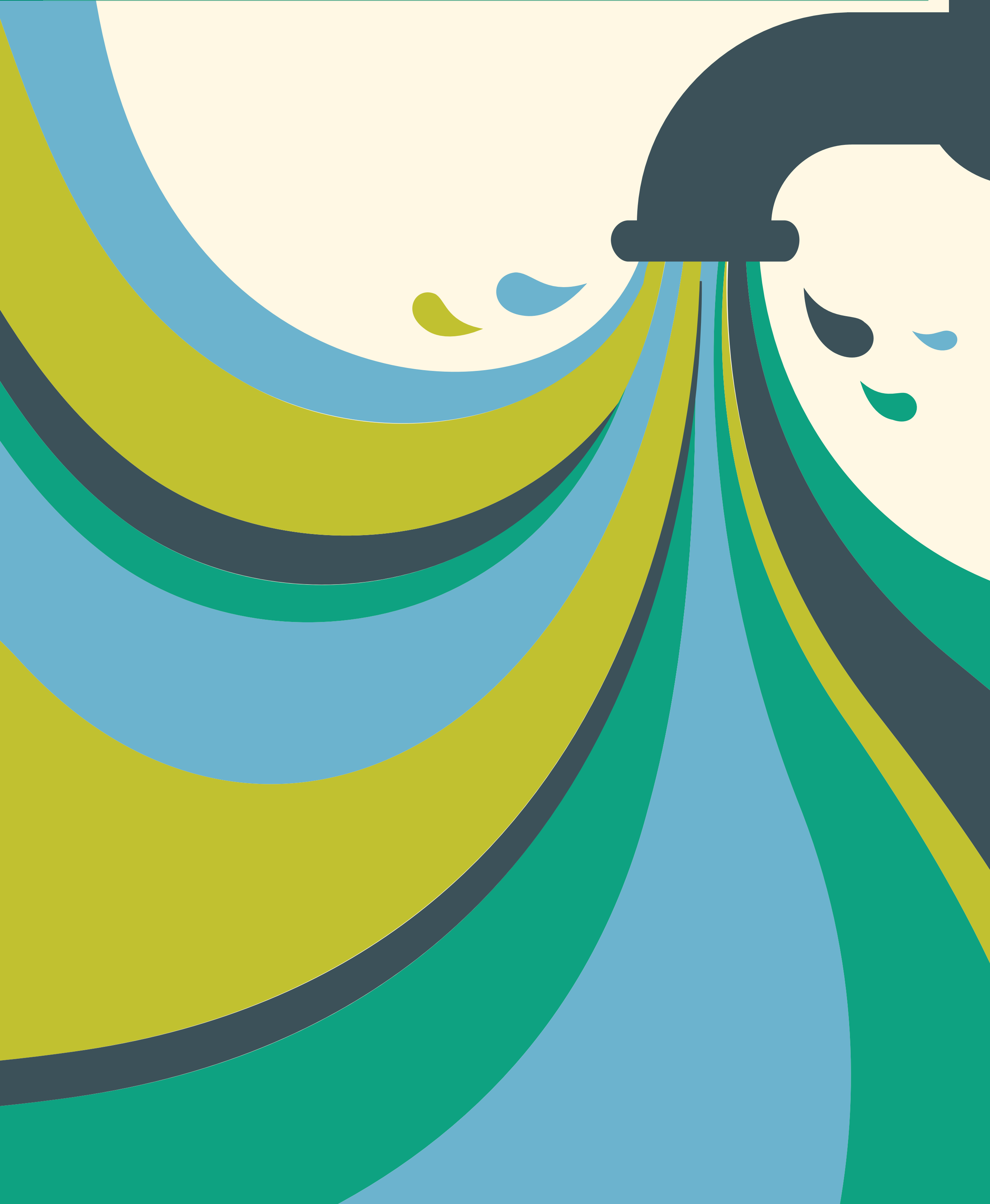
NATIONAL WATER ACCOUNTS FOR SOUTH AFRICA SYSTEMS, METHODS AND INITIAL RESULTS

D Maila, J Crafford, V Mathebula, N Naidoo & W Visser



WATER RESEARCH COMMISSION

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National Water Accounts for South Africa
Systems, Methods and Initial Results

D Maila, J Crafford, V Mathebula, N Naidoo & W Visser

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EXECUTIVE SUMMARY

Background

The South African water economy has experienced severe hazards over the past years. Foremost have been unprecedented droughts and associated raw water scarcity in most parts of the country, but most severely in the Western Cape. However, there are also other significant hazards to the water economy, for example, water pollution, eutrophication of major dams, and aging water infrastructure.

In the face of such hazards, the increasing uncertainty of climate change related rainfall patterns, and the extreme consequences of water supply systems failing, it is non-negotiable to have reliable management information regarding the water economy. Broadly, two categories of management information are required. Firstly, improved meteorological and hydrological models are required to forecast rainfall and its associated hydrological pathways. Secondly, accurate information is required on the supply and use of water across the water value chain. Water accounts deal with this second category of information, which is the focus of this investigation.

In their most simple form, water accounts capture the physical flow of raw water entering the economy from various sources (such as surface water from impoundments, groundwater, water imported from Lesotho, water sourced from sea water through desalinisation or other sources) and trace its pathways through the economy to the point where it gets released back to the environment.

These water flow accounts are normally constructed for a 12-month accounting period. Such flow accounts can be enhanced in several ways, through:

- Increasing the resolution of the flow accounts from national averages to water management area (WMA) level or further to primary catchment or sub-catchment levels.
- Converting the physical flow accounts into monetary accounts, thus expressing the flow of water in monetary terms by applying water prices to the physical flows.
- Developing water quality accounts that measure the levels of pollutants in water.
- Developing physical stock accounts that report the available stock of water in impoundments, aquifers or other storage.
- Developing monetary stock accounts that report on the water economy balance sheet.

There is an international standard for constructing water accounts, namely, the System of Environmental-Economics Accounts (SEEA) of the United Nations Statistics Division (UNSD).

Statistics South Africa (Stats SA) has the mandate to implement the SEEA. Environmental economic accounts (EEAs) are so-called satellite accounts to the System of National Accounts (SNA), which enable monitoring and evaluation of the stocks and flows of natural capital through the economy. Early work on water accounting in South Africa started in the late 1990s under the guidance of Stats SA, the Department of Environmental Affairs (DEA) and the Resource Accounting Network for Eastern and South Africa (RANESA). Thereafter, Stats SA pioneered Water Accounts for South Africa through a series of discussion document publications between 2004 and 2010. Through these publications, Stats SA developed methodologies and a very novel data collection system by data-mining its internal databases. The remaining challenge has been to develop a methodological framework that enables annual updating of the water accounts and publication in the annual compendium of EEAs.

In order to address this challenge, a number of technical challenges had to be overcome, including:

- Aligning water sector and International Standard Industrial Classification (ISIC) classification.
- Assessing data quality.
- Disaggregating spatially to a water management area (WMA) level.
- Integrating diverse data sources (physical and monetary).

- Designing a suitable structure (referring to nomenclature) and architecture (referring to types of table) for the accounts.
- Linking the water accounts in a meaningful way to the outputs of the SNA.

Aims

The overall focus of this study was to develop a methodological framework for Stats SA by achieving the following study aims:

1. Provide a methodological framework for the Water Accounts for South Africa according to international best practices.
2. Consult with all relevant role players through engagement.
3. Create a framework (both structure and architecture) and a knowledge base for these accounts to enable more frequent updates and potentially more detail accounts in the future.
4. Provide a research document containing an overview of the methodology, water tables and water EEAs for South Africa that can be published in collaboration with Stats SA.
5. Provide the water tables and water EEAs for South Africa in Microsoft Excel™ to enable ease of use for integrated impact and policy analysis.

Methodological framework

The methodological framework developed here follows the best international accounting guidelines as recommended in the SEEA. Successful implementation of the SEEA by any national statistical office ideally requires a developmental approach that is built on existing institutional arrangements with respect to data availability, and which builds on existing reporting initiatives. It is further strengthened by establishing data partnerships and implementing data-mining initiatives. Data quality assessment systems are important for addressing the non-official data challenges. The developmental approach is further implemented through a process of prototyping and piloting priority accounts, followed by a continuous improvement process.

Thus, this study proposes a framework to enable Stats SA to update and publish national water accounts on an annual basis. This framework is based on an environmentally extended supply and use table (SUT) approach. The framework comprises a structure (referring to nomenclature) and architecture (referring to types of table) for physical and monetary water flow accounts. The work investigates methods for aligning water sector and ISIC classifications, assesses data quality using the South African Statistical Quality Framework (SASQAF), and integrates diverse data sources (physical and monetary). The resultant framework was used to construct the prototype accounts that accompany this report.

This study also investigates a framework for water quality flow accounts, and demonstrates this using several cases.

In order to achieve the above aims, the project team continuously consulted key stakeholders to receive feedback on their expectations as well as their input into the water accounts, and verified the results. The stakeholder feedback report can be found in Appendix B.

Considerable focus was given to data sources and data mining. The data in the Water Resources 2012 (WR2012) data sets was downloaded and analysed. Stats SA questionnaire audits were performed to identify any questions related to water use in the economy. The related data to these questionnaires was requested from the various departments within Stats SA.

Annual flow accounts were developed for the five-year period from 2012 to 2016. These accounts provide information on the volumes and value of water exchanged between the environment and the economy (abstraction and returns) and water exchanged within the economy. The structure of these accounts followed the SUT approach to enable easy integration with existing Stats SA data sources. The SUT approach has several benefits. Firstly, it allows for an intuitive analysis of the flow of water through the economy and the water value chain. Secondly, it aligns with other Stats SA data products, especially the SUTs, in structure and classification. Thirdly, it enables users to analyse the water economy using economy-wide modelling methodologies.

Physical accounts – measuring water transactions in cubic metres and using data predominantly from the WR2012 of the WRC – were constructed for every WMA, which were then structured into a 28-sector national water account. Monetary accounts – measuring water transactions in monetary terms and using data predominantly from the Stats SA SUTs – were constructed.

Thereafter, the physical account was expanded to a 37-sector national water account using the additional data from the monetary account. A total of 348 transactions were identified in constructing the physical flow accounts at WMA level and the monetary flow accounts at national level. This data was extracted from several data sources. Every data point was referenced for ease of future update. Each data point was rated for accuracy according to the SASQAF.

Water quality is an increasingly important component of water accounts – especially in a dry country where pollution has a more concentrated effect. Thus, in addition to the flow accounts discussed above, the work done in this study also investigated a methodology for water quality accounts. The SEEA framework for water emissions accounts served as a point of departure for this work but demonstrated that additional and intensive consultation and development work is still required to formalise the framework for national accounting purposes. The work performed here used data from the Department of Water and Sanitation (DWS) Resource Quality Information System (RQIS) database, which has more than 2000 monitoring points. A water quality flow account architecture was developed that drew selected data from 34 key monitoring points for selected water chemistry measures. Several reporting tables and data applications were demonstrated. This data was also rated for accuracy according to the SASQAF.

Initial results

The water sector had a combined **annual revenue** of R66.5 billion in 2016. Of this output, the gross value added (GVA; or contribution to gross domestic product) was R30.5 billion. To provide context: this was about 11% of the size of the mining sector, 15% of the size of the retail sector and smaller than the size of the beverage manufacturing sector (78%). The sector had grown at an annual rate of 7.4% since 2012 (R45.5 billion) (refer to Figure 1). The water sector grew on average by 8.6% per year from 2012 to 2016. With the exception of the mining and beverage manufacturing industries (both approximately 3.3%), expenditure on water purchases were less than 1% of the total expenditure of all industry sectors. For a sector of such strategic importance, these economic numbers are small, which indicate that significant strategic thinking is required to sustainably position the sector for infrastructure investment planning.

The derived weighted **average water costs** (which capture both tariffs and cost of own water management) varied considerably from R0.13/m^3 for the irrigation industry to more than R16.00/m^3 for the construction industry. These values are however distorted as own water management costs of sectors such as irrigation and electricity generation were captured elsewhere in the economy, and more work is required in future to improve tariff accuracy.

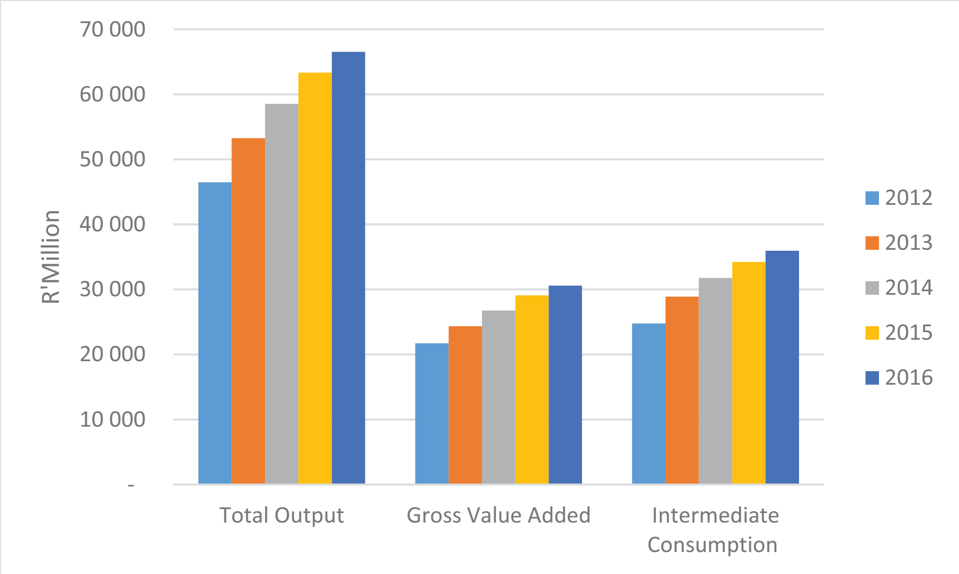

Figure 1: Size and growth of the water economy in South Africa measured as total output (i.e. total revenue earned), GVA (i.e. contribution to gross domestic product) and intermediate consumption (i.e. expenditure not included in GVA items)

The physical flow account indicated that the total **water supply** in South Africa in 2016 was 14.7 billion m^3/a. The bulk of this water was sourced from surface water (11.9 billion m^3/a) (which included imports from the Lesotho Highlands Water Project), with the remainder sourced from groundwater (2.8 billion m^3/a). Although the DWS governs all use through water use licences (WULs), most WUL holders abstract and manage their own water, and thus pay for their own water distribution. Such own water supply is estimated at 6.9 million m^3/a, with the balance (7.8 million m^3/a) distributed by municipalities and other service providers. Water boards and other bulk water users are authorised to extract water (2.8 billion m^3/a and 0.8 billion m^3/a respectively). Municipalities sourced most of their water from water boards, with the remainder being "own sources" through DWS authorisations (5.9 billion m^3/a) (refer to Figure 2).

The total nett **water use** (i.e. total water use minus return flows) was estimated at 9.9 billion m^3/a, with the balance (4.8 billion m^3/a) returned to the environment. Irrigation agriculture was the largest total user of water (with an annual allocation of 6.9 million m^3/a), followed by households, the mining sector, the various manufacturing sectors and the energy sectors. Approximately 13.6% of all distributed water could be classified as non-revenue water, which comprises water losses, own use by water authorities or unaccounted-for water – this was estimated at 2.6 billion m^3/a. Total sewage return flows to waste water treatments works was 1.8 billion m^3/a (refer to Figure 1).

The report demonstrates several applications of water quality accounting using an adapted SEEA emissions account format and selected case study applications. Further work is required, in consultation with the DWS RQIS, to ensure the most appropriate applications are selected for national accounting publication.

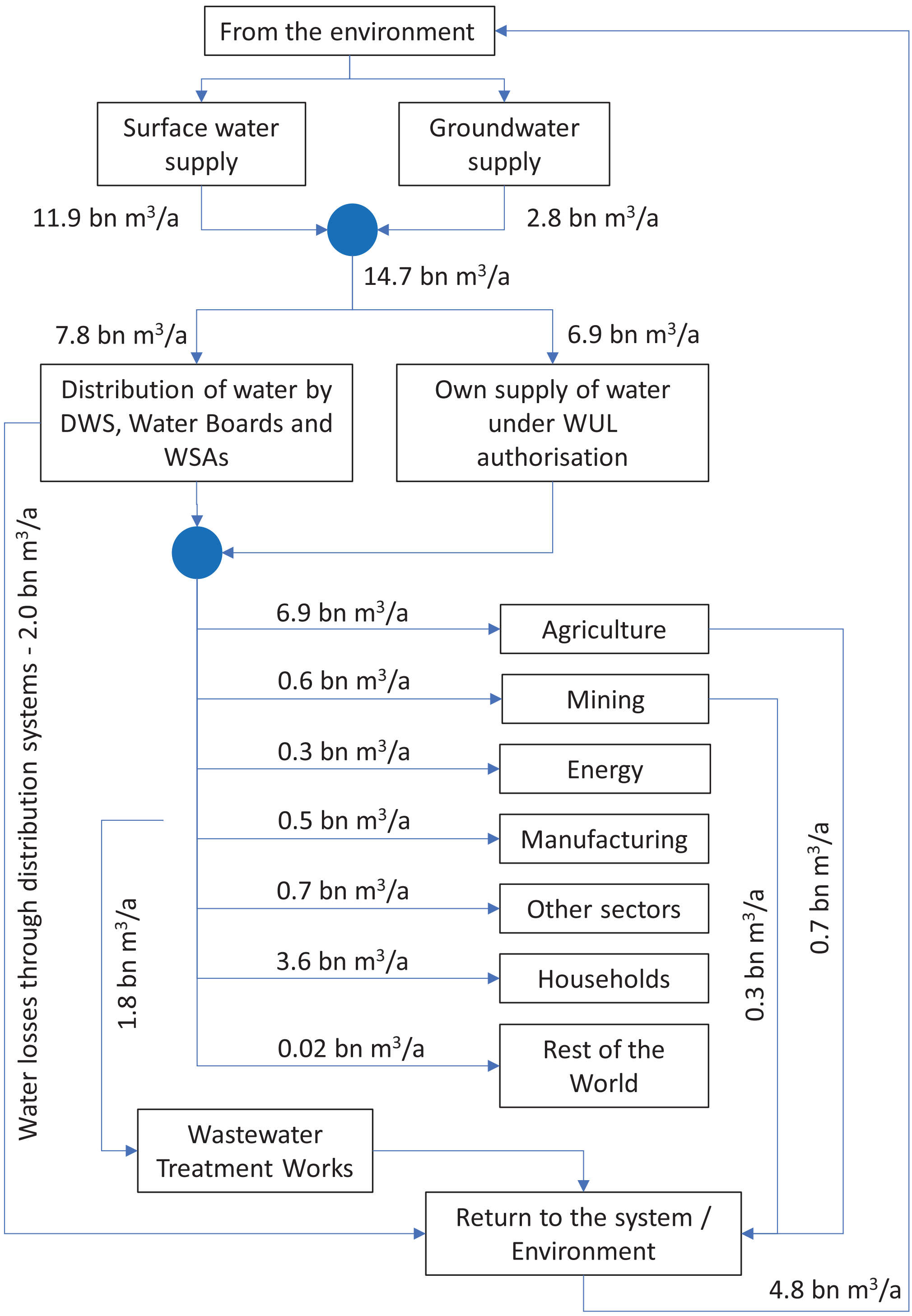

Figure 2: A simplified graphic representation of the water balance for South Africa (2016) (Source: Water environmental accounts developed in this study)

Conclusions and recommendations

Through this project, a national water accounting methodological framework has been developed to a point where annual publication of the monetary flow accounts is possible. The key data sources for annual updates can be sourced, through data-mining, from internal Stats SA and DWS data sets. Several data and methodology gaps exist, which are expected to be addressed through continuous development and improvement of the accounts by Stats SA.

The framework developed here needs to be institutionalised by Stats SA through an appropriate publication and by developing a national water accounting sources and methods document. Stats SA has several publication options, including the Environmental Economic Accounts Compendium, a discussion document format, or an online publication. Stats SA also develops sources and methods documents for all their publications as part of their generic statistical business process. Stats SA needs to develop such sources and methods documents separately for the water flow accounting process and the water quality accounting process as the water accounts proceed through the statistical business process.

The most significant data gaps lie with (a) the physical flow of water and (b) water quality. The Water Research Commission's (WRC) WR2012 data set is the key data source for physical flow data, but it largely represents estimates of water allocations; therefore, it does not enable the analysis of drier or wetter years on the economy. It is recommended that Stats SA and the WRC engage formally through the standard intergovernmental memorandum of understanding (MOU) process to investigate ways of updating the WR2012 as appropriate, including by applying the SASQAF to the WR2012. Similarly, it is recommended that the DWS and Stats SA engage under an MOU to continuously improve the data quality of the various data sources for which DWS is responsible. The application of the SASQAF to the WR2012 and the DWS data sources, and the enhancement of key Stats SA data collection instruments by adding a limited number of key questions, could play a large role in continuously improving the quality of the water accounts.

Water pricing is an important economic instrument for enhancing social equity, improving water use efficiency and ecological sustainability, and securing financial sustainability of water utilities and operators. Thus, water pricing can be a powerful management tool for achieving various objectives across the water value chain. There is however a lack of empirical data/knowledge on how the application of different tariff structures affects water use for different economic sectors and how much water contributes to the economy. Water flow and water quality accounts can be used as tools for setting appropriate water prices. It is recommended that additional data within Stats SA is data-mined and integrated within the water accounts to provide a more meaningful analysis of the costs of water management and the effective water tariffs. Stats SA has already identified these data sources.

For water accounts to become truly useful, clear applications of water accounts need to be developed and improved continuously. Stats SA, as provider of official data, has a limited responsibility to develop such applications. Rather, there is a joint development responsibility on water managers in collaboration with Stats SA. Water managers in this sense would include the DWS, WRC, water boards and water service authorities. Water accounts could inform various water policy initiatives. It could support and inform the National Water Resources Strategy; the Economic Regulator for water; policy design (e.g. water tariffs, water allocation); development planning (e.g. shale gas); catchment planning (e.g. catchment management strategies, water resource classification) and climate change effects. At the same time, it should link water resources to the national economy through the national accounts. With respect to the water quality account, we propose that a consultative process be initiated between Stats SA and the DWS RQIS to agree on the most desirable water quality accounting application(s) and the corresponding accounting framework required. Another specific example of a water accounts application is in the sustainable development goals.

CAPACITY DEVELOPMENT

The project team had a close working relationship with Stats SA team throughout the project.

The following students were involved in the project

- Ms Dineo Maila – Ph.D. Water Quality, North-West University.
- Mr Valmak Mathebula – B.Sc. Quantitative Risk Analysis, North-West University.

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Reference Group Member	Institution
Mr Wandile Nomquphu (Chairperson)	Water Research Commission
Ms Penny Jaca (Coordinator)	Water Research Commission
Ms Esther Koch	Statistics South Africa
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Mr Robert Parry	Statistics South Africa
Mr Niel van Wyk	Department of Water and Sanitation
Dr Johannes Jordaan	Economic Modelling Solutions
Ms Mandy Driver	South African National Biodiversity Institute
Mr David Clark	University of KwaZulu-Natal

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- Key role players from the Department of Water and Sanitation for their input and expectations from water accounts in South Africa.

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ABBREVIATIONS

AMD	Acid Mine Drainage
CMA	Catchment Management Area
DEA	Department of Environmental Affairs
DQAT	Data Quality Assessment Team
DWS[1]	Department of Water and Sanitation
EEA	Environmental Economic Account
GIS	Geographic Information System
GVA	Gross Value Added
ISIC	International Standard Industrial Classification
LSS	Large Sample Survey
MOU	Memorandum of Understanding
NDP	National Development Plan
NEMA	National Environmental Management Act
NSO	National Statistical Office
NWA	National Water Act
PSP	Professional Service Provider
RANESA	Resource Accounting Network for Eastern and South Africa
RQIS	Resource Quality Information System
RQO	Resource Quality Objective
SANBI	South African National Biodiversity Institute
SANSS	South African National Statistics System
SASQAF	South African Statistical Quality Framework
SDG	Sustainable Development Goal
SEEA	System of Environmental-Economic Accounting
SIC	Standard Industrial Classification
SNA	System of National Accounts
Stats SA	Statistics South Africa
SUT	Supply and Use Table
TCTA	Trans-Caledon Tunnel Authority
TDS	Total Dissolvable Solids
TWQR	Target Water Quality Range
UN	United Nations
UNEP	United Nations Environmental Programme
UNSD	United Nations Statistics Division
WARMS	Water Authorisation and Registration Management System
WDCS	Waste Discharge Charge System
WMA	Water Management Area
WR2012	Water Resources 2012
WRC	Water Research Commission
WRCS	Water Resource Classification System
WRM	Water Resource Management
WSA	Water Service Authority
WSP	Water Service Provider
WUA	Water User Association
WUL	Water Use Licence
WWTW	Waste Water Treatment Works

[1] The Department of Water and Sanitation (DWS) was known as Department of Water Affairs (DWA) until 2014. Therefore, many publications still use DWA as their reference. We will, for simplicity's sake, consistently use DWS when referring to this department.

GLOSSARY

Aquifer – A stratum or zone below the surface of the earth capable of producing water.

Architecture of accounts – The set of tables supporting the step-wise development of a water account and appropriate reporting format.

Basin – The area of land that is drained by a large river or river system.

Catchments – The area of land drained by a river. The term can be applied to a stream, a tributary of a larger river, or a whole river system.

Classification – The nomenclature of transactions defined either by common definitions used in water management or International Standard Industrial Classification.

Drainage region – A single or large river basin or groups of contagious catchments or smaller catchments with similar hydrological characteristics. They follow the division of the country into the drainage regions as used by the Department of Water and Sanitation.

Effluent – Effluent is a liquid waste product (whether treated or untreated) that is discharged into the environment from an industrial process or human activity.

Flow accounts – Physical and monetary accounts that capture the flow of water through the economy over an accounting period.

Groundwater – Water in the subsurface that is beneath the water table, and thus present within the saturated zone. In contrast to water present in the unsaturated or vadose zone (underground water in the zone above the water table), which is referred to as soil moisture.

Household – A group of persons who share the same living accommodation, who pool some or all of their income and wealth, and who consume certain types of goods and services collectively. Households can produce goods and services, including water, for sale or own use.

Mean annual run-off – Abbreviated as MAR, this is a long-term mean annual flow calculated for a specific period of time, at a particular point along a river and for a particular and catchment development condition.

Precipitation – Any form of water (such as rain, snow, sleet, or hail) that falls to the earth's surface. The quantity of such water falling in a specific area within a specific period.

Reservoir – A reservoir is a lake-like area where water is kept until it is needed. Reservoirs come in all shapes and sizes and are owned by a water company or authority.

Soil water – Water suspended in the uppermost belt of soil or in the zone of aeration near the ground surface that can be discharged into the atmosphere by evaporation of soil water and transpiration from plants that take up soil water. The soil containing water and the area it occupies could be considered a statistical unit of the environment.

Stock accounts – Asset accounts relating to defined asset classes, reporting the opening and closing stocks of the asset class at the beginning and end of the accounting period.

Sub-area – The sub-divisions used as management regions for this document.

Water supply – Provision of water by the whole value chain, which includes: Department of Water and Sanitation; bulk water providers; and municipalities.

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1 BACKGROUND

1.1 BRIEF HISTORY

The United Nations (UN) Environment [formerly, the United Nations Environmental Programme (UNEP)] launched the Green Economy Initiative in 2008 (UNEP, 2015). The UN Environment defines a green economy as an economy "that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities". This means that it is a low carbon, resource efficient and socially inclusive economy.

The notion of a green economy is highly appropriate in the South African context as South Africa has a carbon- and resource-intensive economy combined with low levels of economic equity. Water in particular is scarce and the quality of water resources is under pressure. Such scarcity delays the achievement of water equity, constrains economic development and negatively affects environmental quality, which in turn have indirect effects on the economy.

The United Nations Statistics Division (UNSD) embarked on developing environmental economic accounts (EEAs) after the Rio Summit (1992). They published a framework for developing such accounts in 2012 (UNSD, 2012a). This framework is referred to as the System of Environmental-Economic Accounting (SEEA) Central Framework. It is an extension of the System of National Accounts (SNA). The SEEA Central Framework is the first international statistical standard for environmental economic accounting and is an important and helpful guideline. It is, however, also a work in progress. The UNSD envisages that the SEEA Central Framework would have to be augmented in future by various other documents, including the SEEA Experimental Ecosystem Accounts and the SEEA Applications and Extensions. The nature of the SEEA Experimental Ecosystem Accounts still has to be determined, and, to this end, the UNSD has launched a number of pilot studies, one of which is based in South Africa under the leadership of the South African National Biodiversity Institute (SANBI).

There are a number of challenges to the implementation of EEAs. For example, the characteristics of natural capital differ from country to country; therefore, the SEEA Central Framework is generic and allows countries to adapt the exact format of EEAs according to their own situations. The EEAs also depend on environmental data structured in a format compatible with national accounts; such data is often difficult to obtain.

1.2 EEAs IN SOUTH AFRICA

Statistics South Africa (Stats SA) is mandated with developing and compiling EEAs in South Africa. These are satellite accounts that provide a monitoring and evaluation tool of the stocks and flows of natural capital through the economy. Early work on water accounting in South Africa started in the late 1990s under the guidance of Stats SA, the Department of Environmental Affairs (DEA) and the Resource Accounting Network for Eastern and South Africa (RANESA). Thereafter, Stats SA pioneered Water Accounts for South Africa through a series of publications between 2004 and 2010, for example:

- Water Accounts for 19 Water Management Areas (WMAs) – Report No. 04-05-01, March 2004.
- Discussion document: Water Quality Accounts for South Africa, 2000 – April 2005.
- Updated Water Accounts for South Africa: 2000 – D0405, December 2006.
- Water Accounts for South Africa: 2000 – D0405.1, March 2009).

Through these publications, Stats SA has developed a series of documents, flow accounts, stock accounts, views on water quality accounting and a very novel data collection system by data-mining its internal databases.

1.3 Policy Relevance

The development of SEEA outputs has, for the largest part, proceeded over the past two decades with insufficient attention given to potential user requirements or applications. SEEA outputs have predominantly been characterised by a push strategy with practitioners developing accounting frameworks that are often complicated to implement and/or demonstrating insufficient usefulness for the potential users of the accounts (Vardon et al., 2016).

Although there is a range of applications for most conventional national statistical office (NSO) outputs, which drive a demand (or pull) for such outputs, much work is still needed to develop applications for SEEA outputs. For instance, inflation rates are used widely in pricing structures of most firms and in salary increase processes. Gross domestic product growth rates are used for economic growth forecasting and credit ratings. Many other similar applications exist. However, for SEEA outputs such as water accounts, too few users and too few applications still exist.

One example of a SEEA application is the use of EEAs to inform and motivate the design of budgets for line ministries. Another example is in sustainable development goal (SDG) reporting. However, given the scope and severity of environmental pressures and the increasing importance of green economy growth strategies, NSOs need to analyse the need for specific applications carefully.

In South Africa, water accounts could potentially inform water resource management (WRM) related policy with respect to water equity, economic use and ecologically sustainable use. Therefore, water accounts could inform the:

- National Water Resources Strategy.
- The activities of the economic regulator for water.
- Water-related policy design (e.g. water allocations, water tariffs, water allocation).
- Development planning.
- Certain aspects of catchment planning (e.g. catchment management strategies and water resource classification).

In future, water accounts could also provide crucially important data to the water services sector, especially if monetary accounts were to be disaggregated to a municipal level.

The development of such applications fell outside the scope of this study, but it is nevertheless an important recommendation (refer to Section 6.4).

1.4 STUDY AIMS

The study aims were to:

1. Provide a methodological framework for the water EEAs for South Africa according to international best practices.
2. Consult with all relevant role players through engagement.
3. Create a framework (both structure and architecture) and a knowledge base for these accounts to enable more frequent updates and potentially more detail accounts in the future.
4. Provide a research document containing an overview of the methodology, water tables and water EEAs for South Africa that can be published in collaboration with Stats SA.
5. Provide the water tables and water EEAs for South Africa in Microsoft Excel™ to enable ease of use for integrated impact and policy analysis.

2 LITERATURE REVIEW

2.1 Overview

Water accounting is subject to several technical challenges that need to be overcome. These challenges include classifying data and nomenclature, dealing with a variety of data sources, designing the architecture of the accounts, balancing supply and demand data, and lastly linking water accounts to the existing SNA.

The UNSD has published a range of documents to serve as guidelines to practitioners of water accounting. The SEEA Central Framework (UNSD, 2012a) and the UNSD Technical Note on Water form the basis of these guidelines. The SEEA Water and the International Recommendations on Water Statistics provide additional information. Together, these documents capture the best international practice regarding water accounting. The purpose of this section is to highlight key aspects relevant to South African water accounts.

The UNSD guidelines define and demonstrate various concepts, definitions, classifications, structure of tables, and types of account for water and water-related emission accounts (UNSD, 2014).

2.2 Structure of Accounts and Classification

The structure of water accounts refer to the nomenclature of the sectors (or statistical units) in the water value chain that transacts water. The structure of the accounts needs to capture the water economy and reflect the relevant parts of the water value chain, which thus requires a consistent classification of the relevant transacting sectors.

When implementing the SEEA, it is essential to understand and define the statistical units of the economy as they interact with each other and with the natural environment. The economy abstracts water from the environment. Water is exchanged and used within the economy and discharged into the environment.

In water accounting, there are three key sets of statistical units:

- Firstly, there is the statistical units of the economy that use water, namely, enterprises and households:
    - An enterprise is an economic unit that is a producer of goods and services. An establishment is an enterprise or part of an enterprise that is situated in a single location. Establishments are classified to industries using ISIC on the basis of their principal productive activity.
    - A household is defined as a group of persons who share the same living accommodation, who pool some or all of their income and wealth, and who consume certain types of goods and services collectively. Households can also produce goods and services for sale or own use.

  The Department of Water and Sanitation (DWS) on the other hand, has a common classification of the key sectors in water value chain. The Governing Board Induction Manual Chapter One: Overview of the South African Water Sector (DWAF, 2000) defines the following major water use sectors, namely, irrigation, afforestation, urban use, rural use, mining, bulk industrial, and power generation. Thus, with water-related data available in these different classifications, a key challenge of the accounting process is to align classification systems. Ultimately, linking the water accounts to the SNA requires that the ISIC be followed. The ISIC has the advantage of having a higher level of disaggregation (with the exception of urban and rural use). Also, since ISIC is an international standard, this would make the water accounts internationally comparable.

- Secondly, the water sector itself need to be disaggregated into the relevant sub-sectors. In the South African context this requires a disaggregation into raw water supply:
  - DWS and own supply governed by water use licences (WULs).
  - Bulk water supply (water boards and other bulk water suppliers).
  - Water services water service authorities (WSAs).
- Thirdly, statistical units of the natural environment provide the supply and return flow linkages between the natural environment on the one hand, and the water sector, establishments and households on the one hand. In the case of water in the environment, these units are the inland water resources or water bodies (the areas or spaces that contain the water).

The key statistical units of the environment for inland waters are classified as surface water bodies (including artificial reservoirs), groundwater, soil water and other water:

- Surface water is defined as water contained in lakes, rivers and streams, wetlands, glaciers, snow and ice, and artificial reservoirs.
- Groundwater is defined as water yielded by aquifers to wells and springs with only the usable groundwater in aquifers measured. Groundwater may be classified further according to depth (e.g. shallow or deep) or as being unconfined or confined.
- Soil water is defined as the water suspended in the uppermost belt of soil or in the zone of aeration near the ground surface that can be discharged into the atmosphere by evaporation of soil water and transpiration from plants that take up soil water. The soil containing water and the area it occupies could be considered a statistical unit of the environment.
- Other water may include other categories unique to a country's water economy, such as water harvesting (from precipitation) or water transfers from neighbouring countries.

2.3 Account Types

Various types of account exist for water (and for other EEAs).

- Stock accounts quantify the change in stock of natural assets over a specific accounting period. Stock accounts are highly relevant to accounts such as forests, minerals and fisheries where measurable opening and closing stocks of natural assets exist. Stock accounts are akin to balance sheets. Stock accounts are relevant to the water sector from the perspective of water storage, i.e. dam water levels and aquifer yields. However, because water is allocated using complex hydrological information, and because of the highly mobile characteristics of water, it is more useful to construct water flow accounts.
- Flow accounts are akin to income statements, and focus on annual flows of natural resource benefits. Flow accounts are typically suited to water accounting and energy accounting. Stock and flow accounts are often closely related but can be developed independently.
- Physical accounts provide either stock or flow information using physical units such as volume, weight, energy or concentration. In the case of water flow accounts, physical accounts measure the volume of exchanged between the environment and the economy (abstraction and returns) and within the economy (supply and use within the economy). In the case of water quality accounts, they measure concentration of chemicals that cause pollution.
- Monetary accounts are a conversion of physical accounts into monetary units.
- Water quality accounts is a special category of accounts. The SEEA approaches water quality accounting as an emissions account that provide information by economic activity and households on the quantity of pollutants that have been added to or removed from the water during its supply and use. Similarly to physical supply and use tables (SUTs), emission accounts provide economic activities classified according to ISIC and report data in physical units.

- Quality accounts that describe the stock of water in terms of its quality. Its general structure is the same as that of the water stock/asset accounts. The only difference is the addition of the quality dimension, which describes the volume of water. The quality dimension is captured through various columns describing the water quality and classifying volumes of water under each column. Because it is generally difficult to link changes in quality to the causes that affect them, quality accounts describe only the total change in an accounting period without specifying the causes. These accounts use physical data to report the indicators.

2.4 Data Availability and Quality

Much of the data required in environmental accounting fall outside the ISIC system. Moreover, SEEA guidelines are by its nature generic and are, by design, not able to foresee unique in-country natural resource economic production and consumption relationships.

The structure of the accounts requires a thorough understanding of the resource economic production and consumption process, and the transactional structure of the particular sector. It also requires the practitioner to resolve data classification problems resulting from domain-specific data classifications. The architecture of the accounts (see below) also do not necessarily follow a step-wise approach, rather, it often follows a process where transaction and data gaps, and issues are resolved in an iterative and sometimes investigative manner. Both the architecture and structure of accounts may change during the account development process as the SEEA practitioner gains more insight and resolves data issues.

In addition, there is the matter of unconventional data sources. NSOs, in their normal (or conventional) course of work, are mandated to produce official data. Official data adheres to strict quality standards, and is often captured in national statistical quality assessment framework guidelines. Such data is mostly collected via primary data collection instruments – either through questionnaires to representative samples – or drawn from audited reports from government agencies. However, much of the data required for environmental accounts do not conform to these strict official data standards. The data can take various forms as it may be:

- Collected by other government agencies without the necessary quality assurance rigour.
- Modelled, as in the case of hydrological data or forest growth data.
- Extrapolated from small samples.
- Derived from data within the EEA.

The SEEA does not provide guidelines on how to deal with data difficulties. In South Africa, however, the South African Statistical Quality Framework (SASQAF) provides an acceptable approach for addressing these data issues.

National statistics can be certified as four levels:

- **Level 4: Quality Statistics** – These are statistics that meet all the quality requirements as set out in the SASQAF. They are designated as **quality statistics** to the extent that deductions can be made from them, and they are fit for use for their designed purpose. Level 4 applies to highly developed statistical activities with respect to their corresponding indicators.
- **Level 3: Acceptable Statistics** – These are statistics that meet most, but not all the quality requirements as stipulated in the SASQAF. They are designated as **acceptable** to the extent that, despite their limitations, deductions can be made, and they are fit for use for their designed purpose. Level 3 refers to moderately well-developed activities with reference to a particular indicator.

- **Level 2: Questionable Statistics** – These are statistics that meet few of the quality requirements as stipulated in the SASQAF. They are designated as **questionable** to the extent that very limited deductions can be made, and they are therefore not fit for use for their designed purpose. Level 2 refers to activities that are developing but still have many deficiencies.
- **Level 1: Poor Statistics** – These are statistics that meet almost none of the quality requirements as stipulated in the SASQAF. They are designated as **poor statistics** to the extent that no deductions can be made from them, and they are not fit for use for their designed purpose. Level 1 refers to activities that are underdeveloped.

Furthermore, the framework provides the prerequisites of data quality (Table 1). The SASQAF therefore defines data quality in a manner that allows for use of all relevant water-related data to construct the water account, and enables continuous improvement of data quality.

Table 1: SASQAF prerequisites and quality dimensions along with their key components. Source: SASQAF (Stats SA, 2010)

Group	Key Component
1. Relevance	• Why do you need to conduct the survey or collect data? • Who are the users of the statistics? • What are their known needs? • How well does the output meet these needs? • Are user needs monitored and fed back into the design process?
2. Accuracy	• Assessment of sampling errors where sampling was used. • Assessment of coverage of data collection in comparison with the target population. • Assessment of response rates and estimates of the impact of imputation. • Assessment of non-sampling errors and any other serious accuracy or consistency problems with the survey results or register based statistics. • Data capturing, data coding and data processing errors. • Source data available provides an adequate basis to compile statistics (e.g. administrative records). • Source data reasonably approximate the definitions, scope, classifications, valuation, and time of recording required. • Source data is timely.
3. Timeliness	• Statistics production time. • Timely receipt of administrative records. • Periodicity of statistical release. • Punctuality of statistical release.
4. Accessibility	• Catalogue systems are available in the organ of state or statistical agency. • Delivery systems to access information. • Information and metadata coverage is adequate. • Measure of catalogue and delivery systems performance. • Means of sharing data between stakeholders.
5. Interpretability	• Concepts and definitions, and classifications that underlie the data. • Metadata on the methodology used to collect and compile the data. • Key findings, giving the summary of the results. • Presentation of statistics in a meaningful way.
6. Comparability and coherence	• The use of common concepts and definitions within and between series. • The use of common variables and classifications within and between statistical series. • The use of common methodology and systems for data collection and processing within series. • The use of common methodology for various processing steps of a survey such as editing and imputations within series.

Group	Key Component
7. Methodological soundness	• International norms and standards on methods. • Data compilation methods employ acceptable procedures. • Other statistical procedures employ sound statistical techniques. • Transparent revision policy and studies of revisions are done and made public.
8. Integrity	• Professionalism and ethical standards that guide policies and practices. • Assurances that statistics are produced on an impartial basis. • Ethical standards are guided by policies and procedures.

2.5 Architecture of Accounts

Institutionalisation of the SEEA requires a developmental approach to constructing accounts. To this end, the approaches of piloting and experimentation are already well established in the SEEA domain. An important aspect of account piloting is to develop the architecture of accounts.

The architecture refers to the design of the set of accounts that comprise the environmental account. The architecture will be determined by user requirements and data availability. This may require any combination of stock and flow, physical and monetary accounts. It is to be expected that both structure and architecture will evolve during the accounts development process, and during the accounts balancing process.

3 METHODOLOGICAL FRAMEWORK

3.1 Overview

The water flow and water quality accounts were developed as two distinct sets of accounts with different methodological frameworks.

Physical flow accounts – measuring water transactions in cubic metres and using data predominantly from the Water Resources (WR2012) data set – were constructed for every WMA, which were then structured into a 28-sector national water account. Monetary accounts – measuring water transactions in monetary terms and using data predominantly from the Stats SA SUTs – were constructed for an aggregated 37-sector national water account. Thereafter, the physical account was expanded to a 37-sector national water account using the additional data from the monetary account. A total of 348 transactions were identified in constructing the physical flow accounts at WMA level and the monetary flow accounts at national level. The water accounts further enabled the derivation of a weighted average water tariff account. These annual flow accounts were developed for the five-year period from 2012 to 2016.

The study also developed a water quality accounting framework for South Africa. The water quality accounts also adopted a flow account approach, monitoring water pollution emissions. Emissions were measured as concentration of key water chemistry indicators. The key indicators used were total dissolved solids (TDS), nitrates, phosphates and pH. Data for this analysis was sourced from the DWS. These accounts were designed to report the status of water quality emissions on an annual basis by WMA. To this end, the DWS's monitoring sites that represent final drainage points were used as far as possible as key reporting points. Several applications of water quality accounts were demonstrated.

Data was extracted from several data sources. Every data point was referenced for ease of future update. Considerable focus was given to data sources, data mining and data quality control. Each data point was rated for accuracy according to the SASQAF.

3.2 Methodological Details

The detailed methodological actions to be followed in constructing the water accounts have been captured through formulae and notes in detailed data sets and tables in the spreadsheets accompanying this report. The requirements for updating the accounts have been workshopped with Stats SA in several multi-day work sessions. Stats SA intends developing a sources and methods document to formalise the water accounts update process (refer to Section 6).

3.3 Physical and Monetary Flow Accounts

3.3.1 Physical and monetary flow accounting framework

The water flow accounts for South Africa follows an environmentally extended SUT approach. This is achieved through a water balance and SUT approach that traces water transactions through the economy from source through the full value chain to sink. The accounts disaggregate the physical flow of water, measured in cubic metres, to a WMA level. This version of the accounts presents monetary accounts at a national level only. It is possible to disaggregate monetary accounts to a WMA level, although this would depend on further development of water tariff accounts.

The structure of the water accounts follows a SUT approach, which has several benefits. Firstly, the structure allows for a very intuitive analysis of the flow of water through the economy and the water value chain. Secondly, it aligns in structure and classification with other Stats SA data products, especially the SUTs. Thirdly, it enables users to analyse the water economy using economy-wide modelling methodologies.

The methodology follows the SEEA guidelines. The detailed methods used to derive each data point are captured in the water accounting spreadsheets attached to this report.

3.3.2 Data sources

A total of 348 transactions were identified in constructing the physical flow accounts at WMA level and the monetary flow accounts at national level. This data was extracted from several data sources.

Accompanying this report is a Microsoft Excel™ file, which contains the 10 physical flow accounts, the national monetary account, and a backwards integrated physical account. The integrated physical account is derived from water tariff per sector and water revenue.

Every data point is referenced for ease of future update. Each data point is rated for accuracy according to the SASQAF.

3.3.2.1 DWS

No Drop data

Data on the system input volume water was obtained from the DWS No Drop database. The data is reported at a municipal level.

Table 2 shows the total system input volume available to municipalities in South Africa. The data was restructured to conform to the WMA; Table 2 reports it at this level. South African municipalities have a total of 4249 million m^3 of water that they abstracted in 2015.

Table 2: No Drop data on system input volumes in 2015

WMA	System Input Volume
Units	*Million m^3/annum*
RSA	**4 249**
1. Limpopo	786
2. Olifants	516
3. Inkomati–Usuthu	119
4. Pongola–Umzimkulu	802
5. Vaal	983
6. Orange	162
7. Mzimvubu–Tsitsikamma	412
8. Breede–Gouritz	84
9. Berg–Olifants	387

Green Drop data

Data on waste water is reported on DWS's Green Drop database. The 2015 Green Drop database was analysed to determine the total volume of water treated in waste water treatment works (WWTW). The data is available at a plant level, and each plant is categorised under a local or metropolitan municipality. The data was restructured using a geographic information system (GIS) to give volumes of treated water per WMA.

Table 3 shows the amount of water treated for the country in 2015. The data is broken down to each of the new WMAs. According to the Green Drop database, a total volume of 1761 million m^3 waste water was treated in the country in 2015.

Table 3: Volume of waste water treated in 2015

WMA	Design Capacity	Operating Capacity 2015
Units	*Million m³*	*Million m³*
RSA	**1 897**	**1 761**
1. Limpopo	292	413
2. Olifants	190	153
3. Inkomati–Usuthu	15	10
4. Pongola–Umzimkulu	339	249
5. Vaal	465	434
6. Orange	92	70
7. Mzimvubu–Tsitsikamma	151	128
8. Breede–Gouritz	70	50
9. Berg–Oilfants	283	254

Reconciliation strategies

The reconciliation strategies of the water supply schemes were analysed to determine the quantity of water demanded within each WMA. Table 4 gives the reconciliation strategies that were available and used at the time of the investigation.

Table 4: Reconciliation strategies for 2015

WMA	Reconciliation Strategy Available for 2015
1. Limpopo	Town Strategies
2. Olifants	Available
3. Inkomati–Usuthu	KZN Reconciliation Strategy
4. Pongola–Umzimkulu	KZN Reconciliation Strategy
5. Vaal	Vaal Reconciliation Strategy
6. Orange	Bloem Reconciliation Strategy
7. Mzimvubu–Tsitsikamma	Algoa Reconciliation Strategy
8. Breede–Gouritz	Breede–Overberg Reconciliation Strategy
9. Berg–Olifants	Western Cape Reconciliation Strategy

3.3.2.1 Water Resources 2012

WR2012 describes the water resources of South Africa, Lesotho and Swaziland. It is the culmination of several water resource appraisals that have been carried out over the past four decades. The deliverables and all the data sets for the WR2012 study are published online with the purpose of providing data, information, GIS maps, water resource models, spreadsheets and tools to allow water resource practitioners to investigate, analyse and plan their water resources studies.

The WR2012 database includes data on streamflow with particular mention of the flow from one catchment area to another, to another country, or to the ocean. Figure 3 diagrammatically illustrates these flows in South Africa. In Figure 4, the 19 original WMAs are used but the colour scheme indicates the relation to the nine new WMAs, i.e. the WMAs in the figure that are shaded the same colour were combined in the new WMA classification.

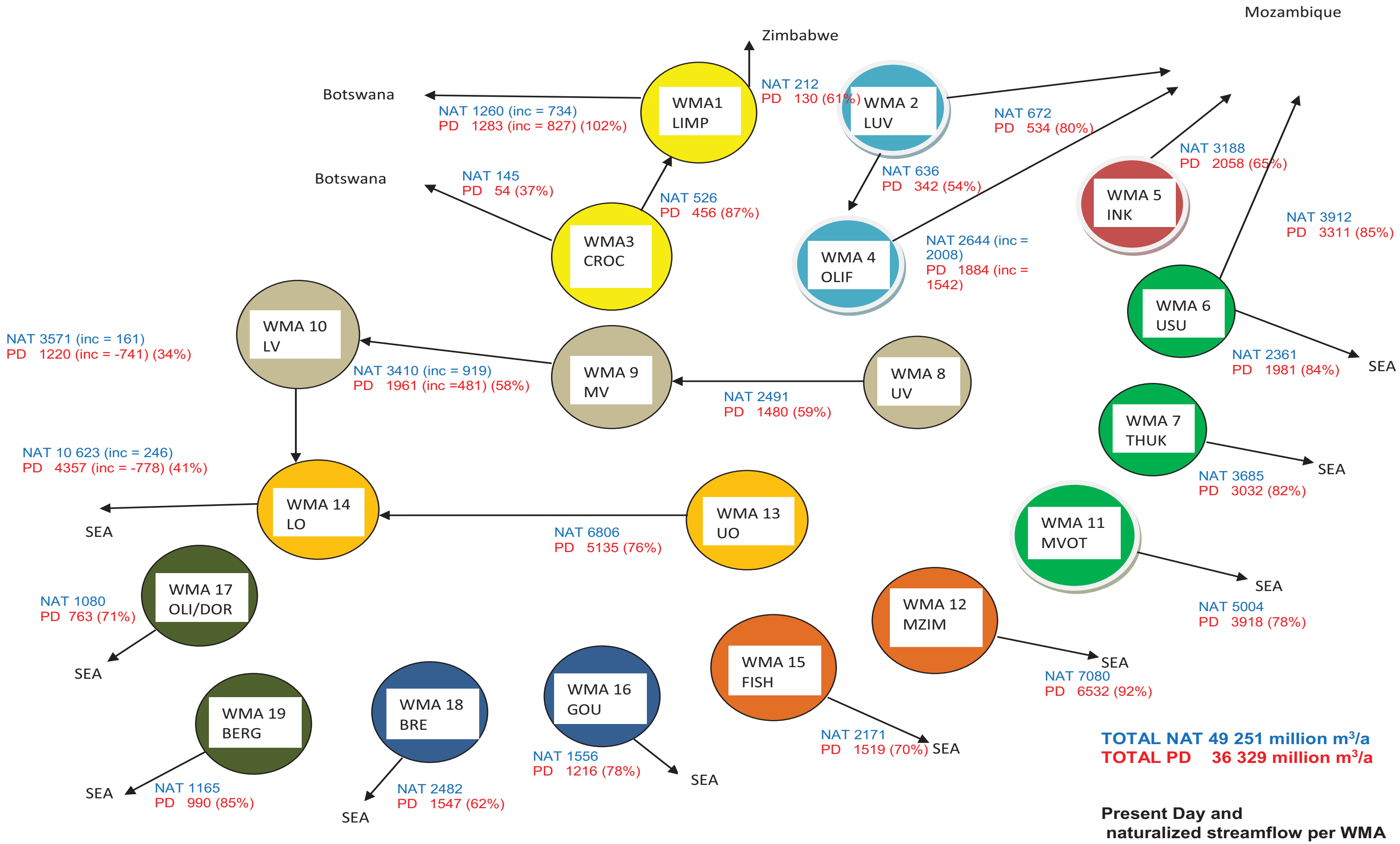

Figure 3: Flows between the 19 WMAs (Source: WR2012, 2015)

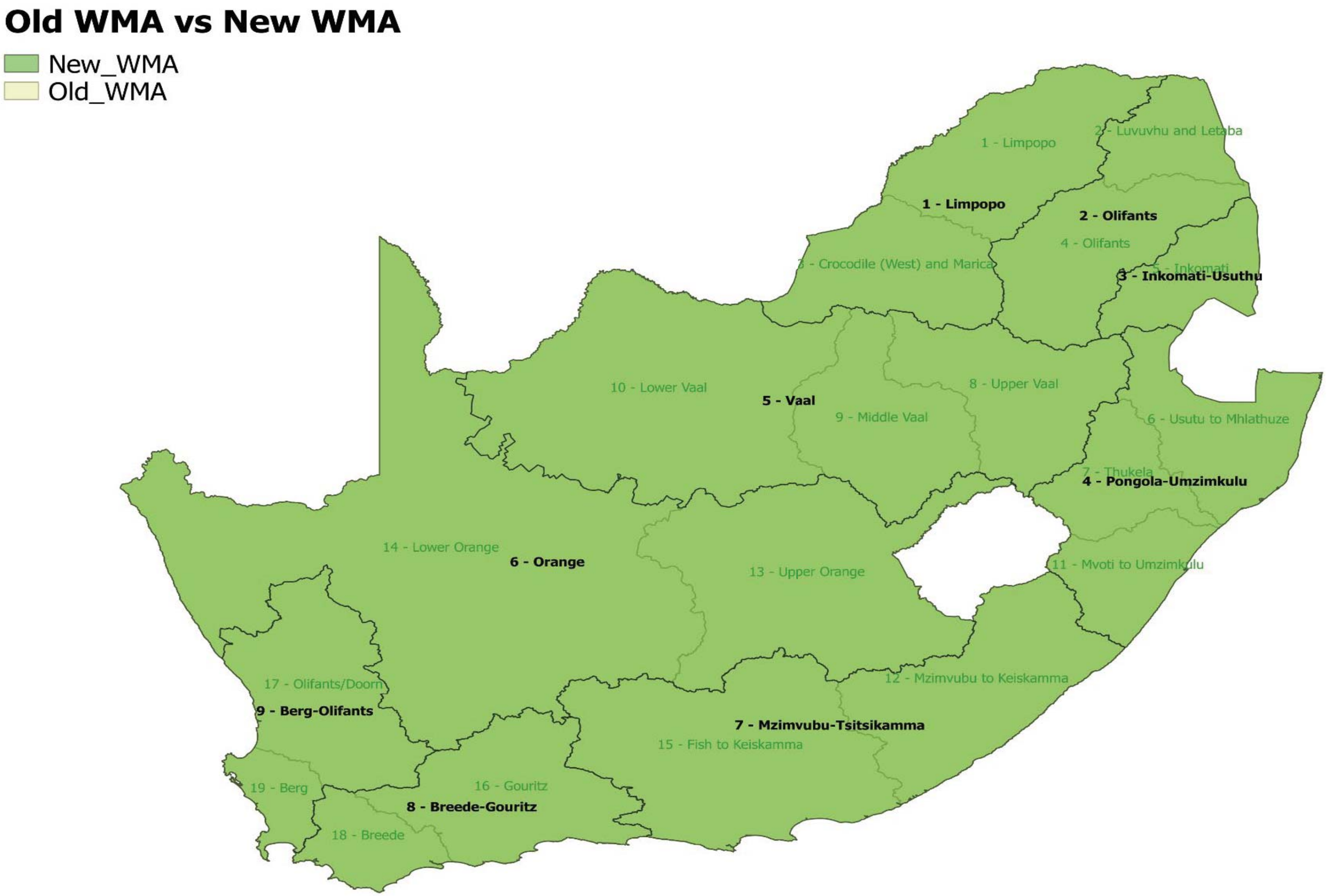

Figure 4: 19 Old WMAs vs the nine new WMAs (Source: DWS, 2016)

A total of 314 data points were identified in constructing the physical and monetary flow accounts. This data was extracted from several data sources. In the Excel™ version of these accounts, each cell containing a value has a comment containing the source for that data, the data quality and its updatability. Table 5 summarises the sources, the sections of the accounts they were required for, and their significance in the accounts.

Table 5: Data sources and their uses for the physical flow accounts

Data Source	Data Points Dependent on this Source	No. of Data Points Using this Data Source*
DWS Green Drop 2015 Data	Volume of waste water treated	40
DWS No Drop System 2015 Data	System input volume per municipality	40
Stats SA Non-financial Census of Municipalities 2005–2006	Municipal water sources	40
WR2012	Total mean annual run-off, flows between catchments and other countries	36
DWS Catchment and All Town Reconciliation Strategies	Source of water and water use	30
DWS Groundwater Strategy 2010	Volume of groundwater extracted and used	10
Stats SA Electricity LSS	Volume of water used in the electricity industry	10
Water Boards Annual Reports	Water supply by water boards in the country	10

* Some data points used information from multiple data sources; therefore, the total number of data points in the far right column adds up to more than the total number of data points

3.3.2.2 Water boards and Trans-Caledon Tunnel Authority (TCTA) annual reports

The annual reports of all the water boards were analysed. Information on the total water available for the water boards was collected using the ports (Table 6). In some instances, system input volumes were not reported in the annual reports. For those cases, it was assumed that the system input volumes were equal to the sales of water by the water board.

Table 6: Water boards supply of water per WMA

WMA	Water board supplied water
Units	*m^3*
RSA	**2 805 813 710**
1. Limpopo	737 093 858
2. Olifants	510 561 249
3. Inkomati–Usuthu	0
4. Pongola–Umzimkulu	606 222 000
5. Vaal	796 044 671
6. Orange	110 309 932
7. Mzimvubu–Tsitsikamma	40 942 000
8. Breede–Gouritz	4 640 000
9. Berg–Olifants	0
TCTA Annual Report	

3.3.2.3 Stats SA (monetary data)

Stats SA collects and estimates transactions data for all the payments for goods and services between industries, governments and consumers (economic sectors). Some transactional data is estimated from base years in the SNA depending on the available transactional data. These transactions are balanced using statistical, mathematical and accounting techniques. The input–output model is constructed from the SUTs. The data in the input–output tables is then used to calculate the large number of values in the monetary accounts.

Table 7 summarises the databases available within Stats SA that were data-mined.

Table 7: Stats SA data audit

Questionnaire	Versions/Years of Data Received	Type of Data
Annual Financial Survey	2013–2014	No direct relevant information
General Household Survey	2006–2014	Qualitative information on service delivery
Census of Agriculture	2007	Crop water use data at magisterial district level
Large Sample Survey (LSS) – Electricity, Gas and Water Supply	2013	Water volumes used Water purchases
LSS – Manufacturing	2015	Water purchases
SUTs	2013, 2014	Monetary transitions for water use sectors defined in the supply use tables
Survey of Actual Capital Expenditure of Municipalities	2007–2014	No direct relevant information
Survey of Actual Capital Expenditure of National Government, Provincial Government and Extra-budgetary Funds	2007–2014	No direct relevant information
Survey of Actual Capital Expenditure of Public Corporations	2007–2014	No direct relevant information
Financial Census of Municipalities	2007–2014	Water purchases by municipalities Water sales by municipalities
Non-financial Census of Municipalities*	2007–2014	Number of consumer units served

* The Non-financial Census of Municipalities questionnaire structure has changed from 2005/6 when the questionnaire included questions about the quantity of water sold, as well as the sources of these quantities for each municipality. The newly structured questionnaire does not have these questions and the older questionnaire's data was used to estimate the ratios of the various sources.

Table 8 and Table 9 summarise data that was obtained from the Stats SA data audit. Firstly, Table 8 summarises the purchases of water in both the electricity and manufacturing sectors. There is only information regarding the value of water used by the manufacturing sector and not the quantity of water used. The information was therefore irrelevant for the physical flow accounts but it will be of critical importance in the monetary accounts.

Table 8: Water use in electricity and manufacturing sectors for 2013

Data source	Electricity		Manufacturing
Units	*Thousand m³*	*R'000*	*R'000*
Water use	335 302	R1681	R4275

Table 9 shows the percentage breakdown of municipal water source per WMA. The information comes from the Non-financial Census of Municipalities of 2005/6. South African municipalities get 54.1% of their water from water boards, 7.6% from other water service providers (WSPs) and 38.3% from their own sources.

Table 9: Non-financial Census of Municipalities proportion of municipal water sources

WMA	Water Boards	Other Service Providers	Own Sources
Units	*%*	*%*	*%*
RSA	**54.1%**	**7.6%**	**38.3%**
1. Limpopo	78.8%	6.1%	15.1%
2. Olifants	68.5%	4.0%	27.5%
3. Inkomati–Usuthu	22.3%	4.6%	73.1%
4. Pongola–Umzimkulu	62.4%	0.8%	36.8%
5. Vaal	74.7%	8.8%	16.5%
6. Orange	36.8%	12.4%	50.8%
7. Mzimvubu–Tsitsikamma	14.1%	22.3%	63.6%
8. Breede–Gouritz	2.5%	7.2%	90.3%
9. Berg–Olifants	3.4%	7.0%	89.6%

3.4 Water Quality Accounts

3.4.1 Water quality flow accounting framework

As is the case with flow of water, water quality is rarely static, but changes over time and space. The proposed water quality accounts for South Africa therefore adopts a flow accounting approach that measures the concentration of key water chemistry variables, which enables an annual water quality assessment.

The structure and nomenclature of the water quality accounts are governed, firstly, by the generic architecture of water emissions accounts as specified by the SEEA Central Framework and, secondly, by the water chemistry parameters used, which require some discussion here. The SEEA Central Framework envisages a generic structure comprising the water sector (ISIC 42), all industries (all other ISIC sectors), households, and the environment (Figure 5).

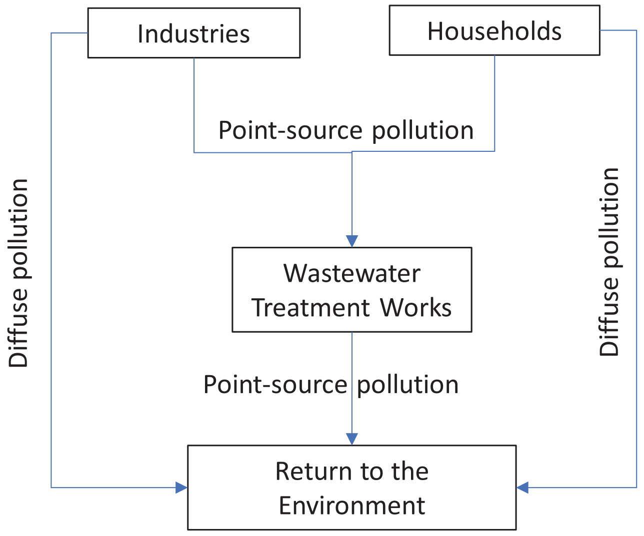

Figure 5: Generic architecture for water emission accounts as defined by the SEEA Central Framework (UNSD, 2012a)

The resultant architecture of the water quality account, as far as a water quality supply table is concerned, requires data on point source and diffuse emissions from industries and households, and waste water inflows and sewage effluent outflows from WWTW. Such data is not available in South Africa at present in the format required for national accounting.

However, the DWS does have a water quality monitoring programme that monitors physical, chemical and microbiological parameters and reporting concentration levels. Water is sampled at a large number of data points across the country at a frequency that varies from weekly to monthly. This data source is available from the DWS Resource Quality Information System (RQIS) unit (available online: www.dwa.gov.za/iwqs/). The DWS RQIS database has more than 2000 monitoring points; as a result, a water quality flow account architecture was developed that drew selected data from 34 key monitoring points for selected water chemistry measures.

For a national water account, it is useful to focus on a smaller number of water quality indicators. This requires a focus on key and generic water pollution contributors, which for the purpose of this pilot water quality accounts in South Africa principally include:

- Water pollution resulting from waste water effluent and return flows from disturbed land, leading to nutrient enrichment or eutrophication; and
- Water pollution resulting from acid mine drainage (AMD) water and containing constituents such as sulphate arising from accelerated oxidation of sulphur-bearing minerals in exposed rock consequent to mining operations.

Four water chemistry indicators provide information on the above, which include TDS, nitrates, phosphates and pH. These indicators enable monitoring of the state of water quality at a national level and, should there be a problem in a particular catchment, other additional indicators reported by the DWS may be interrogated to gain a deeper understanding.

TDS concentration is a measure of the quantity of all dissolved compounds in water that carry an electrical charge. Domestic and industrial effluent discharges and surface run-off from urban, industrial and cultivated areas are examples of the types of source that may contribute to increased TDS concentrations. Nitrogen is found in various forms in terrestrial and aquatic ecosystems. These forms of nitrogen include ammonia (NH_3), nitrates (NO_3), and nitrites (NO_2). Nitrates are essential plant nutrients, but in excess amounts they can cause significant water quality problems (US EPA, 2013).

Phosphorus is an essential nutrient for plants and animals that make up aquatic food webs. Since phosphorus is the nutrient that is in short supply in most fresh water, even a modest increase in phosphorus can, under the right conditions, set off a whole chain of undesirable events in a stream. These could include accelerated plant growth, algae blooms, low dissolved oxygen, and the death of fish, invertebrates and other aquatic animals (US EPA, 2013).

The ISIC and water chemistry nomenclature discussed above are however not sufficient for a water quality accounting framework to comprehensively report on the state of water quality at a national level. One problem is that the concentration of water chemistry indicators vary across the rainfall year as streamflow varies. The water quality accounts therefore have to report several concentration measurements across the rainfall year, for instance minimum, maximum and/or average. An alternative is to derive pollution loads by applying the concentration measurements to corresponding flows.

Another challenge is selecting the most representative water quality monitoring points at a national level. Water quality varies along the length of river basins based on spatial position of emission loads, dilution and the ability of aquatic systems to purify and/or assimilate water pollution. At a minimum, the accounts need to report at least one monitoring point per WMA.

Another problem is to indicate the level of water emissions that is acceptable from an environmental regulation perspective. To this end, the target water quality range (TWQR) of the selected water quality indicators, as specified by the DWS, can be used (DWAF, 1996). The water quality accounts therefore adopt a four-tiered colour-coding system, as set out in Table 10, to indicate whether the water quality at a particular monitoring point is ideal, acceptable, tolerable or unacceptable. A colour scheme is used in water quality accounts to visually provide an indication of the water quality range. Table 11 shows the colour key that should be used in the accounts.

Table 10: TWQR of the indicators

Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
TDS	mg/ℓ	< 260	260 to 975	975 to 2010	> 2010
pH (lower range) (upper range)	pH units	> 5 < 8.4	5 to 4.5 8.5 to 9.5	4.5 to 4 9.5 to 10	> 4.5 > 10
Chloride	mg/ℓ	< 100	100 to 175	175 to 600	> 600
Sulphate	mg/ℓ	< 200	200 to 250	250 to 400	> 400
Nitrate/Nitrite	mg/ℓ	< 6	6 to 10	10 to 20	> 20
Phosphate	mg/ℓ P	< 0.01	0.01 to 0.03	0.03 to 0.25	> 0.25

Table 11: Colour key for Excel™ spreadsheet

Colour Codes Within Water Quality Accounts	
Green	Ideal
Grey	Acceptable
Yellow	Tolerable
Red	Unacceptable

The water quality assessment should not focus on the instantaneous concentration as it seldom has an impact on the water user. Rather, the overall difference in the magnitude of the concentration and range of concentration over a period of time must be used as a measurement of the water quality status. For this reason, individual water quality measurements (or data) are of little use to water quality managers, and regular measurements over a number of years are required. The water quality accounts are therefore structured to report a comprehensive time series of the above indicators, rated as set out above, which thus clearly indicate water quality trends and variations.

Additional work is still needed to develop the required applications of water quality accounts, and thus this study has taken an approach of demonstrating various types of reporting table. To this end, the accounts were structured spatially as WMAs. In addition, a nodal approach was adopted to identify key water quality monitoring points that correspond as far as possible to the DWS ecological water requirement monitoring sites. The DWS monitoring points were therefore used to map each river system by WMA. Four to five monitoring points were used on major tributaries to present the state of the water quality in each WMA. Monitoring sites chosen were also monitored regularly.

3.4.2 Data sources

The data used for the water quality assessment was obtained from the DWS Water Quality database, which is available from the DWS RQIS directorate at www.dwa.gov.za/iwqs/wms/data/000key.asp. This data was used to determine the history and trends of the water quality over a period of time and to assess the present or current water quality status. The time frames of the data used were between 2008 and 2016 as shown in Table 12 and Table 13. There were some limitations during the process of developing the water quality model: There was a lack of some water quality and flow rate data. Some sites were last sampled in 2012 for water quality, and there was no flow rate data in some sites.

Table 12: DWS monitoring points used to develop water quality accounts

Monitoring Stations	Date of First Sample	Date of Last Sample
A7H00Q01	2011	2016
A5H008Q01	2011	2015
B7H017Q01	2011	2016
C9H024Q01	2012	2016
D8H004Q01	2011	2015
G4H007Q01	2011	2016
G1H023Q01	2011	2016
P4H001Q01	2011	2016
X2H036Q02	2008	2016
V5H002	2008	2016
W4H009Q01	2008	2014

Table 13: DWS monitoring points used to develop Olifants WMA case study

Monitoring Stations	Date of First Sample	Date of Last Sample
B1H022	January 2009	August 2012
B1H021	January 2009	November 2012
B1H020	January 2005	August 2015
B1H018	January 2009	August 2015
B1H005	January 2009	September 2012
B1H010	January 2005	November 2012
B2H007	January 2005	September 2012
B2H014	January 2005	August 2015
B2H015	January 2005	July 2015
B3H001	January 2005	April 2012
B3H007	January 2005	August 2015

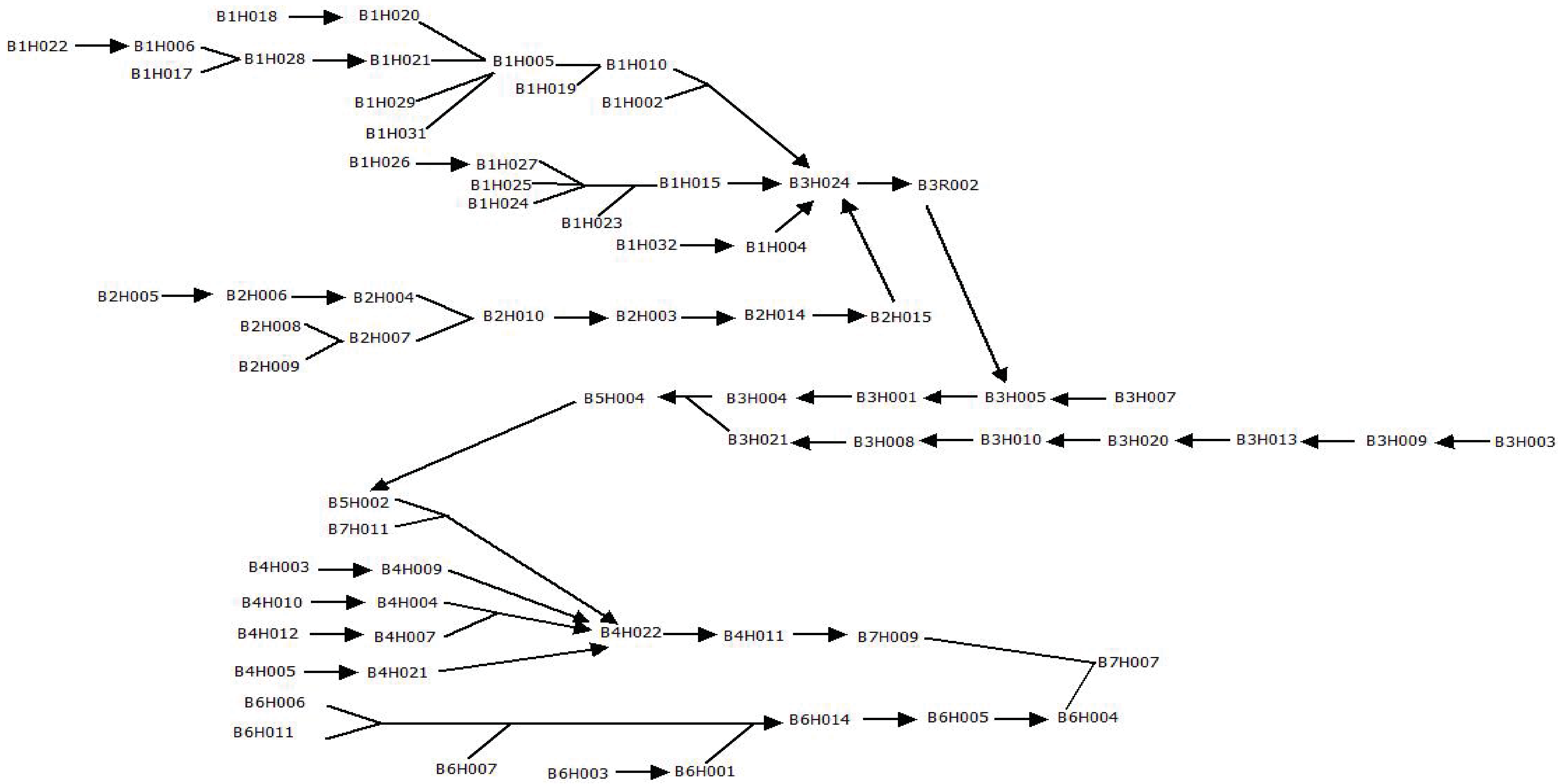

Figure 6: Mapping of DWS water quality monitoring sites in the Olifants WMA (Source: DWS Water Quality Monitoring Points)

3.5 DATA QUALITY

All data used in the flow and quality accounts was assessed according to the SASQAF. The SASQAF guideline was used to define four categories of data quality as set out in Table 14.

Table 14: Summary of informal quality assessment

Colour Codes Within Water Accounts	
White	Expected empty cells
Green	Good statistics from official reports
Khaki	Good statistics from unofficial reports
Yellow	Good statistics but had to aggregate/disaggregate based on additional sources
Red	Poor statistics causing imbalance in the accounts – manual corrections were made

The detailed methodology enabled the different classifications (relating to nomenclature) used in water management and in national accounting to be aligned in a single accounting system. Thereafter, a wide-ranging data-mining initiative was conducted to identify, collect and classify data. Moreover, both the physical and monetary flow accounts followed the structure of an economic input–output table, which traditionally illustrates the transactional flows between the various economic sectors. Similarly, these accounts illustrate the flow of water between the various role players in the industry. By adopting this structure, it was possible to proactively address data discrepancies as every data point has two potential sources through balancing of rows and columns.

Of the 314 data points used in the water flow account, 212 data points were for physical accounts and 102 data points were for monetary accounts. Ultimately, the final consolidated monetary account had 102 data points of which 49 were official data points from Stats SA reports. One data point was good statistics although not from an official data source, 33 data points were good statistics that were disaggregated or aggregated, and 21 data points were rated as poor data. This shows that accurate Water Accounts for South Africa are feasible. In addition, a large number of data points used in the physical accounts were good but unofficial statistics; however, they could likely be made official, over time, by formally adopting the SASQAF approach.

Particular data limitations related to the following:

- Groundwater data is problematic: both at a national level and with respect to the disaggregation of the national volume WMA level.
- The DWS supply of water to other WSPs. The data for this was not available; however, this volume could be estimated by using the official system input volumes from DWS and the Non-financial Census of Municipalities of 2005/6.
- The source of municipal water as well as commercial and domestic customers. The lack of water volume information in the latest Non-financial Census of Municipalities required using the official system input volumes from the DWS and the Non-financial Census of Municipalities of 2005/6 to estimate these volumes.
- Agricultural return flows – Only some agricultural return flow information was available. Based on the relationships between water use and return flow, an estimate could be made for the WMAs without the information.
- Municipal supplies of the WMAs were estimated based on the 2005/6 Non-financial Census of Municipalities and not purely on good statistics from official reports. Manual adjustments were made so that the data conformed to all the other sources of information and balanced accounts.
- DWS reconciliation studies and WR2012 data sources are not available on an annual updated basis.
- Water quality data is available from one source, but is not official as defined by SASQAF.

4 INITIAL RESULTS

4.1 Physical and Monetary Flow Accounts

The national physical water supply and use of South Africa are summarised in Table 15 to Table 17. These tables summarise how water is distributed (or supplied), how water is used, what the monetary size of the water sector is, and what the weighted average water tariffs are.

The total water supply in South Africa in 2016 is estimated at 14.7 billion m^3/a as shown in Table 16. The DWS, through its role of custodian of all water resources in the country, governs the abstraction of all water used in the country, either through WULs or other authorisations. The bulk of this water is sourced from surface water (11.9 million m^3/a) (which includes imports from the Lesotho Highlands Water Project), with the remainder sourced from groundwater (2.8 million m^3/a) (also refer to Figure 2).

Although the DWS governs all water use through WULs, most WUL holders abstract and manage their own water, and thus pay for their own water distribution. Such own water supply is estimated at 7.8 billion m^3/a, with the balance (6.9 billion m^3/a) distributed by municipalities and other WSPs. A small volume of water is also exported (0.02 billion m^3/a).

Water boards and other bulk water users are authorised to extract water (2.8 billion m^3/a and 0.8 billion m^3/a respectively). Municipalities source most of their water from water boards, with the remainder being "own sources" through DWS authorisations (5.9 billion m^3/a). Return flows from electricity producers, domestic users and other users are supplied to municipalities as returned effluent for treatment (1.8 billion m^3/a). These sectors fall within Standard Industrial Classification (SIC) 4200, which are delineated into collection (i.e. water boards and other bulk water suppliers) and local (i.e. municipalities). Some classification discrepancies exist between physical data sources (WR2012, DWS Drop Data and annual reports) and Stats SA monetary data sources.

The total nett water use (i.e. total water uses minus return flows) is estimated at 9.9 billion m^3/a.

Agriculture is the largest total user of water (6.9 billion m^3/a) followed by households, the mining sectors, the manufacturing sectors and electricity generation. Approximately 13.6% of all distributed water can be classified as non-revenue water, i.e. comprises water losses, own use by water authorities or unaccounted-for water – this is estimated at 2.0 billion m^3/a.

Total sewage return flows to WWTW is 1.8 billion m^3/a.

The total monetary water supply and use of South Africa are summarised in Table 18 to Table 22. The water sector (SIC 4200) had a combined annual revenue of R66.5 billion in 2016. Comparison of monetary accounts from 2012 to 2016 reveals much information, in particular, that the sector had an annual growth of 7.4% since 2012 (R45.5 billion).

With the exception of the mining and beverage manufacturing industries (both approximately 3.3%), expenditures on water purchases are less than 1% of the total expenditure of all industry sectors.

Households had the highest payment for water consumption from 2012 to 2016 (R16.5 billion to R23.9 billion), even though agriculture is the largest water use sector. The agriculture water sector had the smallest payment between 2012 and 2016 (R732 million to R917 million).

The monetary accounts underestimate the total cost of water management in the economy as various expenses related to "own use" management of water would be captured under other expense items. This is especially underestimated in the agriculture, mining and electricity generation sectors. For instance, Table 22 indicates that the weighted average cost of water for electricity generation is R0.16/m^3; however, Eskom's cost of water management is approximately R7.65/m^3 (Eskom Tariff Increase Application, 2017).

Table 15: Extract of the physical supply table based on WR2012, DWS Drop data and annual reports

Million m^3/a	Water Distribution			Industry Groups					Residuals/ Return Flows	Total
	Water Boards	Other WSPs	Municipalities	Agriculture	Mining and Bulk Industries	Electricity	Other	Domestic		
DWS	2 806	838	1 571	6 907	521	335				12 979
Water boards			2 366					113	340	2 819
Other WSPs			312					527	0	838
Municipalities							1 306	2 944	1 666	5 916
Agriculture										0
Mining and bulk industries			0							0
Electricity			67							67
Other			422							422
Domestic			1 273							1 273

Table 16: Extract of the physical supply table based on Stats SA collected data, WR2012, DWS Drop data and annual reports

Million m³/a			SIC_4200_Collection	SIC_4200_Local	Flows from the Environment
			Collection, Purification and Distribution of Water – Collection	Collection, Purification and Distribution of Water – Local	
(I) Sources of abstracted water	Inland water resources				
		Surface water	4 957	6 895	11 869
		Groundwater	2 806	n/a	2 806
		Total	7 763	6 895	14 675
	Other water sources				
		Precipitation	n/a	n/a	0
		Sea water	n/a	n/a	0
		Total	0	0	0
	Total supply of abstracted water		7 763	6 895	14 675
(II) Abstracted water	For distribution		0	6 895	6 895
	For own use		7 763	0	7 763
	Total		7 763	6 895	14 658
(III) Waste water and reused water	Waste water				
		Waste water to treatment	0	1 762	1 762
		Own treatment	0	0	0
	Reused water				
		For distribution	0	n/a	0
		For own use	0	0	0
	Total		0	1 762	1 762
(IV) Return flows of water	To inland water resources				
		Surface water	0	1 762	2 780
		Groundwater	n/a	n/a	n/a
		Soil water	n/a	n/a	n/a
	Total		0	1 762	2 780
	To other sources		n/a	n/a	n/a
	of which: Losses in distribution		n/a	2006	2006
	Total returns flows		-	2006	4 786
(V) Other	Evaporation of abstracted water		n/a	n/a	n/a
	Transpiration		n/a	n/a	n/a
	Water incorporated into products		n/a	n/a	n/a
Total nett supply			**7 763**	**4 889**	**9 889**

Table 17: Extract of the physical use table based on Stats SA collected data, WR2012, DWS Drop data and annual reports

Million m³/a		SIC 1 Agriculture, Forestry & Fishing	SIC 2 Mining	SIC 3 Manufacturing	SIC_41 Electricity, Gas, Steam and Hot water supply	SIC_4200 (Local) Collection, purification and distribution of Water - Local	SIC 5 Construction	SIC 6 Wholesale and retail trade	SIC 7 Transport, storage and communication	SIC 8 Business Services	SIC 9 Government Services	Households	Accumulation	Rest of the World	Flows from the environment
(I) Sources of Abstracted Water	Inland Water Resources														
	Surface Water	6,927	600	514	339	2,006	13	301	54	217	103	3,583	n/a	17	14,675
	Groundwater												n/a		
	Soil Water	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Total	6,927	600	514	339	2,006	13	301	54	217	103	3,583	n/a	17	14,675
	Other water sources														
	Precipitation	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Sea Water	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Total														
	Total Use of Abstracted Water	6,927	600	514	339	2,006	13	301	54	217	103	3,583		17	14,675
(II) Abstracted water	Distributed water	-	486	127	3	2,006	13	301	54	217	103	3,583	n/a	-	6,895
	Own use	6,927	114	387	335	-	-	-	-	-	-	-	n/a	17	7,780
	Total	6,927	600	514	339	2,006	13	301	54	217	103	3,583	-	17	14,675
(III) Wastewater and reused water	Wastewater received from	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	-
	Own treatment	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	-
	Reused water														
	Distributed use	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	-
	Own use	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	-
	Total														
(IV) Return flows of water	Return flows of water to the envir														
	To inland water resources	691	328	-	-	2,006	-	-	-	-	-	-	n/a	n/a	3,025
	To other sources	-	4	65	67	-	7	154	28	111	53	1,273	n/a	n/a	1,762
	Total returns flows	691	332	65	67	2,006	7	154	28	111	53	1,273	-	-	4,786
(V) Other	Evaporation of abstracted water	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Transpiration	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Water incorporated into products	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total nett use		6,236	268	449	271	-	6	147	27	106	50	2,310	-	17	9,889

Table 18: Extract of the 2016 monetary SUTs based on Stats SA collected data, WR2012, DWS Drop data and annual reports

Monetary units (R'Million/a)	Units	PC-692: Water distributio		Intermediate demand				Intermediate demand					Final demand		Losses in distribution / Residuals
		SIC_4200 (Collection)	SIC_4200 (Local)	SIC 1	SIC_21	SIC_24	SIC_2	SIC_301 - SIC 304	SIC_305	SIC_306 - 395	SIC_41	SIC_5 - SIC_9			
		Bulk Water Suppliers (Water Boards)	Municipalities	Agriculture, Forestry & Fishing	Mining of coal and lignite	Mining of metal ores, except gold and uranium	Other Mining	Manufacture of food products	Manufacture of beverages	Other manufacturing	Electricity, Gas, Steam and Hot water supply	Construction	Exports	Households	
Natural water (CPC18)	R'M	7,773	2,340	928	25	376	162	170	1,696	81	-	-	5	-	(43)
Water distribution services (CPC692)	R'M	415	15,749	-	598	6,048	1,264	294	22	1,793	53	11,404	-	23,896	(745)
Intermediate Consumption	R'M	11,226	24,739	150,869	48,781	138,154	73,704	226,232	52,857	1,278,430	74,639	2,156,227	-	-	-
Gross_value_added	R'M	15,027	13,907	94,408	71,821	139,166	79,616	94,034	32,382	388,893	113,471	2,669,898	-	-	-
Compensation_of_employees	R'M	3,825	4,609	30,014	21,289	63,987	51,562	48,405	15,038	260,452	32,192	1,429,578	-	-	-
Taxes_less_subsidies	R'M	(482)	140	328	975	1,039	1,758	395	577	2,656	83	64,909	-	-	-
Other_taxes_on_production	R'M	37	140	1,081	975	1,039	1,849	893	791	8,098	836	68,463	-	-	-
Other_subsidies	R'M	(519)	-	(752)	-	-	(91)	(499)	(213)	(5,442)	(753)	(3,554)	-	-	-
Gross_operating_surplus	R'M	11,685	9,158	64,065	49,557	74,139	26,296	45,235	16,767	125,784	81,196	1,175,411	-	-	-
Output	R'M	26,253	38,646	245,277	120,601	277,319	153,320	320,266	85,240	1,667,322	188,110	4,826,125	-	-	-
Total Water	m^3'M	3,644	6,011	6,927	41	440	119	51	339	124	339	689	17	3,583	2,006
Weighted Ave Tariff	R/m^3	2.25	3.01	0.13	15.16	14.60	11.98	9.01	5.07	15.06	0.16	16.55	0.32	6.67	(0.39)

Table 19: Extract of the 2015 monetary SUTs based on Stats SA collected data, WR2012, DWS Drop data and annual reports

Monetary units (R'Million/a)	Units	PC-692: Water distributio		Intermediate demand				Intermediate demand					Final demand		
		SIC_4200 (Collection)	SIC_4200 (Local)	SIC 1	SIC_21	SIC_24	SIC_2	SIC_301 - SIC 304	SIC_305	SIC_306 - 395	SIC_41	SIC_5 - SIC_9			
		Bulk Water Suppliers (Water Boards)	Municipalities	Agriculture, Forestry & Fishing	Mining of coal and lignite	Mining of metal ores, except gold and uranium	Other Mining	Manufacture of food products	Manufacture of beverages	Other manufacturing	Electricity, Gas, Steam and Hot water supply	Construction	Exports	Households	Losses in distribution / Residuals
Natural water (CPC18)	R'M	7,398	2,227	829	23	351	151	159	1,591	76	-	-	5	-	51
Water distribution services (CPC692)	R'M	395	14,989	-	558	5,644	1,179	276	21	1,682	51	10,651	-	22,343	40
Intermediate Consumption	R'M	10,684	23,545	134,697	45,519	128,916	68,776	212,264	49,594	1,199,498	71,036	2,022,341	-	-	-
Gross_value_added	R'M	14,302	13,236	84,288	67,018	129,860	74,292	88,228	30,383	364,882	107,994	2,498,594	-	-	-
Compensation_of_employees	R'M	3,640	4,387	26,797	19,865	59,708	48,114	45,416	14,110	244,372	30,638	1,335,556	-	-	-
Taxes_less_subsidies	R'M	(459)	133	293	910	970	1,640	370	542	2,492	79	60,843	-	-	-
Other_taxes_on_production	R'M	35	133	965	910	970	1,725	838	742	7,598	796	64,214	-	-	-
Other_subsidies	R'M	(494)	-	(672)	-	-	(85)	(468)	(200)	(5,106)	(717)	(3,370)	-	-	-
Gross_operating_surplus	R'M	11,121	8,716	57,198	46,243	69,182	24,538	42,442	15,731	118,018	77,277	1,102,194	-	-	-
Output	R'M	24,986	36,781	218,985	112,537	258,776	143,068	300,493	79,977	1,564,380	179,030	4,520,935	-	-	-
Total Water	m^3'M	3,644	6,011	6,926	41	440	119	52	340	125	339	689	17	3,583	2,006
Weighted Ave Tariff	R/m^3	2.14	2.86	0.12	14.16	13.64	11.20	8.42	4.75	14.07	0.15	15.46	0.30	6.24	0.05

Table 20: Extract of the 2014 monetary SUTs based on Stats SA collected data, WR2012, DWS Drop data and annual reports

Monetary units (R'Million/a)	Units	PC-692: Water distributio		Intermediate demand				Intermediate demand					Final demand		Losses in distribution / Residuals
		SIC_4200 (Collection)	SIC_4200 (Local)	SIC 1	SIC_21	SIC_24	SIC_2	SIC_301 - SIC 304	SIC_305	SIC_306 - 395	SIC_41	SIC_5 - SIC_9	Exports	Households	
		Bulk Water Suppliers (Water Boards)	Municipalities	Agriculture, Forestry & Fishing	Mining of coal and lignite	Mining of metal ores, except gold and uranium	Other Mining	Manufacture of food products	Manufacture of beverages	Other manufacturing	Electricity, Gas, Steam and Hot water supply	Construction			
Natural water (CPC18)	R'M	7,000	2,006	786	25	358	337	151	1,452	74	-	-	5	-	(2)
Water distribution services (CPC692)	R'M	377	13,608	-	611	5,891	456	261	19	1,619	45	9,674	-	20,752	5
Intermediate Consumption	R'M	10,199	21,585	128,282	45,851	130,539	67,194	201,120	46,747	1,185,543	65,188	1,889,556	-	-	-
Gross_value_added	R'M	13,487	11,876	82,917	68,379	132,265	74,020	80,880	26,738	348,758	97,893	2,338,300	-	-	-
Compensation_of_employees	R'M	3,380	4,242	25,259	20,385	51,402	46,423	41,537	13,316	228,527	27,811	1,244,338	-	-	-
Taxes_less_subsidies	R'M	(383)	118	292	806	859	1,457	351	490	2,454	104	54,015	-	-	-
Other_taxes_on_production	R'M	31	118	855	806	859	1,529	743	657	6,731	705	56,891	-	-	-
Other_subsidies	R'M	(414)	-	(563)	-	-	(71)	(392)	(168)	(4,277)	(601)	(2,876)	-	-	-
Gross_operating_surplus	R'M	10,489	7,516	57,366	47,188	80,004	26,140	38,993	12,933	117,777	69,978	1,039,946	-	-	-
Output	R'M	23,686	33,461	211,199	114,230	262,804	141,214	282,001	73,485	1,534,301	163,081	4,227,856	-	-	-
Total Water	m^3'M	3,644	6,011	6,924	48	486	113	50	305	128	338	675	18	3,583	2,006
Weighted Ave Tariff	R/m^3	2.02	2.60	0.11	13.27	12.86	6.99	8.27	4.82	13.18	0.13	14.33	0.28	5.79	0.00

Table 21: Extract of the 2013 monetary SUTs based on Stats SA collected data, WR2012, DWS Drop data and annual reports

Monetary units (R'Million/a)	Units	PC-692: Water distributio		Intermediate demand				Intermediate demand					Final demand		Losses in distribution / Residuals
		SIC_4200 (Collection)	SIC_4200 (Local)	SIC 1	SIC_21	SIC_24	SIC_2	SIC_301 - SIC 304	SIC_305	SIC_306 - 395	SIC_41	SIC_5 - SIC_9			
		Bulk Water Suppliers (Water Boards)	Municipalities	Agriculture, Forestry & Fishing	Mining of coal and lignite	Mining of metal ores, except gold and uranium	Other Mining	Manufacture of food products	Manufacture of beverages	Other manufacturing	Electricity, Gas, Steam and Hot water supply	Construction	Exports	Households	
Natural water (CPC18)	R'M	6,530	1,907	737	25	339	127	157	1,438	74	-	-	5	-	(87)
Water distribution services (CPC692)	R'M	331	12,161	-	561	5,329	1,034	250	18	1,496	40	8,763	-	18,524	(91)
Intermediate Consumption	R'M	9,399	19,505	116,247	43,957	120,491	59,624	189,447	44,671	1,119,966	59,417	1,749,491	-	-	-
Gross_value_added	R'M	12,462	10,666	74,260	67,766	138,203	70,963	71,438	25,460	312,032	92,115	2,177,590	-	-	-
Compensation_of_employees	R'M	3,190	4,152	23,111	18,936	49,611	46,255	37,314	11,929	211,135	25,494	1,136,544	-	-	-
Taxes_less_subsidies	R'M	(395)	106	192	724	771	1,299	266	419	1,671	19	48,179	-	-	-
Other_taxes_on_production	R'M	28	106	767	724	771	1,372	667	590	6,042	633	51,064	-	-	-
Other_subsidies	R'M	(423)	-	(575)	-	-	(73)	(401)	(171)	(4,371)	(614)	(2,885)	-	-	-
Gross_operating_surplus	R'M	9,667	6,408	50,957	48,106	87,821	23,409	33,858	13,112	99,226	66,602	992,868	-	-	-
Output	R'M	21,861	30,171	190,507	111,723	258,694	130,586	260,885	70,131	1,431,999	151,532	3,927,081	-	-	-
Total Water	m^3'M	3,644	6,011	6,926	47	474	116	55	334	128	338	650	19	3,583	2,006
Weighted Ave Tariff	R/m^3	1.88	2.34	0.11	12.37	11.96	9.98	7.41	4.36	12.25	0.12	13.48	0.26	5.17	(0.09)

Table 22: Extract of the 2012 monetary SUTs based on Stats SA collected data, WR2012, DWS Drop data and annual reports

Monetary units (R'Million/a)	Units	PC-692: Water distributio		Intermediate demand				Intermediate demand					Final demand		Losses in distribution / Residuals
		SIC_4200 (Collection)	SIC_4200 (Local)	SIC 1	SIC_21	SIC_24	SIC_2	SIC_301 - SIC 304	SIC_305	SIC_306 - 395	SIC_41	SIC_5 - SIC_9			
		Bulk Water Suppliers (Water Boards)	Municipalities	Agriculture, Forestry & Fishing	Mining of coal and lignite	Mining of metal ores, except gold and uranium	Other Mining	Manufacture of food products	Manufacture of beverages	Other manufacturing	Electricity, Gas, Steam and Hot water supply	Construction	Exports	Households	
Natural water (CPC18)	R'M	5,698	1,540	739	24	299	288	149	1,220	72	-	-	5	-	66
Water distribution services (CPC692)	R'M	298	10,157	-	551	4,617	335	242	17	1,432	30	8,021	-	16,577	(10)
Intermediate Consumption	R'M	8,365	16,404	109,904	40,332	102,146	53,525	180,014	41,617	1,053,619	54,025	1,598,824	-	-	-
Gross_value_added	R'M	11,254	9,454	70,592	66,343	119,486	70,537	63,117	24,428	292,495	84,016	2,005,379	-	-	-
Compensation_of_employees	R'M	2,732	3,540	21,429	17,447	44,313	43,800	33,948	10,479	191,482	23,203	1,032,692	-	-	-
Taxes_less_subsidies	R'M	(390)	95	123	648	691	1,157	204	360	1,123	(36)	42,325	-	-	-
Other_taxes_on_production	R'M	25	95	687	648	691	1,229	597	528	5,411	567	45,732	-	-	-
Other_subsidies	R'M	(415)	-	(564)	-	-	(72)	(393)	(168)	(4,288)	(602)	(3,407)	-	-	-
Gross_operating_surplus	R'M	8,912	5,819	49,040	48,248	74,482	25,580	28,966	13,588	99,891	60,848	930,362	-	-	-
Output	R'M	19,619	25,858	180,496	106,675	221,632	124,062	243,131	66,044	1,346,115	138,042	3,604,203	-	-	-

Total Water	m^3'M	3,644	6,011	6,926	53	466	109	57	299	139	338	683	21	3,583	2,006
Weighted Ave Tariff	R/m^3	1.65	1.95	0.11	10.92	10.55	5.72	6.88	4.14	10.79	0.09	11.75	0.23	4.63	0.03

4.2 TOWARDS WATER QUALITY ACCOUNTS

The water quality accounting framework explored here takes a water quality use table approach (as envisaged by the SEEA), and thus focuses on waterborne emissions to the environment. Acceptable statistics are available from the DWS RQIS database. The water quality framework thus comprises an architecture of transfer and reporting tables, and a structure informed by several considerations, including:

- The key monitoring points to be reported on.
- The frequency of reporting.
- The water chemistry measures that will be reported on.
- The statistical moment(s) of data distribution that will be reported.
- The fitness-for-use thresholds that will be used as benchmarks.

The sections below demonstrates these reporting considerations:

- Variation in water quality spatially and over time for a water quality flow account following a broad SEEA use table format, by applying the DWS TWQR's for minimum, average and maximum water chemistry indicators at key monitoring points within the nine WMAs (Section 4.2.1).
- An application of water pollution load modelling demonstrating change in water quality resulting from land-based activities (Section 4.2.2).

The discussions below demonstrate that additional consultations are required between Stats SA and the DWS RQIS unit to agree on the best format(s) of water quality accounts to be published.

4.2.1 Spatial and temporal analysis

This section demonstrates a water quality reporting format that follows the SEEA water quality use table approach, i.e. reporting on emissions to the environment. The DWS monitoring sites were used to assess water quality spatially and thus work towards a national water quality accounting framework (Figure 7). Water quality accounts were developed for 2011 and 2016 as indicated in Table 23 and Table 24. Such analysis would enable assessment of water quality at a national level; hence, only dominant pollutants such as TDS and phosphates are demonstrated here. Three basic statistical parameters are reported (minimum, average and maximum), and colour-coding following the DWS TWQR is used.

It is clear from Figure 7 that the coastal basins (WMA 4, 7, 8 and 9) require multiple monitoring points. The quality of water in the riverine system deteriorated throughout the country with some exceptions. Observations included:

- Inkomati–Usuthu WMA 3 (X2H036Q02) had an average TDS concentration of 272 mg/ℓ in 2008 and an average of 498 mg/ℓ in 2016).
- Olifants WMA 2 (B7H017Q01) also had an increase in TDS concentration between 2011 and 2016 (363 mg/ℓ to 490 mg/ℓ).
- Vaal WMA 5 (C9H024Q01) had an increase in nitrate concentration between 2012 and 2016 (0.0387 mg/ℓ to 0.0793 mg/ℓ).
- Pongola–Umzimkulu 4 had a slight water improvement in its TDS concentration (387 mg/ℓ to 294 mg/ℓ) between the year 2008 and 2014.
- Pongola–Umzimkulu 4 had a slight water improvement in its phosphate concentration (0.0358 mg/ℓ to 0.01 mg/ℓ) between the year 2008 and 2014.
- Nitrate/nitrite concentrations deteriorated significantly over most of the WMAs, but still remained within the acceptable DWS TWQR threshold.

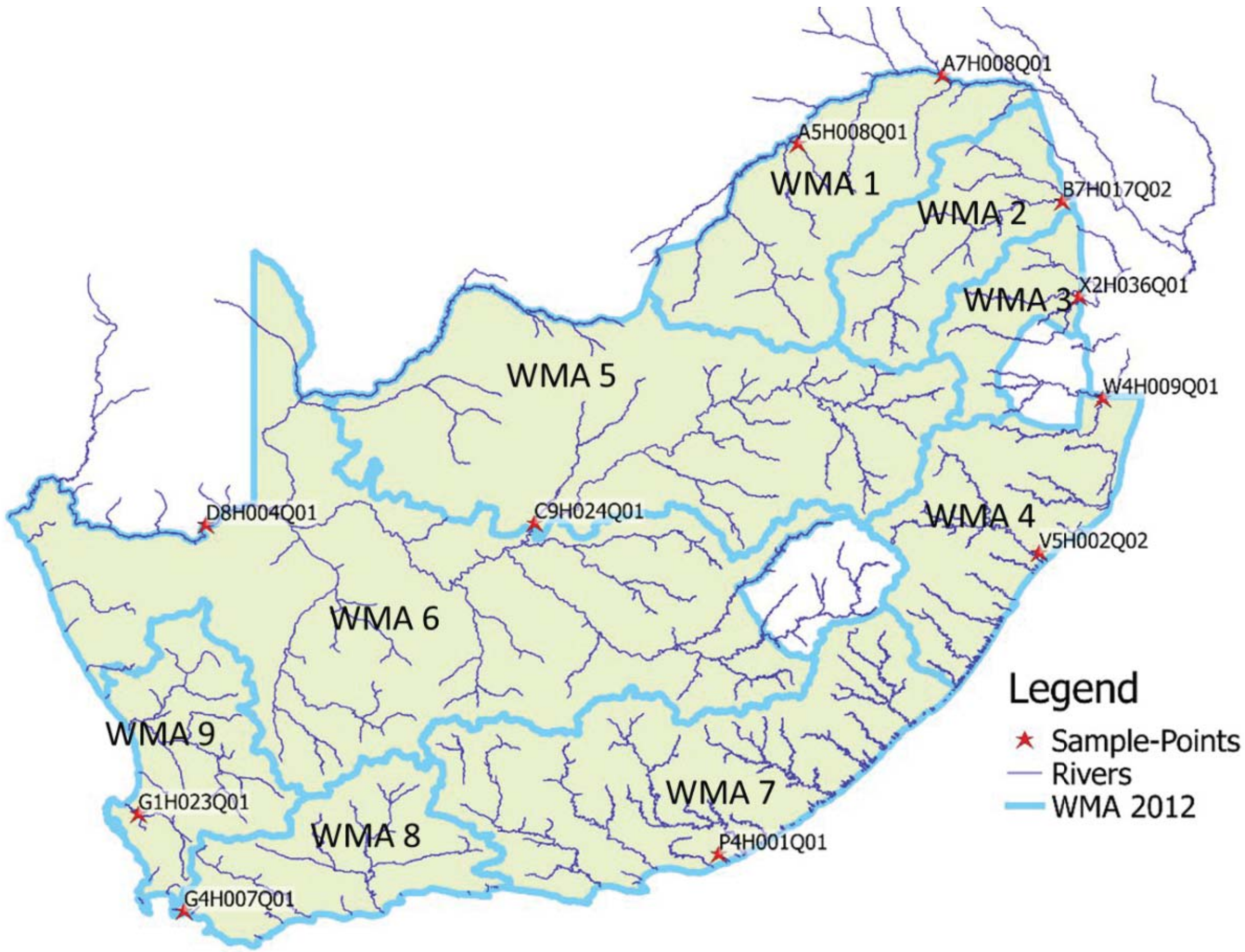

Figure 7: DWS monitoring sites used to develop water quality accounts

Table 23: Water quality use for 2011

	Water Sector (SIC 4)	Indus-try	House-holds	Environment																	
Water Management Area				WMA 1						WMA 2			WMA 3			WMA 4					
Collection by other economic units																					
TDS (mg/L)																					
PO_4 (mg/L)																					
Emissions received by the environment / Flow to the rest of the world																					
DWS monitoring site				A7H008Q01			A5H008Q01			B7H017Q02			X2H036Q01			V5H002Q01			W4H009Q01		
Measure				Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max
TDS (mg/L)				33.3	57	102	224	411	698	262	363	413	174	272	440	95.4	132	185.8	286	388	504
PO_4 (mg/L)				0.005	0.005	0.005	0.05	0.046	0.2	0.005	0.0078	0.013	0.021	0.048	0.1	0.017	0.049	0.1	0.019	0.0358	0.066
NO_3 (mg/l)				0.01	0.066	0.324	0.025	0.233	1.00	0.025	0.095	0.216	0.13	0.266	0.447	0.04	0.236	0.6	0.04	0.076	0.152

	Environment														
Water Management Area	WMA 5			WMA 6			WMA 7			WMA 8			WMA 9		
Collection by other economic units															
TDS (mg/L)															
PO_4 (mg/L)															
Emissions received by the environment / Flow to the rest of the world															
DWS monitoring site	C9H024Q01			D8H004Q01			D4H001Q01			G4H007Q01			G1H023Q01		
Measure	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max
TDS (mg/L)	538	630.6	741.2	172.7	374	684	1457	2000	2489.6	49.1	69.5	88.01	500.37	866.8	1360
PO_4 (mg/L)	0.005	0.01	0.014	0.005	0.005	0.014	0.005	0.256	0.819	0.005	0.0068	0.019	0.027	0.0623	0.162
NO_3 (mg/l)	0.025	0.0387	0.084	0.025	0.174	0.261	0.025	1.245	3.84	0.0025	0.196	0.437	0.04	0.708	1.91

Table 24: Water quality use for 2016

	Water Sector (SIC 4)	Indus-try	House-holds	Environment																	
Water Management Area				WMA 1						WMA 2			WMA 3			WMA 4					
Collection by other economic units																					
TDS (mg/L)																					
PO_4 (mg/L)																					
Emissions received by the environment / Flow to the rest of the world																					
DWS monitoring site				A7H008Q01			A5H008Q01			B7H017Q02			X2H036Q01			V5H002Q01			W4H009Q01		
Measure				Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max
TDS (mg/L)				46.7	66.9	108	120	307	607	260	490	659	383	498	575	150	226	309	196	294	373
PO_4 (mg/L)				0.005	0.005	0.005	0.05	0.068	0.15	0.01	0.0713	0.147	0.01	0.026	0.029	0.01	0.082	0.2	0.01	0.01	0.01
NO_3 (mg/l)				0.025	0.0833	0.2	0.05	0.5	1.25	0.05	0.093	0.31	0.05	0.3	1.54	0.33	1.11	2.9	0.05	0.085	0.149

	Environment														
Water Management Area	WMA 5			WMA 6			WMA 7			WMA 8			WMA 9		
Collection by other economic units															
TDS (mg/L)															
PO_4 (mg/L)															
Emissions received by the environment / Flow to the rest of the world															
DWS monitoring site	C9H024Q01			D8H004Q01			D4H001Q01			G4H007Q01			G1H023Q01		
Measure	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max
TDS (mg/L)	500.5	553.8	794	223.9	385.2	465.5	1627	2047	2518	56.2	79.8	101.7	142	762.3	1820
PO_4 (mg/L)	0.01	0.051	0.334	0.01	0.034	0.079	0.051	0.145	0.158	0.01	0.0178	0.042	0.01	0.099	0.096
NO_3 (mg/l)	0.05	0.0793	0.284	0.05	0.323	0.643	0.05	0.3084	1.359	0.05	0.38	1.081	0.05	0.598	2.19

4.2.2 Water quality load assessment – Case study

Water emissions load estimation provides an innovative water quality accounting approach, which simplifies the water accounts framework in several ways. Firstly, it focuses on a selection of key monitoring points where nett accumulation of pollutants occur. Secondly, it simplifies the selection of the statistical moment(s) of data distribution as it converts water chemistry concentration data to load accumulation. Finally, it simplifies the assessment of the water chemistry threshold regarding fitness-for-use assessment to some extent. Another advantage of the load assessment approach is that it enables valuation in monetary of water quality. This is possible by estimating mitigation cost based on water treatment costs. The resulting mitigation cost can be treated as an environmental externality. A water quality load assessment is essentially the product of water flow and the concentration of polluting substances in the water. Key steps in developing a load assessment include:

- Selecting the key water quality indicators representing the polluting activities.
- Mapping and modelling likely water treatment technologies required to reduce these identified pollutants using economic modelling.
- Selecting target water resource quality objectives for the identified pollutants.
- Estimating the marginal cost of treating to water quality planning limits requirements.

The Olifants WMA was used as a case study to demonstrate the application of water quality load assessment to water quality accounting. The Olifants River is one of the main river systems in South Africa. It has been described as one of the most polluted rivers in Southern Africa, with Loskop Dam acting as a repository for pollutants from the upper catchment of the Olifants River system (Grobler et al., 1994). The Olifants WMA includes a variety of land-based activity and has high pollution levels. The results below show highlighted outcomes for both the sulphate and nutrient models, which estimated the externalities of AMD and nutrient pollution respectively.

4.2.2.1 Impact of mining activities on water quality

Sites B1H0222Q01 and B2H005HQ01 shown in Table 25 are up- and downstream of mining areas respectively. The sulphate concentration recorded monthly by the DWS was converted to sulphate load through flow rates collected on the same day. The effect of mining activities on the sulphate load was consistently high throughout the monitoring period. On average, mining activities increased the sulphate load by one to two orders of magnitude. The results in Table 25 further indicate that the sulphate load is significantly higher during periods of increased run-off.

Table 25: Impact of AMD on water quality in the Olifants WMA

Date	B1H022Q01 (Upstream of Mining Area)			B1H005Q01 (Downstream of Mining Area)			Δ Sulphate Load (Tons/Month)
	Sulphate Concentration	Flow	Load	Sulphate Concentration	Flow	Load	
	mg/ℓ	m^3/s	Tons/Month	mg/ℓ	m^3/s	Tons/Month	
11-Jan	24.1	2.154	139	75.78	36.892	7 488	7 349
11-Feb	28.50	0.773	53	166.67	31.877	12 853	12 800
11-Mar	23.28	0.492	31	188.00	7.501	3 777	3 746
11-Apr				271.90	2.550	1 797	
11-May	20.61	1.883	104	471.00	2.175	2 744	2 640
11-Jun	19.71	1.331	68				
11-Jul				278.00	1.073	799	
11-Aug				264.00	0.579	409	
11-Sep	19.78	1.984	102	212.00	0.537	295	193
11-Oct	20.93	2.702	151	174.85	10.814	5 064	4 913
11-Nov	26.98	1.527	107	306.00	0.520	412	306
11-Dec				438.00	0.356	418	

4.2.2.2 *Impact of a dam on water quality*

Sites B1H005Q01 and B2H010HQ01 are sites up- and downstream of the Witbank Dam respectively. Table 26 shows that, on average, the sulphate load was reduced by the dam. The analysis further shows that although the sulphate concentration had elevated levels below the dam, the dam still plays a role as a sulphate trap.

Table 26: Impact of a dam on water quality in the Olifants WMA

Date	B1H005Q01 (Upstream of Mining Area)			B1H010Q01 (Downstream of Mining Area)			Δ Sulphate Load (Tons/month)
	Sulphate Concentration	Flow	Load	Sulphate Concentration	Flow	Load	
	mg/ℓ	m³/s	Tons/Month	mg/ℓ	m³/s	Tons/Month	
11-Jan	75.78	36.892	7 488	98.41	20.780	5 477	−2 011
11-Feb	166.67	31.877	12 853	111.87	40.552	10 975	−1 878
11-Mar	188.00	7.501	3 777	120.00	7.960	2 558	−1 219
11-Apr	271.90	2.550	1 797				
11-May	471.00	2.175	2 744	120.09	0.964	310	−2 434
11-Jun				140.76	0.063	23	
11-Jul	278.00	1.073	799	155.85	0.074	31	−768
11-Aug	264.00	0.579	409	192.75	0.019	10	−400
11-Sep	212.00	0.537	295				
11-Oct	174.85	10.814	5 064	179.27	0.028	13	−5 051
11-Nov	306.00	0.520	412	163.83	0.148	63	−350
11-Dec	438.00	0.356	418	168.40	0.023	10	−407

4.2.2.3 *Impact of a WWTW on water quality*

Sites B2H007Q01 and B2H014HQ01 are sites up- and downstream of two WWTWs respectively. Table 27 shows that, although all nitrate levels were still within the DWS TWQR threshold, the load was elevated significantly by effluent discharged from the WWTWs. The low relative load of nitrate in the system further indicates that other indicators, such as phosphate load, may also have to be considered for load modelling.

Table 27: Impact of a WWTW on water quality in the Olifants WMA

Date	B2H007Q01 (Upstream of Mining Area)			B2H014Q01 (Downstream of Mining Area)			Δ Nitrate Load (Tons/Month)
	Nitrate Concentration	Flow	Nitrate Load	Nitrate Concentration	Flow	Nitrate Load	
	mg/ℓ	m³/s	Tons/Month	mg/ℓ	m³/s	Tons/Month	
11-Jan	0.03	3.664	0.294				
11-Feb	0.17	0.524	0.216	0.25	2.054	1.242	1.027
11-Mar	0.31	1.250	1.038	0.30	4.010	3.222	2.184
11-Apr	0.17	0.629	0.277	0.30	2.020	1.571	1.294
11-May	0.18	0.948	0.457	0.30	2.057	1.653	1.196
11-Jun	0.33	0.665	0.569	0.42	1.378	1.500	0.931
11-Jul	0.40	0.358	0.384	0.65	1.049	1.826	1.443
11-Aug				0.32	0.932	0.799	
11-Sep				0.25	0.258	0.167	
11-Oct	0.60	0.133	0.214	0.30	1.322	1.062	0.849
11-Nov	0.08	0.056	0.012	0.28	0.105	0.076	0.065
11-Dec	0.03	0.074	0.006				

5 CONCLUSIONS

The work completed in this project provide a methodological framework for the annual publication of Water Accounts for South Africa. It follows the international best practices provided by the SEEA. It also follows a pragmatic approach by adopting an SUT approach. This ensures that the account structure, architecture and data requirements are aligned with the existing Stats SA accounting processes, thus providing Stats SA with an enabling methodology that builds on its existing business process. The water accounting system developed in this project enables a rapid annual update of Water Accounts for South Africa. The key data enabling this update is Stats SA SUTs for the water flow accounts and the DWS water quality data for the water quality flow accounts. The water flow accounts present both disaggregated physical flow and quality accounts at a level of nine WMAs, and monetary flow accounts at a national level. It also presents physical water quality accounts at a level of nine WMAs. As is expected in the implementation of the SEEA, data problems exist. In this pilot version of the accounts, these have been dealt with by applying the SASQAF; however, there is room for data quality improvement. The recommendations (Section 6) addresses this.

The work conducted here followed a consultative process to ensure that the structure and architecture of the accounts are policy relevant and that the appropriate data sources are used (refer to Appendixes A and B).

The methodological framework developed here comprises the structure (referring to nomenclature), architecture (referring to set of tables supporting the step-wise development of a water account in SUT format) and updatable database [principally using data from Stats SA, Water Research Commission (WRC) (WR2012), the DWS and a variety of annual reports] assessed under the SASQAF. A knowledge base for the development and annual publication of these accounts was developed, through this report, through detailed notes appended within the Excel™ tables, and through a series of work sessions with Stats SA. This enables Stats SA to publish more frequent updates and more detailed accounts on an annual basis.

This document and the accompanying Excel™ tables comprise a research document containing an overview of the methodological framework and water accounting tables for South Africa.

6 RECOMMENDATIONS

6.1 Publication of the National Water Accounts

It is recommended that the national water accounts methodological framework proposed here be institutionalised by following the generic statistical business process to its end point of publication within an appropriate Stats SA publication.

As publication is the final step in the generic statistical business process, it follows that all aspects of the business process – including design, data collection, data quality control, data harmonization, determining accounting inputs and outputs, accounts validation and verification – have to be formalised prior to publication.

Stats SA has several publication options, which include the Environmental Economic Accounts Compendium, a discussion document format or an online publication. Initially it is recommended that the SEEA outputs be published as a chapter in an existing publication process. This ensures that the SEEA can easily slot into an existing publication without special budget or new document development requirements. It is recommended that the water accounts be published annually after the completion of the national SUTs. These national SUTs provide the bulk of data required in the water accounts.

As part of their generic statistical business process, Stats SA also develops sources and methods documents for all their publications, which are fundamental to institutionalise the accounts. It is thus recommended that Stats SA develops a national water account sources and methods document that captures the detailed method to be followed in the annual update process.

6.2 Continuous Improvement of Data Quality

It is expected that the implementation of the SEEA will be characterised by data challenges. The application of the SASQAF to the water accounts has enabled the development of a system of data quality rating that also enables a prioritisation of areas of data quality improvement.

The largest data gaps lie with the data that measures the physical flow of water and with the water quality data. The WRC's WR2012 data set is the key data source for the physical accounts, but it largely estimates water allocations; therefore, it does not enable the analysis of impacts of drier or wetter years on the water economy. It is recommended that Stats SA and the WRC engage formally, through the standard intergovernmental MOU process, to investigate ways of updating the WR2012 data set as appropriate. Applying the SASQAF to the WR2012, and enhancing key Stats SA data collection instruments by adding a limited number of key questions, could play a large role.

Water quality accounts rely entirely on the DWS information. The DWS water sampling size is continuously being reduced. Water quality parameters are not analysed in an accredited laboratory. It is therefore also recommended that Stats SA and the DWS engage formally through the standard inter-governmental MOU process to investigate ways of updating the water quality data as appropriate. The MOU could be extended to include other physical data sources such as the Drop databases.

The SASQAF sets out a procedure for designating statistics from organs of state as official statistics. The SASQAF is a framework to guide producing agencies, in this case the WRC and the DWS, to have their data designated as official statistics. These could include surveys (e.g. the DWS Drop databases), registers [e.g. the DWS Water Authorisation and Registration Management System (WARMS) database] and data sets (e.g. DWS's water chemistry database and WRC's WR2012 database).

According to the SASQAF, the relevant organs of state (the DWS and WRC) would apply, through the division responsible for the South African National Statistics System (SANSS) at Stats SA, to the Statistician-General to have their statistics designated as official statistics. Applications would be referred to a data quality assessment team (DQAT), which is constituted by the Statistician-General and which is drawn from Stats SA, the applicant, subject matter experts and Statistics council member(s). The appointed DQAT members will agree to a terms of reference for the review. For the assessment to begin, the applicant and its statistics under review need to comply with three initial criteria, namely:

- The applicant should be a member of the SANSS at Stats SA (via an MOU).
- The statistics need to meet user needs beyond those specific and internal to the producing agency.
- The statistics produced should be part of a sustainable series, not a once-off collection.

The DQAT assesses and recommends the quality of the data product(s) in terms of the SASQAF requirements, and assigns a SASQAF quality level to the product by following a standard procedure. If the product satisfies the requirements of *quality statistics* set out in the SASQAF, the Statistician-General will designate the product as *official statistics*. If the product submitted for evaluation is not classified as *quality statistics* in terms of the SASQAF levels of evaluation, the DQAT will advise the applicant on areas of improvement. Once the product has been designated as official statistics, it will be published with the Statistician-General's official seal of approval (the Official Statistics Mark), and stored in the SANSS archive for public access. The Statistician-General will issue a notice in the Government Gazette to the effect that a product has been designated as official statistics.

Another area of data improvement is within the questionnaires of Stats SA itself. It is recommended that Stats SA, as part of the development process of the sources and methods document (see above), identify data sourced from within Stats SA itself, as noted within the detailed notes in the water accounting Excel™ tables, and investigate ways within which that data may be enhanced. The Stats SA questionnaire collects a significant amount of monetary data on water supply and use. If feasible, this data could be enhanced by collecting the physical equivalent. It is to be noted, however, that adding questions to existing questionnaires follows a specific process within Stats SA, and is subject to decisions around questionnaire efficiency and budget.

6.3 Water Pricing

Water pricing is an important economic instrument for enhancing social equity, improving water use efficiency and ecological sustainability, and securing financial sustainability of water utilities and operators. Thus, water pricing can be a powerful management tool to achieve various objectives across the water value chain. There is however a lack of empirical data/knowledge on how the application of different tariff structures affects water use for different economic sectors and how much water contributes to the economy. Water flow and water quality accounts can be used as tools for setting appropriate water prices. It is recommended that additional data within Stats SA are data-mined and integrated within the water accounts to provide a more meaningful analysis of the costs of water management and the effective water tariffs.

6.4 Development of Applications of Water Accounts

The development of water accounts in this project followed from a largely intuitive recognition by the study proponents that water accounts will play an increasingly important role in development and economic planning in South Africa. This is a typical "push" approach (after Vardon et al., 2016). For water accounts to become truly useful, clear applications of water accounts need to be developed and improved continuously. Stats SA, as provider of official data, has a limited responsibility to develop such applications. Rather there is a joint development responsibility on, broadly, water planners, in collaboration with Stats SA. Water planners in this sense would include the DWS, WRC, water boards and WSAs.

Over the past few years, the DWS has fast-tracked many aspects of the implementation of the National Water Act (NWA), and in addition, the 2014 Budget and State of Nation Address and the National Development Plan (NDP) envisage many water intensive activities that are important to the future economy of South Africa. Water accounts could support many of these initiatives. Water EEAs for South Africa could therefore inform policy with respect to economic use through monetary and physical flow, and ecologically sustainable use through water quality accounts. It could support and inform the National Water Resources Strategy; the Economic Regulator for water; policy design (e.g. water tariffs, water allocation); development planning (e.g. shale gas); catchment planning (e.g. catchment management strategies, water resource classification) and climate change effects. At the same time, it should link water resources to the national economy through the national accounts. It is particularly important that Stats SA consult with DWS RQIS on a desired set of water quality tables to publish.

With respect to the water quality account, we propose that a consultative process is initiated between Stats SA and the DWS RQIS to agree on the most desirable water quality accounting application(s) and the corresponding accounting framework required.

One specific example of a water accounts application is the SDGs. According to the UN General Assembly (2014), there are 17 SDGs in total and 169 targets that relate to the goals. The sixth SDG has a very direct link to water accounting. In South Africa, where water is scarce, this becomes even more urgent. Having concise, clear and transparent water EEAs for South Africa could help the governing bodies to better focus their aims to the relevant economic sectors or communities where water is not being consumed responsibly and sustainability. This would link the 12th SDG indirectly to the water EEAs for South Africa, and sectors or communities transgressing from these sustainable patterns could be addressed.

According to the UN (Leadership Council of the Sustainable Development Solutions Network, 2015), theme indicators may be developed by countries to complement the formal structure of the SDG framework. Goal 6 of SDGs deals with ensuring availability and sustainable management of water and sanitation for all. This goal has eight targets with their suggested indicators. Table 28 demonstrates how national water accounts can be used to report SDGs.

Table 28: Reporting of SDGs

Goal	Target	Indicator	SDG Reporting
6. Ensure availability and sustainable management of water and sanitation for all.	6.3) By 2030, improve water quality by reducing pollution, eliminating dumping and minimising the release of hazardous chemicals and materials, halving the proportion of untreated waste water and substantially increasing recycling and safe reuse globally.	Percentage of receiving water bodies with ambient water quality not presenting risk to the environment or human health.	Water quality and physical water account: • WR2012 database includes data on streamflow with particular mention of the flow from one catchment area to another, to another country or to the ocean. • Water quality account that uses data points from the DWS water quality monitoring sites on the primary drainage region, will assess the quality of the water in each catchment.
	6.4) By 2030, substantially increase water use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity.	Percentage of total available water resources used, taking environmental water requirements into account (level of water stress).	Physical water account: • This account reports on available surface and groundwater.

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APPENDIX A: POLICY CONSIDERATIONS

1 Water equity[2]

The World Summit on Sustainable Development, which took place in Johannesburg, South Africa, in September 2002, challenged global governments to find a means of reconciling social equity with economic efficiency and stability, while ensuring resource sustainability. In other words: to account for the triple bottom line when considering natural resources in a country.

Despite the NWA being premised on the efficient use of resources in an equitable and sustainable manner, access to the benefits yielded by water resources in the country is still not equitable. The same perhaps applies to other resources and services. There are numerous constraints and barriers to making effective use of the above and other water equity mechanisms in the country.

The WRC has been investigating the topic of water equity. This research is being conducted in four phases, namely:

- Develop a working definition for “water equity”.
- Demonstrate mechanisms that may be implemented to achieve water equity objectives.
- Investigate appropriate ways of measuring progress towards water equity.
- Demonstrate the benefits of the concept of water equity.

The water EEAs for South Africa should ideally assist in measuring the state and progress in water equity.

2 Water tariffs

In 2014, the Cabinet published a water policy position related to economic regulation (DWA, 2014). The position states that:

> “*Economic regulation will be applied throughout the water value chain. Scope and functions of economic regulation will encompass the setting of the rules to control, monitor, enforce and/or change tariffs/charge; tariff/charge determination structures and service standards for the water sector whilst recognising and supporting government policy and broader social, environmental and economic imperatives and the function of technical regulation of water infrastructure. To avoid any conflict of interest, real or perceived, water use tariffs will be determined annually by DWS, in consultation with National Treasury.*”

This policy position is motivated by there currently being no coherent economic regulation of the entire water value chain. Accordingly, economic regulation is targeted at specific water management institutions operating in the value chain, which include raw water charge setting, water user association (WUA) charges, bulk water charges, water services charges (water and sanitation), waste discharge charges and other charges that may arise.

There is a lack of empirical data/knowledge on how the application of different tariff structures affects water use for different economic sectors and what water’s contribution to the economy is. However, by using a combination of physical and monetary data, the water EEAs for South Africa will be able to make inferences on the price of water. By studying/analysing the marginal relationship between water and other economic sectors, the shadow price of water should become apparent. Therefore, recommendations on water pricing could be based on its actual value in the economy.

The following acts provide the legal basis for water tariffs:

- NWA (DWAF, 1998) relates to raw water tariffs.

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[2] Adapted from the Water Equity Dialogue (WRC, 2015)

- National Environmental Management Act (NEMA) (1997) relates to dealing with the cost of pollution.
- Water Services Act (1997) relates to bulk water tariffs and water services.
- Municipal Systems Act (2000) relates to water services.

The NWA (DWAF, 1998) identifies three tiers of pricing for water management:

- **Tier 1: Raw water tariffs** – These administered prices are applicable to all water users and comprises the basic input cost of the fresh water supply. These administered prices are relevant for services that include the use of raw water from the water resource by bulk distributors, large users and irrigators. This may also include a water quality pricing component for dealing with pollution. The production of other ecosystem services may also be included here.
- **Tier 2: Bulk water tariffs** – These administered prices are applicable to all water users who are customers of bulk water service supply entities. These prices include the cost resulting from raw water tariffs. These administered prices are relevant for intermediary water services supplied in bulk (often by water boards).
- **Tier 3: Water services tariffs** – These administered prices are applicable to all water users who are customers of water service supply entities (mostly municipalities). These prices include the cost resulting from raw water tariffs and bulk water tariffs. These administered prices are relevant for water provision and sanitation services to households and other urban and domestic users (usually via a municipality).

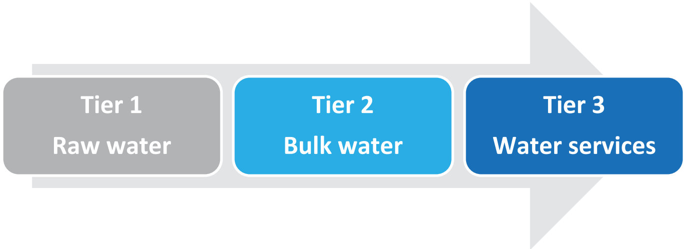

Figure 8: The three water tariff tiers envisaged by the NWA (DWAF, 1998)

Several organs of state manage the administration of water and its tariff collections. These are defined in Table 29. The mandated activities of these organisations comprise the water value chain in South Africa. The value chain structure is adequate provided that all mandated responsibilities are addressed. At present, catchment management agencies (CMAs) and WUAs are not fully functional.

Table 29: Water tariff system organisational[3]

Organisational Entity	Functions Relevant to Water Tariff System	Applicable Water Tariff Tier
DWS – National and Regional Offices	• Custodian of water resources and overall policymaker, regulator and policy enabler. • Oversees the activities of all water sector institutions. • Licenses water use and discharges and collects abstraction and discharge fees (temporary until handover to CMAs). • Manages water resources infrastructure some water services infrastructure. • Manages the Water Trading Entity.	Tier 1 – Raw water

[3] Adapted from (Storer & Teljeur, 2004) and (Eberhard, 2004).

Organisational Entity	Functions Relevant to Water Tariff System	Applicable Water Tariff Tier
TCTA	• The TCTA is a state-owned entity that finances and implements bulk raw water infrastructure projects from commercial investments and nor from commercial investments.	Tier 1 – Raw water
CMAs	• Water resource planning and management at catchment level (where CMAs have not been established yet, DWS regional offices fulfil these functions as proto-CMAs).	Tier 1 – Raw water
WUAs	• A body corporate that has the powers of a natural person to, if mandated by its constitution, to obtain loans and recover financial obligations of members towards the association.	Tier 1 – Raw water
Water Boards	• Regional or bulk WSPs (sell bulk water to, or accept waste water from other WSPs). As WSPs, the boards are accountable to WSAs; as organs of state, the boards are owned, controlled and regulated by the DWS and National Treasury. (Water boards fund infrastructure from commercial investments and not from government transfers.)	Tier 2 – Bulk water
WSAs	• Provision of water services within their appointed areas. Includes metropolitan municipalities, many district municipalities and authorised local municipalities. May contract out service provision to external WSPs.	Tier 3 – Water services
WSPs	• Operational water provision and/or sanitation services (as a bulk or retail service).	Tier 3 – Water services
Water Users	• Water users comprise households, irrigation, mining, strategic users (by Eskom and Sasol) and industrial and commercial users.	Varies depending on supplier

Table 30: Responsibilities for tariff policy[4]

Scope	Responsibility	Source of Authorisation	Policies
Tier 1 – Water resources.	DWS to develop and implement.	NWA (and Cabinet memorandum).	National Water Resource Pricing Strategy.
Tier 1 – Raw water tariffs of DWS schemes (DWS, CMAs, and WUAs).	DWS to develop and implement.	NWA (and Cabinet memorandum).	National Water Resource Pricing Strategy.
Tier 2 – Raw water tariffs of water services authority, water boards and to some WUAs.	WSAs to develop and implement, DWS to approve.	NWA.	Typically collapsed in tariff policy for retail water (in case of WSAs) and policy for bulk water (in case of water boards).

[4] Adapted from (Eberhard, 2004).

Scope	Responsibility	Source of Authorisation	Policies
Tier 2 – Bulk water services provided by water boards.	Water boards to develop and implement, DWS to approve.	Water Services Act.	DWS draft guideline.
Tier 3 – Water services (bulk and retail).	Water services authorities to develop and implement, the DWS to approve.	Water Services Act and Municipal Systems Act.	National norms developed by DWS. Individual policies developed by WSAs.

Table 31: Responsibilities for tariff policy[5]

Applicable Water Tariff Tier	Brief Overview

Tier 1 – Raw water	• Legal basis: NWA (DWAF, 1998) Chapter 5.
	• First pricing strategy developed in 1999.
	• Updated strategy gazetted for comment in 2005.
	• Updated strategy gazetted in 2007 through:
	  ○ The introduction of the Waste Discharge Charge System (WDCS).
	  ○ The treatment of commercial water projects financed by non-governmental funding (off-budget funding).
	  ○ The alignment of the Water Pricing Strategy to the requirements of the Municipal Finance Management Act 56 of 2003.
	• Applies to water supplied by government water schemes, other water management institutions (including CMAs and WUAs), and water subtracted by water users for own use. Separated into two basic components:
	  ○ W*ater resources management charge* (intended to cover the costs of catchment management activities). Set by CMAs (or the DWS where there is no CMA). Tariff should be cost reflective but there is no formal regulation of costs or the charge.
	  ○ The *water resources development charge* (reflecting DWS's broader water resource pricing strategy). Set by the DWS.
	• Strategy implemented through:
	  ○ Annual publications of tariffs.
	  ○ These tariffs raised on WULs issued.
	  ○ Water trading entity issues invoices and raises revenue.
	• DWS's overall water resource pricing strategy intends to recover the full economic costs of providing raw water from the resource while maintaining subsidies for poorer consumers and emerging farmers. The DWS is both the price-setter and regulator (for its own schemes) and has an incentive to increase prices, although in practice, actual prices are in many cases set below the rate allowed by the policy. There are no incentives to cut costs or improve efficiency or other policy objectives.

[5] Adapted from (Storer & Teljeur, 2004) and (Eberhard, 2004).

Applicable Water Tariff Tier	Brief Overview

Tier 2 – Bulk water	• Legal basis: Water Services Act (1997) Par. 31.
	  o No gazetted regulations exist.
	  o However, guideline document available in the DWS.
	• Guideline implemented through:
	  o Annual proposal of water board tariffs to portfolio committee.
	  o Water boards invoices and raises revenue.
	• There are no incentives to cut costs or improve efficiency or other policy objectives. Prices for bulk water provided by other agencies, such as WSAs, are not formally regulated. Where WSAs manage their own bulk supplies, costs (and price) are subsumed in their retail tariffs. Where WSAs provide bulk water to other WSPs, price and other terms are negotiated between the parties.

Tier 3 – Water services	• Legal basis: Water Services Act (1997) Par. 31 and Municipal Systems Act (2000) Par. 74, 75.
	• Norms and standards for municipal tariffs for water services (DWS 2002) exist.
	• Regulations exist as municipal tariffs and by-laws for:
	  o Water tariffs.
	  o Sanitation tariffs.
	• Municipalities invoices and raises revenue.
	• Little guidance provided on the practical application of these tariffs.
	• Significant risk that pressure from municipalities to constrain charges increases below inflation has resulted in final charges being progressively squeezed to below full cost recovery level (i.e. below the level necessary to enable full maintenance of infrastructure). Incentives to improve efficiency tend to result in sub-optimal investment.

In 1998, the DWS published a comprehensive Water Pricing Strategy (DWAF, 1998). This strategy was updated in 2007 (DWAF, 2007). The 2007 strategy updated the 1998 strategy by introducing the WDCS; treating commercial water projects financed by non-governmental funding (off-budget funding); and aligning the Water Pricing Strategy to the requirements of the Municipal Finance Management Act, 56 of 2003. The resultant strategy has several important components, which are discussed below.

WRM expenditure has to be funded, which comprises activities that are required to protect, use, conserve, manage and control water resources, and manage water quality located within WMAs, including securing ecosystem services production by water resources. These tariffs are intended to cover WRM-related costs of CMAs. These costs could include but are not limited to:

- Planning and implementing catchment management strategies.
- Monitoring and assessing water resource availability and use.
- Allocating water use.
- Ensuring water quantity management, including flood and drought management, water distribution, control over abstraction, storage and stream flow reduction activities.
- Ensuring water resource protection, resource quality management and water pollution control.
- Ensuring water conservation and demand management.
- Ensuring institutional development and enabling the public to participate in WRM decision-making.

DWS publishes an annual update of these charges.

Water resource development (waterworks) has to be funded. Water resource development and use of waterworks refer to the planning, design, development, operation, maintenance, refurbishment and betterment (improvement) of government water schemes and schemes to be funded by water management institutions such as the TCTA and WUAs. If water use charges are too low, it will lead to underinvestment, overconsumption and unintended fiscal subsidies. As a result, the revised pricing strategy (DWAF, 2007) uses the depreciation, return on assets, betterments, refurbishment and off-budget funding approach for setting charges to recover capital cost in respect of schemes owned by government. The funding of off-budget infrastructure developments requires loans. State funding is envisaged to be confined mostly to social, water resource development or betterment projects that conform to the purpose set out in section 2 of the NWA (DWAF, 1998) and where the demand is not driven by specific commercial water users or sectors. Capital expenditure related to the promotion of equitable access to water, meeting international obligations and dam safety betterments on state-owned dams is envisaged to qualify for state funding. New infrastructure development may have a social as well as a commercial component in which case state funding and related charges will apply on the social component, while loan funding and related charges will apply on the commercial component.

WRM and water resource development tariffs, together, should theoretically cover the costs of capital, operations and maintenance. Together they comprise the full cost of water supply. There are however, additional costs associated with the consumption of water and other aquatic ecosystem services. These include economic externalities and environmental externalities (Rogers, Bhatia, & Huber, 1998).

The 2007 pricing strategy deals with these externalities to some extent through what it defines as an economic charge as well as a waste discharge charge. The economic charge may either be set administratively by determining a proxy for the economic value of water, or by selling water by public tender or auction to the highest bidders in accordance with regulations required in terms of the NWA (DWAF, 1998). The purpose of the economic charge is to promote beneficial use through the reallocation of water to higher value users in water stressed catchments.

The 2007 pricing strategy further introduces the WDCS. This system is intended to establish an economic instrument for charging waste discharges, or water pollution. This WDCS is based on the polluter pays principle (envisaged in the NEMA) and aims to internalise the environmental costs of waste dischargers by recovering the costs of mitigating water resource quality impacts of pollution. It further intends to create financial incentives for waste dischargers to reduce waste.

It is not clear whether Tier 1 pricing guidelines exist for the TCTA or WUAs. It is important to note that Tier 1 licensing is subject to the award and administration of WULs. These licences, together with the existing use rights under the pre-NWA era, provide the customer base from which these tariffs are collected.

DWS has published a guideline for water board tariffs (DWS, 2010). According to this guideline, bulk potable water tariffs must achieve and maintain the prenegotiated financial targets and capital structure of the water board as expressed in the Shareholders Compact, after providing for expenses, capital investments and loan repayments and for a reasonable amount of flexibility by providing for contingencies and, where applicable, for agreed dividends to the National Revenue Fund. The Guideline allows a water board to set a single tariff for its whole supply area or a separate tariff for each scheme or each water treatment plant. In addition, different tariffs may be set for different customers when this can be motivated by differentials in the cost of supplying the different customers.

Stepped tariffs are generally not charged on the sale of bulk potable water. Free basic water is provided to households at the retail level, and thus the subsidisation or cross-subsidisation of free basic water is a municipal concern and not within the capability of an unsubsidised water board. Only municipalities are entitled to an equitable share of the national revenue in order to fulfil the function of supplying basic services.

The Guideline makes provision for operating surpluses to be earned to correct a water board's capital structure for future capital expansion, refurbishment, repaying debt, reasonable contingencies, or return to the National Revenue Fund in the form of dividends. The Guideline requires tariffs to be calculated based on a discounted cash flow model. The resulting tariffs are to be approved by the DWS. It is not clear whether similar guidelines exist for other WSPs.

The Water Services Act (1997) envisages norms and standards for potable water and sanitation services tariffs. These norms and standards may differentiate on an equitable basis between different users of water services; different types of water services; and different geographic areas. The tariffs must consider the socio-economic and physical attributes of each area; must place limitations on surplus or profit; must place limitations on the use of income generated by the recovery of charges; and must provide for tariffs to be used to promote or achieve water conservation. The norms and standards must further consider:

- The national standards.
- Social equity.
- The financial sustainability of the water services in the geographic area in question.
- The recovery of costs reasonably associated with providing the water services.
- The redemption period of any loans for the provision of water services.
- The need for a return on capital invested for the provision of water services.
- The need to provide for drought and excess water availability.

These tariff guidelines must also be read in conjunction with the National Treasury "Distribution Policy for Government Business Entities" and with the National Treasury "Capital Structure Policy for Government Business Enterprises".

3 Water Resource Classification System

In September 2010, the Minister of Water and Environmental Affairs gave effect to the "Regulations for the Establishment of a Water Resource Classification System" (WRCS) through publication under Government Notice R 810 in Government Gazette 33541 (DWA, 2010). Since then, the DWS has made rapid and tremendous progress with (a) the implementation the classification of water resources, and (b) the implementation of resource quality objectives (RQOs).

WRCS and RQO studies have been completed and/or are in progress in the Olifants WMA, Vaal WMA, Olifants–Doorn WMA, Letaba WMA, Crocodile West/Marico/Mokolo/Matlabas WMA, Mvoti–Umzimkulu WMA and Inkomati WMA.

The regulations referred to above intend to ensure the ecological sustainability of all the significant water resources by considering, in the WRCS methodology, "the social and economic needs of competing interests by all who rely on the water resources". In particular, the classification methodology requires the application of a variety of economic studies through which to evaluate the consequences of changes in river/integrated units of analysis class.

The water EEAs for South Africa will add considerable value to the WRC process, and this will be explored through this study.

The WRC has a parallel study focusing on the development of WRCS socio-economic guidelines, and this study will align to the former. The WRCS study will develop revised socio-economic guidelines and the decision support system that supports the methodology. This will include:

- Data and data sources.
- Economic characterisation.
- Ecosystem service mapping.

- Economic indicators used.
- Linking water resources to the economic models.
- Scenario modelling and forecasting.

4 Target audience

A key outcome of the UNEP workshop was the emphasis placed on the importance of communicating the outcomes of the water EEAs for South Africa to a broad audience.

This project involves technical work that might not be of interest to a non-technical audience, but the work should nevertheless consider the wider, non-technical audience and enable this wider audience to benefit from this work. Ultimately, this will be a tool that will enrich discussions and understanding of the sector, which could lead to better informed decisions and ultimately support policy implementation.

5 Accuracy

The data used in the water EEAs for South Africa was assessed against the SASQAF standards.

The SASQAF is a document published by Stats SA (2010) that describes the process of assessing statistics. The SASQAF covers the various quality aspects of the entire statistical value chain (i.e. need, design, build, collection, processing, analysis and dissemination) and certifies national statistics on one of four levels. The four levels are outlined below:

- **Level Four: Quality Statistics** – These are statistics that meet all the quality requirements as set out in the SASQAF. They are designated as **quality statistics** to the extent that deductions can be made from them, and are 'fit for use' for the purpose for which they were designed. Level 4 applies to highly developed statistical activities with respect to the corresponding indicator.
- **Level Three: Acceptable Statistics** – These are statistics that meet most, but not all the quality requirements as stipulated in SASQAF. They are designated as **acceptable** to the extent that, despite their limitations, deductions can be made, and are 'fit for use' for the purpose for which they were designed. Level 3 refers to moderately well-developed activities with reference to a particular indicator.
- **Level Two: Questionable Statistics** – These are statistics that meet few of the quality requirements as stipulated in SASQAF. They are designated as **questionable** to the extent that very limited deductions can be made, and they are therefore not 'fit for use' for the purpose for which they were designed. Level 2 refers to activities that are developing but still have many deficiencies.
- **Level One: Poor Statistics** – These are statistics that meet almost none of the quality requirements as stipulated in SASQAF. They are designated as **poor statistics** to the extent that no deductions can be made from them, and are not 'fit for use' for the purpose for which they were designed. Level 1 refers to activities that are underdeveloped.

The prerequisites and eight dimensions of quality:

1. Prerequisites of quality
2. Relevance
3. Accuracy
4. Timeliness
5. Accessibility
6. Interpretability
7. Comparability and coherence
8. Methodological soundness
9. Integrity

APPENDIX B: STAKEHOLDER FEEDBACK

As in the terms of reference, the project team envisaged to hold one workshop with key relevant stakeholders to discuss their expectations of and their input into water accounting in South Africa. Upon reflection, the project team proposed a number of one-on-one stakeholder interactions to be done with the expectation to receive better feedback. At the previous reference group meeting this was suggested to the members where it was agreed that a number of one-on-one stakeholder interactions would be of greater benefit than a national workshop.

1 United Nations Environmental Programme

A joint workshop was held between Stats SA, UNEP and the project team as participants. A few key points arose from this workshop:

- **Simplicity** – The final version of the water EEAs for South Africa should have a very simple, easy-to-understand or easy-to-use interface that will allow government and other non-statisticians to be able to use and familiarise themselves with the accounts. The accounts still need to adhere to high technical standards but these would be secondary to the policy implications that will come forth from the accounts.
- **Policy relevance** – An input–output structure for an account cannot be the beginning and the end of this project. There needs to be a focus on what the accounts could be used for, i.e. how can the accounts empower various departments or policymakers?
- **Well-being aspect** – Lastly, we discussed the need for the account to address more than just the environment–economic relationship and, to that end, there needs to be a social aspect incorporated into the accounts. In this part of the account we envisage a link between the environment, the economy and the well-being of people.

2 United Nations Statistics Division

The UNSD visited South Africa during the second week of October 2015 as part of their pilot study in the country on ecosystem services. The project team, Stats SA and the UNSD then held a brainstorming session on the key issues related to environmental economic accounting and specifically the challenges related to water accounting in the country.

Two key outputs of the session was the need to compile a detailed metadata inventory as well as the importance of spatial data regarding environmental economic accounting. These ideas were investigated in more depth and they are discussed in more detail in Chapter 4 of this report.

3 Department of Water and Sanitation

a) *Water Resource Classification System*

Another study under the WRC and DWS is the project around the WRCS. The WRCS is a very important water policy instrument that seeks to enable the protection of water resources. The WRCS is established through the NWA (DWAF, 1998) in Chapter 3. With a view to ensure the comprehensive protection of all water resources, Chapter 3 outlines the WRCS as one of a series of (integrated) WRM and protection “measures” (some of which are policy instruments). These measures include the WRCS, the reserve, pollution prevention and emergency incidents and are intended to be progressively developed and integrated into the National Water Resource Strategy and catchment management strategies of the nine CMAs.

Although the focus of this study is on water accounting, the WRCS is nevertheless intimately related to this. The WRCS is intended to provide guidelines and procedures for determining different classes of water resources.

Since the publication of GNR 810, the DWS has made rapid and tremendous progress with the implementation of the classification of water resources, and the implementation of RQOs. Management class and RQO determinations have been completed and/or are under way in the Olifants WMA, Vaal WMA, Olifants–Doorn WMA, Letaba WMA, Crocodile West/Marico/Mokolo/Matlabas WMA, Mvoti–Umzimkulu WMA, Inkomati WMA and Breede–Gouritz WMA.

Study aims and overall outcome

The WRCS study aims are as follows:

- Revise and update the current WRCS Socio-Economic Guideline document (i.e. DWS, 2007c).
- Investigate and record successes and failures of the current WRCS and RQO socio-economic studies, if any in addition to those identified as indicated under the rationale for the project.
- Address the weaknesses identified in each case.
- Undertake gap analysis of current WRCS and RQO socio-economic studies.
- Review and recommend standardisation of data sources, economic indicators used, analysis approaches and methodologies, and reporting outputs.

The expected outcome of the WRCS project is very clear: a completely revised WRCS Process Socio-economic Evaluation Guideline that is explicit on the methodology to be applied to support decision-making in a systematic and transparent manner, to determine appropriate protection levels of water resources using ecosystem services and socio-economic tools.

Revisiting the purpose of economic studies in the WRCS

The practical challenges relating to socio-economic assessment and stakeholder participation are:

- The analysis outputs must be correct, evidence-based and defensible and support the Minister to make the correct decisions.
- The analysis must set out an analysis framework, baseline assessment and outputs that are acceptable and recognisable to stakeholders.
- The work needs to communicate with a very wide range of stakeholders, ranging across a spectrum of disciplines and education levels.

Thus, the assessment should address the following questions:

- Is the analysis reliable and does it inform making the correct decisions? This would be a key concern from the Minister's point of view, requiring that the analysis be reliable.
- Will any beneficiary lose water as a result of any WRCS scenarios? This is a key stakeholder concern, as the WRCS process may determine that additional water needs to be allocated to the reserve to achieve the desired management class, either in the near term or in the future. This may affect existing operations: livelihoods and/or investment decisions to be taken. Beneficiaries would include poor communities, local government, private sector, government and government entities responsible for economic development initiatives resulting from the NDP.
- Will any beneficiary lose aquatic ecosystem services? Closely associated with the concerns related to possible loss of water for use, various beneficiaries may be concerned about losses of other water resources related benefits, i.e. aquatic ecosystem services. Such concerns may often relate to lower levels of management classes or the failure to implement a minimum acceptable management class (Class III). In most cases, higher management class categories may be associated with higher valued aquatic ecosystem services.
- Will any of the decisions incur additional economic costs? In some instances, it may be possible that stakeholders have to pay more for water, either through higher marginal cost augmentation schemes or higher costs associated with water quality mitigation, such as the WDCS. Thus, the WRCS may result in additional costs as a key stakeholder concern. This concern has become

increasingly relevant since Cabinet's 2014 publication of the National Water Policy Review and its policy position related to economic regulation (DWA, 2014).

- Will the decision be fair? This question deals with stakeholder opinion related to the perceived fairness of the WRCS process.

Moreover, it is a reality of stakeholder consultation processes that many stakeholders have vested interests or seek to achieve specific mandates. Thus, it is not just a matter of answering the above questions, but the analysis should also be done in a manner that can withstand challenges and legal scrutiny where required.

Inconsistent methodology

The guidelines have not been able to specify a suitable set of socio-economic approaches and methodologies that would enable a common understanding of analyses and results. This has resulted in different approaches and methods being used in the different studies, which prevented comparison of results. Associated with this problem is a failure to standardise various aspects of the socio-economic work, including methodologies and socio-economic indicators used. Another failure arises from not standardising data sources to be used. And in addition, there has been a failure to specify a consistent, integrated set of outputs and deliverables for the socio-economic work.

The 2007 Guideline is also vague. For instance, the Guideline refers to scoring systems and application of social accounting matrixes. It uses case study examples to demonstrate permutations of scoring techniques, production functions, micro-economic analyses and macro-economic techniques. Another example is the failure to explicitly recognise the economic role of the informal sector and its dependence on aquatic ecosystem services. Although it does deal with ecosystem services that the informal sector rely on, it fails completely to recognise the importance of the informal sector and the importance of aquatic ecosystem services to this sector.

This essentially creates a situation that leaves professional service providers (PSPs) without guidance on data sources, evaluation methods and consistent application of techniques. As a result, PSPs have used a variety of techniques including multi-criteria analysis, cost benefit analysis, various data sources, various economic models and applications. In some cases, PSPs have used proprietary economic models. Thus, there has been no consistency in methodology.

It is important to recognise that different methodological approaches may be required in different WRCS studies. Drawing from the examples mentioned above, some study areas may have severe water quality problems, some may have significant ecosystem services problems, others may have specifically affected sectors or special interest groups. It is therefore expected that some methodological variation may exist between studies, and that not all studies would strictly follow identical methods.

Inconsistent methodology application also has consequences for data requirements and consequently the intensity and quality of data. A large variety of data sources have been used to date. In most cases, where data has been referenced, the data is of Level 3 and Level 4 SASQAF quality, i.e. official and acceptable data. Guidelines on data sources and their quality remain an important consideration for the revised Guideline document. Similarly, accuracy (as also envisaged by the SASQAF) is also an important consideration, especially where proprietary data or models are used.

The role of two current initiatives are really important here: Firstly, the water accounts development process overseen by Stats SA and the WRC and, secondly, the ecosystem services accounting initiative conducted by the SANBI and Stats SA. Both these processes would enable a more consistent approach to methodology and official data, and therefore also accuracy of results. These two initiatives would also serve to build trust among stakeholders in the methodology and data used as well as in the assessment process. The application of best practices in resource economics are particularly important here.

A key data issue is the delineation of economic data. For the most part, economic activity data is available at a national scale, and some socio-economic data is disaggregated to a provincial or municipal scale. However, no data is available at a WMA level. This is a challenge also to be addressed by the above two initiatives.

Consistent methodology and data would also enable improved linkage to other studies or initiatives, relating for instance to economic regulation, catchment planning or the WDCS. A very important benefit of using consistent methodology relates to empowering and enabling DWS staff to assess, during the course of the project, progress, key issues and results. To this end, standardised report templates that communicate well and clearly is of importance.

Further recommendations for Phase 2 of the WRCS project

The gap analysis have revealed several important recommendations to be taken into Phase 2:

- Standardisation of methodologies is important, thus international best practices (e.g. in cost benefit analysis and resource economics) need to be followed.
- The Guideline should adopt a "progressive methodology" approach, starting with setting an acceptable baseline for economic and ecosystem services assessments; followed by developing scenarios and a progressive, evidence-based assessment thereof. The word "progressive" here refers to an assessment of progressive diligence, which initially uses "rapid"-type assessments to eliminate insignificant economic consequences and progressively introduces more detailed or comprehensive assessment techniques to analyse more significant consequences (i.e. requisite simplicity in methodologies).
- It is recommended that risk assessment techniques could play a particularly important role here, and specifically comparative risk assessment, which allows for multidisciplinary risk assessments.
- The way in which ecosystem services are defined, measured and linked to existing analysis tools, requires attention. The potential for a set of production function-based rules or methods needs to be explored. Consistent methods for internalising water pollution (i.e. water quality) are also required.
- It needs to be verified that the potential questions that stakeholders may have are answerable by applying the respective methodologies. In particular, economic regulation and effects on tariffs and costs are of concern.

DWS contribution at the reference group meeting

In the reference group meeting in September 2015, the DWS staff attending the meeting had a number of inputs that were noted and included here as part of the stakeholders' feedback.

Niel van Wyk from the DWS (National Water Resources Planning) provided the following valuable input to aid in the DWS's willingness and ability to use the output from the project. These included the inclusion of a glossary to avoid cross-talk (among specialist in different fields), which causes confusion, the investigation and inclusion of water sectors/water use sectors as defined by the DWS to ensure easy interpretation by the department, and the importance of investigating the level of sufficiency that water accounts at a WMA level would be for Stats SA.

Other WRC project reference group meeting

In an attempt to stay up to date with water accounting projects in the country, a national workshop was attended on 12 November 2015 where another WRC project, titled Water Resources Accounting, was presented to the audience, which included members from the DWS.

There were a number of considerations brought forth by the DWS regarding water accounting and these included:

- The reference time period of water accounts is a concern within the DWS since water accounts are hard to contextualise within the department when the department tends to use a hydrological year and the water accounts are reported for a financial or calendar year.
- Another concern was that for the department to use water accounts, they needed to be kept "alive" through regular updates on a national scale. Therefore, there needs to be a custodian that has the mandate and the capacity to perform these regular, countrywide updates.

DWS additional feedback

On 9 November 2015, the project team contacted a number of key contact people within the department to determine, firstly, whether or not they are custodians of any economic, water pricing, water supply or water use data and, secondly, what their particular needs from water accounting/economics are that would essentially make them a beneficiary of these or other water accounts.

Appendix B includes a table that lists the contacted people in the department. Stakeholders who have not responded received a follow-up email, which was sent on 17 November 2015, where a response was once again kindly requested. The stakeholders' response to the two questions are discussed in the following paragraphs.

The responses from the DWS thus far have been unsuccessful in identifying data sets that are held by the department. There have been referrals to key contact people within the department that might hold data that could be of use in this project but these contact people have not yet gotten back to us.

The Resource Quality Services directorate within DWS has indicated through two contact people that there is no data within their directorate that will be useful for water accounting. One of the two contacts indicated that they would be interested in water accounting only if its financial implication is a function of water quality.

The Sub-directorate: Integrated Hydrological Planning indicated that there is no data within their sub-directorate but that they use such data to execute their responsibilities. These responsibilities include groundwater development and management plans to promote conjunctive use of surface and groundwater. Furthermore, they are located within the larger Chief Directorate: Integrated Water Resource Planning that has to ensure water security for South Africa through integrated planning. The function involves developing comprehensive plans that guide infrastructure development and systems management. Lastly, the sub-directorate indicated that having water accounting/economics information ready would be a useful tool in executing their functions as it would provide important water statistics to guide their processes.

The Directorate of Surface and Groundwater Information expressed that their interest in water information lies slightly beyond the economic value of water; they are more interested in linking the economic value of water to the value of information and monitoring. Accounting for water would enable them to have insight into how their information feeds into the balancing of the supply/demand equations. This in turn can help them understand what the incremental value of improved coverage and/or accuracy of hydrological and water use data can be, which illustrates the economic return on increased expenditure on monitoring.

The Directorate of National Water Resource Planning expressed their interest in the output of this project to provide a broader understanding of how their discipline fit into the wider economic picture. Concern was raised about the lack of data available and how reliable these projects are on the quality of the input data. The directorate referred another WRC project that was involved in the original paper of this study and is now compiling water information on a countrywide basis. He suggested that since both projects are under the WRC, there could coordination and possible information sharing.