REPORT NUMBER: RDM/WMA06/00/CON/COMP/0115

PROJECT NUMBER: WP 10974

DETERMINATION OF ECOLOGICAL WATER REQUIREMENTS FOR SURFACE WATER (RIVER, ESTUARIES AND WETLANDS) AND GROUNDWATER IN THE LOWER ORANGE WMA

INCEPTION REPORT

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

DECEMBER 2015

DETERMINATION OF ECOLOGICAL WATER REQUIREMENTS FOR SURFACE WATER (RIVERS, ESTUARIES AND WETLANDS) AND GROUNDWATER IN THE LOWER ORANGE WMA

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Report Number: RDM/WMA06/00/CON/COMP/0115

DECEMBER 2015

REFERENCE
This report is to be referred to in bibliographies as:
Department of Water and Sanitation, South Africa, December 2015. Determination of Ecological Water Requirements for Surface water (River, Estuaries and Wetlands) and Groundwater in the Lower Orange WMA. Inception report. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. DWS Report No: RDM/WMA06/00/CON/COMP/0115

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Index Number	DWS Report Number	Report Title
1	**RDM/WMA06/00/CON/COMP/0115**	**Inception report**
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3	RDM/WMA06/00/CON/COMP/0216	River EWR report
4	RDM/WMA06/00/CON/COMP/0316	Buffels, Sout, Swartlintjies, Spoeg, Groen Estuary EWR report
5	RDM/WMA06/00/CON/COMP/0416	Groundwater EWR report
6	RDM/WMA06/00/CON/COMP/0516	BHNR report
7	RDM/WMA06/00/CON/COMP/0616	Wetland EWR report
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10	RDM/WMA06/00/CON/COMP/0317	Main Summary report
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DEPARTMENT OF WATER AND SANITATION

CHIEF DIRECTORATE: WATER ECOSYSTEMS

DETERMINATION OF ECOLOGICAL WATER REQUIREMENTS FOR SURFACE WATER (RIVERS, ESTUARIES AND WETLANDS) AND GROUNDWATER IN THE LOWER ORANGE WMA

INCEPTION REPORT

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REPORT SCHEDULE

Version	Date
First draft	31 December 2015
Second draft	6 March 2016
Final	15 March 2016

EXECUTIVE SUMMARY

BACKGROUND

The Chief Directorate: Water Ecosystems (CD: WE) of the Department of Water and Sanitation (DWS) initiated a study for the provision of professional services to undertake the 'Determination of Ecological Water Requirements for Surface Water (Rivers, Estuaries and Wetlands) and Groundwater in the Lower Orange WMA'. Rivers for Africa was appointed as the Professional Service Provider (PSP) to undertake this study.

STUDY OBJECTIVES

The study objectives as defined by the Terms of Reference(TOR) are as follows:

- The determination of the water quantity and quality component of the EWR and BHN (Basic Human Needs) for the rivers at various EWR sites;
- The determination of the water quantity and quality component of the EWR and BHN for the priority wetlands, pans and lakes, where applicable;
- The determination of the water quantity and quality component of the EWR and BHN of estuarine freshwater requirements for each identified estuary and
- The determination of the groundwater quantity and quality component of the EWR and BHN for each identified resource unit/quaternary catchment in the study area.

GAP ANALYSIS

River Reserve Gap Analysis

The EcoClassification step in the Reserve addressed all quaternary catchments in the study area but EWRs were only determined for the main Orange River within the study area. During this study, desktop estimates will be provided for the tributary rivers.

In terms of the quantification of EWRs for the main Orange River, no gaps have been identified that can cost-effectively improve the EWR determination.

A gap is the lack of response monitoring or the application of the River Ecological Monitoring Programme (REMP). Some monitoring has been initiated by DWS and conservation agencies and once the data is analysed, can be used. Additional monitoring undertaken by ORASECOM is not necessarily applicable as it is at different sites and did not follow up from the baseline set for the EWR sites.

Estuary Reserve Gap Analysis

Only the main Orange River Estuary has been addressed. The four other estuaries (Buffels, Spoeg, Groen, Sout and possibly the Swartlintjies) in the study area will be addressed as part of this study.

Wetland Reserve Gap Analysis

Previous EWR studies addressed the wetland component of the estuaries as well as all floodplain wetlands associated with the main Orange River. Priority wetlands and their status and importance were also identified and assessed. This work will be complemented by adding the Reserve steps that have not been undertaken.

Groundwater

- Groundwater use data are available for the main towns, however the data needs to be updated utilising Water Use Authorisation and Registration Management System (WARMS) and the All Towns studies. This data is not available to the study team at present although it has been requested.
- The Schedule 1 use and groundwater use is not available and will have to be estimated based on population, estimated livestock requirements, and level of service
- There is generally good availability of groundwater quality data, with over 7800 data points with data on Total Dissolved Salts (TDS) and nitrates. However, some catchments have less than 10 boreholes available with water quality data.
- Water quality maps were generally compiled many years ago, or based on old data. There is much more data presently available and these maps need to be recompiled and updated.
- The water quality analysis on a spatial scale is not catchment or lithology specific and needs to be re-evaluated to identify problem lithologies and regions.
- The lack of water level data in many catchments limits the areas where calibration of rainfall-recharge can take place.
- The deterioration of the rain gauge network creates difficulties in calibrating more recent water levels to rainfall recharge.
- The surface-groundwater interactions were not simulated in Groundwater Resources Assessment II (GRAII) due to the lack of baseflow, nor were the interactions included in the Orange-Senqu River Commission (ORASECOM) calibrated hydrology.
- Losses from the Orange River have not been simulated.
- Existing recharge volumes vary significantly, hence may be unreliable. It is unlikely the large volumes of recharge in some estimates can occur without generating baseflow.
- The Harvest Potential is higher than the recharge in some catchments.

Basic Human Needs Gap Analysis

This component was not addressed previously and will be addressed as part of this study. A challenge will be to merge the Basic Human Needs previously assessed as a stand alone task linked to surface water as well as assessed as part of the groundwater components. Since a large part of the population is already provided with groundwater via formal schemes, this resulted in double accounting of existing use and the BHN. During this study, two approaches will be integrated with one Basic Human Needs Reserve (BHNR) report which covers both surface and groundwater components.

Scenario Assessment Information Gap Analysis

Scenarios will be assessed primarily with the integrated network model which covers the study area except for the small rivers along the west coast that lies outside the Orange-Senqu Basin but still form part of the Lower Orange WMA. The confidence rating of the integrated model is medium-high to high, while only basic WRSM2000 (Pitman rainfall-runoff model) configurations are available for the west coast tributaries where the confidence rating is low. It should be noted that the integrated network model also covers the water resource systems in Botswana and Namibia that form part of the Orange-Senqu Basin.

Most of the WRYM and WRPM model setups for the Lower Orange WMA are rated to be at medium, medium high to high confidence. The low confidence portion of the WRYM and WRPM networks is in the Molopo River catchment and is due to the low confidence in the hydrological data.

The area along the west coast has only the WRSM2000 model setup available, representing a low confidence level.

Scenarios affecting the flow at the EWR sites located in the Orange River will be defined in consultation with the Client and with particular reference to what is being analysed as part of the Vioolsdrift Dam Feasibility Study. Alternative settings of the EWR definitions will be selected for analysis in combination with the proposed (most likely) water resource development options. Scenarios formulation meetings will be held with the Client and the Vioolsdrift Dam Study PSP team to formulate the scenarios for analysis in this assignment.

Shale gas will be considered where carbonaceous shales are considered as separate RUs and their resources evaluated.

Validation and Verification of Water Use Gap Analysis

Due to the extensive operational and development planning investigations that were carried out in the past, the absence of comprehensive Validation and Verification assessment in the study is not considered to be a fatal flaw. Estimates of groundwater use in the tributary catchment however remain a challenge and will be estimated from readily available information, as described in the relevant task.

Hydrology Gap Analysis

The flow in the main Orange River is almost entirely dependent on the flows generated in the Upper Orange, Senqu River in Lesotho and the Vaal River along with the related operating rules system management procedures. The hydrological data applied for all the areas upstream of the Orange Vaal confluence were updated and extended as part of the ORASECOM IWRMP Phase 2 study and covers an 85 year period from 1920 to 2004 hydrological years. The hydrology information in the upstream catchments can in general be rated as of high to very high confidence.

Due to the erratic nature of the runoff and very low to zero monthly river flows in the arid tributary catchments within the Lower Orange WMA, several of the quaternary catchments were grouped together to form a larger catchment. These quaternary catchment monthly flow records were added together to represent the flows for the related combined catchment providing flow records at key water resource locations within the Lower Orange WMA. These combined catchments and related monthly flow records were configured in the Water Resources Yield Model (WRYM) and Water Resources Planning Model (WRPM) networks for yield and planning analysis purposes. Hydrological information is available at quaternary catchment scale from the river-runoff modelling and calibration that was undertaken during Phase ll of the ORASECOM study.

Observed flow data in the tributary river in the Lower Orange catchment is sparse and the calibration of the rainfall-runoff model were only possible in a few of the tributaries. The hydrology generated for the calibrated catchments can in general be accepted as hydrology with a high confidence level, while those where calibrations were not possible as medium confidence level.

The Molopo River hydrological data was obtained from the *Feasibility Study of the Potential for sustainable Water Resources Development in the Molopo-Nossob Water Course* by ORASECOM and is regarded as low confidence due to absence of observed flow data in this area and the extremely high losses that occur naturally, and are difficult to estimate accurately.

The hydrology available for the small rivers along the west coast is only available from the country wide WR2012 study. Water use data isin general less accurate and the resolution of the network configurations is lower compared to catchment specific studies. A low confidence level is therefore assigned to the WR2012 hydrology.

None of the Lower Orange WMA hydrology incorporated detailed groundwater surface interaction modelling. In most of these areas there are no to very small base flows indicating groundwater surface water interaction is not prevalent.

PROJECT PLAN: NON-TECHNICAL TASKS

These tasks consist of the following:

- Task A Project Management: Project Management includes a maximum of seven Project Management Committee meetings in Pretoria. Detailed Progress reports will be provided prior to each meeting. Financial management will consist of invoices on a quarterly basis for all deliverables due within the quarters.
- Task B Review of water resources information and data gathered. A large number of Water Resource related studies were carried out in the past, which covers not only the Lower Orange WMA but the entire Integrated Vaal River System (IVRS), the Orange and Senqu river basins. Approximately 12 full EWR studies were undertaken during the last 16 years. Four previous EFR studies that focussed on the Lower Orange WMA consisted of four ORASECOM studies. Rivers for Africa lead all these tasks.
- Task C Communication Coordination – Stakeholder process: Stakeholder participation is important for the study to ensure involvement of all sectors of society, to secure buy-in and support to the objectives set for the study and to provide stakeholders with meaningful information to assist them to provide useful contributions so that they are a part of the study and its implementation. Three Project Steering Committee meetings will be held during the course of the studies. A stakeholder database will be set up, Background information documents produced and minutes of the meetings amongst others
- Task D Capacity Building: The Capacity Building task of this study programme will focus on the further capacitation of DWS staff on EWR and the Reserve. The process to be followed to ensure capacitation through building on earlier exposure of staff members to EWR approaches would require liaison with DWS during the inception phase of the study.

PROJECT PLAN: TECHNICAL TASKS

These tasks consist of the following:

- Task 1: Step 1 Project Inception: Step one of the Reserve process basically describes the inception phase during which project planning and process integration takes place. The objective of this task is to produce a concise, clear and unambiguous Inception Report.
- Task 2: Step 2 - Define Resource Units: The task will consist of the following:
  - Rivers: Resource Units determined for the main river during previous studies will be accepted. For the rest of the study areas, the main rivers in quaternary catchments will be accepted as the Resource Units.
  - Estuaries: Delineation of the Orange Estuary has taken place. Five additional estuaries, namely the Buffels, Sout, Swartlintjies, Spoeg and Groen will be delineated.
  - Wetlands: a review of literature and spatial data (such as International / National importance [such as RAMSAR] status, National Freshwater Ecosystem Priority Area (NFEPA), SANBI Critical Biodiversity Areas (CBAs), ORASECOM) will be conducted in order to prioritise and rank wetlands, and determine which ones will be included in subsequent EWR and BHN assessments.
  - Groundwater: A map of significant Groundwater Resource Units (GRUs) will be compiled.
- Task 3: Step 3 EcoClassification: The task will consist of the following:

  - Rivers: Level IV EcoClassification and the Socio-Cultural Importance have been undertaken at the EWR sites in the Orange River. A Desktop EcoClassification assessment has been undertaken for the rest of the catchment.
  - Estuary: Detailed EcoClassification for the Orange Estuary has been undertaken during the 2013 EWR study and will be accepted as is. A field survey will be undertaken for the additional 5 estuaries and the EcoClassification will be applied during a specialist meeting.
  - Wetlands: Previous data for high priority wetlands will be reviewed and refined where necessary.
- Task 4: Step 4 Quantify EWRs: The task will consist of the following:
  - Rivers: A comprehensive EWR assessment has been undertaken at 4 EWR sites in the Orange River. A desktop model will be applied to address nodes in the rest of the catchment.
  - Basic Human Needs Reserve: The Basic Human Needs Reserve will be determined for surface and groundwater for communities that has no access to formal water schemes.
  - Estuaries: All past assessments have resulted in the most recent assessment of the Orange Estuary EWR being at comprehensive level. The results will be used as is. For the additional 5 estuaries, different inflow regimes (including groundwater) will be investigated in order to estimate sensitivity of ecological processes to modification in freshwater input, and subsequently to inform the recommended EWRs
  - Wetlands: Priority wetlands that have not been catered for during previous studies and where a specified flow regime is not applicable (such as pans or hillslope seeps) will be addressed by quantifying (using best available data or satellite data at least) internal and surrounding landuse and scoring habitat intactness as well as buffer zone integrity.
  - Groundwater: The EWR will be determined as follows: The catchments with baseflow will be identified and baseflow quantified. Baseflow is only relevant in 2 quaternary catchments, where it is minor. The quaternary catchments are to be treated separately in delineation. Large areas of ephemeral groundwater seepage to pans, and groundwater evaporation will be identified and treated as distinct GRUs. Hydraulic fracturing requires large volumes of water and the assessment will take account of this and expand on the fracking issues. The relevance of groundwater to wetlands will also be addressed in the study by delineating RUs based on where significant tracts of wetlands exist. Such regions may require a Reserve in more detail. Estuaries are also supported by groundwater. It is planned to utilise a lakes module to determine the role of ground water that was written as an add-on to WRSM2000 for the WA10 studies in the KZN coastal lakes, which can be calibrated against water quality data from the the estuarine team.
- Task 5: Step 5 Ecological Consequences of operational Scenarios: During this task operational scenarios will be identified and modelled to provide flow scenarios at various points in the study area. The consequences of these scenarios on the status quo of the ecology and socio-economics as well as water balance will be assessed. Based on this, recommendations will be made on future operational scenarios which will maintain either the status quo or will achieve improved future conditions.
- Task 6: Step 7 and 8: EcoSpecs and monitoring: This step refers to the final results and format in which EWR should be provided (EWR rule = Reserve definition), the definition of the EcoSpecs, a monitoring programme and implementation methods specifically linked to the operating of dams.
- Task 7: Study Closure: The study culminates in the final results to be provided in a Main Summary report. A close-out report is also provided and all data on electronically on a flashdrive (10 flashdrives to be provided to DWS).

DELIVERABLES

The deliverables are tabled below:

Deliverables	Date	Financial year quarter
PMC Progress report	Nov-15	Q3
Initiation of stakeholder database	Nov-15	Q3
Review of water resources report	Dec-15	Q3
Draft Inception report	Dec-15	Q3
PMC Progress report	Feb-16	Q4
Draft Resource Units report	Mar-16	Q4
EWR summary of Orange River results	Apr-16	Q1
(Invitations for PSC meeting	May-16	Q1
BID for PSC	May-16	Q1
PD and natural hydro (desktop EWR & groundwater use)	Jun-16	Q1
PMC Progress report 3	Jun-16	Q1
PSC meeting 1	Jun-16	Q1
River EWR analysis	Jul-16	Q2
River EcoClassification Summary report section	Jul-16	Q2
River EWR report	Aug-16	Q2
Wetland EcoClassification report section	Sep-16	Q2
Estuary field assessment	Oct-16	Q3
Groundwater EWR	Oct-16	Q3
BHNR	Oct-16	Q3
Wetland EWR analysis	Oct-16	Q3
PMC Progress report 4	Nov-16	Q3
PSC meeting 2	Nov-16	Q3
Capacity building workshop 1	Nov-16	Q3
Estuary specialist meeting	Nov-16	Q3
Wetland EWR report	Nov-16	Q3
Operational scenarios defined	Nov-16	Q3
Finalisation of all Task 3 & 4 reports	Dec-16	Q3
Capacity building workshop 2	Jan-17	Q4
Socio-economic consequences of scenarios	Feb-17	Q4
PMC Progress report 5	Mar-17	Q4
Ecological consequences of scenarios	Mar-17	Q4
Five small estuaries' EWR report	Mar-17	Q4
Estuary consequences of scenarios	Mar-17	Q4
Consequences of scenarios report	May-17	Q1
PMC Progress report 6	Jun-17	Q1
PSC meeting 3	Jun-17	Q1
EcoSpecs and monitoring report	Jul-17	Q2
PMC Progress report	Aug-17	Q2
Main report	Aug-17	Q2
Close-out report	Aug-17	Q2
Electronic data CD	Sep-17	Q2

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ABBREVIATIONS

BHN	Basic Human Needs
BHNR	Basic Human Needs Reserve
BID	Background Information Document
CBA	Critical Biodiversity Area
CBO	Community Based Organisation
CD: WE	Chief Directorate: Water Ecosystems
CERM	Comprehensive Ecological Reserve Methodology
DRM	Desktop Reserve Model
DWS	Department of Water and Sanitation (Name change applicable after March 2014)
EC	Ecological Category
EFR	Environmental Flow Requirements
EI	Ecological Importance
ES	Ecological Sensitivity
EWR	Ecological Water Requirements
GEF	Global Environment Facility
GIZ	Deutsche Gesellschaft fur Internationale Zusammenarbeit
GRAII	Groundwater Resources Assessment II
GRU	Groundwater Resource Unit
HF	hydraulic fracturing
HGM	Hydrogeomorphic
IEI	Integrated Environmental Importance
IERM	Intermediate Ecological Reserve Methodology
ISP	Internal Strategic Perspective
IUA	Integrated Unit of Analysis
IVRS	Integrated Vaal River System
IWRMP	Integrated Water Resource Management Plan
m^3/a	cubic metres per annum
NFEPA	National Freshwater Ecosystem Priority Area
NGA	National Groundwater Archive
ORASECOM	Orange-Senqu River Commission
PES	Present Ecological State
PMC	Project Management Committee
PSC	Project Steering Committee
PSP	Professional Service Provider
REMP	River Ecological Monitoring Programme
RDM	Resource Directed Measures
RDRM	Revised Desktop Reserve Model
REC	Recommended Ecological Category
RHAM	Rapid Habitat Assessment Method
RO	Regional Office
RQO	Resource Quality Objectives
RU	Resource Unit
SANBI	South African National Biodiversity Institute
SCI	Socio-Cultural Importance
SQ	Sub quaternary
TDS	Total dissolved solids
TOR	Terms of Reference
VEGRAI	Vegetation Response Assessment Index
WARMS	Water Use Authorisation and Registration Management System

WMA	Water Management Area
WR2012	Water Resources of South Africa, 2012
WRPPM	Water Resources Planning Model
WRSM2000	Water Resources Simulation Model 2000
WRUI	Water Resource Use Importance
WUA	Water User Associations

1 INTRODUCTION

1.1 BACKGROUND

The Chief Directorate: Water Ecosystems (CD: WE) of the Department of Water and Sanitation (DWS) initiated a study for the provision of professional services to undertake the 'Determination of Ecological Water Requirements for Surface Water (Rivers, Estuaries and wetlands) and Groundwater in the Lower Orange WMA' study. Rivers for Africa was appointed as the Professional Service Provider (PSP) to undertake this study.

As per the TOR, the need to undertake detailed Ecological Water Requirement (EWR) and BHN studies for various water resource components became apparent due to mainly hydraulic fracturing (HF) that will be undertaken in the WMA, various water use licence applications, the conservation status and the associated impacts of proposed developments on the availability of water.

1.2 STUDY AREA

As indicated in the TOR, the study area is the Lower Orange River Water Management Area (WMA) (the old WMA 14). It is the largest WMA in the country, and covers almost the entire Northern Cape Province, as shown in the locality map in Figure 1.1. This core area forms part of the Orange-Senqu River Basin, which straddles four International Basin States with the Senqu River originating in the highlands of Lesotho, Botswana in the north eastern part of the Basin, the Fish River in Namibia and the largest area situated in South Africa. The focus area of the study comprises only the South African portion of the Lower Orange River Catchment. The Eastern Boundary starts where the Vaal River Tributary enters the Orange River, and the Western Boundary is the Atlantic Ocean. The study area is downstream of the Upper Orange, Senqu and the Integrated Vaal River System and as such is affected by the upstream activities of the highly developed river basin. The Orange River forms the border between the RSA and Namibia to the west of the 20 degrees' longitude over a distance of approximately 550 km.

The study area is the Lower Orange River Water Management Area (WMA) (the old WMA 14). The study area is mostly arid with rainfall varying from 400mm in the east to 50 mm on the west coast. The topography of the area is in general flat, including large pans or endoreic areas that do not contribute to runoff reaching the main Orange River.

The Vaal River is the main tributary to the Lower Orange River with other tributaries including the Ongers and Hartebeest rivers from the south, and the Molopo River and Fish River (Namibia) from the north. There are a number of highly intermittent water courses along the coast which drain directly to the ocean, with the Buffels, Swartlintjes and Swartdoorn being the most significant of these.

The Orange River is an international resource, shared by four countries i.e. Lesotho, South Africa, Botswana and Namibia – this study will only focus on South African role players.

1.3 EWR SITES

Five EWR sites were selected in the main Orange River (Fig 1.2). These sites were selected following the procedures associated with the Comprehensive Ecological Reserve Methodology of DWS as well as placed within Management Resource Units (the detailed delineation process of DWS). Accessibility and the characteristics of the sites to allow for reasonable confidence hydraulic modelling are the overriding criteria and in this case, governed the selection of sites. A site locality table is provided below.

Figure 1.1 Study area forming part of the larger Orange-Senqu Vaal basin

Figure 1.2 EWR sites located in the Orange River in the Lower WMA

Table 1.1 EWR site table

EWR site number	EFR site name	River	Decimal degrees S	Decimal degrees E	Geozone	Altitude (m)	MRU
EWR O2	Boegoeberg	Orange	-29.0055	22.16225	Lowland	871	MRU Orange D, RAU D.1
EWR O3	Augrabies	Orange	-28.4287	19.9983	Lowland	433	MRU Orange E
EWR O4	Vioolsdrif	Orange	-28.7553	17.71696	Lowland	167	MRU Orange F
EWR O5	Sendelingsdrift	Orange	-28.07180	16.95951	Lowland	47	MRU Orange G

1.4 DURATION OF THE STUDY

The set out of tasks will be concentrated in a series of specialist work sessions and will finish within the required 24 months. The duration of the contract is from 15 October 2015 to 14 October 2017.

1.5 STUDY OBJECTIVES

The study objectives as defined by the Terms of Reference(TOR) are as follows:

- The determination of the water quantity and quality component of the EWR and BHN (Basic Human Needs) for the rivers at various EWR sites;
- The determination of the water quantity and quality component of the EWR and BHN for the priority wetlands, pans and lakes, where applicable;
- The determination of the water quantity and quality component of the EWR and BHN of estuarine freshwater requirements for each identified estuary and
- The determination of the groundwater quantity and quality component of the EWR and BHN for each identified resource unit/quaternary catchment in the study area.

2 REVIEW OF WATER RESOURCES INFORMATION (GAP ANALYSIS)

2.1 IDENTIFICATION OF OPERATIONS SCENARIOS

The Orange Reconciliation Strategy study was completed in January 2015. This strategy contains the proposed intervention options required to maintain the water balance and considering the expected demand growth up to the year 2040. This study took into account the expected future developments and intervention options for the Integrated Vaal River System as dictated by the Vaal River System Reconciliation Strategy, which was completed a few years ago and is currently in its implementation phase. The Orange Reconciliation Strategy (DWA, 2014) was also developed and forms part of the Integrated Water Resources Manage Plan (IWRMP) (ORASECOM, 2014) that was developed by ORASECOM Phase lll study for the entire Orange/Senqu Basin. This IWRMP was approved by ORASECOM and the four basin states early in 2015.

Results from the Orange Reconciliation Strategy study indicated that the timing of recommended intervention options as well as the magnitude of the proposed infrastructure developments are significantly influenced by the EWRs selected for the main Orange River as well as for the Orange River estuary.

As part of the ORASECOM Phase lll study an integrated water resource model was compiled incorporating the latest ORASECOM hydrology, the future expected developments as obtained from the Vaal, Orange and Greater Bloemfontein Reconciliation Strategies, as well as expected developments in Lesotho, Namibia and Botswana. This integrated model is applied by DWS RSA for the annual operating analysis, carried out each year for the Integrated Vaal River System (IVRS), the Orange and the Greater Bloemfontein sub-system. The model incorporates the operating rules derived for the 2015/2016 Annual Operating Analysis including EWR definitions applied for the past 10 years.

Appropriate scenarios will be formulated in liaison with the study team of the Vioolsdrift Dam Feasibility Study commissioned by the Permanent Water Commission of Namibia and South Africa that is currently underway.

Lithologies with potential shale gas resources will be delineated as separate GRUs (thick sequences of carbonaceous shale). The groundwater resources and their quality will be evaluated compared to WULAs received for shale gas exploration, and the potential groundwater of these GRUs defined. Shale gas potential in the WMA is limited by the presence of the Namaqua Metamorphic Province basement outcropping over large parts of the WMA. Thick Karoo shales exist primarily in the south, with the sequence being thickest, and the most deeply buried to the south of the WMA.

This network model therefore encompasses the entire Orange-Senqu Basin and takes into account all current water resource developments, proposed future infrastructure options, growth in water requirements, water quality management operating rules as well as future changes to the operating rules. The scenario analyses to be carried out in this study will be applying this model for generating monthly flow time series at the relevant sites and estuary.

2.2 PREVIOUS WATER RESOURCES AND EWR STUDIES

These studies mostly use the term Environmental Flow Requirements (EFR) as requested by ORASECOM.

A large number of Water Resource related studies were carried out in the past, which covers not only the Lower Orange WMA but the entire Integrated Vaal River System (IVRS), the Orange and Senqu river basins. The ORASECOM Phase lll and the Orange Reconciliation Strategy study both used the most up to date hydrology and related WRPM system setups covering the entire Orange/Senqu basin. The 2015annual operating analysis for the IVRS, Orange and Greater Bloemfontein used the same data sets, but included more recent demand updates.

Approximately 12 full EWR studies as well as several smaller, desktop studies were undertaken over a period of about 16 years for different parts of the Orange-Senqu Basin. Previous EFR studies that only focused on the Lower Orange WMA, includes the following ORASECOM studies:

- GIZ IWRM Phase 2: EFR study covering the Molopo River basin by Louw and Koekemoer (2010) (Referred to as the 2010 EWR study)
- GIZ IWRM Phase 2: EFR study focussing on the Orange River (Vaal River excluded) by Louw and Koekemoer (2010) (Referred to as the 2010 EWR study)
- GEFTDA/SAP EFR Study covering the Fish River in Namibia, Orange River downstream of the Fish River confluence and the Orange River Mouth by Louw *et al* (2013) (Referred to as the 2013 EWR study)
- GIZ IWRM Phase 3: Consolidation of Environmental Flow Requirements Report focussing on the Orange Senqu basin by Rivers for Africa (ORASECOM, 2014)

The last of the four studies (ORASECOM IWRMP Phase 3 study, ORASECOM 2014), consolidated the findings especially from GEF/TDA and IWRM Phase 2 work, and included the testing for different flow scenarios based on existing and possible future infrastructure and demands. The WRPM data sets and hydrology as referred to in the beginning of this section was used to provide the required flows for the different test scenarios carried out in the ORASECOM IWRMP Phase 3 study.

Any other relevant information available for the study area will be gathered and reviewed, over and above the mentioned studies and models that will most probably provide the bulk of the available data.

2.3 LEVEL OF RIVER AND ESTUARY RESERVE STUDIES

Note that the TOR refers to only the 2013 study being at Intermediate level (i.e., the application of the Intermediate Ecological Reserve Methodology (IERM) was applied. However, both the 2010 and 2013 studies ended up using the Comprehensive Ecological Reserve Methodology (CERM) and the only difference between the two studies were different study areas.

As can be seen from 2.2 above, much work has been done on the Orange River and key tributaries. Apart from the studies referred to above, there has been many other desktop and monitoring assessments undertaken for the Orange River and Estuary.

The TOR refers to comprehensive assessments but do not specify the requirements for the application of the Comprehensive Ecological Reserve Methodology (CERM). However, the expectations are that especially the main river and estuary will be dealt with comprehensively. The CERM has specific requirements according to the following:

- The type of data that must be available to apply the CERM
- The number of site visits to collate data (for the estuary – this specifically refers to surveying both open and closed mouth conditions if relevant).

The expectations are that the application of the CERM would provide moderate to high confidence; however, unless the CERM is applied where the requirements as bulleted above is met, the confidence will not be as expected.

In the case of the main Orange River, all requirements are met and the CERM was therefore applied. The tributaries have not been identified as hotspots[1] and the CERM is therefore not required. The situation is further compromised as the data requirements (first bullet above) for the application of the CERM cannot be met.

With regards to the Orange Estuary, the type of data available is certainly at the CERM level. However, the mouth has not closed during the last 20 years and surveys during closed mouth conditions will not be possible. It is therefore not possible to improve the confidence through further field work. The other estuaries in the study area do not comply to any of the requirements that the CERM can be applied. Other appropriate levels of EWR determination will be used (see chapter 3)

2.4 GAP ANALYSIS

2.4.1 River Reserve Gap Analysis

The EcoClassification step in the Reserve addressed all quaternary catchments in the study area but EWRs were only determined for the main Orange River within the study area. During this study, Rapid Method A[2] level of detail will be provided for the tributary rivers.

In terms of the quantification of EWRs for the main Orange River, no gaps have been identified that can cost-effectively improve the EWR determination. The EWR sites selected were undertaken following procedures linked to the Comprehensive Ecological Reserve Methodology (CERM) and its usefulness (supporting the statement of no gaps) are provided in Table 2.1.

Table 2.1 Existing EWR sites and usefulness

EWR site number	EFR site name	River	Level of the study	Comment (usefulness)
EWR O2	Boegoeberg	Orange	Comprehensive (CERM)	The site from ecological purposes are useful for monitoring but any changes to the operation are limited due to the constraints of Boegoeberg Dam. No other EWR site further downstream could be selected as it did not answer the criteria of site selection. The constraints in terms of Boegoeberg Dam would still be relevant.
EWR O3	Augrabies	Orange	Comprehensive (CERM)	No other sites were possible in this MRU in terms of answering site selection criteria. In terms of addressing ecological concerns (proximity to the Augrabies National Park and an important fish spawning area) as well as evaluating scenarios; the site is highly useful.

[1]A biodiversity/ecological hotspot is a biogeographic region which is a significant reservoir of biodiversity which is threatened with destruction (http://en.wikipedia.org/wiki/Biodiversity_hotspot). In the context used in the Desktop EcoClassification, the hotspot represents a quaternary catchment with a high Integrated Importance which could be under threat due to its importance for water resource use. These hotspots indicate areas where Reserve assessments should ideally result in high confidence recommendations and requires appropriate methods. The term high priority areas is generally used in newer studies.

[2]Rapid Method A refers to a rapid method to estimate EWRs that does not include the selection of EWR sites or field surveys at EWR sites.

EWR O4	Vioolsdrif	Orange	Comprehensive (CERM)	No other sites were possible in this MRU in terms of answering site selection criteria. In terms of addressing ecological concerns (proximity to the Richtersveld National Park) as well as evaluating scenarios; the site is highly useful.
EWR O5	Sendelingsdrift	Orange	Comprehensive	No other sites were possible in this MRU in terms of answering site selection criteria. In terms of addressing ecological concerns (situated within the Fish Richtersveld Transfortier Park as well as evaluating scenarios; the site is highly useful. The proximity to the estuary also makes this site the key site for scenario development and evaluation.

Although the River Ecological Monitoring Programme (REMP) has not been implemented fully in this region, DWS in conjunction with NC Provincial Nature Conservation body is actively sampling invertebrates and occasionally fish in the area as well (*pers com* Christa Thirion, RQIS). The 2015 ORASECOM JBS2 conducted a comprehensive survey of the whole Orange Senqu system, including the Lower Orange WMA, but did not include the EWR sites.

The gap is that the REMP must be adjusted to also comply to the requirements for EWR monitoring, mostly with reference to a framework where compliance issues can be identified as well as management actions to meet the EWR objectives.

2.4.2 Estuary Reserve Gap Analysis

Only the main Orange River Estuary has been addressed at the Comprehensive Level and the four other estuaries (Buffels, Spoeg, Groen, Sout and possibly the Swartlintjies) in the study area will be addressed as part of this study.

2.4.3 Wetland reserve gap analysis

Previous EWR studies addressed the wetland component of the estuaries as well as all floodplain wetlands associated with the main River. Priority wetlands and their status and importance were also identified. This work will be complemented by adding the Reserve steps that have not been undertaken.

2.4.4 Groundwater

Groundwater use

- Groundwater use data is available for the main towns, however the data needs to be updated utilising Water Use Authorisation and Registration Management System (WARMS) and the All Towns studies. This data is not available to the study team at present although it has been requested.
- The Schedule 1 use and groundwater use is not available and will have to be estimated based on population, estimated livestock requirements, and level of service

Groundwater quality in the catchment area

- There is generally a very good availability of groundwater quality data, with over 7800 data points with data on TDS and nitrates however some catchments have less than 10 boreholes available with water quality data.
- Water quality maps were generally compiled many years ago, or based on old data. There is much more data presently available and these maps need to be recompiled
- The water quality analysis on a spatial scale is not catchment or lithology specific and needs to be re-evaluated to identify problem lithologies and regions.

Groundwater level

- The lack of water level data in many catchments limits the areas where calibration of rainfall-recharge can take place.
- The deterioration of the rain gauge network creates difficulties in calibrating more recent water levels to rainfall recharge.

Surface groundwater interactions

- The surface-groundwater interactions were not simulated in Groundwater Resources Assessment II (GRAII) due to the lack of baseflow, nor where the interactions included in the Orange-Senqu River Commission (ORASECOM) calibrated hydrology.
- Losses from the Orange River have not been simulated.

Groundwater resources

- Existing recharge volumes vary significantly, hence may be unreliable. It is unlikely the large volumes of recharge in some estimates can occur without generating baseflow.
- The Harvest Potential is higher than the recharge in some catchments.

2.4.5 Basic Human Needs Gap Analysis

This component was not addressed previously and will be addressed as part of this study. A challenge will be to merge the Basic Human Needs previously assessed as a stand alone task linked to surface water as well as assessed as part of the groundwater components. Since a large part of the population is already provided with groundwater via formal schemes, this resulted in double accounting of existing use and the BHN. During this study, an attempt will be made to attempt the two approaches with one Basic Human Needs Reserve (BHNR) report which covers both surface and groundwater components.

2.4.6 Scenario Assessment Information Gap Analysis

Scenarios will be assessed primarily with the integrated network model discussed in Section 2.2, which covers the study area except for the small rivers along the west coast that lies outside the Orange Senqu Basin but still forms part of the Lower Orange WMA. The confidence rating of the integrated model is medium-high to high while only basic WRSM2000 (Pitman rainfall-runoff model) configurations are available for the west coast tributaries where the confidence rating is low. It should be noted that the integrated network model also covers the water resource systems in Botswana and Namibia that form part of the Orange-Senqu Basin.

Table 2.2 provides information on the available hydrology and models for the indicated river systems and quaternary catchments.

Table 2.2 Models available for scenario analyses

Key Area	Rivers	Quaternaries	Best available models	Confidence of models
Ongers River	Upstream of Smartt Syndicate Dam	D61A to D61M	WRYM &WRPM	High
	Downstream of Smart Syndicate Dam to Orange	D62A to D62J	WRYM &WRPM	Medium-high
Orange small tributaries upstream of Hartbees confluence	Orange River between Vaal and Ongers confluences	D71A – D71D	WRYM &WRPM	Medium-high
	Orange River between Boegoeberg Dam and Ongers confluence	D72A – D72C	WRYM &WRPM	Medium-high
	Orange River between Boegoeberg Dam and Hartbees confluence	D73A – D73F	WRYM &WRPM	Medium-high
Hartbees River	Vis River upstream of its confluence with the Sak River	D51,D52,D56,D58	WRYM &WRPM	Medium-high
	Sak River upstream of its confluence with the Vis River	D55A – D55M	WRYM &WRPM	Medium-high
	Sak River from Sak-Vis confluence to Sak-Hartbees confluence	D57A – D57E	WRYM &WRPM	Medium-high

Key Area	Rivers	Quaternaries	Best available models	Confidence of models
	Hartbees River upstream of Vanwyksvlei Dam	D54A – D54B	WRYM &WRPM	Medium-high
	Vanwyksvlei Dam incremental catchment	D54C	WRYM &WRPM	Medium-high
	Hartbees River downstream of Vanwyksvlei upstream of Rooiberg Dam	D53A & D54D – D54G	WRYM &WRPM	Medium-high
	Hartbees River downstream of Rooiberg Dam to Orange River	D53B – D53J	WRYM &WRPM	Medium
Orange small tributaries	Orange downstream of Hartbees confluence to Namibia RSA border	D81A – D81C	WRYM &WRPM	Medium
	Remainder of Tertiary D81 on RSA side of Namibia RSA border	D81D – D81G	WRYM &WRPM	Medium
	Tertiary D82 downstream of Tertiary D81 to Vioolsdrift	D82A – D82E	WRYM &WRPM	Medium
	Orange River Vioolsdrift to Atlantic Ocean	D82F - D82L	WRYM &WRPM	Medium
Molopo River within the Lower Orange WMA	Nossob River RSA portion upstream of Aub confluence	D42G	WRYM &WRPM	Low
	Auob River RSA portion	D44C	WRYM &WRPM	Low
	Nossob River RSA between Aub and Molopo River confluences	D44D	WRYM &WRPM	Low
	Molopo River RSA downstream end where water disappear in the Kalahari	D45C	WRYM &WRPM	Low
	Only portion of the Molopo contributing to flow into the Main Orange	D45D	WRYM &WRPM	Low
Small Rivers along the west coast draining directly into the ocean	Alexanderbay to just north of Port Nolloth	F10A F10C	WRSM2000	Low
	Just north of Port Nolloth to just north of the Buffels River estuary	F20A – F20E	WRSM2000	Low
	Buffels River	F30A – F30G	WRSM2000	Low
	Swart Lintjes River	F40A – F40D	WRSM2000	Low
	Unknown small river just south of Swartlintjes	F40E – F40F	WRSM2000	Low
	Unknown small river just north of Swartdoorn River	F40G – F40H	WRSM2000	Low
	Swartdoorn River	F50A – F50G	WRSM2000	Low
	Sout River	F60A – F60E	WRSM2000	Low

Notes: WRYM = Water Resource Yield Model, WRPM = Water Resource Planning Model

Most of the WRYM and WRPM model setups for the Lower Orange WMA are rated to be at medium, medium high to high confidence. The low confidence portion of the WRYM and WRPM networks is in the Molopo River catchment and is due to the low confidence in the hydrological data.

The area along the west coast has only the WRSM2000 model setup available, representing a low confidence level.

Scenarios affecting the flow at the EWR sites located in the Orange River will be defined in consultation with the Client and with particular reference to what is being analysed as part of the Vioolsdrift Dam Feasibility Study. Alternative settings of the EWR definitions will be selected for analysis in combination with the proposed (most likely) water resource development options. Scenarios formulation meetings will be held with the Client and the Vioolsdrift Dam Study PSP team to formulate the scenarios for analysis in this assignment.

2.4.7 Monitoring and EcoSpecs Gap Analysis

See rivers section under 2.4.1.

2.4.8 Validation and Verification of Water Use Gap Analysis

Due to the extensive operational and development planning investigations that were carried out in the past the absence of comprehensive Validation and Verification assessment in the study is not considered to be a fatal flaw. Estimates of groundwater use in the tributary catchment however remain a challenge and will be estimated from readily available information as described in the relevant task.

2.4.9 Hydrology Gap Analysis

The flow in the Orange main River is almost entirely dependent on the flows generated in the Upper Orange, Senqu River in Lesotho and the Vaal River along with the related operating rules system management procedures. The hydrological data applied for all the areas upstream of the Orange Vaal confluence were updated and extended as part of the ORASECOM IWRMP Phase 2 study and covers an 85 year period from 1920 to 2004 hydrological years. The hydrology information in the upstream catchments can in general be rated as of high to very high confidence.

Due to the erratic nature of the runoff and very low to zero monthly river flows in the arid tributary catchments within the Lower Orange WMA, several of the quaternary catchments were grouped together to form a larger catchment. These quaternary catchment monthly flow records were added together to represent the flows for the related combined catchment providing flow records at key water resource locations within the Lower Orange WMA. as is summarised in Table 2.3 and configured in the WRYM and WRPM networks These combined catchments and related monthly flow records were configured in the Water Resources Yield Model (WRYM) and Water Resources Planning Model (WRPM) networks for yield and planning analysis purposes. Hydrological information is available at quaternary catchment scale from the river-runoff modelling and calibration that was undertaken during Phase ll of the ORASECOM study.

Table 2.3 Hydrological Information

Key Area	Sub-catchment	Hydrology reference name	Quaternaries	Source of information	Record Period	MAR (million m^3/a)
Ongers River	Upstream of Smartt Syndicate Dam	LOGR1 *	D61A to D61M	ORASECOM Phase ll hydrology)	1920 – 2004 85 years	22.1
	Downstream of Smart Syndicate Dam to Orange	LOGR2	D62A to D62J	ORASECOM Phase ll hydrology)	1920 – 2004 85 years	30.2
Orange small tributaries upstream of Hartbees confluence	Orange River between Vaal and Ongers confluences	LOGR3	D71A – D71D	ORASECOM Phase ll hydrology)	1920 – 2004 85 years	17.5
	Orange River between Boegoeberg Dam and Ongers confluence	LOGR4	D72A – D72C	ORASECOM Phase ll hydrology)	1920 – 2004 85 years	11.6
	Orange River between Boegoeberg Dam and Hartbees confluence	LOGR5	D73A – D73F	ORASECOM Phase ll hydrology)	1920 – 2004 85 years	21.1
Hartbees River	Vis River upstream of its confluence with the Sak River	LOGR6 *	D51,D52,D56, D58	ORASECOM Phase ll hydrology)	1920 – 2004 85 years	46.4
	Sak River upstream of its confluence with the Vis River	LOGR7 *	D55A – D55M	ORASECOM Phase ll hydrology)	1920 – 2004 85 years	22.1
	Sak River from Sak-Vis confluence to Sak-Hartbees confluence	LOGR8 *	D57A – D57E	ORASECOM Phase ll hydrology)	1920 – 2004 85 years	3.9
	Hartbees River upstream of Vanwyksvlei Dam	LOGR9 *	D54A – D54B	ORASECOM Phase ll hydrology)	1920 – 2004 85 years	9.6
	Vanwyksvlei Dam incremental catchment	LOGR10 *	D54C	ORASECOM Phase ll hydrology)	1920 – 2004 85 years	1.4
	Hartbees River downstream of	LOGR11 *	D53A & D54D – D54G	ORASECOM Phase ll hydrology)	1920 – 2004 85 years	16.0

Key Area	Sub-catchment	Hydrology reference name	Quaternaries	Source of information	Record Period	MAR (million m^3/a)
	Vanwyksvlei upstream of Rooiberg Dam					
	Hartbees River downstream of Rooiberg Dam to Orange River	LOGR12	D53B – D53J	ORASECOM Phase II hydrology)	1920 – 2004 85 years	10.9
Orange small tributaries	Orange downstream of Hartbees confluence to Namibia RSA border	LOGR13	D81A – D81C	ORASECOM Phase II hydrology)	1920 – 2004 85 years	4.5
	Remainder of Tertiary D81 on RSA side of Namibia RSA border	LOGR14	D81D – D81G	ORASECOM Phase II hydrology)	1920 – 2004 85 years	3.1
	Tertiary D82 downstream of Tertiary D81 to Vioolsdrift	LOGR16	D82A – D82E	ORASECOM Phase II hydrology)	1920 – 2004 85 years	4.6
	Orange River Vioolsdrift to Atlantic Ocean	LOGR18	D82F - D82L	ORASECOM Phase II hydrology)	1920 – 2004 85 years	1.6
Molopo River within the Lower Orange WMA	Nossob River RSA portion upstream of Aub confluence	D43C	D42G	Feasibility Study of the Potential for sustainable Water Resources Development in the Molopo-Nossob Water course (ORASECOM)	1920 – 2004 85 years	0.22
	Auob River RSA portion	D44C	D44C		1920 – 2004 85 years	0.01
	Nossob River RSA between Aub and Molopo River confluences	D44D	D44D		1920 – 2004 85 years	0.01
	Molopo River RSA downstream end where water disappear in the Kalahari	D45C	D45C		1920 – 2004 85 years	0.03
	Only portion of the Molopo contributing to flow into the Main Orange	D45D	D45D		1920 – 2004 85 years	0.24
Small Rivers along the west coast draining directly into the ocean	Alexanderbay to just north of Port Nolloth	none	F10A F10C	WR2012	1920 – 2009 90 years	Not yet available on WR2012 website
	Just north of Port Nolloth to just north of the Buffels River estuary	none	F20A – F20E		1920 – 2009 90 years	
	Buffels River	none	F30A – F30G		1920 – 2009 90 years	
	Swartlintjes River	none	F40A – F40D		1920 – 2009 90 years	
	Unknown small river just south of Swartlintjes	none	F40E – F40F		1920 – 2009 90 years	
	Unknown small river just north of Swartdoorn River	none	F40G – F40H		1920 – 2009 90 years	
	Swartdoorn River	none	F50A – F50G		1920 – 2009 90 years	
	Sout River	none	F60A – F60E		1920 – 2009 90 years	0.94

Note * - Catchments where the hydrology were based on calibrations on observed flow records

Observed flow data in the tributary river catchments in the Lower Orange catchment is in general sparse. To produce hydrology of a high confidence level it is necessary to calibrate the simulated flows from the rainfall runoff model on the available observed monthly flows. The calibration of the rainfall-runoff model was therefore only possible at a few sites within the Lower Orange tributaries The hydrology generated for the calibrated catchments can in general be accepted as hydrology with a high confidence level while those where calibrations were not possible as medium confidence level.

The Molopo River hydrological data was obtained from the Feasibility Study of the Potential for sustainable Water Resources Development in the Molopo-Nossob Water Course by ORASECOM

and is regarded as low confidence due to absence of observed floe data in this area and the extremely high losses that occurs naturally, which is difficult to estimate accurately.

The hydrology available for the small rivers along the west coast is only available from the country wide WR2012 study. Water use data are in general less accurate and the resolution of the network configurations is lower compared to catchment specific studies. A low confidence level is therefore assigned to the WR2012 hydrology.

None of the Lower Orange WMA hydrology incorporated detail groundwater surface interaction modelling. In most of these areas there are no to very small base flows indicating groundwater surface water interaction is not prevalent.

3 PROJECT PLAN: NON-TECHNICAL TASKS

3.1 TASK A: PROJECT MANAGEMENT

Project management caters for a maximum of seven Project Management Committee (PMC) meetings in Pretoria. Part of the Project Management function will be providing secretariat and communication coordination services. PMC meetings and all arrangements (invitation, agenda, presentations, and minutes unless otherwise agreed) will be provided by the PSP. The PSP will also prepare detailed progress reports prior to each PMC meeting (available a week before the meeting). Mobilisation of the study team and appointment of all sub-consultants will take place under this task. Ad hoc technical meetings in Pretoria have also been catered for.

Financial management will consist of invoices per deliverable on a quarterly basis. The invoicing is according to fixed amounts as per the contract.

The budget also caters for an independent reviewer that will be appointed in liaison with the client.

3.2 TASK B: REVIEW OF WATER RESOURCES INFORMATION AND DATA GATHERED.

A large number of Water Resource related studies were carried out in the past, which covers not only the Lower Orange WMA but the entire Integrated Vaal River System (IVRS), the Orange and Senqu river basins. The ORASECOM Phase lll and the Orange Reconciliation Strategy study both used the most up to date hydrology and related WRPM system setups covering the entire Orange/Senqu basin. The 2015annual operating analysis for the IVRS, Orange and Greater Bloemfontein used the same data sets, but included more recent demand updates.

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- GIZ IWRM Phase 2: EFR study covering the Molopo River basin (2010) (Louw *et al*., 2010).
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- GEFTDA/SAP EFR Study covering the Fish River in Namibia, Orange River downstream of the Fish River confluence and the Orange River Mouth by Rivers for Africa (2013) (Louw *et al*., 2013).
- GIZ IWRM Phase 3: Consolidation of Environmental Flow Requirements Report focussing on the Orange Senqu basin by Rivers for Africa (2014).

The last of the four studies (ORASECOM IWRMP Phase 3 study), consolidated he findings especially from GEF/TDA and IWRM Phase 2 work, and included the testing for different flow scenarios based on existing and possible future infrastructure and demands. The WRPM data sets and hydrology as referred to in the beginning of this section was used to provide the required flows for the different test scenarios carried out in the ORASECOM IWRMP Phase 3 study.

Any other relevant information available for the study area will be gathered and reviewed, over and above the mentioned studies and models that will most probably provide the bulk of the available data.

A gap analysis was carried out on the available data, results and recommendations as obtained from the data gathering process. The findings and related recommendations of the gap analysis are documented in Section 2 of this report.

***Deliverable*:** Section 2 in this Report which includes:

- Gap analysis results and recommendations.
- Description and list of existing models to be utilised for the purpose of this study.
- Related recommendations to be included in the inception report.

3.3 TASK C: COMMUNICATION COORDINATION – STAKEHOLDER PROCESS

Stakeholder participation is important for the study to ensure involvement of all sectors of society, to secure buy-in and support to the objectives set for the study and to provide stakeholders with meaningful information to assist them to provide useful contributions so that they are a part of the study and its implementation.

During the inception stage of the project, a **stakeholder database** will be compiled (initial database summarised in Appendix A). Identification of stakeholders will take place by contacting local municipalities, communities, networking and from existing databases (e.g. Reconciliation Strategy for Large Bulk Water Supply Systems: Orange River and the 2013 EWR study). Furthermore, reply and comment sheets accompanying mailing, will provide space for stakeholders to add the names of their colleagues or other interested parties. The database will be updated as the process proceeds and as new information becomes available.

Representatives (relevant to the study) of the following sectors of society will be identified so as to afford them the opportunity to comment (the database will be categorised accordingly) and participate in the project.

These sectors are:

- National, provincial and local government;
- Reference groups in the catchment (e.g. Water User Associations (WUAs));
- Agriculture and farmers' organisations;
- Regional and local media;
- Business and commerce;
- Environmental bodies, both as authorities and NGOs; and
- Community representatives, Community Based Organisations (CBOs), development bodies.

A **project announcement** in the form of a **Background Information Document** (BID) will be compiled and distributed to stakeholders on the database. The BID will provide a description of the outcomes of the study, the steps to be taken, at which milestones stakeholders can provide their inputs and proposed timelines. Stakeholders will also be requested to complete a response sheet that will allow them to share any issues and comments that they may have with the proposed study and the methodology. The BID will be distributed before any meetings are held with stakeholders.

A **Project Steering Committee** (PSC) will be vital for the study as the members of the committee will be responsible to guide the process. A Steering Committee was established for the Reconciliation Strategy for Large Bulk Water Supply Systems: Orange River and it is proposed to revive that committee or at least to use it as a start for the establishment of a PSC. The PSC will be a representative body of various sectors in the study area. Its purpose would be to provide guidance in the progressive development of procedures to operationalise Resource Directed Measures in the study area. Members of the Committee will be nominated early in the process and the committee will meet **three** times during the study in Upington.

Each of the meetings will have specific objectives and points of discussion which will set the tone for a productive PSC meeting. It is proposed for the meetings to be scheduled as follows and to have the following broad objectives:

Meeting	Date	Objectives
PSC 1:	June 2016	• Study introduction • Review of the Inception Report and proposed study implementation plan • Overview of study area and current water resources, implementation and operation. • Summary of EWR work undertaken in the study area • Review of draft Resource Unit report
PSC 2:	November 2016	• Groundwater EWR • River & Wetland EcoClassification summary • Presentation of River EWR results • Preliminary overview of 5 estuary pressures, impacts and condition. • Presentation of operational scenarios
PSC 3:	June 2017	• Consequences of operational scenarios and scenario recommendations (ecology, socio-economics, ecosystem services) • EcoSpecs and Monitoring

The PSP will be responsible for the distribution of invitations and information documents to the PSC members two weeks in advance of meetings. These information documents will include an agenda, often draft reports which members can review in preparation of the meeting and some summarised background information. Recording, compilation and distribution of the minutes of each PSC meeting will also be undertaken. A dry-run meeting will be held before each PSC meeting – this may be planned to coincide with PMC meetings.

Ad-hoc meetings: Meetings with stakeholders to discuss specific technical details will be held. The number of meetings will be determined as the need arises, however it is estimated that 6 ad-hoc meetings will be held in Pretoria. The meetings will be arranged and attended by the PSP for presentation, discussion and record keeping purposes.

Recording of comments: An Issues and Response Report will be compiled and updated as the process unfolds. This report will list all the comments and questions from stakeholders during the project and responses to those from the project team. This report will provide a record of stakeholder comments throughout the process and responses from the team.

DWS web site: All public information will be made available to the DWS to upload on the Department's website and this address will be sent to all stakeholders.

Deliverable/s:

- Inputs for the Inception Report, including review of existing information
- A stakeholder database
- Background Information Document and response sheet
- Invitation to three meetings (3 x PSC)
- Agenda, attendance register, minutes of three PSC meetings
- Compilation of the Issues and Response Report (Ongoing with final report at the end of the study)
- Inputs to the DWS website
- Inputs for the Closure Report

Responsibility of the Consultant

- The consultant is not responsible for translations of information documents, setting up newspaper advertisements or placing them. It is assumed that due to the scale of stakeholder engagement required as part of the Reserve study, this will not be required.

3.4 TASK D: CAPACITY BUILDING

The Capacity Building task of this study programme will focus on the further capacitation of DWS staff on EWR and the Reserve. Due to the short time-frame of the study, and the current level of capacitation of many staff members already involved in Reserve, Classification and Resource Quality Objectives(RQO) projects, capacity building activities will encompass two planned training workshops, one with an associated field survey, and attendance of specialist river and estuary workshops. Detailed activities are therefore as follows:

- An **estuary site visit** to the four smaller estuaries (Buffels, Spoeg, Groen, Sout and possibly the Swartlintjies) in early October 2016. Space will be limited and 4x4 vehicles will be required.
- A **reconnaissance groundwater site visit** to the catchment in October / early November 2016: This field survey will be led by the Regional Office (RO), who have local knowledge of the area. Although the groundwater specialist will not attend the site visit he will liaise with the RO regarding areas to visit and field indicators to identify. As fieldwork is of limited value in Reserve or RQO groundwater studies due to the extreme spatial extent of the work required and analysis on a large scale (e.g. quaternary scale assessment), the field survey will focus on factors such as the following:
    - The main GRUs or groundwater regions on a coarser scale
    - An emphasis on different geologies and how they affect groundwater
    - The reasoning for delineation of GRUs
- **Training session 1 (groundwater):** This interactive and extensive 4-day workshop led by the groundwater specialist of the study (Karim Sami), will be held in Pretoria in the second half of November 2016, and will build on the field survey undertaken prior to the workshop. The following types of information will be covered:
    - Geological aspects (seen during the field survey), e.g. lithology, interaction with surface water, groundwater quality, recharge, water level, water use. data sources and grouping of GRUs.
    - The use of examples of how groundwater data is fed into integrated hydrology to provide groundwater data of relevance to ecologists. This will include sources of data, calibration, how the data can be used for setting the groundwater component of the Reserve, what components are utilised to identify priority areas, natural vs present day flows, what monitoring measurements are available for setting RQOs, and the pitfalls of point vs area monitoring.

  The main aim of the groundwater training is therefore to assist DWS staff with understanding the data sources available, the problems with data, and methodologies that can be applied to utilise these data sets to define GRUs and generate numerical data for Reserve and RQO studies.
- **Estuary specialist meeting:** This meeting will be held in Stellenbosch in November 2016, and will cover the EcoClassification of the four smaller estuaries of the study area. Participation in the meeting is welcomed.
- **Training session 2 (wetlands and estuaries):** This 1.5 day workshop will be held in Pretoria in the second half of January 2017. The main aims of the workshop will be an introduction to wetland Reserve applications, which will be run by the wetland specialist on the study, James Mackenzie, and an overview of estuaries and RDM, which will be run by Barbara Weston.

- **River ecological consequences specialist meeting:** This workshop will be held in March 2017 in Pretoria and will focus on the evaluation of consequences of any new Orange River scenarios. Participation in the meeting is welcomed.
- **Estuary consequences specialist meeting:** This workshop will be held in March 2017 in Stellenbosch and will focus on the evaluation of consequences of any new Orange River scenarios on the estuary. Participation in the meeting is welcomed.

It is assumed that further dialogue may take place before and after workshops to “wrap up” discussions. Similar opportunities (e.g. two hour sessions) are also available before or after PMC meetings, on any topic or report DWS may need clarification or discussion on.

4 PROJECT PLAN: TECHNICAL TASKS

4.1 TASK 1: STEP 1 PROJECT INCEPTION (INITIATE RDM STUDY)

Step one of the Reserve process basically describes the inception phase during which project planning and process integration takes place. The objective of this task is to produce a concise, clear and unambiguous Inception Report. This is required to ensure the Client, programme manager and consultants are clear as to the deliverables, timing and budget of the programme. The step will run concurrently with the Water Resources Analysis task (Task B) so that the identified gaps and how it will be dealt with are included in the Inception report.

Task responsibility: **Louw**, Seago, Mare, Van Rooyen, Huggins, Koekemoer, Louw, S, Van Niekerk, Sami, Scherman, Mullins

Information required

- Water Resources Review analysis

Actions

- Compile report

Deliverables

- Deliverable 1: Draft inception report (Dec 2015)

4.2 TASK 2: STEP 2 – DEFINE RESOURCE UNITS

The TOR refers to: '*Conduct site selection and delineation of resource units/integrated units of analysis.'* Integrated Units of Analysis (IUAs) forms part of the Classification process and consists of various Resource Units (RUs). As results during the Reserve process are not specific for the IUA as a whole but focuses on the RUs within the IUA, the focus on this task is on the delineation of RUs.

Rivers: RUs for the main Orange River in the WMA has been established during the 2010 and 2013 EWR study and will be used as is. Five EWR sites have also been selected in the Orange River and will be used as is. For the rest of the study area, subquaternary reaches (SQ) have been identified during the DWS/WRC study, referred to as the PESEIS study (DWS, 2014), and could serve as surrogates for RUs. However, due to the extremely arid nature of the study area, and the extensive number of SQ reaches, the RUs for these arid sections will be represented by quaternary catchments which consist of a number of SQ reaches. This also links to the groundwater units and the previous assessments which have been undertaken at a quaternary basis.

Estuaries: The Orange River estuary represents an RU and has been delineated. Note that the Orange River estuary includes the RAMSAR wetland which the TOR refers to. In addition, the Lower Orange WMA also include another 5 estuaries of national importance namely the Buffels, Sout, Swartlintjies, Spoeg and Groen. The additional estuaries each represents a RU and will be delineated according to the accepted approach. In accordance with the approach followed for estuaries each of these will represent an estuarine resource unit.

Wetlands: During the definition of RUs, a review of literature and spatial data (such as International / National importance [such as RAMSAR] status, National Freshwater Ecosystem Priority Area (NFEPA), SANBI Critical Biodiversity Areas (CBAs), ORASECOM) will be conducted in order to prioritise and rank wetlands, and determine which ones will be included in subsequent EWR and BHN assessments. Priority wetlands (based on Present Ecological State (PES), Ecological Importance (EI) and Ecological Sensitivity (ES) have already been outlined for most of the study area (Louw *et al.*, 2010) at the quaternary scale. These data will be verified and integrated into the

definition of resource units. It is recognised that some wetlands are associated with estuaries, these will be included in the estuary RUs and dealt with in tasks pertaining to that section.

Groundwater: A map of significant Groundwater Resource Units (GRUs) will be compiled. Together with catchment boundaries, the following criteria will have to be utilised when sub-dividing or grouping catchments into GRUs:

- Lithology
- Groundwater Regions
- Yield
- Quality
- Recharge
- Wetlands and Pans
- Pollution potential
- Water level
- Surface groundwater interactions

***Task responsibility*: Louw**, Adams, Van Niekerk, Mackenzie, Sami, Koekemoer, Louw,S, Mare, Seago, Da Sousa

Information required

- Rivers: ORASECOM reports
- Estuaries: ORASECOM report, National Biodiversity Assessment 2012
- Wetlands: Literature and spatial data.
- National Groundwater Archive (NGA) Non-data on borehole yield, water level and water quality
- GRAII data on interactions recharge and harvest potential

Actions

- Compile report

Deliverables and milestones

- River RU, GRU, wetland priority and estuary delineation report (Mar 2016)

Responsibility of the Consultant

- The consultant is not responsible for assessing river RUs at a detailed level for any other river than the main Orange River. For the tributaries, the consultant will not be using the SQs as surrogate RUs but will be using quaternary catchments in the place there-of.

4.3 TASK 3: STEP 3 ECOCLASSIFICATION

The steps contained within Step 3 is still largely relevant apart from terminology that is outdated. These steps also used to refer only to detailed EcoClassification (level IV) at EWR sites and estuaries, but has post-2007 been expanded to include an assessment at desktop level for various reaches within the catchment. Furthermore, this step has been expanded generally to include the identification of hotspots which, additional to the above, require the application of Water Resource Use Importance (WRUI), Integrated Environmental Importance (IEI), and hotspots. Hotspots are used to identify where in a catchment detailed work should be focused and EWR sites selected.

The current and expected future water use will be determined for each of the RUs, using the most recent available information from the ORASECOM Phase lll and Orange Annual Operating Analysis.

Rivers: Level IV EcoClassification and the Socio-Cultural Importance (SCI) have been undertaken at the EWR sites in the Orange River and forms the baseline for further investigations.

Desktop EcoClassification as well as the hotspot analysis (which includes WRUI and SCI) were undertaken at quaternary basis and included the most recent tools. The more recent PESEIS study (DWS, 2014) assessed the rivers at SQ scale and provides more resolution. However, due to the arid nature of the rivers, similarity of land use and the nature of the landscape as well as the lack of perennial systems other than the Orange River within the study area, an update at this scale will not be undertaken. Furthermore, these results are largely used to determine the status quo of the study area, for identifying IUAs and for providing the Ecological Category (EC) for which to run desktop models. The EcoClassification results and hotspots identified during the 2010 EWR study will be used for further assessments during the next task. A comparison with the PESEIS study results will be undertaken and if major discrepancies exist, the results will be checked.

Task responsibility: **Louw**,

Information required

- All previous reports, spreadsheets and the PESEIS results

Actions

- Comparison of the 2010 and 2014 results at the relevant scale.
- Summary of results in report format (Aug 2016)

Deliverables

- River EcoClassification summary report section (July 2016)

Estuaries: Detailed EcoClassification for the Orange Estuary has been undertaken during the 2013 EWR study and forms the baseline for further investigations.

For the additional 5 estuaries, the following approach will be undertaken:
1) Conduct a once off field survey to obtain recent data on the physical, chemical and ecological status of these estuaries (this is necessary as available data on these systems are very limited, if not absent)
2) Determine the PES, Ecological Importance, as well as the Recommended Ecological Category (REC) of these systems in accordance with the EWR methods for estuaries.

Task responsibility: **Van Niekerk**, Taljaard, Adams, Lamberth

Information required

- Indication of modification to surface and/or ground water flow to these systems

Actions

- Field survey (Oct 2016)
- Convene EcoClassification workshop to determine the PES, Ecological Importance, as well as the Recommended Ecological Category (REC) of the smaller estuaries. (Nov 2016)

Deliverables and milestones

- Draft reports on the Buffels, Sout, Swartlintjies, Spoeg and Groen estuaries (March 2017)

Wetlands: Only high priority wetlands (those identified during the 2010 EWR study; Louw *et al.*, 2010, and verified in this study, as well as new additions if there are) will be the focus of EcoClassification. The EcoClassification done before will serve as a guideline for this assessment, but because previous studies were conducted at the quaternary scale it may be necessary to outline important (or priority) wetlands at finer spatial scales (such as explicit Hydrogeomorphic (HGM) wetlands RUs or even SQs). Based on priority HGM wetlands, where it becomes necessary to determine EcoStatus at finer scales, best available data will be utilized (e.g. PESEIS data for wetlands associated with riparian zones) to determine PES, and where such data are absent a combination of land use (habitat intactness) and the RDM method (DWAF, 1999) will be used in conjunction with satellite data (Google Earth ©) to determine EcoStatus.

Task responsibility: **Mackenzie**

Information required

- PESEIS data
- ORASECOM data and reports

Actions

- Prioritise wetlands and rank
- Determine PES for important wetlands
- Include wetlands in RU definition

Deliverables

- Wetland EcoClassification report section (Sep 2016)

4.4 TASK 4: STEP 4 QUANTIFY EWRS

4.4.1 Rivers

In terms of data availability and hydraulic calibration, an assessment applying the CERM has been followed at four EWR sites. The comprehensive assessment included supplying information for the Present Ecological State, a Recommended Ecological State and in some cases an alternative category below the present state. These results as EWR rules for the basis for the scenario evaluation.

EWRs at desktop level for rivers in the rest of the catchment are more complex to assess. These rivers are likely to be ephemeral, with possibly some perennial springs. The Revised Desktop Reserve Model (RDRM) (Hughes *et al.,* 2014) may not be suitable for application to ephemeral rivers, and the original Desktop Reserve Model (DRM) (Hughes and Hannart, 2003) may be more appropriate for providing low confidence (desktop) estimates. Whatever model is finally selected[3], it will be applied for the main rivers in the quaternary catchments where hotspots are indicated. This resolution is most likely the best that can be achieved, taking cognisance of the generally high uncertainty in the present day hydrology and hydrological characteristics of these (high flow driven) systems.

According to WR2012, only drainage regions D51 (Upper Vis River tributary of Sak River) and D73 (Orange River between Boegoeberg Dam and Hartbees confluence) produce baseflows. The baseflow estimates in the ORASECOM Water Resources Simulation Model 2000 (WRSM2000) networks for these systems will be further calibrated using WRSM2000 to ensure recharge in the simulations and groundwater use compared to estimates reported in other studies. For the small rivers along the West Coast the default WR2012 networks will be used. Gauging weirs exist on both these networks hence calibration can be undertaken. The results obtained for calibrated recharge against baseflow can also be utilised to verify recharge in catchments of similar lithology which are ungauged. These calibrated baseflow volumes will be used to derive natural (virgin) and present day low flow durations. The gauged catchments with baseflow will also be useful to derive monthly time series of recharge and estimates of threshold monthly precipitation when recharge occurs. These relationships will be used to estimate recharge in ungauged catchments.

Present day flows will be generated and evaluated in areas where current developments and water use are significant and impacts on the natural flow conditions are evident. The present day flows in these ephemeral rivers will be obtained from the calibrated ORASECOM WRSM2000 sub-system networks as prepared for the areas under consideration. It is foreseen that this will only be required

[3]the output in terms of assurance rules for low and total EWRs, is identical

for limited sub-systems as water use in these low rainfall areas are in general very low. The same approach will be followed for the small rivers along the West Coast with the only difference that the default WR2012 networks will be used. Monthly flows obtained from this analysis will be used as input to the estuary groundwater component of the task (See last bullet on groundwater component). From the groundwater task the water balance for the estuary will be determined and flows be provided for Estuary EWR analysis purposes.

The results will be provided as EWR rules and/or flow duration tables. The results will also be extrapolated to various nodes in the main Orange River for future modelling purposes. This, with the desktop estimates, addresses the following task required in the TOR: *The scaling (extrapolation and/or estimation) of the EWR determination results specifically for the rivers.*

Task responsibility: **Louw**, Birkhead, Seago, Van Rooyen, Huggins, Koekemoer

Information required

- WRSM2000 setups from the ORASECOM Phase ll study
- WRSM2000 setups from the WR2012 study.
- WRYM and WRPM setups from ORASECOM Phase lll study with latest updates from the Orange and Vaal annual operating analyses included.
- EcoClassification results per RU (REC)

Actions

- Re-calibrate areas with baseflows in the D51 and D73 catchments
- Refine WRYM and or WRPM setups to accommodate selected EWR sites
- Run check and improve WR2012 Pitman models setups if required
- Provide natural flows at EWR sites
- Provide present day flows where required at EWR sites
- Run desktop EWR model to estimate EWRs
- Provide desktop results and summarise existing comprehensive results in a report (Aug 2016)

Deliverables

- EWR summary of Orange River results (April 2016)
- Present day and natural hydrology at the tributary nodes (June 2016)
- River EWR analysis for the tributary rivers (July 2016).
- River EWR report (Aug 2016).

Responsibility of the Consultant

- The consultant is responsible for setting up the required models as described in this section.

4.4.2 Basic Human Needs Reserve:

As per the Terms of Reference the BHN associated with all resources will be determined. In order to do this an analysis of the current demographic profile of the WMA will be undertaken. The results of Census 2011 will be used as the departure point. This will be supplemented with available data that is either more recent or the result of dedicated studies undertaken to link the population in the WMA with water resources and usage. The population figures will be adjusted from the 2011 base to a 2015 figure using the currently accepted population growth figures for the applicable districts within the WMA. The data will be matched with the profiles of reliance on water resources as provided by the Census 2011 figures or additional relevant data. The Census 2011 gives a breakdown of reliance on water sources and this will be key in determining the sources used by the population. Sources typically specified in the census include Regional Water supply schemes, boreholes, springs, rainwater dams, rivers or streams, water vendors, and water tanks. The WMA can be analysed in terms of these types of services provided and by ward. This allows for the geographical spread of service types within the WMA. For the riverine use a maximum distance to the relevant

resource is assumed on terms of population reliant on run of river. In terms of groundwater this will be crosschecked with the specialist part of the study so as to ensure that the assumed usage as per the Census is reflected in terms of what is understood with respect to specialist understanding of the groundwater resource. Available information and maps that were used to inform the "Identification and Monitoring of Groundwater Dependent Communities in the Northern Cape" will be used. Where possible a similar approach will be followed for the estuary and for wetlands.

The data will be geo-referenced so that BHN per quaternary and by type of resource reliance are available. Data will be provided in a table that sets out the BHN with respect to a series of mooted models of provision (25L – 100L per capita per day), and by resource, as well as by source/resource.

To avoid double accounting for domestic use in the Reserve, the compilation of future Basic Human Needs reserve will have to exclude those already served by groundwater. This can be undertaken by compiling the BHN from population figures, and subtracting those already accounted for under monitored ground and surface water schemes.

Task responsibility: **Huggins**, K Sami

Information required

- DWS demographic data if such data is deemed to be different from that provided by Statistics SA and as set out in census results.
- Groundwater use is available for the main towns, however the data needs to be updated utilising WARMS and the All Towns studies. This data is not available to the study team at present although it has been requested

Actions

- Analysis of demographic demand
- Estimate Schedule 1 use and groundwater use.

Deliverables

BHNR report (Oct 2016)

4.4.3 Estuaries

All past assessments have resulted in the most recent assessment of the Orange Estuary EWR being at comprehensive level. The results will be as baseline for the scenario evaluation.

For the additional 5 estuaries, different inflow regimes (including groundwater) will be investigated in order to estimate sensitivity of ecological processes to modification in freshwater input, and subsequently to inform the recommended EWRs. This work is to be completed in a workshop setting as part of Task 4.3.

Task responsibility: Van Niekerk, Taljaard, Adams, Lamberth

Information required

Actions

- As part of the EcoClassification workshop determine the consequences of water resource development on the smaller estuaries

Deliverables and milestones

- EWR report on the Buffels, Sout, Swartlintjies, Spoeg and Groen estuaries EcoClassification. (March 2017)

4.4.4 Wetlands

According to the terms of reference, in order to quantify the EWR for wetlands "The wetlands EWR determination method must be applied to the priority wetlands and for those wetlands where the EWR method is not the ideal approach, alternative measures could be applied e.g. EcoSpecs". There is currently no standardised procedure for the determination of the EWR for wetlands. The main reason for this is due to the natural variation in wetland types and their associated role/context in overall water movement (and hence requirement) in the landscape. Floodplain wetlands that are associated with riparian zones, for example, have different functionality and requirements than endorheic pans or hillslope seeps. It follows that the procedure for the quantification of the EWR will be different between wetland types and be specific to their HGM context. An existing manual for the "Rapid Ecological Reserve determination of Inland Wetlands" (Rountree *et al.*, 2012) recognises this difficulty and proposes that methods appropriate for each wetland type be used, and where this does not constitute a formal flow regime (such as hillslope seeps) that measures of habitat intactness or overall health (such as PES) be used to define RQOs and that these will serve a similar purpose.

It is proposed to outline which priority wetlands have already been catered for during previous quantification of the EWR. These will be all the wetlands associated with the riparian zone, such as floodplains and channelled valley bottom wetlands. Priority wetlands that have not been catered for and where a specified flow regime is not applicable (such as pans or hillslope seeps) will be addressed by quantifying (using best available data or satellite data at least) internal and surrounding land use and scoring habitat intactness as well as buffer zone integrity. The reason for this is that the buffer zone is often important for the hydrological input to some wetlands e.g. pans. A measure of both wetland intactness and buffer zone integrity lends itself to the definition of EcoSpecs which stand instead of a quantified EWR.

Task responsibility: **Mackenzie**,

Information required

- Previous EWR data and reports
- Previous wetland classification / reports

Actions

- Outline priority wetlands associated with the riparian zone and summarise the EWR requirement
- Where priority wetlands have been defined and do not lend themselves to a required flow regime, determine the PES, wetland intactness and buffer zone integrity

Deliverables

- Wetland EWR report (Nov 2016).

4.4.5 Groundwater

The TOR call for a comprehensive level of determination for the EWR and BHN components of groundwater. This requires long term observations of water use and water level and water quality, which may or not be available. The level of determination can be addressed based on:

- the degree to which groundwater in a catchment is utilised compared to desk top estimates, or the map of stressed catchments where reserves have been undertaken,
- the degree of groundwater dependency as indicated on the map of groundwater dependent communities in the Northern Cape,
- the identification of average borehole yields, may create the potential for over exploitation
- the ecological sensitivity of the catchment
- and the identification of areas where licences for hydraulic fracturing have been awarded.

Baseflow is only relevant in 2 quaternary catchments, where it is minor. The quaternary catchments will be treated separately in RU delineation. The relevance of groundwater to wetlands will also be addressed in the study by delineating RUs based on where significant tracts of wetlands exist.

Estuaries are supported by groundwater. A lakes module to determine the role of ground water that was written as an add-on to WRSM2000 for the WA10 studies in the KZN coastal lakes has the potential to be adapted to estuaries to derive a groundwater balance, and calibrated with salinity levels.

Hydraulic fracturing requires large volumes of water, estimated to be between 20000- 150000 m^3/a for a single field. The availability of water and water quality may constrain the development scale. Water demand profiles also vary for fracking, drilling and potable use.

The potential areas where fracking may be viable will be identified. The most promising areas are those:

- without intensive dolerite intrusions
- with thick sequences of shale like the Prince Albert, Whitehill, Vischkuil, Fort Brown Formations etc.

The critical criteria affecting fracking in these areas will include borehole yields as a source of water, groundwater storage and recharge, water quality, and existing groundwater use. This section discusses the findings of the literature review and a preliminary analysis of the available data.

Groundwater is of major importance in the study area and constitutes the only source of water over large areas. It is mainly used for rural domestic supplies, mining, stock watering and supplies to inland town. About 60% to 70% of the available water is supplied from groundwater sources. Although proportionately a very small component of the available water in the Orange River sub-area, groundwater also constitutes an important source of water for rural water supplies in this sub-area. Additional future demands may be placed on the resource for fracking.

Groundwater recharge is low, hence somewhat limited and generally only small volumes can be abstracted sustainably. Of critical importance is induced recharge where groundwater abstracted near the river, inducing from the river to the local groundwater regime.

Groundwater quality varies from good to unacceptable in terms of potable standards. The groundwater quality is one of the main factors affecting the development of available groundwater resources. Total dissolved solids (TDS), nitrates (NO3 as N) and fluorides (F) represent the majority of serious water quality problems that occur. Water quality issues that need to be addressed include diffuse pollution sources from agriculture, and the management of local sanitation problems at small towns.

4.4.5.1 Groundwater use

Industrial and mining: Mining plays an important role in the WMA's economic development. Several diamond mines are located in the WMA including the Kleinzee, Alexcor and Hondeklipbaai mines. Diamonds are recovered at these mines from alluvial deposits. A number of small-scale diamond diggings are also found in the area. Other mining activity include (amongst others) zinc near Aggeneys, potential rare earths, and other metals. Mining use can be quantified using WARMs. Fracking, which could occur in the southern area of the Karoo. Groundwater use for renewable energy may also play an increasing role.

Agriculture: Most farming settlements are dependent on groundwater for domestic and stock watering use. The groundwater resource is of such a nature that it cannot be utilized for large-scale irrigation throughout the WMA, except in the areas underlain by dolomitic aquifers. Volumes of total abstraction are available for this use.

Domestic: Groundwater is utilised for individual domestic use in most rural and farming areas. Groundwater is the most important resource for bulk water supply in areas located far from the surface water bulk supply network. The naturally poor quality and poor yields of some aquifers are a constraining factor in the utilization of this resource. This is overcome in some areas by good water management practices and treatment of the groundwater. According to the DWS Internal Strategic Perspective (ISP) for the Lower Orange (2004), the total abstraction for groundwater is 10 million m^3/a. or approximately 100 000 inhabitants. The majority of the water (43%) is abstracted from the granite and gneiss aquifers, 25% is from the Dwyka and Ecca Karoo sediments, 17 % from the Beaufort Karoo sediments and the remainder is abstracted from the dolomites (6%) and other primary aquifers (2%).

Way forward and challenges: To compile the Groundwater Reserve, one of the key components is quantifying the existing groundwater use and the Basic Human Needs (addressed in previous section). The challenges include:

- Compiling the Schedule 1 water use based on populations and livestock not accounted for in the survey of town consumption
- Compiling water use based on the All Towns studies and census data
- To avoid double accounting for domestic use in the Reserve, the compilation of future Basic Human Needs reserve will have to exclude those already served by groundwater. This can be undertaken by compiling the BHN from population figures, and subtracting those already accounted for under monitored ground and surface water schemes.
- WARMS data and evaluation of registered use vs estimated actual water use.

4.4.5.2 Groundwater quality

Groundwater quality is one of the main factors affecting the development of available groundwater resources. Total dissolved solids (TDS), nitrates (NO3 as N) and fluorides (F) are thought to represent the majority of serious water quality problems.

The groundwater quality in the WMA is generally rated as class 2 marginal (TDS <2000 mS/m) to class 4 (TDS >3000 mS/m) unacceptable due to high TDS. The southern and southeast portion of the inland region, De Aar, Victoria West and Sutherland has a class 1 rating (TDS <1000 mS/m), increasing to Class 2 in the areas surrounding Prieska, Griekwastad, Upington and Springbok. The rest of the WMA, particularly north of Brandvlei and Carnarvon and the coastal strip are rated as class 3 and 4. The Sutherland, De Aar, Upington belt has a varying range of potable groundwater from a moderate 50% to approximately 90%. The balance of the WMA, has a predominant potable usage of less than 30%, with the occasional improvement to 50% (V3, 2002).

Natural occurring radioactivity is found in some of the groundwater resources associated with geological formations such as granites and gneisses. Fortunately, the values are mostly low except at Kotzerus, Kharkams, Bulletrap, Fonteintjie, Kenhardt and Riemvasmaak, which fall into Class 2.

Diffuse pollution: Agricultural activities are a source of diffuse water contamination. The contribution of each farm on a local scale is often fairly small but the contribution on a catchment scale needs to be included in assessing any pollution situation. Nitrates are the contaminant of most concern. This problem is associated with areas of intense cultivation due to fertiliser use, and where feedlots occur.

Way forward and challenges

- Interpreting groundwater quality data per catchment and by lithology to identify marginal and poor aquifers
- Quantify groundwater resources according to the volumes of potable groundwater Class 0, 1 or 2 in each Quaternary and specific lithology
- Groundwater quality trace constituent data is available for only 328 boreholes. This data needs to be analysed spatially to detect hotspots and regions where no data is available. The data also needs to be grouped by RU and categorised for Classification purposes

For the quality component of the groundwater Reserve, groundwater will be evaluated using common statistical terms for Total Dissolved solids, nitrates, fluorides and any other constituents such as median, and percentiles, and percentage of samples in each Class.

4.4.5.3 Groundwater level

There are a total of 133 monitoring points throughout the Lower orange WMA. In much of the Central area, no borehole monitoring takes place.

The challenges include:

- Utilising existing water level data to quantify recharge
- Extrapolating rainfall recharge relationships to unmonitored catchments

4.4.5.4 Surface groundwater interactions

Groundwater baseflow and interflow in hillside regions plays an important role in maintaining baseflow. This baseflow can be altered by land use (SFR activities) and groundwater abstraction where groundwater is in hydraulic connection with stream channels, resulting in ephemeral flow or pools, or ephemeral pans. According to GRAII, only 2 catchments have baseflow. Consequently, groundwater plays a minimal role in maintaining baseflow in rivers, however, groundwater evaporative demand may play a significant role in maintaining ecosystems in pan and wetland areas. Recharge of aquifers from the Orange may be locally significant.

The challenges identified include:

- Baseflow simulation is only calibrated against discharge at gauging weirs, hence baseflow to endoreic areas and pans is not considered. The discharge to pans identified by the ecologists as being sensitive will have to be assessed in terms of being groundwater discharge areas
- Quantification of losses from the Orange to local aquifers

4.4.5.5 Groundwater resources

GRAII shows the groundwater use to be 31 million m^3/a, whereas the Harvest Potential is 1320 million m^3/a and the recharge 615 million m^3/a. This is a large discrepancy and it is unlikely such large volumes of groundwater exist. Some of the recharge rates in mm/a seem large compared to rainfall. The stress index was calculated based on dry period recharge to identify stressed areas.

Another issue related to groundwater resource availability with be potability due to the water quality problems. Areas of poor quality groundwater will need to be subtracted from the available groundwater resources, however, such groundwater may still be suitable for stock watering or fracking.

The challenges identified:

- Recharge volumes in GRAII were generated without accounting for a water balance and the fate of the recharge. Recharge will have to be recalibrated using the interaction model and accounting for evapotranspiration from pans to ensure baseflow is not generated. These will have to be calibrated with existing water level data
- Consensus will have to be reached with the DWS regarding revising the recharge figures and Harvest Potential
- Determining groundwater resources by fitness for use for various users

Task responsibility: K Sami, Van Rooyen, Mare

Information required

- All groundwater information from existing databases

Actions

- Analysis of data.
- Report

Deliverable

- Groundwater EWR report Oct 2016

Responsibility of the Consultant

- Applying the GRDM methodology to determine the groundwater Reserve, and providing time series estimates of recharge that can be incorporated into the surface water hydrology in WRSM2000, calibrated against measured baseflow volumes

Summary of Deliverables

A range of reports that include the results of this and the previous task.

- River EWR Report: August 2016
- Groundwater EWR: October 2016
- BHNR Report: October 2016
- Wetland EWR Report: November 2016
- Five estuary EWR report: March 2017

4.5 TASK 5: STEP 5 ECOLOGICAL CONSEQUENCES OF OPERATIONAL SCENARIOS

This task essentially is a classification task and was included in the steps to cater for the lack of a classification system at the time. As the TOR however still requests a scenario evaluation and a socio-economic evaluation, the steps are described below. Note however that the stakeholders above refer to the classification process and the same level of participation as required by the classification process will not be followed.

The scenario assessment is only relevant for the Orange River and Estuary as the other sections of the catchment will be investigated at a level lower than Intermediate (Intermediate level is required for scenario assessment).

Note that a tool has been developed for classification to make recommendation of a balanced scenario evaluation. It is not proposed to use the tool in the Reserve study to provide recommendations as a full stakeholder participation process which includes the other countries will

not be involved. It is also assumed that this will be undertaken as part of a future classification study. Furthermore, there are parallel studies such as the investigation of the Vioolsdrift Dam which may be duplicating some of these tasks. This work will be undertaken independently of this study as the time lines will not necessarily coincide and the objectives and scale will differ.

Definition of scenarios: The recommended intervention options from the Orange Reconciliation Strategy study represents the most likely future developments that will impact on the flow along the Orange River. These recommended intervention options will form the base of the scenarios that need to be considered for the scenario assessment of this study. The present day status or development level will be used as the base scenario. Results from other scenarios selected and as agreed on with the client, will be compared against the base scenario results as well as with natural flow conditions, to determine the impacts on the flow conditions at key EWR sites along the river and at the Orange Estuary. Scenarios required for the estuary will involve estuary specific requirements and related parameters that will be different from those required for EWR sites along the main river. The focus of these scenarios will be on the classification of these sites and the related impacts on the system yield and water supply requirements for different ecological classes. More detail in this regard will be provided in the section below on rivers and estuaries.For budgeting purposes the number of scenarios to be analysed is limited to a maximum of six.

Task responsibility: **Van Rooyen**, Mare, Van Niekerk, Seago, Louw,

Information required

- Results from tasks 2, 3 and 4
- WRYM and or WRPM setup representing the most likely future intervention options as recommended from the Orange Reconciliation Strategy study

Actions

- Identify required scenarios, discuss and obtain agreement with client on suggested scenarios
- Update WRYM data sets with most recent water requirements and agreed scenarios
- Cary out WRYM scenario analysis and evaluate results
- Report on the scenario consequences and recommendations

Deliverable

- Operational scenario defined and modelled (Nov 2016)

Rivers and Estuaries: Two session of scenario assessments have been undertaken, one during the 2010 EWR study (only for EWR O5 and the estuary) (Van Niekerk *et al*., 2013) and a further desktop scenario evaluation during the GIZ IWRM Phase 3 (ORASECOM 2014) study. This last and most updated study in terms of scenarios was not undertaken by the full team of specialists and it is therefore proposed to undertake this assessment in more detail. Furthermore, the scenario evaluation only focussed on the most downstream EWR site. A maximum of 6 scenarios will be evaluated at all the EWR sites. The processes to be followed are the standard approached described for rivers and estuaries as part of the Reserve methodologies.

Task responsibility: **Louw, Van Niekerk**, Kotze, Mackenzie, Deacon, Scherman, Birkhead, Huggins, Koekemoer, Lamberth, Adams, Taljaard

Information required

- Scenario results in the correct format at EWR sites and estuary

Actions

- River specialist meeting (Mar 2017)
- Estuary specialist meeting (Mar 2017)

Deliverable

- Contribution to consequences report (May 2017)

Socio-economics: Economics: Out of River Water Economic Evaluation: The purpose of this task is to evaluate the socio-economic and economic returns of the existing water use by the various water users in the Lower Orange WMA and establish it as a baseline. This is an area with a very low rainfall resulting in a very high dependence on water from the river. The present activities are driven by irrigation, mining and a developing tourism sector. Once the baseline value of water is established for the current water use it will be used for later comparison with the value of water for different proposed ecological flow regimes. A complicating factor is that a number of developmental projects are planned for the area which will have to be accommodated.

The metric of the socio-economic situation of the WMA will be determined on the available information in the catchment drawing extensively on previous studies. Water as a result of its physical nature is a "high-exclusion" cost resource which means that exclusive property rights which are the basis of a market economy are relatively difficult and expensive to establish and enforce. It is therefore useful to group the water values into the following water consuming categories with the benefits realised from the use of water allocated to each:

- Agriculture irrigation;
- Commercial business and industries;
- Mining;
- Manufacturing, and
- Domestic water supply,
- Water linked tourism.

In order to determine the value of water for the various uses in the identified and selected catchments of the tributaries as well as the main river of the Lower Orange WMA, it is important to identify the benefits accrued from its use in each sector which the available water of the identified catchment has been allocated to as well as the water remaining in the river at present. This exercise will provide the baseline for comparison with changes in water availability for different EWR flow scenarios.

Task responsibility: **Mullins**, Van Rooyen,

Information required

- Irrigation Agriculture – Irrigation agriculture is at present the main driver of the economy in the WMA, therefore detailed irrigation data will be required in terms of total hectares irrigated per sub-catchment, crops produced and hectares per crop in the identified sub-catchment.
- Current industrial activities using local produced products (beneficiation) or producing agriculture input products.
- Mining activities.
- Population numbers.
- Tourism numbers.

Actions

- Detailed identification of the sectors directly and indirectly using water from the identified zones in the Lower Orange WMA.
- Determination of the different tributaries and sub-catchments and current water allocation to each use category per catchment. This is necessary as the river flows through a number of temperature zones impacting on the type of crop that can be produced, each with different water requirements and socio-economic impacts.
- Determination of the appropriate valuation technique for each use category.
- Economic value of the use by each category. A water driven econometric model will be used to determine the socio-economic value of water for different EWR scenarios. The results from the model will be used to balance the need for sustainable eco-systems in the catchments of the

Lower Orange WMA with the need for continued socio-economic growth and development of the catchment.

Deliverable:

- Consequences of scenarios summarised: Feb 2017
- Consequences of scenarios Report: May 2017

Socio-economics: Ecosystem services: During the 2013 EWR study an Ecosystem Services assessment was undertaken for the study area downstream of the Fish River confluence. This study included the determination of consequences of scenarios on Ecosystem Services. These results will require updating based on the updated scenarios to be evaluated. Furthermore, the Ecosystem Services study must be extended to include the Orange River upstream of the Fish River confluence (limited to the study area). Ecosystem Services will therefore need to be identified for the rest of the Orange River within the study area. The estuary was analysed with respect to the 2013 EWR but this will also be required to be updated. In addition, provision is made for the evaluation of five additional estuaries within the WMA at desktop level.

Natural habitats and ecosystems provide a huge range of Ecosystem Services that contribute enormously, and are even essential, to human well-being. Protecting these areas is essential in order to achieve sustainable development. River systems and their associated use values are of particular importance.

Based on the literature research, as well as an initial site visit the key Ecosystem Services that form a part of community reliance, livelihoods and subsistence, or provide key non-market related economic functions, will be examined. The list of Ecosystem Services will then be further scrutinized to generate an overview of the likelihood that they will change given anticipated trajectories of modification to the system once scenarios are developed.

In terms of assessment of the impacts of the various scenarios (hypothetical notions of deviation from Present Ecological State (PES)) will be examined at the EFR sites. Essentially the direction of change (either positive or negative), and estimating the magnitude of the change in benefits and costs that may be experienced will be identified

Task responsibility: Huggins,

Information required

- 2013 EWR studies including all Ecosystem Services reports
- Relevant ORASECOM reports
- Scenario inputs from team members

Actions

- Generate report delineating and describing communities that are deemed to be important with respect to EGSA and evaluate against scenarios

Deliverables

- Consequences of scenarios summarised: Feb 2017
- Consequences of Scenarios Report: May 2017

4.6 TASK 6: STEP 7 AND 8: ECOSPECS AND MONITORING

This step refers to the final results and format in which EWR should be provided (EWR rule = Reserve definition), the definition of the EcoSpecs, a monitoring programme and implementation methods specifically linked to the operating of dams. Considering the unique characteristics of the Orange

River as an international river, as well as somewhat updated concepts of some of the issues in the graph, the following is proposed.

Reserve definition: The EWR rule for rivers will be supplied for the PES, the REC and for the preferred scenario. As estuary results are linked to scenarios, a scenario that maintains the PES and that achieves the REC as well as the preferred (or best attainable) scenario that could achieve the REC will be provided.

EcoSpecs and Thresholds of Potential Concern: This has been undertaken for the lowest EWR site (EWR O5) and the estuary and will be accepted as is. The same methods and approaches will be used to provide EcoSpecs at EWR O1, 2, 3 and 4, as well as for the 5 additional estuaries. Recent biomonitoring activities and results undertaken by KAS, DWS and conservation organisations and ORASECOM will be considered in this evaluation.

Monitoring programme: The monitoring programme will be set up for the EWR sites (in terms of hydrology and water quality) and the estuary. The estuary and EWR O5 has been included in a detailed monitoring programme as part of the 2013 EWR study and will be updated to include the 5 additional estuaries. Monitoring the implementation and execution of the related system operating rules as described in the section below, will be included in the monitoring programme. Any updates required for the Orange River estuary will be included. No further information will be supplied for the river monitoring programme in terms of habitat and biota as this is addressed through the REMP and must be undertaken according to DWS procedures

Although not part of the Reserve steps, the TOR has requested the compilation of a monitoring programme also for groundwater resources.

Future monitoring requirements for groundwater will be identified while undertaking the project. Key Indicators of where additional monitoring is needed but not already available will include:

- Stressed catchments where groundwater use is a significant proportion of recharge, or where future use due to fracking and associated infrastructure, requires water use and water level monitoring.
- Catchments where baseflow exists and is significant to the EWR but gauging data and water level data is not available.
- Good groundwater quality areas where hydraulic fracturing may occur.
- Wetlands and estuaries where groundwater inflows are suspected to exist but water level data is not available.

Implementation methods and operating rules: The scenario analysis performed as part of Task 5 already include the operating rules required to supply all the related demands and EWRs imposed on the system. The most appropriate scenario from Task 5 will be selected in consultation with the client, and the related operating rules applicable to the specific scenario will be described.

High level recommendations will be made for the implementation and monitoring of the suggested operating rule. Recommendations for possible further optimisation of the EWR in combination with the proposed augmentation will be made if required, to achieve an acceptable balance between protection of the ecology and use of water for socio-economic purposes.

Further details and refinement should be undertaken as part of Classification or any other study that falls under the ambit of ORASECOM.

Task responsibility: **Van Rooyen**, Mare, Sami, Van Niekerk, Louw, Mackenzie, Koekemoer, Scherman.

Information required

- Task 5 results and recommendations
- ORASECOM EcoSpecs and monitoring programme

Actions

- Detail description of water supply system operating rules.

Deliverables

- EcoSpecs and Monitoring Report: July 2017

Responsibility of the Consultant

As has been instructed by DWS, the consultant will not be providing information regarding habitat and biota river monitoring which is covered by existing DWS approaches.

4.7 TASK 7: STUDY CLOSURE

The study culminates in the final results to be provided in a Main Summary report. A close-out report is also provided and all data on electronically on a flashdrive (10 flashdrives to be provided to DWS).

Task responsibility: Louw, Koekemoer, Louw S

Information required

- All information generated during this study

Actions

- Reporting and copying of flashdrives.

Deliverables

- Main report: Aug 2017
- Close-out report: Aug 2017
- Electronic data: Sep 2017

5 STUDY PROGRAMME

5.1 MILESTONES: DELIVERABLES AND REPORTS

All deliverables and reports are seen as milestones and are tabled in Table 5.1. The timing is provided in the Gantt (Table 5.2). Q refers to the yearly quarter of three months, i.e. Q1-16 would refer to the first quarter in 2016 which covers April, May and June.

Table 5.1 Milestones: Deliverables and reports

Deliverables	Date	Financial year quarter
PMC Progress report	Nov-15	Q3
Initiation of stakeholder database	Nov-15	Q3
Review of water resources report	Dec-15	Q3
Draft Inception report	Dec-15	Q3
PMC Progress report	Feb-16	Q4
Draft Resource Units report	Mar-16	Q4
EWR summary of Orange River results	Apr-16	Q1
(Invitations for PSC meeting	May-16	Q1
BID for PSC	May-16	Q1
PD and natural hydro (desktop EWR & groundwater use)	Jun-16	Q1
PMC Progress report 3	Jun-16	Q1
PSC meeting 1	Jun-16	Q1
River EWR analysis	Jul-16	Q2
River EcoClassification Summary report section	Jul-16	Q2
River EWR report	Aug-16	Q2
Wetland EcoClassification report section	Sep-16	Q2
Estuary field assessment	Oct-16	Q3
Groundwater EWR	Oct-16	Q3
BHNR	Oct-16	Q3
Wetland EWR analysis	Oct-16	Q3
PMC Progress report 4	Nov-16	Q3
PSC meeting 2	Nov-16	Q3
Capacity building workshop 1	Nov-16	Q3
Estuary specialist meeting	Nov-16	Q3
Wetland EWR report	Nov-16	Q3
Operational scenarios defined	Nov-16	Q3
Finalisation of all Task 3 & 4 reports	Dec-16	Q3
Capacity building workshop 2	Jan-17	Q4
Socio-economic consequences of scenarios	Feb-17	Q4
PMC Progress report 5	Mar-17	Q4
Ecological consequences of scenarios	Mar-17	Q4
Five small estuaries' EWR report	Mar-17	Q4
Estuary consequences of scenarios	Mar-17	Q4
Consequences of scenarios report	May-17	Q1
PMC Progress report 6	Jun-17	Q1
PSC meeting 3	Jun-17	Q1

EcoSpecs and monitoring report	Jul-17	Q2
PMC Progress report	Aug-17	Q2
Main report	Aug-17	Q2
Close-out report	Aug-17	Q2
Electronic data CD	Sep-17	Q2

Note that all deadlines provided for reports refer to the first draft to be provided to the Client. It is expected that the Client will provide comments within a month and that the report can be finalised afterwards. Depending on the time to provide comments, reports should be able to be finalised within 6 weeks of providing the first draft.

5.2 GANTT CHART

The study is to be completed within a 24 month period. A Gantt chart is provided below in Table 5.2.

Table 5.2 Gantt chart

TASKS	DELIVERABLES	2015			2016												2017								
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Task A	PMC Progress report		1			2				3					4				5			6		7	
Task B	Review of water resources report																								
Task C, part of	Initiation of stakeholder database																								
Task C, part of	PSC meeting 1									1															
Task C, part of	PSC meeting 2														2										
Task C, part of	PSC meeting 3																					3			
Task D	Capacity building workshop 1														1										
Task D	Capacity building workshop 2																2								
Task 1	Draft Inception report			R																					
Task 2	Draft Resource Units report						R																		
Task 3, part of	River EcoClassification Summary report section																								
Task 3, part of	Wetland EcoClassification report section																								
Task 3, part of	Estuary field assessment																								
Task 4, part of	River EWR analysis																								
Task 4, part of	River EWR report											R													
Task 4, part of	Groundwater EWR													R, R											
Task 4, part of	BHNR																								
Task 4, part of	Wetland EWR analysis																								
Task 4, part of	Estuary specialist meeting																								
Task 4, part of	Wetland EWR report														R										
Task 4, part of	Five small estuaries' EWR report																								
Task 5, part of	Operation scenarios defined																								
Task 5, part of	Ecological consequences of scenarios																								
Task 5, part of	Estuary consequences of scenarios																								
Task 5, part of	Socio-economic consequences of scenarios																								
Task 5, part of	Consequences of scenarios report																								
Task 6	EcoSpecs and monitoring report																								
Task 7, part of	Main report																								
Task 7, part of	Close-out report																								
Task 7, part of	Electronic data																								

6 STUDY TEAM

The study team consists of individuals with extensive experience in the field of water resource planning. The team members have been involved in a variety of studies for DWS since 1988. Furthermore, the study team has undertaken all detailed EWR assessments in the study area and the water resources team has been responsible for the design and implementation of current water resources models and implementation. The study team has been devised into task leaders and specialist according to the team organogram provided in Figure 6.1.

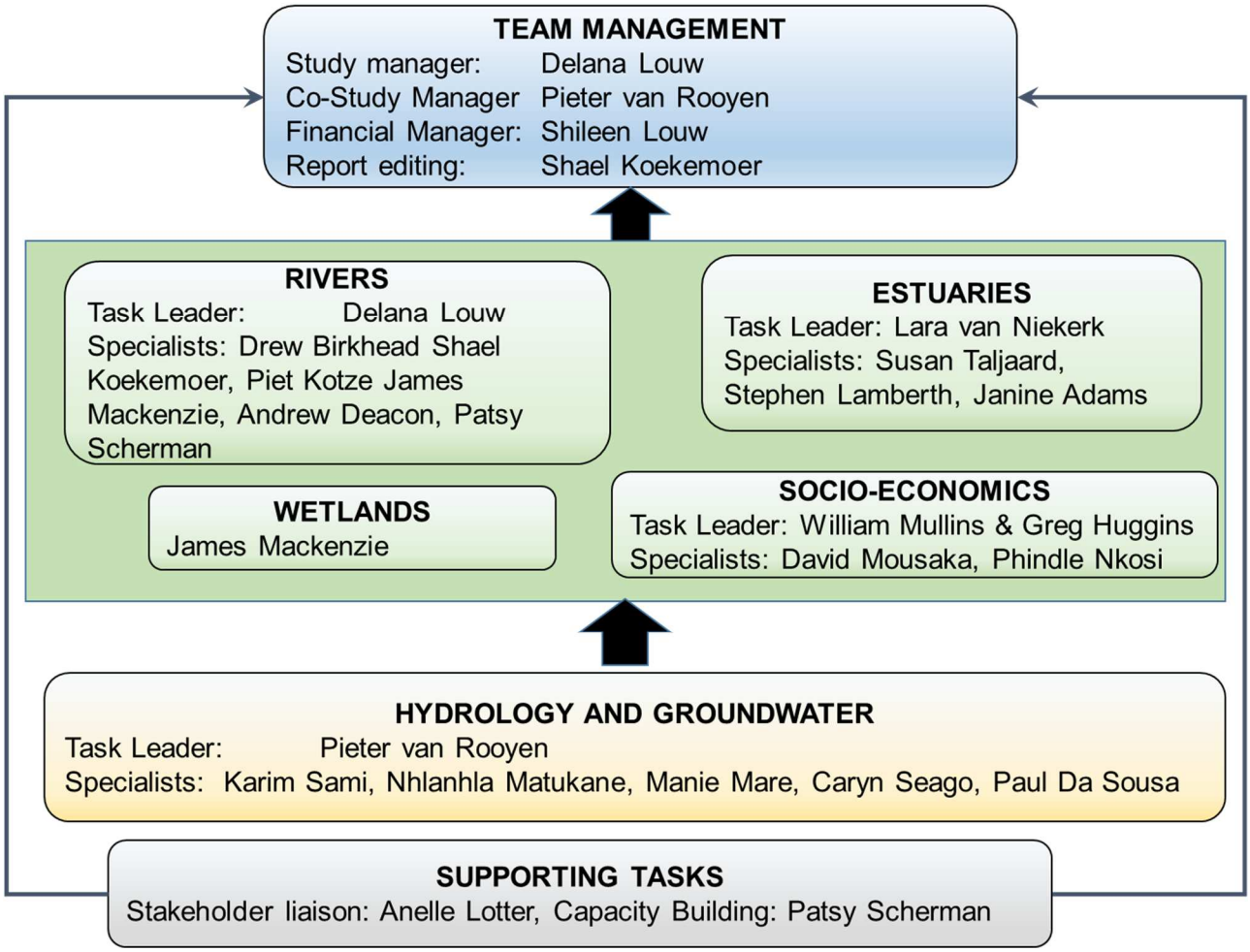

Figure 6.1 Team Organogram

6.1 STUDY LEADER AND RIVER TASK LEADER: DELANA LOUW

Rivers for Africa eFlows Consulting (Pty) Ltd

Rivers for Africa eFlows Consulting (Pty) Ltd (R4A) was formerly known as the Aquatic Ecology Division of Water for Africa Environmental, Engineering and Management Consultants (Pty) Ltd. R4A is committed to providing sustainable solutions to management and environmental problems. Rivers for Africa has a close relationship with the Institute for Water Research (IWR) situated within Rhodes University, Grahamstown. Rivers for Africa and its associated have undertaken all the detailed EWR studies to date in the Lower Orange River.

Delana Louw from R4A has been involved in the development of Environmental Flow Requirements (called Ecological Water Requirements in South Africa) and EcoClassification methods since 1988. She has since applied all of these methods on most Environmental Flow Requirement studies undertaken in South Africa, Swaziland, Mozambique and Lesotho. Delana was also the rivers task

leader for the development and adjustment of methods specifically for the Ecological Reserve. Her focus is on development of integrated project plans for Ecological Reserve, Classification and RQO studies and the providing the technical coordination of these studies.

The Study Leader will be responsible for the liaison with the Client, the general supervision of the Study and the co-ordination of all tasks.

Key areas of expertise include:

- Project Management and co-ordination of Environmental Flow requirement studies.
- Application of Environmental; Water Requirements studies as part of Ecological Reserve determination as required by the National Water Act (1998).
- Development of environmental flow requirement methods.
- Capacity building through association with the Institute of Water Resources, Rhodes University, as well as training provided as an integral part of projects.
- Management and co-ordination of specialist aquatic components on Environmental Impact Assessments
- Ecological classification of rivers.
- Design and management of biomonitoring programmes.

6.2 KEY TEAM MEMBERS AND TASK LEADERS

Co study leader and task leader: Hydrology and groundwater: Pieter van Rooyen (WRP)

Several members of WRP have extensively been involved with DWS in the development of the water resource system analysis models used by South Africa to analyse and manage all of the country's major water resource networks. They were part of the original Vaal River System Analysis team while employed at the time by BKS (Pty) Ltd.

Members of WRP have provided training to several other South African consultants and client bodies in the use of the models and continue to support them when required on a number of studies currently in progress. They have received several awards for their system analysis expertise both nationally and internationally and presented a workshop on system analysis techniques to the American Society of Civil Engineers in Washington in March 1996.

Pieter van Rooyen worked closely with DWS to investigate the operating rules for various water resources in the country including the Orange, Vaal, Mgeni, Mhlathuze and Crocodile river systems He has subsequently been working in close co-operation with Ninham Shand to investigate various possible development options in Lesotho as well as alternative options in adjacent river basins. Mr van Rooyen is generally regarded as the leading expert in South Africa on the operation of the various system analyses models which are used in South Africa and elsewhere.

WRP is also recognised in the field of water conservation. Several key personnel have been involved in various important water conservation initiatives throughout South Africa. Considerable work has also been undertaken on the efficiency of the irrigation canal network along the Lower Orange as well as on the efficiency of releases from Vanderkloof Dam – 1400 km from the river mouth.

Task leader: Estuaries: Lara van Niekerk

Lara van Niekerk is a senior scientist at the Council for Scientific and Industrial Research (CSIR) in South Africa. She specialises in the physical dynamics of estuaries and has been involved in over 35 freshwater flow requirement (EFR) studies on estuaries in Southern Africa. Lara forms part of the

core team of South African specialists that developed the estuarine EFR methods and monitoring requirements. She has extensive experience in linking river and estuary EFRs. She has been instrumental in the development of strategic/operational policies (protocols) and legislation required for the effective management of South Africa's estuaries. Lara led the team of specialists the assessed the health and ecosystem condition of South Africa's estuaries as part of the National Biodiversity Assessment 2011 and currently pilot testing the application of a Desktop Assessment method for estuaries for strategic planning. She and her team has undertaken various estuarine assessments on the Orange Estuary.

Task Leader: Groundwater: Karim Sami:

Karim Sami has extensive experience in groundwater modelling and groundwater resource assessment. He was part of the GRAII study team and author of the surface-groundwater interaction component of the project, as well as making contributions to the recharge project. He is the developer of the groundwater interaction component of the WRSM2000 (Pitman) model. He has participated in DWS Reserve and Reconciliation studies in the Letaba Luvuvhu catchments, Mvoti to Umzimkhulu, and Mhlatuze systems. He has been involved in many multidisciplinary studies involving several firms and disciplines, including environmental assessments. He has also been involved in hydrogeological mapping in other African countries.

Task Leader Wetlands: James MacKenzie

Mr James MacKenzie has been a freelance ecologist since 2003 specializing in the assessments and management of wetlands and riparian zones throughout southern Africa. He completed his BSc Hons in 1993 (cum laude), started his MSc the next year and converted this into a PhD on the regeneration of riparian vegetation along the rivers within Kruger National Park. James has 16 years of experience in riparian and wetland specialist work including vegetation surveys, wetland and riparian zone delineation, determination of Environmental Flow Requirements (IFR, EFR, EWR), assessment of Ecological Importance and Sensitivity, assessment of Habitat Integrity, the development of monitoring protocols (e.g. Rapid Habitat Assessment Method - RHAM) and programs, the development and definition of management goals for Strategic Adaptive Management (SAM) (Ecological Specification and Thresholds of Probable Concern), the development of Flow Stressor Response techniques for hydrological scenario assessment, development of VEGRAI (Riparian Vegetation Response Assessment Index), and presentation of VEGRAI training and vast participation in EIA's with focus on the riparian and / or wetland component of specialist aquatic surveys. He has been involved in several hydro-electric schemes along the Orange River, one on the Kafue River and one on the Kabompo River (both large rivers in Zambia). He has also been involved in the development of wetland offset strategies and their calculation.

Task leader: Economics: William Mullins

In the early years of Mosaka Economic Consultants cc. t/a Conningarth Economists, William worked on projects in a part-time capacity, and then, in 2000, he joined the organization as the resident statistician. William's leadership qualities make him a natural choice as a project team leader.

His extensive experience in the agricultural field means that he is involved in most projects in this field, as well as in impact studies on rivers. William has also worked in specialist fields like the SKA Telescope study, and impact studies for Eskom. Mosaka Economic Consultants cc. t/a Conningarth Economists is a South African multi-disciplinary economic consulting firm that applies economic principles in the solution of practical problems, and in analyzing emerging economic issues. Its

strength lies in the high caliber of its core professional staff, complemented by the backing it receives from expert specialists in the fields of economics, econometrics, and other complementary disciplines. In addition, Conningarth has established links and co-operation agreements with a number of international institutions and specialists. Mosaka Economic Consultants cc and specific William Mullins has been involved in a number of water related projects.

Task Leader: Communication: Anelle Lötter

Anelle Lötter specialises in stakeholder engagement, public participation and awareness creation in the natural resources field. Since 1996 she has worked on a number of related DWS projects ensuring that the relevant role players are involved, informed and are aware that they have the right to comment on the study at hand. Her involvement in DWS projects over the past five years include stakeholder participation for the Orange, Letaba and Luvuvhu, Crocodile (West) Marico, Vaal River and KZN Metropolitan coastal towns Reconciliation Strategy studies and classification studies for Inkomati and Letaba.

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8 APPENDIX A: INITIAL STAKEHOLDER DATABASE

STAKEHOLDER DATABASE			VERSION 1: DEC 2015			
Mr/ Ms	**First Name**	**Last Name**	**Company/ Organisation**	**Job Title**	**Address**	**City**
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Ms	Lizelle	Beukes	Oranje-Vaal WUA		PO Box 314	DOUGLAS
Mr	Tshepo	Bloom	Joe Morolong Local Municipality	Municipal Manager	Private Bag X117	MOTHIBISTAD
Mr	Pieter	Botha	Blouputs Farmers' Association	Chairman	PO Box 430	KAKAMAS
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Mr	Kevin	Chetty	Eskom Holdings SOC Ltd		PO Box 372	WAPADRAND
Mr	Tinashe	Chizema	Department of Water and Sanitation			
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Ms	Neeltjie	Dippenaar	Blouputs Farmers Association		PO Box 430	KAKAMAS
Mr	Gideon	Dippenaar	Sedibeng Water	Regional Manager	Private Bag X5	BOTHAVILLE
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Mr	Hanke	du Toit	Oranje Riet Water Users Association			
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Mrs	Suzanne	Erasmus	Wildlife and Environment Society of South Africa	Chairperson	PO Box 316	KIMBERLEY
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Mr	Herman	Hanekom	Onderstekorseiland Irrigation Board		PO Box 766	KEIMOES
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Mr	Clement	Itumeleng	Gamagara Local Municipality	Municipal Manager	PO Box 1001	KATHU
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Mr	Edward	Mtefang	Ga-Segonyana Local Municipality	Municipal Manager	Private Bag X1522	KURUMAN
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Mr	JA	Olivier	Joint Irrigation Authority		PO Box 15	NOORDOEWER
Cllr	JJJ	Olyn	Kai !Garib Local Municipality	Mayor	PO Box 8	KEIMOES
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Mnr	Hercules	Smith	Oranje-Vaal Water Gebruikersvereniging		Posbus 314	DOUGLAS
Mnr	Jacobus	Smith	Rooiwater Boerdery BK	Grondeienaar	Posbus 800	UPINGTON
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Mr	Alba	Swart	SAD Bokomo Foods			
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Mnr	Andre	van Niekerk	Rooipad Boerevereniging	Chairman		
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Mr	PJJ	van Rensburg	Northern Cape Agricultural Union/Agri Northern Cape		PO Box 102	KIMBERLEY
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Mr	Danie	van Tonder	South African Dried Fruit Co-operative	Co-op Manager	PO Box 99	UPINGTON
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Mr	Pieter	Venter	Black Mountain Mines		Private Bag X01	AGGENEYS
Mr	Chris	Venter	OWK		Posbus 544	UPINGTON
Mr	Ben	Venter	Sedibeng Water			
Ms	Patricia	Viljoen	Department of Water and Sanitation	Secretary to T Nditwani		
Mr	Pieter	Viljoen	Department of Water and Sanitation	Deputy Director	Private Bag X313	PRETORIA
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Ms	Beaulah	Williams	Nama Khoi Local Municipality	Acting Municipal Manager		
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9 APPENDIX B: REPORT COMMENT REGISTER

Section	Report statement	Comments	Changes made?	Comment
Comments in grammar version of report: T Gonah (received 15 February 2016)				
Summary	Priority wetlands and their status and importance were also identified.	Give a table of the priority wetlands that were identified.	No	The wetlands are not available in a table as it is an integrated report of rivers. This work will be done as part of the RU report and as preliminary deliverable
Summary	The lack of water level data in many catchments limits the areas where calibration of rainfall-recharge can take place.	How about Hydstra data	No	The HYDSTRA data was received. The catchments noted as having no data are those without HYDSTRA data
Summary	Most of the WRYM and WRPM model setups for the Lower Orange WMA are rated to be at medium, medium high to high confidence. The low confidence portion of the WRYM and WRPM networks is in the Molopo River catchment and is due to the low confidence in the hydrological data.	Needs to be looked at as its also a fracking site	No	The study area (Lower Orange WMA) excludes most parts of the Molopo River Catchment. The Molopo River areas that form part of the Lower Orange WMA will be considered.
Summary	Due to the erratic nature of the runoff and river flows in the arid tributary catchments within the Lower Orange WMA, several of the quaternary catchments were grouped together as simulation catchment providing flow records at key locations within the Lower Orange WMA and configured in the WRYM and WRPM networks	Explain for the sake of non familiar readers	Yes	Due to the erratic nature of the runoff and very low to zero monthly river flows in the arid tributary catchments within the Lower Orange WMA, several of the quaternary catchments were grouped together to form a larger catchment. These quaternary catchment monthly flow records were added together to represent the flows for the related combined catchment providing flow records at key water resource locations within the Lower Orange WMA. These combined catchments and related monthly flow records were configured in the Water Resources Yield Model (WRYM) and Water Resources Planning Model (WRPM)

Section	Report statement	Comments	Changes made?	Comment
				networks for yield and planning analysis purposes.
1.2	The Vaal River is the main tributary to the Lower Orange River with other tributaries including the Ongers and Hartebeest rivers from the south, and the Molopo River and Fish River (Namibia) from the north.	What about the Sak River?	No	The Sak River is a tributary of the Hartebeest River and thus included
2.1 and page iv		How about any SEA gas scenarios?? How about incorporating fracking as a scenario? The SEA for shale gas is looking at 4 scenarios but its to the south of the Lower Orange WMA. Perhaps it's important to incorporate some of these scenarios.	Yes	Shale gas will be considered in RU delineation, where carbonaceous shales are considered as separate RUs and their resources evaluated
2.4.9	Observed flow data in the tributary river in the Lower Orange catchment is sparse and the calibration of the rainfall-runoff model were only possible in a few of the tributaries	Confusing statement	Yes	Observed flow data in the tributary river catchments in the Lower Orange catchment is in general sparse. To produce hydrology of a high confidence level it is necessary to calibrate the simulated flows from the rainfall runoff model on the available observed monthly flows. The calibration of the rainfall-runoff model was therefore only possible at a few sites within the Lower Orange tributaries.
4.4.3	According to the terms of reference, in order to quantify the EWR for wetlands “The wetlands EWR determination method must be applied to the priority wetlands and for those wetlands where the EWR method is not the ideal approach, alternative measures could be applied e.g. EcoSpecs”.	Confusing statement	No	Cannot change statement as it is a quote from the TOR. What it means is that when flows cannot be determined for the wetlands due to insufficient baseline information, or a lack of methods, Ecological Specifications that describe the condition of wetland is used as a surrogate.
Combined comments from the PMC members received from T Gonah on 15 February 2016				

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Page iii	Comment 1 Page iii under Groundwater first bullet last sentence	A link to the All Town Studies on the DWS website was sent to Mr Sami on 8 October 2015 for accessing reports on groundwater use. The client is not sure what the PSP means by stating that data has been requested but is not available yet. Groundwater quality data (from the National Groundwater Archive) and Hydstra water levels were also sent to Mr Sami on the 19th of October 2015.	N	What was received on October 19 is chemistry data and HYDSTRA data on water levels. It is any other groundwater use data and WARMs data which has not been received. All towns only covers domestic use for towns. Other water use data has not been recieved
Page v	Comment 3 and 9 Page v (Task 3 Step 3: EcoClassification) under Rivers Level IV	This might be out of date. An ORASECOM JBS2 survey was undertaken in July 2015. These results should be included as well as any other available information from REMP surveys conducted by DWS and Environmental/Conservation bodies in the NC and NW.	No	The EcoStatus models and results form the baseline EcoStatus (as it was done at Level IV). The EWRs were set for this baseline. This cannot change. Monitoring information can only indicate whether there are changes from the baseline (doubtful as there has been no operational changes in the river during the las 2 years (last surveys were in 2013 at estuary and EWR O5). Furthermore, JBS2 did not undertake surveys at the EWR sites, neither did they use the results generated during the EWR studies as a baseline. . The initial REMP surveys also follow from the EWR baseline and one of the main purposes are to determine change from the baseline. Lastly, none of the data has been worked into EcoStatus model to determine results at the Level IV EcoClassification method, neither has the full EcoClassification procedures been provided. Therefore, although the information is useful and important, it must be seen as information that will feed into the REMP when it is applied fully.
Page v	Comment 4 Page vi (under Project Plan: Technical Tasks Task 4 last bullet) the opening	The statement needs to be properly explained because	Yes	

Section	Report statement	Comments	Changes made?	Comment
	statement reads "*The level of EWR determination will be based on a variety of factors which will be spelt out and motivated during the study* ".	A) It is the reader's view that the approach that will be taken in the study will be clearly outlined during this phase and NOT being spelt out and motivated during the study. B) It is understood that groundwater per se does not have ecosystems like surface water. However, it plays a role in supporting the EWR through the provision of baseflow. As such it's important to note where the ecological requirements are met and where they will not be met. This analysis is lacking in this part of the report and the rest of the inception report.		
	Comment 5	Several sections of the inception report for instance section 2.2 as well as section 4.4.1 talk about EWR sites from previous studies. It is stated that the results will be used as is. There is no map in the inception report showing the EWR sites, their distribution etc. This needs to be brought to the attention of the PMC and for the PMC to agree on their adequacy, they need to know about their localities. The PMC cannot just adopt them without knowing where they are and their distribution.	Yes	A map will be included. It must be noted that the accepted DWS procedures were used for selection of Management Resource Units and selection of sites. A sentence regarding this will be included in the inception report. It must be noted that the studies before were extremely detailed and the sites were approved by DWS members which were part of ORASECOM reviewers during meetings etc (eg Barbara Weston)
2.3	Comment 6 Section 2.3 on page 2-3, it is mentioned that tributaries are hotspots.	Can you please explain from what perspective the tributaries are hotspots.	Yes	A reference and footnote has been included
2.3	Comment 7: Section 2.3 Level of River and Estuary Reserves	An overview of the WMA including all tertiary drainage regions that exist in the WMA mush be shown and this must be accompanied by a map.	Yes,	The EWR sites, table, and description of tertiary drainage area as well as maps are included in chapter 1 under study area and a new heading EWR sites. It is more appropriate in this section as the gap analysis should not include summaries of

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		The previous study conducted must be showed in the format of a table see the example below		previous studies unless it pertains to the gaps. With reference to your last two column of usefulness of sites and level of studies; that has been included in section 2.3 for rivers as it is supports the statement re no gaps.
2.3	Comment 8 Section 2.3 Level of River and Estuary Reserves (last paragraph) "the other estuaries in the study area who do not comply to any of the requirements that the CERM can be applied".	This has to be clarified and the PSP needs to come up with the solution how to overcome this challenge since according to the ToR all the water resources have to be assessed.	No Yes	Baseline data available to apply the CERM do not exist and cannot be overcome (one cannot create 10 years or more of historical data and measurements). All water resources are addressed in the study as specified in the report. A sentence has been added to indicate that the other estuaries will be addressed at the appropriate levels and a reference to the chapter where more detail is provided is given.
2.4.1, Par 3	Comment 9	Although the REMP has not been implemented fully in this region, DWS in conjunction with NC Provincial Nature Conservation body is actively sampling invertebrates and occasionally fish in the area as well. The 2015 ORASECOM JBS2 conducted a comprehensive survey of the whole Orange Senqu system, including the Lower Orange WMA. As such this means more recent data is available for the study area. Therefore, more recent data should be used to determine the current EcoStatus rather than relying on the 2010 information.		See comment 3
2.4.1,		This study is for the Orange river and its tributaries, therefore there is a gap since the study done by ORASECOM was focusing in the main River. This means since the data for the main river is available and for the tributaries the lowest level that this study will accommodate is	Yes	**Administrative issues:** The TOR does not refer to any work being undertaken specifically at Rapid Level. The TOR states the determination of the EWR at EWR sites. EWR sites are only associated with Rapid Level III. It is uncertain which Rapid level

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		Rapid not Desktop. The Department identified the level of the study to be Comprehensive so it cannot be downgraded to desktop level, a level which the DWS currently determines Reserves at. The areas that will be determined/or extrapolated to Rapid level must be clarified		the comment pertains to. Cost per Rapid Level III is approximately R300 000 per EWR sites. For a study area of this size, many Rapid Level III sites at a huge cost will be needed. The proposal and associated budget which was accepted did not indicate that Rapid Level III will be undertaken. The reasons were provided. **Practicalities:** The comment refers to the ORASECOM study (ies) focusing on the main river. That is however not so as the whole catchment was subject to a hotspot assessment were priority areas for river EWR assessment was undertaken. Hotspots (areas ecological important and under stress or threat for future use) were not identified. Fracking for surface water Reserves are not relevant as no use will be made of surface water. The statements made of exploratory actions' requirements for surface water for two weeks is not relevant as the Reserve will not supply relevant information for this short term impact – it will never indicate that this is a problem. An impact assessment may be relevant however. Rapid Level III Reserve cannot be undertaken for ephemeral rivers – most of these are ephemeral or rivers that very seldom have a continuous base flows. For these rivers an intermediate or comprehensive Reserve method can be followed. However, the required baseline information (such as daily measured hydrology over a period of years) is seldom available. Rapid Level II and I are seldom applied anymore as these methods use EcoClassification Level I, II etc and STILL estimates the EWR by means of a desktop

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				model. These approaches are not cost effective anymore. Delana Louw was the person that, with RQIS, designed these methods and the purposes of applying these were never at catchment Level, but to be used for specific licenses of low impact where appropriate. What has to put on the table is that the current desktop approach at catchment scale provides better answers (and orders of magnitude more cost-effective) than any Rapid I or II. The reasons for this is the existence of the PESEIS database as WELL as the availability of Google Earth imagery at excellent resolution at many areas. The effectiveness of processes are being constrained by approaches designed seventeen years ago. Documentation of these approaches are difficult to get hold of and spread all other the place. It is certain that comments regarding this was made without this detail regarding the methods being on the table. It is urgently recommended (a suggestion made many years ago) that Rapid Level I and II are shelved. A suggestion is (made now) that there is only a Rapid method a) without EWR sites and Rapid method b) with EWR sites. Rapid Method A can then include desktop tools. The above was subsequently agreed to during the meeting of 29 February 2016 and changes will be made in the document accordingly.

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2.4.3		Since the previous studies for wetland assessment were done in wetlands associated with estuaries and the main river but did not consider the tributaries, this means for this current study, the wetlands associated with the tributaries need to be taken in to consideration	No	This is incorrect. The previous wetland work focused on wetlands in the catchment, not on the main river. It is well acknowledged in the study that this work will be refined and that is one of the main focusses of the study.
2.4.4	Comment 12			Duplicated as comment 1, please note response at comment 1.
Section 2.4.4 under Groundwater use First bullet	Comment 13	Tables 2.3 and 2.3 showing groundwater quality cited in this section are not in the Inception report.	Yes	
3.1	Comment 14	Section 3.1 last paragraph outlines the issue of an independent review but leaves out groundwater as among the components that will be reviewed independently.	Yes	
3.3	Comment 15	Section 3.3 (second last paragraph of page 3-2) last sentence mentions that "The BID will be distributed during the Inception phase, before any meetings are held with stakeholders". This should be corrected as this has not taken place.	Yes	
3.3	Comment 16	Section 3.3 (under PSC page 3-3) Kimberley is not in the study area such that Upington should not be an alternative location of conducting the meetings but should rather be the preferred location as it is in the study area. Conducting meetings out of the study area can be problematic with external stakeholders.	Yes	
3.4	Comment 17	Section 3.4 does not adequately address the expectations of the client. This section lacks a clear breakdown of the capacity building components that the PSP intends to initiate in this study. The	Yes	Addressed as per the meeting on 29 February 2016

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		statement that "*Due to the short time-frame of the study, and the current level of capacitation of many staff members already involved in Reserve, Classification and Resource Quality Objectives(RQO) projects, attendance of the two planned workshops would probably be sufficient to ensure effective capacity building*" goes against the expectations of the client clearly outlined in the ToR. This is one of the important components/outcomes of skills transfer of any project awarded by the Department. As such the client rejects workshops as being the main capacity building component of this project. As such the PSP needs to outline areas of capacity building per each component of the study e.g. rivers, estuaries, wetlands and groundwater. The DWS staff need hands on involvement in the field work.		
4.2	Comment 18	Add bullet on no go areas including towns, recharge areas and future aquifers that need protection.	No	Requested an explanation of the comment. Assumed explanation in Email addressed issue
4.2	Comment 19	Section 4.2 page 4-2 under information required WARMS data also need to be looked at.	Y	It is the plan of the project team to utilize WARMS data as that is the basis for a large part of the legal water use which must be accounted for.
4.3	Comment 20	Section 4.3 under rivers first sentence Results should not just be taken as is because this refers to studies done 5 years ago, while newer information (JBS2 and other biomonitoring info) is available.		See comment 3
4.3	Comment 21	Section 4.3 EcoClassification This section talks about all water resources except groundwater. Although it is understood that groundwater *per se* does not have ecosystems like surface	Yes	Note: This Classification is relevant for EWR determination (groundwater) and not EcoClassification. EcoClassification is a described and published method to classify surface water ecosystems. Groundwater

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		water (and therefore we can't talk about pure EcoClassification), it plays a critical role in supporting the EWR through the provision of baseflow. As such it's important to note where the ecological requirements are met and where they will not be met. This analysis is lacking in this part of the report and the rest of the inception report. There are also components like categorisation that are normally done during this phase for groundwater for instance the calculation of the stress index and categorisation of groundwater based on use and quality. For the quality component of the groundwater Reserve, the client expects the results of statistical analysis showing the following components that the client use in the templates (as illustrated in an attached desktop Reserve) i. 5th percentile ii. 95th percentiles iii. Median iv. Groundwater quality Reserve (Median +10%) that allows for reasonable contamination.		forms part of quantifying the water and quality requirements to support these ecosystems. Therefore, the comment is valid, but should form part of the EWR (flow) section. The report includes a statement that statistics will be supplied as according to percentiles etc.
4.4.2	Comment 22	Section 4.4.2 under Information Required second bullet A link to the All Town Studies on the DWS website was sent to Mr Sami on 8 October 2015 for accessing reports on groundwater use. The client is not sure what the PSP means by stating that data has been requested but is not available yet. Groundwater quality data (from the National Groundwater Archive) and		Duplicate of Comment 1

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		Hydstra water levels were also sent to Mr Sami on the 19th of October 2015.		
4.4.2	Comment 23	Section 4.4.2 under Basic Human Needs Requirement There is reference to the “Identification and Monitoring of Groundwater Dependent Communities in the Northern Cape" maps. Which maps are these?	Yes	
4.4.4	Comment 24	Section 4.4.4 does not adequately address baseflow as a component of groundwater that supports EWR.	Yes	
4.4.4.1	Comment 25	Section 4.4.4.1 Groundwater use The report omits significant zinc mining in the Aggeneys area as well as the numerous authorisations for renewable energy use in the WMA. Prieska and De Aar are using huge volumes of groundwater for renewable energy. There is also a need for deliberating on the fracking needs in the context of groundwater and also groundwater that might not be suitable for BHN but is suitable for fracking.	Yes	
4.4.4.5	Comment 26	Section 4.4.4.5 under Responsibilities of the consultant Validation and verification for groundwater must be done of the data that was simulated. 5 points must be identified for field verification i.e. 2 in the south (Karoo); 1 in Central Karoo; 1 north of the Orange River and 1 in Namaqualand. All the other resources have Validation and verification and groundwater must also be validated.	No	Validation and verification studies are not part of the terms of reference. All that can be done is rely on data from All Towns, whatever other data DWS has, WARMS, and an estimate fo Schedule 1 use base on census data of people who are not part of a formal scheme. V&V studies are a major undertaking in themselves and run in parallel.
4.6	Comment 27	Section 4.5 page 4-15 under EcoSpecs and Thresholds	No	EcoSpecs are set for the baseline as explained under comment 3. For biota and habitat, it is set for indicator organisms and

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		The ORASECOM JBS2 must also be included as it provides the most recent results and was a comprehensive survey.		habitat where relevant. These will not change due to any additional surveys.
4.5	Comment 28	Section 4.5 page 4-15 under Monitoring Programmes last sentence of Paragraph 1. Although that can be agreed in principle, BUT the site details of the EWR sites must at least be provided to both DWS and ORASECOM to ensure that they are included in the list of sampling sites.	Yes	Raw data and EcoStatus models will also be provided. All results will also be summarized in reports produced as part of this study.