and protect.

Water marks our city now.

Oh how our city breathes

dwelling in her cycles, seasons and change.

Once more the Mother City nourishes and provides

Introduction

As learnt from the contextual analysis which has allowed for a deeper understanding of the biophysical, socio-economic and, more specifically, the hydrological context of Cape Town. From this it is understood that the City has a diverse urban water system which includes vast differences in the presence and quality of rivers and wetlands, the provision of water supply services, the consumption of water and the quality of waste water. The importance of the urban water system has been highlighted along with a number of critical short-comings and its poor level of sustainability. This includes the large backlog in service delivery, the impending lack of sufficient water supply to the city, and the current detrimental state of many of the rivers and wetlands which inhibits human interaction with freshwater ecosystems and hinders biodiversity; with this all occurring in the face on increasing uncertainty due to Climate Change and a growing population. Overall this condition can be attributed to the detrimental effect that human activities currently have on natural systems through the misuse and overuse of resources. Current sectoral approaches and solutions are also hindering the ability to confront these issues holistically with the limited financial capital and governance capacity available. However, this does not have to be the mark of water in the City of Cape Town now or in the future; this can change for the better.

At this time there is a desperate need to move away from the current anthropocentric ideologies of the earth and its life-supporting provisions by reconceptualising people and their activities as part of a greater system which is at work. There is a need to enable urban environments to be spaces where people dwell within nature through cyclical patterns of the use of resources and thriving as nature does. With water as a vital yet highly threatened and limited life-support in our cities, it is necessary to move towards more sustainable patterns of interaction as nature has evolved to do so. One way in which to enable this is to envision the City as a Catchment; where space is made for water to move with seasonal variations and to absorb water for use within the context in which it falls to enable an increased local subsistence and reduced ecological footprint.

The Purpose of this Spatial Development Water Framework for 2055

This chapter of the study therefore puts forward a Spatial Development Water Framework (SDWF) which aims to enable a transition towards improving the urban water system; where water ecologies are healthy and there exists a virtuous and symbiotic inter-relationship between people, their activities and the environment. This SDWF does not simply guide development in the water sector but looks to how water can guide development in the City of Cape Town. This builds upon the broader understanding from the literature review and then the more intimate knowledge gained from the contextual analysis respectively. The purpose of this SDWF is to guide the City of Cape Town towards a more water-secure, life-giving and equitable future and to reconnect people with their environmental context over the next 40 years. This time period has been chosen as it allows for a new generation of leaders and citizens to develop and grow within this evolving paradigm. This SDWF is envisioned to act as a primary spatial informant in a set of layered plans which guide development in Cape Town. This SDWF also offers the opportunity to engage with new linguistic tools and a new vocabulary to use in the discussion of urban water systems and how people and their activities relate to them. This is a long term plan that provides principles, goals and strategies on which spatial planning and development decisions can be based to achieve the desired structure and condition for this city. These, along with the overarching vision, help spatially co-ordinate strategic public investment and direct appropriate private investment.

This SDWF is a continuation of a long-time interest in and study of the urban water system and environmental sustainability in the City of Cape Town. It is therefore a further development of a previous project undertaken in the second semester of 2013 which was conducted at the city-region scale; *Cape Town City-region Spatial Development Framework 2013 – 2040* (Vaughan, 2013). That proposal looked at a variety of inter-connected systems operating across spatial scales, such as energy, water, waste and biodiversity. Learning from that and other projects undertaken so far, this SDWF then narrows the focus of that study to allow for more in-depth analysis and intervention in the City of Cape Town.

The Structure of this Spatial Development Water Framework for 2055

The structure of this chapter follows the creation and development process of this SDWF. It begins with a short summary of the priorities for the urban water system and their implications for spatial planning in Cape Town as a platform from which to foster the necessary intervention. This is followed by the long term vision for the city from which the principles of reverence, restoration, restraint and responsibility are discussed and these are embedded within the goals of social and ecologically health, connected communities and shared prosperity. To enable a transition from the current state towards achieving these goals various strategies are suggested for implementation. These strategic and spatial strategies are influenced by a combination of learning from local spatial informants and international precedent to develop the appropriate response. These strategies are implemented across a variety of scales; from the scale of a dwelling to the metropolitan, and even the regional and global, scale. While there is currently significant investigation into the development of more water-efficient buildings and water-sensitive neighbourhoods and precincts; there seems to be a lack of spatial investigation into the relationships between water, the environment and human activities at the district and metropolitan scale. This SDWF therefore focuses on these two scales to offer contributions to this sphere of urban planning which has received little attention. The key spatial development strategies put forward include a focus on the urban nutrient and resource cycle with water as a primary nutrient carrier and a focus on local subsistence. As these strategies are discussed, where relevant, precedent is referred to to provide completed and achievable examples that have informed and inspired some strategies. These strategies are then spatialized through the presentation of the SDWF map that indicates the desired long-term spatial structure of the City of Cape Town.

Figure 4.1: Looking over Rondevlei on the Cape Flats to the residential area of Lakeside beneath Muizenberg Peak in the City of Cape Town (Shawka, 2011)

Long term Vision for the City of Cape Town

The priority issues identified such as reduced resource availability, increasing vulnerability, lack of infrastructure capacity and the disjointed relationship between people and nature have direct spatial implications for the City of Cape Town. Cumulatively, these issues can determine the conditions in which people live and where industry and commerce locate within the city. Therefore, even with strong policy and land use guidelines, without sufficient resources and infrastructure capacity to cater for the needs of residents and business, the City of Cape Town will most likely not be able to reach its full development potential.

Therefore, the 2055 vision for the City of Cape Town is one where we are transitioning to an increasingly water-secure development path. Having been proactive in our approach to addressing resource depletion, the services backlog, unemployment and inequality, our city is now anchored in genius of place and structured by improving symbiotic human-nature relationships. This is facilitated through nurturing a reverence for water; enabling restoration of water systems through ecological alignment; embracing restraint towards water use; and cultivating responsibility to develop good stewards of the urban water system thereby promoting social and ecological health, connected communities and shared prosperity.

Figure 4.2: Aerial view of Zeekoeivlei, Rondevlei and Princessvlei on the Cape Flats beneath the Table Mountain Range in the City of Cape Town (CoCT(c), 2014)

Principles of the 2055 Spatial Development Water Framework

To enable this vision the principles of reverence, responsibility, restoration and restraint are employed to guide a more holistic and strategic response to the current and future key priorities in the City of Cape Town. These have been developed from the principles put forward by the Forum on Religion and Ecology at Yale University in the United States of America (Hessel, 1998). This is a further development of the earlier stated normative position, the philosophical underpinning of this study, which has informed this journey. Firstly, as stated earlier in this study the concept of sustainability is envisioned as a tiered system with environmental security and ecological health as the prerequisite condition for social well-being and economic prosperity. Using this as a model of strategic intervention, the principles of this SDWF are also envisioned in such a way. As seen in Figure 4.3, the principle of reverence is placed as the prerequisite condition for the further three principles and these are made possible through being founded in local context and, in turn, in symbiotic human-nature relationships.

Reverence

The Principle of Reverence is defined as having a deep respect and admiration for someone or something thereby holding them in high esteem (Merriam-Webster, 2014). In spirituality, the act of reverence is to evoke awe, to view the sacred in a moment, person or place, and to reduce one's self in honouring the other (Spirituality and Practice, 2014 and Douglas and Tenney, 2011). As stated by Wendell Berry (1971);

> *"the world cannot be discovered by a journey of miles, no matter how long, but only by a spiritual journey, a journey of one inch, very arduous and humbling and joyful, by which we arrive at the ground at our own feet, and learn to be at home."*

This attitude and way of living with water acts as the necessary precondition for positive change in Cape Town; to take responsibility, enable restoration, or exercise restraint. If we care about and improve our understanding of water, we are more likely to look after it. More specifically, incorporating the principle of reverence into design and policy approaches is intended to encourage a reconnection between people and the water environment. This could be through the opportunity to reconnect visually, physically, emotionally and spiritually. In order to do so, there needs to be space in the city set aside for this human-nature interaction.

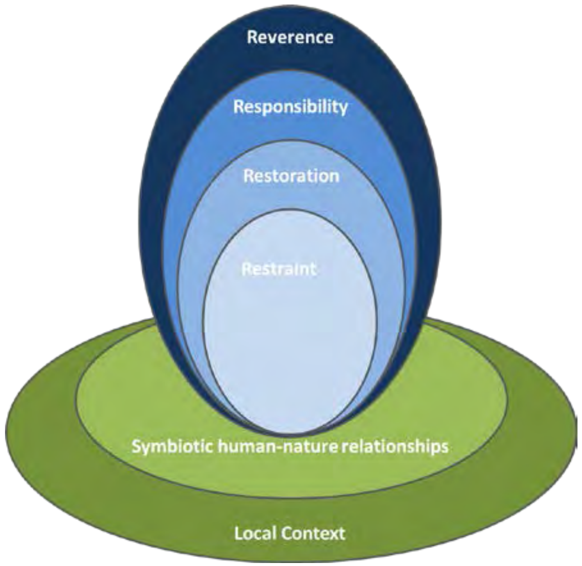


Figure 4.3: A diagram indicating the conceptual model for the relationship of the principles and foundations necessary to enable the vision (Author's Own).

Responsibility

The Principle of Responsibility is defined as the state of having a duty to someone or something and of being accountable for your actions (Merriam-Webster, 2014). The enacting of this principle is purposed to enable stewardship and moving towards a deeper understanding of the public good above personal gain through increased participation in decision-making processes. Too often, decisions, especially regarding water, are set aside for experts and officials which further increases the divide between people and their surrounding ecosystems. This in turn reduces the ability to take communal action towards the protection and maintenance of local freshwater systems.

Restoration

The Principle of Restoration is defined as the act of returning something to a former owner, place or condition (Merriam-Webster, 2014) to allow for rehabilitation, recovery and renewal. The United States Environmental Protection Agency (2014) sees restoration as, "*a holistic process not achieved through the isolated manipulation of individual elements. The objective is to emulate a natural, self-regulating system that is integrated ecologically with the landscape in which it occurs.*" Both the form and function of a system must be restored. This concerns physical restoration and the consideration of legal restoration where the environment is given rights too. It is necessary to allow our knowledge to be subservient to that of nature which has had a far longer time to adapt to life on this earth. To enact this principle is to facilitate ecological realignment through enabling cyclical processes of symbiosis and deepening the understanding of shared resources. It is necessary to allow this principle to permeate not only the soft infrastructure and maintenance of freshwater ecosystems but also the processes employed for the provision and discharge of water and wastewater.

Restraint

The principle of restraint is defined as a measure or condition that keeps someone or something under control, influence or direction (Merriam-Webster, 2014) and with regard to water in the Ctity of Cape Town this is exercised through acting with humility and caution in decision-making before a changing system; characterised by variability, uncertainty and increasing complexity (Ferguson, 2012). This is particularly important with regard to the consumption of resources which must be reduced through action by individuals, communities and governments. This principle also calls for the opportunity for a Sabbath; a rest in consumption, a rest in the demands placed on nature by human activities to offer the opportunity for renewal. With regard to water, this could mean legally enforcing the Ecological Reserve and dedicating space, 'breathing room', to the free movement and seasonal expansion of freshwater ecosystems along with water conservation and demand management strategies.

Goals of the 2055 Spatial Development Water Framework

From these principles a set of goals has been outlined with the aim of allowing water in the City of Cape Town to guide urban development and strategic investment priorities. Each of these goals is accompanied by a set of criteria and respective indicators to allow achievements to be measured and to determine whether the strategies employed will enable the goals to be reached. There are four overarching goals which are Social and Ecological Health, Connected Communities, Shared Prosperity, and Intelligent Water Systems. These broad goals are designed to allow flexibility and necessary adaptations in that they state what the desired condition would look like but do not promote particular strategies. With respect to these goals, the City of Melbourne, Australia, working with the Monash University Sustainability Institute and relevant stakeholders, has been a primary source of learning as Melbourne is dealing with similar priorities and constraints as Cape Town (Ferguson, 2012). This set of goals, criteria and indicators has however been adapted and elaborated upon to make allowance for the particular local context of the City of Cape Town. The goals are presented in a table in Figure 4.4.

	Goals	Criteria	Indicator
Water as the basis for:	**Social and Ecological Health**	Our people are healthy; our physical and mental wellbeing is valued, protected and enhanced.	People live and work within walking distance of green space People interact with freshwater ecosystems regularly - either visually or physically
		Our city is alive, healthy and green; its environmental wellbeing is valued, protected and enhanced. We live in harmony with our natural environment.	All urban waterways are in "good" to "excellent" condition Areas within 100 year flood lines have reduced human activity River corridors and riparian buffer zones are restored
		Our city, people and ecosystems are safe and resilient; we are prepared for surprises and extremes	There is a reduced need for Disaster Relief for annual flooding events No fatalities or loss of critical infrastructure from flood events
	Connected Communities	Our identity embraces water; we celebrate our water sensitive city and take pride in the path it paves for a sustainable future	People are proud of Cape Town's iconic waterway environment Communities are better integrated through shared space at waterways Communal space and living environments incorporate water and plant life as an important urban component
		We are educated, engaged and aware; we understand and take responsibility for our water. Our water sector collaborates and co-creates understanding and solutions with community and associated sectors. We understand and act upon community water needs.	Public involvement in District water decisions All households and businesses are water literate
	Shared Prosperity	We live in a prosperous society that has healthy businesses and healthy communities, supported by our water system.	Every water infrastructure decision delivers the highest societal and ecological benefit
		Our water system is equitable; water is available for us all to meet our basic needs	Innovative and proactive solutions prevent a backlog in service delivery Everyone has access to water and sanitation for basic needs
	Intelligent Water Systems	Our water system embraces the many values of water; benefits and impacts are evaluated to ensure maximum societal value.	All benefits and impacts of water are identified, quantified and communicated
		Our water system is smart, integrated, connected, flexible and adaptive	All possible water sources contribute to fit-for-purpose supply
		Our water system uses resources efficiently; it has a positive impact on how resources such as energy, water, nutrients and physical are consumed and produced.	The urban water system moves towards a closed, cyclical system Maximised energy and nutrient recovery from the water system

Figure 4.4: A Table presenting the goals of the 2055 SDF with the associated criteria and indicators (Ferguson, 2012 with adaptations and additions by Author)

Key Spatial Development Strategies

To enable a transition from the current condition of urban development and water in the City of Cape Town to the desired state as envisioned earlier, this framework allows for the introduction of multiple strategy pathways, otherwise known as transition scenarios, which are still guided by the four principles of reverence, responsibility, restoration and restraint, as seen in Figure 4.5. This is to enable a built-in flexibility to accommodate for uncertainties of future climatic conditions, thought paradigms and the ingenuity of future generations. While this SDWF presents one set of strategies possible, it is necessary to acknowledge that these are guided by a visioning process bound within the forward-looking ideals of contemporary environmental and ecological thought processes.

The development of transition scenarios to move towards achieving an increasingly water-secure Cape Town should consider a long term planning focus, such as this SDWF's 40 year time horizon, future uncertainties and merge creative visioning with rational strategy (Ferguson, 2012). A sustainable city is defined as (CoCT, 2007: 7),

> *"one that meets its present and future human development objectives without growth in throughput of matter and energy beyond the regenerative and absorptive capacities of its local, national or international hinterland".*

Therefore the urban water cycle must be considered across a range of scales; from the household to the globe. The use and discharge of water, as with greenhouse gas emissions, can be displaced across the world, especially in an age of globalised goods and services where the embedded social and environmental cost of water is often not considered. To illustrate this in South Africa, globally this means that we are to be cognisant of the embodied water of the imported goods and services that are made use of. Through reducing imports and increasing local subsistence, there is also the opportunity to mitigate future effects of Climate Change thereby helping to secure water for future generations. Nationally, water is embedded in the food we eat and in the fossil-based energy produced. Efficient irrigation schemes and a transition towards renewable energy production could help reduce this water consumption. Regionally, abstracting and transferring water from adjacent and even far off water basins to meet excessive water demands can cause water insecurity in the home basin of that water which in turn could lead to food and welfare insecurity, as Cape Town does with the Breede River which is 80km away as the crow flies and as Johannesburg does with the Lesotho Highlands which is a straight line distance of 330km away.

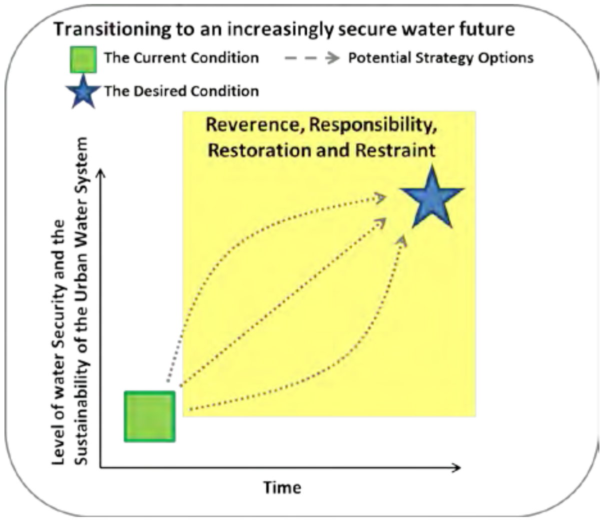


Figure 4.5: A conceptual diagram indicating the process of transition from the current to desired state through a range of scenarios within the same set of principles (Author's Own).

The aim of water-security for the City of Cape Town is therefore not only a local issue but a global issue to prevent the displacement of water insecurity to a future time or another place. To achieve this, two concepts are proposed to guide the implementation of strategies for improved water security in Cape Town; these include that of the nutrient cycle and local subsistence.

Nutrient Cycle

The concept of the nutrient cycle in this study has its foundations in the urban metabolism and the work of William Mc Donough who is the author of the *Cradle-to Cradle* approach. In this approach, Mc Donough seeks to use the outputs or wastes of industrial processes as the inputs or materials for other processes. This can occur through either the biological metabolism, where waste products or biological nutrients can be reabsorbed by nature, or the technical metabolism, where the waste products or technical nutrients are synthetic and therefore must be reused within industrial production or energy generation (Mc Donough, 2003). The concept of the urban metabolism as put forward by Marina Alberti (1999: 606) states that these,

> *"evolve over time and space as the outcome of dynamic interactions between socio-economic and bio-physical processes operating over multiple scales".*

When applied to urban processes, such as wastewater treatment and other urban output streams, there is an opportunity to alter the current urban metabolism's linear resource flow to a cyclical resource flow which could reduce the negative effects of the extractive need of human activities on the environment.

	International Water Management Strategies Precedent
City, Country	Lima, Peru
City Area (km2)	2 672.30
Population	8 472 935
urban density (people/km2)	3 009
growth rate	2%
Inequlaity-adjusted HDI	0.562
Annual Rainfall	9mm
Climate	Mild Desert Climate
Challenges	1) Rapid population growth especially in informal settlements 2)Water supply from seasonal rivers affected by Climate Change 3)Potable water used for park irrigation, while untreated waste water flows into rivers and the ocean and is used for agriculture 4) inequality in water supply between rich and poor - 20% of people without access to municipal sewerage system and 12.5% lack access to municipal water supply 5) lack of systematic approach to water supply and integration with urban planning - viscios cycle of overuse and lack of supply
Objective	To improve planning and management of the water and sanitation system through informed and participatory decision making, focussing on climate change effects, sustainability and energy efficiency.
Solutions offered	**Focus: reuse of Wastewater** - used in parks (increased urban canopy) and urban agriculture (improved food security, employment generation, poverty alleviation and climate change adaptation) - Promotion of centralised treatment with decentralised reuse (both publicly and privately managed 1) Macro-modelling of the urban water system for informed discussions and decision making 2) Simulation of Lima's future development, taking into account climate change effects on the water system for long-term planning 3) Learning Alliances: Round tables as a new form of governance in the water sector 4) Water pricing options and improvement of tariff structure 5) Integrated urban planning strategies and planning support 6) E-Academy for education and capacity building **Strong role of local government as a leader in this field**
Results experienced	A demonstration project in the Lima district of **Villa El Salvador** - wastewater treatment for the reuse of water to irrigate an Eco-Productive Park: Multi-functionality and clustering of activities: recreation, sports, production and a tertiary treatment pond for wastewater on the top of the hill 1) Better general understanding of available treatment and reuse practices 2) The creation of a stakeholder platform 3) The development of an innovative framework of analysis and decision making

Figure 4.6: A case study description of the reuse of wastewater in Lima Peru (compiled by Author from information provided by Switch, 2011)

With regard to water, this concept allows for the reuse of treated wastewater as non-potable water for industry, irrigation for fields, parks and agriculture, and toilet flushing with the resulting sludge used as fertilizer. The reuse of wastewater can cut the cost of water supply as less water needs to be transported from outside municipal boundaries and less water needs to be treated to potable water standards. This is of particular advantage in Cape Town as this would offer extra financial capacity to address the services backlog in informal settlements with more innovative and participatory solutions. At present, this concept is being applied in Lima, Peru which is built in a desert and has similar socio-economic pressures as Cape Town, as seen in a brief case study provided in Figure 4.6 and 4.7. While reducing virgin water demand, this would also help to restore a balance and spatial connection between human activities and ecological systems.

Figure 4.7: A photograph of the Villa El Salvador demonstration project where treated effluent is used for irrigation of the park, sports fields and agriculture and where a rare physical connection to water is offered in the city (Caretas, 2013).

Local subsistence

The concept of local subsistence is derived from the knowledge of nature where ecological systems have evolved to rely upon the resources available in their immediate context. As this is a common aspect of life on earth, being locally attuned and responsive is known as a deep principle of Biomimicry which is "*the practice of learning from and then emulating life's genius to solve human problems and create more sustainable designs*" (BiomimicrySA, 2014). When applied to urban development and growth this would drastically reduce the ecological footprint of the needs of urban dwellers if the resources available within the municipal boundary where protected and utilized before mining resources outside the boundary. With regard to water, this would mean utilizing the annual rainfall runoff that the city receives as a source of water through making space to harvest and treat stormwater. At present there are many international projects underway to put this into practice with the acclaimed city-wide project being in Melbourne, Australia. This city has been awarded the 2014 Adaption and Resilience Award at the City Climate Leadership Awards by the C40 Cities Climate Leadership Group (C40, 2014). Melbourne receives almost double the rainfall than Cape Town and is experiencing similar environmental stresses, as seen in a brief case study provided in Figure 4.8 and 4.9, and is therefore a relevant precedent for improving urban water systems and local subsistence in Cape Town.

	International Water Management Strategies Precedent
City, Country	Melbourne, Australia
City Area (km2)	9 990.50
Population	4 347 955
urban density (people/km2)	430
growth rate	2%
Inequlaity-adjusted HDI	0.86
Annual Rainfall	646.9mm
Climate	Maritime Climate
Challenges	1) Long-term reduction in rainfall (drought) 2) fast increasing population 3) polluted stormwater 4) Challenging relationship between human activities and water: water plays a fundamental role in urban life but is under-valued
Objective	The "water sensitive city" recognises that ecological and built landscapes have an interactive and dynamic relationship that has to be considered while developing urban water management techniques. Urban environments have to be reshaped in order to restore the original water cycle as much as possible and to address the environmental degradation caused by traditional stormwater management schemes.
Solutions offered	**Total Watermark - The City as a Catchment** - flexible strategies **Water Use:** 1) Fit-for-purpose water use 2) Assessing the water balance - analysis of the movements of water streams **Stormwater management and the Water Sensitive Urban Design:** 1) Protect natural systems and water quality 2) Integrate stormwater treatment into the landscape - location specific 3) Reduce runoff and peak flows - rainwater harvesting 4) Add value while minimising development - increase interaction between peple and water to enhance positive perception of water in the city **Groundwater:** 1) preventing pollution 2) increasing the percentage of aquifer recharge in urban areas 3) protecting its quality 4) exploring the potential for aquifer storage and recovery **Strong role of local government as a leader in this field** - strong political commitment - public participation in both community-led and council-led projects
Results experienced	34% absolute water saving with 48% water reduction per employee; 39% per resident; and 29% savings by Council

Figure 4.8: A case study description of stormwater harvesting in Melbourne, Australia (compiled by Author from information provided by Switch, 2011)

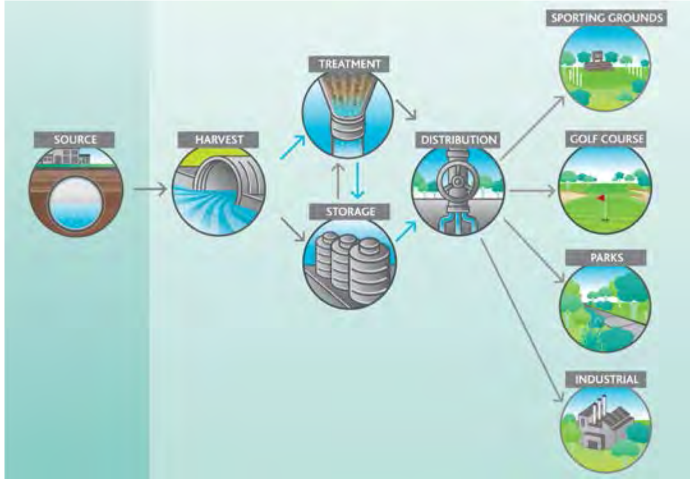


Figure 4.9: A diagram representing the processes of harvesting and use of stormwater in Melbourne, Australia (Melbourne Water, 2014)

Strategies across scales

Using these overriding strategies as guidelines for intervention, more specifically in the City of Cape Town, there are a variety of appropriate strategies that can be implemented at the building, neighbourhood, district and metropolitan scale in accordance with spatial and system thresholds such as capacity, influence and level of supervision. These strategies exist in a spatial hierarchy of networked systems. It is important to see these strategies working simultaneously and in conjunction with one another as no single strategy is able to address the complexity of transitioning to increased water-security in Cape Town. The strategies proposed are seen in Figure 4.10. As mentioned earlier, this SDWF focuses on intervening at the District and Metropolitan scale as research areas that are under-considered in spatializing sustainable urban water systems.

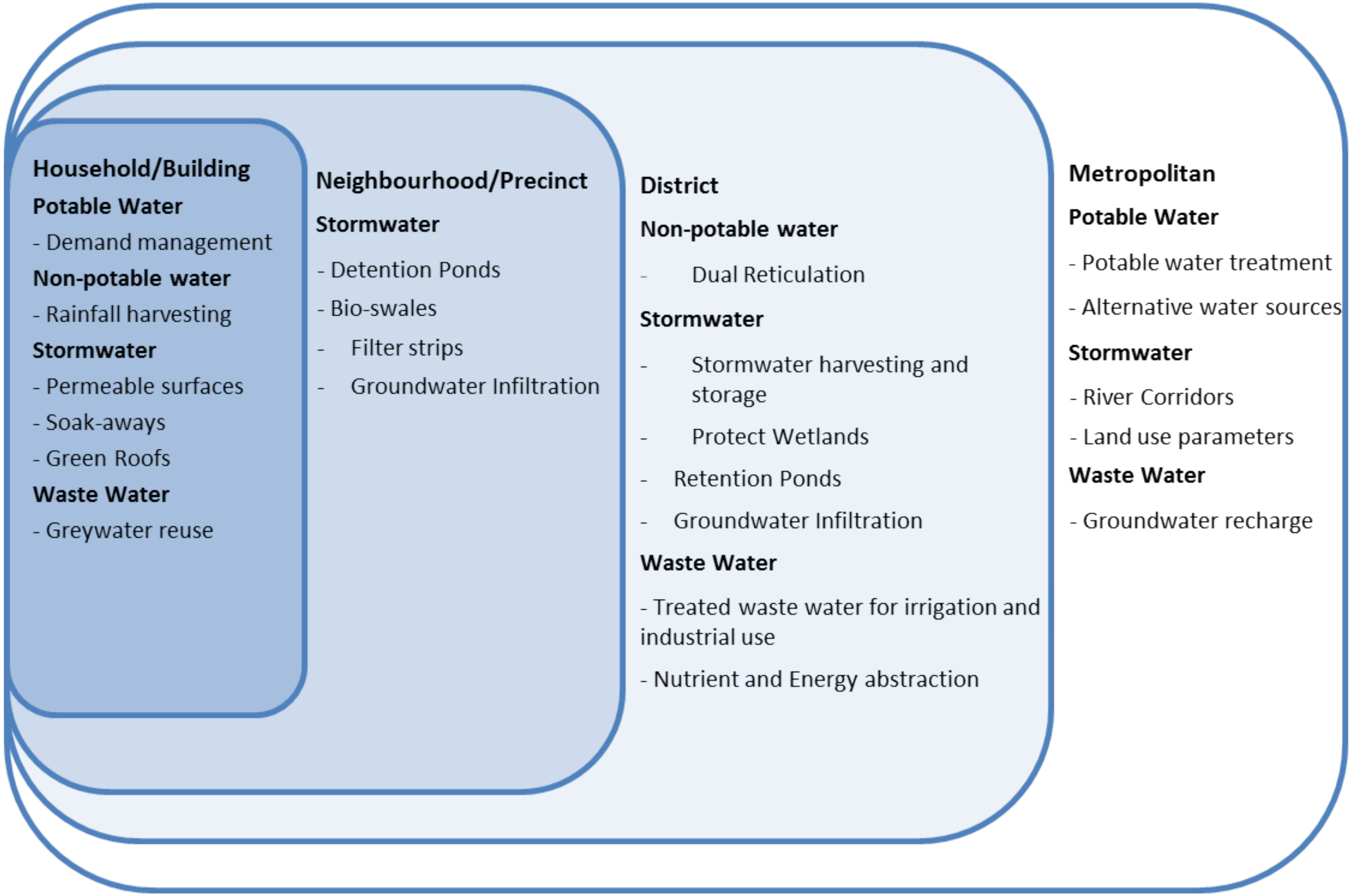


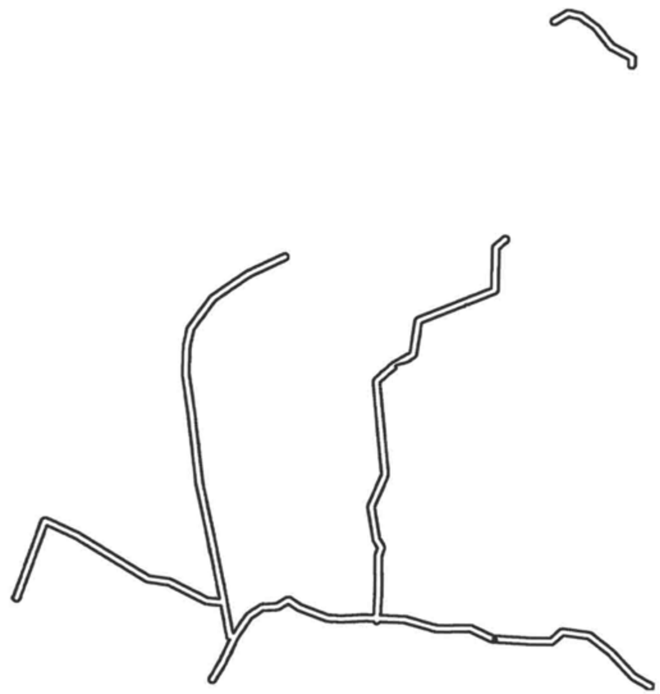
Figure 4.10: A diagram summarising the strategies of intervention possible across these four spatial scales to transition to increased water security (Author's Own). This SDWF focuses on the District and Metropolitan scales with regard to intervention.

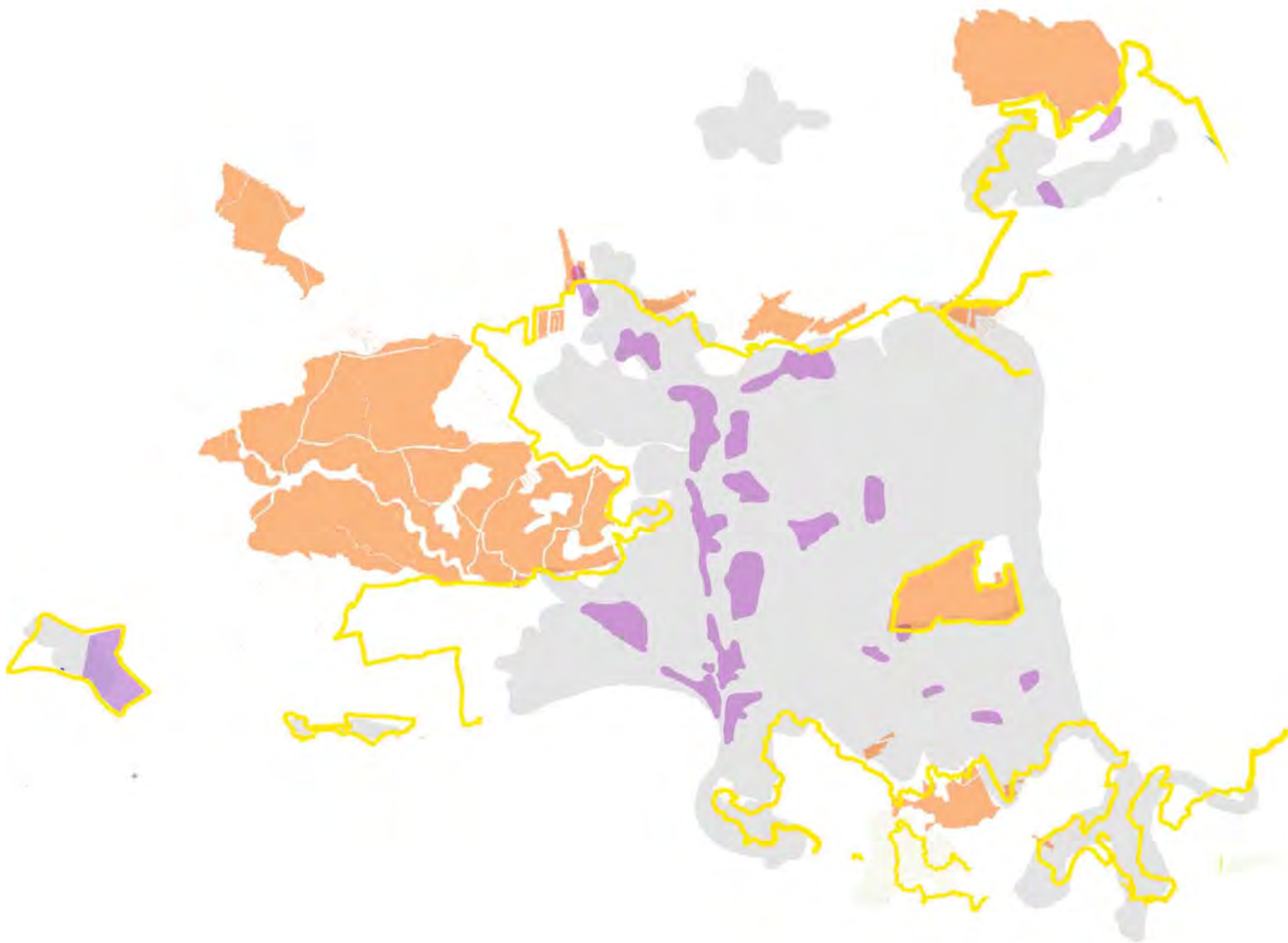
Spatial Informants

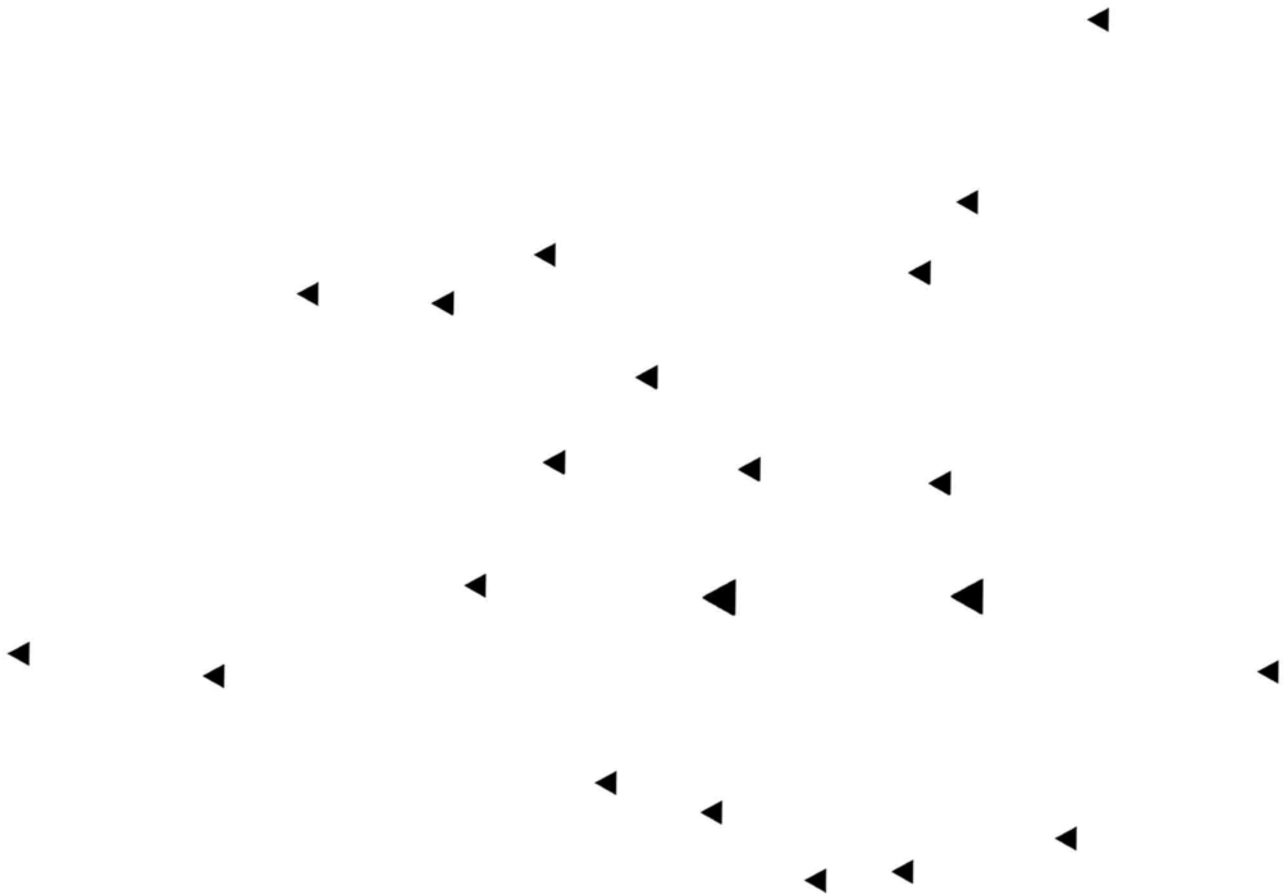
The spatial concept which guides the physical implementation of these principles, goals and strategies has been built up as a series of layers that, when overlaid, become indicators of spatial thresholds and of spatial hierarchy for the urban ecological structures which are to underpin development and growth in the City of Cape Town. To represent this, Figure 4.11 is a series of layered maps which are placed in accordance with the order of this text. These layers of spatial informants begin with the natural systems as anchors for the proposed structure with human activity as a secondary informant. Beginning with the rivers and wetlands, as seen in Figure 4.11, this freshwater system makes up the primary natural structure which guides the flow of materials, flora and fauna in the ecological system in Cape Town. Secondly, the road network is used as a spatial informant as it guides the flow of human activity in the City. Thirdly, the Biodiversity Network as identified by SANBI, recognizes the areas of valuable endemic vegetation and habitat and freshwater ecosystems that must be maintained and protected in order to preserve the biodiversity in Cape Town. This is important to the water system as the plants and land surrounding rivers and wetlands have a direct effect on the state of the water body, and vice versa. These areas of biodiversity are therefore maintained and enhanced in this SDWF. Fourthly, emphasis is placed on the Waste Water Treatment Works within the City as 'engine rooms' of nutrient processing within the urban metabolism. Finally, the current land use and proposed activity routes as provided in the current City of Cape Town SDWF (CoCT(a), 2012), are used as spatial markers of the type and quantity of water demand and output. Agricultural land, as a potentially high user of treated effluent and other biological by-products, is located largely to the north of the urban edge with smaller land parcels in the west, the Cape Flats and Strand. Industrial land is predominantly located along Voortrekker Road with higher density residential areas located in the central and southern city. The activity routes proposed by the City's SDF are intended to become areas of strategic investment and smart growth with increased density and a mix of land uses within close proximity.

Spatial Development Water Framework for the City of Cape Town 2055

Using this composite of urban system activity as a base map, this SDWF proposes a set of interventions at both the Metropolitan and District scale to act out the principles, achieve the goals and implement the strategies discussed. Firstly this has involved identifying the spatial distinction between the metropolitan and district systems followed by acknowledging the hierarchy of the rivers and wetlands in the hydrological system and the necessary green corridors to improve ecological functioning. From this developed the concept of urban bridges as public places of interaction and rest with freshwater systems and water lungs as the mechanisms for harvesting and reusing water thereby promoting local subsistence. Although presented in a linear fashion, this SDWF has been created through an iterative design process whereby the knowledge gained from previous studies has been woven through these ideas and there has been interplay between each of these interventions as they developed.







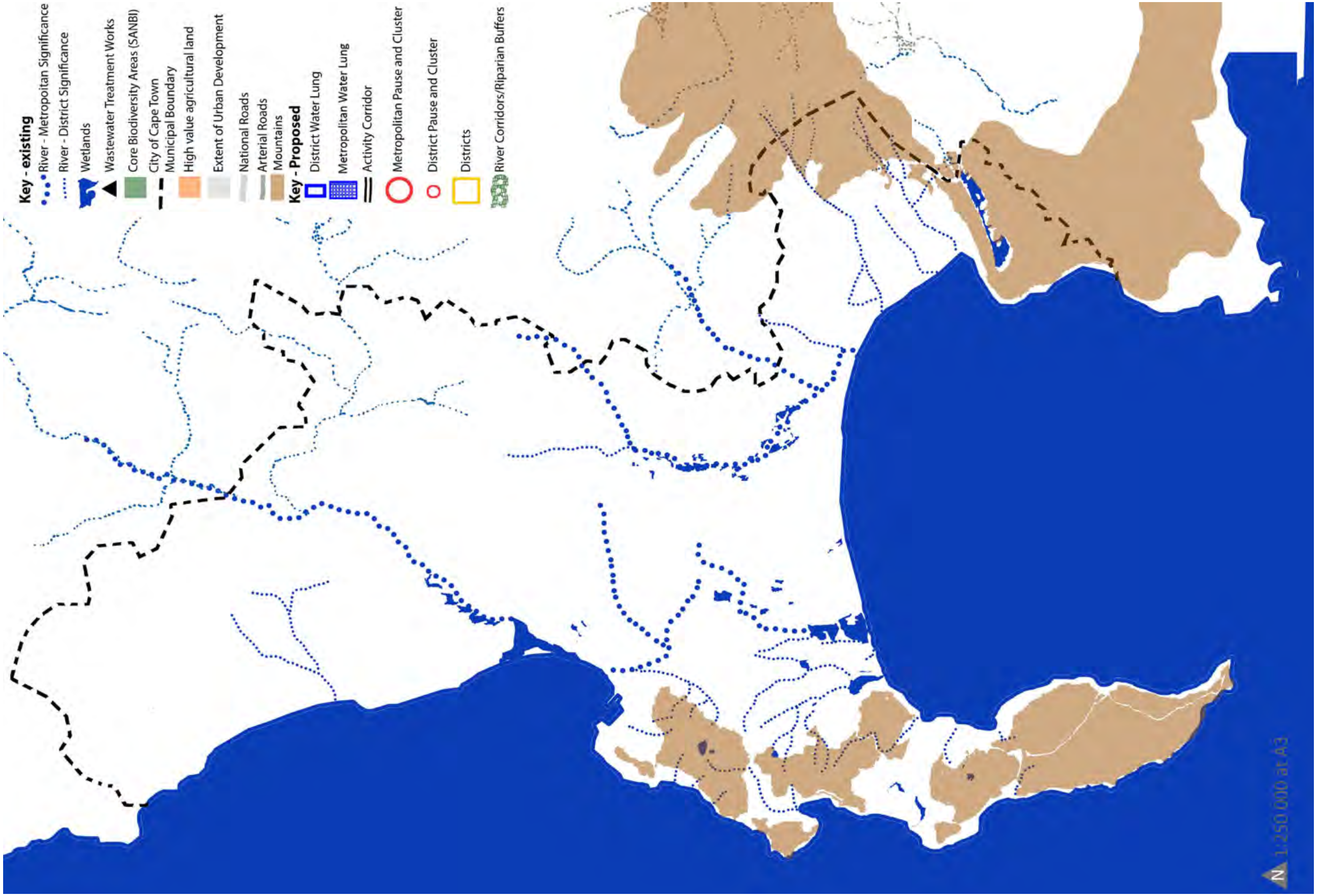


Figure 4.11: A layered map of the spatial informants for the SDWF for the City of Cape Town starting from the rivers and wetlands, the roads, the areas of Critical Biodiversity, the WWTWs, the notable land use and finally the Activity Corridors identified in the City's current SDF (Author's own with data from CoCT(a), 2012)

Metropolitan and District Freshwater Systems and Corridors

The first task undertaken in spatializing this SDWF began with identifying the rivers and wetlands which were of metropolitan significance and which were of district significance. This SDWF defines a Metropolitan River as one which flows through many districts, carries a significant proportion of the water in Cape Town, and, if altered, could greatly influence the urban ecology and structure of Cape Town. The Metropolitan Rivers identified, and seen in Figure 4.12, are the Diep River in the north; the Salt River, including the Black and Elsies River, in the central city; the Lotus River in the southern city; and the Kuils River, including the Eerste River, in the East city. This SDWF defines metropolitan wetlands as water bodies which come into contact through recreational activities and have the potential to affect a significant percentage of the population in Cape Town and which play a vital role in the provision and renewal of habitat for vegetation, fish, birds and other wildlife. The metropolitan wetlands identified are the Zeekoeivlei and surrounding wetlands on the Cape Flats along with Rietvlei in Milnerton. The remaining rivers and wetlands are identified as District systems which have a lower potential impact on the overall urban system and carry water shorter distances. This does not reduce the importance of ensuring that these rivers and wetlands are ecologically healthy but rather offers the opportunity for strategic and prioritised implementation of major interventions.

As learnt from the contextual analysis, land use can have a direct effect on the quality and quantity of water received in freshwater ecosystems. Therefore this SDWF proposes that along each of the rivers identified a river corridor is

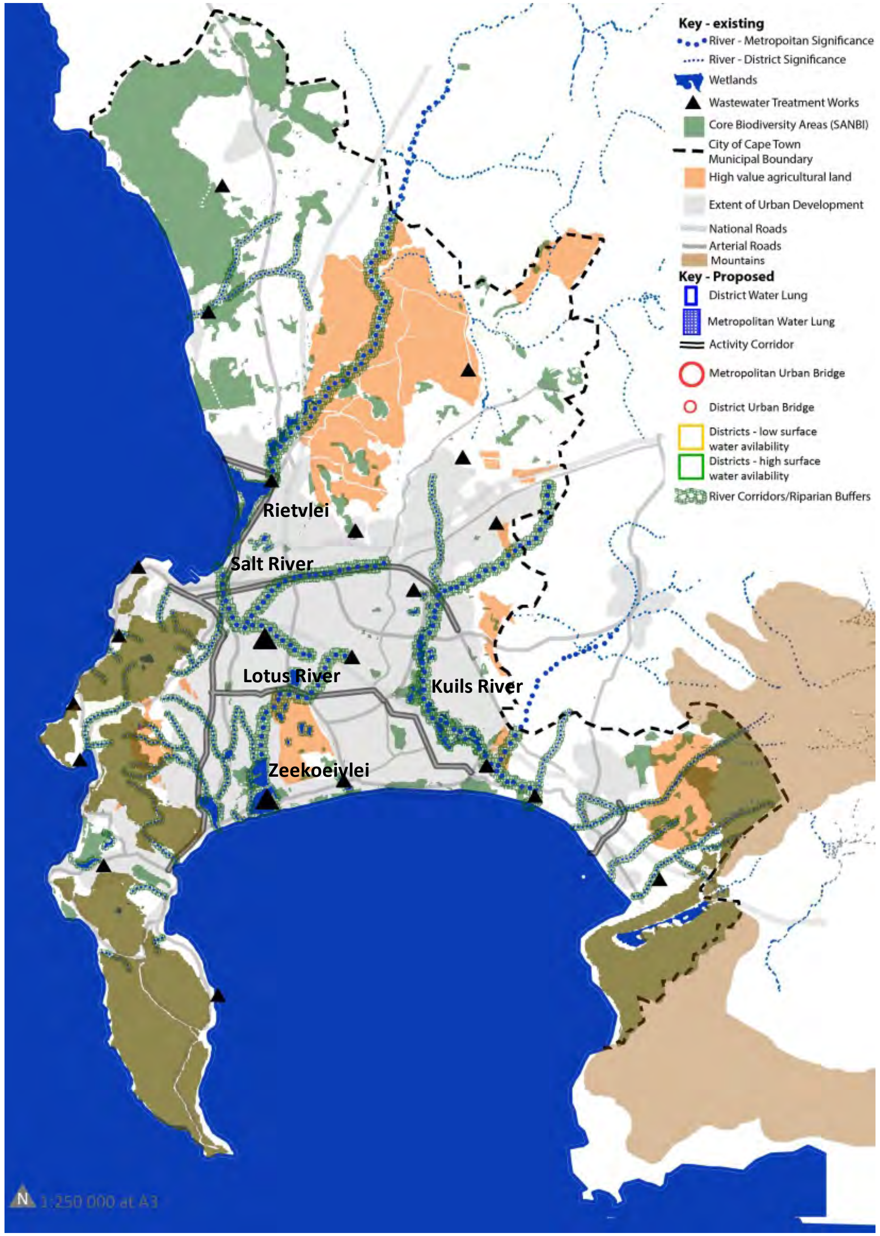


Figure 4.12: The first layer of the SDWF showing the hierarchy of rivers and wetlands with their surrounding biodiversity river corridors (Author's Own)

Figure 4.13: a photograph of the upper Liesbeek River Corridor which is a hybrid canalisation system that includes a well-developed riparian buffer with sufficient vegetation and pathways to encourage recreational activity to enjoy the river environment (Author's Own).

Figure 4.14: A photograph of the lower Liesbeek River corridor showing a large river corridor with a canalised river channel with an adjacent grass flood plain used for recreational purposes (Author's Own).

established from source to discharge, as seen in Figure 4.12, where hard surfaces are reduced to a minimum and the growth of indigenous and endemic vegetation is strongly encouraged. This would include, where possible a move towards the decanalisation of these rivers. However, due to the close proximity of urban development to these rivers there will most likely need to be a hybridised system of part natural, part constructed river banks and canals, as illustrated in the example of the Liesbeek River in Figure 4.13 and 4.14. These areas would not necessarily be in public ownership but would have restraints on the land uses allowed so as to prevent harmful and excessive effluent from damaging the water body and to encourage properties to be orientated toward the river rather than away from it as is currently common practice. The restoration of these riparian buffers would offer the opportunity for urban biodiversity belts which connect areas across the city, from core biodiversity areas to the coast, thereby helping to increase the resilience of the freshwater and broader ecological systems in the City of Cape Town.

The process of restoration and the continued maintenance necessary would also offer the opportunity to create employment within the green economy[1]. This is in conjunction with facilitating the reduction in flow velocity and the pollution load of the incoming water through the processes of infiltration and filtration.

Identifying Metropolitan and District Systems

With the underlying hydrological structure in place, it is possible to differentiate between the overall Metropolitan Systems and the subsequent District Systems. To identify the district systems proposed, various factors were taken into consideration such as the urban edge, population density, the current sewage drainage areas and the location of Wastewater Treatment Works. Where possible, the boundaries of these systems have been aligned with that of a metropolitan river system so that these rivers become the 'zips'

1 The Green Economy can be defined as is one where the economy, "*results in improved human wellbeing and social equity, while significantly reducing environmental risks and ecological scarcities*" (UNECA, 2012).

and points of connection that hold the city together; thereby increasing their urban prominence, as illustrated in Figure 4.15 and 4.16. As shown in Figure 4.10, the implementation of a district is to be concerned with the decentralisation of non-potable water sourcing through stormwater harvesting, treated effluent reuse and dual reticulation systems. The districts identified, as seen in Figure 4.17, have been classified into two categories that include high surface water availability and low surface water availability based upon the biophysical conditions and microclimate of each district. These distinguish the approaches applicable to a district with regard to how best to implement the suggested strategies. The districts presented in this SDWF offer the opportunity to align and harmonise the variety of sectoral boundaries; such as the water supply areas, the wastewater collection areas and the planning districts. This would enable the spatial integration and co-ordination of a variety of issues thereby allowing for a more holistic response that addresses the increasing complexity of urban systems.

Figure 4.15: A conceptual diagram illustrating the concept of the rivers acting as areas of connection; 'zips' within the urban landscape (Author's Own)

The Metropolitan System, as bound by the current municipal boundary, encompasses all districts, the areas that fall outside of the urban edge and the metropolitan rivers which hold together the district systems, as seen in Figure 17. At this spatial scale the aim is to promote a system in balance. This is necessary for the cyclical flow of water, especially with regard to the sources and sinks of water and treated effluent. An example of this is the need to protect agricultural land that is in close proximity to urban areas as these areas are prime candidates for the use of treated effluent and fertiliser manufactured from biological sludge which is a by-product of treated effluent. By maintaining this close proximity, the system has a greater chance of sustainability and resilience through reduced infrastructure provision and transport costs. Therefore this SDWF encourages all decisions on new developments, which might expand the urban footprint, to take cognisance of the sensitive equilibrium of water and waste production and absorption.

Figure 4.16: A zoomed in image of the districts layer to illustrate the differentiation in boundaries and thresholds identified. AT times a river is the boundaries and at others a road is. (Author's Own)

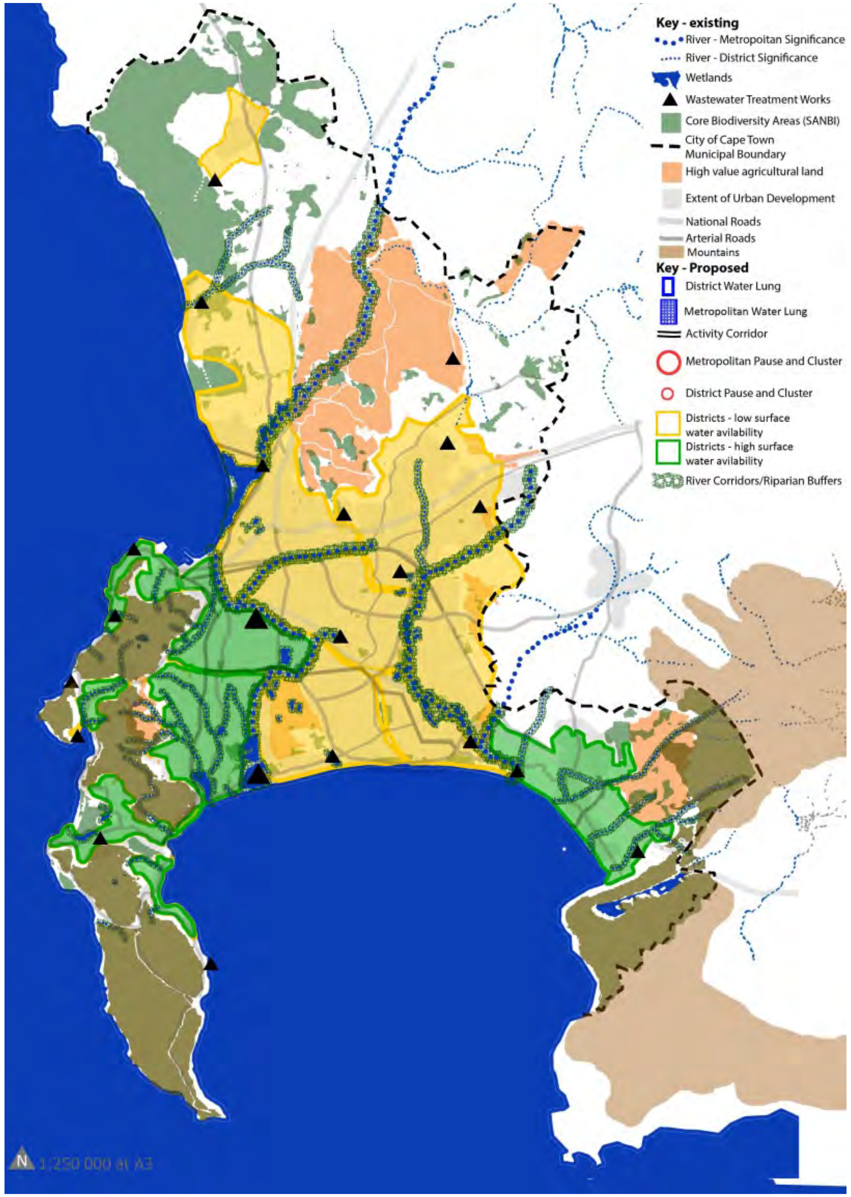


Figure 4.17: The second layer of the SDWF identifying and differentiating between the districts in Cape Town (Author's Own)

Metropolitan and District Urban Bridges

The activity routes identified in the current Cape Town SDF are again emphasised in the SDWF as areas of increased residential density and commercial activity. As discussed with Neil Armitage and Kirsty Carden (2014) of the Urban Water Group based at the University of Cape Town, increasing the urban fabric to a medium to high density along routes would give space for parks and areas of water retention between urban blocks, as seen in Figure 4.18, and along the more sensitive river corridors to decelerate and filter the water received by rivers and wetlands. This would form a network of soft infrastructure which utilizes ecosystem services to help reduce the pollutant load and damage caused by fast flowing stormwater through increasing the pervious surface area in the City. Increasing density would also hinder urban sprawl thereby helping to protect areas of high value biodiversity and agriculture beyond the urban edge.

Figure 4.18: A conceptual representation of the relationship between higher density and increased space for water retention and management in urban areas (Armitage *et al*, 2013).

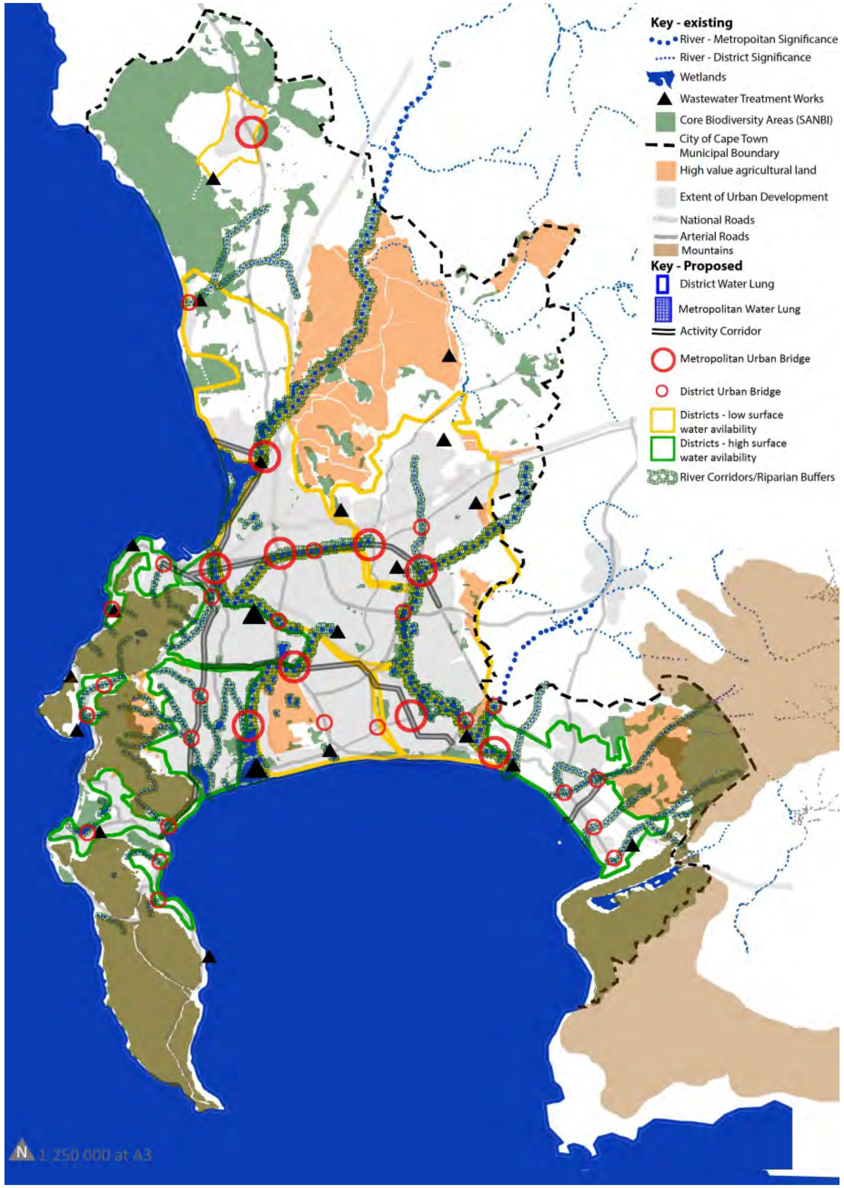


Figure 4.19: The third layer of the SDWF identifies the Metropolitan and District Urban bridges at the intersection of activity routes and urban water ways in Cape Town (Author's Own)

The activity routes and the freshwater network, the rivers and wetlands, are envisioned as lines of energy in the City of Cape Town; that is desire lines for the flow of people and water respectively. Therefore where these intersect, there is a confluence of energy creating a node or hub. In this SDWF these places of intersection, as seen in Figure 4.19, are referred to as Urban Bridges and they offer the opportunity to pause amidst the urban environment and to reconnect socially and ecologically. This is through displaying water rather than hiding it underground thereby giving space for interaction, such as a sitting area or park, as shown conceptually in Figure 4.20 and 4.21. By hiding our water in the City it fosters a negative relationship between people and water. Water becomes a nuisance rather than an advantage and a pleasure. Also, without the opportunity for a visual and physical connection to water in human areas it detaches human activity from its environmental impact. If we can see that water is polluted or the typical level of low has been altered then there is perhaps a greater likelihood that change our behaviour will change accordingly; if given the knowledge and capacity to do so.

In some cases, these Urban Bridges align with current socio-economic nodes such as the Bellville CBD but mostly these urban bridges propose new anchors on which to harmonise the spatial structure the city with the pre-existing natural structure. This means that transport nodes and stops along the activity routes could also be integrated into these urban bridges.

In this SDWF there are Metropolitan and District urban bridges which have been determined according to the hierarchy designated to the intersecting river or wetland. It is envisioned that at these 'bridges' there would be a clustering of social and civic facilities and services to ensure that this space is dedicated as public domain; to the commons. The hierarchy of the services provided would be guided by the spatial hierarchy of the bridge at which it is located. Through this, there is the hope that a connection with water becomes a daily occurrence for all citizens in order to facilitate a new paradigm of human-nature relationships with living water.

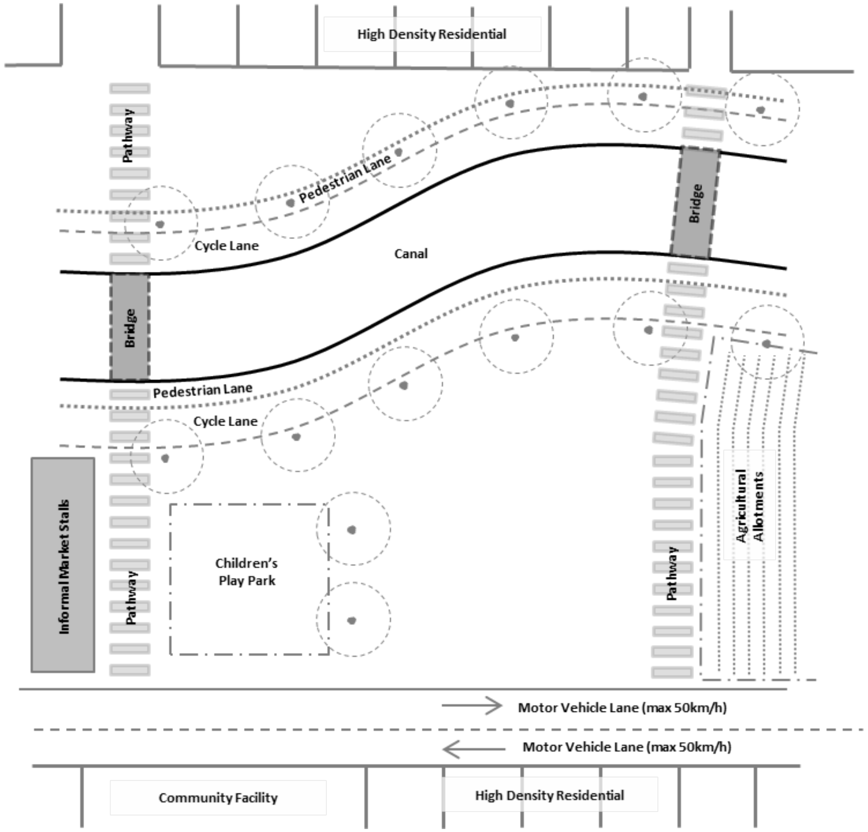


Figure 4.20: An initial conceptual drawing of a spatial layout option for an urban bridge, which includes areas of informal economic activity, rest and recreational activity that are surrounded by community facilities and high density residential dwellings (Vaughan, 2013 with adjustments made by Author)

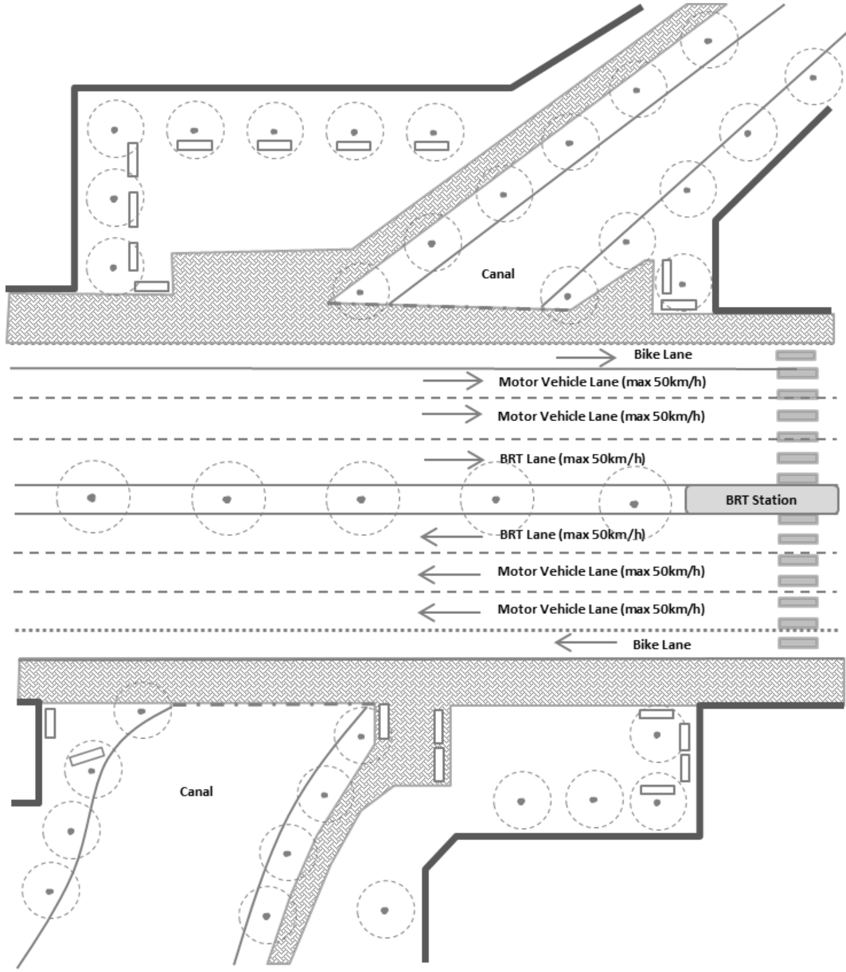


Figure 4.21: A second conceptual drawing of a spatial layout option for an urban bridge, which includes areas of pause and recreational activity that are surrounded by community-orientated buildings with associated public transport stops (Author's Own)

Metropolitan and District Water Lungs

The final strategy proposed in this SDWF is that of urban water lungs (UWL). These are spaces in the city dedicated to the collection and distribution of the non-potable water source. This system, as seen in Figure 4.22, begins with utilizing school fields and playgrounds as areas of water collection with large storage tanks placed beneath them. School fields have been chosen for this purpose due to their quantity and frequency in high water demand areas, such as residential areas, and their permeable surfaces that are generally protected from land use pressures. This water is then transferred, along with treated wastewater effluent from the closest WWTW, to the UWL in that district where it is stored and treated to non-potable water quality. This non-potable water is then transferred to the surrounding neighbourhoods for residential, industrial, agricultural and commercial purposes through a dual reticulation system.

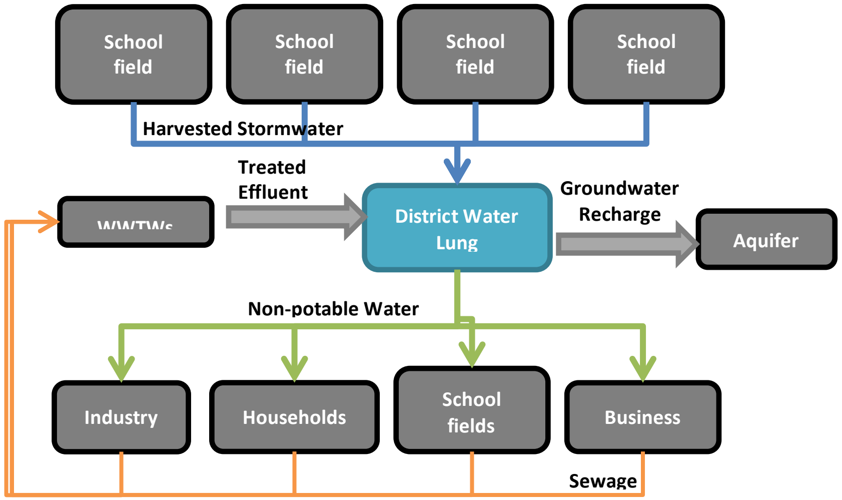


Figure 4.22: A diagrammatic explanation of the Urban Water Lung System in Cape Town that indicates how water is collected and reused to promote a cyclical system of water use (Author's Own)

There is a large seasonal fluctuation in the demand for non-potable water so storage is necessary. This storage however cannot be too large as the water will stagnate and become hazardous therefore this system makes use of small district based storage areas rather than a single metropolitan storage area. This decentralised system also acts a park or sports field and a point of groundwater recharge for the Cape Flats Aquifer. As seen in Figure 4.23 each district has a UWL located within it in an area of currently vacant or underutilised land.

The Metropolitan Urban Water Lung (UWL) is located between Khayelitsha and Mitchell's Plain on a piece of land that is predominantly vacant with a second one to the south of Atlantis, as seen in Figure 4.23. The purpose of this system is to extract water from the Cape Flats Aquifer to be used as a source of non-potable water. The aquifer flows from North West to South East and has its deepest point in the South East, in the area of Khayelitsha and Mitchell's Plain (Adelana and Xu, 2006) therefore making this a prime extraction point. As this aquifer will be used as a large storage area for surplus non-potable water during winter, this Metropolitan UWL will be significant to the whole municipality. As water technologies improve and the state of the rivers and wetlands improves, there is the possibility that this groundwater could be used to supplement the supply of drinking water. Also, with the increase in local subsistence, there will be an increase in the employment of local labour to operate and maintain these various systems.

This strategy, when implemented at both the district and metropolitan scale, could offer up to 311.5 Mm^3/a from stormwater harvesting, having taking into account the necessary Ecological Reserve; 18 Mm^3/a from groundwater extraction; and up to 200 Mm^3/a from treated effluent from all WWTWs. This

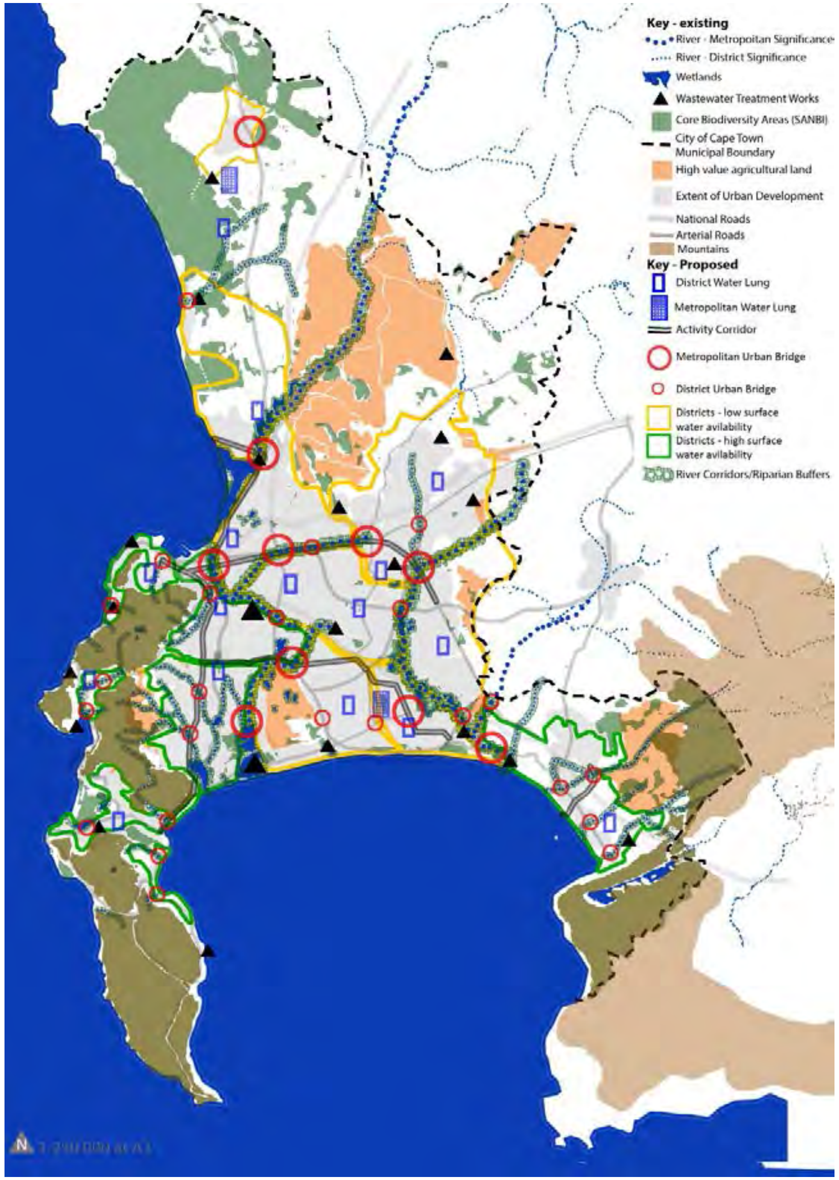


Figure 4.23: The final layer of the SDWF that locates the Metropolitan and District urban water lungs in Cape Town (Author's Own). A larger version can be seen in Figure 4.24 at the end of this chapter.

totals an estimated 529.5 Mm^3/a which is 70% more than the current water demand of the City of Cape Town. This, along with continued and improved WC/WDM strategies, could therefore accommodate for the urban services expansion required, future population growth and, potentially, even allow Cape Town to become a water exporter to our more arid northern and interior neighbouring regions.

When combined, the strategies in this SDWF as seen in Figure 4.24, offer the opportunity to transition to an increasingly water-secure urban paradigm; firstly through affording all citizens the opportunity to safely interact and reconnect with their surrounding freshwater ecologies and secondly through exercising personal and communal restraint to reduce the stress of human activity on the environment within and outside of the municipal boundary.

Conclusion

This chapter has put forward a Spatial Development Water Framework for the City of Cape Town which proposes recommendations and interventions to enable a transition to an increasingly water secure city for all citizens. This SDWF has built upon the knowledge and understanding gained from the literature review, the contextual and spatial analysis and from international precedent to allow the presence and priority of water in Cape Town to guide development. Using this as a foundation, the principles of reverence, responsibility, restoration and restraint are employed to guide the type and the effect of urban development. This is to place Cape Town on a path where social and ecological health is improving; communities are increasingly more connected within themselves and to others; the prosperity gained is progressively shared more; and that the urban water system is smarter and more flexible. The structure proposed in this SDWF encourages a meshing of the human activity with that of the natural environment within the city to reconnect and encourage a symbiotic relationship between them. This is the premise upon which a transition can occur; when people are changed, their behaviour follows.

The concepts of the nutrient cycle and of local subsistence are used as a basis from which the strategies have been developed. These strategies occur at a range of scales with focus placed upon the district and metropolitan scales. At these two scales, it is proposed that rivers and wetlands are used as structural elements in the city and are then aligned with urban biodiversity belts to promoted ecological connectivity. From this the relevant district and metropolitan boundaries were recognised along with the intersections of urban and ecological flows. These Urban Bridges facilitate moments of pause and daily interaction with water in the city while the urban water lungs are engine rooms for the storage and treatment of stormwater and treated effluent and the distribution of non-potable water. In the following chapter, this SDWF is discussed further with regard to implementation responsibilities, strategic phasing and governance. Overall, this SDWF has provided an alternative vision for the City of Cape Town where water is guarded for the enjoyment and survival of all Capetonians, both present and future.

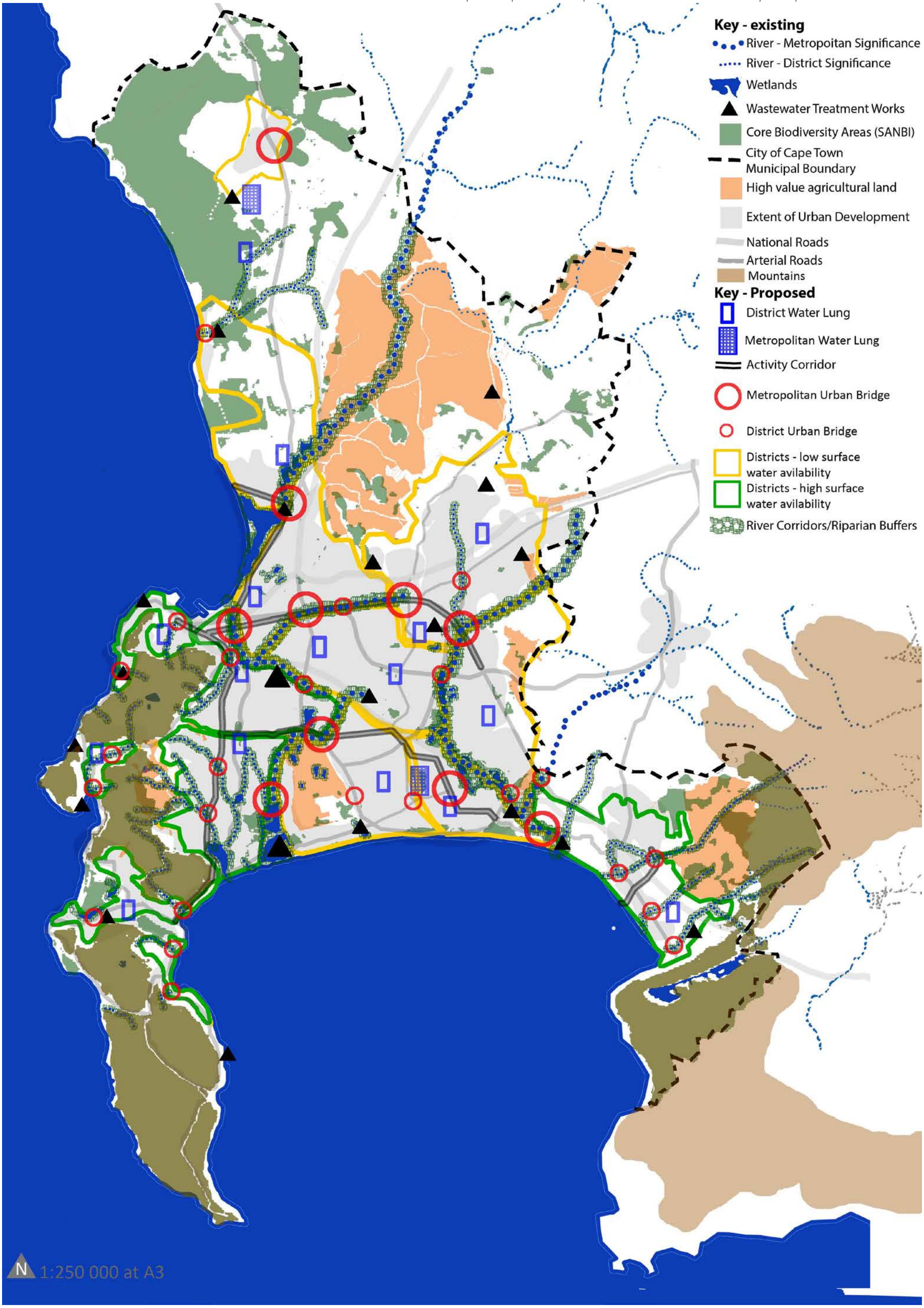


Figure 4.24: The Spatial Development Water Framework Map for the City of Cape Town 2055 (Author's Own).

Chapter Five:

Implementation of the SDWF for the City of Cape Town

Introduction

Using the principles of reverence, responsibility, restoration and restraint as a foundation for intervention and with the goals of social and ecological health, connected communities, shared prosperity and intelligent water systems; four strategies have been identified in the previous chapter of this study, the Spatial Development Water Framework (SDWF) for the City of Cape Town. These strategies include identifying metropolitan and district systems, metropolitan and district freshwater systems and river corridors, metropolitan and district urban bridges, and metropolitan and district water lungs. As a continuation of this SDWF, this chapter is concerned with the implementation of these strategies over the next 40 years with a need to consider the necessary legal and governance parameters required, those who would be responsible for implementation, those who must be consulted and where the funding is expected to come from. This is a long period of time with great uncertainty lying ahead with regard to resource availability, population growth and municipal and private capacity to mention a few. Therefore in this section the strategies discussed have been positioned in four 10 year phases with the first phase being the priority for implementation. While the vision guiding this SDWF is for 2055, it is necessary to intervene in the present situation with a matter of urgency to enable the transition to a more water-secure, equitable and life-giving city.

Firstly, this chapter addresses the necessary phasing of the above mentioned strategies to allow for a considered implementation process which begins with the most urgent interventions and the precursors necessary to enable these strategies. This is necessary as not all strategies can be implemented simultaneously. This chapter then moves to a focus on the actors who would be involved and those who would be responsible for the implementation of various strategies. In this section the importance of public participation and partnerships is emphasised as the scope and nature of intervention requires democratic decision-making processes to enable the socio-economic and ecological resilience of these strategies. Finally, to enable local area planners and building development teams to embrace these principles, goals and strategies at a more detailed spatial scale and level of development, this chapter puts forward guidelines for local area planners to consider when intervening. This is to allow water to guide development in the City of Cape Town across scales which strengthens and supports the strategies discussed in this SDWF.

Phasing of Strategies in the SDWF for the City of Cape Town 2055

Each of the strategies has been broken down into a series of projects and tasks, as seen in Figure 5.1. There are two sets of phasing; the first is where the strategies are phased to indicate the order of implementation across the metropolitan area over the next 40 years with a second phasing process which outlines the order of the tasks necessary to enable a successful intervention of each project. While this phasing lays out the necessary timing for these strategies, it is important to note that ongoing maintenance and upgrade will be required after 2055 to enable increasingly secure water systems in Cape Town. The secondary phasing is not presented in a table in this chapter however the principles and broad approaches to implementation are outlined. Notably, the project task phasing should be an iterative process and includes public participation and ongoing monitoring that should become inputs to the further development of these strategies. This is to allow for flexibility and increasing resilience to the effects of climate change, environmental stresses and socio-economic pressures as available information increases and knowledge, hopefully, expands. However it must be noted that, while the overarching process might be transferable from one district to another, as the socio-economic, biophysical and micro-climatic conditions differ across the city care must be taken to allow the valuable public participation and environmental impact assessment processes to inform the method and scope of intervention. This is evident in each of the strategies put forward.

Figure 5.1: A phasing layout for all strategies and related projects put forward in the SDWF for the City of Cape Town 2055 (Author's Own)

Phasing of Implementation					
Strategies	**Projects**	**Phase 1 2015 - 2025**	**Phase 2 2025 - 2035**	**Phase 3 2035 - 2045**	**Phase 4 2045 - 2055**
Metropolitan and District Rivers and Wetlands	System of spatial hierarchy for freshwater ecology				
	Establish River Corridors and Wetland Buffers	Kuils, Salt and Lotus Rivers	Zeekoeivlei and Rietvlei	District Rivers	District Wetlands
	Land Use parameters				
	Riparian Buffers rehabilitation and maintenance	Metropolitan Rivers		District Rivers	
Metropolitan and District Systems	Align planning and water management with spatial boundaries				
	District Stormwater Design Guidelines		high surface water availability	low surface water availability	
	Secure Agricultural Land protection			Philippi Horticultural Area	Northern Durbanville, Constantia and Somerset West
	District Management Organisations	Milnerton, Blouberg and Atlantis			
	Waste water Treatment Works - upgrades for increased treated effluent capacity	Bellville, Borcherds Quarry, Mitchell's Plain, Zandvliet	Athlone, Kraaifontein and Cape Flats		
Metropolitan and District Urban Bridges	Land Use -Mixed Use Densification		Voortrekker Road	Lansdowne Road	Main Road
	Land Use - Social service clusters				
	Parks and Pause Areas		Bellville CBD		
Metropolitan and District Water Lung	School Fields Stormwater Harvesting Systems	Milnerton District	Athlone, Cape Flats, Khayelitsha		
	Urban Water Lung - Water Collection, Treatment and Park - Groundwater Recharge (if applicable)		Milnerton District	Athlone, Cape Flats, Khayelitsha	
	Dual Reticulation System		Milnerton District	Khayelitsha	
	Groundwater Extraction and Treatment				Khayelitsha

The first phasing is laid out in Figure 5.1, where the implementation of each project is allocated to a single phase or to multiple phases as indicated in light blue, depending on the expected timeframe of the project. Within these project phases, a district of focus is put forward for the initial implementation due to the current socio-economic, biophysical and infrastructural conditions being favourable for pilot projects, as is discussed further in this chapter. Refer to Figure 5.2 to locate each district by name. Firstly, with regard to the strategic intervention of the river corridors in Cape Town, this SDWF identifies three areas of priority; these are the Salt River, the Lotus River and the Kuils River, as seen in Figure 5.3 and identified in the Chapter 3. These rivers have been chosen as they are classified as Metropolitan Rivers and they are each currently in a poor state, either in part or whole. This strategy therefore indicates a particular urgency to the implementation of this SDWF as, although it is a 40 year long term plan, some of Cape Town's most prominent rivers are already in such a poor state that immediate action is required to prevent further and more severe ecological degradation.

Secondly, as a precondition for the successful reuse of treated effluent, priority must be given to upgrading the five most environmentally damaging and over capacity WWTWs which are located in the most populous areas in Cape Town. These are Athlone, Bellville, Borcherds Quarry, Mitchell's Plain and Zandvliet, as shown in Figure 5.3. This upgrading includes an increase in both the overall wastewater treatment capacity and the treated effluent capacity. Furthermore, these WWTWs discharge effluent into the Salt River, the Kuils River and Lotus River, therefore when upgrading these facilities there is also a reduction in the pollution received by the rivers.

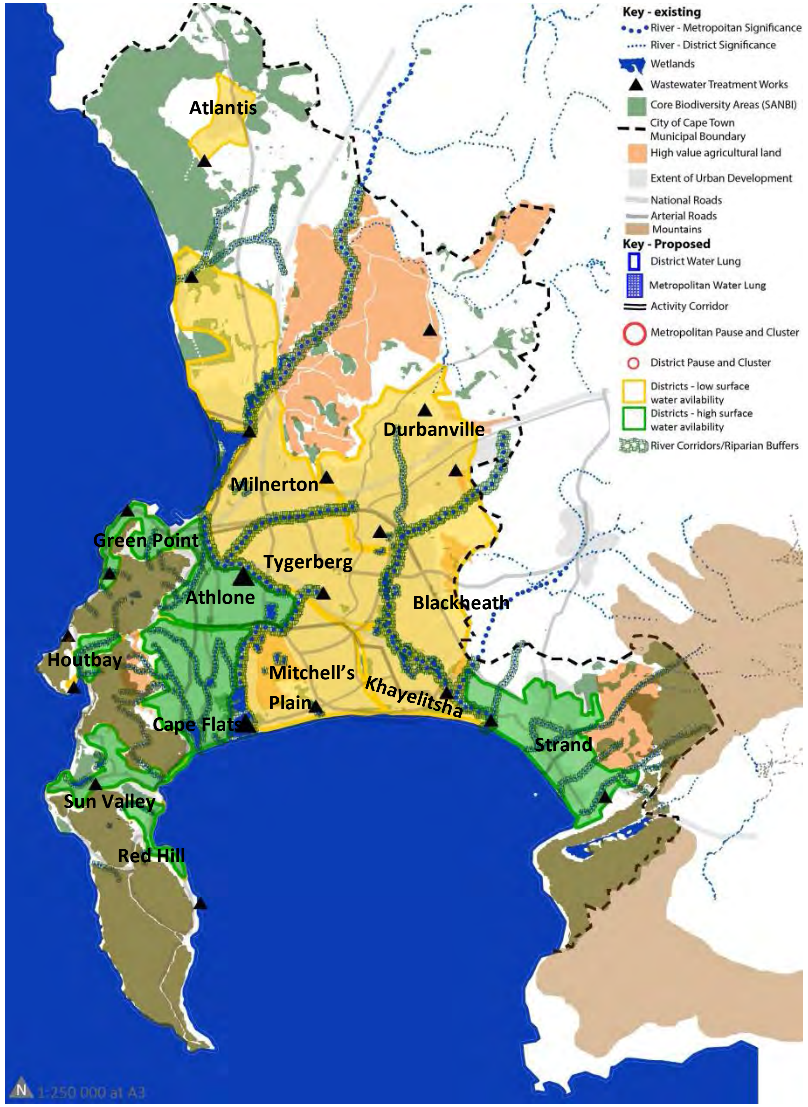


Figure 5.2: A map of the districts of Cape Town from the SDWF with each districts' name shown (Author's own)

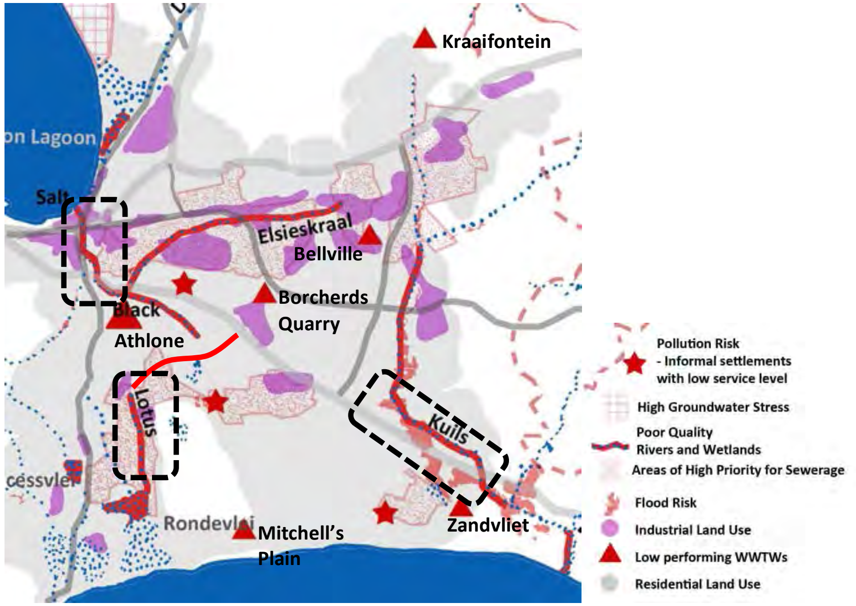


Figure 5.3: A zoomed-in constraints map (Chapter 3) for the City of Cape Town showing the state of the rivers and the priority areas identified for the implementation of river corridors within the dotted black boxes. This map also identifies the relevant WWTWs that have been prioritised as red triangles (Author's own).

This, along with the creation of river corridors and the restoration of riparian buffers, would act collectively to improve the state of urban freshwater ecologies in the City of Cape Town. Thirdly, with regard to establishing Metropolitan and District Urban Bridges the phasing strategy puts forward that the priority should be placed on Voortrekker Road for increasing densification and with the first urban bridge located at the Bellville Central Business District. Currently, Voortrekker Road forms a primary accessible spine of activity in the city. This area offers a mixed use living environment within a medium residential density to citizens in the low to middle economic bracket. It is proposed that an urban bridge be located within Bellville at the intersection of the Elsies River and Voortrekker Road as this area has a high number of people passing through and working there each day.

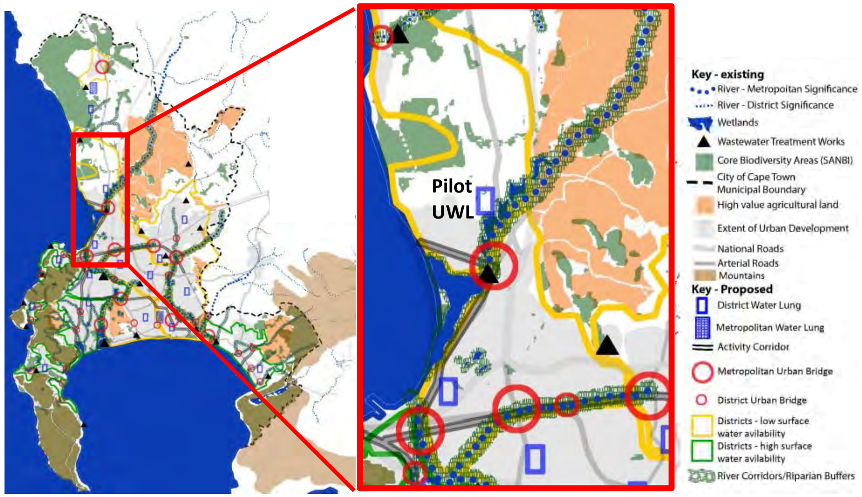


Figure 5.4: A cropped image from the SDWF indicating the Milnerton District in the north of the City of Cape Town where the pilot project for the Urban Water Lung is suggested (Author's Own).

Finally, with regard to the implementation of a District Urban Water Lung, this SDWF proposes that a pilot project be undertaken in the Milnerton District, as seen in Figure 5.4. This is as a result of a combination of factors such as that this area is currently experiencing "*some of the fastest growing new development*" in the City of Cape Town (CoCT(d), 2012); the district's WWTW, Potsdam, has the highest treated effluent reuse capacity in the city with only 25% being used at present (CoCT (b), 2012) and this area will be more severely affected by severe storms and drought as the arid coast and inland climate expand due to climate change (CoCT(d), 2012). This therefore makes the Milnerton area a prime location for the installation of a dual reticulation system from the Urban Water Lung to provide all new developments with both non-potable and potable water supply thereby potentially reducing potable water use by up to 70%. Once this pilot has been successfully installed and functioning, with a monitoring programme having documented the lessons learnt from the successes and mistakes within this process, it will be possible to develop Urban Lungs in other districts in Cape Town.

It is vital that these strategies are implemented in such a way as to allow a transition to an increasingly secure water future in Cape Town. A holistic, yet strategic response to intervention is necessary therefore this SDWF proposes that, where possible, strategies are spatially aligned and co-ordinated within a District System.

Actors and Implementation responsibilities

The second table regarding implementation of the strategies suggested identifies the relevant legislative actions, actors and sources of resourcing responsible. As seen in Figure 5.5, there are existing government bodies and institutions which are noted along with new institutions which are to be established. The most important of these new institutions is the creation of District Community Organisations (DCOs) to aid in the public participation process and to ensure that there is ongoing exchange of information and feedback from project implementation to the relevant government departments. These DCOs are made up of a collection of interested parties such as principals from schools in the area, residents, faith leaders, community-based organisations, representatives from public facilities and business owners to name a few. This combination of voices should facilitate a more socio-economically resilient implementation process as a variety of differing opinions, ideas and conflicts can be discussed, explored and addressed within the process. While National and Provincial government play a guiding role, it is expected that the City of Cape Town Municipality will play a prominent role in implementation. The role of local government is to facilitate partnerships and to take the first step by developing pilot 'show' projects. As illustrated in both the Melbourne, Australia and Lima, Peru case studies discussed in Chapter 4, strong support and leadership from local government is vital to the success of these strategies.

Funding

The funding and resourcing of these strategies plays a vital role as to the process of implementation and the sustainability of the project after development. Funding should not only be considered for the physical construction necessary but for the social and environmental development process prior to construction and the monitoring and maintenance of projects afterwards too. The suggestions provided in the table, Figure 5.5, are initial thoughts as to the source of potential funders and donors to enable the development of these strategies. As noted, while the local government plays a pivotal governance and facilitation role, these projects cannot be funded by the municipal rates and taxes base alone. There is therefore a need to look to provincial and national government, private and collective funding options. With regard to private funding, there is an opportunity to establish partnerships whereby corporate social investments from large corporate firms or groups of smaller firms can sponsor activities on a project-specific basis within the district they are located or a chosen district. With regard to provincial government, the Expanded Public Works Programme (EPWP), which is a national project but administered by provincial government, is highlighted as it aims to create jobs both directly and indirectly through involving unemployed and low-skilled citizens of working age in projects within the city.

Phasing of Implementation				
Strategies	**Regulatory/ Legislative Actions**	**Government Institutions Responsible**	**Other Institutions/ Actors Responsible**	**Funding**
Metropolitan and District Rivers and Wetlands	**Existing:** National Water Act no. 36 of 1998 National Environmental Management Act (NEMA) 1998 NEMA: Biodiversity Act 10 of 2004 Land Use Planning Act of 2014 Municipal By-law: Floodplain and River Corridor Management Policy of 2009 City of Cape Town IDP 2012 - 2017: - Pillar 3: The Caring City - Pillar 2: The Safe City	**Existing:** - National Department of Water and Sanitation - Provincial Department of Environmental Affairs and Development Planning - Provincial Cape Nature -Provincial Department of Public Works - City of Cape Town Municipality - Dept of Safety and Security: Disaster Risk Management - City of Cape Town Municipality - Dept of Economic, Environmental and Spatial Planning: Environmental Resource Management - City of Cape Town Municipality - Dept of Economic, Environmental and Spatial Planning: Spatial Planning and Urban Design - City of Cape Town Municipality - Dept of Transport: Catchment, Stormwater and River Management **To be Established:** - Berg-Olifants Catchment Management Agency	**Existing:** South African Institute of Environmental Health South African National Biodiversity Institute Working for Water Working for Rivers Working for Wetlands **To be Established:** District Community Organisations Friends of the Lotus River Friends of the Kuils River Friends of the Salt River	**Public-private partnerships** **Local Municipality** **Provincial Government** - Expanded Public Works Programme: Infrastructure and Environment and Culture **National Government** - Municipal Infrastructure Grant: Category 1: Households
Metropolitan and District Systems	**Existing:** Land Use Planning Act of 2014 City of Cape Town IDP 2012 - 2017 Pillar 4: The Inclusive City	**Existing:** - Provincial Department of Environmental Affairs and Development Planning - Provincial Department of Agriculture - City of Cape Town Municipality - Dept of Economic, Environmental and Spatial Planning: City Development Strategy and Integrated Development Planning - City of Cape Town Municipality - Utility Services: Water and Sanitation	**To be Established:** District Community Organisations	**N/A**
Metropolitan and District Urban Bridges	**Existing:** Municipal By-law: Floodplain and River Corridor Management Policy of 2009 Land Use Planning Act of 2014 City of Cape Town IDP 2012 - 2017: - Pillar 3: The Caring City - Pillar 4: The Inclusive City	**Existing:** - Provincial Department: Education, Health, human settlements, transport and public works and economic development and tourism - City of Cape Town Municipality - Dept of Human Settlements - City of Cape Town Municipality - Dept of Transport - Cape Town Municipality - Dept of Social Development and Early Childhood Development - Cape Town Municipality - Dept of Community Services: City Parks, Public Space Management and Amenities	**Existing:** South African National Biodiversity Institute Working for Water Non-Governmental Organisations: - such as Open Streets, Violence Protection through Urban Upgrading (VPUU) **To be Established:** District Community Organisations	**Public-private partnerships** **Local Municipality** **Provincial Government**: - Expanded Public Works Programme: Non-state and Environment and Culture
Metropolitan and District Water Lung	**Existing:** National Water Act no. 36 of 1998 National Environmental Management Act (NEMA) 1998 Wastewater and Industrial Effluent By-law - 2013 City of Cape Town IDP 2012 - 2017: - Pillar 3: The Caring City - Pillar 5: The Well-run City	**Existing:** - National Department of Water and Sanitation - National Department of Science and Technology - Provincial Department of Public Works - City of Cape Town Municipality - Dept of Transport: Catchment, Stormwater and River Management - City of Cape Town Municipality - Utility Services: Water and Sanitation - Cape Town Municipality - Dept of Community Services: Sports and Recreation, City Parks and Amenities - Cape Town Municipality - Dept of Social Development - Cape Town Municipality - Dept of Tourism, Events and Marketing: Arts and Culture, Major Events	**Existing:** South African National Biodiversity Institute UCT Urban Water Group Non-Governmental Organisations **To be Established:** District Community Organisations Opportunity for International Partnerships and Learnerships - City of Melbourne, Australia and City of Lima, Peru	**Public-private partnerships** **Local Municipality** **Provincial Government:** - Expanded Public Works Programme: Infrastructure, Environment and Culture, and Social **National Government:** - Municipal Infrastructure Grant: Category 1: Households, Category 2: Public municipal facilities - National Department of Science and Technology: Innovation and Research Funding

Figure 5.5: A table indicating the relevant legislative action, actors and funders of the strategies proposed in the SDWF for the City of Cape Town 2055 (Author's Own)

This programme sponsors four main areas of intervention: Infrastructure, Environment and Culture, Non-state, and Social; which are applied to the relevant strategies. Finally with regard to the financing of the municipal and district system strategy, as seen in the table, it is suggested that no further funding is required as it is envisioned as within the ambit of the role of local government. Furthermore, with this strategy in place where there is improved alignment of municipal functions, it is hoped that this strategy will help reduce overlap and duplication thereby reducing unnecessary expenditure and freeing up funds to support the other strategies or service delivery in Cape Town.

With regard to national funding for these strategies, this SDWF looks to the newly introduced Municipal Infrastructure Grant which unifies all previous municipal grants available. There are three categories of grants available with the First and Second category, that is the Households and Public Municipal Facilities respectively, applicable to these strategies, as shown in Figure 5.5. Furthermore, while a system of funding has been suggested in this SDWF, this must be reviewed on an annual basis to allow for adjustments to new and increasingly creative funding schemes available for the facilitation and implementation of these strategies.

Public Participation

Although not undertaken within this study specifically, public participation is a vital component of successful implementation. As noted within the international literature reviewed in Chapter 2 and then promoted through the SDWF in Chapter 4, a central focus of Integrated Urban Water Management (IUWM) is the inclusion of multiple stakeholders in a new water management paradigm which is decentralised in both physical infrastructure and governance systems. This is important as public participation can have many benefits that include the presence of indigenous knowledge(s) and local context being incorporated into a development process; assisting with problem-solving of complex issues and identifying alternative approaches which might otherwise have not been considered (O'Faircheallaigh, 2010).

Currently in South Africa, public participation is a mandatory requirement for all large development applications that are expected to have a significant socio-economic and or environmental impact, such as is the case with the Urban Water Lung in this SDWF. However, too often this process is reduced to tokenism where a simplistic presentation of proposals occurs without allowing meaningful feedback from residents and affected parties to influence development decisions (Fuggle, 2008). This can be attributed to a lack of time allowed for this important process and the iterative nature of design development and implementation, and the lack of governance capacity within communities to effectively engage with project proposals. Therefore as suggested earlier, the DCOs are to be established as key institutions which facilitate improved processes of public participation through capacity building and knowledge sharing. By allowing the process of public participation to gain greater influence over the outcome of a project it could be possible that citizens become more involved in the development process, through design and construction, and therefore take communal ownership of the project once completed. It is these partnerships between government, citizens, NGOs and the private sector which will strengthen the institutional capacity and networks on which an increasingly flexible, connected and ecologically secure water system can be developed.

Brief for Local Area Planners

Finally, this SDWF proposes a set of design guidelines to facilitate the implementation of these principles and strategies at both the neighbourhood and project scale; where local area planners can take this study further. These guidelines are to be viewed in light of the greater systems that are at work within the municipality, region and globally. It is important that local area plans and projects are not conceived in isolation but are rather envisioned as elements of a system in which the whole is greater than the sum of the parts. These elements should therefore look beyond the project boundaries to identify the possible connections to and symbiotic relationships between other elements. With this understanding of how each project is located within the greater system it is then possible to intervene with an increasingly holistic approach.

Secondly, the group of local area planners should be an inter-disciplinary team which could include landscape architects, architects, urban designers, civil engineers, urban planners, anthropologists, artists, education specialists, and government and community representatives to name a few. Each has a specific role to play but also, within the interdisciplinary environment there is the opportunity to collaborate and expand the knowledge available beyond that existing in each sector.

Thirdly, the concepts of quantity, quality, sense of place and biodiversity are to be nested within each project whether an urban bridge, an urban water lung or a road upgrade. As far as possible, each concept should be incorporated in such a way that a single project can provide for all four simultaneously. Throughout the city water must be slowed down, allowed to infiltrate and be filtered to reduce the pollution load. This is possible through increased penetrable areas, either permeable paving or planted areas, and through allowing space for water on land, such as in roadside filters strips, bio-swales, retention ponds as seen in Figure 5.6 and 5.7. Finally, with regard to new developments near water systems, such as rivers or wetlands, every effort should be made to orientate the development in such a way as to facilitate interaction between the inhabitants, the public and that water system.

Figure 5.6: A photograph of a Bio-swale that is harvesting and filtering stormwater from the surrounding road network and car park, located in the United States of America (MHA Group, 2012).

Figure 5.7: A photograph of a Bio-swale that is harvesting and filtering stormwater from the surrounding road network and residential area, located in Umhlanga, KwaZaulu Natal, South Africa (Armitage *et al*, 2013: 39)

Conclusion

As a continuation of the SDWF for the City of Cape Town, this chapter has explored the process of implementation for the strategies of identifying metropolitan and district systems, metropolitan and district freshwater systems and corridors, metropolitan and district urban bridges, and metropolitan and district water lungs. This SDWF envisions that it is not only the outcomes of these strategies but the processes undertaken to achieve them that will enable Cape Town and her citizens to transition to an increasingly secure water future. This chapter has presented a phasing scenario for the strategies and relevant projects within the metropolitan area along with identifying the location of priority areas and pilot projects. From this it is evident that the formation of district systems and synchronising water and urban planning to these spatial boundaries is a necessary precondition to facilitating further intervention. Then, of first priority is the need to identify the metropolitan and district freshwater systems and begin the process of establishing river corridors which include riparian buffers. With this in place it would be possible to begin the implementation of the Urban Water Bridges and Urban Water Lungs. With this phasing scenario put forward, this chapter then identifies the relevant legislation, actors and funders involved in the implementation of these strategies. From this, the vital role and initiative of local government is identified to facilitate partnerships and to develop innovation through undertaking pilot projects. As this chapter continues with a discussion on the need for iterative and multi-stakeholder public participation processes that allow for knowledge sharing and input into the design process, the need for strengthened institutional capacity is identified as a precursor for improved dialogue between government, professionals and the community. This is addressed through the formation of District Community Organisations which are equipped to holistically engage with complex projects by being bound together within a single spatial context. Finally this chapter offers local area planners four broad guidelines to facilitate intervention at the neighbourhood or project scale with the precondition of locating the project as an element within a greater system.

The purpose of this chapter has been to facilitate an intentional process of strategic intervention with an understanding of the financial and institutional capacity constraints. This implementation strategy is one of many scenarios which is possible and which must remain flexible to allow for adjustments in accordance with the expected and unforeseeable changes in climate, culture and demographics. Ultimately, this strategy has put forward that the transition to an increasingly secure water future needs to start as soon as possible, as with further delay the state of the urban water system could enter into a quicker decline thereby making recovery even more difficult.

Chapter Six:

Conclusion

Introduction

Water, the Hub of Life.

Water is its mater and matrix, mother and medium.

Water is the most extraordinary substance!

Practically all its properties are anomalous,

which enabled life to use it as building material for its machinery.

Life is water dancing to the tune of solids.

- Albert Szent-Gyorgyi (*The Living State*, 1972)

Water is essential to life. Water is a component all natural and human systems, whether a pathway or resource (Wilson and Piper, 2010). Although seemingly abundant and unending, less than 1% of water on earth is freshwater available for use and enjoyment by people, plants and animals. This freshwater exists in a complex network of streams, rivers, lakes and wetlands that structures, carves and forms the Earth's landscapes through a cyclical process of replenishment. However, due to the excessive modification of land by currently parasitic human livelihood activities, the quantity and quality of freshwater is threatened with water increasingly becoming one of the most critically stressed natural systems on Earth. This is because we have rendered water unusable by wasting, polluting and diverting it. This has occurred due to the use of centralised infrastructure and sectoral management systems that enable exorbitant resource use, a linear flow of water with single use strategies, and supply-side management which focusses on providing as much water as possible. This has resulted in a separation of people and their activities from their supporting environment, locally and globally, thereby disabling them from acknowledging and noticing their negative impact on the functioning and flourishing of ecological systems. This is most dominant in urban areas where the influence of anthropogenic modification is greatest.

This is prevalent in Cape Town, South Africa and with the increasing uncertainty of water supply as a result of a warming and drying climate there is an urgent need to find alternative paradigms for water management and the interaction of people with freshwater ecologies to enable increasingly secure, life-giving and equitable water systems. Currently this has been attempted through application of Integrated Urban Water Management (IUWM) in water development policy at the municipal, provincial and national spheres of government. This paradigm aims to engage more holistically by considering all water flow as an integrated system and the voices of multiple stakeholders. However, there is a mounting critique of this paradigm in practice as there has been little successful implementation to enable a sustainable transition pathway (Biswas, 2004 and Merrey, 2008). In light of this and to locate sustainability within the context of the Global South, this study makes use of Edgar Pieterse's framework for sustainability in the Global South. In this he states that a combination of "*sustainable infrastructure, the inclusive economy and efficient spatial form, glued by processes of democratic political decision-making*" (Pieterse, 2011: 312) is necessary. Currently, IUWM addresses issues of infrastructure, the economy and governance but engages little with altering the spatial form of cities to transition to an increasingly secure urban water future. As this is largely missing in current international and local discourse, this study seeks to understand the role of spatial planning in Integrated Urban Water Management in the City of Cape Town.

Following from this, this study has sought to answer and explore the following questions,

- What are current international approaches to the integration of spatial planning and urban water management and how applicable are these to the context of the City of Cape Town?
- What spatial planning issues currently impact water management in the City of Cape Town?
- What is the current urban water cycle and capacity in the City of Cape Town and how is this expected to change in the future?
- What water uses and issues currently impact spatial planning in the City of Cape Town?
- What and where are the sources and sinks of water for the City of Cape Town and what are the current or expected spatial planning threats and opportunities to these areas?
- How can spatial planning positively intervene to enable sustainable water management practices?

This is to recognize how urban water systems can guide development in the city to enable the transition to an increasingly water-secure development pathway.

Structure of Conclusion

In this final chapter and conclusion, the findings of this study across the chapters are synthesized to understand how these various aspects relate to one another and have informed the conceptual development of this study. Secondly, the implications of this research are discussed in terms of the contribution made to theory and policy while positioning the study in response to the major theoretical and policy perspectives for the evolving paradigm of IUWM and the role of spatial planning. Following from this, a section of recommendations for future research is include to acknowledge further aspects of research which have not been covered in this study but are necessary to investigate to support the realisation of the proposed SDWF. This chapter then concludes with a discussion on the overall importance of the study which is linked to the philosophical underpinning and the hope of a way forward.

Findings of Study

This section will discuss the findings of this study across the various chapters where a literature review and contextual analysis was undertaken. This was followed by a proposed Spatial Development Water Framework to better understand current water management practices and how the use of spatial planning can improve implementation of evolving practices and reconcile people with their surrounding ecology for an increasingly water secure future in Cape Town.

In the City of Cape Town, the negative impacts of the current water system are coupled with a variety of socio-economic and biophysical conditions which aggravate the degradation of the freshwater ecosystem. This has led to the current urban water system holding a ‘Poor’ level of sustainability. As noted in the Contextual Analysis, Chapter 3 of this study, this includes a high service provision backlog especially in informal residential areas; a growing population who will increase the demand for water through unwise patterns of use and consumption; that all easily accessible surface water sources have been fully utilised with demand expected to outstrip current supply by 2019; and the mounting uncertainty of water provision from increasing temperature, decreasing precipitation and the severity of weather events, such as droughts and floods, caused by anthropogenic climate change. From a review of national, provincial and local government policy documents and strategies it is evident that there is still a focus on water as a socio-economic resource which is prioritised for consumption in human activities before the environment. This attitude seems to allow for strategies which promote short-term gains to promote fast and high socio-economic growth rates which could undermine the long term livelihood capabilities of future generations. This is concerning as while the rhetoric of sustainability permeates almost all policy little is being done to implement changes which would allow South Africa to transition to an increasingly resource-secure, equal and life-giving presence on Earth.

The key issues identified from this research that need to be addressed to enable the transition to an increasingly secure water future in the City of Cape Town are Reduced Resource Availability, Increasing livelihood vulnerability, Infrastructure capacity and functioning and the relationship between people and nature. The confluence of these within the metropolitan area of the City of Cape Town brings to the fore the need to address water provision and freshwater ecologies in such a way as to promote and enable symbiotic human-nature relationships that benefit and improve natural systems while meeting the socio-economic needs of all citizens.

To engage with this more holistically, the City of Cape Town and the Western Cape Provincial Government make use of the framework of Integrated Urban Water Management (IUWM) in the most recent water management documentation. IUWM is a further development of Integrated Water Resource Management (IWRM) which has arisen out of concern over the current environmental, and in turn socio-economic, degradation caused from current water management practices. As noted in the Literature Review, Chapter 2 of this study, both are evolving paradigms which focus on the integration of water management sectors to consider the man-made water cycle as a part of the natural water cycle, the inclusion of multiple stakeholders in decision-making processes, and demand-side management strategies that take into account the anthropogenic and environmental requirements for water. They differ in that IWRM works at the scale of a river catchment while IUWM focuses on the scale of an urban area. Through this study of IUWM and the growing critique, two key concerns have been identified. This includes the lack of implementation, especially in the Global South, due to the definition being too vague with its origins focused in the social and governance discourse and context of the Global North, and that the ambiguity of the proposed integration has led to institutional paralysis (Biswas, 2004 and Merrey, 2008).

This study therefore proposes the use of spatial planning as a tool within the IUWM paradigm to enable strategic, integrative interventions along with improved implementation of water sensitive development in Cape Town. Spatial Planning is a tool used for long term planning that brings together a variety of policy decisions from diverse sectors to resolve spatial and temporal conflicts through the spatial co-ordination and alignment of strategies and actions. It is therefore uniquely positioned to aid the implementation of IUWM as the use and development of land has both direct and indirect consequences on the quality and quantity of water in freshwater ecosystems. This is based on the premise that (Baker Associates, 2005: 20 *in* Carter, 2007: 332),

> *"there is wide recognition that the water environment is increasingly challenged by the effects of development, and since the management of development is the role of the land use planning system, it is important that sufficient connection is made between the water environment and the planning system".*

In both water management and planning literature there is an increasing recognition of the relationship between land and freshwater ecologies which has led to the call for improved and pro-active co-ordination between urban management sectors and the consideration of water in cities. This is rising from environmentally and socio-economically diverse contexts globally, such as Australia, England, the Netherlands, Israel, and now in South Africa too. Overall, these approaches which are developing to integrate spatial planning and water management in urban areas call for change in how services are delivered, both environmentally and economically, and how people are enabled to engage and participated through socio-political transition.

Using the literature review and the contextual analysis as a platform from which to guide intervention, this study puts forward a Spatial Development Water Framework for the City of Cape Town 2055. In this, the principles of reverence, responsibility, restoration and restraint are considered a nested system where an environment of cultivating reverence is a necessary precondition for establishing the presence of the other principles in the City thereby promoting social and ecological health, connected communities and shared prosperity. To transition towards this, four metropolitan-wide strategies are suggested to acknowledge the presence and priority of freshwater ecosystems by allowing them to become spatial structuring elements the City and affording the opportunity for daily interaction with these systems. Firstly this has involved identifying the spatial distinction between the metropolitan and district systems followed by acknowledging the hierarchy of the rivers and wetlands in the hydrological system and the necessary green corridors to improve ecological connection and functioning. From this developed the concept of urban bridges as public places of interaction and rest with freshwater systems and water lungs as the mechanisms for harvesting and reusing water thereby promoting local subsistence. These strategies are then placed within a phasing framework for optimised and strategic intervention. While these strategies aim to address a reduction in the physical consumption of water and prevent the pollution of water bodies, they also aim to alter the course of urban development through facilitating transition in the hydro-social contract of communities in Cape Town. This relates to the call in the literature for socio-political change along with the environmentally-based evolution of urban systems.

Implications of Research

This study has sought to engage with current and evolving practices of urban water management, consumption and discharge both theoretically and creatively through rigorous academic research and a conceptual design development process. The interplay of these two allows for a more holistic response to the issues facing the current urban water context in Cape Town. It is hoped that the contribution of this study can be an improvement in the water literacy of spatial planning processes and outputs, such as Spatial Development Frameworks, in the City of Cape Town through understanding all urban water existing in a single system, showing how freshwater systems should be honoured as spatial structuring devices in urban areas, by acknowledging that the way freshwater systems and our relationship with them are spoken about has an impact on how we interact with them, and with the recognition of the need for intervention at the metropolitan scale as well as the regional and building scale.

Firstly, through the contextual analysis undertaken, this study has contributed to the knowledge of the urban water system in the City of Cape Town. This is because water supply, water use, wastewater treatment and stormwater have been considered as a single system where usually these are addressed individually within their relevant sectors. This is represented through the presentation of the Material Flow Analysis Diagram. This is especially significant as a holistic diagram such as this has not yet been produced by any sphere of government or other public water interest groups. There is however a growing interest of understanding a systems approach to resource consumption at the metropolitan scale as represented in the work of Green Cape, a Sector Development Agency established by the Western Cape Provincial Government and The City of Cape Town, and the Urban Water Group based at the University of Cape Town. This is a valuable tool as it visualises the system in its entirety and allows for a quantitative understanding of where tangible opportunities for reuse and reduction in use are.

As acknowledged by Wilson and Piper (2010), further research is required in understanding how spatial planning and water management can be integrated and co-ordinated to promote positive interventions in urban environments which enable the development of sustainable livelihoods. Therefore this study has sought to add to this evolving knowledge within the spheres of planning and urban water management through applying current transition frameworks to the context of the City of Cape Town. There are both theoretical and policy implications of this study. Firstly, in South Africa the dominant literature and studies on water security and reducing water use focuses on the scale of the building and the neighbourhood or at the regional scale. While this is important, this study focuses on how the spatial form of urban areas affects water security at the metropolitan scale. Therefore, this study presents the opportunities available at the scale of an urban area in its entirety to promote the co-ordination and balance of strategies. This is not present at other spatial scales as the interventions are often either too piece-meal or too large to alter the relationship between people and their water environments.

Secondly, the language used in this study, especially within the suggested intervention of the SDWF, has been specifically chosen as a new set of terms to frame the relationship between people, their activities and the environment. The language used refers to people being part of rather than separate to their environment; being moulded by context rather than being disengaged consumers; viewing natural systems as that which is to be cherished and honoured rather than simply being a tool for human growth; being participants rather than customers. This style of language moves away from the current dominant discourse in government policy and contributes to the need for a transition in urban development which reconnects people and the consequences their activities to the local and global environment. This is with the aim of promoting behavioural change in all citizens to conserve resources, to consider the needs of the most vulnerable and future generations in urban areas, and to care for the ecological functioning on which our survival depends.

Finally, with the presentation of the SDWF for Cape Town of this study, there is the opportunity to re-imagine the city; one which acknowledges the significance of freshwater ecologies not only in how we manage urban water systems but in how the City is shaped too. This is because, as people, how we manipulate our environments through our activities, either deliberately or unintentionally, is evidence of what we care about most and how we relate to the systems around us. There is therefore an opportunity to make more of our water resources through developing water tour guides for citizens and tourists in Cape Town and by including the histories and stories of these freshwater ecologies as a part of those often told in our social history.

Recommendations for Future Research

This study presents a literature review, contextual analysis and an SDWF to address the primary and secondary research questions. However, this study has been undertaken by a single author within the limited time period of five months, there are further aspects which have not been covered nor considered which are necessary to investigate to support the realisation of the proposed SDWF to address the critical state of urban water systems in the City of Cape Town.

Firstly, this includes the scope of stakeholder involvement in the research and design development process. It would be beneficial to engage and explore both the research and design outcomes of this study together with professionals of other spheres of knowledge such as civil engineers, landscape architects, hydrologists, freshwater ecologists, and anthropologists to gain a broader and hopefully more realistic understanding of the strategies presented. Furthermore, a study such as this would benefit from public participation in both the research and design processes where there could be the opportunity for co-production of space and the development of strategies for water security and honouring natural systems in the City.

Secondly, further research is necessary in the provision and representation of sufficient and relevant data. For suitable intervention and to allow for an adequate monitoring process, there needs to be enough data that is up-to-date and accessible to the public and to the professionals responsible for the various projects. The data necessary includes water quantity and quality in rivers, wetlands and the non-potable water being generated, the overall state of freshwater ecologies, the state of the riparian buffers in river corridors, and the types and quantities of mammals, fish and birds present, to name a few. Further suggestions for the type of data needed could be determined through discussion with relevant professionals, government officials, and citizens. This could even go as far as developing a system of real-time data capturing points across the city that can be tracked and accessed via the internet accompanied by bi-annually or quarterly monitoring reports. This could also offer the opportunity for citizens to upload their relevant information to be share with government officials, businesses, community-based organisations and other citizens. This would allow for a faster response time and the opportunity to be proactive and flexible in the relevant management responses.

Finally, a third area of investigation is to develop educational programmes for children and adults to improve water literacy across the city and to understand the systems being put in place through the strategies suggested in the SDWF. This could be done in association with schools, tertiary institutions, educators, anthropologists and ecologists. These educational programmes should begin prior to public participation process and continue alongside the design development and construction phases. This could involve public events, educational competitions, courses, seminars, and posters in outdoor and indoor public spaces and public transport interchanges. The programmes should also offer the opportunity to learn from interacting with freshwater ecosystems and from participating in the ongoing maintenance requirements of each project. With the success of these programmes, there is the prospect of increasing knowledge and community-based institutional capacity as the information and familiarity necessary to intervene no longer only dwells with elite professionals but with every citizen. This could help shift the power balance and the responsibility from a minority to the majority thereby hopefully improving the resilience of the improving urban water system.

Conclusion

Water is essential to life. Without access to a sufficient quantity and quality of water, people, plants and animals would cease to exist. Yet, even with this reality, the ways in which people source, use and discharge water and waste continue to harm and compromise this precious and life-giving natural system which, as a part of the greater ecological earth system; is the precondition for human life and livelihoods. This situation is only worsened in the face of anthropogenic climate change which, in Cape Town, will lead to drier and warmer conditions with less precipitation. This however does not have to be the future that we leave to the next generation. Currently, we are at a precipice where the opportunity to change our behaviour and systems could not only allow us to adapt but also to mitigate these consequences too.

While currently there is a positive transition underway in the theoretical approaches towards improving the integration and co-ordination between spatial planning and water management, there is little physical change manifest in urban areas. It is for this reason that this study has sought to address and investigate the role of spatial planning in Integrated Urban Water Management in the City of Cape Town. Spatial Planning is uniquely positioned as a tool which has the ability to engage with multiple sectors and co-ordinate the implementation of their policies to deal with the increasing complexity and conflict of intervening in urban environments. This study has shown that through a spatial restructuring according to the freshwater ecologies of Cape Town, there lies the opportunity to not only promote local subsistence and a cyclical use of resource but also to reconcile the human-nature relationship. This is the foundation of the change that will power the City of Cape Town's transition to an increasingly water secure, equal and life-giving future.

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Appendix

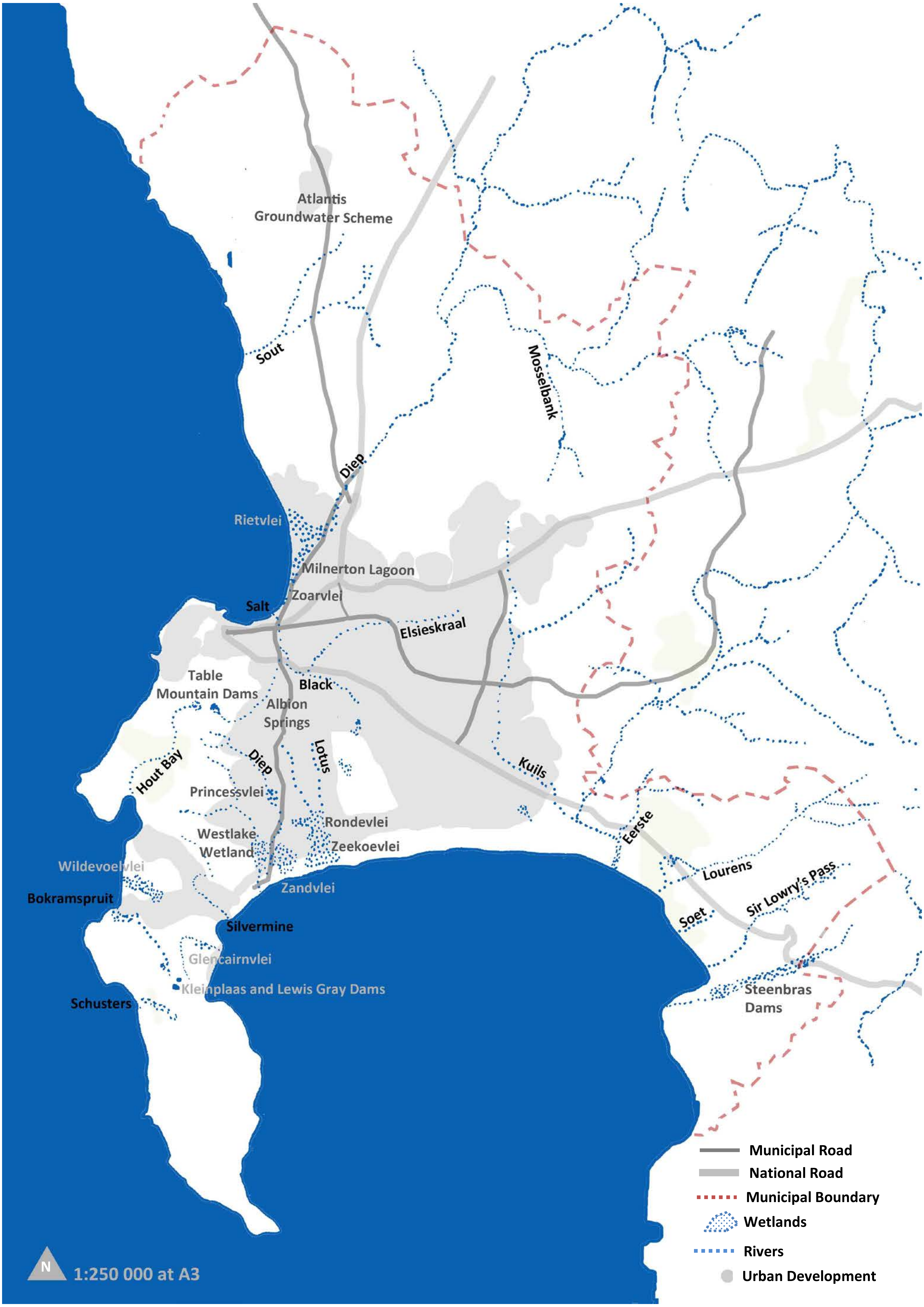
Sphere of Government	National Government			
Policy, Strategy or Plan	The Constitution	National Development Plan - 2030	National Spatial Development Perspective	Medium-term Strategic Framework 2014 – 2019: Outcome 10
Year	1996	2012	2006	2014
Vision	*A united, prosperous, non-racial and non-sexist society; a country that belongs to all who live in it, united in its diversity* (NPC, 2012:35).	*by 2030, South Africa's transition to an environmentally sustainable, climate-change resilient, low-carbon economy and just society will be well under way.*	*To fundamentally reconfigure apartheid spatial relations and to implement spatial priorities that meet the constitutional imperative of providing basic services to all and alleviating poverty and inequality* . (NPC, 2006: ii)	*by 2030, South Africa's transition to an environmentally sustainable, climate-change resilient, low-carbon economy and just society will be well under way.*
Aim	*The Republic of South Africa is one, sovereign, democratic state founded on the following values of human dignity, the achievement of equality and the advancement of human rights and freedoms* (RSA, 1996: 2)	To eliminate poverty and reduce inequality by 2030.	*To provide a framework for deliberating the future development of the national space economy and recommends mechanisms to bring about optimum alignment between infrastructure investment and development programmes within localities* (NPC, 2006: i)	Focuses on the creation of a framework for implementing the vision of the NDP. This first phase will include unblocking regulatory constraints, data collection and establishment of baseline information, and indicators testing some of the concepts and ideas to determine if these can be scaled up (MTSF, 2014: 1)
Key Principles	**Dignity, Equality and Freedom**	1) Just, ethical and sustainable practice 2) Strategic and transformative planning 3) Effective participation of social partners 4) Sound policy-making 5) Least regret 6) Accountability and transparency	1) Rapid economic growth that is sustained and inclusive 2) Provision of basic services to all citizens in all areas of SOuth Africa 3) Government spending on fixed investment should be focused on localities of economic growth and/or economic potential 4) Efforts to address past and current social inequalities should focus on people, not places 5) Focus socio-economic development in activity corridors or nodes that link to main centres for spatial redress (NPC, 2006)	1) Ecosystems are sustained and natural resource are used efficiently 2) Effective climate change mitigation and adaptation response 3) An environmentally sustainable, low-carbon economy resulting from a well-managed just transition 4) Enhanced governance systems and capacity 5) Sustainable human communities
Water/ Environment	**Environment:** Section 24 holds the right to the environment which states that, every citizen has the right to an environment that is "not harmful to his or her health or well-being, and commits the country to conservation and sustainable management and use of our natural resources" (WCPG, 2012: 36) **Water:** Puts forward the right of access to sufficient water along with food, health care and social security which must be progressively realised through reasonable measures taken by the state (RSA, 1996 S27 (1)(b) and (2)). This enshrines the principles of the sustainable development agenda and envisions the environment through an anthropocentric lens by asserting the importance of socio-economic consequences of environmental degradation. This identifies the government as having the role of a developmental state which is pivotal in the provision of services and access to resources.	*Developmental challenges must be addressed in a manner that ensures environmental sustainability and builds resilience to the effects of climate change, particularly in poorer communities* (NPC, 2012: 197) Access to clean water and decent sanitation, along with other resources and services, is vital to climate change resilience and reduced socio-economic vulnerability. The maintenance of ecosystem services and long term planning is promoted to ensure future sustainable resource provision to achieve socio-economic development objectives. Role of National Water Department is for bulk water provision while for local government it is for recylcing and demand -side management.	Water is referenced specifically in two chapters: **Infrastructure and Space** and **Environment and Space.** Maps provided show the analysis which indicate the national levels of access to water and priority service areas with corresponding govenrment investment levels. Cape Town is a municipality which receives high levels of investment in comparison to other more rural municipalities. Cape Town has a high percentage of agricultural land, along with a high percentage of priority biodiversity areas compared to the rest of the country which is accompanied by a relatively low water balance. Water is seen as an vital resource for socio-economic development.	**Outcome 10: Protect and Enhance our Environmental Assets and Natural Resources** This document puts forward an implementation strategy with quantitative targets to be reached for water conservation and demand management, protection of water resources, wetland rehabilitation, maintenance and improvement of water-shed services in rural strategic water source areas. Most of which do not yet have a baseline starting point. There is also the aim of integrating ecological considerations into land use planning through all Spatial Developemnt Frameworks by 2019 supported by standard minimum environmental requirements.
Spatial Interpretation	No	No	Yes, only analysis not suggested strategies	No

Sphere of Government	**National Government**			
Policy, Strategy or Plan	National Environmental Management Act	the National Water Act	National Water Resources Strategy 2	the National Strategy for Sustainable Development (NSSD1)
Year	1998	1998	2013	2011
Vision	*To secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development to reduce inequality*	*Some, for all, forever*	*Sustainable, equitable and secure water for a better life and environment for all*	South Africa aspires to be a sustainable, economically prosperous and self-reliant nation that safeguards its democracy by meeting the fundamental human needs of its people, by managing its limited ecological resources responsibly for current and future generations, and by advancing efficient and effective integrated planning and governance through national, regional and global collaboration (NSFD, 2008).
Aim	Gives effect ot Constitutional right to healthy living and working environment	To ensure that South Africa's water resources are protected, developed, controlled, conserved, managed and used in a sustainable and equitable manner, for the benefit of all (DWAF, n.d.)	To provide a framework for the protection, use, development, conservation, management and control of water resources for the country as a whole and to identify water-related development opportunities and constraints (DWAF, n.d.).	This document provides the National Strategy for Sustainable Development and an Action Plan to support the implementation of the NFSD. It therefore provides a high-level roadmap for strategic sustainable development.
Key Principles	1) the polluter pays 2) Precautionary principle 3) environmental justice and integrated environmental management 4) community participation, empowerment and environmental education	**Sustainability, equity and efficiency** and secondary principles include participation and integration	1) water supports development and the elimination of poverty and inequality 2) water contributes to the economy and job creation, and 3) water is protected, used, developed, conserved, managed and controlled sustainably and equitably.	Fundamental Principles: 1) Human dignity and social equity 2) Justice and fairness 3) Democratic governance 4) A healthy and safe environment Substantive principles: 1) Natural resources must be used sustainably. 2) Socioeconomic systems are embedded in and are dependent on ecosystems 3) Basic human needs must be met Process Principles: 1) Integration and innovation 2) Consultation and participation 3) Implementation in a phased manner
Water/ Environment	*NEMA is an overarching Act that provides a framework for environmental principles and policies and their implementation* (Pithey *et al*, 2007) This law and its requirement for sustainability is relevant to all sectors of government and service provision. Section 24 of NEMA stipulates that an Environmental IMpact Assessment (EIA) is required for activities which could have a significant impact on the environment (NEMA, 1998).	The NWA promotes water use that is in the public interest and beneficial for the achievement of equitable and sustainable economic and social development. *It provides for increased legal protection of water sources and all water users, and requires that all phases of the hydrological cycle be considered and managed.* (Pithey *etal*, 2007). The act calls for the establishment of Catchment Management Agents in each major watershed in South Africa with an Ecological Reserve and Basic Human Needs Reserve legislated for each.	The NWA is implemented through the NWRS, which provides a framework within which water resources are to be managed throughout the country. The NWRS addresses Sustainability, equity and efficiency through stating that water needs to be managed in an integrated way with relation to the hydrological cycle. *Because all water resources are linked to each and are affected by the biophysical environment and human activities, water resources must be managed taking into account the **relationships** between water, the biophysical environment, social, economic and political factors. This requires integrated management and the implementation of catchment management strategies in each water mangement area* (DWAF, n.d.) *The concepts, approaches and themes spelt out in this Strategy are in line with international principles and approaches (World Water Forum and Rio+20 Summit) where social and economic goals are aligned, sector investment is increased and water is recognized as fulfilling a central role in socio-economic planning and development* (DWA, 2013).	*The NSSD1 builds on the National Framework on Sustainable Development that was adopted in 2008. The Action Plan sets out strategic goals and interventions required for implementation. One of the goals of the NSSD1 is to "develop and promote new social and economic goals based on ecological sustainability and build a culture that recognises that socio-economic systems are dependent on and embedded within ecosystems", and linked to this is a key objective that relates to sustainable water management, "sustaining our ecosystems and using natural resources efficiently"* (WCPG, 2012: 36)
Spatial Interpretation	No	No	Yes, new CMAs identified	No

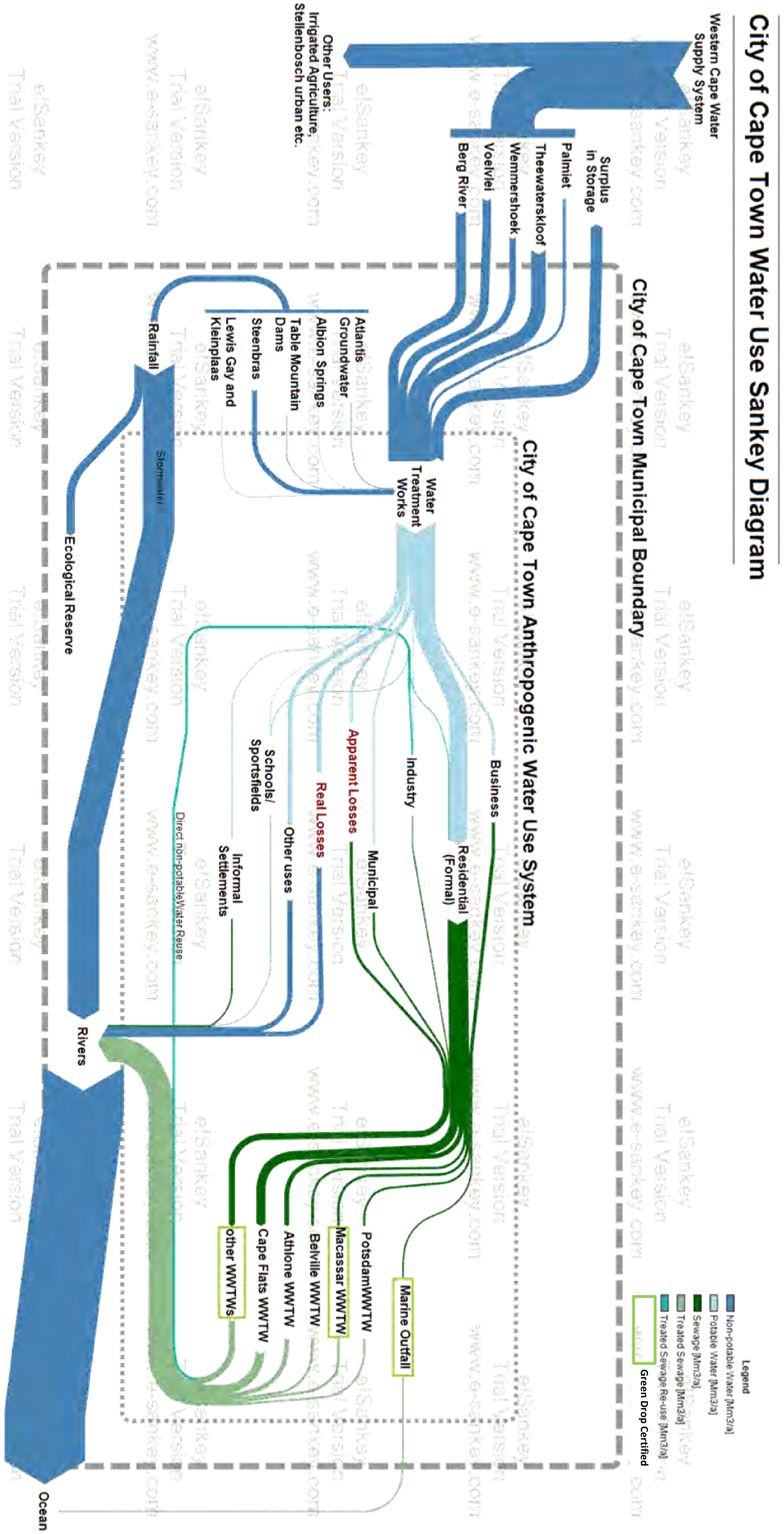
Sphere of Government	Provincial			
Policy, Strategy or Plan	Western Cape Government: Provincial Strategic Objectives (PSO)	Western Cape Infrastructure Framework	Western Cape Water Supply System Reconciliation Strategy	Western Cape Climate Change Response Strategy and Action Plan
Year	2010	2013	2007	2008
Vision	*Open opportunity society for all*	a new approach to infrastructure is needed: one that satisfies current needs and backlogs, maintains the existing infrastructure, and plans proactively for a desired future outcome (WCPG, 2013: 4).	Achieving reconciliation of water supply and requirement for the DWAF, CCT, local authorities and urban and agricultural water users in a water-scarce area (WCPG, 2007: 1)	The government of the Western Cape aims to strengthen the province's resilience to climate change and its adaptive capacity in terms of the provincial economy and in vulnerable communities. It further aims to maintain the Western Cape's status as a low greenhouse gas emitter by reducing the province's carbon footprint (WCPG, 2008: 30).
Aim	Our task is therefore to translate the political philosophy that underpins our vision into an actionable policy agenda designed to achieve quantifiable outcomes (WCPG, 2010: vi)	A framework to align existing planning processes and outline strategic decisions and trade-offs that need to be made to achieve the provincial 2040 vision in a complex and changing environment (WCPG, 2013)	To ensure reconciliation of future water requirement with the supply from the Western Cape Water Supply System (WCWSS) (WCPG, 2007: i).	The aim of this document is to identify the likely changes in climate and to assess the current situation of various vulnerable sectors in the Western Cape (WCPG, 2008: 31).
Key Principles	1) Innovation 2) Citizen-centric philosophy 3) A whole-of-society, inclusive approach 4) Transparency and accountability 5) Fiscal responsibility	Water Principles: 1) Stringent water conservation and demand-management 2) Include alternative and viable water sources 3) Adopt reuse of wastewater more widely	Sustainability, Reservation and Preservation	1) Government leads by example 2) An integrated, consistent long-term approach 3) Assistance to the province's community and industry (WCPG, 2008: 32)
Water/ Environment	*12 PSOs were adopted in order to stimulate growth-led development in the Western Cape. This included PSO7: "Mainstreaming Sustainability and Optimising Resource-use Efficiency" which sets targets on sustainable resource management that includes increasing water saving measures (i.e. WC/WDM) and improving water quality from catchment to coast. Moreover, PSO11: "Increasing Opportunities for Growth and Development in Rural Areas" has five work groups that focus on agricultural production, market access, research and technology, rural development and extension revitalisation. Water forms an integral component of these work groups*. (WCPG, 2012:37) This document puts forward targets for each of the priority areas identified. For water this includes a improvement in water efficiency and water use reduction with the implementation of a provincial integrated water resources management plan.	The Framework recognises that "the Western Cape has limited water resources options for future growth. To address this, increased water conservation and demand management are urgent and necessary, but alternative sources of water will also need to be found. The sanitation infrastructure priority is to rehabilitate and upgrade infrastructure assets. However, there is a chronic shortage of capital for water and sanitation projects" (WCPG, 2013: 3) The spatial location of areas where infrastructure is reaching, or has reached, capacity must directly inform, align and correspond to future infrastructure development plans (WCPG, 2013: 9) This document acknowledges that water is a major constraint to increased agricultural production and socio-economic development.	The on-going Western Cape Water Supply System Reconciliation Strategy is a strategic assessment of water reuse potential to augment the Western Cape water supply system, including WWTWs in the CoCT. Effluent volumes and the potential for implementing water re-use at scale were included (WCPG, 2013: 37)	It identifies water as a significant risk factor when considering climate change impacts, risk and vulnerability. Establishing a cohesive water supply and infrastructure management programme that integrates climate risks is a cornerstone of the strategy and action plan. In terms of water, it prioritises that "An integrated water supply and infrastructure management programme that integrates climate impacts and risks" is needed, which includes researching the cost benefit of irrigation, increasing water efficiency including through pricing strategies, establishing uninterrupted water conservancy targets, systems maintenance and repairs and establishing the ecological Reserve (WCPG, 2012: 37).
Spatial Interpretation	No	Yes	Yes	No

Sphere of Government	Provincial		
Policy, Strategy or Plan	Sustainable Water Management Plan - 'The Water Plan'	Land Use Planning Act	Provincial Spatial Development Framework
Year	2012	2014	2012
Vision	*Sustainable water management for growth and development in the Western Cape, without compromising ecological integrity* (WCPG, 2012: xi)		The PSDF vision is comprised of socially just communities and settlements in the Western Cape.
Aim	GOAL 1: Ensure effective co-operative governance and institutional planning for sustainable water management. GOAL 2: Ensure the sustainability of water resources for growth and development. GOAL 3: Ensure the integrity and sustainability of socio-ecological systems. GOAL 4: Ensure effective and appropriate information management, reporting and awareness-raising of sustainable water management.	To consolidate legislation in the Province pertaining to provincial planning, regional planning and development, urban and rural development, regulation, support and monitoring of municipal planning and regulation	Helps to prioritise and align investment and infrastructure plans of other provincial departments, as well as national departments' and parastatals' plans and programmes in the Province
Key Principles	1) Integration and Innovation; 2) Consultation and Participation; and 3) Phased Development and Implementation. - same 3 Process Principles as NSSD1	Spatial Justice and Resilience Principles: 1) Redress of imbalance through improved access to and utilisation of land 2) the inclusion of persons and areas that were previously excluded, with an emphasis on informal settlements 3) Flexibility and appropriateness through incremental development 4) Land development that is spatially compact and resource-frugal 5) The promotion of Mixed-use development	1) Ecological integrity (health of the Planet) 2) Social equity (situation of the People) 3) Economic efficiency (attainment of Prosperity)
Water/ Environment	After summaring the Western Cape Status Quo Assessment this document looks to implement actions to achieve the 4 goals through 12 themes identified, which are currently concerns and gaps with reccomendations. The water plan is therefore a list of strategies laid out in an implemetation plan with identified targets, timeframes and responsibilities. The highest priority actions include: establishing the CMAs, capacity building and learnerships, **developing an integrated environmental authorisation application to integrate land use and water management.**	There are two provisions in this act for the consideration of water in waters of planning, firstly in Section 3 (5)(h) "The Provincial Minister must monitor provincial land use planning and the **impact of water** and energy resources on provincial land use planning" and Section 59 (2)(b)(iii) states that "Land use planning is guided by principles of **spatial sustainability** in which the sustained protection of the environment should be ensured by having regard to areas unsuitable for development, including flood plains, steep slopes, wetlands and areas with a high water table".	The PSDF is an integrated Provincial wide framework, which has changed our historical development trajectory of urban sprawl, environmental recklessness and inequality, to a path of sustainability and integrated human settlements It therefore provides directives and guidelines to help decision-makers in the land use planning and environmental field to consider whether or not proposed development would be economically, socially and ecologically sustainable. Objective 1: Align the future settlement pattern of the Province with areas of economic potential and the location of environmental resources. Objective 2: Deliver human development programs and basic needs programs wherever they are required. Objective 3: Strategically invest scarce public resources where they will generate the highest socio-economic returns. Objective 9: Minimise consumption of scarce environemtnal resources
Spatial Interpretation	No	No	Yes

Sphere of Government	Municipal			
Policy, Strategy or Plan	City of Cape Town Integrated Development Plan	City of Cape Town Water Services Development Plan	City of Cape Town Integrated Metropolitan Environmental Policy	City of Cape Town Spatial Development Framework
Year	2013/2014	2012/2013	2008	2012
Vision	The City of Cape Town pursues a multi-pronged vision to: 1) be a prosperous city that creates an enabling and inclusive environment for shared economic growth and development; 2) achieve effective and equitable service delivery; and 3) serve the citizens of Cape Town as a well-governed and effectively run administration (CoCT, 2013: 2).	*To be a beacon in Africa for the provision of Water and Sanitation services*	In twenty year's time: - The environmental quality will have improved in terms of air, water, land and sea. - Environmental poverty will no longer exist and all communities will live in an environment that is not detrimental to their health or well-being. - Water and energy resources and utilisation will be optimally and efficiently managed.	By 2040, turn Cape Town into one of the world's greatest cities in which to live and learn, work, invest and discover – a place of possibility and innovation, with a diverse urban community and all the opportunities and amenities of city life, within a natural environment that supports economic vibrancy and inspires a sense of belonging in all.
Aim	The City of Cape Town's Five-year Integrated Development Plan (IDP) represents the overarching strategic framework through which the City aims to realise its vision for Cape Town by building on the five pillars of a caring city, an opportunity city, an inclusive city, a safe city, and a well-run city (CoCT, 2013: 1).	To acknowledge the progress made so far by the municipal Water and Sanitation Department and to identify the critical challenges remaining.	The general policy principles will give guidance and act as a framework for environmental governance. Detailed sectoral strategies will be developed in such a way that plans, actions, targets, indicators and programmes will be implemented to address particular environmental issues. Implementation of IMEP and the sectoral strategies will occur through, with and by the sectors and line functions of the City of Cape Town in an integrated approach.	This document provides a long-term vision of the desired spatial form and structure of Cape Town; and aligns the City's spatial development goals, strategies and policies with relevant national and provincial spatial principles, strategies and policies.
Key Principles	Quality, Equity, Security, Sustainability and Integrity	Integrity, respect, customer focus, trust, transparency and professional	1. open, transparent and effective environmental governance 2. minimising the impact of its activities on the global environment 3. holistic approach 4. maximise the benefit to all 5. responsible stewardship of the resources	1. The public good should prevail over private interests 2. Work harmoniously with nature 3. Equity and equality 4. Urban efficiency
Water/ Environment	"CoCT's IDP identifies development priorities and forms the basis for operational plans and allocation of resources" (Pithey *et al,* 2007: 19). 'Strategy Focus Area 1: The Opportunity City': Focus on taking care of the environment and how we use and manage our resources to ensure that there is enough water and energy to go around to build a robust and resilient city. 'Strategy Focus Area 3: The Caring City': The city intends to continue investment in water quality control and management along with other primary services through infrastructure-led growth - focus on bulk water resources and capacity upgrades at WWTWs. The document also acknowledges the effect of climate change on the city with increased water scarcity. This document acts as an integrator of all sector plans for the city.	An American Water Works Association Framework has been adopted to be used as a balanced scorecard for the effectiveness and efficiency of water services in CoCT. 10 Attributes: Product Quality, Customer Satisfaction, Employee and Leadership Development, Operational Optimisation, Financial Viability, Infrastructure Stability, Operational Resilience, Community Sustainability, Water Resource Adequacy, Stakeholder Management. The challenges identified include: Financial viability, Customer satisfaction, Water Resource Academy, Employee development (internal), Operational Optimisation, Product quality, Operational Resilience. This is accompanied by a set of strategic objectives with target dates to be achieved. Particular reference to reducing the backlog in informal settlements and backyard dwellings	Sectoral Plan Approach: Water Respurces - A commitment to ensuring that the quality of coastal, marine and inland waters of the City of Cape Town is suitable for the maintenance of biodiversity, the protection of human health and a commitment to the principle that all CCT inhabitants have the right to clean, potable and adequate water sources.	5.2 Key strategy 2: **Manage urban growth, and create a balance between urban development and environmental protection** - 5.2.5 Appropriately manage urban development impacts on natural resources and critical biodiversity networks: = P26: Reduce the impact of urban development on river systems, wetlands, aquifers, aquifer recharge areas and discharge areas. This is implemented at district level in DSDPs and through the incorporation of WSUD principles in all land use decisisons so htat land use does not negatively affect high productivity aquifers and freshwater ecosystems
Spatial Interpretation	No	No	No	Yes



Atlantis
Groundwater Scheme
Sout
Mosselbank
Diep
Rietvlei
Milnerton Lagoon
Zoarvlei
Salt
Elsieskraal
Table
Mountain Dams
Black
Albion
Springs
Hout Bay
Diep
Lotus
Kuils
Princessvlei
Rondevlei
Westlake
Wetland
Zeekoevlei
Eerste
Wildevoelvlei
Zandvlei
Lourens
Bokramspruit
Sir Lowry's Pass
Soet
Silvermine
Glencairnvlei
Kleinplaas and Lewis Gray Dams
Steenbras
Dams
Schusters
Municipal Road
National Road
Municipal Boundary
Wetlands
Rivers
Urban Development
N
1:250 000 at A3


City of Cape Town Water Use Sankey Diagram
Western Cape Water Supply System
Other Users: Irrigated Agriculture, Stellenbosch urban etc.
Surplus in Storage
Palmiet
Theewaterskloof
Wemmershoek
Voelvlei
Berg River
City of Cape Town Municipal Boundary
City of Cape Town Anthropogenic Water Use System
Atlantis Groundwater
Albion Springs
Table Mountain Dams
Steenbras
Lewis Gay and Kleinplaas
Rainfall
Stormwater
Ecological Reserve
Water Treatment Works
Business
Residential (Formal)
Industry
Municipal
Apparent Losses
Real Losses
Other uses
Schools/ Sportsfields
Informal Settlements
Direct non-potable Water Reuse
Rivers
Ocean
Marine Outfall
Potsdam WWTW
Macassar WWTW
Belville WWTW
Athlone WWTW
Cape Flats WWTW
other WWTWs
Legend
Non-potable Water [Mm3/a]
Potable Water [Mm3/a]
Sewage [Mm3/a]
Treated Sewage [Mm3/a]
Treated Sewage Re-use [Mm3/a]
Green Drop Certified

Component	Sustainability Criteria	Indicator	Current Practice	30 Year vision -Desired Practice	Level of Sustainability
Social	Access to water supply	percentage of households with access to water supply	99% of households serviced - 100% of formal dwellings and 92% of informal dwellings	100% of households serviced	Good
		access ratio in Informal Settlements	1 tap to 27 people	1 tap to 4 - 6 people	Poor
		current service backlog in informal settlements	Total Backlog: 14 551 households	No backlog	Fair
	Access or use of sanitation facilities	percentage of households with access to sanitation	93% of households serviced - 100% of formal dwellings and 59% of informal dwelling	100% of households serviced	Fair
		access ratio in Informal Settlements	1 toilet to 5.76 people	1 toilet to 4 people	Poor
		current service backlog in informal settlements	Total Backlog: 80 364 households	No backlog	Fair
	Levels of service	Percentage of households with full service level provision	**Water:** 87% piped water inside dwelling or in yard **Sanitation:** 88% of households have access to a flush toilet connected to the public sewer system. **Waste:** 94% of Households have weekly refuse removal	100% of households serviced to full service level for water, sanitation and waste	Good
		Percentage of Houesholds with basic level of service provsion	13% of households only have emergency or basic level of service provision for water and sanitation - all in informal settlements	0%	Fair
	Vulnerability to disaster	percentage of households below poverty line	35.7% of households	0%	Poor
		unemployment rate	23.8% of economically active population	10%	Fair
		percentage of households in flood prone areas	approx. 7% of households	0%	Fair
	health (morbidity and mortality)	average life expectancy	67.1 years	80	Good
		Human Development Index	0.74	0.85	Good
	Education/awareness	Levels of satisfication with service	Residents rate water provsion, sewerage and sanitation, and stormwater performance of the City at **3.3 out of 5** which is 'good' (average) - increase in satisfaction in formal areas with decease in satisfaction in infomral areas	Rating - 4.8 out of 5 (almost excellent)	Fair

Economic	Capacity to pay/access services	Number of indigent households (formal and informal)	432 385 households, that is 39.2% of households	15% of households	Fair
		percentage of Households earning less than R3200	31%	5%	Poor
	Cost recovery	% basic water provision	11.42% of total water consumption	20% of total water consumption	Fair
		% unbilled authorised consumption	4.7% of total water consumption	2% of total water consumption	Fair
		% water losses - leaks	11.44% of total water consumption	5% of total water consumption	Fair
		% water losses -unauthorised consumption/inaccurate meters	7% of total water consumption	0% of total water consumption	Fair
		total percentage of non-revenue water	**23.2% of total water consumption**	7% of total water consumption	Poor
	Investment levels	number of bursts to water mains per annum	6645	1000	Poor
		Investment backlog	more funding is still required to reduce infrastructure backlogs, the demand for which continues to outstrip the City's supply resources	Sufficent funding to cover operational, maintenance and new infrasatructure costs	Fair
Environmental	Freshwater resources	Diversity of resources	98.5% from surface water (WCWSS), 1.5% from Atlantis Aquifer System	reduced surface water reliance	Poor
		Location of Water Supply Resources	85% located outside the municipal boundaries	100% reliance on sources located inside municipal boundary in winter 60% reliance on sources located inside municipal boundary in summer	Poor
		year by which demand will outstrip supply	2019	demand adjusts to not outrip supply	Fair
	Sustainability of water source	Ecological Reserve	67Mm3/a	might increase due to climate change - therefore must be revised regularly	Good
		Ecological Reserve Enforcement	No	Yes	Poor
		resilience to impacts of climate change	Warmer and drier climate: Increased evaporation, salinity ingress and storm occurrence with decreased overall precipiation - increasing uncertainty	Increased resilience to floods and droughts to improve security	Poor

Environmental	Use (resource distribution per sector)	Total annual water use and trend	310 Mm3/a, increasing slightly with population increase	Water use decoupled from population growth - 250Mm3/a	Fair
		Total daily per capita water use and trend	215 litres per capita per day, decreasing	150 litres per capita per day	Fair
		Quality of supply related to use	Potable water used for 95% of water demand	Potable water only used for drinking, washing and food prep.	Poor
	Waste water management	% of water treated in wastewater system	60%	85%	Fair
		Compliance of WWTW to DWAS Standards - Green Drop	9/24 WWTW achieved Green Drop Status	100% WWTW achieved Green Drop Status	Poor
		Nutrient Load Compliance of Rivers and vleis with DWAS standards	7/14 Rivers and 7/13 vleis have a high nutrient load leading to hyper trophic condition	0/14 Rivers and 0/13 vleis have a high nutrient load leading to hyper trophic condition	Fair
		% of Wastewater reused	approx. 10%	80% reused	Poor
		% of sludge reused	none	90% reused	Poor
	Stormwater management	Bacteria Pollution Load Compliance of Rivers and vleis with DWAS standards	10/14 Rivers and 5/13 vleis have <80% compliance with necessary standards	0/14 Rivers and 0/13 vleis have <80% compliance with necessary standards	Poor
		Blue Flag Beach Compliance	8 out of 68 beaches comply	30 out of 68 beaches comply	Fair
		Compliance with National standards	84% of beaches met the strict 80th percentile guideline	100% of beaches met the strict 80th percentile guideline	Good
	Compatibility of water system with surrounding environment	cyclical flow of water	No, Linear flow of water	Cyclical water flow	Poor
		discharge returned to catchment of extraction	No	Yes	Poor
		level of water use confined by immediate environmental context	No	Yes	Poor
	Compatibility of sanitation system with surrounding environment	system provides haven for birds, fauna and flora	1/24 WWTWs - Cape Flats WWTW does but others do not	100% WWTWs	Poor
	Environmental stresses	Pollution release in effluent	lax national standards with no compliance standards for phosphorous release from WWTW	National standards and guidelines in line with or exceed international standards and are adhered to	Fair
		Ecological Reserve Enforcement	No	Yes	Poor

Political	Governance	Management Boundaries	Within the CoCT the various boundaries of managemnet (planning, water use and WW treatment) are not aligned	Boundaries are aligned for greater co-ordination and integration of services	Poor
		Co-operative governance	Line departments still strong at national, provincial and municipal spheres with minimal co-ordination of efforts - more co-ordination in municipal than national sphere	departments co-operate with one another to prevent duplication of service provision and improve delivery time	Fair
	Compliance with policy	Adherence to national and provincial standards - water supply	Exceeds provision of basic water: 50l/person/day	Exceeds provision of basic water: 50l/person/day	Good
		Adherence to national and provincial standards - wastewater	11/26 WWTWs achieved Green Drop status	all WWTWs achieve Green Drop status	Fair
		Progressively realising basic human rights	Backlog of water and sanitation services is decreasing slowly	No backlog	Fair
Institutional	Institutional capacity	Catchment Authority	Berg River Catchment Management Authority still in process of being set up	Berg River Catchment Management Authority is a strong body representing multiple role players in the total water system	Fair
		Community Involvement	Nominal public participation procedures	strong community structures engage in democratic development processes to have the ability to impact the design outcome	Poor
		Management of Water, Wastewater and stormwater system	City of Cape Town and Dept. of Water Affairs and Sanitation (provincial and national)	government enabling and working with community management structures and public-private partnerships	Fair
		WC/WDM Strategy	reduce water demand by 10% -13%	reduce water demand by 25% - 30%	Good
	Technical capacity	Personnel shortage	Limited critical personnel to manage key technical services	Strong capacity development in tertiary institutions and sufficent operating budget to hire staff	Poor

FACULTY OF ENGINEERING AND THE BUILT ENVIRONMENT

FEEDBACK ON THE ASSESSMENT OF ETHICS IN RESEARCH PROJECTS

This form has been prepared to provide applicants with feedback on their Ethics Clearance applications submitted to the Faculty of Engineering and The Built Environment. For further correspondence regarding this assessment please contact Zulpha Geyer **(Zulpha.Geyer@uct.ac.za)**

NAME OF APPLICANT : Rebecca Cameron	
CYCLE DATE: July 2014	
COMPLETED APPLICATION FORM	The application form is complete
DETAILS OF METHODS USED	The methodology that will be followed for this work is comprehensive and thought out in impressive detail
STATEMENT EXPLAINING HOW DATA OR SENSITIVE INFORMATION WILL BE SAFELY USED	The ethical issues that may potentially arise from this work have been adequately considered.
COPY OF QUESTIONAIRE	This is not included, although the subject matter that will be dealt with during interviews is given in sufficient detail.
CONSENT FORM	Included.
PERMISSION (STUDENT INTERVIEW)	The student will need to determine a suitable method of selecting and approaching the relevant subjects. This is well considered in the proposal.
FURTHER COMMENTS	This project poses little risk to the subjects, and would be a valuable contribution to research in this area.
RECOMMENDATION	Accepted

Student Number: vghreb001

Student Name: Rebecca Cameron

Degree: Masters of City and Regional Planning

6 June 2014

To whom it may concern,

RE: LETTER TO OUTLINE NATURE OF INTERVIEWS

This letter is in response to the Addendum 2 requirement of the Assessment of Ethics in Research Projects Form that calls for a questionnaire if my research is making use of human subjects as sources of data. This dissertation will not require administering questionnaires as surveys will not form a formal part of the research. The interviews will conducted with academics and professionals and be a dialogue about my ideas, thoughts and the experiences faced by the study area. This will be a way to gain feedback on my own thinking. The information gathered from the conversations will concern the current social, economic and mainly environmental issues that the study area is currently facing.

Caution and great care will be taken in the capture and conveying of this data. Any information used will be sent to the interviewee for an opportunity for accuracy checks, and to ensure that they are comfortable with what I have written. If there is any information that I am unable to use, I will honour that. A consent form will be provided to ensure proof of consent to be interviewed is attained. This consent form will also detail the permitted use of the information gathered from the interviewees and details on how to treat the identity of the interviewee. The data collected from these interviews will play a supportive role to my findings from secondary sources. It will help identify gaps in current studies about the area and will help get a sense of the everyday experience and reality with the situation described in the literature. Because the timeframe of this dissertation is limited, I require these dialogues to connect to different disciplines and perspectives and to the "on the ground" situation as extensive public engagement and interviews are not possible.

These interviews and dialogues will also help enhance or add to information from the literature as there is no scope for detailed, meaningful surveys or public consultation to take place in the timeframe of this dissertation. At times the dialogue between the interviewees and me is an attempt and gesture to ground my work in daily realities.

In the event that a conversation takes place over the phone or e-mail, I will take the necessary precaution in attaining consent by asking the person for written consent to discuss certain issues and check how I can or cannot reveal their identity. I will also allow them to check any of the information used for accuracy and appropriate representation

Please contact me if you have any further queries regarding this matter.

Kind Regards,
Rebecca Cameron

EBE Faculty: Assessment of Ethics in Research Projects (Rev2)

Any person planning to undertake research in the Faculty of Engineering and the Built Environment at the University of Cape Town is required to complete this form before collecting or analysing data. When completed it should be submitted to the supervisor (where applicable) and from there to the Head of Department. If any of the questions below have been answered YES, and the applicant is NOT a fourth year student, the Head should forward this form for approval by the Faculty EIR committee: submit to Ms Zulpha Geyer (Zulpha.Geyer@uct.ac.za; Chem Eng Building, Ph 021 650 4791).
NB: A copy of this signed form must be included with the thesis/dissertation/report when it is submitted for examination

This form must only be completed once the most recent revision EBE EiR Handbook has been read.

Name of Principal Researcher/Student: Rebecca Cameron
Department: Architecture, Planning and Geomatics

Preferred email address of the applicant: cmrreb@gmail.com

If a Student: Degree: Masters of City and Regional Planning Supervisor: Tania Katzschner

If a Research Contract indicate source of funding/sponsorship: N/A

Research Project Title: Every Last Drop: The role of spatial planning in integrated urban water management in the Cape Town City-region

Overview of ethics issues in your research project:

Question 1: Is there a possibility that your research could cause harm to a third party (i.e. a person not involved in your project)?	YES	NO
Question 2: Is your research making use of human subjects as sources of data? If your answer is YES, please complete Addendum 2.	YES	NO
Question 3: Does your research involve the participation of or provision of services to communities? If your answer is YES, please complete Addendum 3.	YES	NO
Question 4: If your research is sponsored, is there any potential for conflicts of interest? If your answer is YES, please complete Addendum 4.	YES	NO

If you have answered YES to any of the above questions, please append a copy of your research proposal, as well as any interview schedules or questionnaires (Addendum 1) and please complete further addenda as appropriate. Ensure that you refer to the EiR Handbook to assist you in completing the documentation requirements for this form.

I hereby undertake to carry out my research in such a way that

- there is no apparent legal objection to the nature or the method of research; and
- the research will not compromise staff or students or the other responsibilities of the University;
- the stated objective will be achieved, and the findings will have a high degree of validity;
- limitations and alternative interpretations will be considered;
- the findings could be subject to peer review and publicly available; and
- I will comply with the conventions of copyright and avoid any practice that would constitute plagiarism.

Signed by:

	Full name and signature	Date
Principal Researcher/Student:		10 June 2014
This application is approved by:		
Supervisor (if applicable):		10.06.2014
HOD (or delegated nominee): *Final authority for all assessments with NO to all questions and for all undergraduate research.*		
Chair : Faculty EIR Committee For applicants other than undergraduate students who have answered YES to any of the		

above questions.		

ADDENDUM 1:

Please append a copy of the research proposal here, as well as any interview schedules or questionnaires:

1. YOUR NAME

Rebecca Cameron

2. WORKING TITLE OF YOUR DISSERTATION (approx 15 words max)

Every Last Drop: The role of spatial planning in integrated urban water management in the Cape Town City-region

3. PRECISE NATURE OF THE SUBJECT MATTER

Problem or issue to be investigated

Water is essential for life and access to safe water and adequate sanitation are the two fundamental requirements for human wellbeing and dignity; however it is increasingly recognised as one of the most critically stressed resources on Earth. Every person in South Africa has the right to access to clean freshwater but due to the environmental degradation of water sources and sinks, linear water use systems and the unpredictability of future water provision due to climate change whether this life-giving substance will be available for all to access is uncertain.

As classified by the World Resources Institute, South Africa is currently a water scarce country with less than 1000m3 of freshwater available annually per person. This is further exacerbated in the Western Cape by the increasing population and accompanying land use; pollution of water sources; and the high percentage of irrigated crops coupled with the restrained geographical location of water with the region's arid interior. Severe strain is placed upon existing water resources to maintain and increase supply to meet the demand from agriculture, households and industry. This strain is expected to increase as demand is projected to exceed supply by 2019 without even factoring in the influence of a changing climate where drier and warmer conditions are predicted. Also it is not only the availability of water but access to clean water of acceptable quality which is predicted to be "the single greatest and most urgent development constraint facing South Africa" (Scholes, 2001:51).

In response to this impending crisis, the concept of Integrated Urban Water Management (IUWM) has been applied internationally and now in South Africa to holistically improve the resilience and sustainability of clean water supply and waste water treatment within a river basin. As stated by Global Water Partnership, IUWM brings together fresh water, wastewater, storm water, and solid waste to enable better management of water quantity and quality. The principles include environmental, economic, social, technical, and political aspects of water management to better align urban water flows with natural water cycles to enable sustainable development and livelihoods for all citizens.

Sustainable development has multiple definitions in different contexts therefore to go beyond the definition offered by the Brundtland Report, Edgar Pieterse (2011:312) provides the following framework for the applying it to the context of the Global South:

"A robust conceptual framework must tie together three critical meta domains of urban transition that need to be pursued simultaneously if we are serious about advancing sustainable human settlements and cities. These domains are sustainable infrastructure, the inclusive economy and efficient spatial form, glued by processes of democratic political decision-making."

In light of this framework, while current IUWM practices in South Africa encourage a rethinking of current infrastructural, economic and governance systems there is minimal discussion with regard to the need to better integrate spatial planning and water management. As stated by Woltjer and Al (2007:212), The majority of decisions with regard to water management are made without reference to spatial planning issues related to urbanization and population growth, and conversely development and land-use decisions are also made with little consideration of their effects on water systems. Therefore, with the competition for access to water expected to become even fiercer between domestic, recreational, agricultural and industrial land users; it is necessary to intervene not only through policy but spatially in the Cape Town City-region[1].

Spatial Planning can be defined as "the ability to plan, in a democratically accountable way, the activities of economic and services sectors that have spatial or land-use consequences in their wider social and environmental context" (Wilson and Piper, 2010:10). With regard to the need to address climate change through strategies of adaptation and mitigation, simultaneously if possible, while enabling sustainable livelihoods; spatial planning comes to the fore as a tool for integration and sectoral collaboration. This is because, as Wilson and Piper (2010:30) put forward, spatial planning has a vital role to play in assisting the process of minimizing conflicts and identifying synergies between mitigation and adaptation through aligning and organizing the spatial consequences of policy decisions. This is referred to as horizontal integration and, as spatial planning is prevalent in municipal, provincial and national government spheres it also facilitates vertical integration too. Therefore the issue to be investigated is how to enable a more resilient and sustainable water future for this city-region through the use of spatial planning, such as the Municipal Spatial Development Framework, as a tool for improved integrated urban water management in the Cape Town city-region.

Your philosophical/ethical position (briefly) with regard to this type of problem or issue

As water is essential for all life, it fundamental connects and supports the functioning of the

[1] This region is comprised of the City of Cape Town, Stellenbosch and Drakenstein Municipalities as a functional region jointly located within the Berg Water Management.

environment, society and the economy. These form part of a nested system of life on earth where the environment is the platform on which society and, in turn, economic structures exist and operate, as seen in Figure 1. The relationships that exist within this system require that each smaller system functions within the parameters of the larger system to enable symbiotic resource flows with the aim of creating a more environmentally and socio-economically sustainable region to benefit all citizens and the natural environment. Currently these relationships are experiencing strain due to the dominance of human activities, such as agriculture, industry and households, and are expected to worsen with increasing uncertainty of future resource availability due to climate change and increased demand from inhabitants. Therefore a primary goal of current development planning and initiatives should be to not only ensure clean water provision and safe access for all of the current population but to enable those same rights to be experienced by future populations too. This is referred to as intra- and inter-generational equity and equality. Also, as climate change will make it more difficult for these needs of water provision to be met than is currently experienced, greater weighting should be given to the provision of future resources through protecting, restoring and enhancing current water sources and flows. Therefore, it is necessary to employ more holistic, integrated and strategic planning methods to positively intervene in a world of ever-increasing complexity and uncertainty.

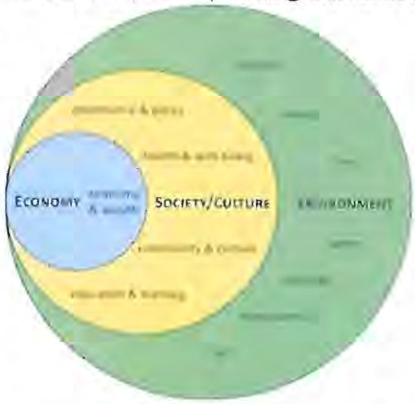


Figure 1: A diagram showing the relationship of environment, society and economy with the environment as the podium upon which the others are built. (http://www.imagine.uwo.ca/sustainability.html)

Broadly, the types and potential uses of the proposals that you expect to put forward (eg. aimed at policy debate, local action plan etc)

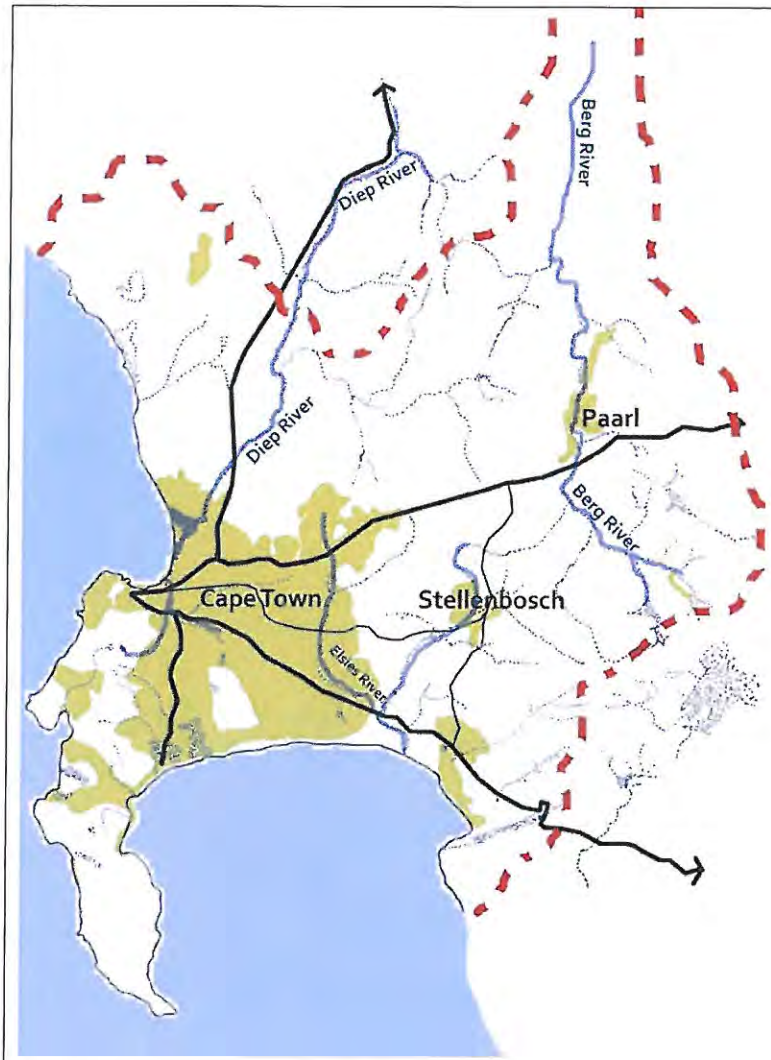
While I recognise the rights of the environment to have access to clean freshwater sources to allow for ongoing system functioning and rejuvenation, the primary focus of this research will be on anthropocentric water use in the Cape Town City-region, as the most dominant force that influences resource consumption due to the highly urbanised and sizable population present.

The research outcome is to put forward an SDF with water efficiency, sustainability and resilience at its core through implementing strategies of restraint, reverence and restoration. This aims to promote environmental recovery and enhancement while reducing anthropocentric water use through the implementation of cyclical systems and wise land use decisions to enable responsible enjoyment of the City-region's freshwater resources to support adequate, satisfied and sustainable livelihoods.

The theoretical field/s likely to be most relevant to your project

The fields most relevant to this project include urban planning, civil engineering, urban water management professionals and national and provincial government water and development departments.

4. MAP OF STUDY AREA (if relevant)



This study area has been chosen as a single functional area comprising of both urban, peri-urban and rural areas and land uses. Although it is not fully urbanized, the impact of urbanised areas is experienced by the surrounding urban areas, especially with regard to the competition for access to water.

5. DRAFT WORK PROGRAMME

The central questions to be investigated

The primary research question:

What is the role of spatial planning in integrated urban water management in the Cape Town City-region?

Secondary questions include:

1. What are current international approaches to the integration of spatial planning and urban water management and how applicable are these to the context of the Cape Town City-region?
2. What is the current urban water cycle and capacity in the Cape Town City-region and how is this expected to change in the future?
3. What and where are the sources and sinks of water for the Cape Town city-region and what are the current or expected spatial planning threats and opportunities to these areas?
4. What water uses and issues currently impact spatial planning in the Cape Town City-region?
5. What spatial planning issues currently impact water management in the Cape Town City-region?
6. How can spatial planning positively intervene to enable sustainable water management practices?

The tasks involved

The tasks involved to answer the above mentioned primary and secondary research questions include:

1. A literature review of relevant international and local theory along with national, provincial and municipal policy and documents.
2. An analysis of the context through the use of existing primary research on water in the region, current spatial plans and interviews with academic and government researchers and spatial planning officials and professionals. More specifically, along with written text and maps, a Material Flow Analysis of water in the region will be undertaken.
3. Interpretation of data is necessary to explain and evaluate the current and future conditions and to best understand how to intervene spatially.

4. A review of relevant precedent or cases of good practice where spatial planning and urban water management have been successfully integrated. An evaluation of how these can be applied to South Africa.

5. The compilation of a Spatial Development Framework to translate suggested interventions to improve water sustainability in the region and how this is implemented.

6. A reflection on the research process and outcomes and where further research topics are also stipulated.

Although these tasks follow a roughly linear outline, it is expected that the research and compilation process will be iterative.

Time allocated to each task

Please see the attached calendar at the end of this document

1. Literature Review – 3 weeks
2. Interviews – 3 weeks
3. Analysis of Context – 2 weeks
4. Data Interpretation – 2 weeks
5. Review of Case Studies of Good Practice – 1 weeks
6. Compile SDF and write report – 5 weeks
7. Write reflections – 2 weeks
8. Review and compile dissertation – 2 weeks

Research method/s to be used

A research method refers to the process used for gathering information and data. The research methods to be used for this dissertation include both quantitative and qualitative methods. Qualitative methods refer to analysis which is more subjective, interpreted and text or image based while quantitative data is objective, precise and numerically based. Both of these methods have value in this research in order to holistically understand urban water cycles and management for better integration with spatial planning.

Case Studies

The case study method allows a researcher to produce context-dependant and value-driven knowledge of a specific area. As this research is focused on the Cape Town City-region it is a valuable research method. The advantages of the Case Study Method are that it reveals how a varied set of factors interact to create the distinctive environmental, social and economic characteristics of a place and it is useful for acquiring deeper insight into the developmental factors of that location. However, the disadvantage of this method is that it is difficult to generalise from a case study therefore the same research will be required in other places to determine a similar outcome.

Discourse Analysis

This research method is an approach to analysing written and verbal text to better understand the ideology of current theoretical and policy frameworks. This is important to this research as current international and local theories and integrated urban water management policies will be analysed to understand whether there is integration with spatial planning present. Whether this integration has occurred, it is necessary to analyse how and why this was or wasn't possible. It must be noted that a limitation to this research method is that it is subject to a researcher's biases and interpretations.

Research techniques to be used

The research techniques to be used include both quantitative and qualitative techniques.

Interviews

This technique allows for a more in-depth understanding of the topic through discussion with those directly involved. More specifically, I intend to interview those policy-makers, private consultants and other service providers involved with the drafting of the City of Cape Town's SDF and water management strategies. A semi-structured interview technique will be used to allow for some freedom of opinion and adaptation to individual interviewees. The strength of this technique is that interviewees' responses can be transcribed and then used directly in the research for a more well-rounded response to the topic. However, the limitations are that this technique can be time-consuming, the personal bias of the interviewee must be taken into account and I, as the interviewer, need to be aware of and prevent the use of leading questions which could guide a response in a certain direction. I aim to address these limitations through research which adheres to a well-constructed schedule to ensure that I don't run out of time, to be aware of the body language, words and attitudes of the interviewee when they are responding to questions to be aware of bias and to compile the list of questions with my supervisor so that leading questions can be removed.

Research findings obtained through interviews will then be transcribed, coded and analysed according to the assessment criteria established from a review of the relevant literature.

Desktop Research:

This technique will be used to undertake a literature review to understand the various theoretical standpoints from contemporary authors on the topic of the integration of spatial planning and IUWM. Another desktop study would be undertaken to gather data on the current water flow of the Cape Town City-region (location of sources and sinks, threats and capacities) and to analyse the current Urban Water Management Documents and strategies used by the City-region. The strength of this technique is that large amounts of information can be investigated, however, the limitations of this technique is that the outcome can be quite self-referential and contain personal bias as this is an individual exercise. I aim to address this limitation through discussion with my supervisor on the topic and to ensure that there is rigorous justification for response to the research, collecting information from various sources and different theoretical standpoints.

Non-participant Observations

This research technique will have a specific focus on mapping as a tool for analysis. This allows the research to locate the analysis to identify spatially overlapping concerns, risks and opportunities in the region. This is especially important as the spatial representation of the analysis will inform the research outcome of a Spatial Development Framework.

Data Analysis

Once the data has been collected, interpretation of data is required. IThis research will undertake the use of mixed methods for this task by using explanatory interpretations to explain the occurrence of certain phenomena and evaluative interpretations to evaluate the findings.

Ethical Considerations

This research will be conducted through interaction with those involved in the drafting of municipal spatial development frameworks, professional researchers and academic researchers therefore it will be important to maintain an unbiased approach to the interviews to allow for unexpected research outcomes. I aim to engage in ethical research by requesting permission to use excerpts of the interviews as direct quotations in my research. I will respect the interviewee's decision as to the level of permission granted. I will be conducting this research of my own accord therefore there shall be no desired bias for my research outcomes.

6. DOCUMENTARY AND RESEARCH MATERIAL AVAILABLE (full details)

Main theoretical texts, case material and Research/professional reports

Scholes, R. 2001. Global Terrestrial Observing System: Regional Implementation Plan for Southern Africa. Food and Agriculture Organization of the United Nations.

World Bank. 2012. Integrated Urban Water Management - Lessons and Recommendations from Regional Experiences in Latin America, Central Asia, and Africa. Water Partnership Programme Case Profile No. 1 November 2012

Bahri, A. 2012. Integrated Urban Water Management Global Water Partnership Technical Committee Background Paper No. 16

Blignaut, J and van Heerden, J. 2009. The impact of water scarcity on economic development initiatives. Water South Africa. 35:4 p 415 – 420

Woltjer, J and Als, N. 2007. Integrating Water Management and Spatial Planning. Journal of the American Planning Association 73:2 p 211 – 222

Laukkonen, J et al. 2009. Combining climate change adaptation and mitigation measures at the local level. Habitat International. 33 p 287 -292

Janicke, M. 2008. Ecological modernisation: new perspectives. Journal of cleaner production. 16 p 557 - 565

Biesbroek, G et al. 2009. The mitigation–adaptation dichotomy and the role of spatial planning. Habitat International. 33 p 230 – 237

Moss, T. 2004. The governance of land use in river basins: prospects for overcoming problems of institutional interplay with the EU Water Framework Directive. *Land Use Policy.* 21 p 85 – 94

Opdam, P et al. 2002. Bridging the gap between ecology and spatial planning in landscape ecology. *Landscape Ecology.* 16 p 767 – 779

Makropoulos, C. K. et al. 2003. Fuzzy Logic Spatial Decision Support System for Urban Water Management. *Journal of Water Resource Management.* 129 p 69 – 77

Sullivan, C. et al. 2006. Application of the Water Poverty Index at Different Scales: A Cautionary Tale. *Water International.* 31:3 p 412 – 426

Van de Meene, S. J. et al. 2011. Towards understanding governance for sustainable urban water management. *Global Environmental Change*. 21 p 1117 – 1127

Brown, R. et al. 2008. Transitioning to Water Sensitive Cities: Historical, Current and Future Transition States. *11th International Conference on Urban Drainage, Edinburgh, Scotland, UK.*

Lundie, S. 2004. Life Cycle Assessment for Sustainable Metropolitan Water Systems Planning. *Environment Science Technology*. 38 p 3465 – 3473

Brown, R. 2005. Implementation impediments to institutionalising the practice of sustainable urban water management. *10th International Conference on Urban Drainage, Copenhagen, Denmark*

Bugliarello, G. 2011. *The Bridge.* Washington, USA: National Academy of Engineering. 41: 1

Hellstrom, D. 2000. A framework for systems analysis of sustainable urban water management. *Environmental Impact Assessment Review.* 20 p 311 – 321

Carter, J. 2007. Spatial planning, water and the Water Framework Directive: insights from theory and practice. *The Geographic Journal.* 173:4 p 330 -342

Pieterse, E. 2011. Recasting Urban Sustainability in the South. *Development*. 54 (3) 309 – 316.

Barraclough, C. L. n.d. Green Development and Closed-Loop Water Systems: A Restoration Economy Approach to Urban Watershed Regeneration. *The Baltimore Charter – A Transformation In Managing Water*. 21 – 35

Department of Water Affairs. 2013. *Chapter 4 Water Resources Planning, Infrastructure Development And Management.* National Water Resources Strategy. P 18 – 37

Department of Water Affairs. 2013. Executive Summary: National Water Resource Strategy Second Edition.

Ramahotswa, B and Still, D. 1992. *Guide to community-based management of water supplies.* Pretoria: CSIR Division of Water Technology

Western Cape Government. 2011. *Western Cape Integrated Water Resources Management Action Plan.* Cape Town

Western Cape Government. 2012. Western Cape Sustainable Water Management Plan: Part 1: 'The Water Plan'. Cape Town

Department of Water Affairs and Forestry. 2007. *Western Cape Water Supply Reconciliation Strategy*

Study. Cape Town

Pithey, S. 2007. Water and Sanitation in the City of Cape Town: Integrated Analysis Baseline Report. Stellenbosch: Sustainability Institute

City of Cape Town. 2001. *Water Services Development Plan of the City of Cape Town*. Cape Town

City of Cape Town. 2006. *Where does our water come from?*

City of Cape Town. 2005. *State of the Rivers Report: Greater Cape Town's Rivers.*

Winter, K. et al. 2009. Sustainable urban water management in Cape Town, South Africa: Is it a pipe dream? *Water, Sanitation And Hygiene: Sustainable Development And Multi-sectoral Approaches*. 34th WEDC International Conference, Addis Ababa, Ethiopia

Swilling. M. 2006. Sustainability and infrastructure planning in South Africa: a Cape Town case study. *Environment and Urbanization*. 18:1 p 23 – 50

Wilson, E and Piper, J. 2010. *Spatial Planning and Climate Change*. New York: Routledge

Maps (subjects and scales)

Base map data will be obtained from 1:50 000 topographical maps from the Depaartment of Land Surveys and Mapping. The primary maps of this research will include maps of the Cape Town City-region showing the current condition depicting the analysis of the region's water cycle, sources and sinks and an SDF showing the location of interventions proposed both of these will be at a scale of 1:250 000 on an A2 Page.

Calendar:

MCRP Dissertation 2014

Jun 2014 (Johannesburg)

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2 Literature Review	3	4	5	6	7
8 Literature Review	9 Interviews	10	11	12	13	14
15 Interviews; Literature Review	16	17	18	19	20	21 Analysis of Content
22 Interviews; Analysis of Content	23	24	25	26	27	28 Holiday - Transkei
29 Holiday - Transkei and Hogsback	30	1	2	3	4	5

MCRP Dissertation 2014

Jul 2014 (Johannesburg)

Sun	Mon	Tue	Wed	Thu	Fri	Sat
29 Holiday - Transkei and Hogsback	30	1	2	3	4	5
6 Holiday - Transkei and Hogsback	7	8	9	10	11	12
13 Analysis of Content	14	15	16	17	18	19
20 Analysis of Content	21 Data Interpretation	22	23	24	25	26
27 Data Interpretation	28	29	30	31	1	2

MCRP Dissertation 2014

Aug 2014 (Johannesburg)

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3	4	5	6	7	8	9
[illegible]		Review Case Studies and Best Practice				
10	11	12	13	14	15	16
Review Case Studies and Best Practice			Compile and write [illegible]			
17	18	19	20	21	22	23
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MCRP Dissertation 2014

Sep 2014 (Johannesburg)

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28	29	30	1	2	3	4
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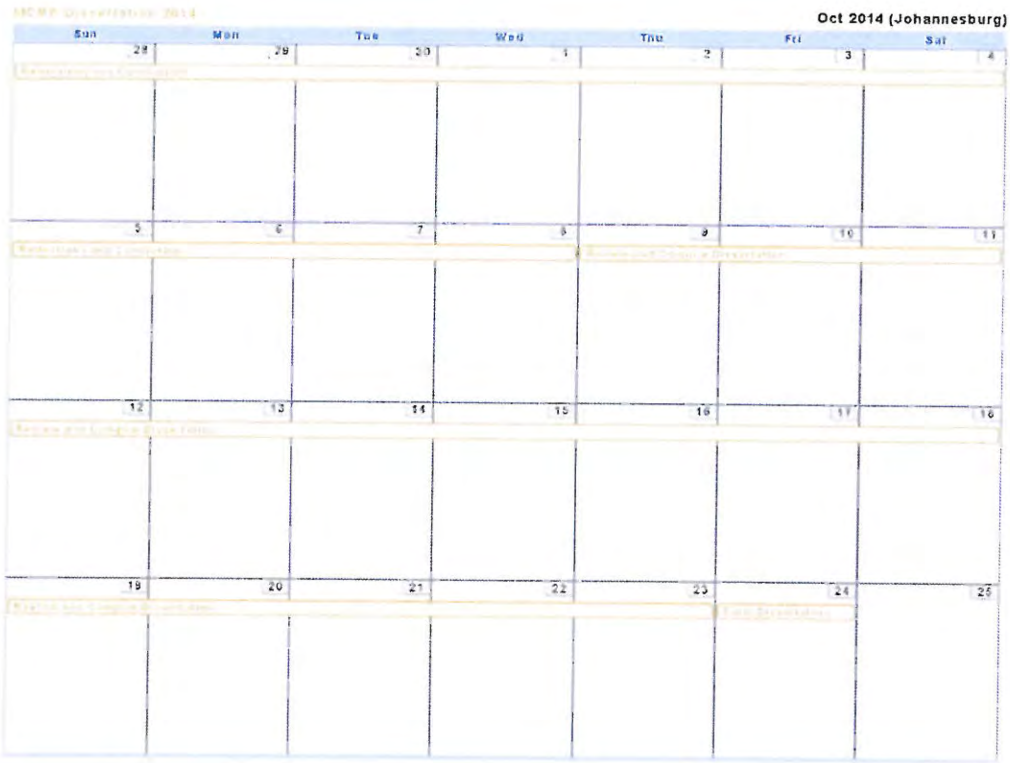
Oct 2014 (Johannesburg)
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SCHOOL OF ARCHITECTURE, PLANNING AND GEOMATICS
University of Cape Town
Private Bag x3, Rondebosch 7701
Centlivres Building
Email: Janine.Meyer@uct.ac.za Tel: 27 21 6502359

UNIVERSITY OF CAPE TOWN

June 2012

STATEMENT TO BE READ OUT TO AN INTERVIEWEE BY A STUDENT ABOUT TO UNDERTAKE AN INTERVIEW FOR THE PURPOSES OF A MASTERS DISSERTATION

A copy of the form can be given to the respondent if they request it, so keep copies with you.

MY NAME IS REBECCA CAMERON AND I AM STUDYING CITY AND REGIONAL PLANNING AT THE UNIVERSITY OF CAPE TOWN.

I AM DOING RESEARCH ON THE ROLE OF SPATIAL PLANNING IN INTEGRATED URBAN WATER MANAGEMENT IN THE CAPE TOWN CTIY-REGION AS PART OF MY MASTERS DISSERTATION AND I WOULD LIKE TO ASK YOU SOME QUESTIONS TO HELP ME WITH MY RESEARCH.

I CAN PROMISE THAT I WILL NOT RECORD YOUR NAME OR ADDRESS, AND YOUR PERSONAL DETAILS WILL NOT IN ANY WAY BE REVEALED IN MY DISSERTATION OR ANY PUBLICATION I PRODUCE.

THE QUESTIONS I ASK ARE ONLY FOR RESEARCH AND THEY CANNOT DIRECTLY BENEFIT YOU OR YOUR COMMUNITY.

IF YOU WANT TO END THE INTERVIEW AT ANY POINT YOU ARE FREE TO DO SO.

MY SUPERVISOR IS TANIA KATZSCHNER AND HER CONTACT DETAILS ARE: tania.katzschner@uct.ac.za

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Signed (student)

This form is to be completed with your details filled in, and submitted with your ethics form

ADDENDUM 2: To be completed if you answered YES to Question 2:

It is assumed that you have read the UCT Code for Research involving Human Subjects (available at http://web.uct.ac.za/depts/educate/download/uctcodeforresearchinvolvinghumansubjects.pdf) in order to be able to answer the questions in this addendum.

2.1 Does the research discriminate against participation by individuals, or differentiate between participants, on the grounds of gender, race or ethnic group, age range, religion, income, handicap, illness or any similar classification?	YES	NO
2.2 Does the research require the participation of socially or physically vulnerable people (children, aged, disabled, etc) or legally restricted groups?	YES	NO
2.3 Will you not be able to secure the informed consent of all participants in the research? (In the case of children, will you not be able to obtain the consent of their guardians or parents?)	YES	NO
2.4 Will any confidential data be collected or will identifiable records of individuals be kept?	YES	NO
2.5 In reporting on this research is there any possibility that you will not be able to keep the identities of the individuals involved anonymous?	YES	NO
2.6 Are there any foreseeable risks of physical, psychological or social harm to participants that might occur in the course of the research?	YES	NO
2.7 Does the research include making payments or giving gifts to any participants?	YES	NO

If you have answered YES to any of these questions, please describe below how you plan to address these issues:

ADDENDUM 3: To be completed if you answered YES to Question 3:

3.1 Is the community expected to make decisions for, during or based on the research?	YES	NO
3.2 At the end of the research will any economic or social process be terminated or left unsupported, or equipment or facilities used in the research be recovered from the participants or community?	YES	NO
3.3 Will any service be provided at a level below the generally accepted standards?	YES	NO

If you have answered YES to any of these questions, please describe below how you plan to address these issues:

ADDENDUM 4: To be completed if you answered YES to Question 4

4.1 Is there any existing or potential conflict of interest between a research sponsor, academic supervisor, other researchers or participants?	YES	NO
4.2 Will information that reveals the identity of participants be supplied to a research sponsor, other than with the permission of the individuals?	YES	NO
4.3 Does the proposed research potentially conflict with the research of any other individual or group within the University?	YES	NO

If you have answered YES to any of these questions, please describe below how you plan to address these issues: