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Development of a Reconciliation Strategy for the Luvuvhu and Letaba Water Supply System

INCEPTION REPORT

FINAL

August 2012

DEVELOPMENT OF A RECONCILIATION STRATEGY FOR THE LUVUVHU AND LETABA WATER SUPPLY SYSTEM

INCEPTION REPORT

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Development of a Reconciliation Strategy for the Luvuvhu and Letaba Water Supply System

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Acronyms

ACRU	Agrohydrological Modelling System
BID	Background Information Documents
CBO	Community Based Organisation
DA	Drainage Area
DM	District Municipality
DPLG	Department of Provincial and Local Government
DWAF	Department of Water Affairs and Forestry
EFR	Environmental Flow Requirement
EMA	Ecological Management Area
GIS	Geographical Information System
GRIP	Groundwater Resource Information Project
IAPs	Interested and Affected Parties
IFR	Instream Flow Requirements
IWRM	Integrated Water Resource Management
LLRS	Development of Water of a Reconciliation Strategy for the Luvuvhu and Letaba Water Supply System
NGDB	National Groundwater Database
NGO	Non-Govermental Organisation
RWQO	River Water Quality Objectives
SAGDT	South African Groundwater Tool
SSC	Study Steering Committee
STW	Sewer Treatment Works
TDS	Total Dissolved Solids
URV	Unit Reference Value
WC	Water Conservation
WDM	Water Demand Management
WMA	Water Management Area
WRC	Water Research Commission
WRP	WRP Consulting Engineers (Pty) Ltd.
WRSS	Water reconciliation Strategy Study
WRPM	Water Resources Planning Model
WRYM	Water Resources Yield Model
WSA	Water Service Authority
WSAs	Water Service Authorities
WSP	Water Service Providers

Development of a Reconciliation Strategy for the Luvuvhu and Letaba Water Supply System

1 INTRODUCTION

1.1 BACKGROUND

The Department of Water Affairs (DWA) has identified the need for the Reconciliation Study for the Luvuvhu-Letaba WMA. The WMA is almost fully developed and demands from the Letaba River currently exceed the yield capability of the system. Regulation for the Letaba is mainly provided by Middle Letaba, Ebenezer and Tzaneen Dams. The recently completed Nandoni Dam located in the Luvuvhu basin will be used in combination with Albasini, Vondo and Damani dams to be managed as one system. It is expected that the total yield from this combined system will be fully utilized by around 2020, considering only the current planned projected demands. The yield of the Albasini Dam has reduced over the years and as a consequence the dam is over allocated. The Shinwedzi catchment is situated almost entirely in the Kruger National Park and for all practical purposes, no sustainable yield is derived from surface flow in the Shingwedzi catchment.

The main urban areas in these catchments are Tzaneen and Nkowakowa in the Groot Letaba River catchment, Giyani in the Klein Letaba River catchment and Thohoyandou and Makhado (Louis Trichardt) in the Luvuvhu catchment. An emergency water supply scheme to transfer water from Nandoni Dam is currently under construction to alleviate the deficits of the stressed Middle Letaba sub-system in the Letaba River basin. Other future developments planned to be supplied from Nandoni Dam will already utilize the full yield available from the Nandoni sub-system by 2021, without supporting Giyani. Supporting Giyani from Nandoni will bring this date forward to approximately 2018

Intensive irrigation farming is practised in the upper parts of the Klein Letaba River catchment (upstream and downstream of the Middle Letaba Dam), the Groot Letaba (downstream of the Tzaneen Dam) and Letsitele rivers, as well as in the upper Luvuvhu River catchment. Vegetables (including the largest tomato production area in the country), citrus and a variety of sub-tropical fruits such as bananas, mangoes, avocados and nuts are grown. Large areas of the upper catchments have been planted with commercial forests in the high rainfall parts of the Drakensberg escarpment and on the Soutpansberg. The area, particularly the Groot Letaba sub-area, is a highly productive agricultural area with mixed farming, including cattle ranching, game farming, dry land crop production and irrigated cropping. Agriculture, with the irrigation sector in particular, is the main base of the economy of the region. Large scale utilization of the groundwater resource occurs

mostly downstream of the Albasini Dam in the Luvuvhu catchment, where it is used by irrigators as well as in the vicinity of Thohoyandou where it is used to supply rural communities. The limited mineral resources in the Luvuvhu basin are dominated by deposits of cooking coal in the northeast near Masisi. In addition to irrigation water supply from the dams in the study area, towns, villages and rural settlements are also supplied with potable water.

DWA and other institutions involved in the management of the water resource and supply systems of the Luvuvhu-Letaba catchments, have in the past carried out various studies on intervention measures to improve the water supply situation. The knowledge base that has been created by these studies provides a sound and essential platform from which the Reconciliation Strategy will be developed. In order to harness this information a Literature Review Report (DWA, 2013) was compiled to summarise the available information in one document and also present a synthesis of the information by highlighting the pertinent aspects of Integrated Water Resource Management that will be assessed and incorporated in the Reconciliation Strategy.

1.2 MAIN OBJECTIVES OF THE STUDY

The main objective of the study is to compile a Reconciliation Strategy that will identify and describe water resource management interventions that can be grouped and phased to jointly form a solution to reconcile the water requirements with the available water for the period up to the year 2040 and to develop water availability assessment methodologies and tools applicable to this area that can be used for decision support as part of compulsory licensing to come. The development of the strategy requires reliable information on the water requirements and return flows (wastewater) as well as the available water resources for the current situation and likely future scenarios for a planning horizon of thirty years.

To achieve the above objectives, the following main aspects will be covered in the study:

- Update the current and future urban and agricultural water requirements and return flows;
- Assess the water resources and existing infrastructure;
- Configure the system models (WRSM2005, WRYM, WRPM) in the Study Area at a quaternary catchment scale, or finer where required, in a manner that is suitable for allocable water quantification;
- To firm up on the approach and methodology, as well as modelling procedures, for decision support to the on-going licensing processes;

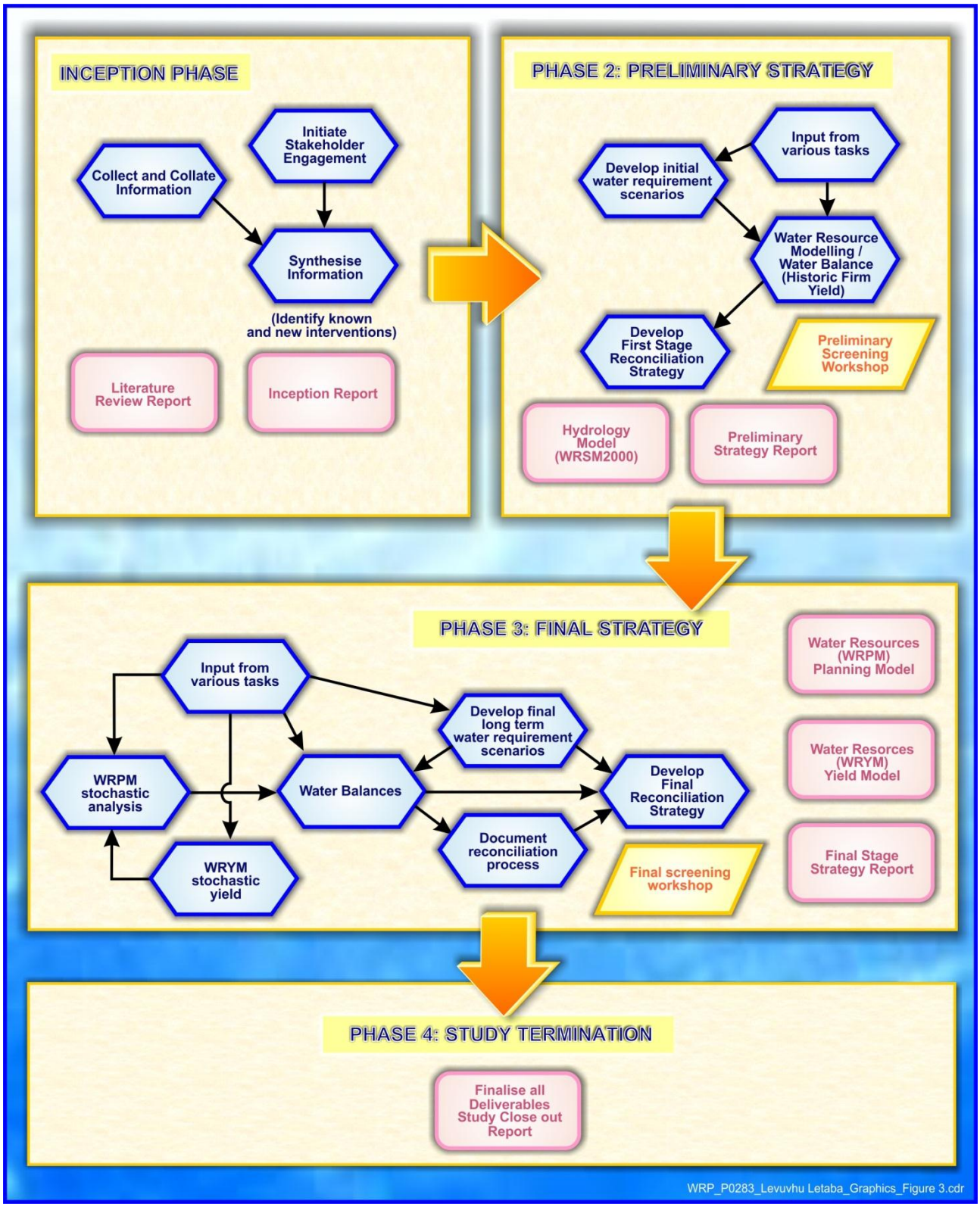

Figure 1.1: Schematic presentation of the Reconciliation Study structure

- To use system models, in the early part of the study, to support allocable water quantifications in the Study Area and, in the latter part of the study, to support ongoing licensing decisions, as well as providing information for the development of the reconciliation strategy;
- Formulate reconciliation interventions, both structural and administrative/regulatory;
- Document the reconciliation process including decision processes that are required by the strategy; and
- Conduct stakeholder consultation in the development of the strategy.

The study has been structured into four phases, an **Inception Phase** which includes collecting and assimilating available information. A **Second phase** focuses on the updating and extending of the hydrology, the initial yield analysis and the development of the Preliminary Strategy. The **Third phase** involves developing the final Reconciliation Strategy by means of the execution of several technical tasks used to guide the process from the results obtained. The **Fourth phase** is referred to as the study termination phase. In this phase all the deliverables will be finalised and a study closure report compiled. (See **Figure 1.1**)

1.3 STUDY AREA

The study area comprises of the water resources of the catchment of the Luvuvhu, Mutale, Letaba and Shingwedzi rivers linked to adjacent systems as indicated by the inter-basin transfers on **Figure 1.2.** This area represents the entire WMA 2 and includes tertiary catchments A91, A92, B81, B82, B83 and B90. Adjacent areas supplying water to this WMA or getting water from this WMA are also part of the study area.

The Luvuvhu-Letaba water management area (WMA) is located in the north-eastern corner of South Africa, where it borders on Zimbabwe in the north and on Mozambique along the eastern side. It falls entirely within the Northern Province, and adjoins the Olifants and Limpopo WMAs to the south and west respectively. The Luvuhu-Letaba WMA forms part of the Limpopo River Basin, an international river shared by South Africa, Botswana, Zimbabwe and Mozambique.

Approximately 35% of the land area of the WMA along the eastern boundary falls within the Kruger National Park. The rivers flowing through the park are of particular importance to the maintenance of ecosystems.

The confluence of the Luvuvhu and Limpopo rivers forms the common point where South Africa borders on both Zimbabwe and Mozambique. The Shingwedzi River first flows into the Rio des Elephantes (Olifants River) in Mozambique, which then joins the Limpopo River.

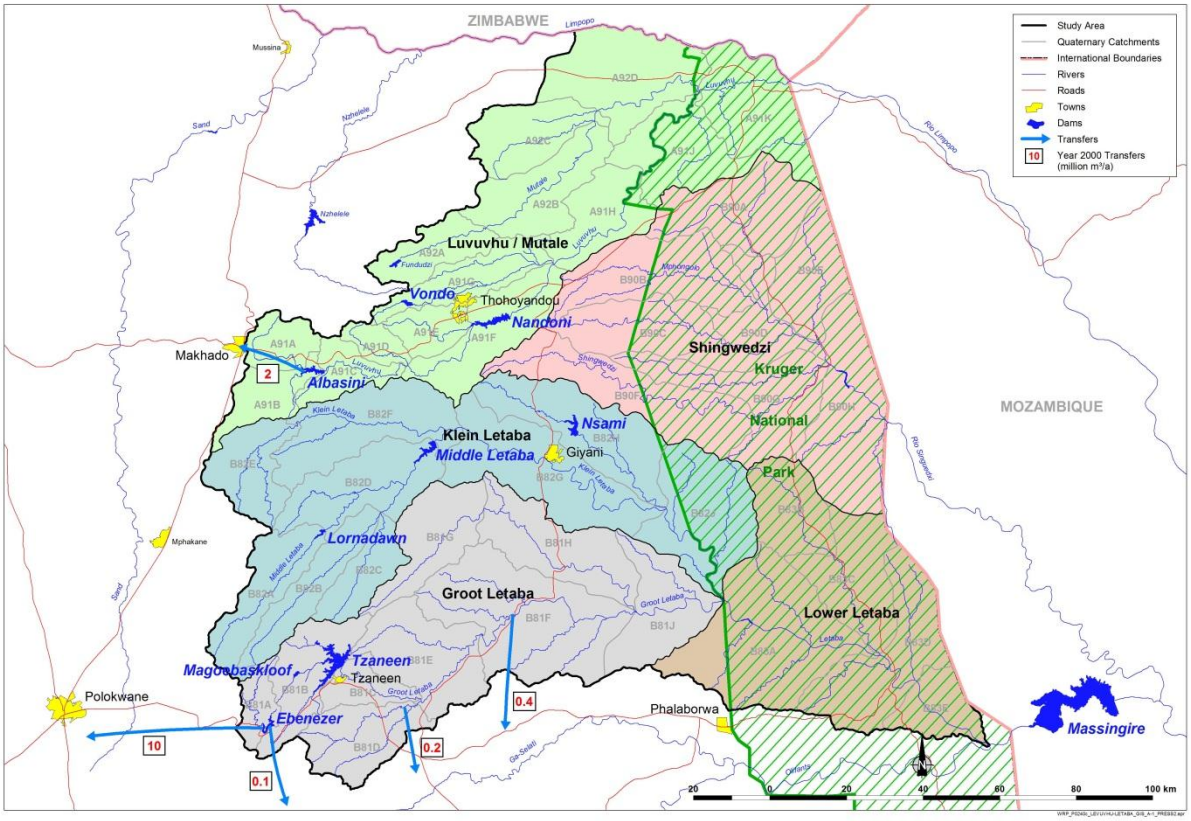

Figure 1.2: Study Area

The two main branches of the Letaba River, the Klein and Groot Letaba, have their confluence on the western boundary of the Kruger National Park. The Letaba River flows into the Olifants River just upstream of the border with Mozambique (**Figure 1.2**).

The topography is marked by the northern extremity of the Drakensberg range and the eastern Soutpansberg, which both extend to the western parts of the water management area, and the characteristic wide expanse of the Lowveld to the east of the escarpment. Climate over the water management area is generally sub-tropical, although mostly semiarid to arid. Rainfall usually occurs in summer and is strongly influenced by the topography.

Along the western escarpment rainfall can be well over 1 000 mm per year, while in the Lowveld region in the eastern parts of the water management area rainfall decreases to less than 300 mm

per year and the potential evaporation is well in excess of the rainfall. Grassland and sparse bushveld shrubbery and trees cover most of the terrain, marked by isolated giant Boabab trees.

The geology is varied and complex and consists mainly of sedimentary rocks in the north, and metamorphic and igneous rocks in the south. High quality coal deposits are found near Tsikondeni and in the northern part of the Kruger National Park. The eastern limb of the mineral rich Bushveld Igneous Complex touches on the southern parts of the WMA. With the exception of sandy aquifers in the Limpopo River valley, the formation is of relatively low water bearing capacity. A wide spectrum of soils occurs in the WMA, with sandy soils being most common.

1.4 STUDY TEAMS

The study team consists of seven consulting firms, namely; DMM Development Consultants, Zitholele Consulting, Golder Associates Africa, Worley Parsons, Kyamandi, Hydrosol and WRP Consulting Engineers (Pty) Ltd as the lead Consultant with support from key specialists and sub-consultants.

2 STUDY PROCEDURE

The study activities have been divided into various tasks as set out in **Table 2.1** and schematically presented in the Logical Flow Diagram as shown in **Figure 2.1.**

The study will be undertaken over a period of 36 months according to the schedule (time line) and duration of the tasks presented in the Gantt Chart provided in **Appendix B**.

Table 2.1: Consolidation of tasks

Task No.	Study Phases	Description
0	INCEPTION PHASE	Compile Inception Report
		• Final description of tasks • Update task & activity flow diagram • Finalise responsibilities and compile study reporting structure • Prepare modular budget for all tasks and disbursements • Detailed schedule of personnel hours and costs • Detail schedule of events, milestones and deliverables • Listing of constraints and risks that may influence the execution of the study plan • Evaluation and agreement of information sources to apply in the study • Define, describe and agree with the client the methods of how information and data generated from the study will be stored and disseminated
1		Compile a Summary Report of Previous and Current Studies

Task No.	Study Phases	Description
		• Obtain and list available studies and reports • Undertake synthesis of all available information • Add perspectives on previously identified intervention options for consideration and assessment in this study • List relevant recommendations and current resource management processes • Collate information on water quality issues • Develop a stakeholder database for this study
2	PRELIMINARY RECONCILIATION STRATEGY	Preliminary Screening Workshop
3		Hydrological analysis
21		Determine Water Use (Additional Task)
4		Water requirements and return flows
5		Water conservation and demand management
6		Water re-use
7		Invasive alien plants
9		Reserve requirement analysis
10a		Groundwater utilization scenarios (part a)
11		Honouring international obligations
12a		WRYM Historic yield analysis
15a		Review schemes and update cost estimates (part a)
16a		Review or assess social and environmental impact (part a)
17a		Assembly of information and formulation of scenarios (part a)
17a		Preliminary Strategy Report
4	FINAL STRATEGY	Refine Water requirements and return flows
5		Final adjustments to Water conservation and demand management
8		Water quality
10b		Groundwater utilization scenarios (part b)
12b		WRYM Stochastic yield analysis
13		Water quality modelling
14		Planning analysis (WRPM)
15b		Review schemes and update cost estimates (part b)
16b		Review or assess social and environmental impact (part b)
17b		Assembly of information and formulation of scenarios (part b) Final Reconciliation strategy report
18		Final Screening workshop
19	All phases	Stakeholder engagement and public participation
20	All phases	Study Management
21	Study Closure	Study Termination

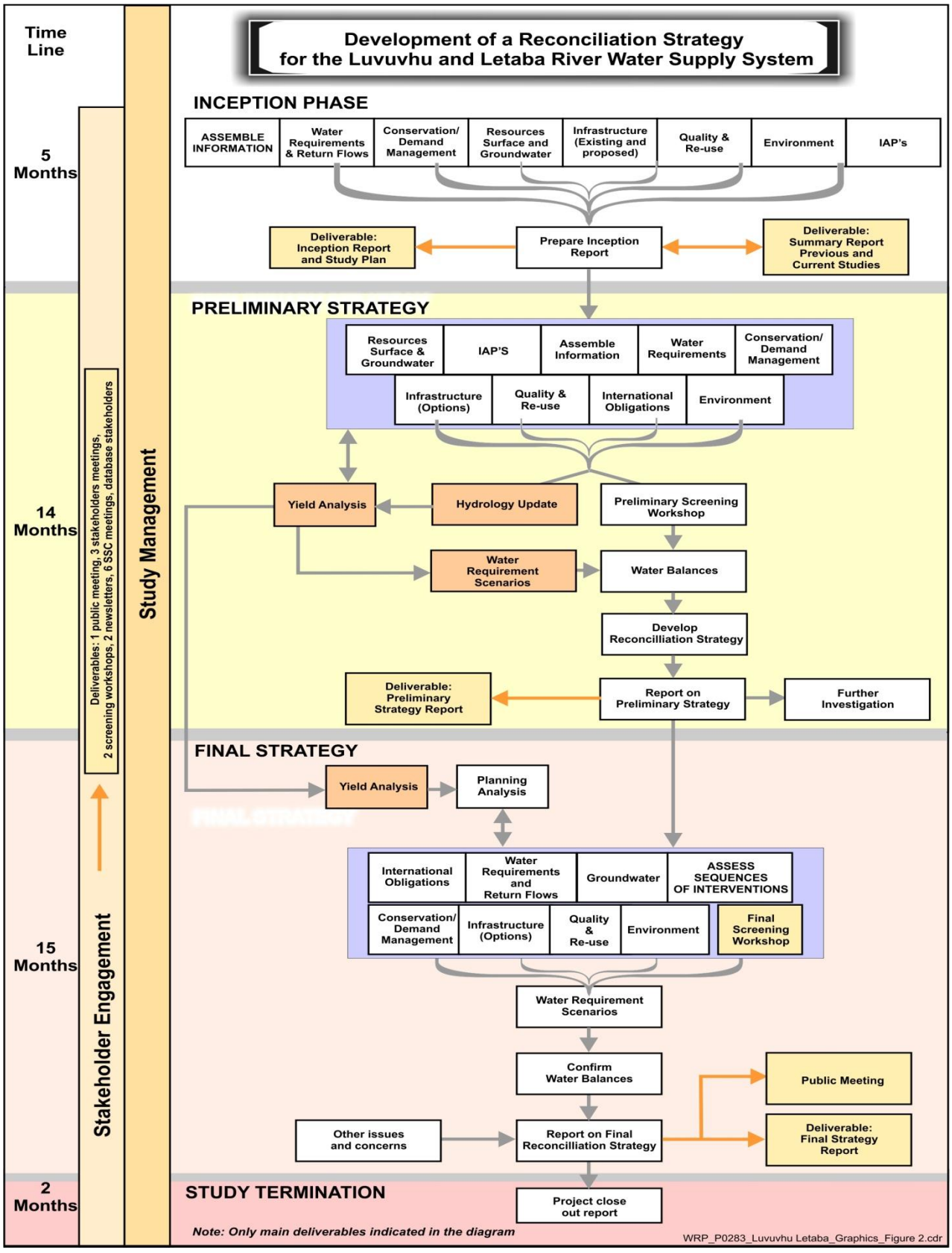

Figure 2.1: Logical Flow Diagram

No additional tasks have been identified in the Inception Phase.

The remainder of this chapter provides detail descriptions of each task and the associated human and financial resources are presented in **Section 2.1 to**.

2.1 TASK 0: INCEPTION REPORT

The project inception phase involves compiling the Study Plan for the execution of the study to be documented in the Inception Report. Information from **Tasks 1** (summary of previous information) and **Task 2** (preliminary screening workshop) form the basis of finalising the methodology, budget and schedule (gantt chart) of tasks in a modular manner with clear milestones for events and deliverables. This is to be carried out in consultation with the Client and through liaison with key stakeholders to ensure that the Study Plan achieves the objectives and expectations for the study. This Study Plan (Inception Report) forms the baseline for monitoring and evaluation of progress during the Study Implementation Phase.

The Inception Report was presented to the Director: NWRP for his comments and inputs before the document was finalised. In addition, the formatting of meeting agenda and minutes, progress reports, records of decisions and administrative tracking was agreed with the Client during the Inception Phase.

The inception report includes the following components:

- Final description of the twenty two (22) tasks
- Updated task and activity logical flow diagram - indicating the dependencies of the tasks.
- Finalising the responsibilities and compile a study reporting structure that clearly defines the communication channels and procedures.
- Modular budget for all tasks and disbursements.
- Detailed schedule of personnel hours and costs.
- Detail schedule of events, milestones and deliverables - detail work breakdown structure.
- Listing of the constraints and risks that may have an influence of the execution of the Study Plan.
- Evaluation and agreement on information sources to apply in the study, especially where the data differs significantly.
- Define, describe and agree with the Client the methods of how information and data generated from the study will be stored and disseminated – especially with respect to; Task 3 (Hydrological analysis), Task 4 (Water requirements and return flows) and Task 8 (Water quality).

This report forms the deliverables from **Task i** and was carried out according to the sub-tasks as described in the subsequent sections. The review information is described in a separate document; Literature Review Report (DWA, 2012), containing a summary of the relevant past studies and documentation.

Deliverable:

- *Report (1): Inception report (see above text for description of content).*
- *Presentation material (Power Point slides) of the Inception Report.*

2.2 TASK 1: SUMMARY OF CURRENT AND PREVIOUS STUDIES

This task involves compiling a summary report of information from previous studies with the aim of preparing for the first Screening Workshop (**Task 2**) as well as to assist in the refinement of the scope in the inception report. **Task 1** will run parallel with phase 1 and all the requirements specified and listed in **Section 6.3.1** of the TOR will be covered.

The Levuvhu Letaba system has been the subject of many studies from different perspectives, and it is essential to collate and understand the approaches as well as the assumptions used in the previous studies. This is necessary to be in a position to *undertake a synthesis of all available information* and adding perspectives on whether the previously identified interventions are suitable for further consideration and assessment in this study. The summary report also lists all relevant recommendations from available reports and current water resource management processes in order to ensure that the developed strategy is not in contradiction with previous recommendations and the formulation is coherent with activities currently happening in the area. The following are some of the studies that were looked into:

- Internal Strategic Perspective: Limpopo Water Management Area.
- Internal Strategic Perspective: Luvuvhu Letaba Water Management Area.
- Kruger National Park Rivers Research Program, Water for Nature: Hydrology, Luvuvhu River.
- Water Resources Planning of the Luvuvhu River Basin.
- Albasini dam (A9R001): Hydrology.
- Water Resources Planning of the Letaba River Basin study of Development Potential and Management of the Water Resources

- Kruger National Park Rivers Research Program, Water for Nature: Hydrology, Letaba River.
- Water Resources Planning of the Luvuvhu River Basin.
- Luvuvhu River Dam Study Feasibility Report.
- Luvuvhu Government Water Scheme: Bulk Water Supply Preliminary Designs
- Luvuvhu River Government Water Scheme
- Letaba Water Resource Development Pre-feasibility Study
- Groot Letaba Water Resource Development Feasibility Study.
- A Reconnaisance Study to Augment the Water Resources of the Klein Letaba River Catchments
- Middle Letaba Water Supply Scheme: WC/WDM Situation Assessment
- Luvuvhu/Letaba Water Resource Situation Assessment
- Natural Water Resource Strategy
- Letaba River System Annual Operating Analysis.
- Luvuvhu River System Annual Operating Analysis.
- Letaba Catchment Reserve Determination Study
- Groot Letaba River Water Development Project
- Water Resources Systems Development Business Support Phase 3
- Socio-economic and Ecological Impacts of Water Restrictions in the Letaba Catchment
- The Development of a Comprehensive WC/WDM Strategic Business Plan for the Limpopo WMA
- Luvuvhu/Letaba WMA Development of a Comprehensive WC/WDM Strategy and Business Plan
- Real Time Operation of the Letaba River System

Summary tables of potential future schemes will be compiled from available information and these will include, amongst others things the following; the potential yields, the likely reduction in yield due to the Ecological Water Requirements (Reserve), economic comparisons such as Unit Reference Values (URVs), the base year for the economic assessment, schedule of activities and timing to implement, social and environmental impacts and mitigation measures as well as any other aspects relating to concerns or uncertainties of each scheme.

Particular attention will be given to collate information on any water quality issues in the study area. These will be summarised in a chapter in the task report. This information will further be augmented by the analysis as described in **Task 8** and **13**.

Expert opinion will be utilized to provide missing information and information on any new schemes not previously identified.

Public participation and stakeholder engagement in current and previous studies in the study area will be reviewed and the necessary information will be provided for the summary document for consideration at the Preliminary Screening Workshop. In particular Comments and Response Report of Environmental Impact Assessments undertaken as well as minutes of meetings will be screened to provide comments and concerns with regards to the systems, particular information about existing and potential schemes and water quality.

Flowing from this task would be the development of a stakeholder database for this study. The stakeholder database will consist of representatives of all sectors of society, including:

- Relevant government departments on national, provincial/regional level from amongst other the DWA, Department of Environmental Affairs, Cooperative Governance and Traditional Affairs, Department of Agriculture, Forestry and Fisheries and others
- District and Local Municipalities
- Agriculture (Irrigation Boards, Unions)
- Mines and industries
- Relevant parastatals (e.g. SANParks (Kruger National Park), Eskom)
- Community representatives organisations such as rate payers organisations
- Civil society (NGOs, CBOs)
- Specialists (from the Valdiation and Verifiation and Ecological Reserve studies)
- Water User Forums

Details of the representative stakeholders will be captured electronically for record keeping purposes. The draft database will be compiled during the first two to three months of the project however a database is dynamic and will be constantly updated as more information become available and as stakeholders change. The information will be submitted to DWA for the establishment of a CMA Reference Group.

Deliverables for Task 1:

- *Report (2): Summary of Previous and Current Studies, including summary tables of all identified potential schemes and interventions. This report will also put emphasis on water quality issues in the WMA.*
- *Database of stakeholders with sector identification and gap identification.*

2.3 TASK 2: PRELIMINARY SCREENING WORKSHOP

The Study Steering Committee (SSC) has to evaluate the scenarios or options presented by the DWA and its study team. The following steps are anticipated:

- Identify stakeholders (those that are part of the SSC) to be invited to the workshop.
- Distribute and invitation letter and proposed agenda to the identified stakeholders providing them with sufficient information about the status of the project, the purpose of the workshop and what will be expected of them (e.g. read through documents prior to the meeting/s and provide inputs and comments).
- Compile a simplified document explaining the various options and distribute that to all stakeholders prior to the workshop.
- Host workshop with proper presentations of the different options where thorough minutes can be taken which will act as a record of stakeholder comments and inputs.
- Facilitate the meeting so that the stakeholders identify their main issues and concerns (related to water resource management in the area) that may influence the reconciliation strategy.
- Distribute proceedings of the workshop.
- The proceedings of the workshop will feed into a document that will define the schemes to be investigated and the shortfalls in information to be provided. This document in turn will feed into the Preliminary Strategy Report.

*The **deliverables** from this task will include:*

- *Workshop starter document.*
- *Document containing the proceedings of the workshop and defining the schemes to be investigated. The pertinent recommendations from the workshop will be included in Report (1).*
- *List of schemes (interventions) to investigate in the study.*

2.4 TASK 3: HYDROLOGICAL ANALYSIS

2.4.1 Approach

The approach of the hydrological analysis will be to build on the existing hydrological model (WRSM2000) configured during the Water Resources of South Africa - 2005 (WR2005) Study (WRC, 2008) for the Luvuvhu and Letaba WMA. The catchment area has a total of 46 quaternary catchments, but the WRSM2000 networks produced during this study made provision for several quinary sub-divisions, totalling to 59 sub-divisions.

The WR2005 study data has been used in areas where no previous analysis has been done before as well as in comparison with more recent analyses. Although the WR2005 Study information is a useful starting point for any analysis, there are often several shortcomings of which the following are a few examples:

- The water use, and in particular the irrigation estimates were based on the Water Situation Assessment Model (WSAM) database. Although this database was useful at the time, there are several areas where there were major omissions and errors. The WR2005 Study seldom had access to detail validated and verified water and land use information which would influence the generated natural runoff.
- The rainfall extension from the previous 1990 version of the study was often based on only one or two rainfall stations. In addition the resulting catchment rainfall records were not tested for stationarity, introducing trends in the generated natural runoff.
- Streamflow networks and positions of gauging stations are often misrepresented in the model networks, leading to unrepresentative calibrations.
- Minor dam information is often accurate in the WR2005 Study, since it is based partly on the dam safety database in the WR20005, which includes most major reservoirs in the country. However, what is often found is that the contribution of runoff that flows through the reservoirs are inaccurate and that irrigation is often provided only from farms dams rather than partly from run-of-river or groundwater. This causes an unreasonably high assurance of supply to the irrigators and lower downstream flow.
- No groundwater abstraction has been implemented in the WR2005.
- Due to the limited knowledge and experience of the system analysts regarding the Sami Surface-Groundwater Interaction Model (GWSWIM), which was used for the whole country, the calibrations was not always done optimally.

Given these obvious shortcomings, considerable effort will be done during this study to verify, correct and update the existing WR2005 setups to provide the best available hydrological model for the catchment.

The hydrological analysis study team also has very applicable experience to identify and overcome the shortcomings of the existing WR2005 system. Mr K. Sami (the developer of the GWSWIM) will be providing the groundwater modelling expertise. Mr. Sami has applied the GSM in the Letaba WMA in other related studies. In the Letaba Catchment groundwater use plays a crucial role in the water balance. Furthermore the Task Leader has been involved in the modelling the upper Mutale River, where the only natural lake in South Africa occurs. This model of the Upper Mutale River is the most comprehensive representation of this river and will already replace what is currently in the WR2005 study.

The following sub-tasks will be undertaken during the analysis.

2.4.2 Task 3a: Data collection and collation

The collection of hydro-meteological, land and water use data is a very important part of the hydrological analysis. Most of the information will be obtained from Task 4 of this assignment (Water Requirements and Return Flows). The following types of information will be sourced:

- Rainfall Data: Based on the needs identified during the rainfall data analysis task, raw point rainfall data will be sourced from the DWA Rain IMS system for the area. The catchment rainfall data available from the WRSM2005 project will be critically reviewed before use.
- Evaporation Data: Based on the needs identified during the rainfall data analysis task, more detailed evaporation data will be sourced from DWA and from the University of Kwazulu Natal.
- Streamflow: Updated and improved streamflow and dam balance information will be obtained from DWA Hydrological Services. The WR2005 study made use of 23 calibration points throughout the WMA. However, it seems likely that there would be more monitoring data used, due to several large reservoirs not being used during the WR2005 study.
- Groundwater Use Data: Irrigational groundwater water use will be based on theoretical demands of validated irrigation areas and crops. Other point sources of groundwater will also be obtained from the Task 4 of this assignment and explicitly modelled. Assumption of growth in groundwater use will be done.
- Irrigation data: The main source of information for irrigation use will be the validation and verification study. Detailed spatial distribution (GIS coverages), water source, crop types, irrigation area growth and irrigation system types will be obtained from this study. From this information the demand configuration in the system network will be determined, as well as

return flow and crop requirements estimations be made. Assumptions regarding growth in irrigation efficiency and other variable will also be made.

- Major Reservoir Data: Detailed areas capacity and reservoir configuration data will be obtained from DWA Hydrological Services. The Luvuvhu and Letaba WMA have 14 major reservoirs that are being monitored by DWA Hydrological Services.
- Minor dams: The main source of information for farm dams will be the validation and verification study. Detailed spatial distribution as well as area and capacities of minor reservoirs will be obtained from this study. Based on the location of the minor dams, the grouping and network configuration of the minor dams will be determined. Assumptions will also be made regarding the growth in farm dams in the area.
- Point Source Data: Point source run-of-river, reservoir or groundwater abstractions will be explicitly modelled.
- AIP: Information will be obtained from the Working for Water Programme in the area and information will be translated into the appropriate format for use in the WRSM2000 model (See Task 7 for more detail). Assumptions regarding growth in AIP will also be made.
- Forestry: The main source of information for irrigation use will be the validation and verification study. Detailed spatial distribution and tree type composition will be obtained and configured in the WRSM2000 model. If not available, assumptions in the growth in forested areas will be made.

2.4.3 Task 3b: Rainfall data analysis

Rainfall is the most important driver in the rainfall-runoff modelling process. The catchment rainfall records produced during the WR2005 Study will be critically reviewed to evaluate if the records:

- Are stationary and no trends are observed.
- Are spatially well represented by a number of point rainfall stations.
- Are temporally well represented by the point rainfall records selected to create the catchment rainfall record.

There are less than 8 catchment rainfall records created during the WR2005 Study. This seems little, but the availability of acceptable point rainfall stations will have to be considered before more detailed catchment rainfall records will be created. If there seems to be enough acceptable point rainfall data or trends are observed in existing catchment rainfall records (or in the point rainfall records used to create them), a more detailed rainfall patching process will be undertaken to improve and extend the rainfall.

In cases where the catchment rainfall record seems reasonable (at the hand of the above mentioned criteria), only the point records used in the creation of the particular catchment rainfall record, and which are still being monitored currently, will be patched and the extended part used to extend the catchment rainfall record. The **Figure 1** below provides an illustration of this process.

Throughout the analysis the resulting rainfall (and the naturalized streamflow) will be checked for stationarity and to avoid trends in the data. **Figure 2** below provides examples of these analyses.

Point rainfall data for the Major Reservoirs will be obtained from the DWA dam balance records obtained from DWA: Hydrological Services. The MAP values as used in the WR2005 will be accepted.

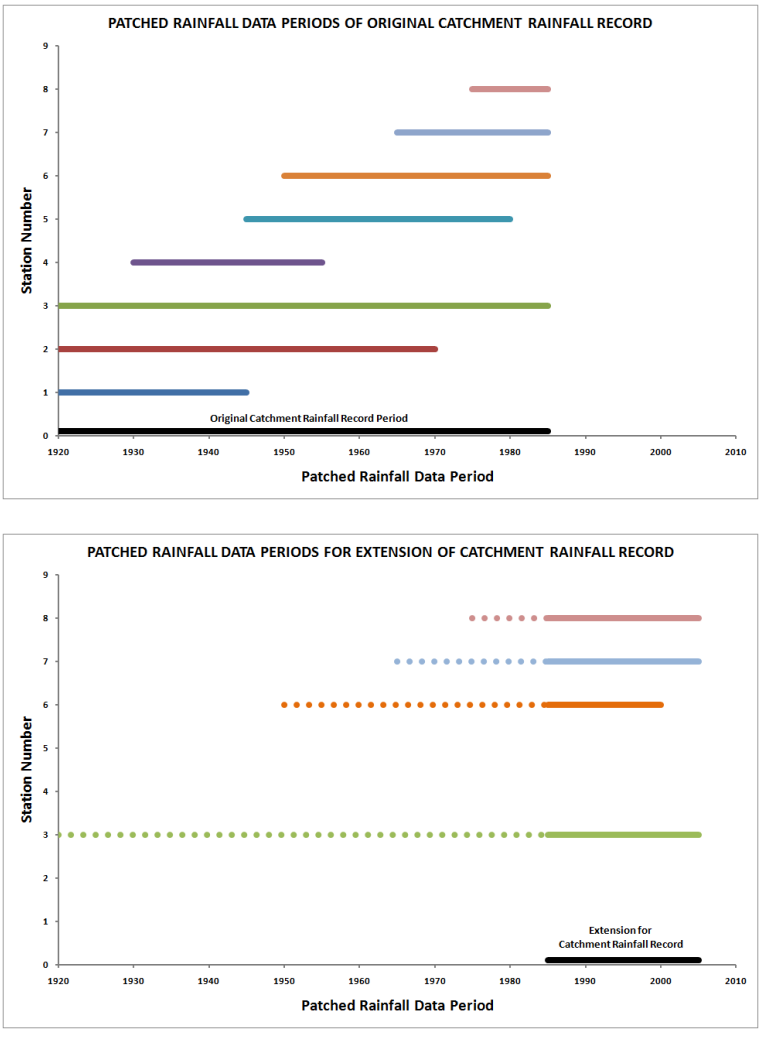

Figure 1: Example of the extension of catchment rainfall records.

Pre-extension **Post-Extension**

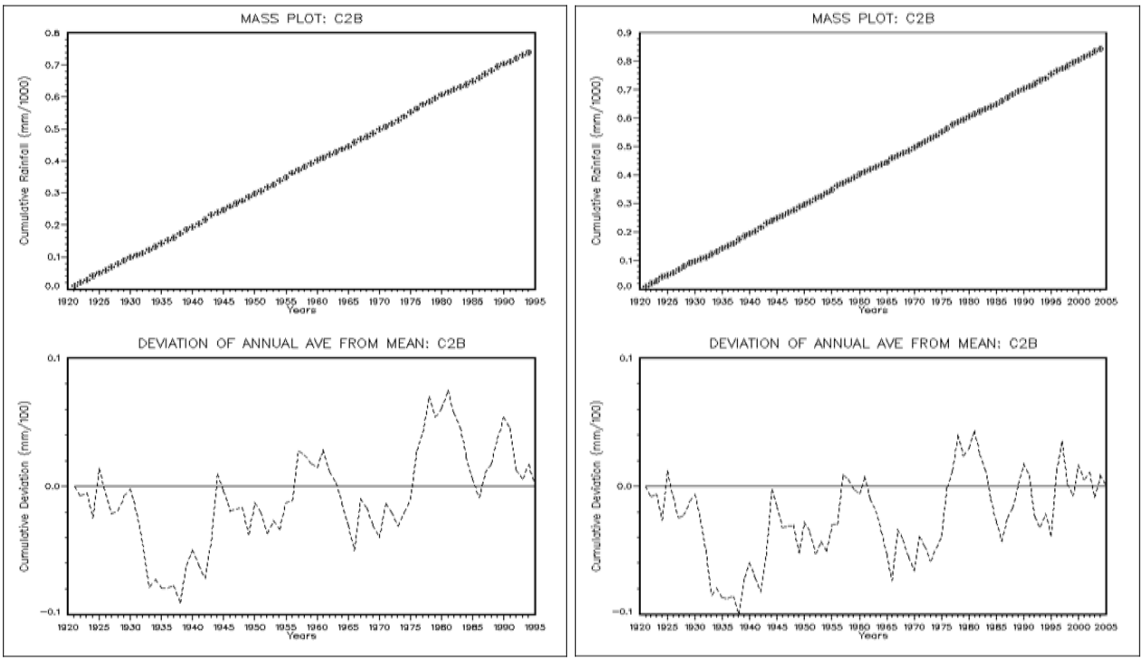

Figure 2: Stationarity tests on catchment rainfall records

2.4.4 Task 3c: Evaporation data analysis

Monthly evaporation data vary relatively little from year to year. However, the WR2005 S-Pan and A-Pan monthly evaporation data will be compared with estimates from other sources such as the University of KwaZulu Natal's Agro-Metereological Database and the Luvuvhu and Letaba River System: Annual Operating Rule Study (2009). Recommendations will be made on which values to use during this analysis.

2.4.5 Task 3d: Stream flow data analysis

Streamflow and reservoir inflow calculations are the other important information required for the proposed rainfall-runoff modelling. Without this information the simulated runoff cannot be properly calibrated and verified. Priority will be given to the stream flow data analysis for the Upper Letaba so that the results for the Nwamitwa and raising of Tzaneen dam can be confirmed.

The WR2005 study made use of at least 23 sites to calibrate the model. There seems to be a good distribution of gauging stations and reservoir dam balances, even in downstream parts of the rivers, as they flow through the Kruger National Park. Although the WR2005 data will be reviewed, it is expected that all available data will be assessed for position in the model network and data availability. It might be that some observed data have been discarded since the record length was too short for use during the WR2005 study (simulation period ended in 2004) Flow and dam

balance data will be obtained for all gauges that have a reasonable length and quality data in the WMA. All elements of the dam balance information (such as releases for urban and irrigation) will be converted to individual flow records for explicit modelling in the WRSM2000.

The first task will then be to linearly infill the daily data to obtain improved monthly flow or dam inflow records. To eliminate gaps in the record, an initial simulation of the flows at the gauging points will be done using the WR2005 calibration parameters, and the gaps in the observed records will be patched with these estimates. After final calibration of the system, the final simulated values will be used to fill in the gaps in the observed record.

2.4.6 Task 3e: Groundwater assessment and groundwater-surface water interaction

Priority will be given to the groundwater assessment for the Upper Letaba so that the results for the Nwamitwa and raising of Tzaneen dam can be confirmed. The Groundwater resources of the basins will be assessed using the following approaches:

- Overview of the characteristics of the groundwater resource: delineation of groundwater units based on hydrogeological criteria, the distribution of lithologies per Quaternary catchment.
- Assessment of Groundwater harvest potential, exploitation potential and baseflow per Quaternary catchment or groundwater unit as per the GRAII and WSAM databases.
- Assessment of Basic groundwater quality in each groundwater unit.
- Configuration of the GWSWIM and verification against baseflows and recharge figures.
- Derivation of a groundwater balance compared to harvest potential and recharge and level of use.

2.4.7 Task 3f: Configuration and testing of the Water Resources Simulation Model (WRSM2000 enhanced model)

Priority will be given to the hydrology for the Upper Letaba so that the results for the Nwamitwa and raising of Tzaneen dam can be confirmed. It was found that the best method for ensuring that the WR2005 network is representing the physical river system accurately, is to develop working maps with all available land and water use information as well as observation point location on 1:50 000 topographical maps with satellite image overlays. DWA: Geomatics has been instrumental in past studies to develop these working maps. By providing all the available data on such working maps to the modeller, it becomes very apparent how to best group land and water uses as well as infrastructure to model the system as accurately as possible. The network will be configured to at least a quaternary catchment level but will likely be configured to several quinaries.

After the network configuration has been established, the existing WR2005 model network will be adapted to represent the desired system configuration. The configured network will also guide the modeller on how to aggregate all the land and water use as well as the infrastructure.

After all the model data has been entered into the model, all data files will be printed and compared with data spread sheets to ensure that data has been entered correctly into the model. Pending approval of the WRC the WRSM2000 network visualizer will be available for use in this study.

2.4.8 Task 3g: Calibration of the WRSM2000 (enhanced)

After the model has been correctly configured and tested, calibration of simulated flows against observed data will be done at all the identified points in the system. Since groundwater use in this WMA is extensive, a process will be undertaken to whereby:

- The WR2005 Study Sami Calibration Parameters will be verified.
- The Surface Water parameters will be calibrated to ensure an as good as possible fit.
- The Sami-groundwater parameters will be calibrated to ensure that the effects of groundwater abstraction are correctly reflected in the base flow generated by the model.

This is foreseen as a major undertaking due to the number of observation points in the system, but it would result in a highly representative hydrological database for the WMA.

2.4.9 Task 3h: Naturalisation of stream flow records

After successful calibration of the WRSM2000 (enhanced) model, naturalized streamflows will be generated for at least each quaternary catchment. This data is required for the yield simulation in later phases of the project. In areas where a good fit could be obtained during the calibration process, simulated natural flows will be generated by developing a WRSM2005 system. Different scenarios of natural flows can then be generated for example:

- Natural conditions (without any land and water uses nor any infrastructure).
- Natural condition including present day development groundwater abstractions.
- Natural condition including present day development groundwater abstractions and AIP.

The reason why different scenarios of natural flows has to be developed, is since there are currently a shortcoming in the WRYM regarding the stochastic modelling of the effects of

groundwater use and AIP runoff reduction. Therefore the effect of these water and land uses has to be catered for by different natural scenarios.

In the some situations, acceptable calibrations cannot be achieved. If the observed data is deemed acceptable a process of naturalization will be undertaken for that area. Naturalization involved adding back the effects of land and water uses as well as upstream infrastructure to the observed record.

2.4.10 Task3i: Verification and Validation of stochastic hydrology

The generated natural hydrological sequences will be assessed using the WRIMS version of the STOMSA. This version is the latest and most updated version of the Monthly Multi-Site Stochastic Streamflow Model. All the monthly stochastic validation and verification graphs for each quaternary catchment will be evaluated and minor adjustments will be made to ensure that the stochastic sequences that are generated, is representative of the historical simulated time series.

Deliverables for Task 3:

- *Rainfall analysis report – Report (4a)*
- *Hydrology report – Report (4b)*
- *Calibrated WRSM2005 model and data files.*
- *Hydrological data in appropriate electronic format.*

2.5 TASK 4: WATER REQUIREMENTS AND RETURN FLOWS

This task will focus on collecting and processing the water requirements and related data for the different water use categories. The project team will liaise closely with the local authorities, local PSPs and DWA officials to utilise existing information and water requirement projection methods that are being applied. The water requirements scenarios will be developed by first defining the baseline year to be used, which will default to the year of the last comprehensive national census and then through:

- consultation with key stakeholders to ensure that reference is made to the most recent data sets (population, demographics, historic water demands, land-use, urbanisation, economic, socio-economic indicators, etc.);

- analysis of current data to firm up on identified drivers which impact on water usage (population – direct water use, socio-economic profile of residential water use categories and other economic indicators – indirect water use) and their correlation with actual water usage data;
- development of water requirement scenarios, which will include the views of key sectors and reflect realistic possibilities for the region, in terms of historic water demands and demographic, economic, geographic and climatological factors;
- In addition to the volumetric water requirements it will be necessary to define the water supply reliability requirements for the different water user groups in the system. The priority classification tables based on the profile of users will be compiled.

2.5.1 Task 4a: Domestic water requirements and return flows

Review existing reports, data sources and relevant information.

The first task will involve gathering information on the water requirements and return flows from previous studies that were undertaken by DWA and other stakeholders. The intention is to extract all usable data from the reports and existing databases and compile comparisons of the different sources of current and projected water requirements and return flow data. The comparison will be used to identify discrepancies that will guide the study team to compile the most appropriate water requirement database to be used for the study.

Demand centre definition and grouping

The approach that will be followed is to identify, from the existing information, the water demand centres that will be created in the water requirement spreadsheet / database for the Study Area. The selection of the demand centres will be based on the layout of the water supply system and the sources of water that can supply the water requirements. The product will be a list of demand centres, grouped according to the different water resource sub-systems. A further consideration, in the selection of the demand centres, will be the availability of recorded water use data that can in future be used for the monitoring of the water use from the Luvhuvhu and Letaba River Systems.

Water Requirements Determination

This task will involve determining the most appropriate data for the historical and future water requirements and return flows. The selection of what future projection to be used will be made in

collaboration with the Client and stakeholders. The methodology will include the following activities:

- A demographic component which entails the refining, updating and extending information relating to economic growth and population size of water users in the Luvuvhu Letaba River system. This will include:
    - Utilising the All Towns Study, the latest spot 5 satellite images, the population and settlement database of the Water Resources Planning Systems and Water Services directorates, as well as the recent Eskom Spot Building Counts (SBCs), time will be spent on each settlement in order to refine, confirm and update the demographic data per settlement. This will include reviewing the latest municipal documents (IDPs, SDFs, LEDs, Housing Sector plans, etc), meeting with the LMs to obtain latest development plans, existing and proposed development applications, future growth areas, subsidy housing plans (Provincial and municipal), and housing plans of agricultural related entities, etc.
    - To determine economic growth, a detailed economic status quo and development potential of the area at municipal and town level will be undertaken. To determine future water requirements of economic sectors, sectoral growth possibilities need to be understood, existing and proposed economic development initiatives need to be obtained, and knowledge of existing and proposed water users is needed in order to have a clear understanding of the development opportunities. This will be obtained by reviewing the latest plans (i.e. IDPs, SDFs, LEDs, GDS, S&LPs, etc) as well as consulting with all of the affected LMs. Private sector initiatives such as growth of existing and start up of major industry developments like new agro-industries also need to be taken into consideration. Existing and proposed strategic water users will also be consulted in order to obtain future plans of both existing and proposed developments in terms of timing, size and water requirements. Public and private economic growth initiatives and growth potential will thus be taken into consideration in order to develop long-term economic growth scenarios so that future population growth, movement and new potential development areas and associated housing implications related thereto are taken into consideration.
    - The base population data will thus be refined and confirmed and scenario assumptions tested based on up-to-date economic growth/decline expectations and associated population migration (in and out) in search of employment opportunities and associated service levels. Growth scenarios for the study area up to 2040 will then be refined

based on more detailed local information relating to structural economic changes, policy changes, income groups, strategic development projects, social dynamics, proposed housing developments, infrastructure developments, urbanization and migration trends, etc.

- development of a comprehensive record of historical water usage and return flows. Where possible information will be drawn from the various local authorities through the information provided in their respective WSDPs, internal publications, treasury/billing database and interactions with the relevant municipal officials. The databases of the Water Services Directorate and Water Resources Planning Systems in DWA will be used for additional information regarding the water requirements and return flows.
- development of land-use maps for the Study area.
- consultation with socio-economic specialists regarding the selection of key economic indicators which could relate to water demand trends and the understanding of the key variables impacting on these indicators. The objective will be to relate historical economic indicators to the historic water usage data, and assess the degree of correlation between the two;
- in consultation with key sector stakeholders, various growth scenarios will be developed for the study area, which will detail the impact on population, demographics and ultimately, water demands. Sector specialists will be consulted during this process, as well as representatives of the identified stakeholders. The objective is to develop scenarios (e.g. high growth and low growth in water requirements) which reflect the trends in a range of variables. It is critical therefore that each scenario clearly sets out the basic assumptions made and which of the driver variable/s selected, should be monitored over time to indicate at some point in the future which scenario is actually being played out in the real world. This will assist in identifying the most appropriate intervention needed in the future, to balance water requirement with water availability; being informed by actual trends in the market place.

The water demand information will take cognisance of the supply from groundwater since some of the areas are supplied from groundwater, and opportunities to further develop and utilise groundwater exist in the study area. The water requirements information (especially the sources) will therefore be provided for two scenarios, with and excluding probable groundwater development, where applicable.

In order to incorporate the domestic water requirements and return flows into the Water Resources Yield and Planning Models, the followings will be explicitly detailed:

- The historical growth patterns of the domestic water requirements together with the abstraction

pattern as well as the sources and locations of any return flows.

- The locations of all major groundwater abstractions and their effective contribution to the overall domestic water requirements will also be assessed.
- Both present and future water uses will be assessed and integrated with the water requirement scenarios.
- The water requirement scenarios will include the effects of Water Conservation and Water Demand Management (WCWDM) measures on the magnitude of the water requirements and return flows, using output from **Task 5**.

Development of a water requirement spreadsheet database

Using the defined demand centres and determined water requirements, a spreadsheet database will be developed and structured to contain the following data elements, for each of the demand centre units:

- Historical water use data if available, or estimates thereof,
- Provision will be made in the spreadsheet to be able to capture the actual future water use and return flow data, as it become available over time. The intention is that the water use information be updated on an annual basis, as a means to monitor trends and detect deviations.
- Provision will also be made to incorporate water requirement and return flow projections for each of the demand centres.

The spreadsheet will also include the following components and functionalities:

- Graphs of the indicated data elements for groups of demand centres.
- Summarise tables and graphs showing the total demands and return flows, grouped according to the water resources.
- A summary table, linking each of the demand centres to an appropriate demand channel in the Water Resource Planning Model (WRPM) model configuration, will be developed.
- From the above summary table, a further sheet will be created that will contain the data in the format required by the relevant WRYM and WRPM input files.

2.5.2 Task 4b: Industrial, power generation and mining water requirements and return flows

The project team will assess the current water use practices within the industrial, power and mining sector in the study area, which will include the following:

- Assessment of best practice worldwide for water use in each key sector;
- Benchmark the water use in the study area for the above mentioned sectors,
- Quantification of water use efficiency within the key industries.
- Identification of scope for possible WC/WDM measures within each key sector, as per **Task 5**.

Furthermore, the project team will identify the key industries in the study area which use large volumes of water. The current water use in each industry will be assessed and discussions held where necessary to assess the current policy regarding water use/reuse. The current and projected water requirements and return flows will then be determined.

2.5.3 Task 4c: Irrigation water requirements and return flows

An investigation of aspects relating to irrigation water requirements, including areas and crops under irrigation, soil types, irrigation quotas, as well as irrigation practices will be undertaken under the Hydrological Analysis Task. The current irrigation requirements will be quantified under this task.

The proposed approach will therefore involve:

- Undertaking a comparison of existing data sources including reports, information from Water User Associations, database developed during the validation and verification process, the WARMS database, local knowledge and results from the Hydrological Analysis Task to determine the extent of legal and unlawful irrigation.
- Identifying irrigation from different sources, dams, rivers, springs and groundwater based on available information and output of the Hydrological Analysis Task and
- Determining the current and projected irrigation requirements for the above-mentioned scenarios and discuss these with the stakeholders for the selection of the appropriate scenarios.

Irrigation is by far the largest consumer of the limited water resources of the catchment and therefore will receive detailed evaluation and assessment based on:

- Reports from previous studies.
- WARMS database.
- Database developed during the validation and verification process.
- Local knowledge of DWA officials and DWA Limpopo Province offices.

Water requirement scenarios will consider:

- The eradication of unlawful irrigation,
- The revitalization of Smallholder Irrigation Schemes and
- The trading of irrigation allocations

Eradication of unlawful irrigation

Unlawful irrigation is a reality in many parts of the catchment and can only be limited by the application of appropriate water controls and management. Effective water management, in turn, is dependent on good water measurement and monitoring by Water User Associations, Irrigation Boards and Irrigation Scheme management committees. The measurement and monitoring process is most likely to be effective where the concept of "Water Management Plans" (as required in terms of the Water Act) is effectively introduced. This approach will be addressed in the study.

Revitalization of Smallholder Irrigation Schemes

Members of the WRP study team have had extensive involvement in the Limpopo Province's major programme for the rehabilitation of smallholder irrigation schemes in the Province, the RESIS programme. There are approximately 30 smallholder irrigation schemes in the Luvuvhu Letaba catchment, covering about 7000ha and involving 5000 farmers. The estimated potential water use on these schemes is in the order of 60 million m^3/annum. Unfortunately the productivity of these schemes is mostly sub-optimal and water-use efficiency is generally low. There is therefore a need to address these shortcomings in this important category of irrigation water use in the study area.

Trading of irrigation allocations

An effective and well managed system of irrigation water trading would be a significant contributor to improved water-use efficiency in the catchment, both in terms of efficient water use and in terms of the economic benefits of that water use to the water stressed region as a whole. This important tool will be fully evaluated in the study.

2.5.4 Task 4d: Afforestation

The runoff reduction due to afforestation in the study area will be comprehensively addressed under the Hydrological Analysis Task. Afforestation will however, be listed as one of the demand centres and the output from the hydrological Analysis Task will therefore be used to populate the water requirements associated with afforestation (runoff reduction).

Deliverables for Task 4:

- *Water requirements and Return Flow Report. Presenting both the historical information and the scenarios for all water users receiving water from the system. – Report (3)*
- *Updated database of water use and return flows in spreadsheet format or an Access database.*
- *Water requirement and return flow scenario database in spreadsheet format.*

2.6 TASK 5: WATER CONSERVATION AND DEMAND MANAGEMENT

2.6.1 Task 5a: Domestic sector (urban and rural)

Objective

The objective of this task will be to review the contents of water conservation and water demand management (WC/WDM) strategies developed by key Water Services Authorities (WSA). Based on the review, a realistic estimate will be made of the potential savings, cost implications and programme of implementation.

The following key WSA and WSP have been identified in the area:

No	Municipality	Key demand centre
1	Greater Giyani Municipality (Mopani DM)	Giyani
2	Greater Letaba Municipality (Mopani DM)	Modjadji'skloof
3	Greater Tzaneen Municipality (Mopani DM)	Tzaneen
5	Mutale Local Municipality (Vhembe DM)	Mutale, Masisi (rural)
5	Thulamela Local Municipal (Vhembe DM)	Thohoyandou/Sibasa
6	Makhado Local Municipality (Vhembe DM)	Louis Trichard
7	Lepelle Water Board	Nkowankowa schemes

Methodology

This task will be undertaken in six sub-tasks of which the details are discussed in the following paragraphs.

Sub-task 5a-1: Collect and collate previous studies

The major urban demand centres will be approached for their latest WC/WDM strategy. Where no WC/WDM strategy exists, the water authority will be requested to complete water balance and scorecard. The objective of the forms will be to determine the status quo and if there is scope for water loss reduction in the supply system. Both the water balance and scorecard have been developed by the project team for the Water Research Commission, and provides a high level assessment of the potential of WC/WDM in the area.

Task 5a-2: Liaise with WSA and Water Board

The existing strategies will be investigated to gain a complete understanding of the existing water supply network, its operation and key problems. This will include a brief review of the existing condition of the infrastructure, the operation of the system, level of cost recovery and management practices.

The SABS 0306:1999 Code of practice for the Management of potable water in distribution zones provides guidelines on the management, administration and operational functions required by water services authorities in order to account for potable water within their distribution systems and to apply corrective actions to reduce and control water.

The existing WCDM strategies will be evaluated in terms of these guidelines to assess the scope for water loss reduction.

Task 5a-3 : Broad based assessment of potential savings

Having reviewed the WC/WDM strategy for each demand centre, a meeting will be set-up with the WSA's to discuss the WC/WDM strategies. The main objective of these meetings will be to establish :

- status quo on the implementation of the WC/WDM strategy;
- discussion of water balance and scorecard;
- results from the various interventions;
- problems and possible solutions for implementing a WCDM project; and

- prioritising of key projects and development of a realistic implementation programme.

The project team will ensure that the goals set by the WSA are realistic and that the savings can be achieved within the current constrains. The project team will attempt to identify the "quick fix" projects whereby major savings can be achieved for limited capital investment.

Task 5a-4 : Develop savings scenarios

Based on the results from Tasks 5a-1 to 5a-3, a revised strategy will be developed for each urban demand centre. This strategy will focus on the following aspects:

- reduction of water losses;
- more efficient use of existing water supplies;
- deferred construction of new facilities;
- increased revenues;
- decreased expenditure on purchasing or producing water, due to lower volumes of water required, reduced power costs, reduced chemical costs, etc.

The results from this task will include a realistic WC/WDM strategy which will assess the potential savings, the cost implication and programme for implementation. The revised strategy will be forwarded to the respective WSA for approval and implementation.

Task 5a-5: Review information and scenarios

It is imperative that the targets set in the strategy are realistic and the goals are met as it has a direct implication on future augmentation schemes. The WC/WDM strategies will be reviewed after 18 months to assess whether the targets have been met.

Should it be found that the targets are unrealistic; the WC/WDM will be changed accordingly.

2.6.2 Task 5b: Irrigation Sector

The implementation of this task will be according to the following steps:

Past and present water use efficiency.

Past and present water use efficiency will be evaluated based on recent studies on WCDM in the catchment, information obtained from Irrigation Boards and WUA's, and, in areas where recent WC/WDM initiatives have been implemented in the study area

The trends in farming practices that affect water use efficiency will also be documented to assist in formulating recommendations for improving water conservation and water demand management.

Existing initiatives on WCDM.

Existing initiatives, strategies or studies on WC/WDM in the catchments will be identified and evaluated against standard Benchmarks and Best Management Practice. Any implementation of recommendations of previous WC/WDM studies will be checked and the ongoing monitoring /assessment of benefits of various interventions will be evaluated.

Liaison with relevant municipalities and water service authorities, concerning the costs and benefits of the various WC/WDM interventions implemented to date, will include the potential diminishing returns of extending some of the interventions.

Any costs –benefit analyses, on WC/WDM initiatives that have previously been undertaken by WSA's (including the implications of reduced effluent flows to wastewater treatment works), will be evaluated and where appropriate updated in this study. The ability of WSA's to apply restriction measures during periods of drought will be assessed. This information will form the foundation for new or additional recommended approaches to WC/WDM for the study area.

Benchmarks and Best Management Practice.

Standard benchmarks and Best Management Practices (for suppliers and irrigators) that are internationally recognised and applied in irrigation will be identified and proposed for application of WC/WDM initiatives in the study area.

Potential benefits of WCDM (water savings).

The potential benefits of WC/WDM or actual water savings that may be achieved through the application of defined WC/WDM practices (existing or proposed) will be quantified and described. In this regard, only practical and achievable targets and time-frames for water saving will be considered and recommended in this study.

Application of findings in other components of the study

The identified WCWD benefits will be included in the development of future water requirements and return flow scenarios in **Task 4** and will be used in **Task 12 & 14** to establish the impacts of WCWDM on yields and the phasing of future schemes.

Recommended approach and modus operandi for Implementation of WC/WDM measures

The appropriate approach to WC/WDM in irrigation will be recommended with consideration given to both the approach for the irrigation water suppliers (Irrigation Boards / WUA,s) and the water users (irrigators).

The modus operandi for WC/WDM will focus on the Water Management Plan approach. In a Water Management Plan, a water user association or irrigation board (or any other water management body) describes its current water use and conservation measures, and sets out how it plans to implement Best Management Practices (BMP's) using accepted benchmarks to improve its water supply to water users and to achieve quantifiable water savings. The main benefits of the Water Management Plan approach, is that it is structured for stakeholder and water user participation in planning and implementation, and it is conducive to ready integration into a broader Water Resource Management Strategy for the study area as a whole.

Deliverables for Task 5:

- *Demand management scenarios, alternative water use projections.*
- *Report (Report 5) describing the assumptions and scenario results.*

2.7 TASK 6: WATER RE-USE

The objective of this task is to assess the role that re-use of treated effluent from the wastewater treatment plants (WWTP) can play in achieving reconciliation. Opportunities will be identified across the study area.

The approach to be followed is:-

- To collect and evaluate the available quantity and quality information of the influent and effluent flows to and from the WWTP. The centres with the major WWTP will be visited to determine the current and future WWTP and sewage management plans and to ensure that the correct data is collected.
- Liaise with the ecology team to determine the role the return flow play in meeting the EWR.
- Based on this assessment, develop possible schemes for inclusion in the reconciliation strategies.

2.7.1 Task 6a: Review planning information on re-use options and water care works

The following activities will be undertaken as part of this task:-

- The available planning information and discharge information will be collated for the WWTP in the catchment. The locations of the WWTP will be determined and a map prepared showing the locations of the WWTP.
- The volumes available will be compared to the water requirement projections and yields of the current supply systems to determine the contribution that re-use can make in achieving reconciliation. Both indirect and direct re-use options for domestic use will be assessed.
- The WWTP identified will be visited and the performance of the plants determined, installed technology reviewed, available space at the WWTP sites determined and the water quality data of the discharges will be reviewed.

2.7.2 Task 6b: Conceptualise possible re-use options

The following activities will be carried out for this task:-

- The available volumes for re-use at the WWTP will be determined accounting for the contributions to the EWR.
- The pipeline routes and scheme layouts will be determined for the options.
- The treatment technologies needed to achieve the water quality requirements of the users will be determined. Conceptual level treatment trains will be developed.
- The schemes will be designed and costed at the prefeasibility level.

2.7.3 Task 6c: Preliminary screening of re-use options

The options will be assessed in the yield models in terms of achieving reconciliation for the system. Unit reference values (URV) will be calculated for the options. The results of the model runs and the URV for the options will be used to identify the best options to take forward.

2.7.4 Task 6d: Reporting

The results of the assessment will be included in the final report (Report 6).

Deliverables for Task 6:

The deliverables of Task 6 is the report (Report 6) detailing the options assessed and the data collected.

2.8 TASK 7: INVASIVE ALIEN PLANTS (IAPS)

Significant areas of invasive alien plants do occur within the study area and affects the runoff generated from the catchments. The areas covered by the invasive alien plants were not fully captured and modelled in the latest studies on the Luvuvhu and Letaba river catchments.

2.8.1 Task 7a: Assemble information

The data from the existing studies and committees will first be obtained and evaluated, in particular the sources of information used for the invasive alien plants. More up-to-date information will be sourced from the DWA Working for Water Directorate, where available. Plans regarding future eradication of IAPs in the catchment will be obtained to determine the future trend in IAP coverage in the catchments.

2.8.2 Task 7b: Define scenarios to be analysed

The effect of the eradication of IAPs in the catchment on the yield of related dams or sub-systems will be determined for a maximum of 6 (six) scenarios. These scenarios will be defined, discussed and agreed on with the Client, before any analyses are carried out. The latest IAP modelling techniques included in the WRSM2000 and WRYM will be used to model the effect of IAP on the runoff. This approach takes into account the physical size of the aliens as well as whether it is riparian vegetation, generally using more water or IAP located far from the streams having a lesser effect on the runoff.

In the defining and selection of scenarios, important factors such as areas of high infestation and in particular those in the riparian zone, the type of IAP, the location of the dams affected, the need for water in the particular sub-system, etc.

2.8.3 Task 7c: Determine effect on system and sub-system yield

Historic firm yield analysis will be carried out for each of the agreed scenarios to determine the increase in yield at the selected dams, affected by the removal of IAPs. Long-term stochastic analysis will be carried out for the most promising options identified if required.

Deliverables for Task 7:

- *Chapter in the hydrology and system analysis report (Report 4 & 11) providing the following:*
    - *GIS map indicating the areas of Invasive Alien Plants (Report 4).*
    - *Description of the scenarios for removal (Report 4).*
    - *Implication of removal scenarios on the yield in the system (Report 11).*

2.9 TASK 8: WATER QUALITY

2.9.1 Task 8a: Collection of data

In order to develop a water quality profile of the Letaba Luvuvhu River System, water quality information will be collected and collated. The objective of the task is to identify the water quality variables of concern, the pollution sources and the water users in the catchment. A set of Interim RWQO will be proposed for use in managing the catchment. This will allow qualitative input to the reconciliation strategy being developed for the river system. The activities that will be undertaken as part of this task are:-

- Collection and analysis of the available water quality data. The available data from the DWA database, mines, EIA processes, ecological Reserve and local municipality databases. The data will be assessed for trends and general statistics such as percentiles determined.
- The available point source discharge volume and water quality information will be collated and analysed to determine discharge loads
- The land use maps will be used to identify areas of diffuse pollution such as urban, irrigation and dry land agriculture.
- The water users in the catchment will be identified and the South African water quality guidelines, ecological reserve requirements coupled with the current water quality status will be used to propose a set of Interim RWQO, for use in developing management strategies for the river system. The water quality will be compared to the Interim RWQO to identify the water quality variables of concern.
- The sources of pollution will be determined for the water quality variables of concern.

2.9.2 Task 8b: Assessment of impacts of new mining developments on water quality

The Regional Offices will be contacted to compile a list of the major new mines planned in the catchment. The important mines from a water quality impact perspective will be assessed in terms of the availability of the mine information, size and location of the operations. A short list will be created of the mines for inclusion in the modelling systems being developed. The information required for inclusion in the models will be compiled.

The mine water management systems will be evaluated against best practise and an estimate of current and potential pollution load from the mine complexes will be made.

2.9.3 Task 8c: Evaluate future water quality impacts from irrigation

The contribution from irrigation areas to the nutrient and salinity loads is difficult to determine without an extensive study. A high level assessment is proposed where the instream qualities will be used to identify areas with high nutrient and salinity concentrations. The land use map will be used showing the locations of the WWTP and the irrigation areas, to try and determine if the high concentrations observed, can be related to the irrigation areas. Use will also be made of the database of export coefficients developed for DWA for irrigation. These will be determined by applying the export coefficients to the irrigation areas to get an idea of the loads that will be contributed from the different areas. These two approaches will enable a qualitative assessment of the contribution from the irrigation areas to the nutrient and salinity concentrations to be made. This understanding can be used to provide a qualitative assessment on the effect of the reconciliation options, on the nutrient and salinity concentrations.

2.9.4 Task 8d: Assessment of potential effects of nutrients and urban area wash-off pollution

The DWA database of export coefficients and the Water Research Commission reports detailing the findings of various urban runoff monitoring programs will be used to generate export coefficients representative of the urban areas in the Luvuvhu Letaba River System. The coefficients will be applied to urban areas and the loads estimated. The data collected for the WWTP will be used to calculate nutrient loads to be compared to the loads in the river system. In this way the contribution of the wash off from the urban areas and the WWTP to the nutrient loads, will be determined.

2.9.5 Task 8e: Identify and assessment of mitigation measures

The following are possible mitigation measures that can be considered for the water quality trends being seen in the catchment:-

- The consideration of more stringent nutrient discharge standards for the WWTP.
- The use of wetlands and attenuation ponds to improve the water quality in the urban runoff.
- Investigate the use of better irrigation efficiency and fertiliser applications, to reduce nutrients.
- The use of source controls to reduce the impact of mines on the system.

2.9.6 Task 8f: Reporting

A report will be produced detailing the water quality profile, pollution sources and contributions from the sources, mitigation measures and issues to be aware of in the reconciliation strategy. An overall assessment of the contribution of the different sources to the salinity and the nutrient loads will be made.

Deliverables from Task 8:

Water Quality Assessment Report (Report 7) – content as described above.

2.10 TASK 9: RESERVE REQUIREMENT SCENARIOS ANALYSIS

This task only requires the collation of existing Ecological Water Requirement (EWR) - Reserve scenario data for use in the study. The available EWR will be sourced from the Directorate: Resource Directive Measures, and after evaluation will be included in the water resource models to be compiled as part of **Tasks 12** and **14**.

Yield analysis scenarios to determine the available water in the case where the EWR is implemented, will be carried out as part of **Task 12**.

Deliverable for Task 9:

- *Summary of the EWR scenario will be provided in the Yield analysis Report 11.*
- *EWR modelling structures in the WRYM and WRPM.*

2.11 TASK 10: GROUNDWATER UTILIZATION SCENARIOS

To determine where groundwater can be utilised to supplement or serve as the primary source of water supply, the following methodology will be adopted:

- Water demand requirements will be assessed and areas of water shortfalls identified, and the shortfalls quantified.
- The groundwater harvest potential of the areas of shortfall will be utilised to determine whether the shortfalls can be fully or partially met from groundwater.
- The average yield of boreholes within a fixed radius of the area of shortfall will be utilised to determine how many boreholes are required to meet these shortfalls, taking cognisance of geological structures that may provide higher yields, such as faults, dykes, primary aquifers etc.

- The water quality will be assessed to verify whether it is suitable for the expected use.
- The potential impact on baseflows from groundwater will be assessed to determine whether groundwater abstraction will have an undesirable impact on the baseflow in terms of the Reserve and inflows to dams.
- The feasibility of utilising groundwater will be assessed through costing of the groundwater options in terms of the number of boreholes required and associated infrastructure.

Deliverables for Task 10:

- *Groundwater Assessment and Utilisation Scenarios (Report 9). Describing potential utilisation of groundwater to meet water requirements in terms of available groundwater resources, borehole yields, water quality, unit costs, and potential impacts on the Reserve and surface water resources.*

2.12 TASK 11: HONORING INTERNATIONAL OBLIGATION

The Luvuvhu and Letaba River Systems flow through the Kruger National Park, join the Olifants River just upstream of the Mozambique border and flows into the Massingir Dam in Mozambique. The current inter-basin transfers information affecting the Study Area will be sourced, which will include source, quantity and operating rules. The current inter-basin transfers which affect the Luvuvhu and Letaba River systems and ultimately the Mozambique water resources, are shown in the Study Area Locality Map. The current operating rules and transfer capacities of these systems will be ascertained for use in the update and configuration of the WRYM and WRPM.

The Luvuvhu and Letaba River Systems can therefore be classified as directly supporting international obligations (Mozambique). Consequent thereof, any agreement between South Africa and Mozambique and Environmental Requirement flows for the Kruger National Park will have to be honoured. Information summarised in the Olifants Reconciliation Study will be used as the point of departure for this task. The requisite water requirements will be included in the current and projected water requirements scenarios under **Task 4**.

Deliverables for Task 11:

- *Detailed appraisal of the international water-related aspects of the WMA.*
- *Report (Report 8) describing findings from this task*
- *Input into the Main Strategy Report.*

2.13 TASK 12: YIELD ANALYSIS (WRYM)

2.13.1 Approach (Overview)

The WRYM was applied in previous studies for both the Letaba and Luvuvhu catchments to carry out various historic and stochastic yield analyses. The latest studies in this regard are the "Luvuvhu River System Annual Operating Analysis" completed in 2005, the Letaba River System Annual Operating Analysis" completed in 2006 followed by the most recent study "Groot Letaba River Development Project (GLEWAP)" which only focussed on the Groot Letaba Catchment. No WRYM system however exists for the Shingwedzi River System.

Yield analysis will be carried out for all major dams in these sub-systems. Priority will be given to the yield analysis for the Upper Letaba so that the results for the Nwamitwa and raising of Tzaneen dam can be confirmed. Coordination with the study team undertaking the development of operating rules for stand-alone dams (study by the Directorate Water Resource Planning Systems) will be necessary to ensure work is not duplicated. Provision has been made in the financial proposal for yield analysis of 15 dams or systems.

The simulation results of Middle Letaba and Albasini dams in previous analysis did not agree with that observed in practice. This problem was overcome for Albasini Dam when the hydrology was updated as part of the "Luvuvhu River System Annual Operating Analysis". It is anticipated that improved hydrology and system analysis results will be obtained with this study since the groundwater surface water interaction will be included in the modelling for the first time.

Six sub-tasks have been identified to compile the model as described in the subsequent sections:

2.13.2 Task 12a: Collect, collate and review model data

In order to ensure that the latest information on the physical characteristics and operating rules are contained in the reconfigured model, this task will involve contacting relevant authorities and organisations to obtain the required information. The data received will be reviewed and appropriate changes will be incorporated into the model.

2.13.3 Task 12b: Define Network model layout and configuration

This task will involve defining the revised network model layout and configuring the input data files for the three river catchments as a single WRYM network. The definition of the configuration will be dictated by the following aspects:

- Abstraction and return flow points in the system.
- Location of groundwater resource units.
- Quaternary catchment boundaries.

- The location of tributary catchments and river confluences.
- Hydrological zones and topographical features.
- Reservoirs and lakes (if applicable).
- Positioning of farm dams and logical groupings of farm dams that can be lumped together.

Appropriate network elements and the associated data files will be configured for the simulation of the Ecological Water Requirements, using the data obtained from **Task 9**.

In cases where runoff-river utilisation occurs, appropriate diversion efficiency modelling structures will be configured using an acceptable procedure.

2.13.4 Task 12c: Model verification

Once the model has been reconfigured, appropriate verification analysis will be undertaken to ensure that all aspects of the model configures correctly. The aspects that will be verified in the task will include the following:

- Water balance around all the nodes and reservoirs in the system.
- Verification that the hydrological data files are correctly simulated.
- Verification of the intended operating rules. This will be undertaken by observing the simulation results graphically and assessing the behaviour of the system under different conditions.
- Specific attention will be given to the functioning of the groundwater modules and the linkages with the other system components.

2.13.5 Task 12d: Historical and Stochastic yield analysis

The verified WRYM configuration will be used in this task to determine historical and stochastic firm yields at various points in the system. Recommendations on the appropriate locations and assumption for the analysis will be discussed with the Client, prior to the execution of the analysis.

Appropriate yield-characteristic curves will be produced and comparisons with previous study results will be made for the purpose of indicating and explaining any differences due to the reconfigured model.

Historical yield analysis

The historic yield analysis will use the total record period 1920/21 to 2009/10 as provided from the hydrology task (**Task 3**). Historic yield analysis will be carried out for all the major dams. Checks will be carried out specifically on Middle Letaba and Albasini Dam to ensure that the modelled results do agree with the observed behaviour of the dams.

The yield for the combined systems will be determined in cases where some of the dams are used and operated as a combined resource to supply a single demand centre. In some cases the demand centres is located downstream of the major dam with the river used as a channel to transfer the water to the demand centres. In such cases the incremental flow between the demand centre and the dam is also of importance and can significantly increase the system yield. This will be taken into account for these sub-system yields.

The historic simulation analysis will also be used to test the current operating rules. The operating rules will where applicable and possible, be improved.

Various scenarios will be analysed to determine the effects of existing and possible future schemes and intervention options obtained from the workshops and proposed from the other supporting tasks. These scenarios however need to be limited to a realistic number, to prevent overspending on the budget allowed.

Stochastic long term yield analysis

A selection of scenarios for the long-term stochastic yield analysis will be made based on the results from the historic analyses and requirements from the stakeholders and client. These will be discussed with the client to determine a list of the most important dams and related scenarios that will require long-term stochastic yield analysis. For budget purposes this will be limited to a maximum of 10 long-term stochastic yield analyses. Long-term stochastic analysis will be carried out by using 301 stochastic flow sequences with the same record period as used for the historic firm yield analysis.

Short-term Stochastic Yield Analysis

The WRPM requires short-term yield characteristics to simulate the allocation (drought curtailment rules) for different assurance levels, depending on the water level in these dams. Short-term yield characteristics of appropriate sub-systems will be developed for starting storage levels of 10%, 20%, 40%, 60%, 80% and 100% of its live storage. For budgeting purposes it is estimated that there will eight (8) sub-systems. Only one decision date per annum will be considered, which will be selected after consultation with the client and stakeholders.

Short-term stochastic analysis will be carried out using 501 stochastic flow sequences of 5 years each.

2.13.6 Task 12e: Determine demand / availability water balance

Given the water requirements from **Task 4** and the reconfigured WRYM from the preceding tasks, the water balance of the system at each abstraction location will be determined for both surface

and groundwater resources. Both historical and stochastic analysis will be undertaken for this purpose using yield-reliability criteria that were agreed on with the Client.

Scenario testing of the model will be undertaken as part of this task in order to ensure the model is functional under various conditions. The water balance analysis will be undertaken for four scenarios. These scenarios could typically include variations of the following variables:

- Different Ecological Management Classes.
- Water requirement projections for a future development level.
- Change in the water use patterns from groundwater resources.

2.13.7 Task 12f: Capture and describe the modelling assumptions

Since the water availability assessments will be used to ratify water use rights (licences), it will be essential that clear and comprehensive descriptions of the assumptions that are contained in the WRYM configuration be provided in order to stand in court when allocation disputes may arise in future.

The purpose of this task will therefore be to describe in the report all the relevant assumptions of the model as it will be configured. This will contain detail description of all aspects of the model in order to be completely transparent and will include statements on the confidence that can be placed in the data and assumptions.

Deliverables for Task 12:

- *Yield Analysis Report 11 – presenting the configuration of the model and providing the yield results.*
- *WRYM data in ASCII and WRYM-IMS database format.*
- *Stochastic yield vs. reliability curves for short and long term analyses.*
- *The short-term stochastic yield coefficient files to be used as input to the WRPM.*

2.14 TASK 13: WATER QUALITY MODELLING (WQT)

The calibration of the WQT was excluded from the scope of work. However allowance has been made in this task to assess the following:-

- The type of water quality modelling system needed to develop water quality management plans and to manage the water quality in the river system.
- The inputs needed for the model.

- A gap analysis on the available database needed to support the modelling system and propose a monitoring system to fill in the information gaps.
- The results of the assessment will be documented in a chapter of Report 7.

2.15 TASK 14: PLANNING ANALYSIS (WRPM)

2.15.1 Task 14a: Priority Classification

The relevant information from the other tasks but in particular **Tasks 3**, **4**, and **12** will be used to compile the WRPM for the study area. Details from the existing WRPM setups for the Luvuvhu and Letaba systems will be re-used where relevant.

Priority Classification

The allocation module of the WRPM requires multi-risk user priority definitions for each used sector and priority class definitions as the basis for simulating drought curtailment rules. Typically three or four priority classes are selected in accordance with the required assurance or reliability levels of the water users. A typical example of what was used in the Luvuvhu system in previous analysis is shown in **Table 2.2**. These will be confirmed through discussions with the client and key stakeholders.

Table 2.2: User category and priority classifications as agreed to be used in the Luvuvhu System

System and User Category	Priority Classification (%)			
	Low (90% assurance) (1:10 year)	**Medium Low (95% assurance) (1:20 year)**	**Medium High (98% assurance) (1:50 year)**	**High (99,5% assurance) (1:200 Year)**
Domestic/Industrial	15%	15%	40%	30%
Irrigation	30%	30%	30%	10%
Losses	0%	0%	0%	100%
EFR	20%	0%	0%	80%

Curtailment level	**0**		**1**		**2**		**3**		**4**

2.15.2 Task 14b: Configuration of the WRPM

The WRPM will be configured mainly on the system layouts as prepared in tasks 3 and 12, but also by taking into account the configurations used in previous and possible new schemes and or interventions defined in this study. Relevant data captured by the other tasks will be prepared for inclusion into the WRPM. This will be followed by thorough testing of the model to ensure that the system is working properly and modelling the reality as closely as possible. In previous studies the WRPM setups consisted of two totally independent models. For the purpose of this study one combined model setup will be created so that transfers from one system to the other can be modelled and evaluated in a realistic manner.

2.15.3 Task 14c: Scenario analysis

Different scenarios will be identified as part of the development of the Reconciliation Strategy of the Luvuvhu Letaba water supply system. The developed scenarios will be analysed with the WRPM and compared based on the projected risk of curtailments. Results from the analysis will be used to indicate when intervention is required based on the defined risk criteria. The number of scenarios analysed should be within a reasonable amount, not to exceed the available budget.

Results from the WRPM analyses will be used to prepare water balances at key points in the system as required and agreed on with the client.

Deliverables for Task 14:

- *Planning Analysis Report 12.*
- *Electronic data defining the WRPM system configuration.*

2.16 TASK 15: REVIEW SCHEMES AND UPDATE COST ESTIMATES

Under this task the configurations for the bulk infrastructure for water supply, irrigation and other major users of the schemes identified by the Preliminary Screening Workshop will be reviewed and adjustments will be made if necessary to ensure that current and future water requirements can be supplied and the cost estimates of the schemes will also be updated accordingly. The state and operational status of the existing bulk infrastructure for water supply, irrigation and other major users will be assessed to determine maintenance and/or refurbishment requirements.

2.16.1 Task 15a: Assessment of Existing Bulk Infrastructure of schemes for Water Supply, Irrigation and Other Major Users

Existing reports and discussions with role players will be used as the main source of information on the state and operational status of the existing bulk infrastructure for water supply, irrigation and other major users and to identify problem areas. Limited site visits will be undertaken to inspect the condition of some of the installations. Desktop assessment of existing infrastructure design capacities will be made and these will be compared with actual measured discharges/volumes. The information gathered will be used to determine refurbishment requirements and to formulate streamlined operation and maintenance procedures to optimise use of the existing infrastructure and where possible postpone the installation of new bulk infrastructure.

2.16.2 Task 15b: Review of Identified Schemes

Reports from previous studies of schemes identified by the Preliminary Screening Workshop will be re-evaluated to determine if the original proposed configurations are still applicable in view of the current situation and projected future developments and to make adjustments where necessary. For newly identified options a first-order selection of possible solutions will be made – at strategic level, but with sufficient detail to determine and compare unit reference values (URVs). Provisionally only one newly identified option has been allowed for in this study. Costs of schemes will be escalated to a common base date. Detail calculations or hydraulic modelling will not form part of the scope of work for this study.

2.16.3 Task15c: Updating cost estimates

The cost estimates for the identified schemes will be updated using itemised descriptions of various scheme components that should enable the relatively quick updating of the information should scheme changes occur. The costs will be estimated for the supply of water to the bulk consumers.

The output from this task will be the updated capital costs, using CPI index, of proposed schemes or asset value for existing schemes (CAPEX) and an estimate of the operational and maintenance costs (OPEX). The updated CAPEX and OPEX will be used to assess the economic viability of the identified schemes. These costs will then serve as input in to calculation of the unit reference values (URV).

Deliverables for Task 15:

- *Water Supply Schemes Report 13.*
- *Input to the Reconciliation Strategy Report.*

2.17 TASK 16: REVIEW OR ASSESS SOCIAL AND ENVIRONMENTAL IMPACTS

2.17.1 Task 16a: Social Impacts

The objective of this socio-economic analysis is to review and analyse the population and their characteristics, settlement patterns, socio-economics, and change in circumstances in terms of impacts of schemes previously identified and assessed by earlier studies.

As such the socio-economic impacts of the proposed schemes will be reviewed in order to determine if circumstances have changed. A desktop evaluation will be undertaken of each scheme with regard to the previous assessments in order to identify the key issues and concerns. If for any reason or a combination thereof, the socio-economic impacts appear to be unacceptably high, the option will be labelled as fatally flawed. The work in **Task 4a** will be combined with this task to confirm demographic information and be able to identify the potential socio-economic issues relating to the proposed schemes.

Information, issues and concerns will thus largely be accessed from the following sources: existing studies, perspectives gained from the technical assessment and interactions performed in the area, 1: 50 000 topographical mapping and spot 5 satellite images, existing general studies undertaken in the study area or part thereof, and technical discussions and meetings with local role players and stakeholders.

Based on the above information, an evaluation and itemisation of key issues and concerns will be made with regard to the magnitude of the socio-economic impacts. The results of this qualitative analysis will be discussed with the other team members and for presentation at the screening workshops. The options will also be ranked according to socio-economic criteria to provide an indication of the relative impacts between the options.

2.17.2 Task 16b: Environmental Impacts

The process to be followed for the compilation of a High Level Environmental Feasibility Scan will include the following:

- **Task Inception**: A meeting will be held with the client to identify the proposed options and study area boundaries in order to determine the extent of the area to be investigated. All relevant existing documentation to be obtained for review as baseline information.
- **Site Visit**: A site visit will be conducted to investigate selected options and identify any potential fatal flaws. Potential areas of concern will be investigated. Although available aerial colour photographs will be utilised during the assessment a site investigation of options not previously assessed will be undertaken.
- **Desktop Evaluation**: All available information will be evaluated to determine the environmental sensitivity of options and whether any of the circumstances have changed since previous assessments. The sensitivity will be rated from low to high. No specialist investigations will be conducted during the process. The following will be investigated:

- Floral sensitivity and distribution.
- Faunal sensitivity.
- Hydrological features.
- Archaeological and heritage features.
- Potential impact on communities.

- **Legislative requirements**: All relevant legislation will be consulted to determine the requirements for the future development of the corridor. The authorisations, licenses and permits as well as the process for obtaining them will be investigated.

Deliverables for Task 16:

- *The outcome of the investigation will be included in a chapter of Report 13.*

2.18 TASK 17: ASSEMBLY OF INFORMATION AND FORMULATION OF SCENARIOS

2.18.1 Task 17.1: Approach (Overview)

The approach for this task will be to use the information from the other study activities to formulate scenarios of how sufficient water at acceptable water quality can be made available to supply the water requirements in all supply areas until the year 2040. The identification and formulation of the scenarios will be based on a synthesis of information on the water resource availability, water quality, distribution infrastructure, potential schemes and interventions (such as WC/WDM) as well as future water requirement and return flow growth centres in the study area.

Annual projected water balance (yield .vs. water requirement) graphs will be compiled for each sub-system and for each scenario. The balances will account for any interdependencies (transfers ect.) between the sub-systems where both the yield and the conveyance infrastructure capacity limitations are taken into consideration.

Based on the study team's understanding of the water resources the following sub-systems were defined, see tables below:

The schedule (sequencing) of interventions will be based on criteria such as lowest URV, shortest time to implement, socio-economic importance of water users (adhering to selected prioritise among competing water users) or a combination of these factors. These projected balances will

be compiled by setting up a spreadsheet balance model (DWA's tool applied in previous reconciliation studies) for each sub-system with appropriate links between the spreadsheet to account for interdependencies. (This modular balance method will ensure local shortages are identified and will not be missed (masked) by global surpluses.)

Table 2.3: Main sub-systems in Luvuvhu Catchments

Sub-system	Other dams & weirs	Comments
Nandoni Dam (Possible future support to Middle Letaba)	Xikundu, Malamulele & Mhinga weir abstractions.	These sub-systems partly support each other or supply portions of the same urban area. An overall system balance would therefore also be required.
Vondo Dam	Phiphidi Dam	
Tshakuma Dam	Single dam sub-system	
Albasini Dam	Single dam sub-system	
Damani Dam	Single dam sub-system	

Table 2.4: Main sub-systems in Letaba Catchments

Sub-system	Other dams & weirs *	Comments
Ebenezer Dam	Dap Naude Dam	Used mainly to support Polokwane and Tzaneen (Tzaneen from Ebenezer only)
Magoebaskloof Dam	Vergelegen Dam	
Tzaneen Dam	Single dam sub-system	
Modjadji Dam	Single dam sub-system	
Middle Letaba Dam	Single dam sub-system	These two dams are operated as sub-system. Their current supply area can in future be supported from Nandoni Dam
Nsami Dam	Single dam sub-system	
Lorna Dawn Dam	Single dam sub-system	
Nwamita Dam	(Proposed development)	Defined in the Groot Letaba Development Project.

Note: * - Single dam sub-systems can in some cases or as part of new operating rules be operated in conjunction with other dams

The “yield” in the water balances will be derived from the long term stochastic yield vs. reliability characteristics of each sub-system and accounting for the risk criteria of the users.

The Reconciliation Strategy will be devised from selecting the appropriate reconciliation scenario that offers solutions that are flexible in their implementation and can accommodate changes in the future water requirements. The strategy will define specific recommendations with clear actions that are needed to maintain a positive water balance in all sub-systems. The appropriate institutions that responsible for each action will be identified. (These institutions will be represented on the Study Steering Committee – see **Task 19** for details)

2.18.2 Task 17.2: Preliminary Reconciliation Strategy

The Preliminary Reconciliation Strategy will be completed by April 2013. This was extended beyond the initial 12 month period requested in the TOR, due to the time required for the completion of the hydrology task (**Task 3**) and the subsequent Yield Analysis task (**Tasks 12**), which will only produce results after twelve months. Although the focus period of the Preliminary

Reconciliation Strategy will be on the initial ten years the annual water balances and sequencing of interventions will be carried out until the year 2040.

2.18.3 Task 17.3: Final Reconciliation Strategy

The Final Reconciliation Strategy is the main deliverable of the study and will define the proposed actions and interventions (demand management and infrastructure) that will be required to make sufficient water available to supply the water needs in the study are up to the year 2040.

In this task reconciliation scenarios will be refined by taking the following aspects into account:

- Allocations of water use in the catchment – application of multi-assurance of supply criteria.
- Water requirement and return flow scenarios, typically considering Low Medium and High scenarios.
- Removal of Invasive Alien Plants.
- Alternative Ecological Water Requirement scenarios.
- Sequence of interventions according to lowest URV.
- Incorporate water quality management implications that could influence the reconciliation strategy.

In addition, the strategy development process will be documented and the institutional responsibilities will be defined for each of the recommendations and actions. The report will also contain revised annual water balances of the selected scenarios which will serve as motivation for the reconciliation strategy.

Deliverable:

- *Preliminary Reconciliation Strategy (or first stage) Report – (Report 10a).*
- *Executive Summary of preliminary reconciliation strategy – (Report 10b).*
- *Final Reconciliation Strategy (or second stage) reconciliation strategy – (Report 14a).*
- *Executive summary of final reconciliation strategy – (Report 14b).*

2.19 TASK 18: FINAL SCREENING WORKSHOP

Stakeholders have to share their views and also provide their agreement on the most favourable future reconciliation options and sequence of implementation and planning priorities in the medium and long term. The following steps are anticipated:

- Confirm stakeholders to be invited to the workshop.
- Distribute and invitation letter and proposed agenda to the identified stakeholders providing them sufficient information about the status of the project, the purpose of the workshop and what will be expected of them (e.g. read through documents prior to the meeting/s and provide inputs and comments).
- Compile a concise document explaining the proposed and most favourable future reconciliation options and distributed that to all stakeholders prior to the workshop.
- Host and facilitate the workshop with proper presentations of the different options where thorough minutes can be taken which will act as a record of stakeholder comments and inputs.
- Distribute minutes of the workshop.
- The minutes of the workshop will feed into a document that will define the most likely future options and their sequence of implementation and their recommendations for future investigations.

Deliverable for Task 18:

- *Workshop starter and proceedings documents.*
- *List of options and schemes to include in strategy.*

2.20 TASK 19: STAKEHOLDER ENGAGEMENT AND PUBLIC PARTICIPATION

The following sub-tasks were identified under **Task 19**:

- Development of a stakeholder database (see further details under **Task 1**))
- Present the findings of the preliminary and final workshops.
- Arrange one public meeting to present the findings of the Final Workshop.

Our methodology for arranging public meetings is as follows:

- Identify attendants for the meeting and “advertise” the public meeting through communication in different structures (municipalities, Ward Committees, etc) and the placement of information in

the press.

- Define a clear purpose for the meeting and thus the objectives of what needs to be achieved by the meeting.
- Send out notification of the meeting date and its objectives at least three weeks in advance.
- Follow a formal advance registration process for the meeting
- Make sure that stakeholders have received documentation for the meeting at least five working days before the meeting, with a formal information letter of their attendance (an agenda and a background document helps stakeholders to understand the purpose of the meeting)
- Conduct a dry-run meeting for the project team in advance to agree on the content and comprehensive levels of presentations and to strategise for discussion sessions
- Take thorough minutes of the meeting and distribute to all who have attended within one month of the meeting.
    - Present the findings of the of the workshops to three other committees or groups
- The team will be of assistance to arrange such meetings and to act as the secretariat as explained above.
    - Prepare and distribute two newsletters on the workshops

Stakeholders need to be taken by the hand from the beginning to the end of a project. Often stakeholders are just called upon to give their inputs without providing them with the tools to meaningfully participate. The distribution of a printed and electronic newsletter to all stakeholders on the database will assist in keeping them updated. Should the project deliver something “news-worthy” the media can also be called upon to publish a news release to inform its readers.

Zitholele Consulting will assist with the arrangements and secretariat services of the Steering Committee meeting that will take place.

With regards to this task, the team will undertake the following activities:

a) Confirm the members of the Steering Committee and a Terms of Reference for the Committee

b) Compile an agenda, invitation letter and response sheet and distribute that and the necessary preparation documents to members of the committee

c) Undertake all arrangements with regards to the venue, catering and equipment required at each meeting

d) Arrange for name tags, copies of required documents, attendance registers

e) Attend the meeting and record the minutes

f) Distribute the minutes once approved by DWA

Deliverables for Task 19:

- *Database of interested and affected parties.*
- *Agenda, supporting information and proceedings of the following meetings (*
    - *One public meeting.*
    - *Present the findings of the preliminary and final workshops.*
    - *Six (6) Study Steering Committee meetings.*
- *Two newsletters.*

2.21 TASK 20: STUDY MANAGEMENT

2.21.1 Task 20a: Client liaison (SMT meetings)

Liaison with the DWA Study Manager will include the following activities:

- Convening thirty (30) SMT progress meetings with the DWA Study Manager on a four to six weekly cycle. Technical, administrative and financial progress reports will be presented at each of these meetings.
- Attending and facilitate Study Steering Committee (SSC) meetings (six meetings).
- Establishing interim communication (between meetings) to advise the Study Manager of, inter alia, important events or problem situations, possible changes to the scope of work, appointment of sub-consultants, etc.
- Compiling and updating the “Record of Decisions” and “Record of Requests” and ensuring that all recorded actions are attended to within the specified budget and time limits.
- Motivating the appointment of proposed new members of the consultant team to the Study Manager as and when required.
- Motivating the appointment of sub-consultants and/or co-consultants and specialists to the Study Manager

- Implementing the appointment of the sub-consultants and/or co-consultants and specialists after approval by the Client.

2.21.2 Task 20b: Coordination of Consultant Team

The **Study Leader** will be responsible for overall coordination of the Consultant Study Team and activities will include:

- Serving as link between DWA Study Manager and Consultant Team
- Ensuring that the sub-consultants and/or co-consultants and specialists are properly briefed by the Task Leaders prior to commencing with work.
- Convene regular meetings with the Task Leaders as dictated by programme and progress.
- Rendering guidance and assistance to the Task Leaders.
- Monitoring and control of performance, programming and cost of study, including revision of the Study Plan if and when necessary.

2.21.3 Task 20c: Performance monitoring

A performance monitoring system will be instituted whereby all key activities under each main Task will be assigned milestone dates against which progress will be monitored. The monitoring system will basically be in bar chart format for ease of reference.

The system will allow for detecting potential problem areas at an early stage to enable remedial measures to be instituted to ensure that the study remains on course.

2.21.4 Task 20d: Financial control

A budget monitoring system comprising basically an interactive spreadsheet model will be used to monitor and control costs. Budgets will be assigned to the key activities (sub tasks) under each main Task. Actual costs incurred will be correlated with completion targets to ensure compliance with progress.

Should deviations from the allocated costs for the key activities become evident, the Study Leader shall assess the reason/s and impact of such deviations and institute corrective action as required.

Where additional work may be required, the Study Leader shall obtain a detailed motivation and budget (both time and costs) from the relevant Task Leader for such additional activities for assessment and submission to the Study Manager for consideration and approval. *No additional*

expenses outside the approved budget will be allowed without the prior written approval of the Client.

The Study Leader will submit progress report to the Client outlining costs against progress for each Task in a format as prescribed by the Study Manager.

2.21.5 Task 20e: Study administration

Study administration duties to be performed will include:

- Compiling, certifying and submitting monthly invoices to the Client from input received from the Task Leaders. The Client will be presented with only one invoice monthly from the Consultant Study Team. The Study Leader will arrange payment to the other members of the Study Team after receiving same from the Client.
- Keeping minutes of meetings with the Client and other stakeholder bodies and distribution thereof to the interested parties.
- Ensuring that all project files are kept up to date and accessible to the Client if and when required.

The **Study Leader** will provide a secretariat to perform the required duties for the Study Management Committee.

Deliverables from Task 20:

- *Progress and financial reports will be submitted to the Study Manager throughout the duration of the study.*
- *Minutes of meetings as well as lists of administrative and study decisions will be maintained throughout the duration of the study.*

2.22 TASK 21: STUDY TERMINATION

The third and final phase of the study will involve the finalisation of all deliverables and compiling a study close out report which will highlight the successes and difficulties that were experienced during the execution of the study and document the lessons learned.

Deliverables from Task 21:

Close out report which will highlight the successes and difficulties that were experienced during the execution of the study and document the lessons learned.

2.23 ADDITIONAL TASK – TASK 22: DETERMINE WATER USE IN THE LUVUVHU/LETABA WMA

2.23.1 Introduction and Motivation

An assessment of data availability and reliability carried out during the Inception Phase revealed several anomalies and deficiencies in the water use data obtained from the Validation Study. Comparisons of the Validation Study water use and land use data with those from previous hydrological and planning studies (as well as visual observations using Google Earth) showed inconsistencies in both location and size of irrigation land. These discrepancies render the validation water use data unsuitable for developing high confidence and high resolution hydrological models that are essential for accurate water resources availability estimation in the study area.

The purpose of this additional task is therefore to compile a reliable water use database for application in the Hydrological Analysis (Task 3), which will ensure that reliable yield estimates can be determined (Task 12) and ultimately a sound Reconciliation Strategy can be formulated (Task 17).

The study TOR clearly stated that the irrigation water requirements and return flows are of great importance for this analysis and that one of the main sources of information would be the database developed during the Validation Study for this area. No resources were therefore included in the study proposal's cost estimates to generate primary water use data.

2.23.2 Background to water use estimation

Although some very sophisticated analytical software is available to identify land use from satellite images it is normally only used to confirm the areas that were visually identified and digitised. From experience, the most accurate method in determining land use is by visual inspection and manual digitising. If a water use was registered, the data obtained from the WARMS must be cross-referenced with the digitised feature to establish the type of crop/trees, irrigation system, water

resource etc. per field per property. During the validation study very little manual digitising and visual inspection took place and the identified irrigation was not necessarily cross-referenced with the WARMS data, which resulted in a database with low confidence.

In the absence of high confidence data from the Validation Study, the LLRS Study Team identified an alternative water use data source for the Groot Letaba River catchment, that is of sufficient confidence and was produced from detail water use surveys carried out for DWA as part of the Groot Letaba River Water Development Project by Schoeman and Vennote. This data unfortunately only covers the Groot Letaba catchment and represents water use at 1998 development level. This means that this water use data is currently more than 10 years old. Although this is still valuable data to apply, more recent data are required for the hydrology calibration purposes. Similar data is therefore also required for the entire WMA at a recent development level (2011).

Schoeman and Vennote is currently involved as part of the Professional Service Provider (PSP) group for the Verification Study in the Limpopo WMA. Their local knowledge of the study area, competency in estimating irrigation water use, past experience in producing data for hydrological studies and current involvement, renders them most suitable to undertake this assignment on a sub-consultant basis to WRP.

2.23.3 Task description

It is of vital importance to apply reliable land use data and related water use volumes in the hydrology process and system analyses. It is thus of utmost importance that the land use is determined by visual inspection and manual digitising and that data from the WARMS be cross-referenced with the digitised data to establish the type of crop/trees, irrigation system, water resource etc. per field per property. The purpose of this task is to establish actual water use as accurately as possible. For the purpose of the Hydrology Analysis Task, only actual historical water use data is required for model calibrations and the legal status of the water use is therefore irrelevant. The derivation of the legality of the water use therefore still resides with the verification study and is not part of this task.

This additional task therefore includes the following data elements:

- Identification of irrigation areas and calculation of irrigation water use for the 1998/99 and the 2011development levels for the entire Study Area. This includes the identification of related crops under irrigation, irrigations systems, practices and efficiencies. Estimates of return flow presentences will be deduced from the irrigation practises and efficiencies.

- Identification and calculation of areas of stream flow reduction activities (focus on Afforestation) for 1998/99 and the 2011development levels.
- Identification of irrigation related infrastructure data (pipelines and canals) where possible. This information will be captured in GIS for use by relevant other study tasks.
- Identification and calculation of storage of small dams. By using aerial photographs, 1:50 000 topo-cadastral maps, satellite imagery, dam safety information, a DTM and historic survey results, the area and depth of each storage structure will be determined and used to calculate the storage capacity. If a dam was surveyed during the field surveys conducted in the study area and the dam remained unchanged, the capacity calculated during the field survey will be used.
- Generation of water use records (monthly time series) for both development levels. Rainfall records as produced from the hydrology task from this study will be used. It assumes there will be approximately 70 sub-catchments and irrigation schemes for which time series will be developed.

It is estimated that 2 700 properties will have to be assessed covering the Luvuvhu/Letaba WMA. The cost estimate therefore assumes 0.8 hours per property, 100 hours for infrastructure identification and 80 hours for the generation of monthly time series.

The total estimated cost for the task is R860 193 (including VAT) and will require an extension of the study period by another 5 months.

Deliverables from Task 22:

- Data base with all land use data and related water requirements.
- Sections in Hydrology and Water Requirements & Return Flow reports, describing the methodology followed and summarising the results from this task.

3 STUDY DELIVERABLES AND PROGRAMME

Table 3.1: List of Study Deliverables

Deliverable type	Name or description		Associated task
Reports, hard and electronic copies.	1)Inception report	Chapter on the main study objectives, background study area	0
	(Report 1)	Study procedure Chapter on each task	0
		Study deliverables and study programme	0
		Study Team details	0
		Study costs and cash flow projection	0
		Study risks	0
	2) Literature review report (Report 2)	Summary of information assessment task Literature Review Report	1
		DVD with Previous reports in electronic format	1
	Preliminary strategy		
	3)Preliminary Screening Workshop	Workshop starter document	2
		Document containing the proceedings and recommendations of the workshop	2
		List of schemes (interventions) to investigate in the study	2
	4)Determine Water use	Data base with land use data and related water requirements	22
		Monthly time series of water use at 1998 & 2011 development	
		levels	
		Sections in the Hydrology and Water Requirement & Return	
		Flow reports describing the methodology followed and	
		Summarising the results from Task 22	
	5) Hydrological analysis	Rainfall analysis report (4)	3
	(Reports 4 & 5)	Hydrology report (5)	3
		Calibrated WRSM2005 model and data files	3
		Hydrological data in appropriate electronic format	3
	6)Water Requirements & Return flows	Water requirements and Return Flow Report (3)	4
	(Report 3)	Updated database of water use and return flows	4
		Water requirement and return flow scenario database	4
	7) WC/WDM Report	Demand management scenarios, alternative water use projections (Irrigation and urban industrial	5
	(Report 6)	Report describing the assumptions and scenario results	5
	8)Water re-use (Report 7)	Report detailing the options assessed and the data collected.	6

Deliverable type	Name or description		Associated task
	9) Invasive alien plants	GIS map indicating the areas of Invasive Alien Plants	7
	(Include in Report 5)	Description of the scenarios for removal	7
		Implication of removal scenarios on the yield in the system	7
	10) Reserve requirement analysis	Summary of the EWR scenarios will be provided in the Yield analysis Report (11)	9
	(Include in Report 11)	EWR modelling structures in the WRYM and WRPM	9
	11) Ground Water (Part a) (Report 9).	Groundwater Assessment and Utilisation Scenarios	10a
	12) International obligations	Detailed appraisal of the international water-related aspects of the WMA	11
	(Report 15)	Report describing findings from this task	11
		Input into the Main Strategy Report	11
	13) WRYM Historic yield analysis	Yield Analysis Report	12
	(Report 12)	WRYM data in ASCII and WRYM-IMS database format	
	14) Review schemes and update cost estimates (part a)	Water Supply Schemes Report	15a
	(Report 14)	Input to the Reconciliation Strategy Report.	15a
	15) Review or assess social and environmental impact (part a) (Report 14)	The outcome of the investigation will be included in a chapter of Report 14	16a
	16) Assembly of information and formulation of scenarios (part a) (Report 10)	Preliminary Reconciliation Strategy (or first stage) Report – (Report 10)	17a
	(Report 11)	Executive Summary of preliminary reconciliation strategy –.	17a
	Final strategy		
	17 Refine Water requirements and return flows) Yield analysis	Refined water requirements and Return Flow Report Report (3)	4b
	(Report 3)	Refine database of water use and return flows	4b
		Refine water requirement and return flow scenario database	4b
	18) Final adjustments to Water conservation and demand management	Demand management scenarios, alternative water use projections (Irrigation and urban industrial)	5b
	(Report 6)	Report describing the assumptions and scenario results	

Deliverable type	Name or description		Associated task
	19) Water quality (Report 8)	Water Quality Assessment Report	8
	20) Groundwater utilization scenarios (part b) (Report 9)	Groundwater Assessment and Utilisation Scenarios.	10b
	21) WRYM Stochastic yield analysis	Yield Analysis Report	12b
		WRYM data in ASCII and WRYM-IMS database format.	12b
	(Report 12)	Stochastic yield vs. reliability curves for short and long term analyses	12b
		The short-term stochastic yield coefficient files to be used as input to the WRPM	12b
	22) Water quality modelling (Report 8)	The results of the assessment will be documented in a chapter of Report 8	13
	23) Planning analysis (WRPM)	Planning Analysis Report	14
	(Report 13)	Electronic data defining the WRPM system configuration	14
	24) Review schemes and update cost estimates (part b)	Water Supply Schemes Report	15b
	(Report 14)	Input to the Reconciliation Strategy Report.	15b
	25) Review or assess social and environmental impact (part b) (Report 14)	The outcome of the investigation will be included in a chapter of Report 14	16b
	26) Assembly of information and formulation of scenarios (part b)	Final Reconciliation Strategy (or second stage) reconciliation strategy – (Report 15).	17b
	(Reports 15 & 16).	Executive summary of final reconciliation strategy – (Report 16)	
	27) Final Screening workshop	Workshop starter and proceedings documents	18
		List of options and schemes to include in strategy	
	Study Termination		
	28) Study closure	Finalise deliverables	All relevant tasks
		Study Close Out Report	21
Models	Calibrated WRSM2005 model		3
	WRYM-IMS Integrated Water Resources Yield Model		12
	WRPM Integrated Water resources Planning model		14
Data on CD/DVD	Previous reports in electronic format		1
	All the study reports		All tasks'
	Data sets and input data for all the models used		4, 12, 14

Deliverable type	Name or description	Associated task
	Water demand and return flow data base	4
Presentation Material on CD	Presentations at first stakeholder meeting	19 & others
	Final Public meeting	19 & others
	Presentations at SCC	19 & others
Stakeholder engagement:	One public meeting	19
	Present the findings of the preliminary and final workshops	19
	Six Study Steering Committee meetings	19
	Two newsletters	19
Workshop 1	Workshop starter and proceedings document	2
	List of options and schemes to include in strategy	2
Workshop 2	Workshop starter and proceedings document	18
	List of options and schemes to include in strategy	18

4 STUDY TEAM

The names and rates of the team members involved with the *Development of a Reconciliation Strategy for the Luvuvhu-Letaba Water Supply Systems* are presented in **Tables 4.1**.

Table 4.1: Study team members for Reconciliation Strategy Study Luvuvhu-Letaba Water Supply System

Name	Responsibility Level	Position in team	Hourly Rate (R/hr)	Rate Base
Golder Associates Africa (Pty) Ltd				
Coleman T	E	Task Leader	1100	Negotiated
Moodley P	C	Key Support	750	17.5c/100
Rutherfoord J	E	Specialist	950	Negotiated
van Niekerk A	E	Specialist	1200	Negotiated
Hydrosol (Pty) Ltd				
Haasbroek B	D	Task Leader	750	Negotiated
Ngoepe S	B	Support	400	15c/100
Worleyparsons				
Chinyowa F	D	Key Support	875	Negotiated
Enslin K	C	Key Support	745	17.5c/100
Geldenhuys H	E	Specialist	1100	15c/100
Hattingh L	B	Support	380	15c/100
Humphries F	B	Support	520	15c/101
Louw L	E	Specialist	1100	Negotiated
Maponya K	B	Support	272	15c/100
Motswane T	B	Support	240	15c/100
Nangammbi R	B	Support	197	15c/100
Ramashapa L	B	Support	420	15c/100
Smook D	E	Task Leader	1200	Negotiated
Van Der Mescht J	E	Specialist	1100	Negotiated
Van Staden W	C	Support	586	17.5c/100

Kyamandi				
Aird R	E	Task Leader	950	Negotiated
Churr N	C	Key Support	550	17.5c/100
Sub-consultant (Muondli)				
Jeleni A	E	Task Leader	900	Negotiated
WRP Consulting Engineers (Pty) Ltd				
de Sousa P	B	Support	400	15c/100
Godzwana T	B	Support	270	15c/100
Harmse C	C	Key Support	693	17.5c/100
Mare HG	E	Task Leader	1100	17.5c/100
Mlotshwa M	B	Support	270	15c/100
Neethling C	B	Support	300	15c/100
Renke R	B	Support	400	15c/100
Sami K	E	Task Leader	945	Negotiated
Seago C	C	Key Support	800	17.5c/100
Swart HS	D	Key Support	850	Negotiated
Talanda C	C	Key Support	750	17.5c/100
van Rooyen PG	E	Project Manager	1200	Negotiated
Wegelin W	E	Task Leader	1100	Negotiated
Sub-consultant Murango				
Hovy D	E	Specialist	950	Negotiated
Mushiana A	B	Support	250	15c/100
Mamabolo E	B	Support	125	15c/100
Sub-consultant EVN				
Pienaar S	E	Specialist	950	Negotiated
Mamabolo E	B	Support	190	15c/100
Sibuyi T	B	Support	380	15c/100
Zitholele Consulting				
Joubert A	C	Task Leadert	600	17.5c/100
Mnqokoyi P	B	Support	380	15c/100
Manyaka S	D	Specialist	850	Negotiated
DMM Development Consultants (Pty) Ltd				
Mnguni D	E	Task Leader	980	Negotiated
McGee S	C	Key Support	750	15c/100
Schoeman en Vennote				
Schoeman H	E	Specialist	1000	Negotiated
Joubert F	E	Specialist	950	Negotiated
Mlambo D	C	Key Support	550	17.5c/100
Mahlangu G	C	Key Support	450	17.5c/100
Mojela A	B	Support	300	15c/100
Pretorius C	B	Support	250	15c/100
van der Walt C	B	Support	490	15c/100
Pretorius D	B	Support	250	15c/100
Manewyk H	B	Support	180	15c/100
Jackson J	B	Support	180	15c/100
Moseki S	B	Support	180	15c/100
Stopforth C	E	Specialist	950	Negotiated
van Staden A	D	Key Support	650	17.5c/100

5 STUDY COSTS

5.1 PROFESSIONAL FEES

The breakdown of the input by task for each team member is indicated in the, “Human Resources and Time Schedule Chart” in **Table C-1** of **Appendix C**. A summary of the proposed professional fees for the various tasks is provided in **Table 5.1**. It should be noted that the professional fee rates at the time of tendering for the study were based on prevailing cost as at the end of August 2006, after which they will be subject to an annual increase based on the CPIX escalation which will take effect on the **1st September** each year following 2011 for negotiated rates. Salary increases will apply for non-negotiated rates in the month of the year that each consulting firm reviews its annual salary increases, normally the 1 April of each year. For the purpose of cost estimate, an annual escalation rate of 7% has been used.

Table 5.1: Summary of professional fees by task.

Task		Professional fees (R)			% of total
No.	Description	Excl. VAT	VAT	Incl. VAT	
0	Inception Phase	350 500	49 070	399 570	3%
1	Summary of Previous and Current Studies	427700	59878	487578	4%
2	Preliminary Screening Workshop	271275	37979	309254	2%
3	Hydrological Analysis	1422475	199147	1621622	12%
4	Water Requirements and Return Flows	575346	80548	655895	5%
5	Water Conservation and Demand Management (WCDM)	409970	57396	467366	4%
6	Water Re-use	246200	34468	280668	2%
7	Invasive Alien Plants (IAPs)	119000	16660	135660	1%
8	Water Quality	491094	68753	559847	4%
9	Reserve Requirement Scenarios Analysis	120024	16803	136827	1%
10	Groundwater Utilization Scenarios	487508	68251	555759	4%
11	Honoring International Obligation	77420	10839	88259	1%
12	Yield Analysis (WRYM)	653183	91446	744628	6%
13	Water Quality Modelling (WQT)	62100	8694	70794	1%
14	Planning Analysis (WRPM)	503920	70549	574469	4%
15	Review Schemes and Update Cost Estimates	1221492	171009	1392500	11%
16	Review or Assess Social and Environmental Impacts	207803	29092	236895	2%
17	Assembly of Information and Formulation of Scenarios	1156669	161934	1318603	10%
18	Final Screening Workshop	293824	41135	334959	3%
19	Stakeholder Engagement and Public Participation	500024	70003	570028	4%
20	Study Management	987967	138315	1126282	9%
21	Study Termination	226 730	31 742	258 472	2%
21	Determine Water Use	734 000	102 760	836 760	6%
	Total	**11 546 222**	**1 616 471**	**13 162 693**	**100%**

A summary of the allocation of professional fees to each participating entity is given in **Table 5.2**.

Table 5.2: Professional fees allocated to each participating entity.

Company	Hours	Professional fees (R)			% of total
		Exl VAT	VAT	Incl VAT	
WRP	4 934	4 727 921	661 909	5 389 830	40.9%
DMM	515	525 039	73 506	598 545	4.5%
Zitholele	864	569 559	79 738	649 297	4.9%
Golder	1 321	1 280 358	179 250	1 459 608	11.1%
WorleyParsons	2 225	1 617 819	226 495	1 844 313	14.0%
Kyamandi	543	398 771	55 828	454 598	3.5%
Hydrosol	2 034	1 205 850	168 819	1 374 669	10.4%
Specialist sub-consultants	514	486 906	68 167	555 073	4.2%
Schoeman en Venote	2 328	734 000	102 760	836 760	6.4%
Total	15 277	11 546 222	1 616 471	13 162 693	100.0%

5.2 HDI INVOLVEMENT

The breakdown of professional fees allocated to each team member is provided in **Table 5.3**, which highlights the extent of involvement of Historically Disadvantaged Individuals (HDI). From **Table 5.3** a total of 35.7% of the professional fees has been allocated to HDI Study Team members, which meets the minimum requirements as set by DWA.

Table 5.3 : Breakdown of professional involvement according to HDI status.

Consulting firm / name	HDI status	Professional involvement		
		Hours	Fees (R, excl. VAT)	% of total fees
Golder Associates Africa (Pty) Ltd				
Coleman T	White Male	477	537 867	4.7%
Moodley P	Black Female	500	379 148	3.3%
Rutherfoord J	White Male	274	276 992	2.4%
van Niekerk A	White Male	70	86 352	0.7%
Hydrosol				
Haasbroek B	White Male	1166	879 173	8.2%
Sikosana S	Black Male	748	261 600	3.2%
Kyamandi				
Aird R	White Male	192	195 634	1.7%
Churr N	White Female	351	203 137	1.8%
Muondli				
Jeleni A	Black Male	202	189 360	1.6%

Table 5.3 (Continue): Breakdown of professional involvement according to HDI status.

Consulting firm / name	HDI status	Professional involvement		
		Hours	Fees (R, excl. VAT)	% of total fees
WorleyParsons				
Chinyowa F	Black Male	322	301 473	2.6%
Enslin K	White Male	220	177 042	1.5%
Geldenhuys H	White Male	166	195 228	1.7%
Hattingh L	White Female	96	40 081	0.3%
Humphries F	White Male	119	66 066	0.6%
Louw L	White Female	74	87 252	0.8%
Maponya K	Black Female	136	39 696	0.3%
Motswane T	Black Female	232	59 914	0.5%
Nangammbi R	Black Male	133	28 132	0.2%
Ramashapa L	Black Female	232	104 849	0.9%
Smook D	White Male	232	294 276	2.5%
Van Der Mescht J	White Male	110	126 841	1.1%
Van Staden W	White Male	154	96 971	0.8%
WRP Consulting Engineers (Pty) Ltd				
de Sousa P	White Male	80	32 476	0.3%
Godzwana T	Black Male	100	28 058	0.3%
Harmse C	White Male	80	57 034	0.5%
Mare HG	White Male	879	1 001 429	9.3%
Mlotshwa M	Black Male	100	28 058	0.3%
Neethling C	White Female	72	23 112	0.2%
Renke R	White Female	112	47 516	0.4%
Sami K	White Male	766	750 087	7.0%
Seago C	White Female	870	714 568	6.7%
Swart HS	White Female	364	343 052	3.2%
Talanda C	White Male	502	402 036	3.7%
van Rooyen PG	White Male	891	1 144 032	10.7%
Wegelin W	White Male	118	140657	1.3%
DMM Development Consultants				
McGee S	White Female	24	19 260	0.2%
Mnguni D	Black Male	487	505 685	4.7%
Murango				
Hovy D	White Male	156	145512	1.3%
EVN				
Pienaar S	White Male	156	145512	1.3%
Zitholele				
Joubert A	White Male	389	269 232	2.3%
Mnqokoyi P	Black Female	590	229 742	2.0%
Manyaka S	Black Male	98	70584	0.6%

Table 5.3 (Continue): Breakdown of professional involvement according to HDI status.

Consulting firm / name	HDI status	Professional involvement		
		Hours	Fees (R, excl. VAT)	% of total fees
Schoeman & Venote				
Schoeman H	White Male	60	60000	0.5%
Joubert F	White Male	40	38000	0.3%
Mlambo D	Black Male	50	27500	0.2%
Mahlangu G	Black Male	140	63000	0.5%
Mojela A	Black Male	640	192000	1.7%
Pretorius C	White Female	188	47000	0.4%
van der Walt C	White Male	50	24500	0.2%
Pretorius D	White Male	50	12500	0.1%
Manewyk H	White Female	640	115200	1.0%
Jackson J	White Female	120	21600	0.2%
Moseki S	Black Female	240	43200	0.4%
Stopforth C	White Male	60	57000	0.5%
van Staden A	White Male	50	32500	0.3%
Total		15277	11 546 222	100.0%
HDI component		**7 891**	**4 381 976**	38.0%

5.3 DISBURSEMENTS

The estimated disbursement costs for the various tasks are summarised in **Table 5.4**. The proposed tariffs for reimbursable expenses remain as outlined in the proposal.

Table 5.4 : Summary of disbursement costs.

Task		Disbursement costs (R)			% of total
No.	Description	Excl. VAT	VAT	Incl. VAT	
0	Inception Phase	30 000	4 200	34 200	3.4%
1	Summary of Previous and Current Studies	35 000	4 900	39 900	4.0%
2	Preliminary Screening Workshop	25 000	3 500	28 500	2.9%
3	Hydrological Analysis	100 000	14 000	114 000	11.4%
4	Water Requirements and Return Flows	50 000	7 000	57 000	5.7%
5	Water Conservation and Demand Management (WCDM)	40 000	5 600	45 600	4.6%
6	Water Re-use	25 000	3 500	28 500	2.9%
7	Invasive Alien Plants (IAPs)	10 000	1 400	11 400	1.1%
8	Water Quality	45 000	6 300	51 300	5.1%
9	Reserve Requirement Scenarios Analysis	10 000	1 400	11 400	1.1%
10	Groundwater Utilization Scenarios	45 000	6 300	51 300	5.1%
11	Honoring International Obligation	5 000	700	5 700	0.6%
12	Yield Analysis (WRYM)	60 000	8 400	68 400	6.9%
13	Water Quality Modelling (WQT)	5 000	700	5 700	0.6%
14	Planning Analysis (WRPM)	40 000	5 600	45 600	4.6%
15	Review Schemes and Update Cost Estimates	70 000	9 800	79 800	8.0%
16	Review or Assess Social and Environmental Impacts	20 000	2 800	22 800	2.3%
17	Assembly of Information and Formulation of Scenarios	70 000	9 800	79 800	8.0%
18	Final Screening Workshop	25 000	3 500	28 500	2.9%
19	Stakeholder Engagement and Public Participation	60 000	8 400	68 400	6.9%
20	Study Management	70 000	9 800	79 800	8.0%
21	Study Termination	15 000	2 100	17 100	1.7%
21	Determine Water Use	20 000	2 800	22 800	2%
	Total	**875 000**	**122 500**	**997 500**	**100.0%**

5.4 CONTINGENCIES

No allowance for contingencies has been made and any additional costs due to change in scope of work will be motivated as additional work with the Client requesting approval for an variation order to cover the additional professional fees and disbursements. This will however be avoided as far as possible.

5.5 SUMMARY OF COSTS

A summary of the costs for the *Development of a Reconciliation Strategy for the Luvuvhu-Letaba Water Supply System* is provided in **Table 5.5**. This includes professional fees, disbursements and office infrastructure costs. Please note that this does not include any additional work still to be approved by the Client.

Table 5.5 : Summary of costs.

Cost item	Cost (R)			% of total
	Excl VAT	VAT	Incl VAT	
Professional fees	11 546 222	1 616 471	13 162 693	93.0%
Disbursement costs	875 000	122 500	997 500	7.0%
Office infrastructure costs	0	0	0	0.0%
TOTAL	12 421 222	1 738 971	14 160 193	100.0%

5.6 COMPARISON OF COSTS

Table 5.6 : Comparison of estimated costs.

The estimated cost as included in the Inception report remained unchanged to that given in the proposal. No detail comparison is therefore included

5.7 CASH FLOW PROJECTION

A cash flow projection for the *Development of a Reconciliation Strategy for the Luvuvhu-Letaba Water Supply System* is provided in **Table C-2** of **Appendix C**. It should be noted that the monthly expenditure listed here represents the expected monthly invoicing and not necessarily payments.

6 STUDY RISKS DUE TO UNCERTAINTIES

A number of factors have been identified that may influence the execution and completion of the study. These factors can influence both the cost and the timing of the Study. **Table 6.1** provides a summary of the possible delays and an explanation of these.

Table 6.1: Possible delays to the study programme resulting from Study uncertainties.

No.	Task description	Possible Delay (weeks)
	Hydrology & Water Requirements and Return flows	
1.	Land use data from the Validation study seems suspect. There is a possibility that the given information from the validation will need to be validated before it can be used	6
2.	Irrigation water requirements are not included in the data received from the validation study team. The team promise to still supply that. There is therefore the risk that need to be determined as part of the LLRS.	3
3.	Data on the dams in the study area as obtained from the validation study seems suspect as all the dams were not listed and the storage volumes given for the dams seems wrong.	1
4.	Data from the study "Development of Reconciliation Strategies for All Towns in the Northern Region" seems to be unreliable and information for all the towns might not be available.	4

7 REFERENCES

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Authors: Midgley, DC, Pitman, WV and Middleton, BJ

DWA (2011) **Validation and Verification of Water Use in the Luvuvhu-Letaba Water Management Area** Personal communication

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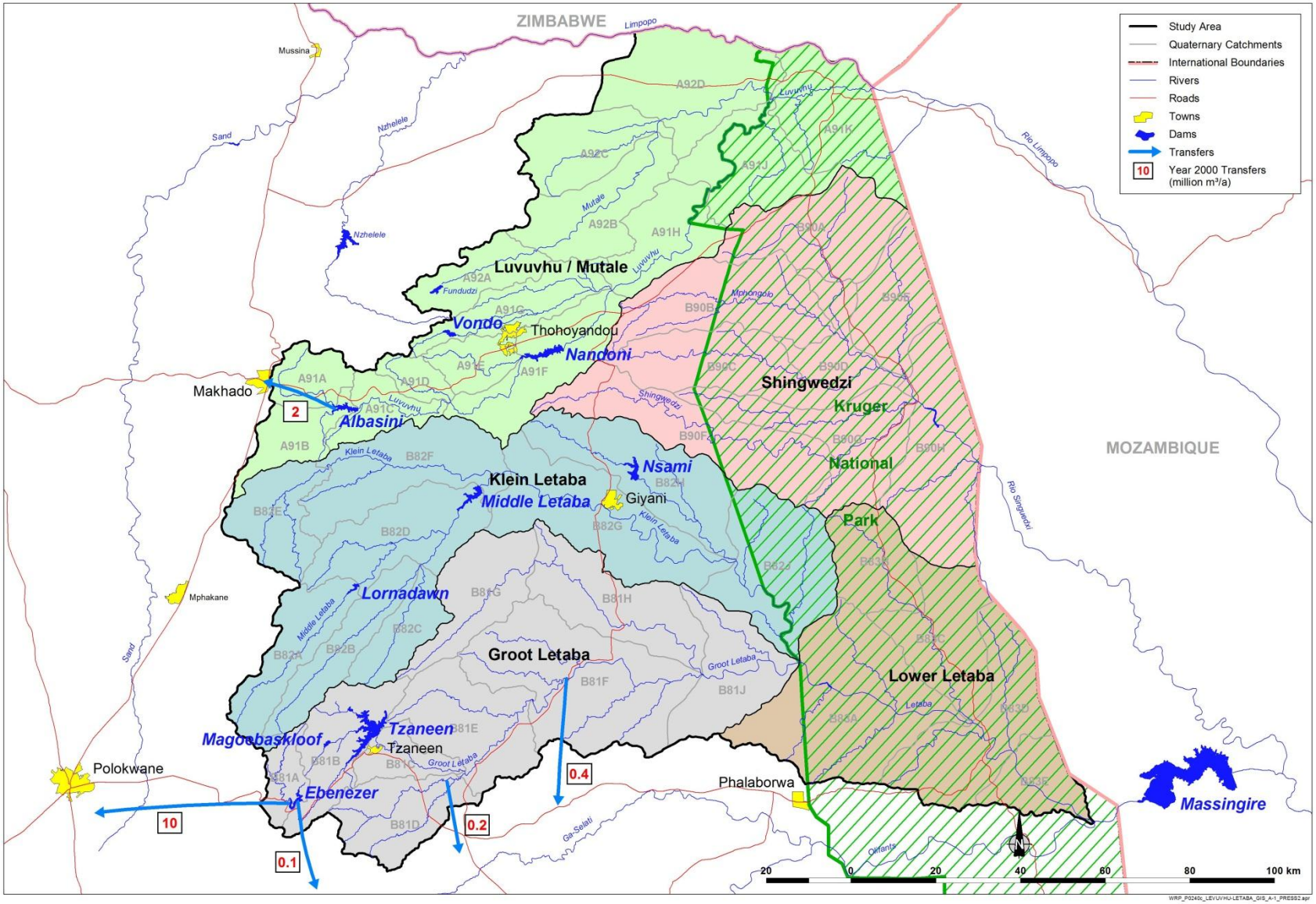
DWA (2012) ***DEVELOPMENT OF A RECONCILLIATION STRATEGY FOR THE LUVUVHU AND LETABA WATER SUPPLY SYSTEM*: LITERATURE REVIEW REPORT:** Report No ???? compiled by WRP Consulting Engineers DMM Development Consultants, Golder Associates Africa, WorleyParsons, Kyamandi, Hydrosol and Zitholele Consulting for the Department of Water Affairs, Directorate: National Water Resource Planning

Appendix A

Map of the Study Area


ZIMBABWE
MOZAMBIQUE
Limpopo
Rio Limpopo
Rio Singwedzi
Study Area
Quaternary Catchments
International Boundaries
Rivers
Roads
Towns
Dams
Transfers
10 Year 2000 Transfers (million m³/a)
Mussina
Sand
Nzhelele
Luvuvhu / Mutale
Mutale
Luvuvhu
Fundudzi
Vondo
Thohoyandou
Nandoni
Makhado
2
Albasini
Shingwedzi
Kruger
National
Park
Klein Letaba
Middle Letaba
Nsami
Giyani
Lornadawn
Mphakane
Groot Letaba
Lower Letaba
Letaba
Magoebaskloof
Tzaneen
Polokwane
Ebenezer
10
0.1
0.2
0.4
Phalaborwa
Massingire
Olifants
Ga-Selati
A92D
A92C
A92B
A92A
A91H
A91K
A91J
A91G
A91E
A91F
A91A
A91D
A91C
A91B
B90A
B90B
B90C
B90D
B90E
B90F
B90G
B90H
B82F
B82H
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B82J
B82D
B82C
B82A
B82B
B81E
B81G
B81H
B81F
B81J
B81C
B81D
B81B
B81A
B84A
B84D
B84E
0 20 40 60 80 100 km
WRP_P0240c_LEVUVHU-LETABA_GIS_A-1_PRESS2.apr

Appendix B

Bar-Chart of Study Programme

Appendix C

Detail Cost Tables

Table C-1 : Human resources and time schedule

No.	Description	Manpower, Time and Cost Schedule							
		Name	Company/ Firm	Fee Category	Rate Base	Study Position	Time Schedule (Manhours)	Hourly Rate (Rand/hour)	Costs Excl VAT (Rand)
0	**Inception Phase**								
		Jeleni A	WRP	E	Negotiated	Task Leader	40	900	36 000
		Smook D	WorleyParsons	E	Negotiated	Task Leader	8	1 200	9 600
		Van der Mescht J	WorleyParsons	E	Negotiated	Specialist	8	1 100	8 800
		Chinyowa F	WorleyParsons	D	Negotiated	Key Support	8	875	7 000
		Lotter A	Zitholele	C	17.5c/100	Task Leader	40	770	30 800
		van Rooyen PG	WRP	E	Negotiated	Project Manager	45	1 200	54 000
		Mare HG	WRP	E	17.5c/100	Task Leader	45	1 100	49 500
		Seago C	WRP	C	17.5c/100	Key Support	30	800	24 000
		Moodley P	Golder	C	17.5c/100	Key Support	12	750	9 000
		Coleman T	Golder	E	Negotiated	Task Leader	12	1 100	13 200
		Haasbroek B	Hydrosol	D	Negotiated	Task Leader	24	750	18 000
		Mnguni D	DMM	E	Negotiated	Task Leader	40	980	39 200
		de Sousa P	WRP	B	15c/100	Support	24	400	9 600
		Pienaar S	WRP	E	Negotiated	Specialist	22	950	20 900
		Hovy D	WRP	E	Negotiated	Specialist	22	950	20 900
	Sub-total for Task						**380**		**350 500**
1	**Summary of Previous and Current Studies**								
		Jeleni A	WRP	E	Negotiated	Task Leader	90	900	81 000
	KV3 budget to be	Smook D	WorleyParsons	E	Negotiated	Task Leader	20	1 200	24 000
	increased to	Van der Mescht J	WorleyParsons	E	Negotiated	Specialist	18	1 100	19 250
	R80 000	Chinyowa F	WorleyParsons	D	Negotiated	Key Support	42	875	36 750
		Coleman T	Golder	E	Negotiated	Task Leader	16	1 100	17 600
		Moodley P	Golder	C	17.5c/100	Key Support	16	750	12 000
		van Rooyen PG	WRP	E	Negotiated	Project Manager	26	1 200	31 200
		Mare HG	WRP	E	17.5c/100	Task Leader	39	1 100	42 900
		Seago C	WRP	C	17.5c/100	Key Support	30	800	24 000
		Sami K	WRP	E	Negotiated	Task Leader	40	945	37 800
		Haasbroek B	Hydrosol	D	Negotiated	Task Leader	40	750	30 000
		Mnguni D	DMM	E	Negotiated	Task Leader	30	980	29 400
		Pienaar S	WRP	E	Negotiated	Specialist	22	950	20 900
		Hovy D	WRP	E	Negotiated	Specialist	22	950	20 900
	Sub-total for Task 1						**451**		**427 700**

No.	Description	Manpower, Time and Cost Schedule							
		Name	Company/ Firm	Fee Category	Rate Base	Study Position	Time Schedule (Manhours)	Hourly Rate (Rand/hour)	Costs Excl VAT (Rand)
2	**Preliminary Screening Workshop**								
		van Rooyen PG	WRP	E	Negotiated	Project Manager	28	1 200	33 600
		Lotter A	Zitholele	C	17.5c/100	Task Leader	15	770	11 550
		Mare HG	WRP	E	17.5c/100	Task Leader	30	1 100	33 000
		Smook D	WorleyParsons	E	Negotiated	Task Leader	15	1 200	18 000
		Geldenhuys H	WorleyParsons	E	15c/100	Specialist	12	1 100	13 200
		Chinyowa F	WorleyParsons	D	Negotiated	Key Support	15	875	13 125
		Humphries F	WorleyParsons	B	15c/101	Support	12	520	6 240
		Mnguni D	DMM	E	Negotiated	Task Leader	31	980	30 380
		Coleman T	Golder	E	Negotiated	Task Leader	35	1 100	38 500
		Joubert A	Zitholele	C	17.5c/100	Key Support	59	600	35 400
		Mnqokoyi P	Zitholele	B	15c/100	Support	56	380	21 280
		Manyaka S	Zitholele	D	Negotiated	Specialist	20	850	17 000
	Sub-total for Task 2						**328**		**271 275**
3	**Hydrological Analysis**								
		Haasbroek B	Hydrosol	D	Negotiated	Task Leader	1030	750	772 500
		Swart HS	WRP	D	Negotiated	Key Support	20	850	17 000
		Ngoepe S	Hydrosol	B	15c/100	Support	220	400	88 000
		Sikosana S	Hydrosol	B	15c/100	Support	618	350	216 125
		Mare HG	WRP	E	17.5c/100	Task Leader	13	1 100	14 300
		Sami K	WRP	E	Negotiated	Task Leader	270	945	255 150
		Seago C	WRP	C	17.5c/100	Key Support	27	800	21 600
		Talanda C	WRP	C	17.5c/100	Key Support	20	750	15 000
		Pienaar S	WRP	E	Negotiated	Specialist	12	950	11 400
		Howy D	WRP	E	Negotiated	Specialist	12	950	11 400
	Sub-total for Task 3						**2242**		**1 422 475**

No.	Description	Manpower, Time and Cost Schedule							
		Name	Company/ Firm	Fee Category	Rate Base	Study Position	Time Schedule (Manhours)	Hourly Rate (Rand/hour)	Costs Excl VAT (Rand)
4	**Water Requirements and Return Flows**								
		Mnguni D	DMM	E	Negotiated	Task Leader	70	980	70 795
		Aird R	Kyamandi	E	Negotiated	Task Leader	133	950	133 732
		McGee S	DMM	C	15c/100	Key Support	24	750	19 575
		Mare HG	WRP	E	17.5c/100	Task Leader	24	1 100	28 710
		Rutherfoord J	Golder	E	Negotiated	Specialist	36	950	34 200
		Jeleni A	WRP	E	Negotiated	Task Leader	12	900	10 800
		Seago C	WRP	C	17.5c/100	Key Support	40	800	33 120
		Talanda C	WRP	C	17.5c/100	Key Support	38	750	29 340
		Churr N	Kyamandi	C	17.5c/100	Key Support	250	550	141 543
		de Sousa P	WRP	B	15c/100	Support	40	400	16 000
		Pienaar S	WRP	E	Negotiated	Specialist	30	950	28 766
		Howy D	WRP	E	Negotiated	Specialist	30	950	28 766
	Sub-total for Task 4						**727**		**575 346**
5	**Water Conservation and Demand Management (WCDM)**								
		Wegelin W	WRP	E	Negotiated	Task Leader	68	1 100	79 112
		Rutherfoord J	Golder	E	Negotiated	Specialist	158	950	159 610
		van Rooyen PG	WRP	E	Negotiated	Project Manager	24	1 200	30 312
		Mare HG	WRP	E	17.5c/100	Task Leader	24	1 100	27 786
		Harmse C	WRP	C	17.5c/100	Key Support	80	693	57 034
		Godzwana T	WRP	B	15c/100	Support	100	270	28 058
		Mlotshwa M	WRP	B	15c/100	Support	100	270	28 058
	Sub-total for Task 5						**554**		**409 970**
6	**Water Re-use**								
		Coleman T	Golder	E	Negotiated	Task Leader	80	1 100	88 000
		Rutherfoord J	Golder	E	Negotiated	Specialist	20	950	19 000
		Moodley P	Golder	C	17.5c/100	Key Support	128	750	96 000
		van Rooyen PG	WRP	E	Negotiated	Project Manager	36	1 200	43 200
	Sub-total for Task 6						**264**		**246 200**
7	**Invasive Alien Plants (IAPs)**								
		Haasbroek B	Hydrosol	D	Negotiated	Task Leader	50	750	37 500
		Swart HS	WRP	D	Negotiated	Key Support	70	850	59 500
		Mare HG	WRP	E	17.5c/100	Task Leader	20	1 100	22 000
	Sub-total for Task 7						**140**		**119 000**

No.	Description	Manpower, Time and Cost Schedule							
		Name	Company/ Firm	Fee Category	Rate Base	Study Position	Time Schedule (Manhours)	Hourly Rate (Rand/hour)	Costs Excl VAT (Rand)
8	**Water Quality**								
		Coleman T	Golder	E	Negotiated	Task Leader	181	1 100	203 566
		van Niekerk A	Golder	E	Negotiated	Specialist	54	1 200	65 640
		Moodley P	Golder	C	17.5c/100	Key Support	292	750	221 888
	Sub-total for Task 8						**527**		**491 094**
9	**Reserve Requirement Scenarios Analysis**								
		van Rooyen PG	WRP	E	Negotiated	Project Manager	33	1 200	39 600
		Humphries F	WorleyParsons	B	15c/101	Support	30	520	15 600
		Mnguni D	DMM	E	Negotiated	Task Leader	25	980	24 500
		Sami K	WRP	E	Negotiated	Task Leader	8	945	7 324
		Coleman T	Golder	E	Negotiated	Task Leader	30	1 100	33 000
	Sub-total for Task 9						**126**		**120 024**
10	**Groundwater Utilization Scenarios**								
		Sami K	WRP	E	Negotiated	Task Leader	394	945	386 420
		Mare HG	WRP	E	17.5c/100	Task Leader	45	1 100	51 117
		van Rooyen PG	WRP	E	Negotiated	Project Manager	17	1 200	21 072
		Pienaar S	WRP	E	Negotiated	Specialist	15	950	14 450
		Hovy D	WRP	E	Negotiated	Specialist	15	950	14 450
	Sub-total for Task 10						**486**		**487 508**
11	**Honoring International Obligation**								
		Mnguni D	DMM	E	Negotiated	Task Leader	79	980	77 420
	Sub-total for Task 11						**79**		**77 420**
12	**Yield Analysis (WRYM)**								
		Mare HG	WRP	E	17.5c/100	Task Leader	96	1 100	107 910
		van Rooyen PG	WRP	E	Negotiated	Project Manager	78	1 200	95 784
		Talanda C	WRP	C	17.5c/100	Key Support	154	750	118 073
		Seago C	WRP	C	17.5c/100	Key Support	184	800	150 280
		Swart HS	WRP	D	Negotiated	Key Support	171	850	148 504
		Sami K	WRP	E	Negotiated	Task Leader	16	945	15 385
		Renke R	WRP	B	15c/100	Support	48	400	17 248
	Sub-total for Task 12						**747**		**653 183**

No.	Description	Manpower, Time and Cost Schedule							
		Name	Company/ Firm	Fee Category	Rate Base	Study Position	Time Schedule (Manhours)	Hourly Rate (Rand/hour)	Costs Excl VAT (Rand)
13	**Water Quality Modelling (WQT)**								
		Coleman T	Golder	E	Negotiated	Task Leader	24	1 100	26 400
		van Rooyen PG	WRP	E	Negotiated	Project Manager	11	1 200	13 200
		Moodley P	Golder	C	17.5c/100	Key Support	30	750	22 500
	Sub-total for Task 13						**65**		**62 100**
14	**Planning Analysis (WRPM)**								
		Mare HG	WRP	E	17.5c/100	Task Leader	54	1 100	67 100
		van Rooyen PG	WRP	E	Negotiated	Project Manager	54	1 200	73 200
		Talanda C	WRP	C	17.5c/100	Key Support	133	750	111 615
		Seago C	WRP	C	17.5c/100	Key Support	139	800	124 248
		Swart HS	WRP	D	Negotiated	Key Support	103	850	98 320
		Sami K	WRP	E	Negotiated	Task Leader	8	945	8 222
		Renke R	WRP	B	15c/100	Support	48	400	21 216
	Sub-total for Task 14						**539**		**503 920**
15	**Review Schemes and Update Cost Estimates**								
		Smook D	WorleyParsons	E	Negotiated	Task Leader	74	1 200	95 184
		van Rooyen PG	WRP	E	Negotiated	Project Manager	53	1 200	68 136
		van der Mescht J	WorleyParsons	E	Negotiated	Specialist	68	1 100	79 805
		Louw L	WorleyParsons	E	Negotiated	Specialist	74	1 100	87 252
		Geldenhuys H	WorleyParsons	E	15c/100	Specialist	154	1 100	182 028
		Chinyowa F	WorleyParsons	D	Negotiated	Key Support	213	875	202 484
		Enslin K	WorleyParsons	C	17.5c/100	Key Support	220	745	177 042
		Van Staden W	WorleyParsons	C	17.5c/100	Support	154	586	96 971
		Motswane T	WorleyParsons	B	15c/100	Support	232	240	59 914
		Ramashapa L	WorleyParsons	B	15c/100	Support	232	420	104 849
		Maponya K	WorleyParsons	B	15c/100	Support	136	272	39 696
		Nangammbi R	WorleyParsons	B	15c/100	Support	133	197	28 132
	Sub-total for Task 15						**1743**		**1 221 492**
16	**Review or Assess Social and Environmental Impacts**								
		Aird R	Kyamandi	E	Negotiated	Task Leader	59	950	61 902
		Churr N	Kyamandi	C	17.5c/100	Key Support	101	550	61 595
		Humphries F	WorleyParsons	B	15c/101	Support	77	520	44 226
		Hattingh L	WorleyParsons	B	15c/100	Support	96	380	40 081
	Sub-total for Task 16						**333**		**207 803**

No.	Description	Manpower, Time and Cost Schedule							
		Name	Company/ Firm	Fee Category	Rate Base	Study Position	Time Schedule (Manhours)	Hourly Rate (Rand/hour)	Costs Excl VAT (Rand)
17	**Assembly of Information and Formulation of Scenarios**								
		van Rooyen PG	WRP	E	Negotiated	Project Manager	138	1 200	179 124
		Mare HG	WRP	E	17.5c/100	Task Leader	138	1 100	164 197
		Smook D	WorleyParsons	E	Negotiated	Task Leader	39	1 200	46 800
		Coleman T	Golder	E	Negotiated	Task Leader	23	1 100	25 300
		Moodley P	Golder	C	17.5c/100	Key Support	22	750	17 760
		Mnguni D	DMM	E	Negotiated	Task Leader	128	980	136 485
		Seago C	WRP	C	17.5c/100	Key Support	201	800	173 680
		Sami K	WRP	E	Negotiated	Task Leader	22	945	20 790
		Rutherfoord J	Golder	E	Negotiated	Specialist	60	950	64 182
		Talanda C	WRP	C	17.5c/100	Key Support	157	750	127 598
		Wegelin W	WRP	E	Negotiated	Task Leader	50	1 100	62 700
		Jeleni A	WRP	E	Negotiated	Task Leader	60	900	61 560
		Pienaar S	WRP	E	Negotiated	Specialist	39	950	38 247
		Hovy D	WRP	E	Negotiated	Specialist	39	950	38 247
	Sub-total for Task 17						**1116**		**1 156 669**
18	**Final Screening Workshop**								
		van Rooyen PG	WRP	E	Negotiated	Project Manager	55	1 200	75 240
		Lotter A	Zitholele	C	17.5c/100	Task Leader	20	770	17 556
		Mare HG	WRP	E	17.5c/100	Task Leader	55	1 100	68 970
		Smook D	WorleyParsons	E	Negotiated	Task Leader	12	1 200	16 416
		Coleman T	Golder	E	Negotiated	Task Leader	12	1 100	15 048
		Sami K	WRP	E	Negotiated	Task Leader	8	945	8 618
		Joubert A	Zitholele	C	17.5c/100	Key Support	44	600	30 096
		Mnqokoyi P	Zitholele	B	15c/100	Support	36	380	15 595
		Haasbroek B	Hydrosol	D	Negotiated	Task Leader	36	750	30 780
		Manyaka S	Zitholele	D	Negotiated	Specialist	16	850	15 504
	Sub-total for Task 18						**294**		**293 824**

No.	Description	Manpower, Time and Cost Schedule							
		Name	Company/ Firm	Fee Category	Rate Base	Study Position	Time Schedule (Manhours)	Hourly Rate (Rand/hour)	Costs Excl VAT (Rand)
19	**Stakeholder Engagement and Public Participation**								
	180	Lotter A	Zitholele	C	17.5c/100	Task Leader	168	770	139 924
	120	Joubert A	Zitholele	C	17.5c/100	Key Support	136	600	88 236
	120	Mnqokoyi P	Zitholele	B	15c/100	Support	120	380	49 324
	24	van Rooyen PG	WRP	E	Negotiated	Project Manager	16	1 200	20 712
	24	Mare HG	WRP	E	17.5c/100	Task Leader	16	1 100	18 986
	24	Smook D	WorleyParsons	E	Negotiated	Task Leader	16	1 200	20 712
	24	Coleman T	Golder	E	Negotiated	Task Leader	16	1 100	18 986
	24	Van Niekerk A	Golder	E	Negotiated	Specialist	16	1 200	20 712
	24	Haasbroek B	Hydrosol	D	Negotiated	Task Leader	16	750	12 945
	24	Mnguni D	DMM	E	Negotiated	Task Leader	16	980	16 915
	24	van der Mescht J	WorleyParsons	E	Negotiated	Specialist	16	1 100	18 986
	40	Renke R	WRP	B	15c/100	Support	16	400	6 904
	40	de Sousa P	WRP	B	15c/100	Support	16	400	6 904
		Pienaar S	WRP	E	Negotiated	Specialist	16	950	10 849
		Hovy D	WRP	E	Negotiated	Specialist	16	950	10 849
		Manyaka S	Zitholele	D	Negotiated	Specialist	62	850	38 080
	Sub-total for Task 19						**678**		**500 024**
20	**Study Management**								
		van Rooyen PG	WRP	E	Negotiated	Project Manager	252	1 200	322 980
		Mare HG	WRP	E	17.5c/100	Task Leader	255	1 100	299 904
		Seago C	WRP	C	17.5c/100	Key Support	144	800	123 040
		Lotter A	Zitholele	C	17.5c/100	Task Leader	72	770	59 213
		Smook D	WorleyParsons	E	Negotiated	Task Leader	36	1 200	46 140
		Chinyowa F	WorleyParsons	D	Negotiated	Key Support	36	875	33 644
		Neethling C	WRP	B	15c/100	Support	72	300	23 070
		Coleman T	Golder	E	Negotiated	Task Leader	36	1 100	42 295
		Mnguni D	DMM	E	Negotiated	Task Leader	36	980	37 681
	Sub-total for Task 20						**939**		**987 967**

No.	Description	Manpower, Time and Cost Schedule							
		Name	Company/ Firm	Fee Category	Rate Base	Study Position	Time Schedule (Manhours)	Hourly Rate (Rand/hour)	Costs Excl VAT (Rand)
21	**Study Termination**								
		van Rooyen PG	WRP	E	Negotiated	Project Manager	25	1 200	36 300
		Mare HG	WRP	E	17.5c/100	Task Leader	25	1 100	33 275
		Smook D	WorleyParsons	E	Negotiated	Task Leader	12	1 200	17 424
		Coleman T	Golder	E	Negotiated	Task Leader	12	1 100	15 972
		Seago C	WRP	C	17.5c/100	Key Support	75	800	72 600
		Chinyowa F	WorleyParsons	D	Negotiated	Key Support	8	875	8 470
		Mnguni D	DMM	E	Negotiated	Task Leader	36	980	42 689
								0	0
	Sub-total for Task 21						**193**		**226 730**
23	**Determine Water Use**								
		Schoeman H	S&V	E	Negotiated	Specialist	60	1 000	60 000
		Joubert F	S&V	E	Negotiated	Specialist	40	950	38 000
		Mlambo D	S&V	C	17.5c/100	Key Support	50	550	27 500
		Mahlangu G	S&V	C	17.5c/100	Key Support	140	450	63 000
		Mojela A	S&V	B	15c/100	Support	640	300	192 000
		Pretorius C	S&V	B	15c/100	Support	188	250	47 000
		van der Walt C	S&V	B	15c/100	Support	50	490	24 500
		Pretorius D	S&V	B	15c/100	Support	50	250	12 500
		Manewyk H	S&V	B	15c/100	Support	640	180	115 200
		Jackson J	S&V	B	15c/100	Support	120	180	21 600
		Moseki S	S&V	B	15c/100	Support	240	180	43 200
		Stopforth C	S&V	E	Negotiated	Specialist	60	950	57 000
		van Staden A	S&V	D	17.5c/100	Key Support	50	650	32 500
		Mare HG	WRP	E	17.5c/100	Task Leader		1 100	0
		Talanda C	WRP	C	17.5c/100	Key Support		750	0
		Seago C	WRP	C	17.5c/100	Key Support		800	0
		Haasbroek B	Hydrosol	D	Negotiated	Task Leader		750	0
		Sikosana S	Hydrosol	B	15c/100	Support		350	0
								0	0
	Sub-total for Task 23						**2328**		**734 000**
Totals:							**15277**	**-**	**11 546 222**

Table C-2a : Cash flow projection (month 1 to 12)

Task	Description	Sep 2011	Oct 2011	Nov 2011	Dec 2011	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012	Jun 2012	Jul 2012	Aug 2012
		Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12
	Inception Phase	0	35 550	105 000	54 900	155 050	0	0	0	0	0	0	0
1	**Summary of Previous and Current Studies**	0	128 375	87 300	68 300	143 725	0	0	0	0	0	0	0
2	**Preliminary Screening Workshop**	0	12 780	12 780	11 640	4 160	60 780	78 805	90 330	0	0	0	0
3	**Hydrological Analysis**	0	48 600	97 100	48 600	81 850	113 300	101 800	102 600	72 630	76 330	59 580	62 155
4	**Water Requirements and Return Flows**	0	0	54 610	19 650	56 810	83 340	74 260	0	0	0	0	0
5	**Water Conservation and Demand Management (WCDM)**	0	0	0	0	0	26 062	22 597	10 960	16 811	26 594	13 918	7 172
6	**Water Re-use**	0	0	0	0	0	0	0	0	0	0	0	113 650
7	**Invasive Alien Plants (IAPs)**	0	0	0	0	0	0	0	0	0	0	0	0
8	**Water Quality**	0	0	0	0	0	0	0	0	0	0	20 800	47 550
9	**Reserve Requirement Scenarios Analysis**	0	0	0	0	0	0	0	0	0	0	0	0
10	**Groundwater Utilization Scenarios**	0	0	0	0	0	0	0	0	0	0	0	0
11	**Honoring International Obligation**	0	0	0	0	0	0	0	0	0	0	0	0
12	**Yield Analysis (WRYM)**	0	0	0	0	0	0	0	0	0	0	113 480	0
13	**Water Quality Modelling (WQT)**	0	0	0	0	0	0	0	0	0	0	0	0
14	**Planning Analysis (WRPM)**	0	0	0	0	0	0	0	0	0	0	0	0
15	**Review Schemes and Update Cost Estimates**	0	0	0	0	0	0	0	0	0	0	0	40 116
16	**Review or Assess Social and Environmental Impacts**	0	0	0	0	0	0	0	0	0	0	0	0
17	**Assembly of Information and Formulation of Scenarios**	0	0	0	0	0	0	0	0	0	43 935	57 635	65 980
18	**Final Screening Workshop**	0	0	0	0	0	0	0	0	0	0	0	0
19	**Stakeholder Engagement and Public Participation**	21 620	11 490	22 820	0	0	24 520	11 490	31 320	0	0	0	0
20	**Study Management**	25 595	25 595	25 595	25 595	25 595	25 595	25 595	25 595	25 595	25 595	25 595	25 595
21	**Study Termination**	0	0	0	0	0	0	0	0	0	0	0	0
22	**Determine Water Use**	0	0	0	0	0	0	0	0	0	0	0	0
Total professional fees		47 215	262 390	405 205	228 685	467 190	333 597	314 547	260 805	115 036	172 454	291 008	362 218
Disbursement costs		24 306	24 306	24 306	24 306	24 306	24 306	24 306	24 306	24 306	24 306	24 306	24 306
Office infrastructure costs				0	0	0	0	0	0	0	0	0	0
Total cost excl. VAT		71 521	286 696	429 511	252 991	491 496	357 903	338 853	285 111	139 342	196 760	315 313	386 524
Total cost incl. VAT		**81 533**	**326 833**	**489 642**	**288 409**	**560 305**	**408 009**	**386 292**	**325 026**	**158 849**	**224 306**	**359 457**	**440 637**
Cumulative total cost incl. VAT		**81 533**	**408 366**	**898 008**	**1 186 418**	**1 746 723**	**2 154 731**	**2 541 023**	**2 866 049**	**3 024 899**	**3 249 205**	**3 608 662**	**4 049 298**

Table C-2b : Cash flow projection (month 13 to 24)

Task	Description	Sep 2012	Oct 2012	Nov 2012	Dec 2012	Jan 2013	Feb 2013	Mar 2013	Apr 2013	May 2013	Jun 2013	Jul 2013	Aug 2013
		Month 13	Month 14	Month 15	Month 16	Month 17	Month 18	Month 19	Month 20	Month 21	Month 22	Month 23	Month 24
	Inception Phase	0	0	0	0	0	0	0	0	0	0	0	0
1	**Summary of Previous and Current Studies**	0	0	0	0	0	0	0	0	0	0	0	0
2	**Preliminary Screening Workshop**	0	0	0	0	0	0	0	0	0	0	0	0
3	**Hydrological Analysis**	90 580	99 700	90 150	98 900	123 200	55 400	0	0	0	0	0	0
4	**Water Requirements and Return Flows**	0	0	0	0	0	43 170	66 320	30 730	0	0	0	0
5	**Water Conservation and Demand Management (WCDM)**	0	0	0	0	33 100	28 200	4 750	40 018	35 096	15 087	18 137	0
6	**Water Re-use**	132 550	0	0	0	0	0	0	0	0	0	0	0
7	**Invasive Alien Plants (IAPs)**	0	0	0	0	17 000	29 500	72 500	0	0	0	0	0
8	**Water Quality**	40 500	74 700	96 000	71 500	14 800	0	0	65 805	59 439	0	0	0
9	**Reserve Requirement Scenarios Analysis**	0	0	0	0	0	0	120 024	0	0	0	0	0
10	**Groundwater Utilization Scenarios**	0	0	0	17 195	64 750	75 500	73 600	65 110	82 765	55 811	52 778	0
11	**Honoring International Obligation**	0	0	0	0	0	38 220	39 200	0	0	0	0	0
12	**Yield Analysis (WRYM)**	0	0	0	0	104 830	83 590	137 090	114 212	99 981	0	0	0
13	**Water Quality Modelling (WQT)**	0	0	0	0	62 100	0	0	0	0	0	0	0
14	**Planning Analysis (WRPM)**	0	0	0	0	0	0	0	0	0	22 031	31 126	76 227
15	**Review Schemes and Update Cost Estimates**	97 337	131 584	106 237	61 491	79 071	0	0	0	0	0	0	0
16	**Review or Assess Social and Environmental Impacts**	0	0	0	0	0	0	0	0	0	32 731	32 935	32 731
17	**Assembly of Information and Formulation of Scenarios**	56 180	36 528	43 910	23 740	73 860	131 800	0	0	0	0	0	0
18	**Final Screening Workshop**	0	0	0	0	0	0	0	0	0	0	0	0
19	**Stakeholder Engagement and Public Participation**	21 620	10 290	21 620	0	0	0	25 870	11 010	32 228	0	0	23 133
20	**Study Management**	25 595	25 595	25 595	0	25 595	25 595	25 595	27 387	27 387	27 387	27 387	27 387
21	**Study Termination**	0	0	0	0	0	0	0	0	0	0	0	0
22	**Determine Water Use**	0	193 550	196 300	185 750	132 000	26 400	0	0	0	0	0	0
Total professional fees		464 362	571 947	579 812	458 576	730 306	537 375	564 949	354 272	336 895	153 047	162 362	159 478
Disbursement costs		24 306	24 306	24 306	24 306	24 306	24 306	24 306	24 306	24 306	24 306	24 306	24 306
Office infrastructure costs		0	0	0	0	0	0	0	0	0	0	0	0
Total cost excl. VAT		488 668	596 252	604 118	482 881	754 612	561 681	589 254	378 577	361 200	177 353	186 667	183 784
Total cost incl. VAT		**557 081**	**679 727**	**688 694**	**550 484**	**860 257**	**640 316**	**671 750**	**431 578**	**411 768**	**202 182**	**212 801**	**209 513**
Cumulative total cost incl. VAT		**4 606 379**	**5 286 107**	**5 974 801**	**6 525 285**	**7 385 542**	**8 025 858**	**8 697 608**	**9 129 186**	**9 540 955**	**9 743 137**	**9 955 938**	**10 165 451**

Table C-2c : Cash flow projection (month 25 to 36)

Task	Description	Sep 2013	Oct 2013	Nov 2013	Dec 2013	Jan 2014	Feb 2014	Mar 2014	Apr 2014	May 2014	Jun 2014	Jul 2014	Aug 2014
		Month 25	Month 26	Month 27	Month 28	Month 29	Month 30	Month 31	Month 32	Month 33	Month 34	Month 35	Month 36
	Inception Phase	0	0	0	0	0	0	0	0	0	0	0	0
1	**Summary of Previous and Current Studies**	0	0	0	0	0	0	0	0	0	0	0	0
2	**Preliminary Screening Workshop**	0	0	0	0	0	0	0	0	0	0	0	0
3	**Hydrological Analysis**	0	0	0	0	0	0	0	0	0	0	0	0
4	**Water Requirements and Return Flows**	80 267	66 188	0	0	0	0	0	0	0	0	0	0
5	**Water Conservation and Demand Management (WCDM)**	0	0	55 735	55 735	0	0	0	0	0	0	0	0
6	**Water Re-use**	0	0	0	0	0	0	0	0	0	0	0	0
7	**Invasive Alien Plants (IAPs)**	0	0	0	0	0	0	0	0	0	0	0	0
8	**Water Quality**	0	0	0	0	0	0	0	0	0	0	0	0
9	**Reserve Requirement Scenarios Analysis**	0	0	0	0	0	0	0	0	0	0	0	0
10	**Groundwater Utilization Scenarios**	0	0	0	0	0	0	0	0	0	0	0	0
11	**Honoring International Obligation**	0	0	0	0	0	0	0	0	0	0	0	0
12	**Yield Analysis (WRYM)**	0	0	0	0	0	0	0	0	0	0	0	0
13	**Water Quality Modelling (WQT)**	0	0	0	0	0	0	0	0	0	0	0	0
14	**Planning Analysis (WRPM)**	119 632	78 432	68 628	54 264	53 580	0	0	0	0	0	0	0
15	**Review Schemes and Update Cost Estimates**	0	0	139 578	139 578	118 978	118 978	118 978	69 565	0	0	0	0
16	**Review or Assess Social and Environmental Impacts**	0	0	0	0	0	0	37 381	37 381	34 645	0	0	0
17	**Assembly of Information and Formulation of Scenarios**	0	0	0	0	0	61 058	54 560	61 058	64 478	68 810	68 810	65 390
18	**Final Screening Workshop**	0	0	0	0	0	0	0	0	0	0	77 497	216 326
19	**Stakeholder Engagement and Public Participation**	11 731	34 337	0	0	29 492	11 731	22 481	0	0	22 481	11 731	22 481
20	**Study Management**	29 178	29 178	29 178	0	29 178	29 178	29 178	1 254	29 178	1 254	29 178	29 178
21	**Study Termination**	0	0	0	0	0	0	0	0	0	0	0	0
22	**Determine Water Use**	0	0	0	0	0	0	0	0	0	0	0	0
Total professional fees		240 808	208 136	293 119	249 577	231 228	220 946	262 578	169 258	128 301	92 545	187 217	333 376
Disbursement costs		24 306	24 306	24 306	24 306	24 306	24 306	24 306	24 306	24 306	24 306	24 306	24 306
Office infrastructure costs		0	0	0	0	0	0	0	0	0	0	0	0
Total cost excl. VAT		265 113	232 441	317 425	273 882	255 534	245 251	286 884	193 563	152 607	116 851	211 522	357 681
Total cost incl. VAT		**302 229**	**264 983**	**361 864**	**312 226**	**291 309**	**279 586**	**327 048**	**220 662**	**173 972**	**133 210**	**241 135**	**407 757**
Cumulative total cost incl. VAT		**10 467 681**	**10 732 663**	**11 094 527**	**11 406 753**	**11 698 062**	**11 977 649**	**12 304 696**	**12 525 358**	**12 699 330**	**12 832 540**	**13 073 675**	**13 481 432**

Table C-2d : Cash flow projection (month 37 to 41)

Task	Description	Sep 2014 Month 37	Oct 2014 Month 38	Nov 2014 Month 39	Dec 2014 Month 40	Jan 2015 Month 41	Total
	Inception Phase	0	0	0	0	0	350 500
1	**Summary of Previous and Current Studies**	0	0	0	0	0	427 700
2	**Preliminary Screening Workshop**	0	0	0	0	0	271 275
3	**Hydrological Analysis**	0	0	0	0	0	1 422 475
4	**Water Requirements and Return Flows**	0	0	0	0	0	575 346
5	**Water Conservation and Demand Management (WCDM)**	0	0	0	0	0	409 970
6	**Water Re-use**	0	0	0	0	0	246 200
7	**Invasive Alien Plants (IAPs)**	0	0	0	0	0	119 000
8	**Water Quality**	0	0	0	0	0	491 094
9	**Reserve Requirement Scenarios Analysis**	0	0	0	0	0	120 024
10	**Groundwater Utilization Scenarios**	0	0	0	0	0	487 508
11	**Honoring International Obligation**	0	0	0	0	0	77 420
12	**Yield Analysis (WRYM)**	0	0	0	0	0	653 183
13	**Water Quality Modelling (WQT)**	0	0	0	0	0	62 100
14	**Planning Analysis (WRPM)**	0	0	0	0	0	503 920
15	**Review Schemes and Update Cost Estimates**	0	0	0	0	0	1 221 492
16	**Review or Assess Social and Environmental Impacts**	0	0	0	0	0	207 803
17	**Assembly of Information and Formulation of Scenarios**	69 406	64 808	44 722	0	0	1 156 669
18	**Final Screening Workshop**	0	0	0	0	0	293 824
19	**Stakeholder Engagement and Public Participation**	0	0	25 313	13 903	25 313	500 024
20	**Study Management**	30 970	30 970	30 970	1 331	30 970	987 967
21	**Study Termination**	0	0	0	110 642	116 087	226 730
22	**Determine Water Use**	0	0	0	0	0	734 000
Total professional fees		100 376	95 778	101 005	125 876	172 371	11 546 222
Disbursement costs		0	0	0	0	0	875 000
Office infrastructure costs		0	0	0	0	0	0
							0
Total cost excl. VAT		100 376	95 778	101 005	125 876	172 371	12 421 222
Total cost incl. VAT		**114 428**	**109 186**	**115 145**	**143 499**	**196 502**	**14 160 193**
Cumulative total cost incl. VAT		**13 595 860**	**13 705 046**	**13 820 192**	**13 963 691**	**14 160 193**	