Tripartite Permanent Technical Committee (TPTC) between Mozambique, South Africa and Swaziland

Progressive Realization of the IncoMaputo Agreement (PRIMA)

Interim Technical Document
First Draft

PRIMA Operating Objectives

IAAP10: Consulting Services for System Operating Rules for the Incomati and Maputo Watercourses

Submitted by DHI
In Collaboration with

Aurecon

REPUBLIC OF MOÇAMBIQUE
MINISTRY OF PUBLIC WORKS AND HOUSING
Direcçάo Nacional De Aguas

CONSULTING SERVICES FOR SYSTEM OPERATING RULES FOR THE INCOMATI AND MAPUTO WATERCOURSES

SYSTEM OPERATING RULES: PRIMA OPERATING OBJECTIVES

Prepared by: DHI

Prepared for: **Tripartite Technical Committee (TPTC) between Moçambique, South Africa and Swaziland**

SYSTEM OPERATING RULES: PRIMA OPERATING OBJECTIVES

Title	Consulting Services for System Operating Rules for the Incomati and Maputo Watercourses
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Status	Draft, V0.1
Date	October 2010

Reason for Circulation

For comments and discussion

Circulation list

PRIMA: Project Manager
Project Coordinator
TASK TEAM MEMBERS

Nature of comments required

Date of comments required	30 November 2010

PRIMA Operating Objectives

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List of Acronyms

ARA-Sul :	Administração Regional de Aguas do Sul
ARC :	Agricultural Research Council
BTP :	Bushbuckridge Transfer Pip
DARDLA :	South African Department of
DNA :	Direcçáo Nacional De Aguas
DSS :	Decision Support System
DWA :	Department of Water Affairs
EDM :	Electricidade de Moçambique
ESKOM :	Electricity Supply Commission
EWR :	Environmental Water Requirement
FSL :	Full Supply Level
IAAP :	Implementation Activity and Action Plan
ICMA :	Inkomati Catchment Management Agency
IIMA :	Interim IncoMaputo Agreement
IMS :	Information Management System
ISOTG :	Incomati System Operating Task Group
KJOF :	Komati Joint Operations Forum
KOBWA :	Komati Basin Water Authority
LUSIP :	Lower Usuthu Smallholder Irrigation Project
MABEDI :	Maruleng Bushbuckridge Economic Development Initiative
MDALA :	Mpumalanga Department of Agriculture and Land Administ
MNRE :	Swaziland Mimistry of
MOL :	Minimum Operating Le
NOAA :	National Oceanic and Atmospheric Administration
PRIMA :	Progressive Realization of the IncoMaputo Agreement
REIWQ :	Resolution on the Exchange of Information and Water Quality
SADC :	Southern African Development Community
SASRI :	South African Sugar Research Institute
SAWS :	South African Weather Services
SEC :	Swaziland Electricity Corporation
SWADE :	Swaziland Water and Agricultural Development Enterprise
TPTC :	Tripartite Permanent Technical Committee
WAS :	Water Administration System Model
WREMP :	Water Resources Modelling Platform
WRPM :	Water Resource Planning Model
WRYM :	Water Resources Yield Model

1 Introduction

The Progressive Realization of the IncoMaputo Agreement (PRIMA) is a programme where the primary goal is to realize the objectives and purpose of the Interim IncoMaputo Agreement (IIMA) by supporting the TPTC to promote cooperation among the parties and to ensure the protection and sustainable utilization of the water resources of the Incomati and Maputo watercourses. The National Directorate of Water Affairs of Mozambique, on behalf of the Tripartite Permanent Technical Committee (TPTC) between Mozambique, South Africa and Swaziland, has received grant funds from the Government of the Netherlands for the implementation of the Progressive Realization of the IncoMaputo Agreement (PRIMA) Programme. As part of the PRIMA programme a study was commissioned to specifically look at the developing a set of operating rules for the Incomati and Maputo water courses. As part of this project there was a requirement to develop a set of integrated operating objectives which could be used to develop the operating rules to manage the entire catchment area.

Setting integrated operating objectives for the entire Inco-Maputo area is a challenging task. Complexity involved with the task revolves around the arrangement that these large basins are split between 3 countries which individually have a number of different management units and institutional structures to address operational water management challenges. The key challenge it to optimise the local resource usage while at the same time not compromising the system as a whole. This will thus require a multi tiered approach to the management of the basin where overall key management objectives will need to be produced at a global level and then the systems will need to be operated on a local basis while ensuring compliance with the larger overall objectives. This document thus takes on a structure where the initial methodology is described and then this is followed by the specification of more defined operating objectives which will be finalised for each of the management units. The management units operating objectives will however need to ensure they are compliant with the overall operating objectives.

2 Methodology

In terms of the process that will be followed in this particular component of the project which focuses on the development of the operating rules. A four step approach will be undertaken (Figure 2.1) where:

- The operating objectives will be defined
- An operating rule will be determined for the key resources (this will be done through interviews and where no operating rules are present the consultants will develop their own operating rules)
- The operating rules will be tested to ensure there is compliance with the overall operating rules and objectives of the entire catchment
- Finally compliance will be tested on both a longer and shorter term basis through regular system updates

The key focus of this particular document is the development of the operating objectives and the development of the compliance testing. The process of developing and testing the different operating rules is currently underway. A final deliverable of this project will be the operating rules associated with the entire project and it however does not form part of this initial discussion document.

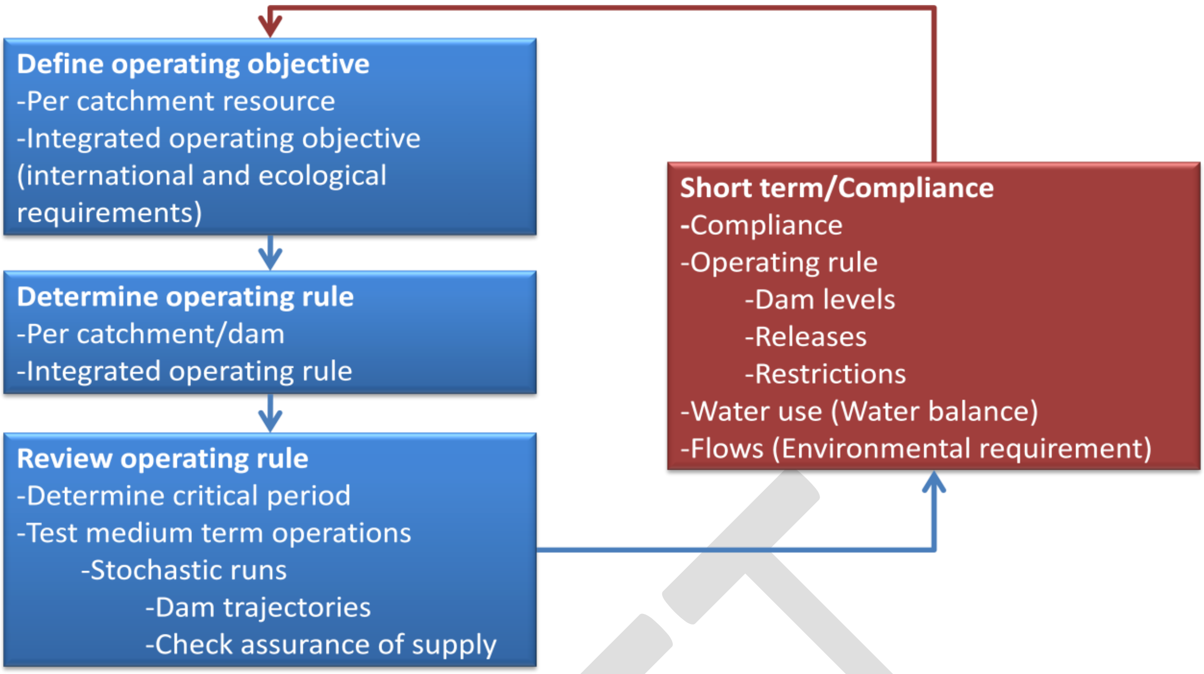

Figure 2.1: Process outlined to develop and test the operating objectives and rules

A multi tiered approach to setting the operating objectives will be undertaken. In order to obtain the optimal rules and best allocation of water in the system it was decided to take an approach where the operating objectives are set independently of existing structures. The approach would adopt a methodology of starting with a key set of principles and developing the operating objectives from these principles. Once these objectives are defined then specific operating rules and paradigms will be analysed and compared to ensure that they are commensurate with the principles and operating objectives that have been initially proposed. This methodology will enable the development of effective operating rules without biasing them against existing and entrenched paradigms which may lead to inefficient or ineffective operations. It will also allow for the consultants to incorporate local objectives in a more comprehensive framework. In developing the rules the following process will be followed. Initially the principles associated with the development of the rules will be put in place. The overall catchment operating objectives will then be developed. These will then be further refined for the individual catchments and finally reconciled with operations for an individual resource.

An initial workshop was held in which the key operating objectives where discussed in detail. The workshop was then supplemented with a field trip (Combined with the development of the TOR for the System Operation Task Group) to the different areas in the catchment to interview specific stakeholders on the operations of their individual resources. Added to this a large amount of detail on the operation of the system has already been provided in the baseline report (PRIMA, 2010).

3 Principles

The approach devised for this component of the study was to return to the first principles. The initial IWRM principles were set out in Dublin in 1992 and have been used as the basis for much of the subsequent water sector reform. The current SADC water policy is based on these initial principles and has additionally used as its basis:

- The Southern African Vision for Water, Life and Environment adopted in March 2000, aimed at "equitable and sustainable utilisation of water for social and environmental justice, regional integration and economic benefit for present and future generations"
- The Revised SADC Protocol on Shared Watercourses, which entered into force in September 2003, with the overall objective to foster "closer cooperation for judicious, sustainable and

coordinated management, protection and utilisation of shared watercourses and advance the SADC agenda of regional integration and poverty reduction".

A summary of the SADC comprehensive water policy guidelines is provided by the statement "*The State Parties recognise the principle of the unity and coherence of each shared watercourse and in accordance with this principle, undertake to harmonise the water uses in the shared watercourses and to ensure that all necessary interventions are consistent with the sustainable development of all Watercourse States and observe the objectives of regional integration and harmonisation of their socio-economic policies and plans.*"

The TPTC agreement is identified to align with the general principles of the SADC protocol and especially highlights the following 4 principles namely:

- The sustainable utilization principle;
- Equitable and reasonable utilisation and participation principle;
- Prevention principle; and
- Co-operation principle.

In reviewing the SADC water policy and strategic plans and the TPTC agreement, the following key principles where thus identified as important to take forward into the development of the operating objectives:

- The principle of unity and coherence of shared water courses: This becomes important in identifying that a catchment unit extends and responds as a natural system and ignores the artificial international boundaries imposed over these natural entities. Thus in order to extract maximum efficiency it is understood that the operating objectives should consider the catchment as a whole. The entire Inco-Maputo basin should thus be managed through the different state structures as a single entity.
- The equitable, reasonable utilisation and participation principle: Essentially this recognises that the basin needs to be developed and managed in a manner which fairly allows for the economic and social benefit of all the participating states. It recognises that not state should benefit at the sacrifice of another party.
- The sustainable development and utilisation principle: This principle realises that water users can compromise the overall sustainability of a water resource by introducing either pollutants or use water in excess. This can impact vital ecosystem services which provide a valuable service to the water user community such as water filtering.
- The prevention and co-operation principles which suggests that the due course of action is through a continuous transparent dialog between states to ensure that conflict does not arise around water use and allocation.
- The principles of coherence and harmonisation: This suggests a unified approach to catchment operations is required which should be consistently understood and applied throughout the Inco-Maputo basin. The challenge here is to create a framework which is flexible enough to allow for local operations to optimise their own social and economic well being while ensuring that overall the entire basin is dealt in a fair and equitable manner without compromising the environmental integrity. Minimum standard rules should be applied which could be adopted from the SADC water policy or other international water related guideline e.g. WHO guidelines.
- Efficiency is still a key principle and it is recognised that the ability to maximise benefit through local operations must be explored, however this should not have any detrimental impact on other water users in the system.

In determining the operating objectives the above key principles outlined have been taken into account. A top down approach will be discussed where initially the overall catchment operating objective will be reviewed and then broken down and discussed in for the smaller basin and management units.

4 Operating Objectives

In this document it is imperative to define the meaning of operating objectives and separate them from the actual management and operating rules of a system. Essentially the operating objectives are a set of guidelines defining from a conceptual perspective the key criteria which should form a basis for operating the system. The objectives are separate from the actual operating rules in that a specific objective may be attained through many different modes of actual operations and operating rules. The operating objectives discussed in this section are thus a set of key criteria associated with complying with the SADC principles and maximising overall regional benefit from the Inco-Maputo catchment system.

In terms of the earlier discussion a major difficulty in coming up with operating objectives is to provide a framework which can be uniformly applied across the basin and yet be flexible enough to maximise local benefit. Another key challenge is that the operating objective needs to be translated into a set of metrics that can be measured and applied across the entire basin area. These elements have been taken into account in formulating the overall catchment operating objectives. A risk based approach was formulated, which would allow for great flexibility while providing a consistent manner in which to operate the overall basin.

The following characteristics make the risk based approach attractive:

- Uniform: Applicable to both consumptive and non consumptive water users, it can be applied for environmental requirements, hydropower and water users. The methodology translates effectively to water quality elements as well as water quantity.
- Quantifiable and measurable: The information can be translated into measurable outcomes that can be checked on an ongoing basis to ensure that the objectives are being met.
- Consistent: It gives a consistent basis throughout the catchment from a geographical perspective to provide a good basis for developing and analysing existing operating rules while allowing for the flexibility associated with the local operations.

It is thus suggested that in further developing an entire catchment operating objectives that a risk based approach be taken where water user's information is translated into assurance criteria. This will provide a consistent approach throughout the entire catchment. Currently, however none of the TPTC agreement stipulations mention risk in their formulations and it is recommended that the final agreements have these stipulations in place. In the context of this document the overall catchment objectives will be formulated for discussion and information associated with local agreed parameters will be analysed accordingly.

The agreement currently stipulates that amount of water for maximum utilisation under mean conditions as well as stipulating certain minimum cross border flows. The information provided in the agreement however does not address the situations where a water deficit occurs. Added to this it does not take into account the potential benefits that could accrue during a surplus situation. The risk based approach however provides the flexibility for the water users to adapt to both situations of surplus and deficit.

4.1 Operating Objectives Level 1: Entire catchment overview

The key principle of Unity will be applied to the operations of the entire Inco-Maputo basin. The basin operating objectives should thus be defined recognising that it is possible to manage the system as a single unit. While the Incomati and Maputo basins are defined separate entities with natural boundaries and runoff systems, they have been connected in two locations which enables the management both basins as a single unit. The upper catchment area is connected via a series of transfers that are managed by DWA and ESKOM jointly. Added to this the lower catchments water supply to Maputo town will potentially be drawn from both basins. This would mean that in principle if a particular catchment (e.g. the Incomati) was in stress that water should be drawn from the other basin in preference. It must be noted that the unity principle does not mean that the same rules and methods of operation need to be applied to all water users in both basins. This is the reason the risk based approach is applied, as it allows for a unified consistent approach while also allowing for the exploitation of local surplus or the control of local deficit situations.

Added to the unity principle the equity principle should also be applied where both basins should be developed in a co-operative manner ensuring that the risks associated with the water supply to similar users is similar throughout the region. It should thus be added that any development taking place within these basins should take into account the availability of supply in each of the catchments. It is thus suggested that the basins be developed in a way that allows for the utilisation and risk to be commensurate for both the Incomati and Maputo areas.

In the earlier discussion it was mentioned that the Interim Inco Maputo Agreement does not include a description of risk which would encompass deficit and surplus conditions. It is thus suggested that a risk based approach be adopted where water supply is translated into assurance figures. If this principle is invoked then essentially water supply capabilities need to be translated into specific risk classes. To a certain extent this has been done in some of the basin areas already where the water users have been divided into specific categories namely first priority supplies and irrigation. The definition however is incomplete in that the categories are not then broken down further into the amounts of water that can be supplied at specific levels of assurance (The exception to this rule is in the Komati catchment where KOBWA has provided a breakdown of the risk categories as described below). This for instance means that an irrigator will have a large portion of his water at a low assurance but also have a small amount of water at a much higher assurance, while a first priority user may have a large proportion of his water at a high assurance and a small proportion at a lower assurance.

In terms of the equity principle the catchments should be developed in such a way as to ensure that water users in the same categories get a similar assurance of supply. It is thus recommended that the water available in a particular catchment be divided into specific assurance categories with water being separated into at least 3 different categories of supply (Table 4.1).

Table 4.1: Example of assurance categories

Assurance category	Assurance value
High	1:100 year return period or alternatively amount of water supplied 99% of the time
Medium	1:10 year return period or alternatively amount of water supplied 90% of the time
Low	1:5 year return period or alternatively amount of water supplied 80% of the time

* It should be noted that return period and water supplied for % of the time are not necessarily commensurate and the calculated values depend on the length of record used to produce the information.

In discussion with the water users it should be possible to translate all consumptive and non – consumptive water use into the specific assurance categories. It is possible to extend the assurance categories to allow for the exploitation of surplus conditions. It is for instance possible to reduce introduce assurance category such as surplus condition which may only occur 5% of the time and allow a certain quantity of water to be accessed by different users according to a specific set of operating rules under such surplus conditions, i.e. water users with off channel storage dams could potentially pump excess water during the surplus condition. An example of translating this information into assurance categories is provided below:

Table 4.2: Example of user categories translated into assurance categories. This is an example and not actual suggested values this will need to be done through a consultative process

User category	Quantity	Proportion of water in assurance categories		
		High	Medium	Low
Environmental flow (Non Consumptive)	94.6 M m^3a^{-1} 3 m^3s^{-1}	30%	40%	30%
Cross border flow (Non Consumptive)	82 M m^3a^{-1} 2.6 m^3s^{-1}	70%	20%	10%
First priority use	73 M m^3a^{-1} 2.31 m^3s^{-1}	60%	20%	20%
Irrigation	307 M m^3a^{-1} 9.73 m^3s^{-1}	20%	30%	50%

This table is an example which could be further refined to provide actual quantities varying on a monthly basis. The requirements defined for the entire area are based on the first priority and irrigation water user could be defined consistently across the entire catchment using this method.

The operating rules in each catchment could then be set up in such as way as to ensure that each water user is provided the water at these minimum levels of assurance. Current development patterns throughout the Inco-Maputo area may mean that specific areas have developed more than others and these consequently may not meet the level of assurance discussed for the different users across the entire catchment. In such cases there may need to be a process invoked where water is rescheduled or allocated in a manner that meets the assurance requirements. This may entail curtailment of use or the introduction of various incentives to remove ineffective water use and improve surety of supply. Added to this in other catchment areas where a surplus condition exists it may be possible to allow additional use as long as it does not compromise individual and overall users assurance of supply. The operating rules can be adjusted in a manner that will allow for the assurance to be maintained.

The information associated with assurance of supply can be summarised into yield curves (duration curves) for different water users and groups of water users. The yield at specific levels for specific water use quantities and operating rules then can readily be compared to the allocations and the required assurance levels. If an assurance level is compromised then an adjustment will need to be made to the operating rules or to the allocations to ensure that the assurance of supply can be maintained for all the users. It should be noted that the criteria for assurance of supply for the different water use sectors needs to be negotiated and discussed between the various countries involved in the agreement. An initial set of anticipated rules will be established as part of this project but these may later be refined in the modelling and interaction process.

A review of various existing studies ()of the basin area there appear to be two levels of water supply that are provided at different levels of assurance. In these studies it appears that the first priority users are supplied at a value of 1:50 year return period (approx 98% level of assurance depending on the record length) and in the irrigation (other) water users appear to supplied at a return period of 1:5 years (roughly translating to 80% level of assurance). While this provides some level of description of the risk associated with supply it again is not fully complete as only a certain proportion of the water can only be provided at the described level of assurance. A smaller proportion of the water could be provided at higher levels of assurance. Various reports have also provided information on the reserve requirement and have described these adequately in terms of duration curves which provide an assessment of risk (assurance of supply). An example is provided in figure 4.1 below.

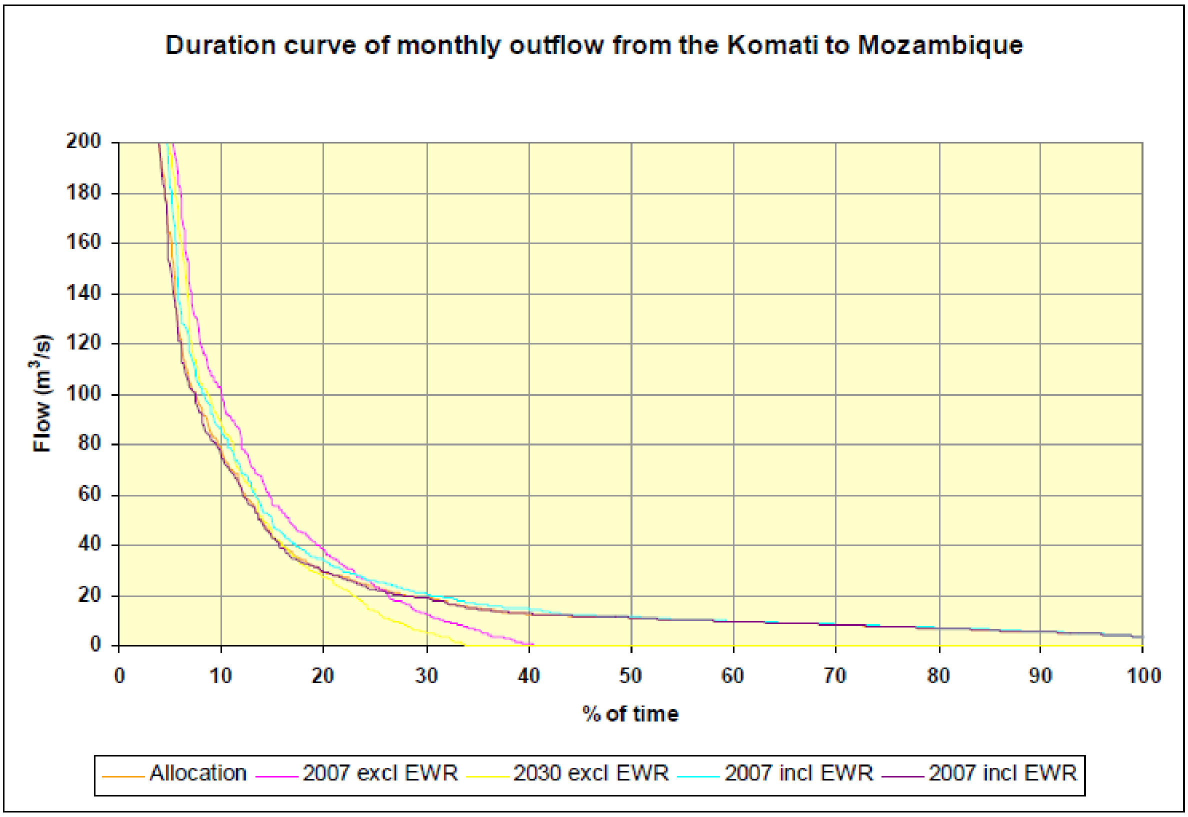

Figure 4.1: Duration curve showing downstream allocation and environment water requirement (EWR) for the Komati River

The view has thus been taken that the assurance of supply for specific user groupings in the catchment will be standardised according to specific assurance of supply classes, while the EWR will be described for each individual catchment respectively. The initial suggested assurance categories are provided in table 4.3 below. These will be subject to review by stakeholders as the operating rules and objectives are further developed. The assurance table provided is a based on the existing classification in terms of the IIMA but it is suggested that this be updated at a later stage to allow for more categories and risk descriptions and allow for the greater flexibility in operating the system. Currently, for the majority of the catchment the water use is split into two categories, namely: First Priority Use and Irrigation. It is recommended that initially these definitions be used in the initial scope of the modelling framework (Table 4.3) and that the assurance categories defined by KOBWA be used. The ability to supply these quantities of water at these assurances is being tested in the modelling framework. It is recommended at a later stage that a larger number of categories be defined to allow for more flexibility in the allocation of water and the operations of the system.

Table 4.3: Suggested assurance classes for present condition based on KOBWA information and the IIMA categories

User category	High Assurance (98% assurance 1: 50 year return period)	Low Assurance (80% assurance 1:5 year return period)
First priority user	100%	0%
Irrigation user	70%	30%

A critical component to defining operating objectives over an entire catchment is the requirement to be able to measure and report on this information. The availability of supply information can easily be summarised for different water users and water user groups. This information could be reported on in various ways such as graphically (figure 4.2) or in table format (table 4.4).

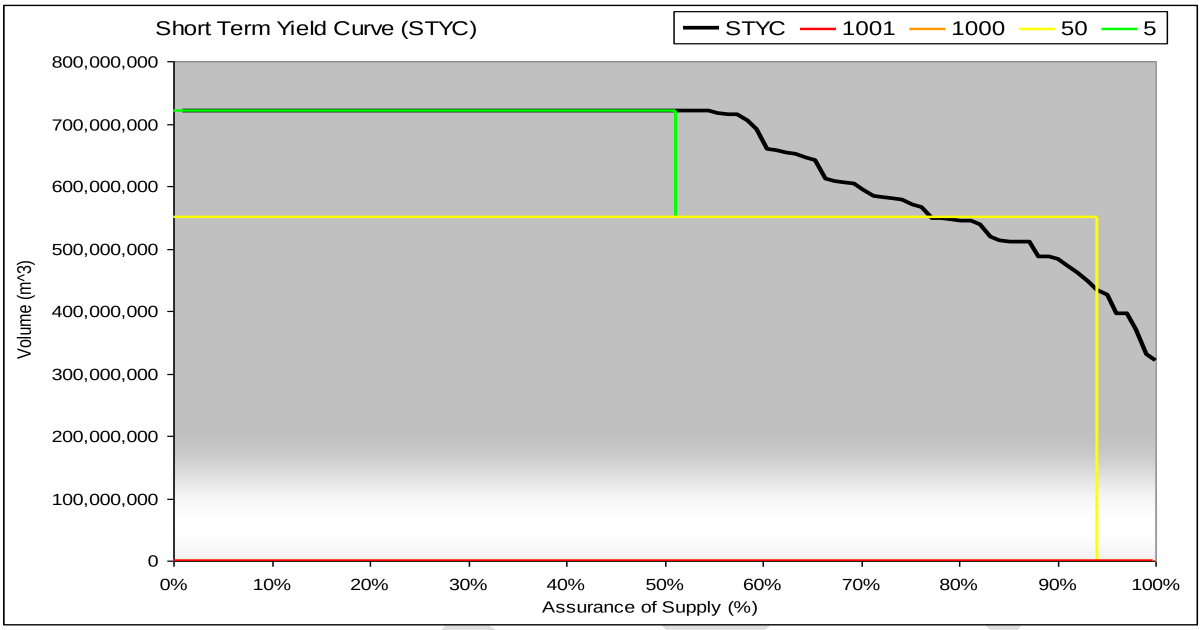

Figure 4.2 : Short term yield curve comparing actual supply (black line) to the volumes required for the 1:50 (Yellow) and 1:5 (Green) year return period. In this case the current supply capabilities cannot support this demand.

Table 4.4: Comparing volume that can be supplied at specific levels of assurance. Red shows that the required volume cannot be supplied or alternatively the actual assurance RP that the required volume could be supplied at.

Water user	High assurance (1:50 RP) Allocation	Actual	Low Assurance (1:5 RP) Allocation	Actual
First priority Inkomati	1.25 M m^3	1 M m^3		
Irrigation Inkomati	4.25 M m^3	3.5 M m^3	1.75 M m^3	1.75 M m^3
Actual assurance of allocation	1:20 RP		1:5 RP	

It is thus possible to set up a set the assurance of supply constraints for the entire catchment and compare actual values to these figures. The risk based approach thus allows the individual catchment management units to develop their own operating rules and these can be monitored and compared to the required assurance of supply figures to ensure that one area is not compromising another in terms of an equitable right to the water. The following section thus describes the initial overview of the catchment operating objectives for each catchment using the IIMA as a basis. Where operating rules were developed these will be tested to ensure they do not compromise the assurance figures. At a later date it is recommended that the assurance classes and water use categories be refined and that more classes and user categories be added into the agreement this could potentially result in more water being made available for use in different catchment areas.

4.2 Operating Objectives Level 2: Individual Management Units

Incomati and Maputo water courses constitute a number of catchment management units. National and Local water authorities' in conjunction with water user associations in the area operate individual catchment management units. The Incomati water course is made of Komati, Crocodile, Sabie, Massintonto, Uanetse and Mazimechopes River catchments while Maputo water course is made of Usuthu, Pongola and Rio Maputo River catchments as shown in Figure 1. Each individual catchment management units in each country have its local operating objectives. The operating objectives are dependent of the local conditions, and overall economic benefits of the respective country where the catchment Management units are located. Each country is entitled to optimal use of the water resources within their respective territory without compromising the interest of the other parties and sustainability of the water course. The utilisation of the water course is based on a principle of equitable use as explained in the Interim IncoMaputo agreement (IIMA) on Article 7(1), "the three countries (parties) shall be entitled, in their respective territories, to optimal and sustainable utilisation of and benefits from the water resources of the Incomati and Maputo, taking into account the interest of the other parties concerned, consistent with the adequate protection of the water courses for the benefit of the present and future generations."

Furthermore IIMA outlines the agreed flow regimes and maximum utilisation of the water for each of the catchment management units in Incomati and Maputo water courses in Annex I. The agreed utilisation of the Incomati and Maputo water course as outlined in Article 4 and Article 5 of the Annex I are summarised below in Table 4.5 and Table 4.6. The utilisation of the Incomati and Maputo water courses which are outlined in IIMA are based on the evaluation of the availability of water in the two water courses at the time of the IIMA is Signed (August 2002).

Table 4.5: Utilisation of the Incomati water course

	The Republic of Mozambique	**The Republic of South Africa**	**The Kingdom of Swaziland**
First Priority Supplies*	19 million m^3/a (up to 87.6 million m^3/a reserved)	336.6 million m^3/a	22 million m^3/a
Irrigation Supplies	280 million m^3/a	786 million m^3/a	261 million m^3/a
Afforestation Area	25 000 ha	364 975 ha	32 442 ha
Afforestation Runoff Reduction	25 million m^3/a	475 million m^3/a	46 million m^3/a

*The first priority Supplies include the water required for domestic, livestock and industrial use.

Table 4.6: Utilisation of the Maputo water course

	The Republic of Mozambique	**The Republic of South Africa**	**The Kingdom of Swaziland**
First Priority Supplies*	6 million m^3/a (up to 87.6 million m^3/a reserved)	242 million m^3/a	44 million m^3/a
Irrigation Supplies	60 million m^3/a	538 million m^3/a	413 million m^3/a
Afforestation Area	Nil	284 600 ha	97 300 ha
Afforestation Runoff Reduction	Nil	198 million m^3/annum	82 million m^3/annum

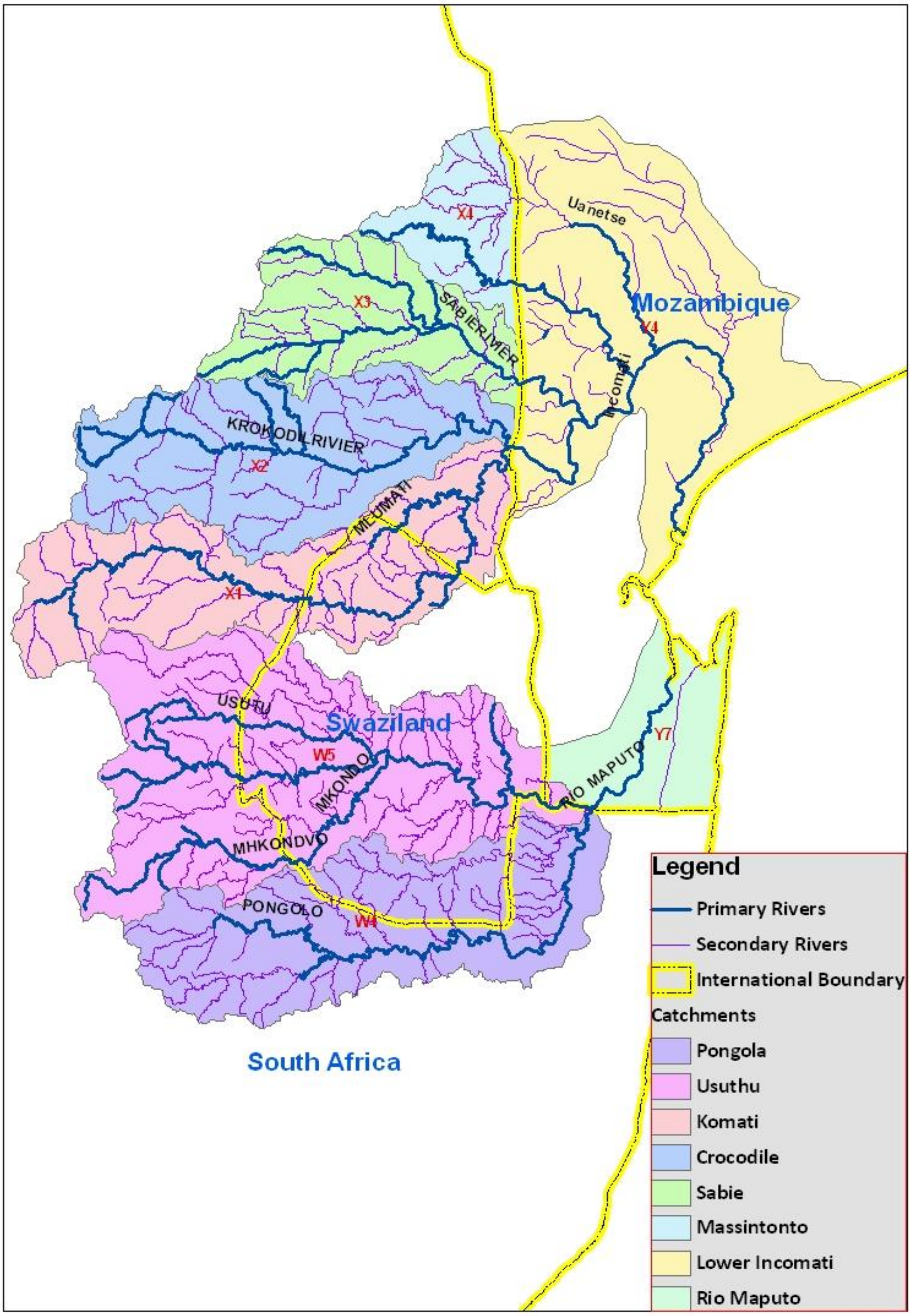

Figure 4.3: IncoMaputo catchment management units

IIMA stresses the need to protect and sustain the ecology of the water course and including the estuary of the Incomati River. A minimum Instream flows at various key points are identified by TPTC and the required minimum at these key point is shown in Table 4.7 and 4.8, as indicated in the IIMA agreement.

Table 4.7: Minimum instream flows at key point in the Incomati water course

River	Key Point	Interim Target Instream Flow	
		Mean (million m3/a)	Minimum(m3/s)
Sabie	Lower Sabie (E 630?) Incomati River (E 634?)	200 200	0.6 0.6
Crocodile	Tenbosch(X2H016)	245	1.2
Komati	Diepgezet Mananga (GS-30) Lebombo	190 200 42	0.6 0.9 1.0
Incomati	Ressano Garcia Sabie Marracuene(E 572)	290 290 450	2.6 2.6 3.0

Table 4.8: Minimum instream flows at key point in the Maputo water course

River	Key Point	Interim Target Instream Flow	
		Mean (million m3/a)	Minimum(m3/s)
Maputo	Salamanga (E-4)	840	2,7
Pongola	Ndumo	300	0,8
Ngwavum	At the border	50	0,1
Mkhondvo	GS 25	35	0,1
Hlelo	GS 22	35	0,1
Ngwempsi	GS 21	30	0,1
Usuthu	GS 23 Big Bend(GS 16)	20 520	0,1 1,7
Mpuluzi	Dumbarton	65	0,1
Lusushwana	GS 33	35	0,1

A major focus at present is on the minimum flows across the border. The IIMA however puts a focus on both maintaining the minimum flows as well as supplying the mean flow condition across the border. It is believed that the cross border flow requirement needs to be translated into a more meaningfully risk profile (duration curves) which gives a better definition of cross border flow requirements.

Further information on the specific operations of each catchment where available is provided in the section to follow. It should be noted that there is a lot of different methods being applied from an operational perspective and the initial task of this project was to analyse whether these operations were producing acceptable compliance in terms of the IIMA. The philosophy of running the entire catchment as a unit is being tested where the risk based approach will be refined and improved.

In the sections to follow a focus has been placed on the existing Interim Inco-Maputo Agreement (IIMA) requirements. A description of the actual operating rules is also provided however more detail is available in the project Baseline report (PRIMA, 2010).

4.3.1. Incomati Water Course

a. Crocodile Catchment Management Unit

Crocodile Catchment management unit is one of the most stressed catchment in Incomati water course. The operations of the Crocodile catchment are divided into specific areas. The main Crocodile River is managed with a daily release from the only major dam, Kwena Dam, in the river, which is used to support the supply of water to the irrigation, domestic and industrial users in the area at consistent assurance of supply. White river and crocodile sand river are operated by white water irrigation board and the main objective is to supply water to the white water irrigation board users (Domestic and Irrigation users) using the seasonal Dams (Witklip, Klipkopjie, Longmere, Primkop). The two subcatchments, namely Kaap and Elands have no major resources on them and users extract water on a run of river basis where water is abstracted at numerous locations.

Two approaches used as an operating objectives for Kwena Dam in main crocodile river, namely normal and a drought approach, based on the medium term forecast including the El Nino and La Nina forecast. The forecast determines what approach will be followed for the next water year. The dam level at May will also be taken into account. The two approaches are summarized below; the first approach is identified as Normal or for Normal weather forecast and second approach as for Drought forecast.

1. Normal

- Dam level should be back above 90% the next May. An increase in dam level of more than 40% can be expected from November to May.
- Dam level should preferably not go down below 60% but be kept above 50% as far as possible.
- Restrictions should normally be implemented from May to October/November.
- It is assumed the turning point of the dam (when it normally starts to increase again) to be in November/December. Therefore, the level of the dam is draw down to 60% at 15 December.

2. Drought

- Dam level should at least be back at 70% if the previous year was a drought year. Increase in dam level of 30% to 35% could be expected if it is a dry year again.
- Dam level should not go down below 35% but preferably be kept above 40% under these conditions.
- Restrictions will be dependent on the situation. During the first year of a drought the restrictions will be fairly in line with the above therefore maximizing crop production under these conditions and therefore severe restrictions from half May to half August and making more water available from September to January. Rainfall could change the situation over night.
- If it is the third or fourth year of a drought and still a dry year ahead, then normally the dam would not be able to come back to the 70% level. At this stage water is allocate just enough for the crops to survive. Normally at this stage most of the irrigators have cut back their area under irrigation by ploughing out their poorest fields and orchards to lie fallow until after the drought. Under these conditions it is possible to go down to below 20% but not lower than 15% depending on the time of the year and the forecast.
- In a drought, the turning point assumed to be the end of January.

The crocodile catchment is located in South Africa and maximum water utilisations from the catchment by South Africa are outlined in Table 4.9, as indicated in the IIMA agreement, Article 4 of Annex I.

Table 4.9: Maximum Utilisation of Crocodile catchment

	The Republic of Mozambique	The Republic of South Africa	The Kingdom of Swaziland
First Priority Supplies*	Nil	73 million m^3/a	Nil
Irrigation Supplies	Nil	307 million m^3/a	Nil
Afforestation Area	Nil	199 715 ha	Nil
Afforestation Runoff Reduction	Nil	247 million m^3/a	Nil

b. SABIE Catchment Management Unit

Sabie Catchemnt constitutes of Sabie river catchment, Sabie Sand river catchment in South Africa side and while Sabie River Catchment in Mozambique is operated as part of the Lower Incomati Management unit in Mozambique. The DWA regional office is responsible for overall operation of the Sabie and Sabie Sand river catchments. The Sabie irrigation board is responsible for the operation of the diversion of the water at the abstraction point. The abstraction point is located upstream of the confluence of Sabie and Mac-Mac River. While the white water irrigation board is responsible for the sabie white river, in particular the Da Gama Dam. The Sabie Sand Irrigation board is also responsible for operation of the small dams in the Sabie Sand River catchment.

Operating objectives of Sabie River Catchment is to supply the water users (domestic and irrigation) at consistent assurance of supply, while protecting the sustainability of the river ecology.

Inyaka is the only major Dam in Sabie River Catchment, it is located in Marite River which is a tributary to the Sabie River, and Inyaka Dam main operating objective is to supply water to Bushbuckbridge for domestic use and supplement Sand river environmental requirement to meet the ecological requirement at the border of Kruger Park.

A number of small Dams have been built in Sand River Catchment where their main operating objectives is to supply irrigation users and in some cases domestic users at consistent assurance of supply.

Maximum utilisation of the Sabie catchment by South Africa and Mozambique is outlined in Table 4.10, according the agreed figures in IIMA agreement.

Table 4.10: Maximum Utilisation of the Sabie Catchment

	The Republic of Mozambique	The Republic of South Africa	The Kingdom of Swaziland
First Priority Supplies*	0.5 million m^3/a	80 million m^3/a	Nil
Irrigation Supplies	12.0 million m^3/a	98 million m^3/a	Nil
Afforestation Area	Nil	75 027 ha	Nil
Afforestation Runoff Reduction	Nil	129 million m^3/a	Nil

c. Komati Catchment Management Unit

Komati Catchment, is situated in South Africa and Swaziland, is divided into two management units, namely Upper Komati catchment management unit and Lower Komati catchment management unit. The two management units are operated separately, where the upper Komati, is situated only in South Africa and operated by national ESKOM with support from DWA, main objective is to supply strategic water user (Eskom). The Lower Komati Catchment unit is operated by KOBWA, an organisation which is established by South Africa and Swaziland. The main operating objective is to supply water users (Domestic, Industrial and Irrigation) from Dripkoppies and Maguga Dam at assurance supply outlined in KOBWA treaty. Added to this Maguga Dam has a hydropower scheme that operating which supplies peak power demands and is factored into the operation of the catchment.

There are four major Dams in upper Komati catchment, where Nooitgedacht and Vygeboom Dams are the two upstream dams and their main objective is to supply water to the Eskom thermal power station in Olifants catchment, and a compensation flow for downstream environmental water requirement. While Shiyalongubo and Lomati Dams are built to supply water to louw's Creek Irrigation board in Kaap river catchment and Umjindi Local Municipality (Barberton) in the Crocodile catchment respectively.

The run of river in the upper catchment is utilised by Domestic and Irrigation users, while ensuring the ecological sustainability. Operating objectives of the Nooitgedacht and Vygeboom are summarised below:

- meet the requirement of strategic water users at specified assurance of supply
- maximise the Upper Komati catchment yield
- prevent spill for the two dams during wet season
- meet environmental water requirement downstream of the dams

Lower Komati Catchment management unit, is situated in South Africa and Swaziland, and is operated jointly for optimal use of water in the catchment management unit. There are two major Dams, namely Dripkoppies and Maguga Dam, which are built to maximise the use of water in the catchment for domestic, industry and irrigation.

The Operating Objectives of Lower Komati Catchment Management unit are outlined below:

- Ensure the conjunctive use of water from both Driekoppies and Maguga Dams to supply high assurance water users (domestic and industrial) and low assurance users (irrigators) downstream of these dams, as well as for maintaining a minimum flow rate into Mozambique.
- Determine the timing and degree of demand curtailment that is necessary to ensure that sufficient water reserves remain in the system to avoid an unacceptable risk of supply failure. In the medium term, curtailments are introduced to ensure that the assurance criteria fixed by the Treaty for the so-called high assurance water and the low assurance water are complied with
- The KOBWA Treaty specifies the maximum annual water allocations to the Parties in terms of high assurance and low assurance users as:
  - High Assurance Users: 2% risk in any one year of partial availability, i.e. an assurance of supply of 98%
  - Low Assurance Users: 70% of allocation is supplied at an assurance of 98% and 30% of allocation is supplied at an assurance of 80%

Maximum utilisation of the Komati Catchment unit by South Africa and Swaziland is outlined in Table 4.11, according to the IIMA agreement in Annex I.

Table 4.11: Maximum Utilisation of the Komati Catchment

	The Republic of Mozambique	**The Republic of South Africa**	**The Kingdom of Swaziland**
First Priority Supplies*	Nil	183 million m^3/a	22 million/a
Irrigation Supplies	Nil	381 million m^3/a	261 million/a
Afforestation Area	Nil	90 233 ha	32 442 ha
Afforestation Runoff Reduction	Nil	99 million m^3/a	46 million m^3/a

d. Lower Incomati Catchment Management Unit (Mozambique)

Lower catchment management unit constitutes of Massinoto, Uanetese, mazimchope, lower of the Incomati River and Sabie River catchment downstream of the Mozambique and South Africa border. Lower Catchment unit is operated by ARA-Sul (regional Water Authority). Corumuna Dam is the only major dam situated in the Lower incomati catchment management unit.

The main operating objective of the Lower Incomati catchment management unit is to supply water from the run of river and Corumuna Dam, to first priority users (domestic and industry) and irrigation users at a consistent assurance of supply while maintaining the sustainability of catchment ecology.

Corumana Dam makes Consistent release of 3 cubic meters per second for Hydropower generation and extra releases are also made to meet requirement for downstream users.

Maximum Utilisation of the subcatchment in the Lower Incomati Catchments is outlined in Table 4.12, according the IIMA agreement.

Table 4.12: Maximum utilisation of the Lower Incomati Catchments

	The Republic of Mozambique	**The Republic of South Africa**	**The Kingdom of Swaziland**
Massintonto River catchment			
First Priority Supplies*	0.7 million m^3/a	0,3 million m^3/a	Nil
Irrigation Supplies	Nil	Nil	Nil
Afforestation Area	Nil	Nil	Nil
Afforestation Runoff Reduction	Nil	Nil	Nil
Uanetse River Catchment			
First Priority Supplies*	0,6 million m^3/a	0,3 million m^3/a	Nil
Irrigation Supplies	Nil	Nil	Nil
Afforestation Area	Nil	Nil	Nil
Afforestation Runoff Reduction	Nil	Nil	Nil
Incomati river catchment upstream of Sabie River Confluence			
First Priority Supplies*	1,1 million m^3/a (up to 87.6 million m^3/a-reserved)	Nil	Nil
Irrigation Supplies	29 million m^3/a	Nil	Nil
Afforestation Area	Nil	Nil	Nil
Afforestation Runoff Reduction	Nil	Nil	Nil
Incomati river catchment downstream of Sabie River Confluence			
First Priority Supplies*	15,6 million m^3/a (up to 87,6 million m^3/a-reserved)	Nil	Nil
Irrigation Supplies	239 million m^3/a	Nil	Nil
Afforestation Area	25 000 ha	Nil	Nil
Afforestation Runoff Reduction	25 million m^3/a	Nil	Nil
Mazimchope River Catchment			
First Priority Supplies*	0,5 million m^3/a	Nil	Nil

	(up to 87.6 million m^3/a-reserved)		
Irrigation Supplies	Nil	Nil	Nil
Afforestation Area	Nil	Nil	Nil
Afforestation Runoff Reduction	Nil	Nil	Nil

4.3.2. Maputo Water course

a. Upper Usuthu Catchment management unit

Upper Usuthu catchment management unit refers to upper part of the Usuthu catchment, upstream of the South Africa and Swaziland border. There are four Major dams built in the Upper Usuthu Catchment Management unit, namely Westoe, Jericho, Heyshope and Morgenstond Dams. The main operating objectives of the Dams are to supply to strategic water users in South Africa (Eskom and Sasol) at specified assurance of supply and release a compensation flow for Environmental requirement in downstream of the catchment.

The operating objectives of the upper Usuthu catchment, referring to the four major dams, are summarized below:

- Supplement water supply to water demand of Eskom Thermal power stations in Vaal and Olifants catchments
- Maximise the Upper Usuthu catchment yield
- Reduce the spills from the four dams in the Upper Usuthu Catchment
- Minimise transfers from Morgenstond and Heyshope dams due to high cost of pumping

The Westoe, Jericho and Morgenstond Dams are operated as a combined unit and are used to support the supply of water to the Vaal and Upper Inkomati Catchments. The annual demand from the dams varies considerably and is informed by the Vaal River System Management Committee which meets annually to decide on the operations of the system.

b. Lower Usuthu Catchment management unit

Lower Usuthu catchment management unit refers to lower and middle part of the Usuthu catchment, downstream of the South Africa and Swaziland border. Lubovane Dam is the only major Dam and there are relatively small dams, namely Lake Luphohlo, Hendrick Van Eck, Nyetane and Sivunga Dam.

Lubovane Dam main objective is to supply water to smallholder sugarcane irrigators in Lower part of the Usuthu catchment. Lake Luphohlo is built for hydropower electric generation, while Hendrick Van Eck, Nytane and Sivangu Dam are built to supply water for hydropower electric generation and to irrigation users in Big Bend area of the Lower Usthtu catchment.

The Lower Usuthu catchment is mainly a run of river and there is no significant storage built which could stabilise the water supply and potentially prevent flash flooding to downstream habitants of the Maputo River water course (Mozambique). Flooding is main problem in downstream catchment area below the confluence of Usuthu and Pongola River. It is mainly caused by the combination of the flash floods of the Usuthu River and continuous release from Pongolapoort Dam.

The Operating Objectives of the Lower Usuthu catchment management unit is to supply water to first priority water users (domestic and industrial) and irrigation users at consistent assurance of supply and reduce the impact of flash flooding to downstream habitants of the Maputo River Water course, downstream of the Swaziland and Mozambique border.

Maximum utilisation of the Usuthu Catchment by South Africa and Swaziland is outlined in Table 4.13, according to IIMA agreement. Usuthu catchment constitutes Mkhnodvo, Ngwempisi ,Usuthu, Lusushwana and Mpuluzi River catchment.

Table 4.13: Maximum utilisation of the Usuthu Catchments

	The Republic of Mozambique	**The Republic of South Africa**	**The Kingdom of Swaziland**
Mkhondvo River Catchment			
First Priority Supplies*	Nil	117 million m^3/a	
Irrigation Supplies	Nil	13,9 million m^3/a	
Afforestation Area	Nil	57 000 ha	
Afforestation Runoff Reduction	Nil	42 million m^3/a	
Ngwempisi River Catchment			
First Priority Supplies*	Nil	60 million m^3/a	
Irrigation Supplies	Nil	4,8 million m^3/a	
Afforestation Area	Nil	82 400 ha	
Afforestation Runoff Reduction	Nil	52 million m^3/a	
Usuthu River Catchment			
First Priority Supplies*	Nil	38 million m^3/a	39,4 million/a
Irrigation Supplies	Nil	Nil million m^3/a	372,4 million/a-Class 1 89,6 million/a – Class 2
Afforestation Area	Nil	21 800 ha	32 442 ha
Afforestation Runoff Reduction	Nil	14 million m^3/a	46 million m^3/a
Lusushwana river catchment			
First Priority Supplies*	Nil	1 million m^3/a	
Irrigation Supplies	Nil	0,2 million m^3/a	
Afforestation Area	Nil	7 700 ha	
Afforestation Runoff Reduction	Nil	7 million m^3/a	
Mpuluzi River Catchment			
First Priority Supplies*	Nil	6 million m^3/a	
Irrigation Supplies	Nil	0,8 million m^3/a	
Afforestation Area	Nil	50 700 ha	
Afforestation Runoff Reduction	Nil	37 million m^3/a	

*The Maximum water utilisations of the subcatchments in Usuthu catchment by Swaziland are combined under maximum utilisation of the Usuthu River catchment.

c. Pongola River Catchment Management Unit

Pongola river catchment lies upstream of the South Africa and Mozambique border, where most of the catchment is located within South Africa and small part of it in Swaziland. There are two dams built in the Pongola river catchment, Pongolapoort dam is one of the largest dams in South Africa and situated in the main Pongola River and Bivane Dam is situated in Bivane River, which is a tributary to the Pongola River.

Pongolapoort Dam is operated by Kwazulu-Natal DWA office and Bivane Dam is operated by Impala Irrigation Board and is built to supplement water supply to the Impala Irrigation Scheme. The Operating Objectives of the Pongolapoort Dam are summarised below:

- One of the main objectives is to release water from the dam for inundating numerous pans along the Pongola River, which is equivalent of 800 m^3/sec discharge, 18 million m^3 volumes, for three weeks from mid September to mid October. This release is scheduled and changed on a regular basis depending on the status of the water resources in the lower catchment area.
- Supply to irrigation users in Swaziland and South Africa at consistent assurance of supply
- Keep a constant release to maintain sustainability of the downstream river ecology, to keep the Pongolapoort Dam at manageable level to prevent flooding of downstream habitants during extreme inflows to the Dam and supply Mozambique water use requirement at consistent assurance of supply

Maximum utilisation of Pongola River catchment by South Africa and Swaziland are outlined in Table 4.14, according to the IIMA agreement in Article 6 of Annex I.

Table 4.14: Maximum utilisation of Pongola Catchment

	The Republic of Mozambique	**The Republic of South Africa**	**The Kingdom of Swaziland**
First Priority Supplies*	Nil	18 million m^3/a	2,0 million/a
Irrigation Supplies	Nil	517 million m^3/a	6,4 million/a – Class 1
Afforestation Area	Nil	65 000 ha	1 000 ha
Afforestation Runoff Reduction	Nil	46 million m^3/a	0,5 million m^3/annum

d. RIO Maputo River Catchment Management Unit

Rio Maputo river catchment is located downstream of South Africa and Mozambique border, the Usuthu and Pongola river join inside Mozambique to form Maputo river. There is no dam storage built in Maputo River, the only forms of storage that exists in the Maputo River are the natural pans and lakes. The Operating objectives are to supply water from the run of river to irrigation users along the Maputo River and the Salamanga and Bela Vista domestic users.

Some of the challenges of the operation of the catchment are summarised below:

- Provide a relatively constant amount of water in the Maputo River. Water availability is dependent on the cross border flows from Swaziland and South Africa in Usuthu and Pongola river respectively
- Regulate the ever increasing water use by irrigation users at pumping/abstraction points
- Lack of real-time flow information to implement restriction of water use by irrigators when there is no deficit water availability
- Lack of real time information to prevent flood impacts in the lower sections of the river

Maximum utilisation of the Rio Maputo river catchment is outline in Table 4.15, according the IIMA agreement.

Table 4.15: Maximum utilisation of Rio Maputo Catchment

	The Republic of Mozambique	The Republic of South Africa	The Kingdom of Swaziland
First Priority Supplies*	6,0 million m^3/a (up to 87,6 million m^3/a- reserved)	Nil	Nil
Irrigation Supplies	60 million m^3/a	Nil	Nil
Afforestation Area	Nil	Nil	Nil
Afforestation Runoff Reduction	Nil	Nil	Nil

5 Institutional framework

A key element to the implementation of the IIMA and the operating rules developed as part of the PRIMA program is the institutional framework. The institutional framework refers to the boarder definition of an institution (organization; custom; convention; law or activity which is accepted in a society) in that it involves the laws, treaties and organisations involved in the implementation of a specific objective. If no effective institutional framework is in place to give effect to decisions it is unlikely that any technical or management interventions will be effective. There are already several institutions involved in the implementation of the Interim Inco-Maputo Agreement (Figure 5.1), with the most notable being the establishment of the Tripartite Permanent Technical Committee (TPTC). There are a number of joint water commissions established between the different countries and it is anticipate that these will be consolidated into a single joint commission that will involve all 3 countries and will provide the political interventions which would inform the TPTC. Presently the institutional structures are fairly disconnected and operate with different mandates under different conditions. It is believed that it would be more effective to consolidate these management units into a single body represented by the TPTC secretariat.

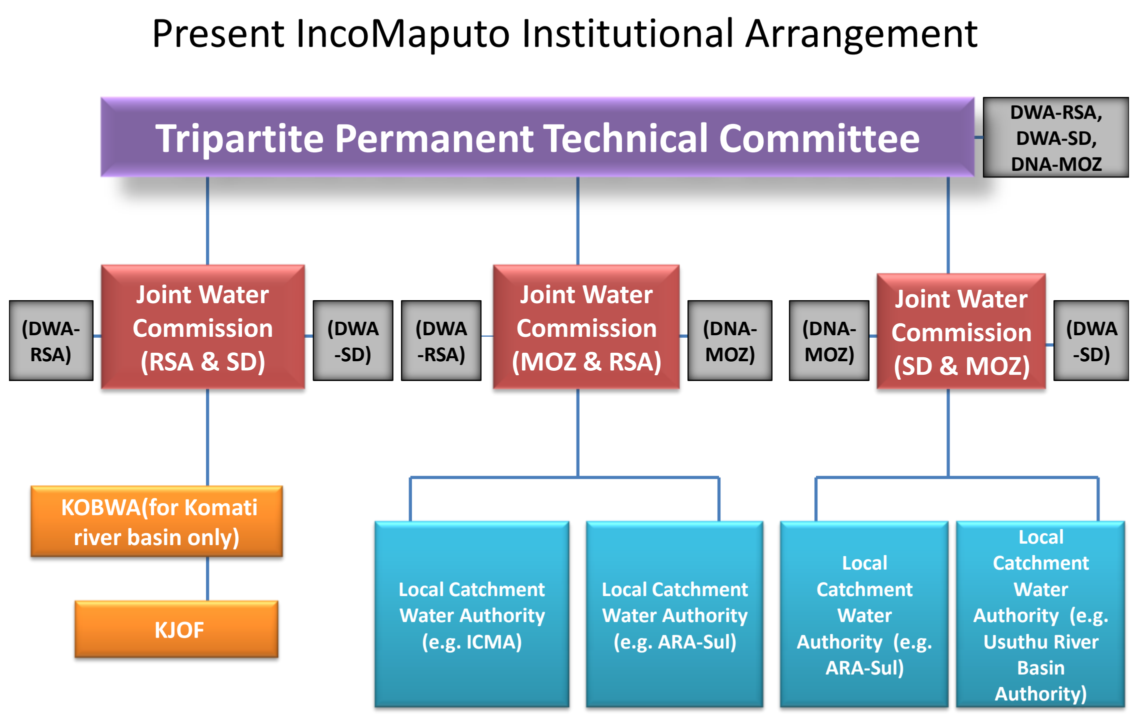

Figure 5.1: Existing institutional framework setup to implement the various water acts and joint agreements between the different countries

The institutional framework is currently being examined as part of this project in order to establish the terms of reference for the establishment of the Systems Operations Task Group. The systems operations task group will be an organisation that is set up to run in parallel with the TPTC secretariat and will be used to implement the day to day operations on the Inco Maputo System (Figure 5.2). The TPTC secretariat is likely to consist of two components the TPTC executive unit which will be responsible for making decisions on a political level that may involve the negotiation and discussion at different levels. The data unit which will essentially be a unit set up to maintain the technical solutions implemented to support the TPTC. The data unit will thus keep the Management Information System up to date as well as maintaining the software required to give the short to medium term projections on the catchment operations.

The information provided by the data unit will need to be discussed with the TPTC secretariat. The secretariat or specific nominated representatives of the TPTC will then have to have regular meetings with the Systems Operations Task Group which will consist of a small group of representative stakeholders who are responsible for the operations of the systems on a day to day basis. These representatives are likely to include people from various organisations such as the Incomati Catchment Management Forum, the Komati Water Basin Authority, various water user associations and representatives from the different government departments. Figure xx. Shows the new assumed future Inco Maputo Institutional Arrangement which is likely to change.

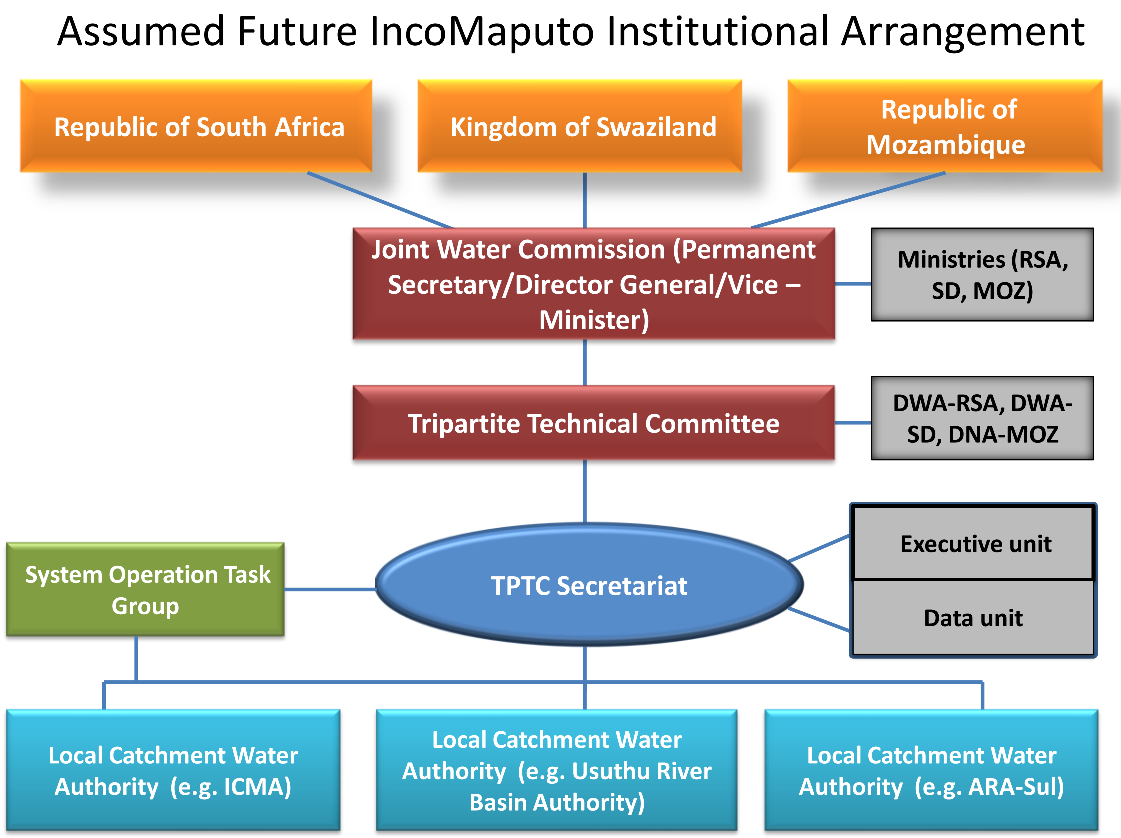

Figure 5.2: Anticipated institutional structure

The System Operating Process is illustrated in Figure 5.3 below. The operating process illustrates how local catchment operating rules will be derived by TPTC secretariat and System Operation Task Group (SOTG) in accordance with overall IncoMaputo Operating objectives.

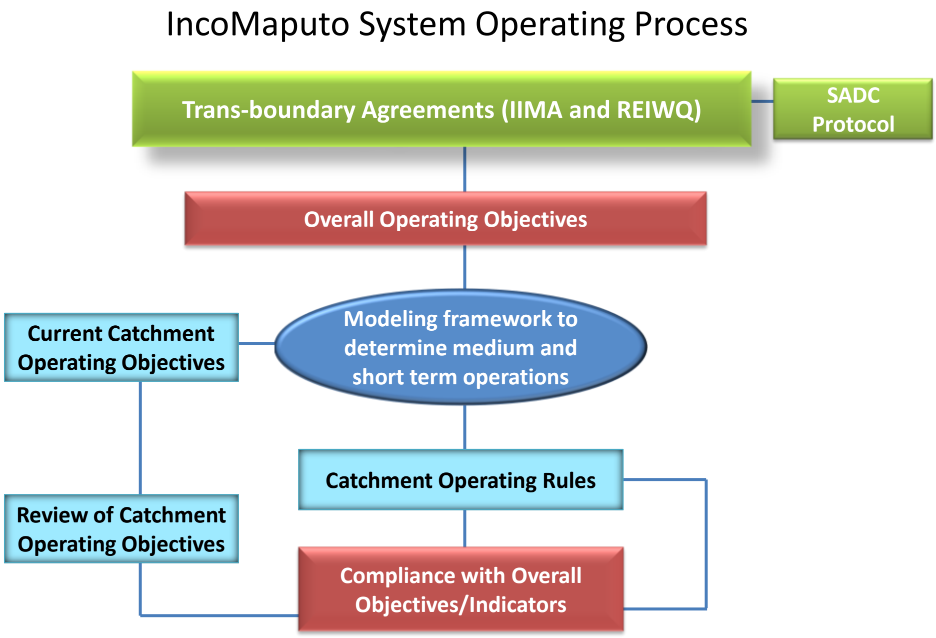

Figure 5.3: System Operating Process

A key component of setting the operating objectives is then once they have been established is to continuously monitor them to ensure compliance and to make adaptations to the framework if information appears to be correct. The next section thus focuses on the various information, provided through the MIS, required to support the operations in the system and ensure compliance with the overall operating objectives.

6 Measuring compliance

In order to ensure the effective implementation of the IIMA and future developed Inco-Maputo Agreement it is necessary to check compliance with the terms set out in the agreement. Initially overall operating rules can be tested against the risk criteria developed in the operating framework. This will determine if the operating rules and current levels of resource utilisation are in compliance with the conditions specified in the IIMA. Added to this it should ensure that all water users obtain the level of assurance as defined in the overall operating objectives. Any new users added to the system should not impact other users in the catchment area by compromising their assurance of supply. Initial design specifications were drawn up where various information reporting through the MIS has been developed. The anticipated system interaction is provided in Figure 6.1 where the DSS communicates information to the MIS. A DSS operator will need to be nominated and form part of the Data Unit this person will essentially be a super user who could change the System Operations Model setup. The information produced from the DSS will be communicated to the MIS and various information on the system will be presented to specific users and the public.

Functional specifications have been set up as part of this process and some examples of the type of information that could be provided by the system are provided in figures 6.2 and 6.3. Further examples of screen mock-ups are provided in the annexure xx.

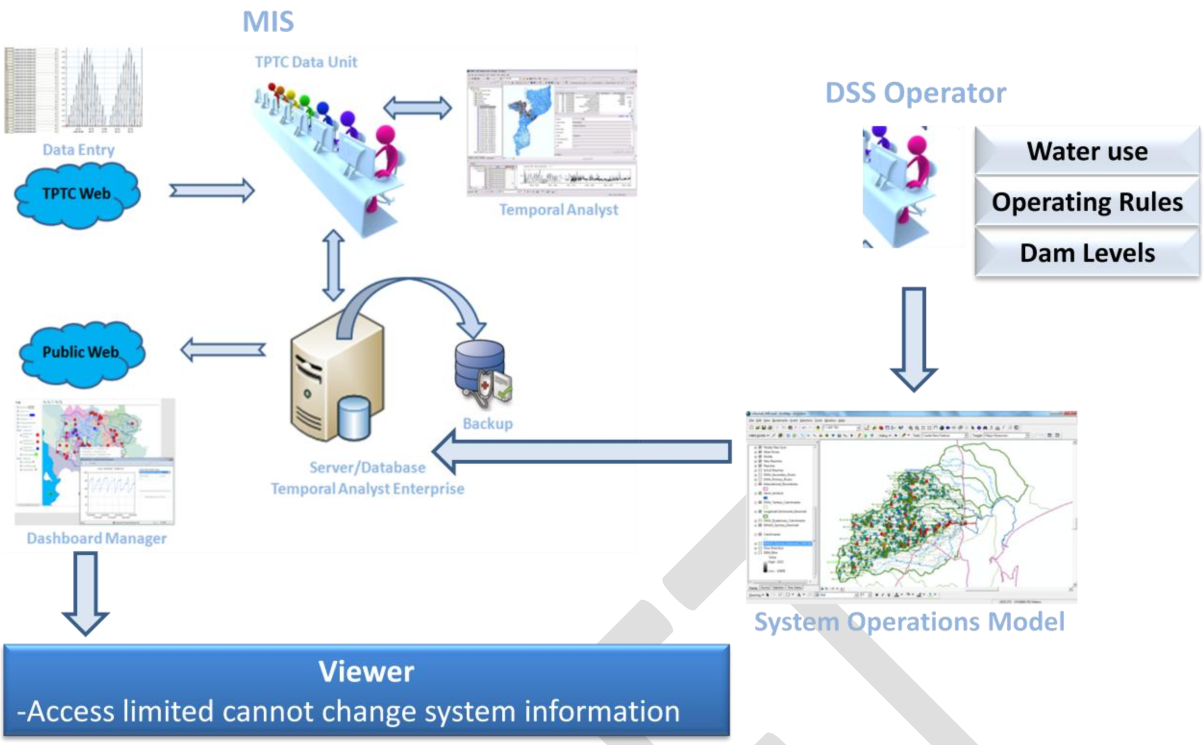

Figure 6.1: Setup and interaction between the MIS and the DSS developed as part of the PRIMA OR project

The operating methodology as conceptualised in this particular project is an approach where the operating rule is decided on a regular basis (every 6 months). The operating rule is then negotiated in the SOTG meeting the delegates then need to communicate the operating rule/objective with their local catchment operating bodies who will then attempt to manage the catchment area according to the overall operating rules. To ensure that the catchment operations achieve the objectives and the operating rules there is a need for continuous monitoring to ensure that criteria are met. It is believed that the following key information would be required for testing compliance associated with the operations of the system:

- Cross boarder flows to ensure they comply with both the minimum flow requirement and the identify they meet the flow duration curve requirements which may need to be based on an index value
- Dam level information where projected dam levels equating to current operating rules are compared with the actual dam levels. The values according to different trajectories associated with the operation of the reservoir should correspond to probabilities associated with the inflow compared to historical inflow values. The dam levels should also fall within the probability window associated with the stochastic run probability window.
- Reservoir release information where comparisons could be made against scheduled operating releases. A comparison could identify areas where the model is either incorrect or the releases are not compliant with the operating assumptions. Reservoir releases could also be compared against scheduled maximum releases which would indicate an unacceptable risk associated with reservoir failure.
- Water use estimates where water balances are possible a comparison should be made to identify if any unaccounted for water exists. This could potentially indicate problem areas on the system.

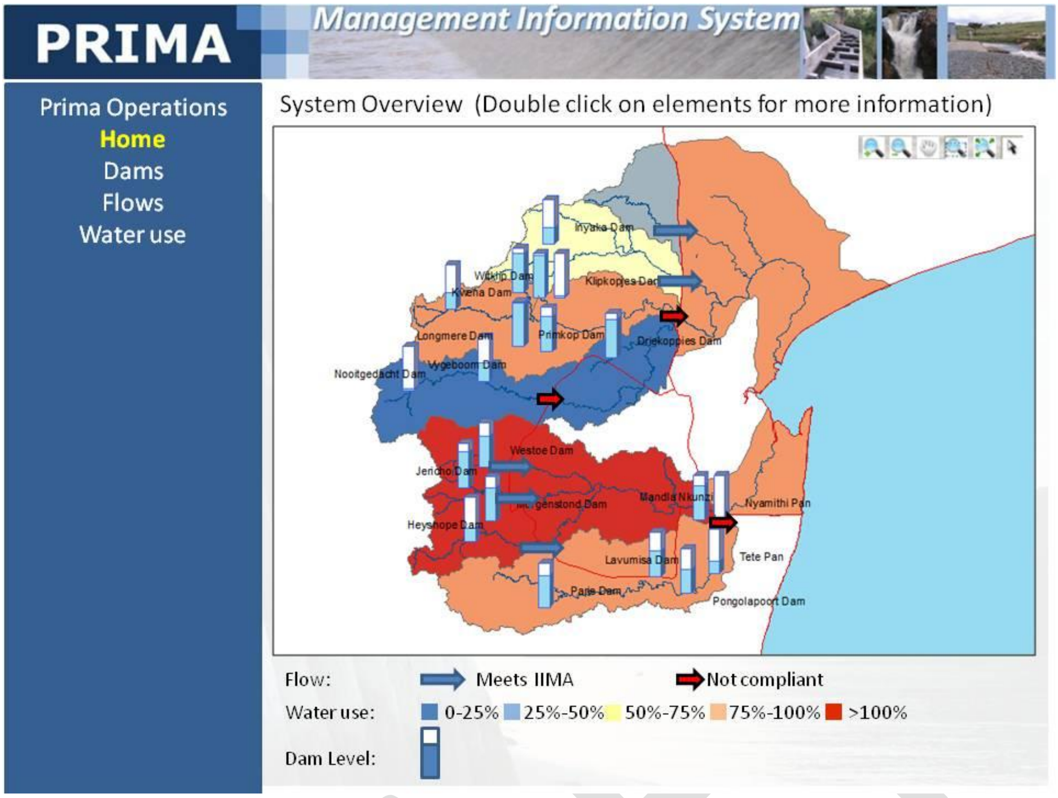

Figure 6.2: Summarised system overview

In the figure above a summary of the entire system is shown. By clicking on individual elements in the system further information can be produced associated with the specific component. The information provided below shows the information produced by clicking on Pongolapoort dam.

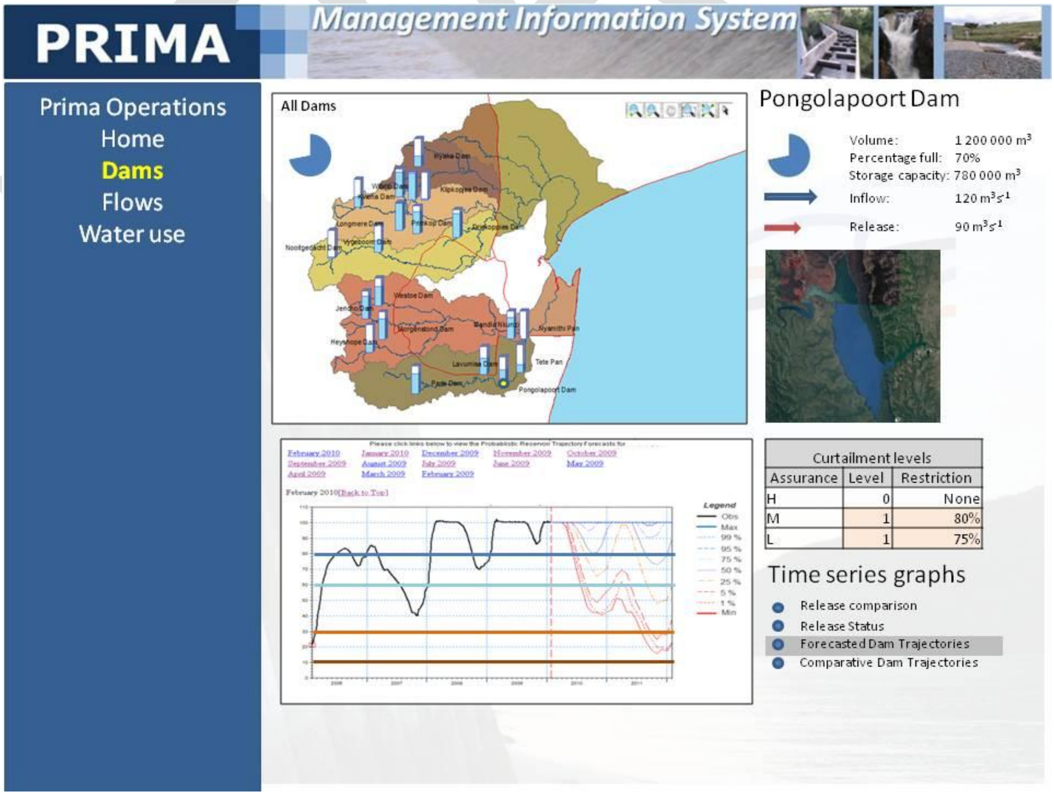

Figure 6.3: Reservoir trajectory comparison associated with Pongola Poort dam

7 Discussions and conclusions

It is recommended that a risk based approach be adopted by the TPTC in updating the IIMA. Currently risk is taken into account to a certain degree in that users are divided into two categories namely; first priority use and irrigation. Unfortunately, no risk criteria (assurance of supply) have been defined for the water user categories. An initial approach has been adopted which translates this information into two main categories which have been based on the KOBWA definition.

Currently, operating methods have been discussed with all the different water authorities and operating bodies on the system. These operating methods, have been translated into operating objectives and rules. Where no clear method of operation was obtained a rule will be developed and applied to the management unit. Various modes of operation have been defined in chapter 4 of this report however for a more comprehensive discussion of the actual catchment conditions you are referred to the baseline report (PRIMA, 2010). The key focus of chapter 4 was to determine the conditions associated with the IIMA to identify if the current system was complying with the agreement stipulations.

Added to the description of the operating rules, a methodology was employed where the key principles associated with sound IWRM were defined. The operating objectives could thus be formulated in this context and tested to ensure they did not compromise any principles outlined. The risk based approach where water requirements and water use were defined in terms of risk from both a consumptive and non consumptive perspective was found to be the best approach. It allowed for flexibility in the management of the resource, while maintaining a unified approach across the entire Inco – Maputo catchment area. Further risk based approach allows for the management of both surplus and deficit conditions, where further benefit can be derived from surplus conditions and an appropriate unified and equitable methodology of managing deficit or drought conditions is provided.

Currently however the number of categories associated with the agreement might be somewhat limiting and there is a requirement to further develop the descriptions of water use into more categories added to this it might also be preferable to also introduce more assurance categories (an example is provided in the table 7.1 below). A further surplus condition class could be invokes at a lower assurance of supply (20%) which could be used by various operators to use water for off channel storage purposes. This can be tested in the current framework.

Table 7.1: Example of more categories established for further development of the IMA

User category	High Assurance (98%) 1:50	Medium Assurance (90%) 1:10	Low Assurance (80%)1:5
First Priority User (Strategic, Industrial)	100%	0%	0%
High Assurance user (Domestic, Orchard)	70%	20%	10%
Low Assurance user (Sugar cane, veg)	40%	30%	30%

In section 5 the institutional arrangement was discussed in some detail. Currently, the terms of reference for the system operations task groups are being established as part of this project. An important consideration is that the institutional framework is a key factor in the implementation of the agreement. All the technical analysis and systems that are currently being developed and implemented as part of this study are unlikely to be adopted without a good institutional framework been established. Essentially, a set of legal and organisational structures need to be implemented in order to give effect to the accord and ensure compliance and consistent implementation of the accord throughout the Inco – Maputo area. The legal and political structures have already to a large degree been established and the focus should shift towards the development of the organisations required to implement the IIMA.

The methodology adopted as part of this particular project is to develop long/medium term operating rules which are discussed and reviewed as part of the SOTG meetings on a regular basis (at least every 6 months). These recommendations associated with the operating rules will then be discussed with the local management authorities in the different catchment management units (local organisations responsible for water management i.e. ICMA and WUA) which are represented on the SOTG. The short term operations are then analysed and tested for compliance. The short term compliance testing is thus the focus of the short term operations. Currently, the specifications have been developed and the methodology of incorporating information into the Management Information System developed as part of the access and exchange component of PRIMA is underway. The likely results of this system are discussed in section 6 and more information is provided in annexure xx.

It is anticipated that by the end of the project a fully established installed operating modelling framework will be established which reports information on a regular basis to the PRIMA secretariat and is managed through the data unit.

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