Augmentation of Water Supply to the City of Maputo and its Metropolitan Area

Final Project Report

30 October 2009

SWECO International
DHI, BKS, CONSULTEC

Augmentation of Water Supply to the City of Maputo and its Metropolitan Area

FINAL PROJECT REPORT

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1 SUMMARY

The project “Augmentation of Water Supply for the City of Maputo and its Metropolitan Area” has been conducted between 15 October 2008 and 31 October 2009. This Final Report summarises the project activities and deliverables of the project.

The project aims to study in detail the forecasts of water requirements for the City of Maputo and its metropolitan area and the possibility of supplying these from the Umbeluzi River watercourse, augmented by new supplies from the Incomati and the Maputo watercourses and/or groundwater resources and by increasing water use efficiencies and other water demand management measures.

All project outputs have been delivered in accordance to the ToR and the requests by the Project Steering Committee. Major outputs have been the background reports on Water Availability, Water Demand and Water Balance as well as the Final Report on Water Supply Strategies for the Greater Maputo Area until 2030. In addition two major training courses have been held for key staff of the water authorities in Mozambique, Swaziland and South Africa, focussing to create understanding of the methods and results of the study.

The results of the project have been presented to the water authorities and stakeholders of the three countries at two large workshops in Maputo and at six half-day workshops in Pretoria, Mbabane and Maputo. At these workshops the consultant received feedback, which has directed the formulation of the final strategies to augment the water supply to Maputo City and its metropolitan area.

The time plan has been met with the exception of a slight delay in the final process of getting acceptance and ownership of the final strategy report, which resulted in an extension of the project with one month in comparison with the original plan. The reason was high workload on the Client and the consultant.

No major problems were encountered during the project.

The total contract sum of 433,069 EURO has been invoiced by the consultant and has been paid, except for the final invoice due in 29 Dec 2009. 20% of the contract sum has been paid as withholding tax to the Ministry of Finance in Mozambique.

In conclusion, through the joint contribution from the Client, stakeholders and the consultant, the project has been successful in delivering all expected outputs without any major delays and in accordance with the budget.

2 INTRODUCTION

The project "Augmentation of Water Supply for the City of Maputo and its Metropolitan Area" aims to study in detail the forecasts of water requirements for the City of Maputo and its metropolitan area and the possibility of supplying these from the Umbeluzi River watercourse, augmented by new supplies from the Incomati and the Maputo watercourses and/or groundwater resources and by increasing water use efficiencies and other water demand management measures

The project started in 15 October 2008 and ends in October 2009. This report concludes the project and includes the minutes from the final workshops that guided the finalisation of the project's end product: the report on Water Supply Strategies fro Greater Maputo Area until 2030.

3 EXPECTED PROJECT DELIVERABLES

The ToR specifies the following outputs of the project:

- An *Inception Report*, describing a detailed work plan for the project, and a listing of reports.

- *Greater Maputo Water Demand Scenarios.* Presentation of the current and future water demands for the Greater Maputo Area, specified for domestic, commercial, industrial and public services water use groups until the year 2027 with 5-year intervals;

- *Water Balances for the Greater Maputo Area.* Presentation of the water balances for the city of Maputo and the Greater Maputo Metropolitan Area until the years 2027 with 5-year intervals based on the water availability (under current circumstances without additional infrastructure), the projected water demands for Greater Maputo and the projected water demands upstream of Maputo. The report shall clarify when and to what extend structural water deficits will occur for Greater Maputo and for some of the other crucial water users in the basins;

- *Water Supply Strategies for Greater Maputo Area until 2027.* Evaluation of two (most suitable) alternative strategies to secure sufficient water supply to the greater Maputo area until the year 2027. The report shall include a listing and timing of measures to be proposed under each strategy, related water flows and reliabilities, updated water balances for the city of Maputo and the greater Maputo Metropolitan Area under normal and drought conditions; total investment and operation cost; social and environmental impacts including environmental flow conditions; economic impacts; major technical / institutional / legal challenges related to each water supply strategy. The report shall also include a proposed update of annex 1 of IIMA, and recommendations on the proposed role and responsibilities for a future secretariat in the further preparation and implementation of one of the water supply strategies;

- *Instruction and training events and reports* will be required to ensure that the three parties will be fully familiar with this study, and will be ready to implement the strategies. For this purpose the PSP will prepare training materials and hand-outs in English and Portuguese, will identify the organizations and related staff members to be trained, will provide the related training courses including running pilot case scenarios. The PSP will further test the trainees, and will provide training evaluation report to the Client;

- *Final Project Report:* describing the main outputs, conclusions and recommendations of the PSP.

At the Project Steering Committee meeting on the 9th March 2009, the end year to be considered for the water balance calculation, and subsequently also for the water supply strategies was agreed to be 2030. The reason for this change was that input data on water demands from previous studies were generally expressed up to 2030.

4 PROJECT ACTIVITIES

4.1 Activities and time plan

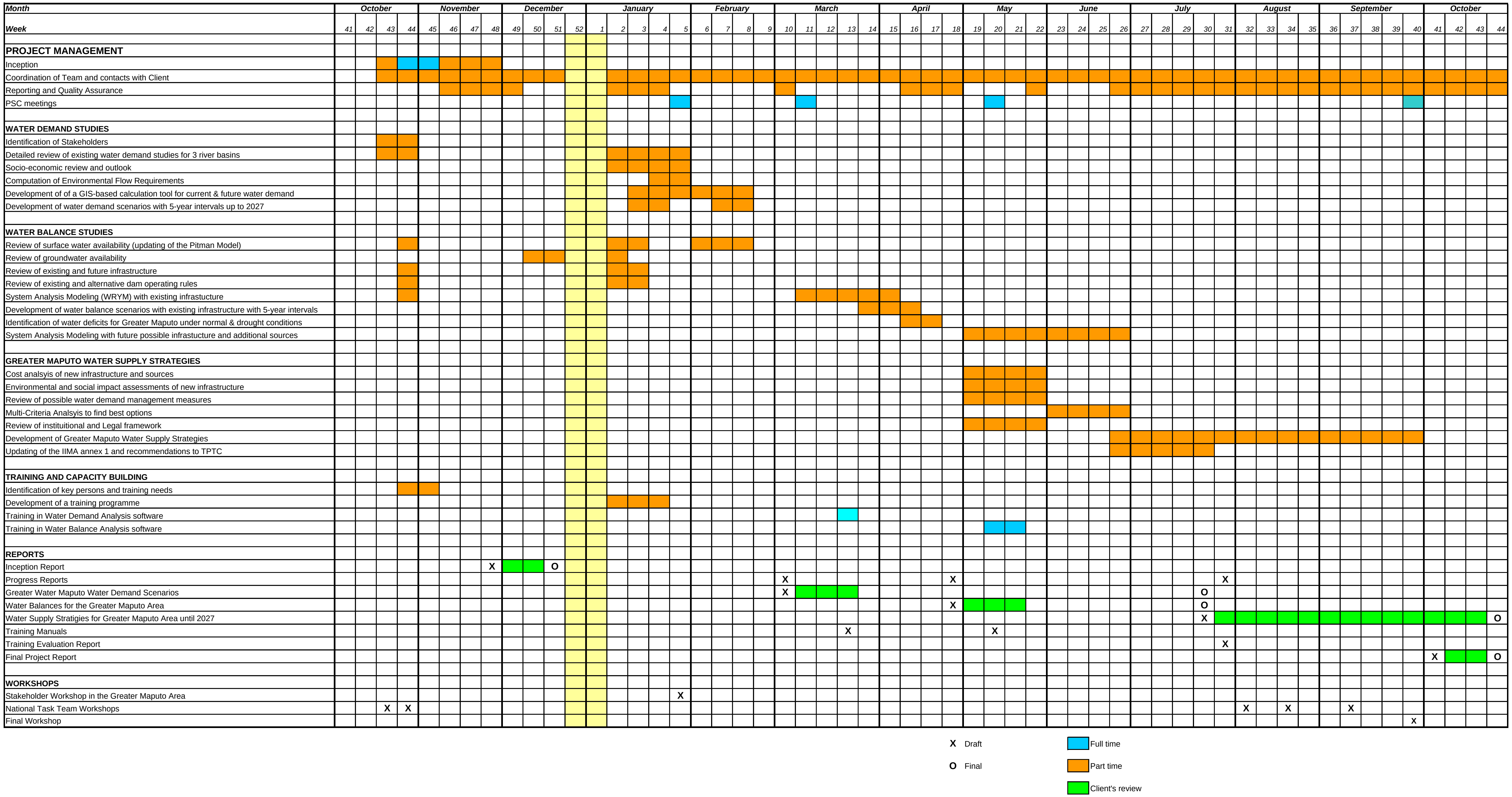
The project activities have in general followed the time plan presented in the Contract. Some delays of the final project deliverables were experienced to accommodate a proper ownership of the final strategy report. The final time plan is presented below.

The major activities of the project were

- An inception phase from mid October to end of November 2008 including three half-day workshops in Maputo, Mbabane and Pretoria to get feedback on the proposed methodology.

- The period from mid December to end of February was focussed on water availability and water demand studies. The following main activities were conducted:

AUGMENTATION OF WATER SUPPLY TO THE CITY OF MAPUTO AND ITS METROPOLITAN AREA



Final Time Plan of the project

- A review of groundwater resources in the Greater Maputo area was made in December 2008 including estimation of possible yield for the three main areas of interest for groundwater supply: North of Maputo, Catembe and Inhaca.

- A detailed review on Environmental Flow was made in December 2008, including all recent studies conducted for the three rivers Inkomati, Umbeluzi and Maputo. Both instream as well as estuarine requirements were looked at.

- A thorough review of the surface water hydrology, including review of the two recent studies on Inkomati (IWAAS) and the Maputo (JRMBS), was made in January-February 2009.

- A detailed review of previous work for Greater Maputo's water demand was made in January 2009, including computation of water demand for the coming period up to 2035. These results were presented at a Stakeholder Workshop on Water Demand of Greater Maputo on the 28th January 2009, in which valuable feedback was obtained from the Client and stakeholders.

- A detailed review of water demand in upstream river basins was made during January and February 2009. This included a review of previous studies and calculation of future water demand up to 2027. To get detailed information on the latest finding of the on-going DWAF study for Komati, Crocodile and Sabie rivers a meeting was held in Pretoria between Water for Africa (that conducts the study), DWAF and SWECO.

- Development of a GIS-based database has been started in mid February 2009 to store and present the above information on water demand.

- All findings from these activities were documented in the two milestone reports on Water Demand and Water Availability, submitted to the Client by first week of March 2009.

- The 1st training course was held in Maputo on 25-27 March. The course aimed at raise the understanding of transboundary integrated water resources management and to learn the methodologies of estimating future water demand. A preliminary training report was presented as part of the 2nd Progress Report submitted 5 May 2009.

- Water balance modelling and preparation of the Draft Water Balance Report for the Greater Maputo were conducted during March to April 2009. This activity started immediately after the PSC meeting on 9th March in which the PSC gave a go ahead to use the presented input data on hydrology, groundwater and water demand that were presented in the draft Water Demand and Water Availability

Reports. The work has included definition of scenarios and system analysis modelling by the WRYM model. A major part of the work was also to review the recent studies on Incomati, Umbeluzi and Maputo, which included detailed system analysis modelling. The findings from this activity were documented in the milestone report on Water Balance for the Greater Maputo submitted last week of April 2009.

- The 2nd training course was held in Maputo on 11-13 May. The training session focused on the water balance analysis that is the core of water resources management. The training included detailed description of the WRSM2000 and the WRYM model tools as well as application of these. Application of the tools was based on the developed model set up for Incomati, Umbeluzi and Maputo Rivers. The objective of running these models was well explained to the participants as a way of introducing them to the concept of River Basin Water Balance Study. The course also entailed a specific presentation on the role of River Basin Simulation Models for Water Allocation in Transboundary Systems.

- The period May to July 2009 was focussed on preparation of the Draft Final Report on Water Supply Strategies for Greater Maputo Area until 2030. This activity started immediately after the PSC meeting on 13th May in which the PSC gave a go ahead to use the presented Water Balance Report. The work has included an identification and screening of a wide range of water supply alternatives, based on environmental, social and economical factors. It also included identification of potential water demand management measures for the Maputo City. It further entailed detailed water balance analysis of the main alternatives and the tentative design and costing of infrastructural development projects to augment the Maputo water supply. The results from this activity were documented in the final milestone report of the project, the Water Supply Strategies for Greater Maputo Area until 2030, which was submitted in draft format on the 23rd July 2009.

- In parallel with the production of the strategy report, the finalisation of the reports on Water Availability, Water Demand and Water Balance were conducted. The reason for the late finalisation was to await final results from the on-going IWAAS study and to coordinate the reporting with the strategy report. The three final reports were submitted to the Client in the lat week of July 2009.

- The last phase of the project, from August to October 2009, was aimed to get feedback from the Client and stakeholders and to get acceptance and ownership of the final strategy report. Three half-day workshops were held in Pretoria (3 August), Mbabane (19 August) and Maputo (10 September) in which the technical contents of the reports were presented and discussed in details with the experts of the water authorities in the three countries. Based on the feedback a final draft strategy report was prepared and presented at the Final Workshop in Maputo on 29th September 2009, giving additional comments for the final product.

- The 4th and final PSC meeting was held on the 29th September 2009 after which the Final Strategy Report was prepared and the project was concluded by the present Final Project Report.

4.2 Consultants involved

The following consultants have been involved in the project:

- Mr. Lennart Lundberg, SWECO, reporting and Quality Assurance, tentative design and costing of the infrastructural development alternatives for augmenting Maputo water supply, formulation of water supply strategies.
- Dr. Rikard Lidén, SWECO, reporting, team coordination and contacts with Client, participation in training courses, review of the surface water resources of the three river basins, water balance modelling and formulation of water supply strategies.
- Prof. Alvaro Carmo Vaz, CONSULTEC, contacts with the client, management and execution of the water demand studies, input to the formulation of water supply strategies.
- Dr. Dinis Juizo, UEM, Planning, execution and reporting of the training courses, input to the review of groundwater resources in the Greater Maputo area.
- Mr. Johan Rossouw, BKS, water balance analysis for the formulation of water supply strategies.
- Mr. Jonathan Schroeder, BKS, participation in the 2nd training course, water balance analysis for the formulation of water supply strategies.
- Mr. Willem van Wyk, BKS, tentative design and costing of the infrastructural development alternatives for augmenting Maputo water supply.
- Ms. Vera Ribeiro, CONSULTEC, environmental and social screening of alternatives for augmenting Maputo water supply.
- Mr. Eugene de Beer, Urban-Econ, assessment of water demand management options for Maputo City, financial Analysis of the main alternatives for augmenting Maputo water supply.
- Dr. Cate Brown, Southern Waters, review of environmental flows

- Mr. Olof Persson, SWECO, review of surface water resources in the three river basins.

- Mrs. Graciete Gomes, CONSULTEC, arrangement of workshops, data collection in Mozambique.

4.3 Delivered outputs

The following deliverables have been produced:

- The final Inception Report, including minutes for all major meetings and workshops held so far in the project (16 February 2009).

- 1st training course held for 12 participants in Maputo 25-27 March 2009.

- The GIS tool for water demand including one licence for ArcGIS.

- 2nd training course held for 10 participants in Maputo 11-13 May 2009.

- The final Greater Maputo Water Demand Scenario Report, including data and information also on water demand in the three river basins as well as on environmental flow requirements (22 July 2009).

- The final Incomati, Umbeluzi and Maputo River basin Water Availability Report, including information on surface water, groundwater and hydraulic infrastructure (22 July 2009).

- The final Water Balances for the Greater Maputo Area Report, including projected water deficits in Maputo and safe yields for the major options to augment the future water supply (22 July 2009).

- The Training Evaluation Report (30 July 2009).

- The final report on Water Supply Strategies for Greater Maputo until 2030 (30 October 2009).

- The Final Project Report summarising the project achievements and including minutes for all final workshops (30 October 2009).

All major reports were delivered in English and Portuguese in digital format and in hard copy.

4.4 Meetings and workshops held

The following workshops have been held:

- Half-day workshop in Maputo on 23 October 2008, 24 participants
- Half-day workshop in Mbabane on 24 October 2008, 12 participants
- Half-day workshop in Pretoria on 31 October 2008, 6 participants
- Stakeholder workshop on Future Water Demand in Greater Maputo on 28 January 2009, 30 participants
- Half-day workshop in Pretoria on 3 August 2009, 9 participants
- Half-day workshop in Mbabane on 19 August 2009, 22 participants
- Half-day workshop in Maputo on 10 September 2009, 29 participants
- Final workshop on Water Supply Strategies for Greater Maputo until 2030 on 29 September 2009, 34 participants

The following meetings with the Client have been held:

- Project meeting with PRIMA on 21 October 2008 in Maputo
- Project meeting with PRIMA on 3 December 2008 in Maputo
- 1st Project Steering Committee Meeting on 29 January 2009 in Maputo.
- 2nd Project Steering Committee Meeting on 9 March 2009 in Maputo.
- 3rd Project Steering Committee Meeting on 13 May 2009 in Maputo.
- 4th Project Steering Committee Meeting on 29 September 2009 in Maputo.

5 FEEDBACK FROM THE CLIENT AND STAKEHOLDERS

Through-out the project the Consultant has got feedback from the Client and the major stakeholders through PSC meetings and workshops.

The initial feedback received at the three half-day workshops in the inception phase focussed on the final methodology to adopt for the study. The stakeholder workshop on Future Water Demand for the Greater Maputo was aimed at informing and getting acceptance of the projection of water supply. A large attendance by essential stakeholders, such as FIPAG and Águas de Moçambique, during the workshop gave valuable feedback to the consultant. The first PSC meeting was further held directly after the workshop to allow the PSC members to give their view on the water demand projections. The presentations and feedback of these workshops and the 1st PSC meeting are presented as appendices of the Inception Report.

The 2nd and 3rd PSC meeting were located in time to allow feedback from the Client on the milestone drafts reports on Water Availability, Water Demand and Water Balance. During the PSC meetings these reports were presented by the Consultant and feedback was given by the PSC members. This feedback is documented in the minutes of the PSC meetings, and included in these report as Annexes 1 and 2 of this report.

The half-day workshops in August and September 2009 gave very valuable feedback from the Client on the draft report on Water Supply Strategies for Greater Maputo until 2030. The reports were presented in detail followed by extensive technical discussions. The notes from the three half-day workshops are presented in Annexes 3-5. The Consultant also received written comments from the Mozambican delegation on the draft report (Annex 6).

As a result of the feedback the Consultant made significant changes in the final draft Strategy Report. The made changes are documented in Annexes 3-6 as the Consultant's responses to the feedback.

The final draft report on Water Supply Strategies for Greater Maputo until 2030 was presented at the Final Workshop in Maputo on 29 September, where additional feedback was received from the Client and stakeholders. Based on this feedback the Final Report was produced. Notes from the Final Workshop are given in Annex 7 and the Power Point presentation is presented in Annex 8.

The final approval procedure of the project deliverables was defined at the 4th PSC meeting held in connection with the Final Workshop. Minutes are given in Annex 9.

6 PROBLEMS ENCOUNTERED

No major problems have been encountered during the project.

Minor delays in the process of getting acceptance and ownership of the final strategy report resulted in an extension of the project with one month in comparison with the original plan. The reason was high workload on the Client and the Consultant.

7 PROJECT ECONOMY

The total contract sum was 433,066 EURO. The following invoices have been submitted during the project:

Invoice No.	**Invoice date**	**Total Amount (Euro)**	**WHT (20%)**	**Amount excluding WHT to be paid to SWECO**	**Status**
1	2 Oct 2008	86,613	17,322	69,291	Paid
2	1 Dec 2008	86,613	17,322	69,291	Paid
3	6 May 2009	129,920	25,982	103,937	Paid
4	31 Aug 2009	86,613	17,323	69,291	Paid
5	30 Oct 2009	43,307	8,661	34,645	Due in 29 Dec 2009
		433,066	**86,611**	**346,455**	

20% of the total contract sum was paid as Withholding Tax to the Ministry of Finance in Mozambique.

The below table shows the distribution of the project costs based on SWECO's internal accounting as of 30 September 2009 and estimated finalisation costs. It can be concluded that compared to the budget an additional input from the international experts was needed, which also caused unexpectedly high travel costs. The main reason for this required additional input was the prolonged stakeholder participation process in September and October 2009, which led to the approved final strategies.

Due to savings in reimbursable costs, mainly for cheaper workshop facilities, this additional input from the international experts was possible within the contract sum.

Fees	**Budget (EURO)**	**Budget (weeks)**	**Spent (weeks)**	**Spent (EURO)**	**Weeks remaining**	**Remaining Balance (EURO)**	**Remaining Balance (%)**
International Consultants	119,000	26	32	146,171	-6	-27,171	**-23%**
Local and Regional Consultants	131,000	38	36	122,610	2	8,390	**6%**
SUB-TOTAL FEES	250,000	64	68	268,781	-4	-18,781	**-8%**
Reimbursable Costs	**Budget (EURO)***			**Spent (EURO)**		**Remaining Balance (EURO)**	**Remaining Balance (%)**
Air Travel incl. miscellaneous travel expenses	15,404			24,517		-9,113	**-59%**
Ground Transport	957			677		280	**29%**
Allowances & Accomodation	11,051			10,598		453	**4%**
Office and Communication costs	3,444			1,375		2,069	**60%**
Reports	5,530			2,142		3,388	**61%**
Translation of reports	5,530			7,333		-1,803	**-33%**
Stakeholder workshops & Training	41,144			18,580		22,564	**55%**
Computer software	13,395			10,922		2,473	**18%**
SUB-TOTAL REIMBURSABLE COSTS	96,455			76,146		20,309	**21%**
Total Costs excl taxes	**Budget (EURO)**			**Spent (EURO)**		**Remaining Balance (EURO)**	**Remaining Balance (%)**
Total cost excluding taxes	346,455			344,927		1,528	**0%**
Withholding Tax	86,614			86,614		0	**0%**
Total Costs	**Budget (EURO)**			**Spent (EURO)**		**Remaining Balance (EURO)**	**Remaining Balance (%)**
Total Cost	433,069			431,541		1,528	**0%**

8 CONCLUSIONS

The project on Augmentation of Water Supply to the City of Maputo and its Metropolitan has delivered all major milestones.

No major problems have been encountered.

9 ACKNOWLEDGEMENTS

This project has been conducted in close liaison with the Client and the major stakeholders.

The PRIMA management has assisted the Consultant in the execution of the project and given valuable feedback. The TPTC and its task groups, the Project Steering Committee and stakeholders have all given constructive feedback and suggestions.

All assistance, support and feedback are greatly acknowledged by the Consultants.

APPENDIX 1

MINUTES FROM 2ND PSC MEETING IN

MAPUTO 9 MAR 2009

Progressive Realization of the IncoMaputo Agreement (PRIMA)

Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

Minutes of 2nd Meeting with the PSC held on the 9th March 2009 at the VIP Hotel, Maputo, Mozambique

Final Version 13 May 2009

Present:

Representing PRIMA:

- Issufo Chutumia, Project Manager of PRIMA
- Ivo van Haren, PRIMA Program Coordinator
- Pedro Cambula, Senior Engineer

Representing DNA, Mozambique:

- Delário Sengo, Head, International Rivers Office
- Sérgio Sitoe, International Rivers Office
- Custódio Vicente, Head, Technical Department, ARA-Sul

Representing DWA, Swaziland:

- Nompumelelo Matsebula, PRIMA Country Staff
- Trevor Shongwe, Chief Water Engineer
- Sakhiwe Nkomo, Senior Water Engineer

Representing DWAF, South Africa:

- Niel Van Wyk, RSA Delegation Leader
- Kennedy Mandaza, Country Staff, PRIMA

Representing SWECO International and Associates:

- Rikard Liden, Team Coordinator, SWECO Southern Africa
- Alvaro Carmo Vaz, Deputy Team Leader, CONSULTEC, Mozambique

1 Opening

Mr Chutumia opened the meeting and welcomed everyone. There was a round of introduction of the participants.

2 Approval of the Agenda

The tentative agenda was discussed and a final agenda was approved.

Agenda
1) Opening
2) Approval of the Agenda
3) Approval of minutes of 1st PSC meeting 4) Brief presentation by Consultant of reports on Water Demand and Water Availability
5) Dates and details of first training course
6) Outstanding issues for the next phase on Water Balance 7) Brief presentation of progress report
8) Contractual and financial matters a. Brief follow-up on project finance by Consultant b. Invoices and payments
9) Other matters
10) Date for next PSC meeting
11) Closure of meeting

3 Approval of minutes from 1st PSC meeting

Corrections were made on the functions of the staff present at the meeting.

On last line of page 2, “have been solved” was replaced by “were resolved”.

Pg 3, second paragraph, “provisions” instead of “procedures”.

Pg 4, heading 7, “financial” instead of “economic”.

Pg 4, 3rd paragraph, “South Africa” instead of “DWAF”.

The footnote of 6.c) was eliminated.

It was agreed that the minutes should be signed by Mr. van Wyk, Mr. Sengo, Mr. Shongwe (heads of the delegations), Mr. Chutumia (for PRIMA) and Dr. Lidén (for the Consultant).

Page numbers must be included.

4 Presentation of the reports

4.1. Prof. Carmo Vaz presented the Water Demand report. The presentation is appended in Annex 1. The following issues were raised by the participants:

a) Mr. van Wyk asked if losses had actually been measured or they were just estimates. Prof. Carmo Vaz explained that there were no bulk meters but a consultant was hired to make a campaign of measurements of water losses at the water treatment works and at the transmission from ETA Umbeluzi to the various distribution centres; losses at the distribution network could not be well measured and were estimated.

b) Mr. Trevor Shongwe asked if the report of Hydroplan covered the same area as the one of the present study. Prof. Carmo Vaz confirmed that the areas coincide.

c) Mr. Trevor Shongwe asked if there was no risk for double counting because of redistribution of people within the Greater Maputo. Prof. Carmo Vaz explained that the distribution of population by “bairros” was checked against the total population of the Greater Maputo area.

d) Mr. van Wyk commented that in South Africa the approach to include non-domestic water use is similar to the one adopted in the present study.

e) Mr. van Wyk asked if the study considered possibilities both passive (repair of leaks) and active (pressure control) for future loss reduction. Prof. Carmo Vaz indicated that he did not have all the details about the loss reduction program that is going to be implemented until 2015 but he thought that it did not include pressure reduction due to the topographical conditions in the Greater Maputo area. The program includes large investments in the infrastructure and bulk meters, rapid leakage detection and repair as well as improvements in management of this specific area.

f) Mr. Shongwe asked what measures are planned by FIPAG for reducing losses in the existing systems. Prof. Carmo Vaz said that it includes renovation of the networks. In fact, part of the network is new (Laulane) and losses are estimated to be below 25%. Prof. Carmo Vaz also referred to the experience of other cities managed by FIPAG in Inhambane Province (Inhambane and Maxixe) where the investment in infrastructure and loss reduction is allowing for operation with losses of approximately 20%.

4.2. Dr. Lidén presented the Water Availability report. The presentation is appended in Annex 2. The following issues were raised by the participants:

a) Mr. van Wyk noted that the report on WR2005 is not from DWAF, it is from Water research Commission.

b) Mr. van Wyk also commented that he thinks that the water availability figures of the JMRBS may be a bit optimistic.

c) Mr. van Wyk asked what model is going to be used for the water balance. Dr. Lidén clarified that it will the WRYM.

5 Dates and details of first training course

The date for the first training course was set to 18-20 March in Maputo. However, this had to be changed due to limitations from the Consultant. The new dates are 25-27 March. There will be three participants from Swaziland, three from South Africa and six from Mozambique. The names from South Africa are Kennedy Mandaza, Colin Zwane and Brian Jackson. The names from Swaziland are Trevor Shongwe and Sakhiwe Nkomo, a third name will be given until 12 March. There will be 6 participants from Mozambique, the names will be given until 13 March.

South Africa – two will take their own transport and per diem, the arrangements for the third one will be confirmed.

Swaziland – will confirm the requirements for accommodation and payment for per diem and transport.

There were some questions for clarification by Dr. Lidén:

a) The contents of the course will be on integrated water resources management, water demand model and GIS. Water availability is not included in the first training course. It will be included in the second course, in May.

b) The output of the GIS part will be an introduction to GIS (assuming that the participants have little knowledge about it) and it will include the results of the water demand study. The lecturer, Mr. H Muller is an expert, he can do the training at any level that is required, depends of the previous knowledge of the participants. Mr. Chutumia considered that it is good to start the GIS at basic level; if an upgrade is needed, PRIMA can include it in the other PRIMA project.

c) Mr. van Wyk informed that Mr. Brian Jackson (now with the Incomati Catchment Management Agency) has a good knowledge of GIS. As he has done hands-on field work on finding out real irrigation consumption, Dr. Lidén suggested that he could make a presentation on this issue. The PSC agreed that Dr. Lidén could invite him to make a presentation.

6 Outstanding issues for the next phase on water balance

Dr. Lidén explained that the Consultant updated the JIBS hydrology using the results of the recent IWAAS study that allowed to extend the series of flows until 2004. The IWAAS study also made a detailed evaluation of the present water use in the Inkomati river basin in South Africa, and the Consultant used it as a basis to update the projections made in JIBS. As the water allocation for irrigation in the Crocodile sub-catchment exceeds the limits imposed in the IncoMaputo agreement, this creates a problem.

Therefore, it was agreed to consider two scenarios:

- the best estimates of water demand, as presented in the water demand report, including the non-compliance with the IIMA, to give the Client information on the consequences of this situation
- water demand reduced to meet the IncoMaputo agreement allocations.

The PSC agreed to have the two scenarios as proposed. The PSC also agreed with a suggestion of the Consultant to present the results for the years 2007, 2010, 2015, 2020, 2025 and 2030, instead of 2007, 2012, 2017, 2022 and 2027.

7 Progress report

Dr. Lidén informed that the project progress is in accordance to plan and that the Consultant does not foresee any problems with the coming deadlines and with the end of the project. Also there are no problems with the financial part.

Regarding the update of the work plan, the only change is the dates of the training course.

There are some minor errors in the progress report that will be corrected. A new version will be delivered until 11 March for comments.

8 Contractual and financial matters

There are no problems of contractual or financial nature. The next invoice will be in end of April 2009.

9 Other matters

Mr. Shongwe said that when reports are delayed, it is important to notify because it is not useful to come to the meeting without the information that is required for decision. The Consultant accepted the criticism regarding the delay in relation to the delivery of the water availability and water demand reports.

At the request of the Consultant, it was agreed to have the comments on these two reports until the 20th March. All parts will send the comments to the PRIMA office and they will send it to the Consultant. To facilitate the comments, the Consultant will deliver the Word version of the two documents.

10 Date for the next PSC meeting

Dr. Lidén said that the next report (water balance) will be delivered by 30 April. The PSC meeting should take place at least one week later to allow the participants to read the report and prepare their comments. Eventually, the PSC could be linked to the second training course.

It was agreed to have the PSC meeting on 11 May (morning). The second training course will take place from 11 May (afternoon) to 13 May.

11 Closure of Meeting

Dr. Lidén thanked for the part of the Consultant and invited everybody for lunch.

The heads of the delegations expressed their appreciation for the work done by the Consultant and for being able to proceed in accordance with the work plan. They also thanked for the arrangements for the meeting.

Mr. Chutumia thanked all participants and closed the meeting.

Maputo ___________ 2009

Mr. Issufo Chutumia, Project Director PRIMA

Mr. Pedro Cambula, DNA

Mr. Niel van Wyk, DWAF

Mr. Trevor Shongwe, DWA

Mr. Rikard Lidén, SWECO

ANNEX 1: Power Point presentation of the Water Demand Report

ANNEX 2: Power Point presentation of the Water Availability Report

APPENDIX 2

MINUTES FROM 3RD PSC MEETING IN

MAPUTO 13 MAY 2009

Progressive Realization of the IncoMaputo Agreement (PRIMA)

Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

Minutes of 3rd Meeting with the PSC held on the 13th May 2009 at the VIP Hotel, Maputo, Mozambique

Final Version dated 29 September 2009.

Present:

Representing PRIMA:

- Issufo Chutumia, Project Manager of PRIMA
- Ivo van Haren, PRIMA Program Coordinator
- Pedro Cambula, Senior Engineer

Representing DNA, Mozambique:

- Delário Sengo, Head, International Rivers Office
- Hélio Banze, Director UGBU, ARA-Sul

Representing DWA, Swaziland:

- Nompumelelo Matsebula, PRIMA Country Staff
- Sakhiwe Nkomo, Senior Water Engineer
- Edward Mswane, Environmental Engineer

Representing DWAF, South Africa:

- Niel Van Wyk, RSA Delegation Leader
- Kennedy Mandaza, Country Staff, PRIMA

Representing SWECO International and Associates:

- Rikard Liden, Team Coordinator, SWECO Southern Africa
- Alvaro Carmo Vaz, Deputy Team Leader, CONSULTEC, Mozambique

12 Opening

Mr Chutumia opened the meeting and welcomed everyone. The Swaziland delegation presented apologies for the absence of Mr Trevor Shongwe who could not attend due to other urgent commitments. The Mozambique delegation presented apologies for the absence of Mr. Custodio Vicente and Mr. Sérgio Sitoe who were busy with other work. The South African delegation presented apologies for the absence of Mr. Collin Zwane who had one member of his family that passed away. The Consultant apologized for the absence of the Team Leader, Mr. Lennart Lundberg.

13 Approval of the Agenda

The tentative agenda was discussed and approved.

Agenda
12) Opening
13) Approval of the Agenda
14) Approval of minutes of 2nd PSC meeting 15) Brief presentation by Consultant of the report on Water Balance
16) Progress Report
17) Contractual and economic matters a. Brief follow-up on project economy by Consultant b. Invoices and payments
18) Other matters
19) Date for next PSC meeting
20) Closure of meeting

14 Approval of minutes from 2nd PSC meeting

The presentations referred to in the draft minutes were not included. It was decided that the presentations should be appended in the final version of the minutes.

The first two paragraphs of point 6 were changed to:

Dr. Lidén explained that the Consultant updated the JIBS hydrology using the results of the recent IWAAS study that allowed to extend the series of flows until 2004. The IWAAS study also made a detailed evaluation of the present water use in the Inkomati river basin in South Africa, and the Consultant used it as a basis to update the projections made in JIBS. As the water allocation for irrigation in the Crocodile sub-

catchment exceeds the limits imposed in the IncoMaputo agreement, this creates a problem.

Therefore, it was agreed to consider two scenarios:

- *the best estimates of water demand, as presented in the water demand report, including the non-compliance with the IIMA, to give the Client information on the consequences of this situation*
- *water demand reduced to meet the IncoMaputo agreement allocations.*

The minutes were approved with these corrections.

15 Presentation of the report on Water Balance

4.1. Mr. Lidén presented the Water Balance report. The presentation is appended in Annex 1. The following major issues were raised by the participants:

g) Mr Niel van Wyk commented that because Crocodile River is over-utilised, Mountain View Dam is again being considered to alleviate the situation.

h) Mr Sengo asked if it should not be 3 scenarios that need consideration. The Consultant clarified that in the last meeting it was agreed that only two scenarios should be considered. However, the JIBS study is an important base for this study and has been updated with new information from more recent studies for the water balance assessment of the Incomati River basin. After discussion it was agreed that the use of JIBS as a base for this study should be clarified in the minutes of the 2nd PSC meeting and the suggested changes in 3 above was agreed.

i) Mr. Nkomo pointed out that it is important that the recent studies, such as IWAAS, used for updating the JIBS study should be made available to all parties. Mr. van Wyk informed that the Final Report of the IWAAS will soon be available and suggested that the service providers of this study could make a presentation for the three countries.

j) Mr van Wyk pointed out that it is important to distinguish between the internal requirements for environmental flows in South Africa and the IIMA targets. It is further essential that these flows cannot be converted to yield for domestic and agricultural purposes without considering environmental flows for the rivers and estuaries downstream in Mozambique. Mr Lidén confirmed that this will be considered in the coming strategy phase and that clarifications will be made in the Final Water Balance Report.

k) Mr Sakhiwe asked how drought conditions were defined. Mr. Liden said that in the analyses made the drought conditions were studied through the historical safe yield, which is the worst period observed in the historical records.

l) Mr van Wyk pointed out the importance of considering water re-use as an alternative for future water supply source. Water re-use is cheaper than desalination, can be put in place much faster. Mr Liden confirmed that a larger range of alternatives will be considered in the strategy phase.

It was agreed that the comments from the Client should come until 27 May for the Consultant to finalise the report.

16 Progress report

Dr. Lidén informed that the project progress is in accordance to plan and that the Consultant does not foresee any problems with the coming deadlines and with the end of the project. Also there are no problems with the financial part.

There is a delay on the delivery of the final reports of Water Demand and Water Availability. The Consultant is waiting for the final version of the IWAAS report. It is expected to have it ready by the first week of June. At the same time, the water balance final report will be delivered.

The Consultant asked for a delay of the delivery of the draft Strategy Report and requested on preliminary dates for the remaining workshops and PSC meetings. The following dates were agreed for key milestones:

20 July: Delivery of the English Draft Strategy Report

27 July: Half-day workshop in Pretoria

28 July: Half-day workshop in Mbabane

29 July: Half-day workshop in Maputo

10 August: Delivery of the Draft Portuguese Strategy Report

8 September: Stakeholder Workshop in Maputo

9 September: 4th PSC Meeting held in Maputo

17 Contractual and economic matters

There are no problems of contractual or financial nature. An invoice has been delivered to the Client on 11th May

18 Other matters

No other matters.

19 Date for the next PSC meeting

It was agreed to have the PSC meeting on 9 September (morning) in Maputo.

20 Closure of Meeting

Dr. Lidén thanked for the part of the Consultant.

The heads of the delegations expressed their appreciation for the work done by the Consultant and for being able to proceed in accordance with the work plan. They also thanked for the arrangements for the meeting.

Mr. Chutumia thanked all participants and closed the meeting.

Maputo ___________ 2009

Mr. Issufo Chutumia, Project Director PRIMA

Mr. Delário Sengo, DNA

Mr. Niel van Wyk, DWAF

Mr. Trevor Shongwe, DWA

Mr. Rikard Lidén, SWECO

ANNEX 1: Power Point presentation of the Water Balance Report

APPENDIX 3

NOTES FROM HALF-DAY WORKSHOP IN

PRETORIA 3 AUG 2009

1 Participants

No.	Category	Organisation	Name	E-mail
1	Counterpart	DWA: NWRP (Director)	Johan van Royen	javr@dwaf.gov.za
2	Counterpart	DWA: NWRP	Niel van Wyk	VanWykN@dwaf.gov.za
3	Counterpart	DWA: NWRP (PRIMA Country Staff)	Kennedy Mandaza	MandazaK@dwaf.gov.za
4	Counterpart	DWA: NWRP	Zimkitha Peteni-Kave	IFJ@dwaf.gov.za
5	Counterpart	DWA	Johann Geringer	
6	Counterpart	DWA	Benny Sithole	
7	Consultant	SWECO	Rikard Lidén	Rikard.Lidén@sweco.se
8	Consultant	BKS	Johan Rossouw	jonathans@bks.co.za
9	Consultant	BKS	Jonathan Schroeder	jonathans@bks.co.za

2 Agenda

Venue: **BKS Office, Hatfield Gardens, Pretoria**

Time: **3 August 2009, 12:00-16:00**

Time	Subject	Action
12:00-12:15	Welcome	
12:15-13:30	Lunch	
13:30-13:50	Background and initial screening of water supply alternatives	Rikard Lidén, SWECO
13:50-14:10	Water balance analysis and infrastructural solutions for main alternatives	Jonathan Schroeder, BKS
14:10-14:30	Transboundary issues and formulation of strategies	Rikard Lidén, SWECO
14:30-15:00	Coffee/Tea	
15:00-16:00	Discussions and feedback from DWA	

3 Minutes

Opening/Welcome

Mr. Rikard Lidén welcomed everyone and presented the agenda.

Mr. van Wyk thanked for the invitation and asked the consultant to present the broad picture of the results for the study.

Presentation of the report on Water Supply Strategies for Greater Maputo until 2030 by Rikard Lidén and Jonathan Schroeder

Mr. Lidén and Mr. Schroeder gave a presentation of the basis for the formulation of the two strategies. The presentation had the following main points:

- Objective and background to the study
- Previous work made in the study
- Setting of boundary conditions for the strategy formulation
- Screening of gross list of supply alternatives
- Water demand management alternatives
- Water balance analysis of main alternatives
- Tentative infrastructural design for the main alternatives
- Costing and financial analysis of the main alternatives
- Transboundary issues
- Formulation of the two strategies

Discussion and feedback from DWA.

A number of minor questions were clarified. The following main comments were noted to be studied further/taken into account by the consultant:

- The experience from Durban in South Africa is that it is essential to be prepared on beforehand for emergency curtailment in a water scarcity situation. It is therefore very important to include this in the strategies, as have been made.
- The experience by DWA to use cheaper piping material, as e.g. reinforced glass fibre has been bad for larger transfer schemes. DWA therefore support the choice of steel pipes as a basis for the cost estimates of the strategies.
- It is unclear if desalination can be ruled out. In Durban the Unit Reference Value (URV) for desalinated water was 8 rand/m^3. It is important that the consultant will calculate the URV for the two strategies to prove that desalination is not a viable option.
- It should be emphasised that the Maputo River option is favourable because it has no competition for other uses of water, except for the environmental releases to the estuary.

- Besides detailed design for the completion of Corumana Dam it is further important to conduct a thorough EIA.

Closure

Mr van Wyk thanked the Consultant for the presentation and the meeting was closed.

4 Actions of the Consultant

As a result of the feedback from the South African delegation Unit Reference Values (URV) were included in the report both for the screening of gross alternatives and in the financial analysis of the main alternatives.

The used cost estimate of desalination was further scrutinised and the difference in price compared to the recent study in Durban is due to considerably higher anticipated electricity prices in Mozambique. The figure presented in the report is thus judged as the most probable for the conditions in Maputo City.

APPENDIX 4

NOTES FROM HALF-DAY WORKSHOP IN

MBABANE 19 AUG 2009

1 Participants

No.	Category	Organisation	Name	E-mail
1	Counterpart	DWA	Trevor Shongwe	shongwetr@gov.sz
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5	Counterpart	DWA	Petros Simelane	wrb-wcon@realnet.co.sz
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7	Counterpart	DWA	Emelda Dlamini	dlamininmapule@gov.sz
8	Stakeholder	Mbuluzi River Basin Organisation	Leonard Ndlovu	lndlovu@rssc.co.sz
9	Stakeholder	Lomati River Basin Organisation	George Brown	ngonini@swazi.net
10	Stakeholder	Ngwavuma River Basin Organisation	Gerrie Sheepers	
11	Stakeholder	KOBWA	Dennis Dlamini	Dennis.dlamini@kobwa.co.za
12	Stakeholder	Swaziland Environmental Authority	Jabu Myeni	jmyeni@sea.org.sz
13	Stakeholder	Nonhlanhla Zwane	SZWP	Nonhlanhla@Swade.co.sz
14	Counterpart	DNA, Mozambique	Pedro Cambula	pcambula@dnaguas.gov.mz
15	Stakeholder	Komati River Basin Organisation	Binda Zwane	Binda.zwane@pfp.co.sz
16	Stakeholder	SWADE	Eugene Simelane	eugene@swade.co.sz
17	Stakeholder	Min. of Agriculture	Duminisane Mngomezulu	mngomezulud@gov.sz
18	Stakeholder	SWSC	Nontombi Maphanga	Nontombi.motsa@swsc.co.sz
19	Stakeholder	SWADE	Musawenkosi Masulela	musa@swade.co.sz
20	Stakeholder	Siphofaneni ID	Ruth Mamba	
21	Consultant	SWECO	Rikard Lidén	Rikard.Lidén@sweco.se
22	Consultant	BKS	Jonathan Schroeder	jonathans@bks.co.za

2 Agenda

Venue: Mountain Inn, Mbabane

Time: 19 August 2009, 08:45-13:30

Time	Subject	Action
08:45-09:00	Welcome	
09:00-09:30	Background and initial screening of water supply alternatives	Rikard Lidén, SWECO
09:30-10:00	Water balance analysis and infrastructural solutions for main alternatives	Jonathan Schroeder, BKS
10:00-10:30	Coffee/Tea	
10:30-11:00	Transboundary issues and formulation of strategies	Rikard Lidén, SWECO
11:00-12:00	Discussions and feedback from DWA	
12:10-13:30	Lunch	

3 Minutes

Opening/Welcome

Mr. Shongwe welcomed everyone.

Presentation of the report on Water Supply Strategies for Greater Maputo until 2030 by Rikard Lidén and Jonathan Schroeder

Mr. Lidén and Mr. Schroeder gave a presentation of the basis for the formulation of the two strategies. The presentation had the following main points:

- Objective and background to the study
- Previous work made in the study
- Setting of boundary conditions for the strategy formulation
- Screening of gross list of supply alternatives
- Water demand management alternatives
- Water balance analysis of main alternatives
- Tentative infrastructural design for the main alternatives
- Costing and financial analysis of the main alternatives

- Transboundary issues
- Formulation of the two strategies

Discussion and feedback from DWA.

A number of minor questions were clarified. The following main comments were noted to be studied further/taken into account by the consultant:

- Mr Shongwe requested clarification on how development of water demand in the Mbuluzi River in Swaziland had been derived. Mr Lidén responded that the results of the Joint Umbeluzi study (JURBS) have been used without changes since it was the latest and most reliable estimate.
- Mr. Ndlovu noted that the reduction of losses in water reticulation system of Maputo is essential for the estimate of water demand and asked for how this had been taken into account for the future water demand. Mr. Lidén clarified that the present estimated losses of 55% has been assumed to decrease down to 25% as a result of FIPAG's present programme to reduce losses. This reduction has been included in the estimate of future water demand fro Maputo City.
- A general clarification on the afforestation in Usutu was requested since the draft report indicates that the water used for afforestation in Swaziland is higher than the IIMA agreement. Mr. Lidén explained that the estimation of streamflow reduction because of afforestation is complicated and that it varies depending on which scientific method has been used. For the afforestation in Usutu the water demand has been taken from the Joint Maputo Study (JMRBS), which have used a rather conservative formula giving a high streamflow reduction. It is believed that the latest scientific findings, which have been used in e.g. Incomati, are more accurate. It should be noted that the areas of afforestation in the Usutu in Swaziland are complying with the IIMA.
- Mr. Shongwe asked why re-cycling is give so little attention. Mr Lidén said that the re-cycling of wastewater was part of the screening of gross alternatives. However, because of its imitation in yield (judged as maximum 25 Mm^3/year) and the high costs of treatment (requires reverse osmosis that demand large energy load) this alternative was not found economically competitive with the other alternatives.
- Mr Nkomo asked if salt water intrusion has been taken into account for the alternatives of groundwater extraction north of Maputo. Mr Lidén acknowledged that no detail test pumping or modelling has been made but that the estimation is based on very conservative abstraction rates (less than 40% of the estimated recharge). Before the groundwater alternatives can be implemented this issue, however, needs to be studied in detail.
- Mr Shongwe asked how much of the irrigation development in Umbeluzi was in Mozambique. Mr Schroeder clarified that the water balance analysis has assumed an increase in irrigation in Swaziland of 72 Mm^3/year and in Mozambique 18 Mm^3/year up to 2030. The development in Mozambique thus is about 20% of the total irrigation growth in the river basin.
- Mr Shongwe also needed a clarification on the Net Present Value. Mr Lidén explained that the NPV is taking into account all anticipated costs for the period of 2010-2030 and

recalculates this to 2009 years value, thus taking into account inflation. The purpose of the procedure is to compare different alternatives.

- Mr Shongwe requested the comment from the Consultant on the development of Maputo City despite the scarce water resources. Mr. Lidén explained that the present IWRM principle in Southern Africa, as described by the SADC Protocol, is that urban water supply has priority over other uses. However, this refers mainly to existing water demands and the question of expansion is a valid point.
- A number of participants requested clarification if climate change has been taken into account. Mr Lidén said that climate change has not been explicitly taken into account. The uncertainties in this study, e.g. in the water demand projections are much higher than the uncertainty of climate change. The study horizon is up to 2030 and for this period not even the highest climate change projections show much difference to the present climate. However, even if not explicitly taken into account the formulation of the water supply strategies has taken into account the uncertainties involved (e.g. by climate change) and thus include flexibility for the long-term solution.

Closure

Mr Shongwe thanked the Consultant for the presentation and the stakeholders for the contribution and closed the meeting.

4 Actions of the Consultant

The issues raised by the stakeholders in Swaziland were mainly for clarifications and no changes in the report were therefore made as a result of the workshop in Mbabane.

APPENDIX 5

NOTES FROM HALF-DAY WORKSHOP IN

MAPUTO 10 SEP 2009

1 Participants

No.	Name	Organisation	Cell NO.	E-mail
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2 Agenda

Venue: **VIP Hotel, Maputo**

Time: **10 September 2009, 08:45-13:30**

Time	**Subject**	**Action**
08:45-09:00	Welcome	Mr. Issufo Chutumia
09:00-09:30	Background and initial screening of water supply alternatives	Rikard Lidén, SWECO
09:30-10:00	Water balance analysis and infrastructural solutions for main alternatives	Rikard Lidén, SWECO
10:00-10:30	Coffee/Tea	
10:30-11:00	Transboundary issues and formulation of strategies	Rikard Lidén, SWECO
11:00-12:00	Discussions and feedback from Mozambican delegation	All
12:30-13:30	Lunch at Zambi Restaurant	All

3 Minutes

Opening/Welcome

Mr Chutumia welcomed everyone and made a brief presentation on the project, the main objectives, the Consulting team, what has been done and what will be done.

Mrs Susana Saranga expressed the project's importance for the future of Maputo water supply

Presentation of the report on Water Supply Strategies for Greater Maputo until 2030 by Rikard Lidén

Mr. Lidén gave a presentation of the basis for the formulation of the two strategies. The presentation had the following main points:

- Objective and background to the study
- Previous work made in the study
- Setting of boundary conditions for the strategy formulation
- Screening of gross list of supply alternatives
- Water demand management alternatives

- Water balance analysis of main alternatives
- Tentative infrastructural design for the main alternatives
- Costing and financial analysis of the main alternatives
- Transboundary issues
- Formulation of the two strategies

Discussion and feedback from the Client and stakeholders.

Rui Gonzales:

- The climate change, financial crises and development of technologies must be taken into account not only the financial costs.
- There is a need to have a source of water near the N4 development.
- The Moamba Major dam will be built before 2020 according to the funding agency.
- The IIMA agreement must be revised.
- Desalination and export of water must also be taken into account.

Mr. Lidén acknowledged that these are valid comments. The final decision on the Maputo water supply solution must take into account other issues than financial costs. It is also foreseen that the transboundary agreements will be revised, which will change the analysis of the different alternatives. The ToR of the present study has, however, limited the study to look at only technical, environmental and financial studies to supply Maputo City up to 2030 and with the existing IIMA as the legal basis.

Francisco Mestre

- Maputo has conditions for desalinization. What about the URV cost? Why does this alternative have an environmental and social high cost?
- Why don't the consultants considerate the Moamba Major dam has a final alternative
- Why the abstraction in Corumana and not in the Incomati?

The Consultant clarified that the URV costs for desalinisation is given in the report and is unfavourable compared to the other alternatives. Desalination as a major source of water for Maputo will require a very large treatment plant that needs to be located within the existing urbanised area of Maputo. The social impacts of this are considerable. Environmentally there is also an issue of the deposition of a large amount of salt that is arrest product.

The Moamba Major is, with the present assumption and IIMA agreement, less favourable from a financial point of view than the other alternatives to be implemented the coming years. If conditions change, e.g. in the IIMA agreement and as a long term solution (after 2030) the Moamba Dam may however be a strong alternative.

The possibility of abstracting water from a point downstream of Incomati/Sabie Confluence was found to be more expensive than taking the water from Corumana. Both options can provide the allocated 87.6 Mm3/year. Should the need for a larger abstraction occur in the future there is, however, a need to source water also from the Incomati River, e.g. at Moamba Major.

Helio Banze

- The water balance only considerate the water demand stated in the IIMA agreement what about the high uses of water (above the IIMA allocation) that has been indicted in previous reports?
- Why does the consultant consider Maputo river and not Moamba Major Dam?
- Are desalinization and other alternatives are for now? Or should they only be considerate for long term options.
- The Umbeluzi agreement exists but need to be implemented

Mr Lidén clarified that the water balance calculations have been made with the assumption that the uses of water do not exceed the IIMA allocation. Present over-utilisation has thus been curtailed.

As discussed above the Moamba Major is, with the present assumption and IIMA agreement, less favourable from a financial point of view than the other alternatives to be implemented the coming years. If conditions change, e.g. in the IIMA agreement and as a long term solution (after 2030) the Moamba Dam may however be a strong alternative.

Desalinisation is only a long term alternative when all other options are utilised because the cost of treatment by reverse osmosis (demanding large amount of electricity) is very high.

Susana Saranga

- The study has many aspects for the establishment of long term strategies.
- How did the consultant passed from a large amount of alternatives to only 2?
- The Moamba Major impacts are so bad? Has the benefits been taken into account?
- And what are the sources for Inhaca and Catembe?

Mr. Lidén explained that the gross list of alternatives was reduced through a multi-criteria screening. The purpose of the screening was to remove more far-fetched alternatives. After the screening major alternatives like the Corumana, Moamba Major, Maputo River and groundwater remained that were further studied from a technical and cost perspective.

The Moamba Major has, relatively seen, larger environmental and social impacts, than the other main alternatives. This, however, does not mean that it is possible to mitigate these impacts if Moamba Major is the chosen alternative. No explicit benefit analysis was made but the multi-purpose use of Moamba Major for irrigation and flood control was implicitly included through accounting only 45% of the dam costs into the financial analysis. The remaining 55% of the cost must be motivated from other users.

The groundwater assessment shows that with the estimated probable development of Inhaca and Catembe the existing groundwater sources will be sufficient for the period up to 2030.

Almirante Neto

- Industries have been introduced as a water demand?

Prof. Carmo Vaz clarified that both industrial and domestic water use are part opf the water demand projections.

Olinda Sousa

- How long it will take to complete preparatory studies for Maputo Basin?
- It will be much easier to finish Corumana.
- Is there political influence to use Maputo river as a source?
- In Moamba Major Dam there are negative environmental impacts but there are also positive impacts. And we can use mitigation measure to minimize the negative impact.

The Consultant acknowledges that the non-existing preparatory studies for Maputo River are an uncertainty. It is the consultant's estimate that the studies will take at least two years but depending on problems encountered these may need to be extended. The alternative of Corumana is in this sense a much securer alternative since studies and funding is partially already there.

The study has been made from purely technical, financial and environmental aspects in an objective way by the consultants. No political issues have been taken into account.

The Moamba Major has many multi-purpose benefits and most of the negative environmental and social impacts will be possible to mitigate. The mitigation will, however, be associated with costs to be added to the overall construction cost, which at the moment is the major stumbling block for Moamba Major to be the best alternative.

Delário Sengo

- Corumana completed can accommodate 88 Mm3
- Maputo River is a black box. It will have developments upstream.
- The screening process only considerate Costs, Environmental and Social Impacts what about the risks.
- It is there possible to have Corumana and Moamba? If yes, it should be stated that there is water for the 2 dams.

Mr Lidén explained that the water balance analysis indicate that the Corumana can almost accommodate the 88 Mm3/year and also support irrigation up to the IIMA allocation in lower Incomati. However, almost is not good enough and the Corumana Dam can therefore not be considered as the long-term solution but must be augmented by another future source of water, e.g. Moamba Major or the Maputo River.

The Maputo river option is to a certain degree dependent on the development in the upstream area because of the low storage capacity of the off-channel storage. Based on the most probable development up to 2030 there is not a problem but as a long-term solution this alternative must be associated with a water-sharing agreement and a commitment from the upstream countries.

Mr. Lidén also acknowledged that risks have not been described sufficiently well in the report. There are risks in costs and lead time for especially the Maputo River and the groundwater options.

Mr. Lidén clarified that Corumana and Moamba Major would supply 88 Mm3/year at 100% assurance, which is currently the IIMA allocation.

Belarmino Chivambo

- The Study made by SWECO and Ninham Shand stated the Maputo River is not a source for water supply.
- Does the assurance of supply in 2030 include all FIPAG users along the N4 and Catembe?

Mr Lidén explained that new technologies and solutions of river abstraction have emerged, which has made the Maputo River a possible option for water supply. There are risks associated with the infrastructural solution, but these risks refer more to higher costs and extended lead times. Experiences from other rivers, such the Nile, have shown that the proposed technical solution is possible.

Mr Lidén clarified that the existing groundwater in Catembe and Inhaca is sufficient until 2030. Water demand estimation has taken into account all users in the Greater Maputo Area.

Closure

Mrs Saranga and Mr Chutumia thanked the participants for their contribution and asked the consultant to take these comments into account for the final strategy report.

4 Actions of the Consultant

The constructive comments from the Mozambican delegation have shown that the final decision of how to secure the long-term Maputo Water Supply must be based on other issues than only technical, environmental and financial. The Mozambican delegation also pointed out the large uncertainties that exist because of lack of preparatory studies for some alternatives. The consultant has therefore made the following major changes for the Final Strategy Report:

- The two proposed strategies will only differ in the short-term (intermediate) solution to supply Maputo City with additional water as soon as possible. The long-term solution must be open including all major alternatives, such as Moamba Major, groundwater, and Maputo River, and give the Mozambican government to take the best strategic choice to solve the supply of water for

Maputo City and all other users in southern Mozambique. To enable the Mozambican government to choose the long-term solution further preparatory studies must be conducted and the water-sharing agreements need to be finalised.

- The issues of risks associated with the different alternatives have been extended and included in the final report.

- The importance for Mozambique to have considerable storage to deal with emergency drought conditions has been highlighted in the final report.

- Clarifications on the water balance analysis for the Incomati River have been made.

APPENDIX 6

WRITTEN COMMENTS FROM THE MOZAMBICAN DELEGATION ON THE FIRST VERSION OF THE DRAFT STRATEGY REPORT WITH RESPONSES FROM THE CONSULTANT

Comments on report "Water Supply Strategies for Greater Maputo Area until 2030" for the project on "Augmentation of Water Supply to the City of Maputo and its Metropolitan Area"

Response to comments from the Consultant

Thank you very much for these valuable comments. The finalisation of the Strategy report has taken into account the comments as far as possible. The taken actions are described in responses given in blue text below.

The Consultant would like to emphasise that the consultancy services has been made in a professional and objective way, without being biased in any direction, and with the guidance of the ToR and information from TPTC. The study has been limited to a technical, financial and environmental analysis based on the most probable scenarios up to 2030, in accordance with the ToR.

General Comments

The Strategy is comprehensive and covers most of the elements mentioned in the Terms of Reference. It provides a good impression of the current situation and contains most of the information required to assess alternatives. However, the report could be better structured and it seems that the presented information is not fully used to justify the selection of alternatives and strategies. In some cases the arguments are even contradictory.

The applied methodology for the assessment of the alternatives is not well elaborated and lacks a scientific approach / basis. The result is that only part of the assessment criteria are used for the selection of preferred alternatives (especially costs and lead time), simply because comparison between the different assessment criteria did not seem to be possible. Due to uncertainty involved with some of the strategies proposed, as the report extensively documents, the risk involved in the implementation of a certain strategy was not considered in the screening process. The beneficial and multipurpose use of some of the alternatives were given less weight than the cost and the environmental criteria. This played role in the in strategy ranking.

The first screening of alternatives must be based on a general level because of limitation in time and budget of the project. The main purpose of the screening is to compare all possible (and maybe more far-fetched) alternatives with the well-known (from previous studies) alternatives such as Corumana, Moamba Major and Maputo River. The screening process has been made as far as possible from an objective basis.

The Consultant acknowledges that risk was not explicitly taken into account in the screening and a new chapter has been added to cover this area.

The result of the screening was that all the well-know alternatives (Corumana, Moamba Major and Maputo Rivers) remained as strong alternative together with groundwater. Costs are a very essential criterion and options as desalination, reuse of water and taking water from Limpopo are comparatively very expensive, which is clearly shown in Table 7.1 of the report.

The Consultant thinks it is unfair to say that only part of the criteria was used. An example is the Moamba Major dam that was included as a main alternative despite its negative environmental and social scores and long lead time. The reason for including the Moamba Major is the multipurpose benefits. Additional text has been included in the report to explain this further.

The report states that for the assessment of the alternatives, the allocations, as stipulated in the IIMA are considered. This is true for the additional 87,6 Mm3/year to supply Maputo City, but the IIMA allocations for other uses seem to be less taken into consideration for the choice of certain options (Corrumana Dam). The Consultant was biased toward the amount allocated by IIMA for Maputo Water supply, disregarding other water use. The IIMA allocate similar quantity of water either in Maputo or Incomati watercourse for wider options of use. A decision for infrastructure option for the best use of water allocated by IIMA will also be governed by wider strategic objectives by the relevant authorities in Mozambique.

The Consultant has assumed expansion of all water uses, including irrigation, in accordance with ARA-Sul's plans up to what is limited by the IIMA agreement, all in accordance with the instructions of the ToR. It is therefore not true that the Consultant has been biased towards only water supply allocations.

The importance of IIMA for which strategies to choose has been highlighted by the Consultants and has therefore included recommended negotiations on the changes of the finalization of IIMA the coming two years. In parallel with implementing preparatory studies for the immediate supply of a first 44 Mm3/year from either Incomati or Maputo River, the Mozambican government can therefore choose the more long-term solution for Maputo City based on a more comprehensive and clarified IncoMaputo Agreement.

The disregard of Moamba Major as one of the option was based on cost and environmental as well as on the lead time grounds and not on unavailability of water resources in the basin to accommodate this development. This should be clearly discussed in the report and also flagged in the conclusions.

Following the comments from the Mozambican delegation the Moamba Major has been included in both scenarios as an option for the second phase. This has been motivated by more long-term strategic objectives. The chapter of strategy formulation has been changed accordingly.

The list of required preparatory studies (chapter 9, page 91) is comprehensive and reflects well the type of studies which are required. However, it should be clear that the selection of the final strategy(ies) still depends on some crucial feasibilities studies. Especially the risk of seawater intrusion in the Maputo River at the Salamanga intake and the risk of seawater intrusion, due to groundwater abstraction are not well understood yet. These are not just technical issues for which solutions can be found or unfortunate losses in exchange for development, but may destroy the water sources aimed at.

Additional text on risks has been included in chapter 7, chapter 9 and chapter 12.

The parties may have to be consulted about how the IIMA should be interpreted in relation to the additional amount which can be made available for the future Maputo Water Supply: 87,8 Mm3/year from the Incomati River **or** the Maputo River or 87,8 Mm3/year from the Incomati River **and** 87,8 Mm3/year from the Maputo River.

The information given to the Consultant by the TPTC early in the project was very clearly that the Consultant should not elaborate on interpretations of the IIMA agreement. It was also clarified at this stage by TPTC to the Consultant that the current accepted interpretation of the agreement is “87.6 mm3/year from Incomati or Maputo River” The Consultant acknowledge the uncertainties in the formulation of the IIMA in regards to the allocation to Maputo City, and emphasize again that negotiations for finalization of the IIMA is utmost essential in the coming two years to allow the Mozambican government the possibility to take a long-term strategic decision on Maputo water supply. Negotiations on the finalization of the IIMA have therefore been included in both suggested strategies.

Specific Comments

Terms of Reference

The Terms of Reference is mentioning *to assess the consequences of the selected strategies in terms of cross-border discharges of the Incomati and Maputo Rivers within the framework of IIMA and in terms of water balance for Greater Maputo Area under normal and drought conditions*.
The scenarios for normal and drought do not appear in the study.

As was explained in the Water Balance Report normal conditions are not a problem for water supply to the Maputo City. Even the existing situation with only the Pequenos Libombos Dam in place would during normal rains give sufficient water to Maputo and all other users up to 2030 and beyond. Urban water supply therefore needs to be designed on drought situation since a very high assurance of supply is needed (98%). Drought conditions are analyzed through the use of a water balance model of which Chapter 8 describes in detail.

The Terms of Reference is mentioning, as specific objective, *to propose an update of annex 1 of IIMA, and proposing role and responsibilities for a future secretariat in the further preparation and implementation of one of the most suitable water supply strategies, such that*

it offers a case study to examine the roles and rules in watershed management under the IIMA.
The report is not elaborating the abovementioned issue.

The Consultant has given general recommendations on the update of the IIMA and has proposed negotiations for the finalization of the IIMA in the coming two years being part of the strategies. It is the Consultant's opinion that the details of updating Annex 1 and TPTC's role must be determined by TPTC themselves and must be the results of negotiations between the parties. It is therefore not appropriate for the Consultant to elaborate this further at this stage of the process.

The Terms of Reference is asking for the evaluation of two (most suitable) alternative strategies to secure sufficient water supply to the greater Maputo Area until the year 2027; However, the consultant elaborated only one strategy; the second strategy only seems to be an adjustment of strategy one, in case strategy turns out to be not feasible.

Both strategies are feasible but can be attributed to changed costs and lead times. However, following the comments from the Mozambican delegation it has been acknowledged that a larger flexibility is needed in the two strategies. These have therefore been reformulated.

Comments related to applied Methodology and Screening of Alternatives
The applied methodology for the assessment of the alternatives is not well elaborated and lacks a scientific approach / basis. For the selection of strategies, it seems that the cost and time criteria have been given the highest priority, however, the consultant does not present justifications why these criteria have been prioritized. It would have been preferred for the consultant to present a methodology for the screening of the alternatives based on all criteria, while preference (or giving weight) for each criteria is left to politicians.

The ToR clearly requires two strategies to be prioritized, which would be impossible for the Consultant if the different criteria would have unspecified weights. It is inevitable that these weights would be given differently by the three countries comprising the TPTC, which would lead to a long process of negotiations.

The Consultant has used an approach in which the technical, financial and environmental/social issues have been taken into account, as far as possible, in an objective and equal way. This has been based on the Consultant's professional expertise and objectivity.

The indicators of the model, used for environmental and socio-economic screening are not clear. The mentioned ones are not really indicators because they should be measurable and have to be quantified. They are only mentioned once at page 46/47 and are not referred to anymore in the preceding text.

Environmental and socio-economic impacts have been defined. In order to assess the impacts of each alternative, scores have been given to each impact, assuming that each impact can be compared to one another (one to one). Nevertheless, some impacts are more negatively

impacting the environment than others. Therefore, weights have to be given to each impact (this can be done by the partners or other stakeholders), in order to be able to compare each effect better.
Also, the scoring should be more quantified, based on measurable (SMART) indicators and the scaling factor should be taken into account – some impacts are only local, others are affecting an entire system.

The environmental and socio-economic scoring is very difficult to conduct for principally different options such in the case for water supply to Maputo City. The environmental-screening has been conducted, as far as possible, in an objective way made by professional experts in environment and social sciences. The alternative of having an iterative process in which the partners and stakeholders would allow different weights would be impossible within the time frame and budget of the present project.

It should, however, be clearly noted that environmental and social impacts must be studied in detail for whatever strategy is chosen. It should also be noted that environmental and social impacts can always be mitigated and the detailed ESIA must include proposals for such mitigation measures. This has not been clear in the report and additional text has been included in a new Chapter 6.5.

The environmental and socio-economic impacts should also be weighed against the benefit of each alternative (safe yield). E.g. the use of more groundwater north of Maputo may threaten the water supply of 350.000 people, but the gain is only 9 Mm3/year. Seawater intrusion and an over-abstraction of groundwater may destroy the aquifer for a long period.

The groundwater alternatives are all based on utilizing only a part of the natural recharge, as is extensively explained in the Water Availability Report. Seawater intrusion has been discussed in the new chapters and text related to risks.

In order to be able to compare all criteria and for clarity the consultant is requested to make a table in which environmental and socio-economic, benefits (safe yield), costs, time span and risks are combined.

A new table has been included in accordance and additional text has been added to clarify the choice of the three main alternatives.

The consultant is requested to provide justifications for rejecting alternatives based on costs (please provide an overview of the calculations for the Massingir pipeline, Desalinization plant, reuse of waste water and artificial recharge).

All costs are given in detail in Table 7.1.

Comments related to the selection of Strategies
The report states that some alternatives should be considered as main potential sources for the future Maputo Water Supply, while others have to be considered as additional sources.

Some main alternatives are discarded as potential option due to costs (pipeline from Massingir, Desalinization Plant), but no calculations are provided. Also additional resources like reuse of waste water and artificial groundwater recharge are rejected based on costs, but without providing calculations.

All costs are given in detail in Table 7.1. Additional text has been added to clarify.

The remaining main potential alternatives are the completed Corrumane Dam, the Moamba Majore Dam and the Maputo River intake near Salamanga. Additional resources are required to fulfill the needs until 2030, due to the fact that the IIMA only allows for an amount of 87.8 Mm3/year from Incomati and/or Maputo Rivers to additionally supply Maputo City.

For the selection of the main alternatives, the consultant used the following arguments (chapter 7, page 67):

- ⇨ *Although being the cheapest alternative of the large transfer schemes, the Moamba Dam has not been considered on its own because of the long lead time;*
- ⇨ *The transfer from the Corrumane Dam and the transfer from Maputo River upstream of Salamanga both have moderate costs, moderate environmental and social impacts and relatively short lead times, and should therefore be strong options;*
- ⇨ *The existing Corrumane Dam option is not considered because it is already committed for irrigation in lower Corrumane. For the same reason it is neither judged viable to take the full amount of 87.6 Mm3/year from the completed Corrumane Dam;*

Based on these arguments the consultant selected the following main alternatives:
A – Main source from Incomati River augmented by groundwater and WDM – (main source Moamba Majore (87,6 Mm3/year) from 2020 onwards and, Corrumane Dam (43,8 Mm3/year)) as an emergency until 2020;
B – Main source from Incomati and Maputo River augmented by groundwater and WDM – (43,8 Mm3/year from Corrumana Dam and 43,8 Mm3/year from Maputo River);
C – Main source from Maputo River augmented by groundwater and WDM – (87,6 Mm3/year from Maputo River through an intake upstream Salamanga)

The choice of the final two strategies (B and C) is, among others, based on the following arguments:

- ⇨ *Due to the serious water scarcity in the Umbeluzi River, the IIMA stipulated 87.6 Mm^3/year from Incomati and/or Maputo Rivers will not be sufficient, which is why a third source needs to be included in the strategy. The development of the groundwater schemes north of Maputo and north of Maracuene has been found to be the most cost-efficient alternative.*
- ⇨ *Although being the cheapest alternative, the development of 87.6 Mm^3/year from Maputo River in one phase is not recommended to give flexibility for the final solution. The development of a first phase taking 43.8 Mm^3/year from either Incomati or Maputo would allow time for updating water demand projections and finalising the trans-boundary water-sharing agreements with South Africa and Swaziland, which will enable an optimisation of the design and timing of the final phase.*

⇨ *Besides being the most expensive of the main alternatives, the inclusion of Moamba in the second phase is also discarded since the water balance analysis indicated that the completed Corumana Dam can accommodate both the 43.8 Mm^3/year transfer to Maputo City as well as the projected increase of irrigation up to the IIMA allocation level for the lower Incomati.*

Concerning the selection of the two strategies we would like to make the following observations:

The two presented strategies are actually one and the same. Strategy 1 (or C) suggests the Maputo River as only resource, but in case it turns out that seawater intrusion may threaten the intake at Salamanga then additionally supply should come from the Corrumane Dam.

In the *chapter 12, page 111*, it is mentioned that *if the Maputo River turns out to be less favourable, after a detailed feasibility study, the water balance analysis has indicated that the full amount of 87,6 Mm3/year can, from a water availability perspective, be transferred from the completed Corrumane Dam with only limited reduction in agriculture development in the Lower Incomati* (remark Client – please check results table 8.2; from the table it seems that scenario 1 (Pequenos Libombos only), 3 (Pequenos Libombos and raised Corrumana) and 5 (Pequenos Libombos and Maputo River 44) are clearly less favorable – This is misreading – Irrigation in Incomati has the same assurance of supply in all alternatives, it is only the Umbeluzi irrigation that varies with scenarios 1, 3 and 5 having the lowest assurances)

Furthermore, in chapter 7, at page 67 the consultant states that *the existing Corrumane dam option is not considered because it is already committed for irrigation in lower Corrumana. For the same reason it is neither judged viable to take the full amount of 87,6 Mm3/year from the completed Corrumane Dam*.

This is contradictory to the argument mentioned in chapter 12 at page 111.

The Consultants acknowledge that the issue of Corumana Dam and the assurance of supply for irrigation in Incomati have been presented in a confusing way. Changes in the text in Chapter 8 and in Chapter 12 have been made to clarify this issue.

The need for more flexibility in the proposed strategies to allow the Mozambican government to choose a final strategy based on their long-term strategic objectives has been acknowledged. The two proposed scenarios have therefore been changed to be more flexible in the second phase, thus becoming only different in the first phase (which is to supply additional 44 Mm^3/year as soon as possible). Chapter 12 has been changed accordingly.

In our opinion, the risk of seawater intrusion in the Maputo River and the consequences for the future water supply of Maputo City is underestimated. The consultant admits that if a feasibility study shows that Maputo River is less favorable, both selected strategies have to be discarded. As an alternative, the consultant is suggesting to using only the Corrumana Dam as main source for Maputo City, however, none of the main alternatives B and C of chapter 7 are mentioning Corrumana Dam as single supplier of the 87.8 Mm3/year.

The Consultant's professional view is that seawater intrusion is not a major problem. If salt water intrusion is a problem at the suggested sites a technical solution can easily be adopted, either by moving the intake upstream or by allowing pumping to the off-channel storage only during low tide. The risk that that the Maputo River option is not technically feasible is very small although minor changes in the cost and lead time may be the case, as described in Chapter 12.2.

The Corumana Dam is not considered as a good option for supplying the whole allocation of 87.6 Mm3/year. The text indicating this has been removed and further clarifications have been made in Chapter 8.

The report states that for the assessment of the alternatives, the allocations, as stipulated in the IIMA, are considered.
These are for the Incomati River Basin as follows: for agriculture 29 Mm3/year Incomati upstream Sabie; 239 Mm3/year Incomati downstream Sabie and 12 Mm3/year Sabie, for afforestation 25 Mm3/year and for the Water Supply of Maputo 87,8 Mm3/year.
The total allocated amount is 393 Mm3/year (be aware that environmental flow has not been considered!!!)
To allow for the supply of the allocated amount, the safe yield of the supply sources should be at least 393 Mm3/year. The combined safe yields of the completed Corrumane Dam (Completed Dam 250-256 Mm3/year) and Moamba Majore Dam (130 to 150 Mm3/year) is 380-406 Mm3/year.
To allow Mozambique for supplying their share of the IIMA, the Corrumana Dam will be, by far, not enough to satisfy the requirements, which disqualifies the Corrumana Dam as single source for the Maputo Water Supply. Most of the water of the existing Corrumana Dam is already allocated to farmers and only the additional amount of water of the completed Corrumana Dam was meant to be allocated for the future Maputo Water Supply (World Bank Study, reference???).

The safe yield is assuming 100% assurance for all users. The detailed water balance analysis in Chapter 8 has assumed 80% assurance for irrigation, which is generally agreed between the three countries. It is therefore not possible to compare the results of Chapter 8 with safe yields.

The detailed water balance indicates that the Corumana dam is not yet fully committed taking into account the 80% assurance. However, with an additional expansion of irrigated are by approximately 10,000 ha and the transfer of water to Maputo City of 44 Mm3/year the dam will be fully committed and needs the completion by installing the gates.

As most of the water of the Corrumana Dam is already allocated to farmers (current allocated amounts are still below the IIMA allocations), the Corrumana Dam should actually be discarded as main single source for the water supply of Maputo.
This leaves the Maputo River intake and the Moamba Majore Dam as the only two single source alternatives.

The Corumana Dam is not considered as a good option for supplying the whole allocation of 87.6 Mm3/year. However, it is a good candidate to providing the short-term solution for the Maputo City as have been explained in the updated report in Chapter 12.

Main Alternative A (chapter 7, page 68) is, in principle, proposing Moamba Majore Dam as single future source for Maputo. However, to overcome the time span until the finalization of the Dam, as a case of emergency, 43,8 Mm3/year will be used from the Corrumana Dam until 2020. After 2020, Moamba Majore Dam will have to be used as single source in order to comply with the IIMA.
Nevertheless, the cost analysis (chapter 10, page 106) seems to be done based on costs for the development of both sources, while at the end (after 2020) only the Moamba Majore Dam will be used as main source for Maputo.

The large water deficit of water supply in Maputo up to 2020, when the Moamba major Dam can be place is not acceptable. The Moamba Major dam alternative therefore must be combined with a short-term solution. To not include the cost of this short-term solution would not be appropriate.

The additional advantages of the Moamba Majore Dam are not taken into consideration during the assessment –

- ⇨ Flood prevention / mitigation (costs analysis and socio-economic impact analysis should take into consideration possible future flood damages – reference could be made to the floods of 2000 and 2001)
- ⇨ Environmental flow (to assure a (regular) flow, which could be geared to the ecological needs of the Incomati delta; this may help in the preservation of the Maputo Bay and estuaries, which is listed as one of the 10 environmental hotspots on the East African continent);
- ⇨ Irrigation requirements (easier supply of water for irrigation to farmers downstream of the Sabie);

It is suggested that all these benefits are assessed in detail in an updated feasibility study in 2010-2011, see updated Chapter 12.

Summary

The summary does not clearly reflect the content of the report. At least it should mention the different alternatives considered in the study, the criteria used for the assessment and reasons for choosing the two strategies. Also the applied methodology for screening should briefly be explained.

A new extended summary will be produced for the final workshop and final report.

APPENDIX 7

NOTES FROM FINAL WORKSHOP IN

MAPUTO 29 SEP 2009

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2 Agenda

Venue: VIP Hotel
Time: 29 Sep 2009, 8:30-13:30

Workshop session:

Participants: Stakeholders in Greater Maputo Area
PRIMA Management
Representatives from TPTC
Consultant team

Time	Subject	Action
8.30-8:45	Welcome	Ms. Suzana S. Loforte, Deputy National Director of Water, Mozambique
8.45-9:15	Introduction to the PRIMA programme	Mr. Issufo Chutumia, PRIMA Program Manager
9:15-9:30	Introduction to the Project	Mr. Lennart Lundberg, Team Leader
9:30-10:00	Options for future water supply to the City of Maputo	Prof. Alvaro Carmo Vaz
10:00-10:30	Coffee/Tea	
10:30-11:00	Formulation of water supply strategies	Dr. Rikard Lidén
11:00-12:00	Discussion	All
12:00-12:15	Closing	Mr. Lennart Lundberg, Team Leader Mr. I Chutumia, PRIMA Program Manager Ms. Suzana S. Loforte, Deputy N.D.Water Mozambique
12:15-13:30	Lunch	All
14:30-16:30	PSC meeting	PRIMA management, TPTC, Consultant

3 Minutes

Opening/Welcome

Mr Chutumia welcomed everyone and gave the objectives of the workshop.

The three delegations from the countries expressed the importance of the study.

Presentation of the PRIMA Program by Mr Issufo Chutumia

Mr. Chutumia gave a presentation of the PRIMA programme and the linkages between the different projects.

Presentation of the updated report on Water Supply Strategies for Greater Maputo until 2030 by Mr Lennart Lundberg, Prof. Alvaro Carmo Vaz and Dr. Rikard Lidén

Mr. Lidén gave a presentation of the basis for the formulation of the two strategies. The presentation had the following main points:

- Introduction to the Project
- Options for future water supply to the City of Maputo
- Formulation of water supply strategies

Discussion and feedback from the Client and stakeholders.

Rui Gonzales:

- In the presentation there was a reference about metering as a proposed water demand management measure. Is the concept the same as is implemented by FIPAG?
- In grey water system are there not different pipes needed.

Prof. Carmo Vaz explained that the water demand measures discussed refers to further measures than is presently implemented by FIPAG. The water demand measures, and especially grey water systems, must be seen on the long-term. Presently FIPAG must focus on reduction of losses by e.g. metering. Prof. Carmo Vaz also confirmed that grey water systems need investments in the piping system.

Helio Banze

- It is important to Mozambique to be independent from the upstream countries. This is possible from Moamba Major.
- The figure of 40 Mm^3/year for groundwater is different from the 20 Mm^3/year that appeared in previous projects.

Mr. Lundberg explained that the basis of the study has been that the IIMA will be complied with and if this is the case both the Incomati and Maputo River option are sufficient to supply Maputo City up to 2030. The issue of storage in Mozambique will augment the Mozambican authorities to deal with an extreme drought situation by reallocating water from secondary users to urban supply and may be taken into account when the final long-term strategic solution will be chosen by the Mozambican government.

Mr. Lidén explained that the estimate of groundwater yield has been based on the latest updated studies in 2003. The figure of 39 Mm3/year from the aquifers in the north Maputo and north of Maracuene has been judged probable.

Belarmino Chivambo

- In the Maputo River the previous study showed that water quality was bad. There is further no EIA studies conducted for this alternative, which makes this alternative risky.
- Similarly, there are no EIA studies in groundwater.
- On the other hand, there are studies conducted for Moamba Major. The feasibility study has been done and has shown that the dam is feasible.

Prof. Carmo Vaz and Mr. Lidén said that the Consultant has found no indication of bad water quality in previous studies or in the WQ records. The lack of preparatory studies for both the Maputo River and the groundwater options is an uncertainty that should be taken into account for the choice of strategy.

The preparatory studies conducted fro Corumana and Moamba Major make these option less risky. These studies were well conducted and are important documents to consider for the future development. However, especially the Moamba Major feasibility study needs to be updated because of the new conditions that Corumana is an intermediate short-term option and because cost for construction of infrastructure has changed considerably since 2002-03 when the feasibility study was conducted.

Suzana Saranga

- The strategy no 2 (Maputo River) is very dependent of the upstream countries. We must take this risk into account.

Mr. Lidén acknowledged that in the long-term the Maputo option put Mozambique dependent on upstream countries. On the short-term to supply 44 Mm3/year up to the year 2020 (as proposed by Strategy no.2) the more or less unregulated flow from the Usutu River will guarantee the required flows. On the longer term if Maputo River should be the option taking further water volumes the issue of dependence on upstream development exist and should be taken into account decision by the Mozambican government.

Jaime Mianga

- Take the Corumana as a source to supply the Great Maputo is an emergency solution. If it is to considerate as a final solution this will affect the Moamba Major Strategy but if it is taken as a associative with Moamba Major it will be helpful

Mr. Lidén clarified that an additional source of water to Maputo water supply is needed urgently and Corumana is probably the option with the least lead time before commissioning. The completed Corumana Dam will however not be sufficient to be the long-term solution and another source needs to be developed. The choice of this second source must be made on the basis of the first source being implemented, which is the reason why updated feasibility studies need to be conducted.

Rui Gonzales

- Why not considerate abstraction of the 2 m3/s in Incomati at Moamba

Mr. Lidén explained that an option of taking water directly from the Incomati River downstream of the confluence with Sabie has been considered but was found to be less favourable from a financial point of view than the Corumana alternative. The main reason is that the Incomati River is quite wide and intake infrastructure becomes large and expensive. To take water at Moamba village has not been considered since the run-off-the-river safe yield is judged to low.

Helio Banze

- How has the exceeded water use in the Crocodile River in South Africa been considered in the water balance?

Mr. Lidén explained that it was assumed that the IIMA agreement will be complied.

Rui Gonzales

- For the determination of the financial cost what parameters has been taken into account
- Preparation for emergency situations is very crucial.

Prof. Carmo Vaz and Mr. Lidén explained that all costs have been included in the financial analysis.

The importance of being prepared for emergency situation is included in both strategies because of the lead time.

Closure

Mr Chutumia thanked the participants for their contribution.

The delegations from the three countries thanked the PRIMA management and task team as well as the consultant for the conducted work.

The workshop was closed.

4 Actions of the Consultant

The comments from the stakeholders will be taken into account in the final Strategy Report to be delivered in October 2009.

APPENDIX 8

POWERPOINT PRESENTATION IN FINAL WORKSHOP IN

MAPUTO 29 SEP 2009

TPTC

Progressive Realisation of the IncoMaputo Agreement
PRIMA Program

TPTC

Progressive Realisation of the IncoMaputo Agreement
PRIMA Program

Background

- The SADC region is unique in having 15 major trans-boundary watercourses – of which 9 in Mozambique;
- Unique opportunity to built experience on how to manage shared water courses under different natural, economic and political conditions;
- Many of these river basins are under stress, due to economic pressure of water consumers;
- The region is also highly prone to extreme environmental events, such as floods and droughts, which compels for an international joint response;
- Countries in the SADC region understand the necessity of joint utilization of shared waters, resulting in the signing of agreements and the establishment of River Basin Organizations;

TPTC

Progressive Realisation of the IncoMaputo Agreement
PRIMA Program

Background

Incomati, Maputo, Umbeluzi River Basins and their sub-cathments

TPTC

Progressive Realisation of the IncoMaputo Agreement
PRIMA Program

TPTC

- A **Tripartite Permanent Technical Committee** (TPTC) was established in *February 1983* –

  To guide the implementation of agreements in regard to the protection and sustainable utilization of water resources in River Basins covering Swaziland, South-Africa and Mozambique.

  It consists of equal member representatives from each of the three governments.

  TPTC meets twice a year and when circumstances require.

TPTC

Progressive Realisation of the IncoMaputo Agreement
PRIMA Program

IIMA

- During the Johannesburg World Summit on Sustainable Development, on August 29, 2002
  the "*Tripartite Interim Agreement for Co-operation on the Protection and Sustainable Utilization of the Incomati and Maputo Watercourses*"(IIMA) was signed
  by Mozambique, South Africa and Swaziland.

TPTC

Progressive Realisation of the IncoMaputo Agreement
PRIMA Program

IIMA

- The IIMA is an interim agreement until more comprehensive agreements have been concluded

- The general principles of the SADC revised Protocol on Shared Water Courses shall apply for this agreement:
  - Sustainable utilization principle;
  - Equitable and reasonable utilization principle;
  - Prevention principle; and
  - Cooperation principle

TPTC

Progressive Realisation of the IncoMaputo Agreement
PRIMA Program

Task Team – IAAP

- TPTC appointed a Task Team (TT) to develop an Action Plan for the implementation of the IIMA.

  The Implementation Activity and Action Plan (IAAP) resulted in 12 projects;

TPTC

Progressive Realisation of the IncoMaputo Agreement
PRIMA Program

Task Team – IAAP

	Project Description
IAAP 1	Shared Watercourse Institutions
IAAP 2	***Review of National Water Policies and Legislation***
IAAP 3	Integrated Water Resources Management
IAAP 4	Augmentation of the Water Supply for the City of Maputo and its Metropolitan Areas
IAAP 5	Disaster Management Plan for the Incomati and Maputo Watercourses
IAAP 6	***Transboundary Impacts in the Incomati and Maputo Watercourses***
IAAP 7	Exchange of and Access to Information
IAAP 8	Capacity and Confidence Building
IAAP 9	Stakeholder participation and communication
IAAP 10	System operating rules for the Incomati and Maputo watercourses
IAAP 11	Preparatory Work for Comprehensive Water Use Agreements for the Incomati and Maputo Watercourses
IAAP 12	Managing the Implementation of the IIMA

TPTC

Progressive Realisation of the IncoMaputo Agreement
PRIMA Program

The PRIMA Program

- To implement the IIMA, the "*Progressive Realization of the Incomati-Maputo Agreement*" (PRIMA) Program was developed;
- The PRIMA Program is following the scope of the IAAP and aims at the realization of the objectives of the IIMA;
- The TPTC is "Client" for PRIMA.

  However, for legal personality, the TPTC nominated DNA Mozambique as lead agency;
- Implementation Period – January 2007 until December 2011;

TPTC

Progressive Realisation of the IncoMaputo Agreement
PRIMA Program

PRIMA Program – Overall Objective

- Overall objective of PRIMA is:

  To realize the objectives of the IIMA by supporting the TPTC to promote –

  Cooperation among the Parties and

  Ensure the protection and sustainable utilization of the water resources of the Incomati and Maputo Watercourses

TPTC

Progressive Realisation of the IncoMaputo Agreement
PRIMA Program

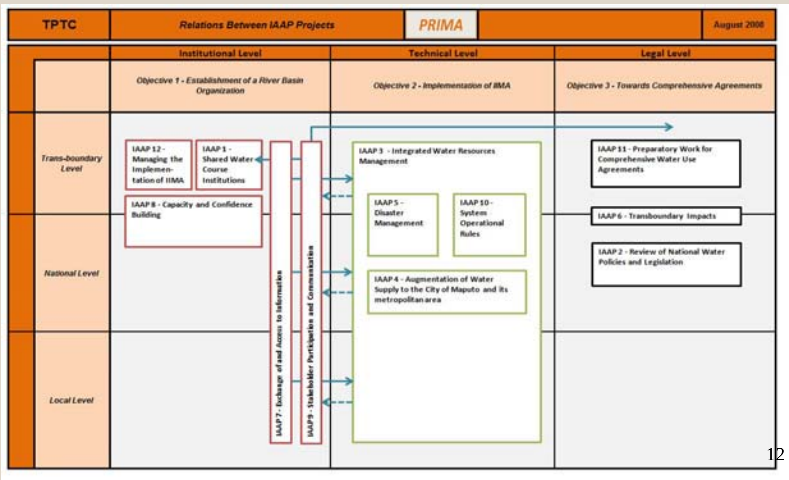
PRIMA Program – Main Objectives

- Objective 1 – Technical
  Implementation of Technical PSP Projects
  IAAP 2 – 7, 9 and 10
- Objective 2 – Legal
  Preparatory Work for Comprehensive Agreements
  IAAP 11
- Objective 3 – Institutional
  To support the TPTC in finding the best institutional arrangement for implementation of the Comprehensive Agreements
  IAAP 1 and IAAP 8

TPTC

Progressive Realisation of the IncoMaputo Agreement
PRIMA Program

PRIMA Program - Integrated Approach



TPTC

Progressive Realisation of the IncoMaputo Agreement
PRIMA Program

PRIMA Program – PSP Projects

- Implementation of 6 PSP Projects
  - Augmentation of the Water Supply for the City of Maputo and its Metropolitan Areas (IAAP 4)
  - Disaster Management Plan for the Incomati and Maputo Watercourses (IAAP 5)
  - Exchange of and Access to Information (IAAP 7)
  - Integrated Water Resources Management (IAAP 3)
  - Stakeholder Participation and Communication (IAAP 9)
  - System operating rules for the Incomati and Maputo watercourses (IAAP 10)

TPTC

Progressive Realisation of the IncoMaputo Agreement
PRIMA Program

PRIMA Program – PSP Projects

IIAP 4 - Augmentation of the Water Supply for the City of Maputo and its Metropolitan Areas

- Main Objectives
  - To forecast until 2030 the water requirements for the Greater Maputo metropolitan area (the city of Maputo, the Catembe and Inhaca islands, the cities of Matola and Boane, plus the new urban development areas around these cities).
  - Assessing the foreseen water deficits for Greater Maputo Area, under normal hydrological conditions and under drought conditions.
  - Evaluate all existing water supply strategies to meet the future water demands of the Greater Maputo metropolitan area.
  - Prepare a set of recommendations on how to provide the future urban water supply to the City of Maputo and its metropolitan area .

TPTC

Progressive Realisation of the IncoMaputo Agreement
PRIMA Program

Thank you for your Attention!

OBRIGADO!

Final Workshop 29 September 2009, Maputo

Water Supply Strategies for Greater Maputo until 2030

Basic info

Programme:	Progressive Realisation of the IncoMaputo Agreement (PRIMA)
Client:	Tripartite Permanent Technical Committee (TPTC) of Mozambique, Swaziland and South Africa
Consultant:	SWECO International, DHI, BKS, CONSULTEC
Time:	Oct 2008 – Sep 2009
Funds:	Dutch Government

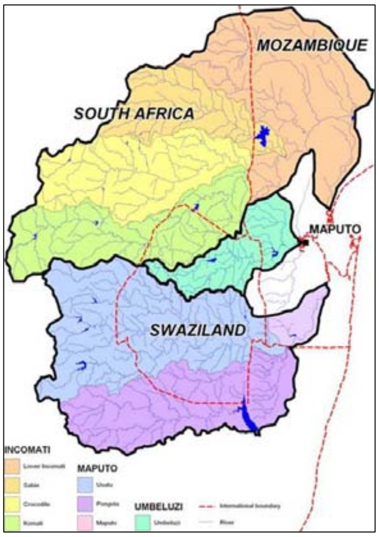
AGENDA

08:30	*Welcome*	*Mrs. Suzana Loforte*
8:45-9:15	*Introduction to PRIMA*	*Mr. Issufo Chutumia*
9:15-9:30	*Introduction to the project*	*Mr. Lennart Lundberg*
9:30-10:00	*Current situation and main options*	*Prof. Alvaro Carmo Vaz*
10:00-10:30	*Coffee/tea*	
10:30-11:00	*Formulation of Strategies*	*Dr. Rikard Lidén*
11:00-12:00	*Discussion and feedback*	
12:00-13:00	*Lunch*	

OVERALL OBJECTIVE

- *Project water requirements for the City of Maputo*
- *Possibility of supplying these from the Umbeluzi River*
- *Possibility to augment by*
  - *Incomati and Maputo watercourses*
  - *Groundwater resources*
  - *Water demand management measures*

Study Area



Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

ESTIMATE OF WATER DEMAND

REVIEW OF WATER RESOURCES

WATER BALANCE ANALYSIS

LEGAL FRAMEWORK

STRATEGY FORMULATION

IDENTIFICATION OF OPTIONS

MULTI-CRITERIA ANALYSIS

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CURRENT SITUATION

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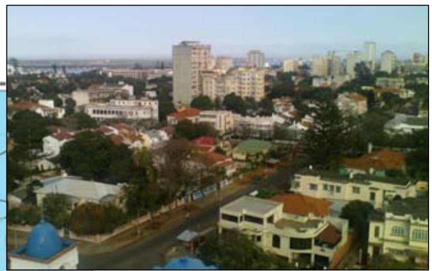
Augmentation of Water Supply for the City of Maputo and its Metropolitan Area



GREATER MAPUTO IS GROWING!

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Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

Water consumption in the Greater Maputo Area in 2006

- from the Umbeluzi River – 68 M m3
- small systems using groundwater – 2.5
- Catembe – 0.33

Physical losses in 2006 – 55%

Projections of future demand based on:
- population growth in the various areas
- unit consumption according to type of connection
- evolution of coverage rate
- non-domestic water consumption
- evolution in reduction of physical losses

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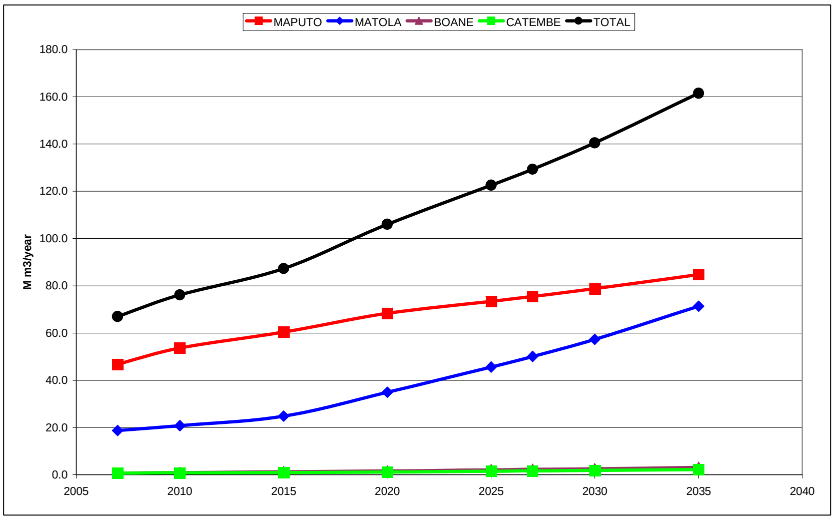
Augmentation of Water Supply for the City of Maputo and its Metropolitan Area



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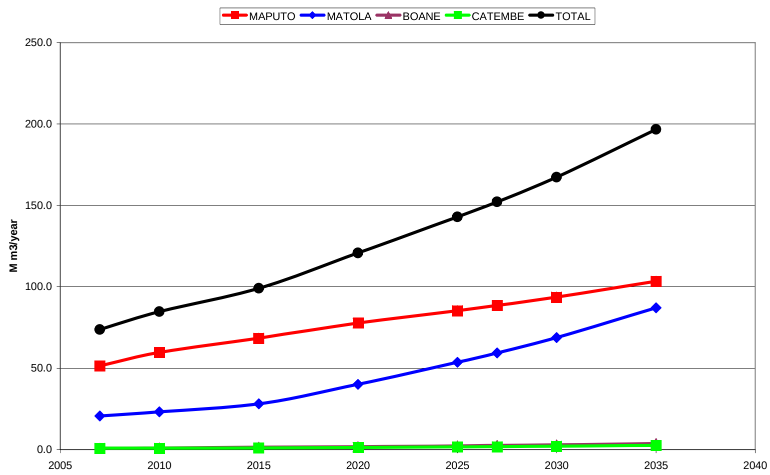
Augmentation of Water Supply for the City of Maputo and its Metropolitan Area



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Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

WATER DEMAND FOR OTHER USERS

Other users considered in the Umbeluzi, Incomati and Maputo River Basins, in Mozambique, South Africa and Swaziland: domestic, irrigation, industry, afforestation, livestock, water transfers

Other water uses limit the water availability for the supply of the Greater Maputo Area

Allocations defined by the IncoMaputo Interim Agreement

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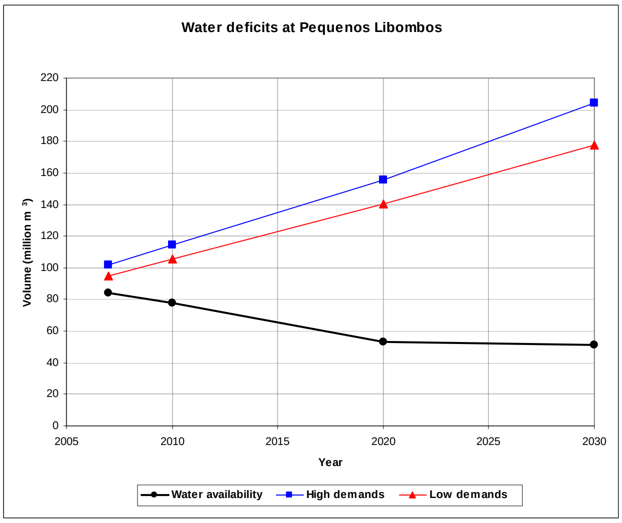
Augmentation of Water Supply for the City of Maputo and its Metropolitan Area



Deficit for PQL

in 2030:

125-150 Mm^3/year

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Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

OPTIONS TO AUGMENT FUTURE WATER SUPPLY

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Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

POSSIBLE WATER SUPPLY SOURCES

1. Existing Corumana Dam
2. Completed Corumana Dam
3. Intake weir downstream of confluence
4. Moamba Major Dam
5. Moamba Major Dam combined with Movene Dam
6. Intake on Maputo River at Catuane
7. Intake on Maputo River upstream of Salamanga
8. Groundwater north of Maputo
9. Groundwater north of Marracuene
10. Groundwater north of Marracuene with artificial recharge
11. Intake at Massingir Dam
12. Desalination plant north of Maputo
13. Reuse of wastewater

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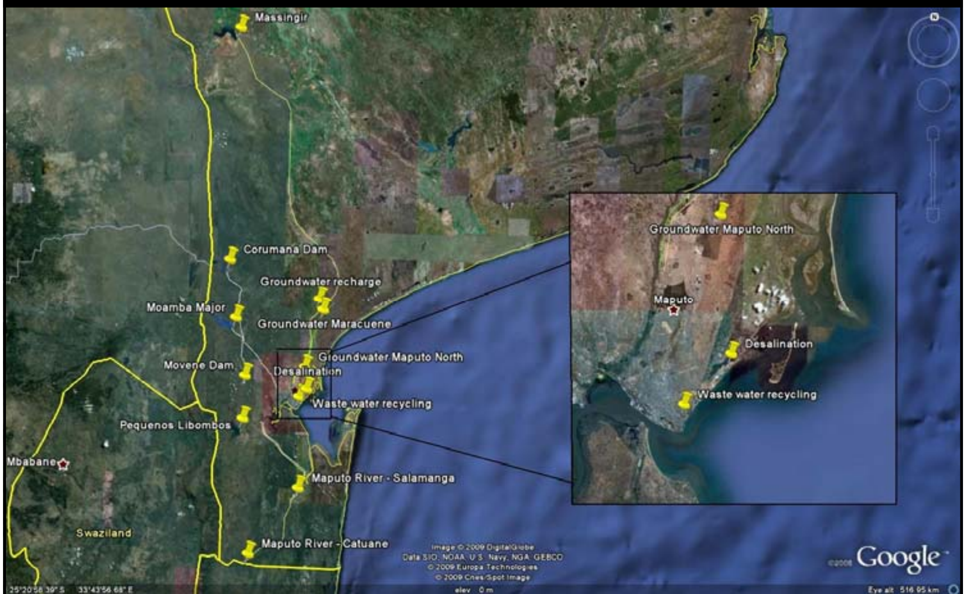
Augmentation of Water Supply for the City of Maputo and its Metropolitan Area



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Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

SCREENING OF SUPPLY ALTERNATIVES

1. Safe yield
2. Environmental screening
3. Social screening
4. Unit cost per cubic metre
5. Multipurpose use
6. Lead time before operation
7. Risks

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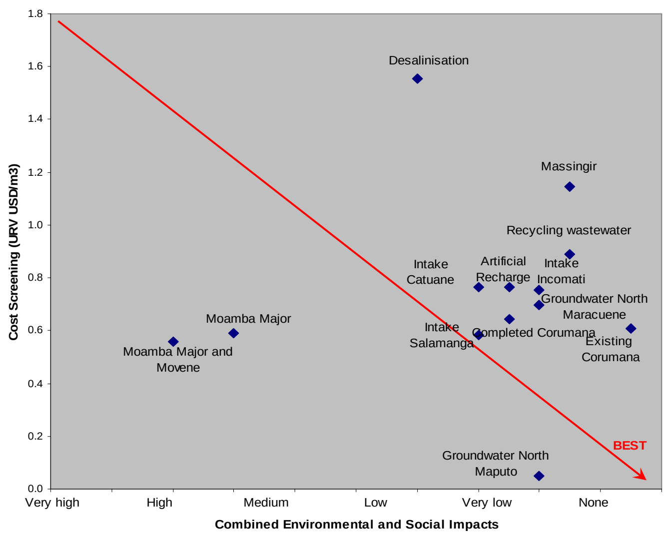
Augmentation of Water Supply for the City of Maputo and its Metropolitan Area



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Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

WATER DEMAND MANAGEMENT

Based on Cape Town, Durban and India case studies

	POTENTIAL WDM	Cost (MUSD/year)	Annual Savings (Mm^3)
Water wastage reduction	•Pressure management •Grey water systems •Rainwater harvesting •Metering, tariffs and billing control	7.96	16.4
Water usage reduction	•Water saving devices •Education and advocacy	0.68	12.6
Total		8.64	29.0

Note: Leakage reduction down to 25% losses already accounted for in water demand projections

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Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

MAIN ALTERNATIVES

A: INCOMATI

- *Phase1: 44 Mm^3/yr from Corumana*
- *Phase2: 88 Mm^3/yr from Moamba Major*
- *Complementary GW*
- *WDM*

B: INCOMATI/MAPUTO

- *Phase1: 44 Mm^3/yr from Corumana*
- *Phase2: 44 Mm^3/yr from Maputo River at Salamanga*
- *Complementary GW*
- *WDM*

C: MAPUTO

- *88 (44+44) Mm^3/yr from Maputo River at Salamanga*
- *Complementary GW*
- *WDM*

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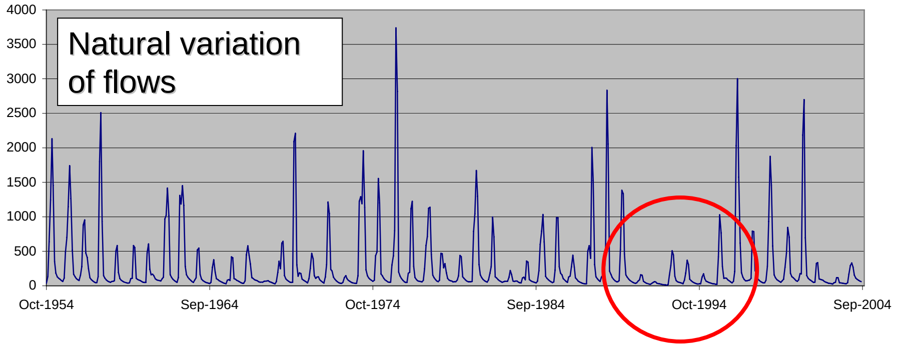
FORMULATION OF STRATEGIES

1. *Screening to find main alternatives*
2. *Water balance analysis of main alternatives*
3. *Tentative design of infrastructure and costing*
4. *Financial analysis of main alternatives*
5. *Tranboundary and strategic issues*
6. *Formulation of 2 final strategies*

Water balance analysis

Water Balance Assessment

Comparing water resources with demand taking into account the temporal variation in river flows

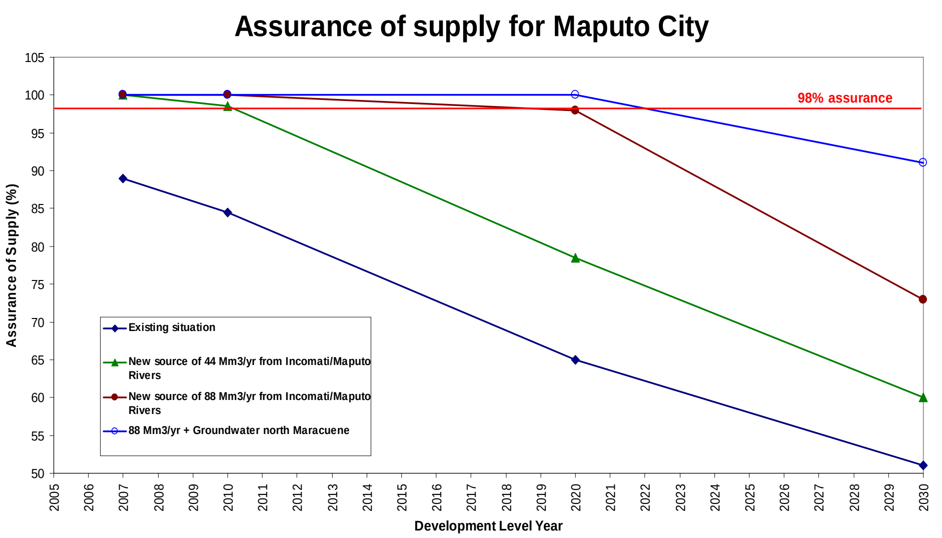


Water balance analysis

ASSURANCE OF SUPPLY

The percentage of time that Maputo City is guaranteed the wanted supply of water

98% assurance is required fro urban supply



Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

Water balance analysis

CONCLUSION

MORE THAN ONE WATER SOURCE IS REQUIRED TO MEET THE FUTURE WATER DEMAND OF MAPUTO CITY

A NEW SOURCE IS NEEDED URGENTLY!

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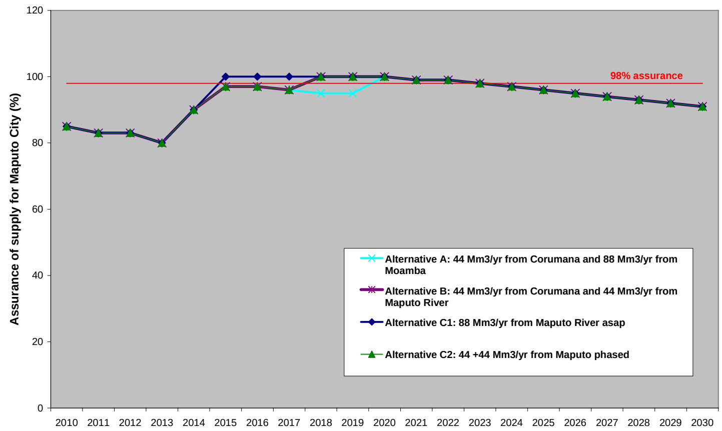
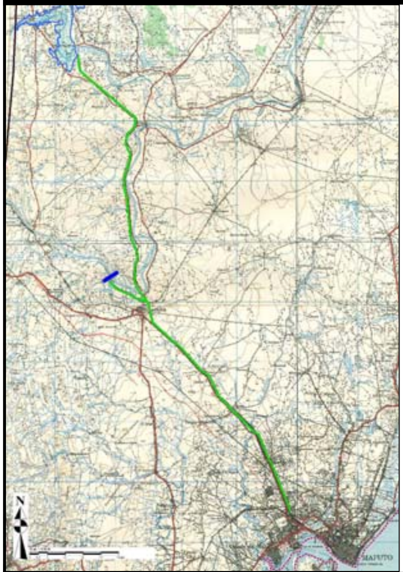


Assurance of Supply for Maputo with the main alternatives implemented

Preliminary Design for Main Alternatives

Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

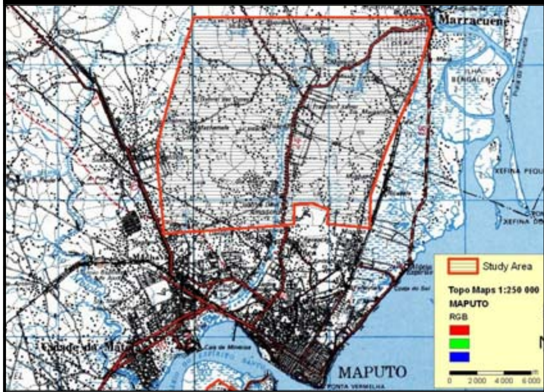


Inkomati transfers

Maputo transfers

Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

Augmentation of Water Supply for the City of Maputo and its Metropolitan Area



Groundwater from north of Maputo city – suited to local supply

Groundwater piped from boreholes along the Inkomati river road to Maputo city for distribution

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Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

COSTING

- ***Based on experience of transfer schemes in South Africa***
- ***10% escalation per year (observed in SA)***
- ***25% extra for Mozambique***
- ***Steel pipes assumed because of large transfer volumes***

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COSTING

• *GW scheme north of Maracuene*	*193 MUSD*
• *44 Mm^3/year from Corumana*	*410 MUSD*
• *44 Mm^3/year from Moamba*	*395 MUSD*
• *44 Mm^3/year from Maputo River*	*335 MUSD*

COSTING

	Total Capital Cost in 2009 (MUSD)
A: 44 Mm^3/yr from Corumana and 88 Mm^3/yr from Moamba	1,022
B: 44 Mm^3/yr from Corumana and 44 Mm^3/yr from Maputo River	960
C: 44 + 44 Mm^3/yr from Maputo phased	862

Groundwater schemes north of Maputo and Maracuene included in all alternatives

UNIT REFERENCE VALUE (USD/m^3)

	URV @ 4%	URV @ 6%	URV @ 8%
A: 44 Mm^3/yr from Corumana and 88 Mm^3/yr from Moamba	0.85	0.96	1.08
B: 44 Mm^3/yr from Corumana and 44 Mm^3/yr from Maputo River	0.79	0.90	1.02
C: 44 +44 Mm^3/yr from Maputo phased	0.73	0.82	0.92

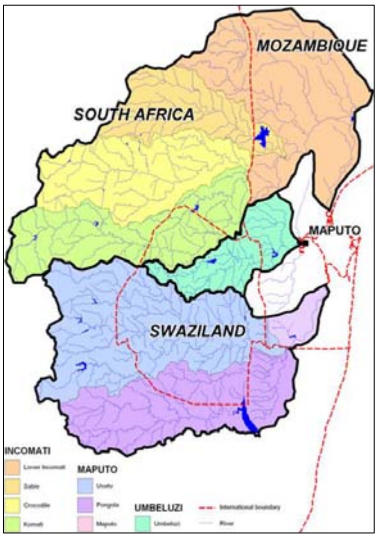
Groundwater schemes north of Maputo and Maracuene included in all alternatives

Transboundary and strategic issues

TRANSBOUNDARY AGREEMENTS

The Interim IncoMaputo Agreement (2002)

The 1976 water sharing agreement for Umbeluzi River



STRATEGIC DECISION

- ***Mozambican government must be given the possibility to independently secure the water supply to the City of Maputo and to other users in southern Mozambique***

- ***The strategy must be long-term, i.e. look beyond 2030***

Formulation of the strategies

Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

BASELINE

- ***Urgent need to add new source of supply***
- ***Considerable uncertainties still exist***
  - technical design and costing
  - funding
  - finalisation of water-sharing agreements

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Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

2010	2011	2012	2013	2014	2015

- Design, tendering and securing funds for a new source of 44 Mm³/year (2010–2012)
- Implementation of new source of 44 Mm³/year (2012–2015)
- Feasibility studies for long-term solution (2010–2012)
- Finalisation of water-sharing agreements (2010–2012)

Decision on long-term strategy

Preparatory studies, fund raising and implementation of long-term solution

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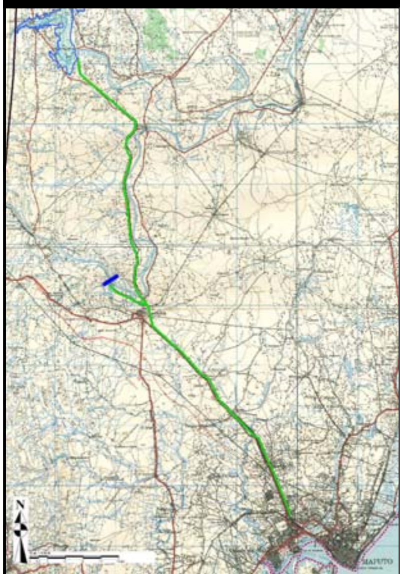
Augmentation of Water Supply for the City of Maputo and its Metropolitan Area



Strategy 1

Corumana transfer

Options for first phase

2010-2015

Strategy 2

Maputo transfers

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STRATEGY Alternative 1

1. ***Complete the <u>Corumana Dam</u>, source funds and develop a transfer scheme of 43.8 Mm³/year to Maputo City***
2. ***Initiate detailed feasibility studies for***
   Moamba Major
   Maputo River
   Groundwater resources north of Maracuene
3. ***Finalise the IncoMaputo Agreement and a comprehensive Agreement on the Umbeluzi River***
4. ***Based on the above decide on the long-term water supply solution to Maputo City and other users in southern Mozambique***

STRATEGY Alternative 2

1. ***Initiate feasibility, technical design, source funds and develop an intake, off-channel storage in <u>Maputo River</u> and a transfer scheme of 43.8 Mm³/year to Maputo City***
2. ***Initiate detailed feasibility studies for***
   Moamba Major
   Groundwater resources north of Maracuene
3. ***Finalise the IncoMaputo Agreement and a comprehensive Agreement on the Umbeluzi River***
4. ***Based on the above decide on the long-term water supply solution to Maputo City and other users in southern Mozambique***

WDM MUST BE PART OF STRATEGIES

1. *Preparations for emergency curtailment 2010-2015*
2. *Initiate Education and Advocacy campaign asap*
3. *Support FIPAG in leakage reduction programme*
4. *Initiate from 2015*
   - *Improved tariff and billing control*
   - *Meters at households*
   - *Water saving devices*
   - *Pressure management*
5. *Continue development of small-scale GW in north Maputo*

Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

Year	2010	2011	2012	2013	2014	2015	2016	2017
STRATEGY 1: 43.8 Mm³/yr from Corumana								
WDM: Emergency plan to curtail water use if necessary								
Master Plan for Maputo City water supply network								
Plan for reaching compliance of the IIMA allocations								
Finalise IIMA and agreement for the Umbeluzi River								
Development of small-scale groundwater in north Maputo								
Design, funding and tendering of Corumana completion								
Completion of Corumana Dam, treatment plant and pipeline								
Detailed feasibility studies for Moamba, Maputo River and GW								
Decision on long-term strategy			X					
Design, Financing and tendering for long-term solution								
Development of long-term solution								
WDM: Education and advocacy of reducing water usage								
WDM: Comprehensive programme								

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Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

Year	2010	2011	2012	2013	2014	2015	2016	2017
STRATEGY 2: *43.8 Mm^3/ from Maputo River upstream Salamanga*								
WDM: Emergency plan to curtail water use if necessary								
Master Plan for Maputo City water supply network								
Plan for reaching compliance of the IIMA allocations								
Finalise IIMA and agreement for the Umbeluzi River								
Development of small-scale groundwater in north Maputo								
WQ monitoring, Feasibility/ ESIA study for Maputo River								
Design, Financing and tendering transfer from Maputo River								
Development of transfer from Maputo River								
Detailed feasibility studies for Moamba and large-scale GW								
Decision on long-term strategy			X					
Design, Financing and tendering for long-term solution								
Development of long-term solution								
WDM: Education and advocacy of reducing water usage								
WDM: Comprehensive programme								

Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

PROS AND CONS

STRATEGY Alternative 1:

- *Funding partly secured*
- *Little risk, shortest lead time*
- *Adds the source in the NW expansion area of Maputo City*
- *Provides storage that gives more flexibility for reallocation in a drought emergency*
- *More expensive*

STRATEGY Alternative 2:

- *Cheapest*
- *Less competition amongst water users*
- *Risk of extended lead time because of no preparatory studies*

SWECO International, DHI, BKS, Consultec

APPENDIX 9

MINUTES OF 4TH PSC MEETING IN

MAPUTO 29 SEP 2009

Progressive Realization of the IncoMaputo Agreement (PRIMA)

Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

Minutes of 4th Meeting with the PSC held on the 29th September 2009 at the VIP Hotel, Maputo, Mozambique

Draft Version

<u>Present:</u>

Representing PRIMA:

- Issufo Chutumia, Project Manager of PRIMA
- Ivo van Haren, PRIMA Program Coordinator

Representing DNA, Mozambique:

- Delário Sengo, Head, International Rivers Office
- Hélio Banze, Director UGBU, ARA-Sul
- Jaime Mianga, ARA-Sul

Representing DWA, Swaziland:

- Nompumelelo Matsebula, PRIMA Country Staff
- Trevor Shongwe, Chief Water Engineer
- Sakhiwe Nkomo, Senior Water Engineer
- Sindy Mthimkhulu, Senior Water Engineer

Representing DWAF, South Africa:

- Niel Van Wyk, RSA Delegation Leader
- Kennedy Mandaza, Country Staff, PRIMA

Representing SWECO International and Associates:

- Lennart Lundberg, Team Leader, SWECO
- Rikard Liden, Team Coordinator, SWECO Southern Africa
- Alvaro Carmo Vaz, Deputy Team Leader, CONSULTEC, Mozambique

1 Opening

Mr Chutumia opened the meeting and welcomed everyone.

2 Approval of the Agenda

The tentative agenda was discussed and approved.

Participants: PSC members, Consultants
Agenda
1) Opening
2) Approval of the Agenda
3) Approval of Minutes from 3rd PSC meeting
4) Finalisation of the Strategy Report
5) Ending of the project a. Final Project Report and minutes from workshops b. Invoices and payments
6) Other matters
7) Closure of meeting

3 Approval of minutes from 3rd PSC meeting

Wording on Page 4, 2nd paragraph, was changed to “At the same time, the final Water Balance report shall be delivered".

With that change the minutes were approved.

It was agreed that the minutes should be signed by Mr. van Wyk, Mr. Sengo, Mr. Shongwe (heads of the delegations), Mr. Chutumia (for PRIMA) and Dr. Lidén (for the Consultant).

4 Finalisation of the Strategy Report

It was decided on the following agenda

2 Oct	Minutes of the workshops and minutes of the PSC meeting to be delivered by the Consultant.
12 Oct	Comments on minutes by the Client to be sent to the Consultant
16 Oct	Submission of Final Draft Strategy report in English
20 Oct	Submission of Final Draft Strategy report in Portuguese
30 Oct	Submission of Final Strategy Report and Final Project Report

5 Ending of the project

With the delivery of the Final Strategy Report and the Final Project Report in accordance with the agenda above the project will be ended.

Mr Chutumia said that the 4th invoice was currently being processed an will in short be paid to the Consultant.

The last invoice will be submitted to the Client by 30 October to enable final payment before end of contract at 12 December 2009.

No other formal documents besides the Final Project Report and the last invoice are needed for closure of contract.

6 Other matters

None

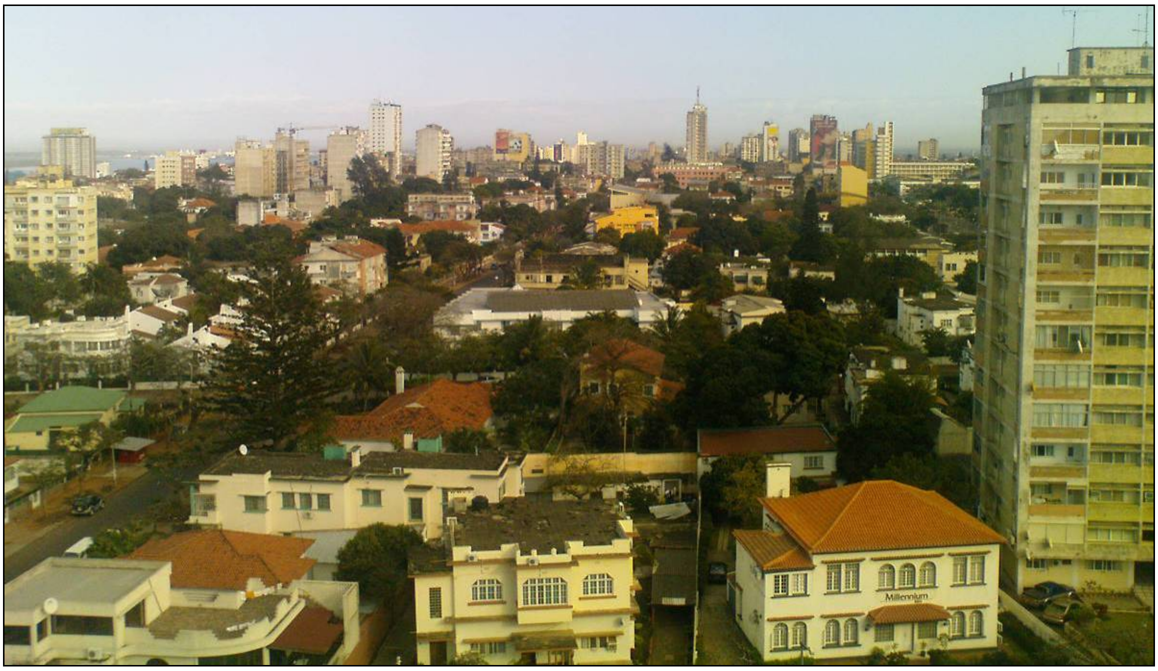
7 Closure of Meeting

The PRIMA management and the heads of the delegations expressed their appreciation for the work done by the Consultant and were glad to see the first PRIMA project ending with a tangible result guided by the involvement of the three countries.

Mr Lundberg thanked the PRIMA Management and the three countries for their support and inputs during the project.

Mr Chutumia closed the meeting.

Augmentation of Water Supply to the City of Maputo and its Metropolitan Area



Water Supply Strategies for Greater Maputo Area until 2030

Final Report, 30 October 2009

SWECO International
DHI, BKS, CONSULTEC

Client:	**National Directorate of Water, Mozambique, on behalf of the Tripartite Permanent Technical Committee (TPTC) between Mozambique, South Africa and Swaziland**
Project:	**Progressive Realization of the IncoMaputo Agreement (PRIMA)**
Study:	**Augmentation of Water Supply to the City of Maputo and its Metropolitan Area**
Title:	**Water Supply Strategies for Greater Maputo Area until 2030**
Sub title:	**-**
Status of report:	**Final**
SWECO Project No:	**1989705**
Date:	**30 Oct 2009**
Project team:	**SWECO International AB, Sweden (lead)** **CONSULTEC Lda, Mozambique** **BKS Group, South Africa** **DHI Water, Environment, Health, Denmark**

Approved and quality controlled by:

SWECO INTERNATIONAL CONSULTING WORLDWIDE SWECO

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EXECUTIVE SUMMARY

Background and general methodology

This report is the final result of the project "*Augmentation of Water Supply for the City of Maputo and its Metropolitan Area*". The objective of the project is to present two alternative strategies to secure sufficient water supply to the greater Maputo area up to the year 2030.

The development of the strategies has been conducted through a process in which new supply alternatives for the City of Maputo have been identified, evaluated and reduced to a set of main alternatives, taking into account water availability, costs, environmental and social impacts, multi-purpose benefits and lead times before commissioning. In the process possible Water Demand Management measures for the urban area of Maputo have been identified and proposed.

The main alternatives have been studied in detail by conducting water balance analyses to assess the assurance of water supply, preliminary design of the storage, abstraction and conveyance infrastructure and the investment cost. Financial analyses have been conducted to provide the comparative Unit Reference Values, expressed as USD per m^3, for the main alternatives.

The results of the water balance analysis and the financial analysis were evaluated in the perspective of the transboundary framework in which Mozambique, Swaziland and South Africa are sharing the Incomati, Maputo and Umbeluzi rivers. Based on this evaluation, the two final strategies for augmentation of the water supply to the City of Maputo and its metropolitan area were selected.

Current situation

The City of Maputo and its metropolitan area is currently supplied with water from two sources:

1. Intake from the Umbeluzi River downstream of the Pequenos Libombos Dam;
2. Groundwater supply from a number of small independent systems within the northern part of the city and in Catembe.

The present water use (2007) is estimated at 67 Mm^3/year. Of this about 57 Mm^3/year is supplied from the Umbeluzi River, while the remaining 10 Mm^3/year comes from groundwater. In 2030 the forecasted water demand, under the assumption that water losses (unaccounted for water) will be reduced to 25%, would reach 141 Mm^3/year in the most probable scenario. The corresponding high scenario would reach 167 Mm^3/year.

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The Pequenos Libombos is a multi-purpose dam that also supplies water to irrigators. According to ARA-Sul, the present use of water for irrigation downstream of the dam is 28 Mm^3/year, while the projected use in 2030 is 37 Mm^3/year.

The water balance calculations show that the greater Maputo will over time face increasingly serious water deficits. If both water supply and irrigation is to be supplied at 100% assurance there is already today a slight water deficit, while in 2030 the required additional water supply would be 125-150 Mm^3/year. Although, neither water supply nor irrigation requires 100% assurance, this demonstrates that additional sources are urgently required to secure water supply to the City of Maputo and its metropolitan area in both the short and long term.

The assessment of groundwater water resources in Catembe and Inhaca indicates that these sources will be sufficient to supply the local demands for the period up to 2030.

Screening of gross list of supply alternatives

Possible future water supply sources for the Greater Maputo area are:

- Piped surface water from the nearby Umbeluzi, Incomati and Maputo rivers;
- Groundwater from aquifers within or adjacent to the City of Maputo;
- Desalination of sea water;
- Re-use of water; and
- Piped water from distant large sources such as the Limpopo River.

Based on previous studies and consultations with stakeholders thirteen possible developments of surface and groundwater resources were identified to supplement the existing water resource at Pequenos Libombos Dam (see Table S.1).

Cost estimates were made for all the gross supply alternatives. For the Corumana, Moamba and Movene dams, previous studies carried out by Lahmeyer and Associates (2003), Norconsult (2003) and SWECO and Associates (2005a), which all conducted cost estimates at different degrees of detailing, were reviewed. The costs were escalated to 2009 price level by using a 10.1% escalation rate per annum, based on actual escalations seen during the last seven years. For the Maputo River, groundwater and Massingir alternatives new estimates were made based on preliminary designs of the water abstraction and conveyance infrastructure. References from Australia and South Africa were used to guide the estimates for large desalination and recycling schemes.

Pipelines and pump stations generally make up the largest part of the total costs of the schemes. The use of steel pipelines was assumed for alternatives based on the experience from large water transfer schemes in South Africa. Unit prices were taken from recent and on-going projects in South Africa with an additional allowance of 25% to make it applicable to Mozambican cost level.

The cost estimates in Table S.1 indicate that, except for the small-scale development of boreholes within northern Maputo, no new source would cost less than 0.55 USD/m^3. The developments of the transfers from Corumana/Moamba and Maputo River at Salamanga have similar unit reference costs being in the order of 0.55-0.65 USD/m^3. Desalinisation exhibits by far the highest unit reference cost followed by the transfer of water from Limpopo and recycling of waste water.

Environmental and social screenings of the alternatives were conducted based on a group of five indicators:

1. Environmental pressures: used to analyse the causes of environmental problems.
2. State of the environment: related to the quality of the environment and natural resources from human actions/pressures.
3. Impact on the environment and society: looks at the impacts and effects of human activities on the environment.
4. Responses to the environment: related to the responses and measures that society applies to the environment.
5. Management Indicators: related to the management of legal and economic instruments developed by society.

These indicators were evaluated through a desk-top assessment of the social and biophysical characteristics of the thirteen potential areas of intervention.

The projects with less global socio-economic and environmental impact are the intake and transfer from the existing Corumana Dam, re-use of wastewater and the intake and transfer from Massingir Dam. All these schemes do to a large degree count on already existing infrastructure and thus have relatively small negative additional impacts. The largest relative impacts are expected from the construction of Moamba Major Dam in combination with the Movene Dam.

It should be noted that the environmental and social screening has been limited to gross impacts. Most environmental and social impacts may be handled through environmental management and mitigation measures. As possible environmental mitigation and management measures have not been assessed, the scores in Table S, for favouring or discarding alternatives, should therefore be taken with caution as the only criterion.

Besides the costs and environmental and social impacts other factors must also be taken into account to evaluate the different alternatives. The most notable factor is the possible use of the water supply schemes for other users than Maputo City.

The Moamba Major has the most obvious multi-purpose function since it would augment the expansion of irrigation in the lower Incomati in Mozambique. The Moamba Major dam also has potential flood mitigation merits for the lower Incomati, which is prone to large floods. All the alternatives of distant sources, such as Corumana, Moamba Major, Massingir, Maputo River and groundwater north of Maracuene, would also make it possible to deliver treated water directly to settlements along the pipeline routes

The time required before commissioning also restricts the possible supply options. Maputo water supply needs to be augmented as soon as possible as from 2015 there will be serious water deficits if the existing situation prevails. The Corumana alternative has a short lead time prior to being in operation (2014) as the World Bank has targeted funds for this alternative and is currently preparing technical studies within the NWRDP1. Moamba Major is deemed to have the longest lead time (2020), mainly because of the magnitude of the project, and the need for extensive preparatory studies, resettlement, environmental management and the relocation of the railway line. For the groundwater schemes and the transfers from the Maputo River the size of the civil works are relatively smaller and the lead time thus becomes shorter (2015).

All supply alternatives are to some extent exposed to various risks. The main risks that are not implicitly taken into account in the above criteria are uncertainties in infrastructure design and cost, environmental and social impacts, and lead times because of none or limited preparatory studies. Supply alternatives such as the Maputo River and the groundwater scheme north of Maracuene lack preparatory studies and thus involve considerable risk for increased costs or extended lead times.

All alternatives also include to varying degree an uncertainty of funding. The completion of the Corumana Dam has been secured through funding from the World Bank and involves the least risk in this regard. The search of funding for the Moamba Major Dam, pipeline from Corumana/Moamba and the treatment plant has been initiated by the Mozambican water authorities but no funding has yet been assured. Search for funding for all other alternatives have not been initiated and thus involves larger risk for extended lead time.

The results of the screening are summarised in Table S.1, which displays all criteria for all the supply alternatives.

	Criterion	URV	Env Impacts	Social Impacts	Lead Time	Multi-purpose use	Safe yield	Risks	Funding
	Unit	USD/m^3	*Relative*	*Relative*	*Year*		*Mm^3/year*		
1	**Existing Corumana dam**	0.61	-5	1	2014	Water supply along pipeline route along EN4	>87.6	Small	Search for funding of pipeline and WTP initiated
2	**Completed Corumana dam**	0.64	-11	-3	2014	Water supply along pipeline route along EN4	>87.6	Awaiting detailed dam safety and EIA study	Funding for completion secured. Search for funding of pipeline and WTP initiated
3	**Completed Corumana dam, Intake weir downstream of confluence of Sabie and Incomati**	0.76	-12	-3	2015	Water supply along pipeline route along EN4	>87.6	No feasibility or ESIA for intake made	Funding for completion secured. Search for funding of pipeline and WTP initiated.
4	**New multi-purpose dam at Moamba Major on the Incomati upstream confluence with Sabie**	0.59	-21	-10	2020	Irrigation, Power production, Flood control, Water supply along pipeline route along EN4	>87.6	Update of feasibility and ESIA studies required	Search for funding of dam, pipeline and WTP initiated. Funding of part of the dam for multi-purpose uses unclear.
5	**Moamba combined with Movene Dam**	0.56	-23	-15	2020	Irrigation, Power production, Flood control	>87.6	No feasibility or ESIA for Movene Dam made	Search for funding of dam, pipeline and WTP initiated. Funding of part of the dam for multi-purpose uses unclear.
6	**An intake at the Maputo River at Catuane**	0.77	-17	-1	2015	Water supply along pipeline to Salamanga and Bela Vista	>87.6	No feasibility or ESIA for intake and lake storage made	No search of funding initiated
7	**An intake in the Maputo River upstream Salamanga**	0.58	-17	-1	2015	Water supply along pipeline to Salamanga and Bela Vista	>87.6	No feasibility or ESIA for intake and off-channel storage made. Assessment of salt water intrusion needed to confirm intake site	No search of funding initiated
8	**Developed groundwater within northern part of Maputo south of Maracuene**	0.05	-6	-8	2011	None	9	Small	Funding partially secured through FIPAG program
9	**Developed groundwater north of Maracuene**	0.70	-12	-2	2015	Water supply along pipeline to Manica and Maracuene	30	No detailed GW modelling or test pumping made. Risk for salt water intrusion must be further investigated.	No search of funding initiated
10	**Artificial recharge from Incomati on the area north of Maracuene**	0.75	-9	-7	2015	Water supply along pipeline to Manica and Maracuene	60	No feasibility or ESIA for intake made. No detailed GW modelling or test pumping made.	No search of funding initiated
11	**Intake at Massingir Dam**	1.15	-8	-5	2017	Water supply along pipeline	>87.6	No feasibility or ESIA made	No search of funding initiated
12	**Desalinisation plant north of Maputo**	1.55	-16	-11	2017	None	>87.6	No feasibility or ESIA made. Risk for increased electricity prices.	No search of funding initiated
13	**Reuse of wastewater**	0.89	-2	-8	2015	None	28	No feasibility or ESIA made. Risk for increased electricity prices.	No search of funding initiated

Table S.1 Summarised screening for gross list of supply alternatives.

Water Demand Management

In addition to the supply sources it is important to consider water demand management as an indirect source by minimising the water demand. Based on the recent experience from water demand management in Cape Town and Durban possible measures were assessed for Maputo City.

The most efficient water demand management measure is loss reduction in the distribution network. Current estimates of unaccounted for water in Maputo are 55%. FIPAG is therefore at the moment conducting extensive measures aiming to reduce the losses down to 25%. The assumption of 25% losses has, however, already been taken into account in the estimated future urban water demand and further loss reduction is not judged reasonable up to 2030. Loss reduction has therefore not been considered further as part of the water demand management even if it is strongly recommended to support FIPAG in the present and future programme for loss reduction.

Besides loss reduction, it was found that the most cost effective approaches at reducing water usage are household metering, improved tariffs and billing system as well as education and advocacy. Also pressure management and fitting of water saving devices have reasonable costs, while grey water systems and rain harvesting appear to be the least cost efficient tools of WDM.

For the Maputo City the desk-top assessment indicated that annual water savings of 29 Mm^3/year are possible from the interventions, such as household metering, improved tariffs and billing system, education and advocacy, pressure management, water saving devices, grey water systems and rain harvesting. The annual cost of this full bundle of recommended water demand interventions is estimated as 8.6 MUSD.

Of the 29 Mm^3/year, some 44% are judged to be reached with education and advocacy as well as with fitting of water saving devices, which are judged easily implementable in the short-term in the City of Maputo. The implementation of pressure management and household metering, and in the long-term grey water systems and rainwater harvesting, will require longer lead time awaiting the extensive upgrade of the distribution network that FIPAG is currently conducting.

Choice of main alternatives

Based on the screening of supply alternatives and the assessment of water demand management three main alternative combinations were chosen. The major motivations for the choice of main alternatives were:

- The forecasted deficit for 2030 of 120-150 Mm^3/year requires more than one source to be developed because the IIMA limits the allocation from Incomati or Maputo Rivers to 87.6 Mm^3/year.

- The transfer from the completed Corumana Dam and the transfer from Maputo River upstream of Salamanga both have moderate costs, moderate environmental and social impacts and relatively short lead times, and should therefore be considered options.
- The existing Corumana dam option is not considered because it is already committed for irrigation in lower Incomati. For the same reason it is neither judged viable to take the full amount of 87.6 Mm^3/year from the completed Corumana Dam and this option should therefore only be considered in combination with other sources from Incomati or Maputo Rivers.
- Although being the cheapest alternative of the large transfer schemes, the Moamba Major has not been considered exclusively because of the long lead time. The very low assurance of supply would not be acceptable for a 10-year period up to 2020, when the Moamba Major dam can be in operation. However, because of its potential multi-purpose benefits and its possibility of being a long-term solution for Maputo water supply, the Moamba Major Dam deserves to be included as an alternative water supply sources subsequent to a first source that can be implemented within the coming five years.
- Groundwater in north Maputo and north of Maracuene are viable options with no competing uses and should be developed, if needed, as a complement to the transfer schemes from Incomati and/or Maputo.
- Water demand management would in all cases be economically motivated and should be implemented as soon as possible.
- From a cost perspective the use of desalinisation, reuse of wastewater and piping from Massingir Dam in Limpopo are too expensive as compared to the options of retrieving water from the Incomati and/or Maputo Rivers. Similarly, the artificial recharge and the Catuane intake in Maputo River are comparatively more expensive relative to nearby options of piping the water directly from the rivers at Corumana/Moamba and Salamanga.
- The intake on the Incomati downstream of the Sabie confluence is not considered because of its higher cost compared to taking water directly from Corumana, and because the weir on the Incomati River would require more maintenance to manage possible problems with siltation .
- Risks due to lack of preparatory studies or large environmental and social impacts have been assumed to be manageable as detailed feasibility studies and ESIA will be conducted for all alternatives before implementation.

The selected main alternatives thus include:

A: Main source from Incomati River augmented by groundwater and WDM.

43.8 Mm^3/year from Corumana Dam followed by the development of Moamba Major Dam for the full transfer of 87.6 Mm^3/year. Pipeline for raw water from Corumana to Moamba. Treatment plant at Moamba and a pipeline from Moamba to Maputo City. Development of the groundwater schemes in north Maputo and north of Maracuene. Immediate Water Demand Management measures implemented.

B: Main sources from Incomati and Maputo rivers augmented by groundwater and WDM

43.8 Mm^3/year from Corumana Dam followed by the development of 43.8 Mm^3/year from Maputo River through an intake upstream Salamanga and an off-river-storage. Pipeline for raw water from Corumana to Moamba. Treatment plant at Moamba and a pipeline from Moamba to Maputo City. Treatment plant at Salamanga and pipeline to Maputo City. Development of the groundwater schemes in north Maputo and north of Maracuene. Immediate Water Demand Management measures implemented.

C: Main source from Maputo River augmented by groundwater and WDM

87.6 Mm^3/year from Maputo River through an intake upstream Salamanga and an off-river-storage. Treatment plant at Salamanga and pipeline to Maputo City. Development of the groundwater schemes in north Maputo and north of Maracuene. Immediate Water demand Management measures implemented.

Water balance analysis

The assurances of supply of water to the city of Maputo and for irrigation in the Umbeluzi and Incomati were calculated for each of the main alternatives. The assurances of supply are primarily used to determine the suitable phasing of the development of new water sources. Ideally the development options should be implemented to ensure that the projected demands can be supplied at the required 98% and 80% assurances for urban supply and irrigation respectively.

The water balance and assurance of supply exercise was conducted using the Water Resources Yield Model (WRYM). The WRYM is a monthly time step water balance model developed to model the yield and hydropower of a catchment or multiple catchments. The model utilises naturalised hydrology as input and simulates the catchment at a constant development level, i.e. water infrastructure, water demands and land use remain constant during each simulation of development years. The model was thus set-up for a number of development levels up until 2030, namely 2007, 2010, 2020 and 2030. The naturalised hydrology of the most recent and up to date studies on the Umbeluzi, Incomati and Maputo Rivers was utilised.

The water balance analysis assumed the most probable development of water demand and dam development in the upstream countries up to 2030. It further assumed that the existing water sharing agreements will be complied with for the three rivers. Water allocations stipulated by the IIMA that are presently exceeded (Crocodile) were therefore curtailed. The minimum border flows in the Incomati and Maputo Rivers were set to the IIMA-defined flows for the ecosystem. In the Umbeluzi River the border flows were set according to the 1976 agreement assuming minimum flows corresponding to 40% of the measured low flows at the GS3 and GS10 stations in Swaziland.

The results show that the assurance of supply for Maputo city with only the Pequenos Libombos was already around 90% in 2007, and decreases significantly beyond 2010. Possible interventions that can provide 43.8 Mm^3/year will improve the assurance of supply in 2010, but shortages and a lower assurance of supply occur again in 2020. This shows that the implementation of a new water source providing 43.8 Mm^3/year is not sufficient in 2020, and alternative sources need to be implemented for an additional water supply of 43.8 Mm^3/year, as the full allocation of 87.6 Mm^3/year needs to be made available before 2020. The inclusion of an additional 39 Mm^3/year from groundwater sources does improve the assurance of supply although in 2030, not even this additional source will be sufficient to reach 98% assurance.

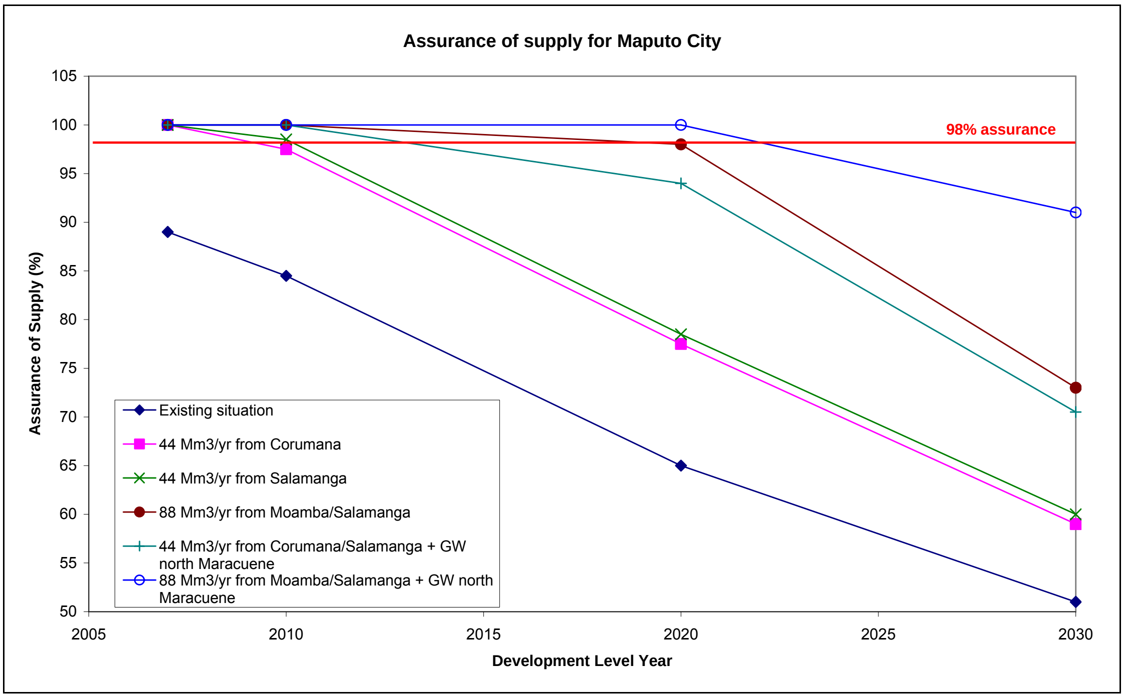

Figure S.1 Assurance of supply for Maputo city

Cost and financial analyses

The cost analysis made in the screening process was refined for the main alternatives. The total capital costs are given in Table S.2

Table S.2 Total capital cost for the implementation alternatives.

	Total Capital Cost in 2009 (MUSD)
A: 44 Mm^3/yr from Corumana followed by 88 Mm^3/yr from Moamba	1,000
B: 44 Mm^3/yr from Corumana followed by 44 Mm^3/yr from Maputo River	940
C: 44 + 44 Mm^3/yr from Maputo phased	842

Note: Groundwater schemes north of Maputo and Maracuene included in all alternatives

The costs for the four large schemes are for comparison

- GW scheme north of Maracuene 193 MUSD
- 44 Mm^3/year from Corumana 410 MUSD
- 44 Mm^3/year from Moamba Major 395 MUSD
- 44 Mm^3/year from Maputo River 335 MUSD

The majority of the costs relates to the cost items pipelines and pumping stations. The large sources, Incomati River, Maputo River and groundwater north of Maracuene require transfer of water over distances 60-90 km, which makes the infrastructural cost considerable. Because of significantly increased costs for pipelines and pumping stations in recent years these new cost estimates are generally higher compared with previous estimates.

Assuming a phased implementation of the main alternatives and talking into account maintenance and operation costs as well as discounted income from water sales for the period up to 2030 the Unit Reference Values (URV) vary from approximately 0.7 to 1.1 USD/m^3 depending on alternative and discount rates (Table S.3).

Table S.3 Unit Reference Values in USD/m^3.

	URV @ 4%	**URV @ 6%**	**URV @ 8%**
A: 44 Mm^3/yr from Corumana followed by 88 Mm^3/yr from Moamba	0.85	0.96	1.08
B: 44 Mm^3/yr from Corumana followed by 44 Mm^3/yr from Maputo River	0.79	0.90	1.02
C: 44 +44 Mm^3/yr from Maputo phased	0.73	0.82	0.92

Note: Groundwater schemes north of Maputo and Maracuene included in all alternatives

Transboundary and strategic issues

Besides technical and financial criteria, the choice of the final strategy to provide sufficient water supply to the greater Maputo also depends on transboundary issues and strategic choices related to securing water resources for all users in southern Mozambique in the long-term.

The allocation of water in the three river basins, Incomati, Umbeluzi and Maputo, is presently guided by the two water sharing agreements:

- Water-sharing agreement for the Umbeluzi River signed in 1976 between Mozambique and Swaziland. This agreement defines that Mozambique should receive 40% of the flows measured at two hydrometric stations, GS3 and GS10 in the Umbeluzi River, at the border between Swaziland and Mozambique. The agreement does not refer to any water allocations in the two countries and lacks any reference to minimum cross-border flows or how annual volumes agreed for cross-border flows should be distributed with time.
- Interim IncoMaputo Agreement (IIMA) signed in 2002 between South Africa, Swaziland and Mozambique. This agreement's general objective is to promote co-operation among the three countries to ensure the protection and sustainable utilisation of the water resources within the Incomati and Maputo river basins. The joint body for co-operation between the countries shall be the Tripartite Permanent Technical Committee (TPTC). The IIMA includes details on water allocation between the countries and sectors as well as on specific border flows for the ecological reserve.

The approach in this study has been, in accordance with the ToR, to assume that the existing bi-lateral and multi-lateral agreements are complied with. With this assumption the City of Maputo will have serious problems to secure its water supply up to 2030 and the suggested strategies therefore require utilisation of less cost-efficient options such as the groundwater resources north of Maracuene.

A change in the magnitude of border flows into Mozambique, such as a negotiated comprehensive water-sharing agreement for Umbeluzi or a re-negotiated IIMA may change the preferred strategy and may make it possible to find more cost-efficient solutions. It is therefore essential to include the process of transboundary river basin management in the water supply strategies.

Nevertheless, the decision of the final strategy for Maputo supply must give the Mozambican government the possibility to independently secure the long-term water supply to the City of Maputo, as well as to other water users in southern Mozambique. At the same time, as much flexibility as possible should be built into the strategies to enable more cost efficient solutions, should the transboundary water-sharing agreements be updated or more detailed information becomes available after further preparatory studies.

Choice of two alternative strategies

Based on the uncertainties involved in the present status of the water-sharing agreements and the risks associated with limited preparatory studies for some of the main alternatives, it was concluded that none of the three main alternatives (A-C) should be excluded as the proposed strategy. The uncertainties and risks make it difficult for the Mozambican water authorities to decide on the long-term solution based only on the findings of this study.

However, the immediate water deficit that Maputo City faces already in the coming five years makes it of utmost importance to start implementation of at least one additional source as soon as possible. Both proposed strategies are therefore structured with a first phase, the short-term strategy, focussing on preparation and implementation of infrastructure for a transfer of 43.8 Mm^3/year either from Incomati or Maputo before 2015 (Figure S.2).

In parallel with the preparation for implementation of infrastructure for the short-term augmentation of Maputo water supply it is essential to conduct necessary technical and financial feasibility studies and ESIA for alternatives aiming for a long-term solution of water sources for the Greater Maputo and other users in southern Mozambique. It is also essential to finalise the negotiations for water sharing agreements for all three rivers during the coming years.

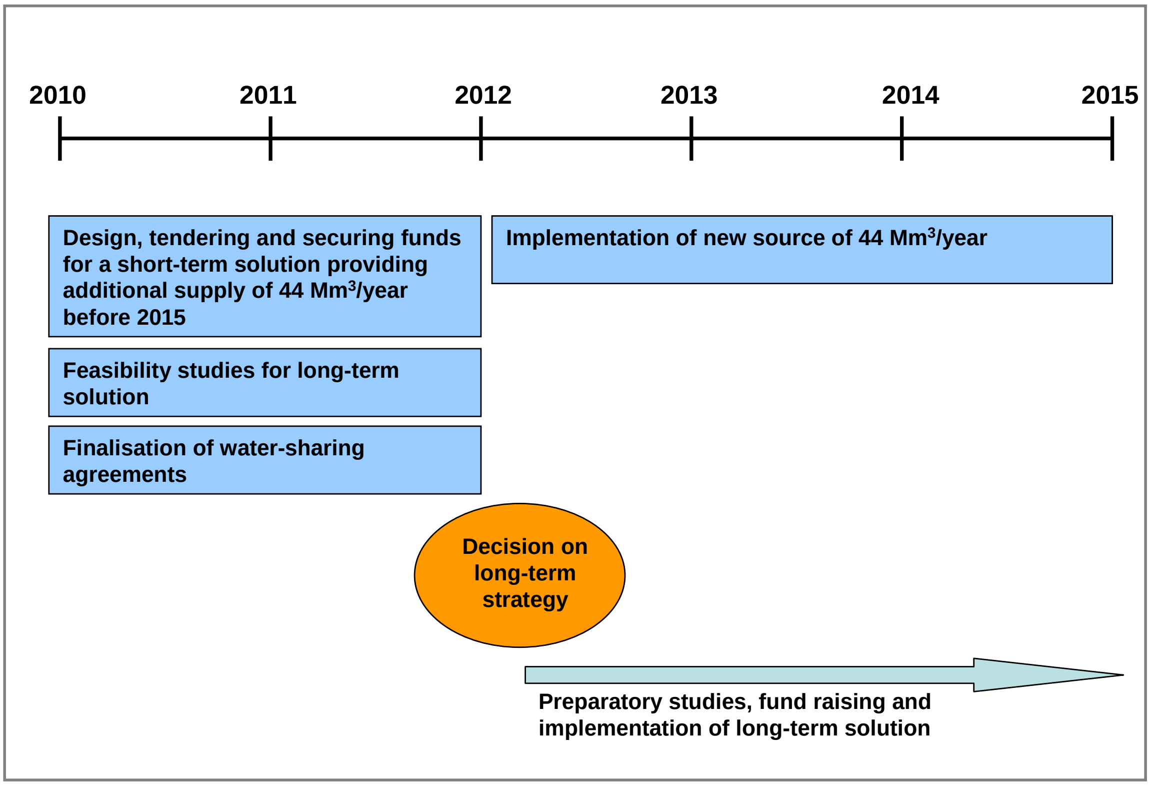

Figure S.2 General structure of the proposed strategies.

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With updated information from conducted feasibility studies for all main alternative sources and with the boundary conditions set out in the agreed final water-sharing agreements, the Mozambican Government should be able to take the final decision on the long-term strategy for the Maputo water supply. Both strategies therefore include a second phase, which is open depending on the outcome of more knowledge on the alternatives and the strategic decisions of the Mozambican Government.

Accordingly the proposed alternative strategies on the short-term (up to 2015) are:

Strategy 1: ***Development of a transfer scheme for 43.8 Mm^3/year from the completed Corumana Dam to Maputo City in parallel with exploiting groundwater resources and implementing Water Demand Management measures, as well as feasibility studies for long-term infrastructural solutions and finalisation of water-sharing agreements.***

Strategy 2: ***Development of a transfer scheme for 43.8 Mm^3/year from the Maputo River upstream of Salamanga in parallel with exploiting groundwater resources north of Maputo City and implementing Water Demand Management measures, as well as feasibility studies for long-term infrastructural solutions and finalisation of water-sharing agreements.***

The two strategies are shown graphically in Figure S.3. In Strategy 1 the Corumana Dam option was chosen because the preparatory studies are already being initiated and the funding is partially secured, which make it possible to implement before 2014. It thus probably provide the option that can be implemented first of all alternatives. In Strategy 2 the option of an intake and off-channel-storage dam at Maputo River close to Salamanga was chosen because it seems to be the most cost-efficient alternative and because the relatively lean infrastructural solution makes the lead time comparably short although no preparatory studies have yet been conducted.

Both short-term strategies are followed by the implementation of infrastructure in 2016-2020 for the long-term solution. Alternatives are the Moamba Major dam, groundwater north of Maracuene and further development of the Maputo River. The final choice of the long-term solution must therefore be made in 2012, following the finalisation of the water sharing agreements and updated preparatory studies, to allow preparatory works and tendering procedures.

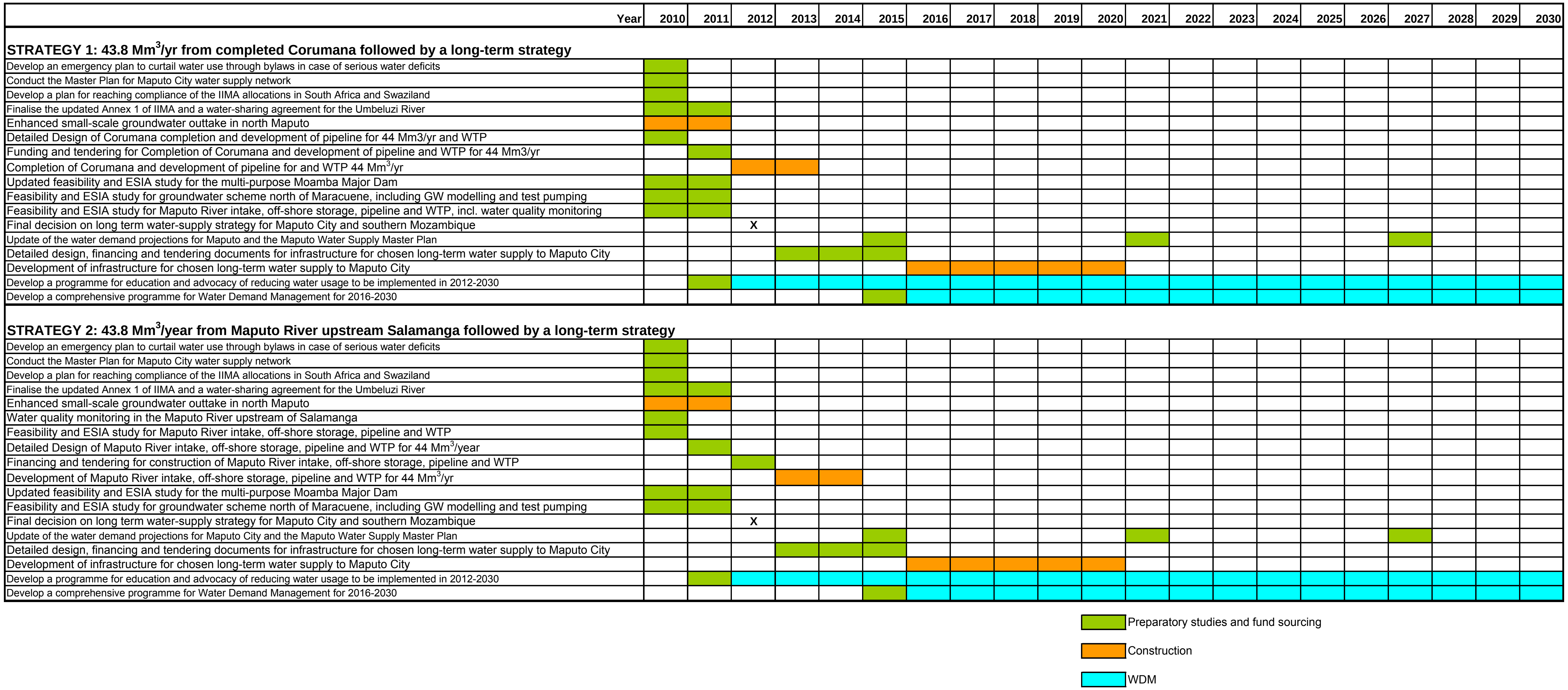

Figure S.3 Implementation plan for the chosen two alternative strategies for augmentation of the water supply to the City of Maputo and its metropolitan area.

None of the strategies will reach 98% assurance of supply because of the lead times to implement the transfers. Both strategies must therefore include Water Demand Management measures, such as emergency plans for curtailment in water scarcity situations. Also in the long-term water demand measurements are judged economically favourable and should be developed as far as possible.

Evaluation of the alternative strategies

The choice between the two proposed alternative strategies is to a certain extent a choice between risk and cost:

- Strategy 1 with the development of a transfer from the Corumana Dam as a first phase is more expensive but with less risk. Construction-wise the Corumana transfer has already been indicated to be feasible and funding is secured for the completion of the dam through the World Bank.

- Strategy 2, assuming Maputo River as the next source of the 43.8 Mm^3/year, is the cheapest alternative (estimated 70 MUSD less for the first phase) but also has the higher risk. The major risks involved with this strategy are the uncertainties regarding the infrastructural solutions and the water quality as well as the lack of secured funding. These risks may result in extended lead times or increased costs.

Strategy 1 would allow water supply to the smaller urban settlements along the EN4 and give more flexibility for FIPAG to optimise its distribution network by a new distribution centre in the north-west part of the city.

Strategy 1, especially if followed by the Moamba Major Dam, would also give the Mozambican water authorities more flexibility to manage the water resources within the country in a drought emergency situation because of the provided large storages.

From a transfer failure perspective, such as pipeline failure or similar, a final strategy with many sources is, however, preferable. This would favour a strategy involving both the Incomati and the Maputo rivers as sources.

There are also risks involved in the development of the groundwater scheme north of Maracuene as complement to the transfers from Incomati or Maputo Rivers. Because of these uncertainties it is of utmost importance to finalise the water-sharing agreements for the Incomati, Maputo and Umbeluzi Rivers within the coming two years. If the groundwater yield north of Maputo City is not sufficient, the possible additional augmentation from the transboundary water allocations from the three rivers would be the only reasonable alternative, from a cost perspective, to secure the water supply to the City of Maputo and its metropolitan area in the long-term.

Table S.4 summarises the major advantages and disadvantages for the strategic choices to augment the water supply for the Maputo City and its metropolitan area. It also gives the necessary information needed before a final decision can be taken.

It should be noted that in Table S.4 the cost estimates for the long-term alternatives are based on utilising the water allocation up to the present IIMA agreement. The results of this study have indicated that further yield can be obtained should the water-sharing agreements be revised, but this would incur higher capital costs.

For the long-term alternatives it is essential that the finalisations of the water-sharing agreements for both IncoMaputo and Umbeluzi Rivers are made in coordination with the updated feasibility studies and basic design since the allocated water is an essential input to find the most cost-efficient solution. For all alternatives the process of securing funds is essential to meet the expected year of commissioning.

Table S.4 Summary of advantages and disadvantages with the different short-term and long-term solutions.

	Yield (Mm^3/year)	**Cost (MUSD)**	**Major Advantages and Benefits**	**Major disadvantages**	**Required information / studies to be able to take a final decision**	**Expected Year to supply water**
Short-term Alternatives						
Completed Corumana	43.8	410	• Short lead time • Funds for completion secured • Provides the new source in the NW expansion areas of Maputo	• High cost because of long pipeline transfer		2014
Maputo River	43.8	340	• Least cost	• Uncertainties in cost and lead times because of lack of preparatory studies	• Assessment of salt water intrusion • Feasibility Study and Basic Design	2015
Long-term Alternatives						
Moamba Major Dam	Additional 43.8	395	• Multi-purpose use • Large storage capacity which give independence in a drought situation	• Largest negative environmental and social impact • Long lead time • Relatively high cost	• Updated feasibility study and ESIA • Secured interest and funding for other uses • Finalised water-sharing agreements for IncoMaputo and Umbeluzi Rivers	2020
Maputo River	Additional 43.8	313	• Least cost	• Uncertainties in cost and lead times because of lack of preparatory studies • Small storage giving dependence of South Africa and Swaziland in a drought situation	• Assessment of salt water intrusion • Feasibility Study and Basic Design • Finalised water-sharing agreements for IncoMaputo and Umbeluzi Rivers	2017
Additional Sources						
Groundwater	39	193	• No competing users	• Uncertainties because of lack of preparatory studies	• Monitoring and modelling of yield and salt water intrusion • Feasibility Study and Basic Design	2015
WDM	29	9	• Low cost per m^3	• Difficulties to implement because of low coverage of piped water • Uncertain effect of measures	• More detailed study on possibility to implement larger WDM measures such as grey water system and rain harvesting	Gradually 2015-2030

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WATER SUPPLY STRATEGIES FOR GREATER MAPUTO AREA UNTIL 2030

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PREFACE

This report is the results of inputs from a large number of persons representing the Client, the consultant, stakeholders and others. The Project Steering Committee, which has guided the work, has included:

Representing PRIMA:

- Mr Issufo Chutumia, Project Manager of PRIMA
- Mr Ivo van Haren, PRIMA Program Coordinator

Representing DNA, Mozambique:

- Mr Delário Sengo, Head, International Rivers Office
- Mr Pedro Cambula, PRIMA Country Staff
- Mr Sergio Sitoe – International Rivers Office

Representing DWA, Swaziland:

- Mr Trevor Shongwe, Chief Water Engineer
- Ms Nompumelelo Matsebula, PRIMA Country Staff

Representing DWAF, South Africa:

- Mr Niel Van Wyk, RSA Delegation Leader
- Mr Kennedy Mandaza, PRIMA Country Staff

The management team of the consultant has consisted of Mr Lennart Lundberg, Team Leader, Prof. Alvaro Carmo Vaz, Deputy Team leader and Dr Rikard Lidén, Study Coordinator. Essential inputs to the study have been given by FIPAG, Water for Africa, Ninham Shand and Salomon, which has enabled the latest model set ups and data to be used for developing the water supply strategies.

All inputs to the work are greatly acknowledged.

LIST OF ABREVIATIONS

DNA	National Water Directorate in Mozambique
DWA	Department of Water Affairs in Swaziland
DWAF	Department of Water Affairs and Forestry in South Africa
EFR	Estuarine Flow Requirements
EIA	Environmental Impact Assessment
ESIA	Environmental and Social Impact Assessment
FIPAG	Fundo de Investimento e Património de Abastecimento de Água
FSL	Full storage level
GOM	Government of Mozambique
GWh	Giga-Watt-hour
IIMA	Tripartite Interim Agreement for Co-operation on the Protection and Sustainable Utilization of the Incomati and Maputo Watercourses (Interim IncoMaputo Agreement)
IWRM	Integrated Water Resources Management
IWAAS	Incomati Water Availability Assessment Study
JIBS	Joint Incomati Basin Study
JMRBS	Joint Maputo River Basin Study
JURBS	Joint Umbeluzi River Basin Study
JWC	Joint Water Commission
MAR	Mean Annual Runoff
m.a.sl.	Mean annual sea level
Mm^3	Million Cubic Metres
M&E	Mechanical and Electrical
MUSD	Million US Dollars
Mw	Mega-Watt
Ml/d	Mega litre per /day
NASA	National Aeronautics and Space Administration
NGO	Non-Governmental Organisation
NPV	Net Present Value
NRW	Non-Revenue Water
PRIMA	Progressive Realization of the Incomati Maputo Agreement
PSC	Project Steering Committee
PSP	Project Service Provider (named Consultant in this report)
SADC	Southern Africa Development Community
ToR	Terms of Reference
TPTC	Tripartite Permanent Technical Committee

LIST OF ABREVIATIONS (cont.)

UAW	Unaccounted for Water
UN	United Nations
URV	Unit Reference Value
USD	US Dollars
WB	World Bank
WC	Water Conservation
WDM	Water Demand Management
WRB	Water Resources Branch (part of DWA in Swaziland)
WRSM	Water Resources Simulation Model (runs the Pitman hydrological model)
WTP	Water Treatment Plant
WRYM	Water Resources Yield Model

1 INTRODUCTION

1.1 Background

The project "*Augmentation of Water Supply for the City of Maputo and its Metropolitan Area*" aims to study in detail the forecasts of water requirements for the City of Maputo and its metropolitan area, and the possibility of supplying these from the Umbeluzi River watercourse, augmented by new supplies from the Incomati and the Maputo river watercourses and/or groundwater resources and by increasing water use efficiencies and other water demand management measures.

The study stems from the fact that the Umbeluzi River basin, which Maputo City takes its major water supply from, is very committed and its resources will not be sufficient to meet the projected water demand growth of the metropolitan area. At the same time the adjacent rivers, the Incomati and Maputo, are also highly committed.

The Governments of Mozambique, Swaziland and South Africa have recognised the problem of water scarcity. Already in 1983 they created the Tripartite Permanent Technical Committee (TPTC) to advice on best utilisation of the three countries' water resources of the Maputo and Incomati Rivers, and a Joint Water Commission between Mozambique and Swaziland was established in 1999 for the Umbeluzi River. The Governments have since conduced transboundary basin studies for the three rivers, such as the Joint Incomati Basin Study (CONSULTEC and BKS 2001), the Three-Basins study (SWECO and Associates 2005a), the Joint Umbeluzi River Basin Study (SWECO and Associates 2005b) and the Joint Maputo River Basin Study (PLANCENTER and Associates 2008).

The outcome of the Joint Incomati Basin Study resulted in a process leading to a water-sharing agreement between the three countries regarding the Incomati and Maputo Rivers (Tripartite Interim Agreement for Cooperation of the Protection and Sustainable Utilization of the Incomati and Maputo Water Courses – IIMA), which was signed in 2002. For the Umbeluzi River basin the process of establishing a comprehensive water-sharing agreement between Mozambique and Swaziland is on-going. Until such agreement is in place the 1976 Agreement between the two countries is valid.

The three Governments have since the signing of the IIMA, through the TPTC, initiated the process of implementing the agreement. As a result the Progressive Realisation of IIMA Agreements (PRIMA) was launched, and one of the proposed projects was the consultancy services to study the Augmentation of Water Supply to the City of Maputo and its Metropolitan Area.

1.2 Objective

The aim for this report is given in the Terms of Reference:

"*Presentation of two alternative strategies to secure sufficient water supply to the greater Maputo area until 2027. The report shall also include a proposed update of annex 1 of IIMA, and recommendations on the proposed role and responsibilities for a future secretariat in the further preparation and implementation of one of the water supply strategies."*

The specific objectives of the activities related to the strategy component, given in the ToR, are:

- Evaluate all existing water supply strategies to meet the future water demands, such as optimising / conjunction of dam operating rules (including Pequenos Libombos Dam), enlargement of the Corumana dam plus construction of the Moamba Major Dam, rehabilitation or construction of other hydraulic structures such as water retention basins or reservoirs (such as Catuane), artificial groundwater infiltration and recharge measures, development of existing groundwater resources, water demand management, increasing water use efficiencies. Prioritize supply options and activities to realize the future supply.

- Prepare a set of recommendations on how to provide the future urban water supply to the City of Maputo and its metropolitan area including steps to be taken by the Parties and the TPTC, and costs and timing of proposed measures.

- Assess the consequences of these strategies in terms of cross-border discharges of the Incomati and Maputo rivers within the framework of IIMA, and in terms of water balance for Greater Maputo Area under normal and drought conditions, social and environmental impacts, environmental flow conditions, economic impacts and major technical / institutional / legal challenges related to each water supply strategy.

- Proposing an update of annex 1 of IIMA, and proposing role and responsibilities for a future secretariat in the further preparation and implementation of one of the most suitable water supply strategies, such that it offers a case study to examine the roles and rules in watershed management under the IIMA.

At the Project Steering Committee meeting on the 9th March 2009, the end year to be considered for the water balance calculation, and subsequently also for the water supply strategies was agreed to be 2030. The reason for this change was that input data on water demands from previous studies were generally expressed up to 2030.

1.3 Previous reports

The Strategy Report is the final report of the project. Inputs to this report are described in detail in the three previous reports produced in this study:

- SWECO and Associates (2009a) Water Availability, Augmentation of Water Supply to the City of Maputo and its Metropolitan Area, Final Report, 22 July 2009

- SWECO and Associates (2009b) Water Demand, Augmentation of Water Supply to the City of Maputo and its Metropolitan Area, Final Report, 22 July 2009

- SWECO and Associates (2009c) Water Balance, Augmentation of Water Supply to the City of Maputo and its Metropolitan Area, Final Report, 22 July 2009

In addition the following river specific studies have given major inputs to the strategy:

- CONSULTEC and BKS (2001) Joint Incomati Basin Study

- SWECO and Associates (2005b) Joint Umbeluzi River Basin Study

- PLANCENTER and Associates (2008) Joint Maputo River Basin Study

- Water for Africa and Associates (2009) Inkomati Water Availability Assessment

2 CURRENT WATER SUPPLY SITUATION FOR MAPUTO CITY

The City of Maputo and its metropolitan area (Figure 2.1) is currently supplied with water from two sources:

- Intake from the Umbeluzi River downstream of the Pequenos Libombos Dam;
- Groundwater supply from a number of small independent systems within the northern part of the city and in Catembe.

From the water treatment works at Umbeluzi, water is pumped a distance of 26.4 km through two parallel transmission mains to the Chamanculo distribution centre. In between, three branch mains feed Boane, Matola and Machava Distribution Centres.

The present water use (2007) is estimated at 67 Mm^3/year. Of this about 10 Mm^3/year is supplied from groundwater, while the rest comes from the Umbeluzi River.

The present treatment plant is designed for 6,000 m^3/hour (52.5 Mm^3/year) and is thus operated above its nominal capacity. FIPAG is currently in the process of increasing the capacity to 10,000 m^3/hour (87.6 m^3/year). In 2030 the forecasted water demand, including an assumption that water losses (unaccounted for water) will be reduced to 25%, is 141 Mm^3/year in the most probable scenario. The corresponding high scenario is 167 Mm^3/year.

The Pequenos Libombos is a multi-purpose dam that also supplies water to irrigators. According to ARA-Sul, the present use of water for irrigation downstream of the dam is 28 Mm^3/year, while the projected use in 2030 is 37 Mm^3/year.

The water balance calculations (SWECO and Associates 2009c) show that the greater Maputo has a serious water deficit (Figure 2.2). If both water supply and irrigation is to be supplied at 100% assurance there is already today a slight water deficit, while in 2030 the required additional water is 125-150 Mm^3/year. Although, neither water supply nor irrigation requires 100% assurance, Figure 2.2 shows that additional sources need to be identified and developed immediately to secure water supply to the City of Maputo and its metropolitan area.

The assessment of groundwater water resources in Catembe and Inhaca indicated that these will be sufficient to supply the local demands for the period up to 2030 (SWECO and Associates 2009a and 2009b).

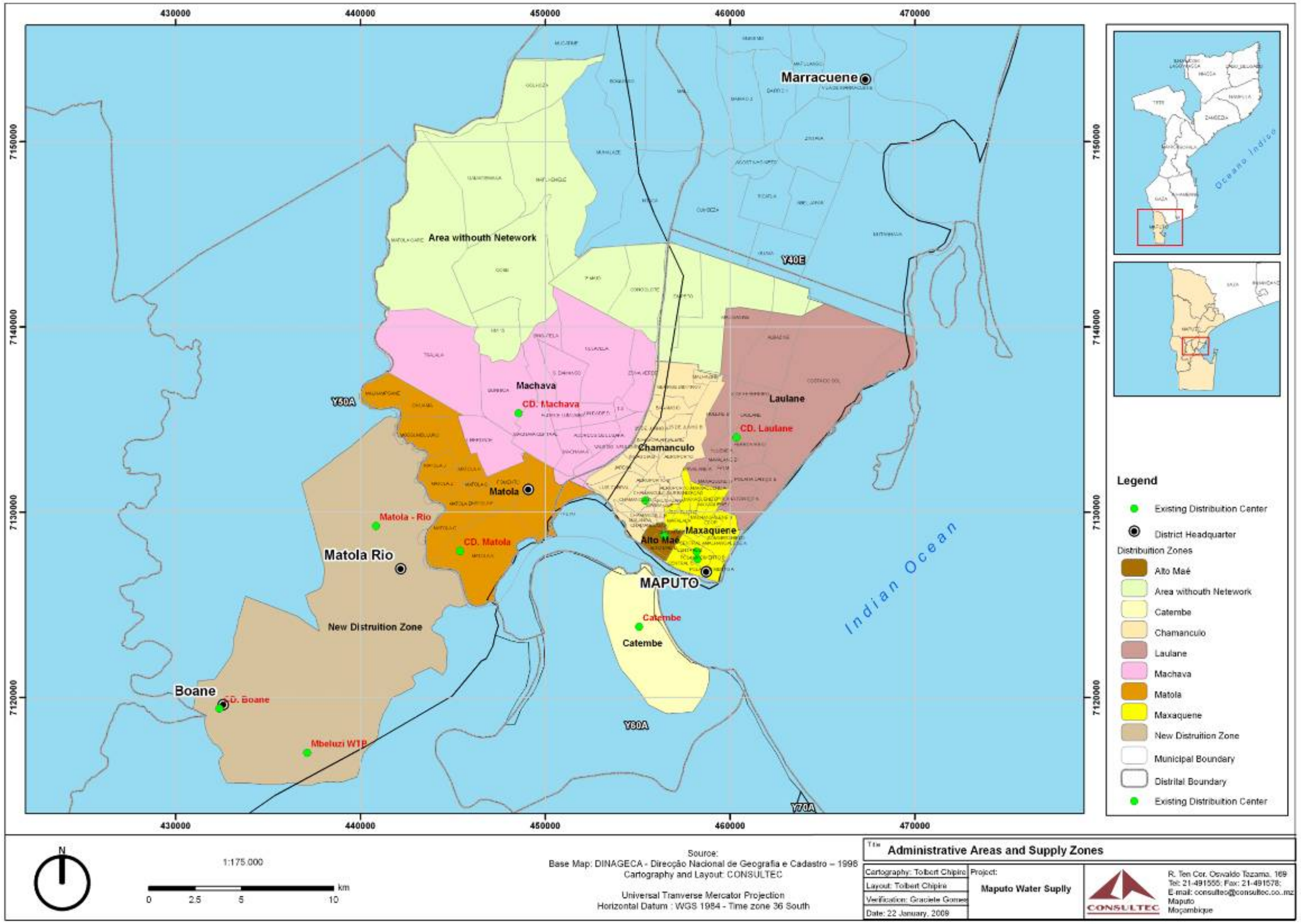


Figure 2.1

The Greater Maputo Area.

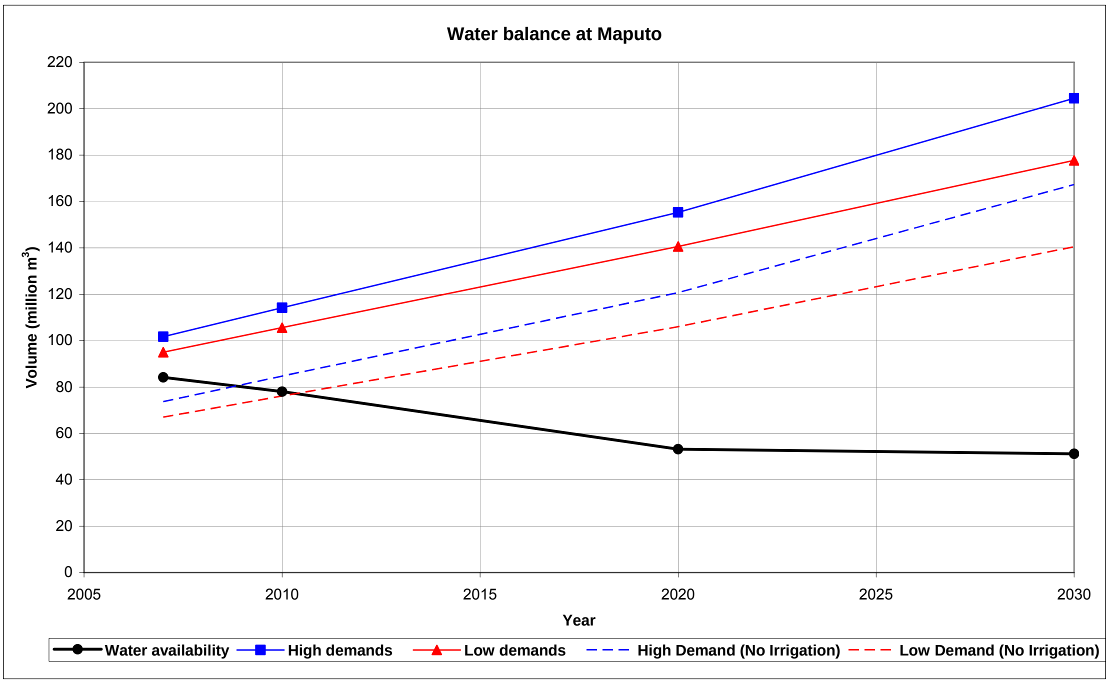


Figure 2.2 *Water balance for Maputo City assuming only existing sources of water. Water availability is based on safe yield (100% assurance) for Pequenos Libombos assuming probable development of water demand and dams in Swaziland and assuming 0.5 m^3/s releases for the estuary, and adding 10 $Mm^3/year$ as groundwater outtake. Irrigation is estimated on information from ARA-Sul on present and planned schemes downstream of Pequenos Libombos.*

3 LEGAL FRAMEWORK

3.1 Current legal setting

3.1.1 The Umbeluzi River

In 1976 Mozambique and Swaziland signed an agreement on water sharing in the Umbeluzi River basin. This agreement contains a general introduction and two articles:

- The first article defines that Mozambique should receive 40% of the flows measured at two hydrometric stations, GS3 and GS10 in the Umbeluzi River, at the border between Swaziland and Mozambique.
- The second article defines conditions for a transition period, until the construction of the Pequenos Libombos Dam in Mozambique.

As the Pequenos Libombos Dam has been completed and started operating in 1988, the second article is not valid anymore and the agreement is thus limited to its first article.

The agreement does not refer to any kind of water use or water allocations in the two countries. There is no reference in the agreement to natural or virgin flows. The agreement also lacks any reference to minimum cross-border flows or how annual volumes agreed for cross-border flows should be distributed with time.

Not part of an agreement between the two countries, but included in the environmental impact assessment for the Pequenos Libombos Dam, is the release of 0.5 m^3/s of water from the dam for downstream environmental flows for the estuary.

3.1.2 The Incomati and Maputo rivers

In 2002 South Africa, Swaziland and Mozambique signed and agreed on water sharing in the Incomati and the Maputo River basins, the Interim IncoMaputo Agreement (IIMA). This agreement's general objective is to promote co-operation among the three countries to ensure the protection and sustainable utilisation of the water resources within the basins. The joint body for co-operation between the countries shall be the Tripartite Permanent Technical Committee (TPTC) between Mozambique, South Africa and Swaziland.

Annex 1 of the agreement gives the natural mean annual runoff (MAR) for the two river basins (Table 3.1 and 3.2). The IIMA also state the allocated water for each country and sub-catchment (Tables 3.3 and 3.4). In addition to the first priority allocations, 87.6 $Mm^3/year$ was reserved for the city of Maputo and will be drawn from the total water available from further development of the Maputo or Incomati rivers.

Finally, the IIMA states the water requirements of the ecosystems of the Incomati and Maputo (Table 3.5).

Table 3.1 Contribution of the sub-catchments of the Incomati River catchment to the total natural mean annual runoff (Source: IIMA).

Sub-catchment	**Contribution to natural MAR (Mm^3/year)**			
	Mozambique	**South Africa**	**Swaziland**	**Total**
Komati	0	955	475	1 430
Crocodile	-	1 225	-	1 225
Sabie	0	750	-	750
Massintonto	10	10	-	20
Uanetze	10	5	-	15
Mazimechopes	20	-	-	20
Incomati	130	0	-	130
Total	**170**	**2 945**	**475**	**3 590**

Table 3.2 Contribution of the sub-catchments of the Maputo River catchment to the total natural mean annual runoff (Source: IIMA).

Sub-catchment	**Contribution to natural MAR (Mm^3/year)**			
	Mozambique	**South Africa**	**Swaziland**	**Total**
Lusushwana	-	80	340	420
Mpuluzi	-	220	40	260
Usuthu	5	100	505	610
Ngwempisi	-	290	210	500
Mkhondvo	-	370	200	570
Ngwavuma	-	20	160	180
Pongola	-	1 100	60	1 160
Maputo	100	-	-	100
Total	**105**	**2 180**	**1 515**	**3 800**

Table 3.3 Allocated water use in the Incomati in Mm^3/year (Source: IIMA).

South Africa	First Priority	Irrigation	Afforestation	Total
KOMATI SA	183	381	99	
CROCODILE	73	307	247	
SABIE	80	98	129	
MASSINTONTO	0.3	0	0	
UANETSE	0.3	0	0	
Total	*337*	*786*	*475*	*1,598*
Swaziland	First Priority	Irrigation	Afforestation	
KOMATI	22	261	46	329
Mozambique	First Priority	Irrigation	Afforestation	
INCOMATI U/S SABIE	1.1	29	0	
INCOMATI D/S SABIE	15.6	239	25	
SABIE	0.5	12	0	
MASSINTONTO	0.7	0	0	
UANETSE	0.6	0	0	
MAZIMCHOPE	0.5	0	0	
Total	*19*	*280*	*25*	*324*
				2,251

Table 3.4 Allocated water use in the Maputo in Mm^3/year (Source: IIMA).

South Africa	First Priority	Irrigation	Afforestation	Total
Pongola	18	517	46	
Ngwavuma	2	1.3	0	
Mkhondvo	117	13.9	42	
Ngwempisi	60	4.8	52	
Usuthu	38	0	14	
Mpuluzi	6	0.8	37	
Lusushwana	1	0.2	7	
Total	*242*	*538*	*198*	*978*
Swaziland	First Priority	Irrigation	Afforestation	
Pongola	2	6.4	0.5	
Ngwavuma	2.6	58.6	1.5	
Usuthu	39.4	462	80	
Total	44	527	82	653
Mozambique	First Priority	Irrigation	Afforestation	
Maputo	6	60	0	*66*
				1,697

Table 3.5 Allocated water for the ecosystem (Source: IIMA).

Key Point	Target Instream Flow	
	Mean	Minimum
	Mm^3/year	*m^3/s*
Incomati – Ressano Garcia	200	2.6
Sabie at border	290	0.6
Incomati – Maracuene	450	3.0
Pongola - Ndumo	300	0.8
Usutu – Big Bend	520	1.7
Nagwavuma at border	50	0.1
Maputo - Salamanga	840	2.7

3.2 Compliance of multi-lateral agreements

The latest estimated water demand for the Incomati and Maputo Rivers (SWECO and Associates 2009b) show that today's demand comprises 91% of the allocation in the Incomati in the three countries (water demand is 2056 Mm^3/year of allocated 2251, excluding Maputo City). In 2030 the demand will be 99% of the allocation.

In the Maputo River demand is presently 83% of the allocation (water demand is 1402 Mm^3/year of allocated 1697, excluding Maputo City), while projections give 93% in 2030.

Tables 3.6 and Table 3.7 show the compliance with the IIMA allocation for each of the main rivers. Water demand for irrigation in the Incomati in South Africa is today higher than the allocation, especially in the Crocodile River. Afforestation in the Usutu and Pongola significantly exceeds the allocation in both South Africa and Swaziland. In 2030 the planned irrigation in Swaziland also exceeds the IIMA allocation.

It should, however, be noted that water demand is not equal to supplied water for irrigation. The detailed water balance analysis for the Sabie, Crocodile and Komati (Water for Africa and Associates 2009) shows that actual supply are 83, 450, and 372 Mm^3/year, respectively, which shows that only the users in the Crocodile River abstract more water than stated in the agreement.

For the afforestation the actual areas for the Usutu are more or less in compliance with the allocated areas given in the IIMA, while the stream flow reduction in Tables 3.6 and 3.7 is significantly above the allocation. As a comparison, the stream flow reductions determined in the Incomati are all less than the water use allocated in the IIMA, despite the fact that the areas are more or less in accordance IIMA allocation. The reason for the differences in afforestation water use between the Usutu and the Incomati, are that the streamflow reduction methodologies used by JIBS, JMRBS and IWAAS are not the same.

Table 3.6 Compliance of the IIMA agreement in 2007. Posts marked yellow denote where the demand exceed the allocation. Data for Swaziland and South Africa taken from IWAAS and JMRBS.

SOUTH AFRICA									
	First Priority		Irrigation		Afforestation		TOTAL		
	Allowed	Actual	Allowed	Actual	Allowed	Actual	Allowed	Actual	%
SABIE	80	27	98	100	129	90	307	217	71%
CROCODILE	73	73	307	514	247	158	627	745	119%
KOMATI	183	131	381	406	99	82	663	619	93%
USUTU/PONGOLA	242	161	538	330**	198	342	978	833	85%
							2575	*2414*	*94%*
SWAZILAND									
KOMATI	22	4	261	219*	46	35	329	258	78%
USUTU/PONGOLA	44	64	527	387	82	111	653	562	86%
							982	*820*	*84%*
MOZAMBIQUE									
INKOMATI	19	12	280	180	25	25	324	217	67%
MAPUTO	6	0.3	60	7	0	0	66	7.3	11%
							390	*224.3*	*58%*

**Interbasin-tranfer to Umbeluzi for sugar cane irrigation included*
***Interbasin-tranfer to Mkuze for sugar cane irrigation included*

Table 3.7 Compliance of the IIMA agreement in 2030 based on projected water demand. Posts marked yellow denote where the demand exceed the allocation.

SOUTH AFRICA									
	First Priority		Irrigation		Afforestation		TOTAL		
	Allowed	Actual	Allowed	Actual	Allowed	Actual	Allowed	Actual	%
SABIE	80	34	98	100	129	90	307	224	73%
CROCODILE	73	88	307	514	247	158	627	760	121%
KOMATI	183	131	381	406	99	82	663	619	93%
USUTU/PONGOLA	242	163	538	334**	198	342	978	839	86%
							2575	*2442*	*95%*
SWAZILAND									
KOMATI	22	4	261	267*	46	35	329	306	93%
USUTU/PONGOLA	44	69	527	541	82	111	653	721	110%
							982	*1027*	*105%*
MOZAMBIQUE									
INKOMATI	19	18	280	280	25	25	324	323	100%
MAPUTO	6	0.3	60	24	0	0	66	25	37%
							390	*347.7*	*89%*

**Interbasin-tranfer to Umbeluzi for sugar cane irrigation included*
***Interbasin-tranfer to Mkuze for sugar cane irrigation included*

In terms of cross border flows of the Incomati at Ressano Garcia, reports have indicated that the minimum flow of 2.0 m^3/s has not been fulfilled during the driest months for the years since the signing of the agreement. No firm measurements have, however, been found that confirms these reports.

In the Umbeluzi River basin, the border flows comply on an annual basis with 84% of the flow at the GS3 and GS10 gauges flowing into Mozambique. However, on a monthly basis the border flows are less that the stipulated 40% during the dry months May to October.

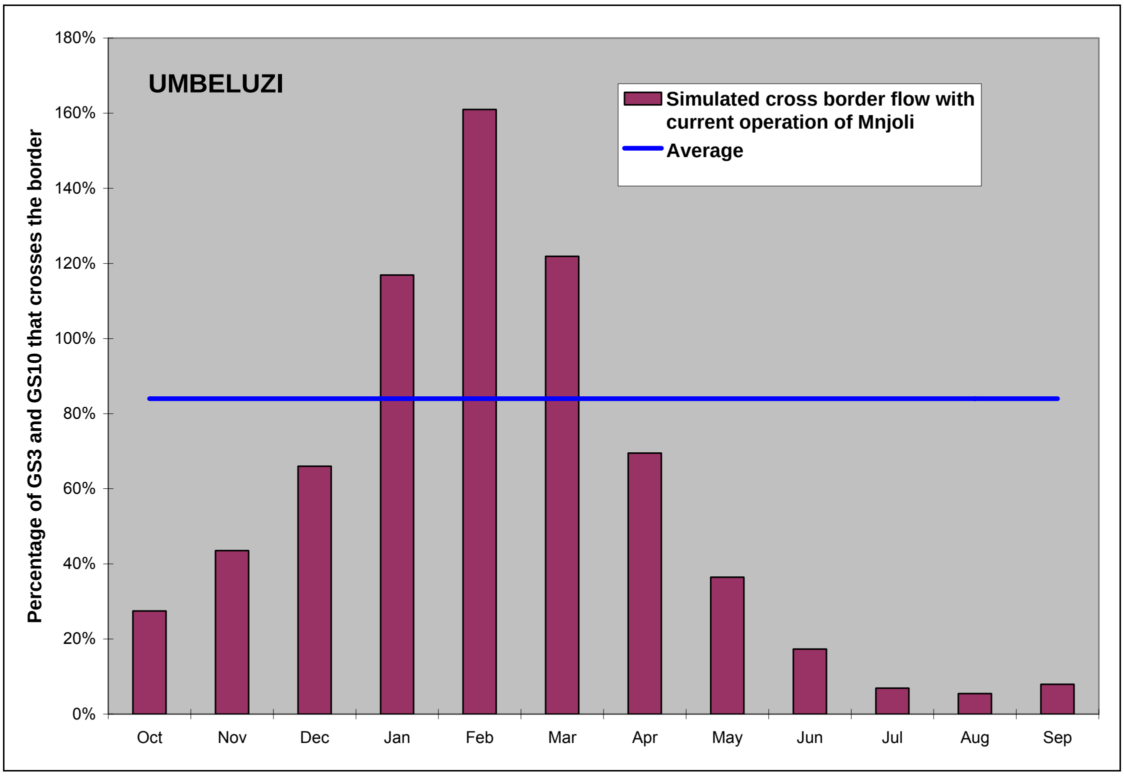


Figure 3.1 Average simulated cross border flow with the WRYM based on present operation of the Mnjoli Dam.

3.3 Assumptions for developing the water supply strategies

The strategies for the future water supply sources to the City of Maputo and its metropolitan area must be based on assumptions of the future water management of the three river basins. In accordance with the Terms of Reference the assumptions have mainly been based on the existing bi-lateral and multi-lateral agreements between the countries.

3.3.1 Compliance of water allocation in upstream countries

Based on the joint willingness to comply with the international agreements and the most probable development of water use for the different sectors, the following assumptions have been made for the separate river basins in South Africa and Swaziland for the formulation of the strategies for Maputo water supply (Table 3.7).

The basis for the assumptions is that irrigated supply should not exceed the IIMA allocation on average and that afforestation areas and streamflow reduction are kept in accordance with the IIMA.

Table 3.7 Assumptions made for the formulation of strategies for water supply to the city of Maputo.

River basin	Country	Water allocation up to 2030
Sabie	South Africa	• Irrigation will be kept at 2007 supply level, which is below the IIMA allocation. • Domestic water use is assumed to grow according to projection • No expansion in afforestation is assumed
Crocodile	South Africa	• Irrigation supply will decrease from today's supply level down to the IIMA allocation level through enforcement by the water authorities. The decrease is assumed linear from 2007 to 2015 • Domestic water use is assumed to grow according to projection. • No expansion in afforestation is assumed
Komati	South Africa	• Irrigation will be kept at 2007 supply level, which is below the IIMA allocation. • Domestic water use is assumed to grow according to projection • No expansion in afforestation is assumed • Transfers to Vaal River is assumed kept at 2007 level
Komati	Swaziland	• Irrigation will increase from today's level up to the IIMA allocation level in 2030 supplied by the Maguga Dam*. The development is assumed linear starting from 2010. • Domestic water use is assumed to grow according to projection • No expansion in afforestation is assumed
Usutu/Pongola	South Africa	• Irrigation will only marginally increase from 2007 supply level according to projections. • Domestic water use is assumed to grow according to projection • Afforestation reduced to the IIMA levels • Transfers to Vaal River is kept at 2007 level • Releases from Pongola of 5 m^3/s for preservation of the river channel is assumed to continue
Usutu	Swaziland	• Irrigation will increase from today's level up to the projected level in 2030 supplied by new infrastructure. Although the projected demand is slightly higher, the average supply will be lower than the IIMA allocation. The development is assumed linear starting from 2010. • Afforestation reduced to the IIMA levels • Domestic water use is assumed to grow according to projection.

**A study for utilisation of Maguga Dam to develop irrigation in Swaziland is presently ongoing by Swaziland Water and Agricultural Development Enterprise (SWADE).*

In addition, it is assumed that Mozambique's allocation for irrigation in the Incomati upstream of the Sabie confluence (29 Mm^3/year) is supplied by the Maguga and Driekoppies dams as a minimum flow of 0.9 m^3/s, since no other source exist for this allocation.

The Pongolapoort Dam has currently releases for three purposes:

- 5 m^3/s to preserve the water channel and keep the water level at a minimum level for pumping.
- A flood once a year (often in October) to flood the Makatini Flats for subsistence agriculture
- A release through a canal to irrigation in the Makatini Flats

Part of the 5 m^3/s is used by small water users along the river downstream of the dam, while a large part passes the border. Because no plans up to 2030 exist for expansion of irrigation downstream of the Pongolapoort Dam it is assumed the 5 m^3/s release will continue.

3.3.2 Environmental flows

For the strategy, the environmental flows are assumed to follow the Water Requirements of the Ecosystems as defined by the IIMA agreement (see Table 3.5). This means that a minimum flow of 2.6 m^3/s is supplied in the Incomati at Ressano Garcia and another 0.6 m^3/s in the Sabie. For the Usutu, Ngwavuma and Pongola the minimum flows are 1.7, 0.1 and 0.8 m^3/s, respectively. Environmental flows in the Umbeluzi are based on the 1976 agreement between Swaziland and Mozambique, and assume that for each month a minimum flow of 40% of the lowest combined flow recorded at the GS3 and GS10 gauges will be maintained at the border.

Also for the estuarine flow requirements it is assumed that the IIMA requirements for the Ecosystem at Macarretane in Incomati and Salamanga in Maputo of 3.2 and 2.7 m^3/s, respectively, will be applied. For Umbeluzi it is assumed that the presently practised releases of 0.5 m^3/s will be continue.

Both the river flow and estuarine flow requirements stipulated in the IIMA are rather small compared to the ecological reserve and estuarine flow requirements recommended in South Africa. If the ecological reserve is followed in the Komati and Crocodile rivers the minimum border flows at Ressano Garcia are in the order of 11 m^3/s, while the estuarine flow should be in the order of 35 m^3/s (SWECO and Associates 2009b). However, considering the difficulties experienced in implementing such high environmental flows in a water stressed environment, it is judged appropriate to only consider the IIMA flows. It is further judged reasonable from an ecological perspective that if the ecological reserve is released in South Africa and Swaziland the corresponding flow should be reserved for the estuaries and can thus not be utilised by Mozambique for other uses.

3.3.3 Assurance of supply within Mozambique

In accordance with general water policies in southern Africa and in Mozambique it is assumed that 98% assurance is acceptable for urban supply, while 80% assurance is acceptable for irrigation.

4 GROSS LIST OF WATER SUPPLY SOURCES

Possible future water supply sources for the Greater Maputo area are:

- Surface water conveyed from the nearby Umbeluzi, Incomati and Maputo rivers;
- Groundwater from aquifers within or adjacent to the City of Maputo;
- Desalination of sea water;
- Re-use of water; and
- Piped water from distant large sources such as the Limpopo River.

In addition to the sources listed, water demand management should also be mentioned as an indirect source by minimising the water demand. Water demand management is further discussed in Chapter 5.

The possible new sources for Maputo water supply have been studied for many years and are well known. The transfer from Incomati River from the Corumana and Moamba Major dams have been studied by Lahmeyer International and Associates (2002), Norconsult (2003) and SWECO and Associates (2005a) and were also analysed as part of the World Bank's Country Water Resources Assistance Strategy for Mozambique (World Bank 2007a, 2007b). Possible abstraction from the Maputo River has been investigated by SWECO and Associates (2005a) and PLANCENTER and Associates (2008). Groundwater sources in the area north of Maracuene were identified already in the 1980s by IWACO (1986) and further studied by SWECO and Associates (2004).

Based on previous studies the following possible developments of surface and groundwater resources have been identified to augment the existing source at Pequenos Libombos Dam (Table 4.1). To enable a wide screening other sources, such as desalinisation and transfers from the Massingir, have been added to the previously identified options. Figure 4.1 shows the location of the alternatives in Google Earth.

It is assumed that Catembe and Inhaca will be locally supplied by groundwater, which is judged possible due to its low water demand (SWECO 2009a,b), and the supply options have therefore been focussed on the main water supply system of the Maputo City.

Table 4.1 Identified gross list of alternatives for augmented water supply to the City of Maputo.

No.	Source	Reference	Short description	Safe yield*
1	Existing Corumana dam	-	An intake directly from the Corumana Dam at FSL = 111 m or just downstream to enable power production. Pumping of raw water to Moamba village where a new treatment plant will be established. Pumping of treated water along the EN4 to a new distribution centre in north-west of Maputo. Parallel pipelines to supply villages along the EN4.	230-237 Mm^3/year
2	Completed Corumana dam	Lahmeyer (2003), World Bank (2007)	Same as above but with the gates installed to reach the originally intended FSL=117 m.	250-256 Mm^3/year
3	Intake weir downstream of confluence of Sabie and Incomati	-	Similar to above but utilising the run-off-the-river in the Incomati River. A weir is constructed for intake of the water in the Incomati River from which the raw water is pumped to Moamba. Minimum flows are guaranteed by the upstream Corumana Dam.	>260 Mm^3/year
4	New multi-purpose dam at Moamba Major on the Incomati upstream of confluence with Sabie	Norconsult (2003)	Construction of earth-fill dam at Moamba with a FSL of 112 m for multipurpose use (water supply, irrigation and hydropower). Intake at the dam. New treatment plant at Moamba and otherwise similar distribution as for the Corumana alternative.	130-150 Mm^3/year
5	Moamba Major combined with Movene Dam	SWECO and Associates (2005a)	Same as above but instead of treating the water at Moamba, the raw water is pumped from the Moamba Dam to the Movene tributary, where a new dam (FSL 80-84 m) will regulate the flow down to the existing intake and treatment plant in Umbeluzi. An increase of the existing treatment plant distribution capacity for the Umbeluzi plant.	An additional 3-5 Mm^3/year from the Movene Dam
6	An intake on the Maputo River at Catuane	SWECO and Associates (2005a) and PLANCENTER and Associates (2008)	A run-off-the-river intake in the Maputo River at Catuane for pumping to the natural Lake Madjene that will work as a sediment trap and provide temporary storage. An intake from the lake for pumping of the raw water to the Umbeluzi River at the existing treatment plant. An increase of the existing treatment plant distribution capacity for the Umbeluzi plant.	160-200 Mm^3/year**

** Assuming no ecological reserve releases from South Africa and Swaziland*

*** Assuming present releases of 5 m^3/s for channel preservation at Pongolapoort Dam*

Table 4.1 (Cont.) Identified gross list of alternatives for augmented water supply to the City of Maputo.

No.	Source	Reference	Short description	Safe yield*
7	An intake in the Maputo River upstream of Salamanga	PLANCENTER and Associates (2008)	A run-off-the-river intake in the Maputo River some 5 km upstream Salamanga for pumping to a nearby off-the-river-storage built as a small dam in the Xembene tributary. Off-channel storage for sediment trapping and short-term regulation to optimise pumping from the river. New treatment plant at the off-channel storage. Pumping of treated water along the Bela Vista road to the distribution centre at the existing treatment plant on the Umbeluzi.	160-200 Mm^3/year**
8	Developed groundwater within northern part of Maputo south of Maracuene	SWECO and Associates (2009a)	Continued development of shallow groundwater boreholes and legalisation and organisation of the small-scale water providers (POPS). Partly already initiated by FIPAG.	9 Mm^3/year
9	Developed groundwater north of Maracuene	SWECO and Associates (2004)	A set of 50 boreholes along the old EN1 road utilising the natural recharge of groundwater that flows into the Incomati River just upstream the estuary. Pumping of water to a new distribution centre in northern parts of Maputo, where a simplified treatment is applied.	30 Mm^3/year
10	Artificial recharge from Incomati on the area north of Maracuene	SWECO and Associates (2004)	A water intake at the Incomati River downstream of the Sabie confluence, and pumping water during the on-set and after the rainy season to recharge groundwater at four infiltration basins on the groundwater divide west of Manhiça. Outtake of water from a set of 60 boreholes 1-2 km east of the infiltration ponds. Pumping of water to a new distribution centre in northern parts of Maputo, where a simplified treatment is applied.	60 Mm^3/year
11	Intake at Massingir Dam	-	An intake at the Massingir Dam and pumping to Maputo.	>260 Mm^3/year
12	Desalinisation plant north of Maputo	-	An intake of sea water to the north of Maputo. Establishment of a desalinisation plant close to the coastline and pumping to a new distribution centre in northern parts of Maputo.	Abundant
13	Reuse of wastewater	-	Establishment of a re-cycling treatment plant at the existing wastewater treatment plant.	20% of used water

** Assuming no ecological reserve releases from South Africa and Swaziland*

*** Assuming present releases of 5 m^3/s for channel preservation at Pongolapoort Dam*

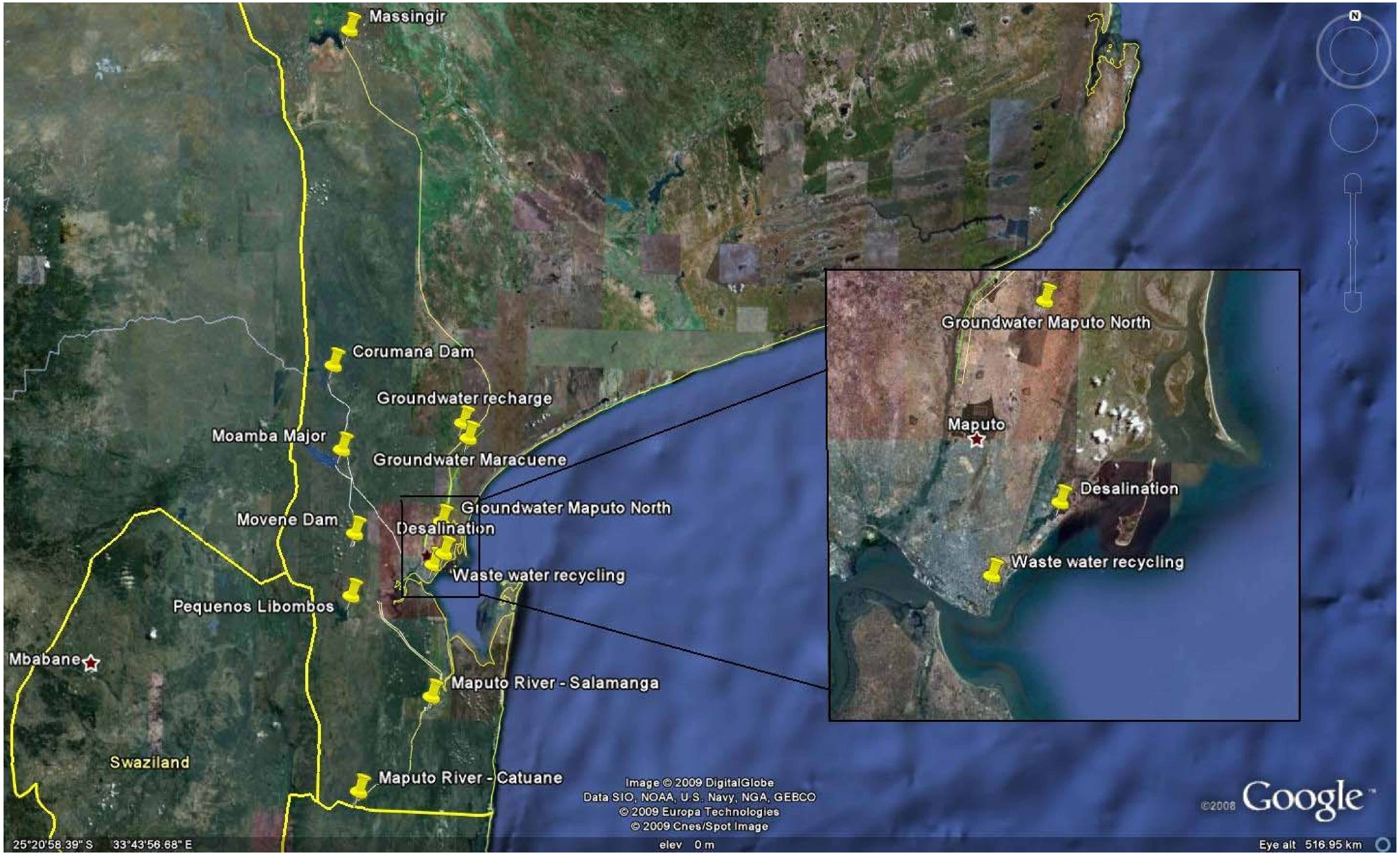


Figure 4.1 Identified gross list of alternatives for augmented water supply to the City of Maputo.

5 WATER DEMAND MANAGEMENT

5.1 Defining Water Demand Management

Water Demand Management (WDM) is a component of an Integrated Water Resource Management (IWRM) approach to managing resources traditionally allocated by the public sector. By effectively managing water demand, pressures on supply may be alleviated. Although WDM is classified as a demand side approach insofar as it aims to alter the behavior of users in order to reduce demand, it is not separable from the implications it has for supply. Thus, WDM may be considered as an interface of supply and demand side considerations in the provision of water.

WDM may also be pivotal in balancing efficiency and equity concerns in the supply of water. With water as a basic input to human livelihoods, as well as a key input to an economy's production, it is necessary, in the context of Maputo, to discern between different types of users and ensure that in the domain of basic needs equity concerns predominate over cut and dried economic efficiency maximization. By using progressive tariff structures and involving the civil society in the planning and implementation of demand side management of water, there exists potential for WDM to embody anti-poverty interventions, and so making it a pro-poor development strategy (UN-HABITAT 2009).

Water Demand Management is the lowest cost approach to meeting water demands without expanding supply, by improving the efficiency of water use. WDM uses physical (technical), social and economic interventions (Stephenson 1999) in order to reduce water usage demands and decrease water losses in order to achieve water balances. The cost efficiency of WDM is seen primarily through its role to postpone or make redundant bulk infrastructure investments and through optimizing the equity returns of investments through careful project sequencing strategies. It is, however, important to note that, because of the development stage of Mozambique, bulk infrastructure investments are likely not be in the genre of those that may be permanently delayed. WDM is necessarily pursued in conjunction with supply side infrastructure investments (World Bank 2007b).

Meeting domestic, industrial, commercial and environmental water requirements without infrastructural supply increases, necessitates improved management of currently exploited reserves. Table 5.1 below indicates the potential for WDM gains through augmenting revenue water sources. Various combinations of the tools available for WDM are used to minimize Non Revenue Water (NRW). Thus the revenue water to NRW ratios increased and via a more efficient allocation of the existing supply demands may be satisfied.

Table 5.1 Water balance terminology and composition. Source: UN-HABITA (2003).

System Input Volume	Authorised Consumption	Billed Authorised Consumption	Billed Metered Consumption	Revenue Water
			Billed Unmetered Consumption	
		Unbilled Authorised Consumption	Unbilled Metered Consumption	Non-Revenue Water
			Unbilled Unmetered Consumption	
	Water Losses	Apparent Losses	Unauthorised Consumption	
			Customer Meter Inaccuracies	
		Real Losses	Leakage on Transmission and Distribution Mains	
			Leakage and Overflow at Storage Tanks	
			Leakage on Service Connections up to point of Customer Meter	

The need for dynamic approaches to reducing Non Revenue Water (NRW) is emphasized, taking cognizance of the following types of feedbacks Vermersch and Rizzo (2008):

- The Coefficient of Return of Anomalies may become relevant when, following repairs of invisible leakages, a host of new invisible leakages become apparent; while regulating a number of illegal connections other illegal connections are installed elsewhere or when replacing old meters those which remain unchanged age and produce additional metering losses.

- The Migratory Attribute of Losses may occur in the context of leakage repairs in low income communities. The resulting improvement in pressure is likely to raise Apparent Losses by increasing Unmetered and Unbilled consumption. Thus Real Losses may decline but Apparent Losses increase.

- Time Factor and Visibility Threshold pertains to the necessary duration involved before benefits show up as tangible loss reductions. It is necessary that detection thresholds are identified and management pursues the interventions to this level, after which losses are predicted to decline exponentially.

By dynamically managing losses through awareness of antagonistic and synergistic effects on the individual components of losses the success of WDM strategies may be enhanced.

5.2 Tools of Water Demand Management

Water Demand Management strategies to limit water consumption include technical, social and economic interventions (Table 5.2). Interventions are used to alter user behaviour and need to be time-framed according to the expected impact on changing habits of water consumers. Reducing water demands involves minimizing system input losses, increasing billing coverage and collection and reducing currently metered consumption.

Table 5.2. Water Demand Management Strategies (Stephenson 1999).

	Crisis response	Short to Medium term operating framework	Long term planning and design
Technical	Load shedding Pressure reductions Valve closure	Flow control	Metering Loss control Water saving devices
Economic	Fines Punitive measures	Differential tariffs Trade	Supply and demand economics Marginal prices
Social	Appeal Social persuasion Advertisements	Legislation	Consumer consciousness

5.2.1 Technical Interventions

Water Pressure Management is the primary tool for short-term crisis response management. In addition, Pressure Management in the medium- and long-term may be the most effective and cost efficient for of WDM that can be applied to a particular system (UN-HABITAT 2003). By eliminating excess pressure in a system during periods of low demand Pressure Management is justified on both cost effectiveness and conservation ground. With losses from leakages and bursts positively correlated with system pressure, Pressure Management is an important leakage and burst management strategy. A range of techniques and equipment[1] options are available and should be applied with avoidance of detrimental impacts on users as well as cost effectiveness in mind.

Pressure Management in the medium- and long-term requires substantial data and planning inputs. In addition accurate metering is fundamental in designing flow and loss control strategies through pressure control. Thus water meters are a critical investment. Metering also forms the basis of water tariffs, discussed in the proceeding paragraphs.

Longer-term technical investments include water saving investments in rain harvesting during the wet months and storage for use in drier periods. Grey and black water recycling systems increase the velocity of water, whereby a unit of water is used an increasing number of times. Water saving plumbing devices, including

[1] Pressure Reticulating Valves, either flow or time modulated, are an example of equipment options available for reducing excess pressure, where software calibrations provide the economic justification of the extent and coverage thresholds.

waterless toilets, double action cisterns, low volume showers and automatic tap closures are important considerations for technical interventions to alleviate long-term supply pressures. The aforementioned interventions are more cost effective than other capital investment options such as desalinization projects and inter-basin transfer schemes. Rain harvesting and grey water equipment may be installed in a series of small scale initiatives. So water budgets may be drawn upon incrementally through time as coverage to homesteads in designated areas is extended.

Reviews of the effectiveness of technical interventions should be pursued in a dynamic framework. Monitoring of progress including identifying feedbacks and visibility thresholds is also expected to be a cost effective strategy.

5.2.2 Economic Interventions

The scope for economic instruments to reduce water demand focuses upon the implementation of pricing strategies that allocate water to users based on (*i*) need and (*ii*) ability or Willingness to Pay or a combination thereof. Designing tariff packages which reduce water use relies heavily on estimating the value of water. The question of value is not an easy one, and valuations are necessarily differentiated between different types of users. With water as a basic livelihood input distinguishing user groups permits equity considerations to be incorporated to moderate efficiency based allocations.

The estimation of shadow prices for water should optimally be linked to water usage (necessitating accurate metering). In order to gain efficiency for the use of Marginal Cost pricing is preferred to Average Cost pricing (Stephenson 1999). Tariffs for public goods, of which water is a prime example both in terms of its basic need status and on the costs associated with its provision (that is, as with other bulk utilities, the capital outlay costs are prohibitive for a completely private sector undertaking, thus the provision is relegated to the public domain) conventionally utilize Average Cost pricing. In part, this is justified by the innate difficulties in attaching a marginal value to water[2]. Marginal Cost pricing strategies are justified on the basis that in regard to conventional supply strategies which first use cheap water reserves and moves toward more expensive sources (due to increasing extraction and pumping distances) as demand grows over time, an unsustainable demand pattern is reinforced. Average Cost pricing encourages demand that grows asymptotically, by providing higher output at lower prices compared to a Marginal Cost pricing strategy.

Determining the responsiveness to change in prices (the price elasticity of demand) by different user groups is an important variable in informing the correct design of tariff packages. Differential demand elasticity's provides important equity information to be incorporated into pricing schemes in order to enhance the distributional efficiency of allocations. For example, it is empirically observed that lower income users have more inelastic demand for water compared to middle income users,

[2] Average Cost pricing is a much simpler strategy involving a purely financial calculation based on total expenditure and total revenue from sales. In practise the estimation of MCs are based on a complex and necessarily differentiated equation where Marginal Cost = *f*(Capital Costs, Operating Costs, Purification Costs, Pressure Management Costs, Time of Use, Use Zoning, Wealth Redistribution Considerations, Water Conservation Considerations, Reserves for Future Expansion,…, Location) (Stephenson, 1999: 117-119).

although high income users also display price inelastic demand tendencies. However price increase burdens fall disproportionately on the poor given comparatively lower water. In poorer households water is more likely directed toward satisfying basic sanitation and food needs. Thus there is little scope for poorer households to reduce their demand in the wake of price increases. Middle income households are likely to exhibit price elastic demand for water that is they will reduce their volumetric consumption significantly in response to a price increase. Given these relative price elasticity it is clear that the most stands to be gained out of focusing tiered pricing strategies at middle income households, and to a lesser extent higher income households.

Tiered tariff packages designed for domestic users, industrial users and commercial users are a dominant strategy in practice for allocating water in light of both equity and efficiency considerations. Regardless of whether Cost Recovery Pricing, Production Cost Pricing or Water Scarcity Pricing strategies are followed, the potential for instituting pro-poor water access exists to the extent that tariffs are tiered in a progressive fashion.

The effectiveness of any pricing strategy will be determined by the extent to which user volumes may be monitored as well as the collection efficiency of water use charges. The former relies on capital investment in and maintenance of meters at the desired unit of analysis (for example domestic users may be metered at the household level or as a neighbourhood). The latter relies upon the method of billing and collection charges. Collection efficiency may be enhanced by reducing the intervals at which payments are recouped and by making the payment geographically convenient to the user, such as door to door collection (UN-HABITAT and ADB 2007).

5.2.3 Social Interventions

Sociological WDM interventions are expected to be more effective in the long-term as opposed to the short-term. Changes in user behaviour and habits are only sustainable when the correct incentives are in place (Stephenson 1999). To the greatest degree possible, negative incentives such as water restrictions and fines should be avoided. By introducing excess transactions costs incurred by monitoring needed to stake compliance, these costs represent a misallocation of resources. Positive incentives are preferred. Generically these may be envisaged as reward systems for behaviour which makes efficient use of a scarce resource. It is most likely that user behaviour using incentives of these types is realistically achieved in the longer term through education and advocacy campaigns.

Education and advocacy for general awareness on water conservation and other sustainable livelihoods issues requires a broad commitment by national policymakers to a multifaceted awareness campaign (UN-HABITAT 2003). Campaigns that increase public awareness of regarding the scarcity of water and the need to use it efficiently (DWAF 2007) imply mutually reinforcing benefits by building an educational backbone emphasizing that the condition of physical environments is not separable from human health and welfare.

Education may assist with justifications to users for economic interventions where price increases are in accordance with reflecting the full cost of their resources use

(White and Fane 2001). Other positive multipliers of education are the innovations that may occur at a grassroots level if the correct incentives for people to innovate exist. In addition, green technologies, such as rain harvesting and water recycling through grey- and black-water- systems, are easily implemented at the micro-level, however their success depends critically on the ability of individual users to engage in sustainable practices.

Educational extensions must filtrate not only scholarly environments; in addition to schools and tertiary institutions, educational programmes regarding the efficient use of water, are necessarily encouraged for municipal and utilities workers and management level local and national government officials and service providers. Materials produced by UN-Habitat, such as the Water Demand Management Cookbook (UN-HABITAT 2003), provide a comprehensive and easy to navigate introduction to implementing WDM.

Another type of social incentive that may be harnessed to improve the efficiency of water use includes social network effects. Peer monitoring behind the success of micro-level anti-poverty interventions such as the Grameen Bank uses innovative ways to harness neighbourhood effects to ensure commitment to the desired objective. In the case of WDM, this would involve the decentralization of advocacy in order to minimise default (in the form of individually inappropriate or excessive use of water being considered an negative externality by other community members). In addition group monitoring schemes may also significantly reduce the unauthorised extraction of water.

Social network effects are identified as critical to the success of decentralized tariff collections, as introduced above under Economic Interventions. Please see the recommendations regarding Community Managed Operations, Billing and Collection schemes as applied to Maputo from the comparative review of Jabalpur, Gwalior, Bhopal and Indore, below.

5.3 Water Demand Management: Case Studies

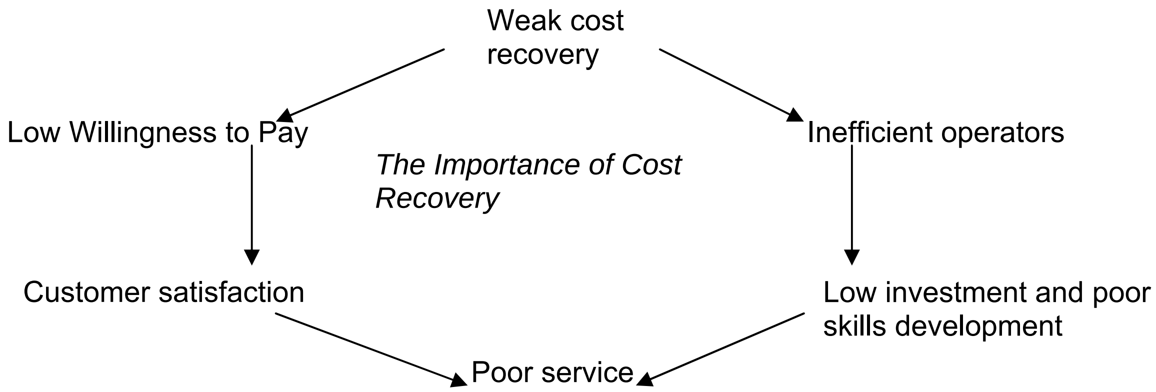
5.3.1 India: Gwalior, Jabalpur, Indore and Bhopal

The UN and Asian Development Bank Water for Asian Cities Programme include Water Demand Management as a key strategy through which to address Non-Revenue Water (NRW), particularly the element of Unaccounted for Water. Poor billing arrangements, high proportions of NRW, limited metering, non-viable pricing, lack of dues collection, poor revenue recovery and inadequate service coverage present generic challenges to management in the four Indian cities under review.

Individual studies for each city were conducted in terms to assess the technical interventions. In addition, a combined study investigated modes of operation, billing and collection generated recommendations for improving the management side of water utilities.

Technical interventions in Gwalior, Jabalpur, Indore and Bhopal include installation of meters, development of a data management system using GIS, water auditing and balancing, sectorisation, energy auditing, active and passive leakage control, an asset management programme, planned maintenance, alternative delivery mechanisms and pressure management.

Water users are disaggregated into domestic, commercial and industrial, with domestic use constituting the bulk of consumption. With entire revenues from households realized on a flat rate basis wastage has occurred. In addition, a lack of metering and volumetric tariffs is cited as a major reason for inequities between water supplied and recoveries made from consumers. Reviews indicate that revenue collection is hindered less by the ability to pay and more by the payment system itself.



Source: UN-HABITAT & ADB (2007)

Metering and tariff rationalization according to the cost recovery principle are identified as critical for effective demand management. Revenue from water sales are required to cover operating, maintaining, as well as costs for capital investment extensions.

Billing systems are formulated to meet the following objectives

- Timely estimate of water bills
- Time scheduling for estimation, tendering to consumers and their payment of bills
- Collection from consumers on the due date
- Implement door to door collection, where possible. Maximise the ease with which consumers can pay their water bills
- Daily collection accounting
- Elimination of avoidable delays
- Minimising the cost of collection
- Pay attention to disputed cases and defaulters
- Rigorous follow up of defaulters
- Incentive mechanism for workers involved in dues collection

A comparison of collection efficiency between the four cities highlights the need for more frequent dues collections. For example, bi-monthly collections in Gwalior resulted in collection efficiency in the range of 51% to 64% compared to Bhopal, with quarterly collection and lower collection efficiency rates of 40% to 51%.

Thus, the interval between collections has a significant effect on the successful recovery of costs to outlay water services. Furthermore, billing which corresponds to consumers' income cycles is found to have a significant positive impact on collection. This is particularly so in the context of poor consumers.

A further recommendation pertains to the geographical distribution of collection. By decentralizing collection to the level of face to face accountability, collection rates are expected to improve. The Jabalpur municipality experimented with individual versus bulk collection of bills and found that between 2000 and 2005 average collection efficiency was 99.53% for bulk consumers compared to 61.21% for individual consumers.

Implementing bulk consumer collections increased total revenue accrued to the municipality whilst reducing expenditure by lower-consuming households by lowering the previously flat rate. The cost reductions to municipality were both pecuniary, for example in terms of reducing costs of paper and printing, as well as in terms of labour hours of bill collectors.

Increasing consumer awareness is required in conjunction with improving operational efficiency in order to promote the optimal use of water. Improving relations with and the general public conception of water management bodies is identified as having a critical effect of the success of WDM in Gwalior, Jabalpur, Indore and Bhopal. Improving the civil society interface is necessary in order to promote the municipal water provider as a 'responsible, customer orientated organisation'. To thus end, the municipality has facilitated a citizen charter for water supply which aims to engage civil society in the decision making process. Thus public participation has a role beyond merely the voicing of customer complaints. Low levels of consumer dissatisfaction and the link to low willingness to pay is addressed in this manner. Public awareness raising regarding the economic costs of water is required to gain the cooperation of community with municipal providers of water. Special training units have been established in order to cultivate a culture of water conservation and the recognition of water as a scarce, life-giving resource.

5.3.2 South Africa: Cape Town

An Integrated Water Resource Planning study was conducted in 2001 by the City of Cape Town, and WDM and Water Conservation (WC) strategies were initialised. In 2007 a study by the DWAF reviewed the response in the 7 year period. The bundle of interventions were streamlined across city implementation and promotion in order to reduce Unaccounted for Water (UAW) and decrease consumer demands through education and tariffs and included the following (DWAF 2007):

▪ Pressure management ▪ User education ▪ Elimination of automatic flushing urinals ▪ Tariffs, metering and credit control	City Implementation
▪ Use of water-efficient fittings ▪ Use of private boreholes ▪ Grey water use	City Promotion

Leakage repair is also included as a WDM intervention in the DWAF (2007) City of Cape Town Report.

The DWAF (2007) highlights the distinction between drought mitigation methods of reducing water demand and longer term sustainable reductions in water wastage through increasingly efficient use of limited water supplies. The former, through punitive measures including fines and restrictions, are likely to be associated with a decrease in user quality of life as well as declining revenues for the local municipality. The latter is expected to improve the quality of life of users through reducing the volatility in supply and is anticipated to catalyze financial benefits for the local municipality.

The Cape Town water demand strategy is based on the understanding that water is a scarce resource used strategically to facilitate human livelihoods and economic activities and stipulates the necessity that all water must be measured and accounted for and the non-tolerance of water wastage. The strategy bolsters equity and sustainability by universal access and a minimum level of service guaranteed through metered connections as well as a commitment to assured water for future generations. Through education and where appropriate legislation the optimal use of water is to be encouraged to the extent that, in conjunction with commitments to minimize water losses water demand will be down by 20%. In addition the strategy encourages alternative sources of water, at both micro-level options and coordinated projects, with specific emphasis placed on environmentally friendly, water wise technology including wastewater recycling and tapping into boreholes.

Since 2000, dry season water demand has declined significantly. Consumer surveys indicate that the major catalyst of changing behaviour was their responses to price changes (44% of respondents). Restrictions (32%) and awareness campaigns (20%) were also significant driving forces behind enhanced water efficiency.

Annual costs to implement and the potential water savings from each intervention, as presented by DWAF (2007), are shown in Table 5.3. The fourth column represents a broadly comparable efficiency measure across the different interventions and is equal to the potential water saving divided by the cost of implementation.

Although column 4 shows crude estimates of efficiency across measures, the comparison is simple and immediate interpretations may be made. In reality, matters such as the discount rate and project sequencing are necessary components to making cross category comparisons.

Table 5.3 Annual costs, potential water savings and water saved per unit expenditure for the City of Cape Town WDM interventions. ***.*** *Leakage repair has an annual cost to implement of R63.1 million, an associated water saving of 15.6 Mm^3/year giving the savings per unit expenditure of 0.25 million. Source: DWAF (2007).*

	Annual cost to implement	**Potential water savings (Mm^3/year)**	**Water saved per expenditure (m^3)**
Pressure Management	R79.1million	27.8 – 16.7	0.35 – 0.21
User Education	R7.0 million	20.0 – 10.0	2.86 – 1.43
Elimination of automatically flushing urinals	R14.2 million	4.2	0.30
Tariffs, metering and credit control	N/A	20.0 – 10.0	N/A
Use of water efficient fittings	R62.0million	26.3 – 7.9	0.42 – 0.13
Use of boreholes	R3156/ household	9.0 – 0.45	0.0032
Grey water use	R5600/ household	3.3 – 1.0	0.0007
Rainwater tanks	R7013/ household	15m^3/household	0.021

In the Cape Town context user education appears to exhibit the “biggest bang for the buck” where between 1.43 m^3 and 2.86 m^3 may be saved for each rand spent in public awareness campaigns about efficient water use. It is necessary to note that due to the long term nature of this strategy, these gains need to be discounted in order for true savings to be reflected in levels comparable to other interventions’. A rand spent in Pressure Management, repair or eliminating automatically flushing urinals can be expected to induce a water saving of between 0.21 m^3 and 0.35 m^3 for every rand. Expenditure to encourage water efficient fittings (the bulk of the cost of the investment is transferred to the end-user) is anticipated to save between 0.21 m^3 and 0.46 m^3 per rand.

The last three interventions, encouraging the use of boreholes, grey water systems and rain harvesters, appear to be the least cost effective way of inducing water savings. However, because these interventions are implemented at the household level a significant benefit arises in terms of the opportunities to stagger investments by neighbourhoods, thus diffusing costs over time. In addition rain harvesting and grey water systems technologies are increasing in use and popularity across the globe. Thus with increased research and development as well as supply of the necessary capital inputs, installations costs are likely to decrease over time.

5.3.3 South Africa: Durban (Ethekwini)

Ethekwini WDM (Pers Comms Simon Struyten, 19 June 2009) is based upon best practices recommended by the International Water Authority. A culture of 'implement, intervene and move on' rather than plan and report has transpired as a lack of formal reporting on local experiences. The critical link between water and socio-economic development forms the fundamental ethos of local operations. In the context of increasing costs of extending the water supply as full-utilisation is approached has promoted a strategic change in the use and conservation of water resources. Shifting consumer thinking is regarded as the key to sustaining behavioural changes identified as critical components of WDM. Water-wise attitudes that are promoted include water efficient gardening and planting, recycling of used water for car washing and cleaning and the fixing of household leaks.

In Ethekwini Water Losses are at approximately 39% with 80% accounted for by Real Losses. Although illegal connections and other Apparent Losses constitute only 5% of total water losses, addressing these unauthorised connections forms part of the WDM focus, both technically and on social grounds.

WDM is implemented on the grounds that it should not be punitive or restrictive. Increasing coverage in order to address backlogs as well as provide for an expanding population is undertaken in a framework that promotes environmental health as a determinant of the health of communities and individuals. Of particular relevance is the need to address inequalities inherited from Apartheid that manifest as unequal access to water across historically white suburbs and black townships. Major technical interventions are salient to address UAW in the latter areas. At the same time, overcoming a culture of non-payment is a massive challenge to municipal water providers.

At present households receive between 8.5 m^3 and 10.5 m^3 of free water per month. Thereafter increasing charges apply to each successive block unit consumed. Average domestic water use is approximately 35 m^3 per month. A lack of metering in townships has resulted in water tariffs charged at a flat rate. A new system of pre-paid water is currently being tested, however it is too early for any conclusions or recommendations to be formed.

Education for household consumers of water is identified as an important way to reduce corrupt service delivery. With community's assistance in the management and monitoring water delivery operations become visible and provide the rationale for responsible consumption of water in return for payment. Consumer awareness is therefore a critical factor in the sustainability of water services.

Ethekwini WDM strategy envisages a 11% reduction to UAW by leakage repair in network distribution. A further 20% reduction in domestic use is expected in response to reducing household plumbing leakages. Retrofitting of plumbing fitting is expected to reduce domestic and commercial water use by up to 40%. In addition reducing water used in gardening, as well as curbing the growth rate for new consumptive demand is anticipated to prompt further water savings in the municipality.

To actualise the above goals communication and education schemes, grant incentive schemes where part of cost of retrofit is subsidized by water institutions, regulation, marketing and school audits, effective billing systems are some of the tools to utilised. Establishing and maintaining effective consumer data bases is a necessary complimentary feature of the strategy. Social surveys to elicit common perceptions, opinions and knowledge are critical in establishing effective communication and awareness campaigns. In addition, water wise demonstrations and exhibitions are key educational tools to be used in the community.

5.4 Water Demand Management: Application to Maputo

Maputo experiences system losses of approximately 55% (SWECO and Associates 2009b). As outlined earlier in the report technical interventions, particularly leakage repairs, by FIPAG are envisaged to reduce water losses to 25% by 2030 and have been taken into account in the estimation of the projected water demand. The WDM component for Maputo City therefore focuses on the social and economic interventions that may further alleviate supply-demand pressures.

Recommendations for WDM interventions in Maputo have been based on the optimal application of theory in the unique context of Maputo, as well as by experiences from other structurally similar contexts as found by the case studies. In addition the plan to control for Non Revenue Water (NRW) is based on the study by Vermersch and Rizzo (2008).

Increasing efficiency in the usage of currently supplied water is implicit in NRW minimisation insofar as undervalued water usage is reduced at the same time as losses, both Apparent and Real are minimised. A holistic, dynamic approach is motivated for in order to adequately deal with the complexity inherent in the sustainable control of NRW. The following paragraphs outline potential WDM tools suitable for the Maputo context.

5.4.1 Technical interventions

Besides leakage repair, which is the main part of FIPAG's programme to reduce losses to 25%, other technical interventions are possible to implement in Maputo:

(i) Pressure management
(ii) Metering
(iii) Water saving devices
(iv) Small-scale recycling of water
(v) Rain water harvesting

The study advocates, on cost effectiveness grounds, against technical interventions pursued in a void, that is without the necessary accompanying interventions in how the technical installations are managed. Training in dynamic loss management is imperative for water utilities managers, in order for awareness of the feedbacks and knock-on implication of one type of loss reduction on other losses.

At present there is almost a complete lack of installed meters. Insofar as meters are installed in order to monitor demand and bill users accordingly, it will be prudent for managers to determine the optimal extent and location of meters. This will be determined, in part, by the type of billing and collection system that the municipality decides to implement (see below).

5.4.2 Economic Interventions

With Indian experience suggesting that revenue problems stem more from the actual payment system and less from a lack or willingness to pay on the consumers' part, flexible and innovative payment schemes are recommended as the future focus of economic WDM interventions.

Billing and collection schemes should be decentralized to the doorstep of the consumer, should correspond to the income cycle of the consumer and should be done so at regular intervals (for example insofar as monthly intervals are optimal if this is aligned with income cycles). Due to the prohibitive costs of such decentralized billing and collection system creative mechanisms for interfacing municipalities, community groups and households should be developed.

Creative mechanisms to reduce the number of bills exist. Although metering is required at the household level, the collection by the municipality would be more centralized on the one hand, but collection from households would be more decentralized and executed by community members doorstep to doorstep. Bulk water collection and the potential to devolve collection to the community level require specific research to be undertaken and partnerships with neighbourhood committees, civic organizations and NGOs.

Non-domestic users of water should be charged for their use in a manner which is consistent with the overall development paradigm of Maputo. It is recognized that commerce and industry contribute directly to household wellbeing through earned income. Preferential rates may be granted up to a certain usage delineated individually by economic activity and according to employment multipliers in said industries. Tariff packages of this nature are a form of indirect subsidy and should be used wisely so as to allocate water to users who place the highest value upon it. Therefore it is not a viable strategy to subsidize water to commerce and industry that are wasteful due to their payment not capturing the true value of water. Commerce and industry that can provide evidence of their labour absorption capacities may be granted privileged rates as a form of employment incentive scheme.

Thus tariff packages are necessarily differentiated by user group and therein specific schemes may be identified (Table 5.4).

Table 5.4 Proposed tariff packages

	Domestic	Commerce	Industry
Payment interval	Corresponding with income cycle	Monthly	Quarterly
Fixed connection fee	None	Yes	Yes
Tariff schedule	First 8 Kilolitres free, thereafter rate increases at increasing rate with volumetric use.	Increasing at increasing rate with volumetric use	Increasing at increasing rate with volumetric use

Tariff schedules such as the above may be justified on both water usage efficiency and equity grounds.

5.4.3 Social Interventions

In order to promote awareness of wise water use various education and advocacy mechanisms are available. Given the informal nature of many of the settlements, as well as low levels of literacy it is important that educational outreach is inclusive and directed in ways that are suitable to the development context. Consumer attitudes and behaviours are only realistically changed in the long term through ongoing public awareness campaigns.

Modes of communication that are most effective in reaching the broader population may include radio service announcements as well as on the ground exhibitions and demonstrations in wise water use. Hinging on the mode of billing and collection it is necessary that community interface groups be established in order to enhance perceptions of the integrity of water servicing institutions. Public participation may be further encouraged in the domain of management and decision making processes. A broad buy in by community will increase the collection efficiency, thereby increasing the revenue water base.

5.4.4 Possible WDM in Maputo

Costs of water demand management tools must be considered with regard to the expected impact on water savings. In addition, it is necessary to consider the pecuniary costs of action compared to both pecuniary and non-pecuniary costs of not implementing such WDM interventions. Quantifying the costs of delaying unjustifiably or permanently is not an objective task, thus this section aims to quantify only the former, that is deriving a value for the quantity of water saved per unit of currency spent on WDM initiatives.

The table below gives potential costs, savings and Unit Reference Values (URVs) for different WDM interventions for Maputo, until 2030, based on DWAF (2007), inflation adjusted and converted into 2009 USD value.

Table 5.5 Estimated potential costs, savings and Unit Reference Values (URV) of WDM options in Maputo City.

	Cost (MUSD/year)	Water Savings (Mm^3/year)	URV (USD/m^3)
Pressure management	0.78	7.01	0.110
Water saving devices	0.61	6.30	0.096
Grey water systems	$329/ household	0.92	0.285
Rain harvesting	$389/household	2.06	0.151
Education and advocacy	0.069	6.30	0.010
Metering, tariffs and billing control	N/A	6.40	N/A
Total		29.0	

Notes: Household population of 275 000 in 2009

URVs estimate water savings per dollar invested in each WDM tool, where lower values for URV indicate a higher return on the cost of implementing the WDM intervention. The results can be concluded as follows:

- With costs of metering, tariffs and billing at effectively zero, the URV is not applicable, however it may be observed that with a projected saving of 6.4 Mm^3 per year this strategy constitutes the most cost effective approach at reducing water usage.

- Education and advocacy comprises the second most cost effective WDM intervention, with expected savings due to a reduction in water usage of 6.3 Mm^3 per year and an associated cost of $0.069 million per annum giving a URV of 0.010.

- Pressure management ranks third in terms of cost effectiveness. Water savings are in the form of a reduction in water wastage as well as water usage. By managing water pressure, at a projected cost of 0.78 MUSD per year, an expected annual saving of 11.68 Mm^3 gives a URV of 0.11.

- The fitting of water saving devices is expected to decrease water usage by 6.3 Mm^3 per year. The expected cost is 0.61 MUSD per year, with a URV of 0.078

- Grey water systems and rain harvester appear to be the least cost efficient tool of WDM. However, not included in these cost saving evaluations are the gains from environmentally efficient technologies, thus the seemingly high costs of saving are necessarily interpreted in light of such. Grey water systems to recycle household water is expected to cost 389 USD per household and water savings per annum are estimated as 0.92 Mm^3, giving a URV of 0.285. Rain harvesters cost 389 USD per household and are expected to reduce water demands by 2.06 Mm^3 per annum. This gives a URV for rain harvester of 0.151.

The table below gives aggregated costs and savings for WDM interventions according to their classification as water wastage reduction and water usage reductions. Water wastage reductions include those arising from pressure management, grey water systems and rain harvesters. Water usage reductions are those originating from the installation of water saving/ efficient devices, education and advocacy and metering, tariffs and billing controls.

Table 5.6 Estimated potential WDM and related costs for Maputo.

		Cost (MUSD/year)		Annual Savings (Mm^3)	
Water wastage reduction	• Pressure management • Grey water systems • Rainwater harvesting • Metering, tariffs and billing control	7.96	92%	16.4	56%
Water usage reduction	• Water saving devices • Education and advocacy	0.68	8%	12.6	44%
Total		8.64	100%	29.0	100%

Notes: Assuming a rollout rate of grey water systems and rain harvesters of 10 000 households per year.

The annual cost of the full bundle of recommended WDM interventions is estimated as 8.64 MUSD. Annual water savings of 29 Mm^3 are expected in response to said interventions. 92% of total costs of WDM interventions are associated with those aimed at decreasing water wastage, with 56% of total volumetric savings attributed to these interventions. Interventions aimed at reducing water usage constitute 8% of the total cost and 44% of total savings. It is apparent that strategies aimed at reducing water usage demand have a higher savings-cost efficiency compared to those strategies aimed at reducing water wastage.

6 ENVIRONMENTAL SCREENING OF SUPPLY ALTERNATIVES

6.1 General impacts

6.1.1 Existing Corumana dam

This alternative entails the intake of water directly from the Corumana Dam, with its present FSL at 111 m. The raw water will then be pumped to Moamba where a new treatment plant will be established. The treated water will be pumped along the EN4 highway to a new distribution centre in north-west of Maputo. There will be secondary pipelines to supply towns and villages along the EN4.

The main impacts associated with this alternative are:

a) socio-economic – limited population displacement along the pipeline route, with some positive impacts in terms of employment, basic services and infrastructures, and quality of life associated with the development of a large investment project.

b) Environmental – the most important impact will be the change in the ecological flows as the diversion to Maputo will reduce the available flows downstream.

6.1.2 Completion of the Corumana Dam

This water supply alternative entails the completion of the Corumana dam, i.e., installing the spillway gates, therefore allowing the FSL to increase from 111 m to 117 m. Like the previous alternative, it also includes a pipeline taking raw water to the town of Moamba where it will be treated and pumped to Maputo in a pipeline along the EN4 highway.

The main impacts associated with this alternative are:

a) socio-economic – destruction of productive land, changes in land use patterns and some population displacement in the new inundated area, with positive impacts in terms of employment, basic services and infrastructures, and quality of life associated with the development of a large investment project.

b) Environmental – the most important impacts will be the loss of vegetation and fauna in the new inundated area and the increased sediment deposition in the reservoir. Other negative impacts are the changes in aquatic fauna and in the Incomati estuary (reduced flow) and in water quality. Some improvement can be expected in environmental flows associated with the increased storage capacity.

6.1.3 Intake weir downstream of confluence of Sabie and Incomati

This alternative is similar to the above but utilises also the Incomati River flows. A weir is to be constructed for the intake of water in the Incomati River from which the raw water is pumped to Moamba. Minimum flows are guaranteed by the upstream Corumana Dam.

The main impacts to be expected are:

a) socio-economic – similar to the previous alternative.

b) environmental – similar to the previous alternative.

6.1.4 Moamba-Major Dam

The proposed dam will be constructed with a FSL at 112m. It would also include the construction of a new treatment plant at Moamba and a similar transmission method as for the previous alternatives.

The main impacts for this alternative are:

a) socio-economic – population displacement, destruction of agricultural land, changes in land use pattern and land conflicts, are serious impacts, all related to the inundated area created by the new dam and reservoir. Community disintegration is also a possibility that negatively affects this alternative. On the positive side, one should consider employment (during the construction of the dam and afterwards in increased agricultural and agro-industrial production), increase in family income, improved basic services and infrastructures.

b) environmental – serious impacts regarding loss of terrestrial vegetation and fauna, loss of aquatic fauna and trapping of sediments in the reservoir. Other important impacts are changes in water quality (thermal stratification, progressive euthrophication of the reservoir) and in ecosystems. There may be an improvement in the ecological flows due to the large storage capacity.

6.1.5 Moamba dam combined with Movene dam

In this alternative, the raw water is pumped from the Moamba Dam to the Movene tributary, where a new dam (FSL at 80-84 m) will regulate the flow down to the existing intake and treatment plant in Umbeluzi. It requires also an increase of the existing intake and treatment plant at Umbeluzi.

The following major impacts can be considered, besides those associated with the previous alternative:

a) socio-economic – the negative impacts are somewhat worse than in the previous alternative due to the new dam and reservoir on the Movene. The positive impacts are similar to those of the previous alternative.

b) environmental – the negative impacts indicated in the previous alternative will be aggravated by the new dam and reservoir.

6.1.6 Intake at the Maputo River in Catuane

This alternative comprises a run-off-the-river intake in the Maputo River at Catuane for pumping to the natural Lake Madjene, that will work as a reservoir and sediment trap; an intake from the lake; a pipeline, following existing roads, to carry raw water to the Umbeluzi River at Boane, where it flows down to the existing intake and treatment plant in Umbeluzi. An increase of the existing treatment plant at Umbeluzi will also be required.

The following major impacts can be expected for this alternative:

a) socio-economic – there are only minor negative impacts and also some positive impacts in terms of employment, basic services, infrastructures and quality of life.

b) environmental – the most significant impacts are the changes in the ecological flows and in the ecosystems, particularly Lake Madjene. Other important negative impacts are the loss of aquatic fauna and the changes in the river's sediment transport regime.

6.1.7 Intake at the Maputo River upstream of Salamanga

This alternative entails a run-off-the-river intake in the Maputo River immediately upstream of Salamanga, a nearby off-the-river storage built as a small dam in one of the small tributaries; a pipeline, following existing roads, to carry raw water to the Umbeluzi River at Boane; and an increase of the existing treatment plant at Umbeluzi.

The main impacts for this alternative are:

a) socio-economic – similar to the previous alternative.

b) environmental – similar to the previous alternative but with less impact of changes in ecosystems like Lake Madjene and the additional possible impact of increased salt water intrusion.

6.1.8 Groundwater development north of Maputo

This alternative implies a continued development of boreholes in the tertiary dunes between Mahotas and Maracuene, a program partly already initiated by FIPAG. A total of about 25 boreholes are foreseen.

The main impacts for this alternative are:

a) socio-economic – land conflicts can be expected in relation to the protected areas needed around the boreholes. Other impacts of less dimension are population displacement, destruction of agricultural land, changes in land use pattern and some loss of employment and income. On the positive side, it can be expected that this alternative will bring some improvement of quality of life, basic services and infrastructures.

b) environmental – the only significant impacts are some loss of vegetation and fauna and the lowering of the water table.

6.1.9 Ground Water development North of Maracuene

This alternative entails setting a series of 50 boreholes along the EN1 road, between Maracuene and Manhiça, utilising the natural recharge of groundwater. The boreholes are linked to a pipeline that carries the water to Maputo (Laulane distribution centre).

The main impacts for this alternative are:

a) socio-economic – the negative impacts are less important than in the previous alternative, the positive impacts are similar.

b) environmental – the negative impacts are more important than in the previous alternative, particularly because the groundwater abstraction will reduce the base flow in the estuary, facilitating salt water intrusion.

6.1.10 Ground Water Field North of Maracuene with artificial recharge

This alternative includes a small water intake at the Incomati River downstream of the Sabie confluence pumping water during the wet season to recharge groundwater at four infiltration basins on the groundwater divide west of Manhiça. It involves the outtake of water from a set of about 50 boreholes 1-2 km east of the infiltration ponds, after which the water is pumped to a new distribution centre in the northern part of Maputo, where a simplified treatment is applied.

The main impacts for this alternative are:

a) socio-economic – because more area has to be occupied with the infiltration basins, there is more potential for land conflicts, although the location is in a less populated region. Other serious negative impacts are the displacement of people and / or destruction of cultivation areas, as well as terrestrial fauna and flora.

b) environmental – the negative impacts are less important than in the previous alternative, regarding the effects on the estuary.

6.1.11 Intake at Massingir dam

Besides the intake at the existing Massingir Dam, this alternative requires also a treatment plant in Massingir and a very long pipeline until Maputo, of more than 200 km.

The major impacts of this alternative are similar to those indicated to the intake at the existing Corumana Dam but aggravated, particular for the socio-economic indicators, due to the extension of the pipeline, which leads to more people and land being affected.

6.1.12 Desalination plant north of Maputo

This alternative involves an intake of sea water to the north of Maputo and the establishment of a desalinisation plant close to the coastline. The water will then be pumped to a new distribution centre in northern parts of Maputo.

The following main impacts are expected:

a) socio-economic – a large area will be needed for the desalination plant and, to a lesser extent, by the pipeline. This will result in displacement of population, destruction of agricultural land, changes in land use pattern and land conflicts.

b) Environmental – the major impacts will be the disturbance of marine fauna due to brine discharge and the associated change of water quality. Other important impacts will be the changes in ecosystems and the loss of terrestrial ecosystems in the area occupied by the desalination plant.

6.1.13 Reuse of wastewater

A new and large treatment plant will be required to process wastewater to potable /drinking water standard, plus a pipeline to link it to a distribution centre. It will also require a system to collect wastewater and get it to the treatment plant.

The major impacts associated with this alternative are the following ones:

a) socio-economic – the area needed for the treatment plant will result in some displacement of population and land conflicts.

b) Environmental – the only significant impact is the loss of terrestrial ecosystems in the area occupied by the new water treatment plant.

6.2 Methodology for detailed screening

The methodology used allowed us to organise existing and simplified information at a macro level, which was then used to structure indicators. It implies the overall structuring of effects (impacts) from projects on the social and biophysical environment, in order to respond with measures or actions that minimise or avoid impacts. These measures may be mitigation plans which contribute to minimise negative impacts on the human and natural environment.

Due to the characteristics and nature of impacts associated with each type of project, the model must be adapted to suit each individual case/project. Therefore, it is necessary to establish relationships based on assumptions and / or plausible evidences related to each project in order to determine appropriate responses / actions.

This model is based on a group of five indicators, namely:

6. Environmental pressures: used to analyse the causes of environmental problems.
7. State of the environment: related to the quality of the environment and natural resources from human actions/pressures.
8. Impact on the environment and society: looks at the impacts and effects of human activities on the environment.

9. Responses to the environment: related to the responses and measures that society applies to the environment.
10. Management Indicators: related to the management of legal and economic instruments developed by society.

In order to apply this methodology, it is necessary to identify and define problems as well as priority areas of intervention. Therefore, the social and biophysical characteristics of the thirteen potential areas of intervention / project alternatives have been briefly assessed in order to identify priority areas of intervention based on the main environmental and social problems associated with these.

Once project alternatives have been identified and described, there is a better understanding of the magnitude of works required for each alternative, which allows for the identification of potential effects (impacts) and evaluation (scoring).

The selected impacts for both components are the minimum impacts that must be taken into consideration in order to rate the best alternatives as per a cause and effect matrix. A cause and effect matrix allows the identification and the rating of causes and effects from a project on the social and biophysical environment.

For the selection of the socio-economic impacts, an analysis of potential project impacts on the social environment was followed based on local livelihoods and basic conditions such as housing, productive systems and subsistence, access to education, health services and public infra-structure as well as socially organised groups with certain standards of living.

These aspects are an integral part of the social well-being of human settlements or communities. The loss of these conditions constitutes a great threat to the affected people, which, if not properly managed, may become an obstacle to project implementation.

The environmental impacts were chosen based on project characteristics and location of each. The physical placement of a structure on the environment will affect the natural environment where the structure is located, which may be a terrestrial, aquatic, coastal and / or riverine ecosystem.

These impacts on the other hand will be linked to the potential loss of species such as flora and fauna species (which may be rare, endangered and/or endemic) and or will affect how systems function within this ecosystem.

For this particular study, a matrix was developed by selecting eight variables for the social and eight variables for the environmental components, which were considered to be the main expected impacts associated with the 13 project alternatives.

Social impacts:

1. Displacement of people
2. Destruction of cultivated land

3. Changes in land use patterns
4. Land conflicts
5. Unemployment and lower incomes
6. Community disintegration
7. Loss of basic social services and infra-structures
8. Worsening of quality of life

Environmental Impacts:

1. Loss and / or disturbance of terrestrial ecosystems (vegetation and fauna)
2. Loss and / or disturbance of aquatic fauna
3. Changes in the river's ecological flow
4. Changes in the river's sediment transport regime
5. Changes in ecosystems such as lakes, estuaries, wetlands, bays
6. Changes in water quality
7. Lowering of water table and salt intrusion
8. Disturbance of marine fauna

The following impact evaluation (scoring) was attributed:

- Very high – 5;
- High – 4;
- Medium – 3;
- Low – 2;
- Very low – 1;
- No effect – 0.

It must be noted that all the impacts that are listed above are negative impacts. However, there may be also some positive impacts. To take these into consideration, the negative impacts are taken as negative numbers and the positive impacts as positive numbers.

Furthermore, it is important to note that impact evaluation was done taking into account the following assumptions:

- that mitigation measures will be implemented whenever applicable;
- that international best practices will be applied to each individual project.

6.3 Results

6.3.1 Scores of the alternatives

The impacts associated with each project are scored in the matrices presented in Tables 6.1 and 6.2. By adding the scores of each impact for a particular project, it is possible to quantify a higher or lower impact incidence of a project on the socio-economic and biophysical environment.

Some comments on the scores given below to each project alternative for the various socio-economic and environmental indicators.

S1 – Population displacement – This indicator has the highest negative impact when two new dams (Moamba-Major and Movene) are constructed. In decreasing order, appear:

- the construction of Moamba-Major large dam,
- desalination and re-use of wastewater because they will need large areas in densely occupied urban areas,
- groundwater with artificial recharge due to the areas needed for the infiltration ponds
- the completion of Corumana dam as a small number of families will be displaced by the new inundated area
- the intake at Massingir Dam considering that the increase in length of the pipeline will affect more people along the way.

S2 – Destruction of productive land (cultivation) – The indicator is highly negative when the two new dams are constructed because it corresponds to large inundated areas with the new reservoirs. Then follows the construction of Moamba-Major Dam, desalination, re-use of wastewater, completion of Corumana Dam, groundwater with artificial recharge and the intake at Massingir Dam

Table 6.1 Evaluation matrix of socio-economic impacts of the different alternatives.

		SOCIO-ECONOMIC IMPACTS								
		S1	S2	S3	S4	S5	S6	S7	S8	
	PROJECT ALTERNATIVES	Population displacement	Destruction of productive land (cultivation)	Changes in land use patterns	Land conflicts	Loss of employment and lower incomes	Community disintegration	Loss of basic services and infra-structure	Changes in the quality of life	**SUM**
1	Intake at existing Corumana Dam	-1	0	-1	0	1	0	1	1	**1**
2	Completion of Corumana Dam	-2	-3	-2	-1	2	0	1	2	**-3**
3	Intake weir downstream of confluence of Sabie and Incomati	-2	-3	-2	-1	2	0	1	2	**-3**
4	Moamba-Major Dam	-4	-4	-4	-4	3	-3	3	3	**-10**
5	Moamba-Major Dam combined with Movene Dam	-5	-5	-5	-5	3	-4	3	3	**-15**
6	Intake in Maputo River in Catuane	-1	-1	-1	-1	1	0	1	1	**-1**
7	Intake in Maputo River, upstream Salamanga	-1	-1	-1	-1	1	0	1	1	**-1**
8	Groundwater in northern Maputo	-2	-2	-2	-3	-1	0	1	1	**-8**
9	Groundwater north of Maracuene	-1	-1	-1	-1	0	0	1	1	**-2**
10	Groundwater north of Maracuene with artificial recharge	-2	-2	-2	-3	0	0	1	1	**-7**
11	Intake at Massingir Dam	-2	-2	-2	-2	1	0	1	1	**-5**
12	Desalination	-3	-3	-3	-3	-1	0	1	1	**-11**
13	Reuse of wastewater	-2	-2	-2	-3	-1	0	1	1	**-8**
	SUM	**-28**	**-29**	**-28**	**-28**	**11**	**-7**	**17**	**19**	**-73**

S3 – Changes in land use pattern – The scoring for this indicator follows the same arguments that for indicator S2.

S4 – Land conflicts – Again the alternatives involving the construction of two new dams give the highest negative scores as the dam's reservoirs will inundate large areas. The score is also high for the alternatives of groundwater south of Maracuene (densely populated area), groundwater with artificial recharge (less populated but larger area needed), desalination and re-use of wastewater.

S5 – Loss of employment and lower incomes – in this indicator losses may be compensated by gains of employment or incomes by the directly affected population or by other population in the project area. There may be a net loss, although small, for the alternatives of groundwater south of Maracuene, desalination and re-use of wastewater while net gains can be expected particularly from the dam projects due to employment in the construction phase and the increase in irrigated agriculture activities.

S6 – Community disintegration – this can be expected only in relation to the construction of the new dams as none of the other alternatives is expected to affect large number of families in a community.

S7 – Loss of basic services and infrastructure – here the impacts will be mostly positive due to the social infrastructure associated with large investment projects, the largest net gains being expected with the construction of new dams.

S8 – Changes in the quality of life – again positive impacts can be expected for most of the affected population due to the improvement in the water supply and the increase in economic activities, the largest impacts associated with the construction of the new dams. The basic assumption with this indicator and also with S7 and S5 is that the investment projects will include a social component that not only compensates but improves the existing basic services and infrastructure.

A reference must be made regarding the impact of the project alternatives in relation to the HIV/AIDS pandemic. Experience indicates that concentration of male workers in construction sites is usually a focus of dissemination of the virus. At this stage, it is difficult to define the dimension of the construction works and one can only distinguish those that are of a clearly higher dimension and concentration:

- higher dimension – Moamba-Major dam, Movene dam, completion of Corumana dam, desalination
- smaller dimension – all the other alternatives

E1 – Loss and / or disturbance of terrestrial ecosystems (vegetation and fauna) – the highest impacts appear with the construction of the new dams of Moamba-Major and Movene. Smaller impact will be associated with the completion of Corumana Dam, desalination, re-use of wastewater and the intake at Massingir Dam. The other alternatives have even smaller impact, the least one being the intake from the existing Corumana Dam.

Table 6.2 Evaluation matrix of environmental impacts

		ENVIRONMENTAL IMPACTS								
		E1	E2	E3	E4	E5	E6	E7	E8	
	PROJECT ALTERNATIVES	Loss and / or disturbance of terrestrial ecosystems (vegetation and fauna)	Loss and / or disturbance of aquatic fauna	Changes in the river's ecological flow	Changes in the river's sediment transport regime	Changes in ecosystems such as lakes, estuaries, wetlands, bays	Changes in water quality	Lowering of water table and salt intrusion	Disturbance of marine fauna due to brine discharge	**SUM**
1	Intake at existing Corumana Dam	-1	0	-2	-1	-1	0	0	0	**-5**
2	Completion of Corumana Dam	-3	-2	1	-3	-2	-2	0	0	**-11**
3	Intake weir downstream of confluence of Sabie and Incomati	-3	-3	1	-3	-2	-2	0	0	**-12**
4	Moamba-Major Dam	-5	-5	1	-5	-3	-4	0	0	**-21**
5	Moamba-Major Dam combined with Movene Dam	-5	-5	-1	-5	-3	-4	0	0	**-23**
6	Intake in Maputo River in Catuane	-2	-3	-3	-3	-4	-1	-1	0	**-17**
7	Intake in Maputo River, upstream Salamanga	-2	-3	-3	-3	-3	-1	-2	0	**-17**
8	Groundwater in northern Maputo	-2	0	0	0	-1	-1	-2	0	**-6**
9	Groundwater north of Maracuene	-3	0	-2	0	-3	-1	-3	0	**-12**
10	Groundwater north of Maracuene with artificial recharge	-3	0	-2	-1	-2	-1	0	0	**-9**
11	Intake at Massingir Dam	-3	0	-2	-1	-2	0	0	0	**-8**
12	Desalination	-3	-1	0	0	-4	-4	0	-4	**-16**
13	Reuse of wastewater	-3	0	0	0	1	0	0	0	**-2**
	SUM	**-38**	**-22**	**-14**	**-25**	**-29**	**-21**	**-9**	**-4**	**-162**

E2 – Loss and / or disturbance of aquatic fauna – again the highest impacts result from the construction of the new dams. The other alternatives with important negative impacts are the intakes in the Incomati and in the Maputo rivers. The other alternatives have much smaller impacts or even zero impact (intakes at the existing Corumana or Massingir Dams, groundwater alternatives).

E3 – Changes in the river's ecological flows – the highest impacts regarding this indicator are associated with the alternatives of intakes in the Maputo river even if the water abstraction is a relatively small percentage of the flow. The alternatives of intakes at the existing Corumana or at Massingir Dams and in the Incomati represent a smaller impact, the same happening with the Moamba-Major plus Movene alternative and the groundwater north of Maputo and artificial recharge (which will decrease the base flow of the Incomati river near the estuary). The completion of Corumana Dam and the construction of Moamba-Major Dam will be an improvement to the present situation as the increase in storage capacity will allow for effectively guaranteeing the ecological flows.

E4 - Changes in the river's sediment transport regime – the highest impacts result from the construction of the new dams, Moamba-Major and Movene. Other alternatives with significant impacts are the completion of Corumana Dam, the intake downstream of the confluence Sabie-Incomati and the intakes in the Maputo river.

E5 - Changes in ecosystems such as lakes, estuaries, wetlands, bays – for this indicator, the biggest impacts will derive from the intake at Catuane (possible impacts over Lake Madjene) and from desalination. Other significant impacts will come from the construction of the Moamba-Major and Movene dams and groundwater abstraction north of Maracuene. The alternatives of completion of Corumana Dam, groundwater with artificial recharge and intake at Massingir dam will have smaller impacts. The re-use of wastewater will have a small positive impact.

E6 – Changes in water quality – the most important impact is from the alternative of desalination due to the disposal of brine in the estuary. Other very significant impacts are associated with the construction of new dams with large reservoirs where the impounded water will lose quality due to thermal stratification and progressive euthrophication of the lakes. The same, although at a smaller degree as the reservoir already exists, can be expected with the completion of Corumana Dam.

E7 – Lowering of water table and salt water intrusion – the most significant impacts are associated with the groundwater abstraction north of Maracuene followed by groundwater abstraction north of Maputo and the intake in the Maputo river at Salamanga (because Salamanga is still subject to the tidal effect of the estuary). The negative impact of the third groundwater alternative is compensated by artificial recharge. The other alternatives have zero impact regarding this indicator.

E8 - Disturbance of marine fauna due to brine discharge – the only alternative relevant for this indicator is desalination and the impact is very high.

6.3.2 Comparative analysis

In Figure 6.1 it can be seen that indicators S1-S4 and S6 (displacement of people, loss of agricultural land, changes in land use, land conflicts, community disintegration) are the highest negative social impacts for alternatives 4 and 5. Indicators S5, S7 and S8 are mostly positive, corresponding to the idea that such large project, if correctly implemented, will result in improvements in employment, family income, basic services, infrastructures, and ultimately quality of life.

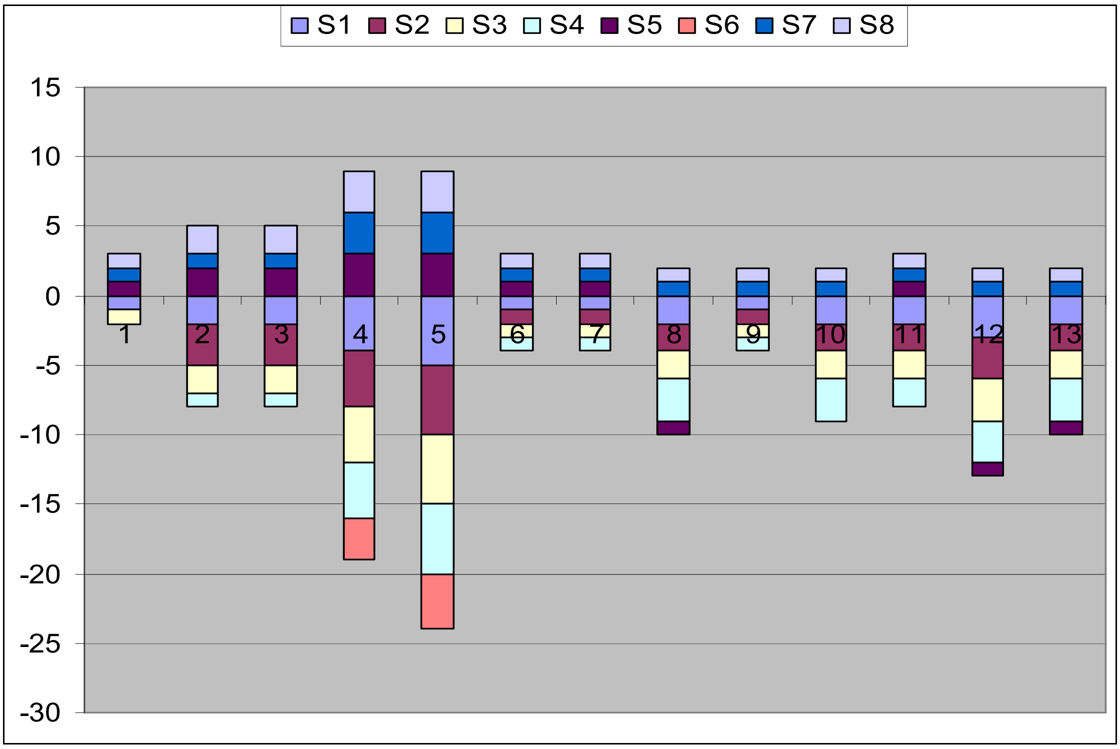


Figure 6.1 Socio-economic indicators impacts per project.

In Figure 6.2 it can be seen that the following alternatives have the **best** scores in terms of socio-economic impacts (positive or low negative scores):

- *Intake at existing Corumana Dam (+1 point)*
- *Intakes in the Maputo River at Catuane or Salamanga (-1 point)*
- *Groundwater abstraction north of Maracuene (-2 points)*
- *Completion of Corumana Dam* and *Intake downstream of the confluence in the Incomati (-3 points)*

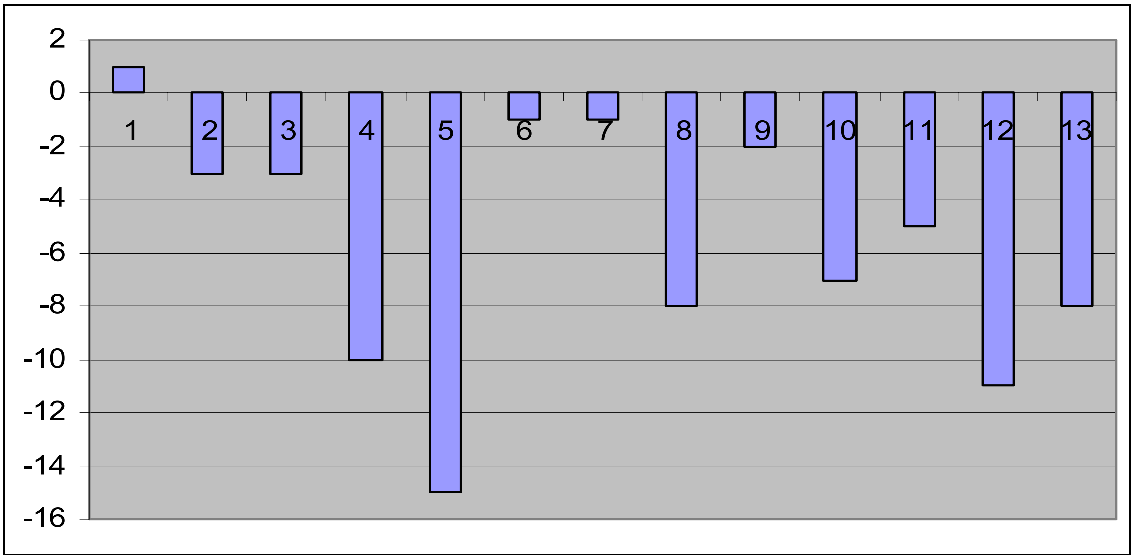


Figure 6.2 Overall socio-economic impacts per project.

On the other hand, the alternatives with the **worse** scores (highest negative) are:

- *Construction of Moamba-Major and Movene Dams (-15 points)*
- *Desalination (-11 points)*
- *Construction of Moamba-Major Dam (-10 points)*

Lastly, the projects with a **medium** score are:

- *Intake at Massingir Dam (-5 points)*
- *Groundwater with artificial recharge (-7 points)*
- *Groundwater north of Maputo* and *re-use of wastewater (-8 points each)*

Figure 6.3 shows that indicators E1, E5 and E6 (disturbance of terrestrial ecosystems, changes in aquatic ecosystems and water quality) have impacts on almost all of the projects. The same happens with indicator E3 (changes in ecological flows) but in this case, it is positive for some projects. Indicator E8 (disturbance for marine fauna) only appears for project 12 (desalination).

As for the global environmental impacts of the various projects, it becomes clear from Figure 6.4 that the alternatives with the **lower** impacts are the following:

- *Re-use of wastewater (-2 points)*
- *Intake at existing Corumana Dam (-5 points)*
- *Groundwater abstraction north of Maputo (-6 points)*

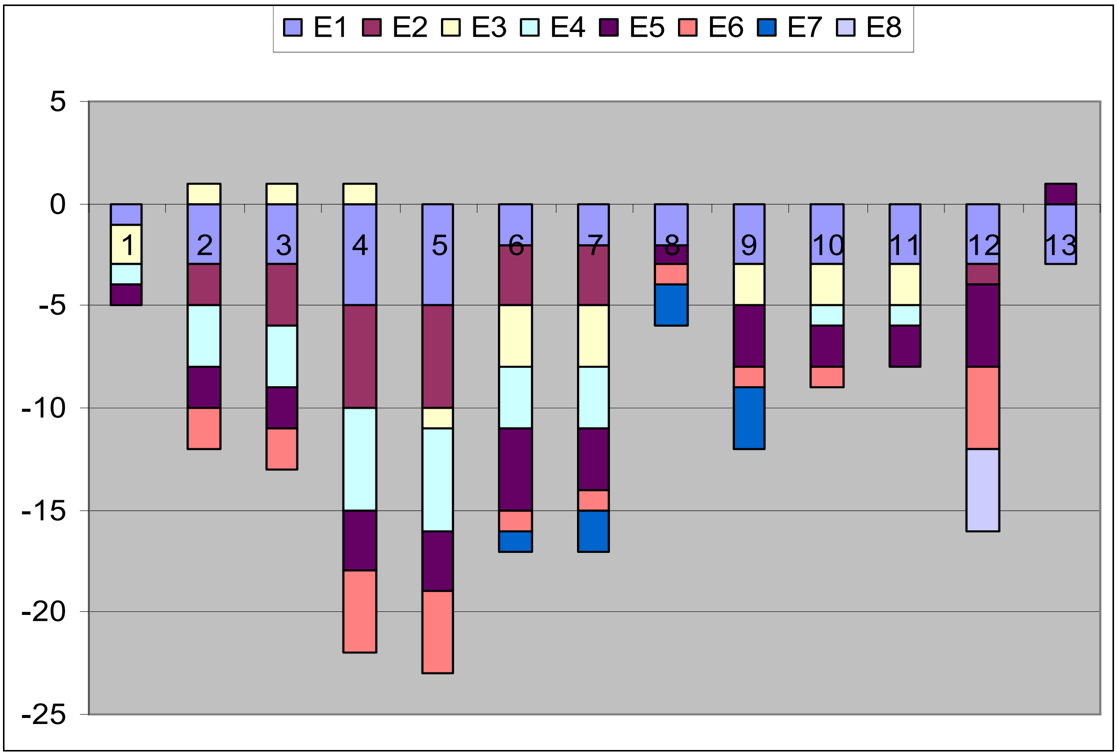


Figure 6.3 Environmental indicators impacts per project.

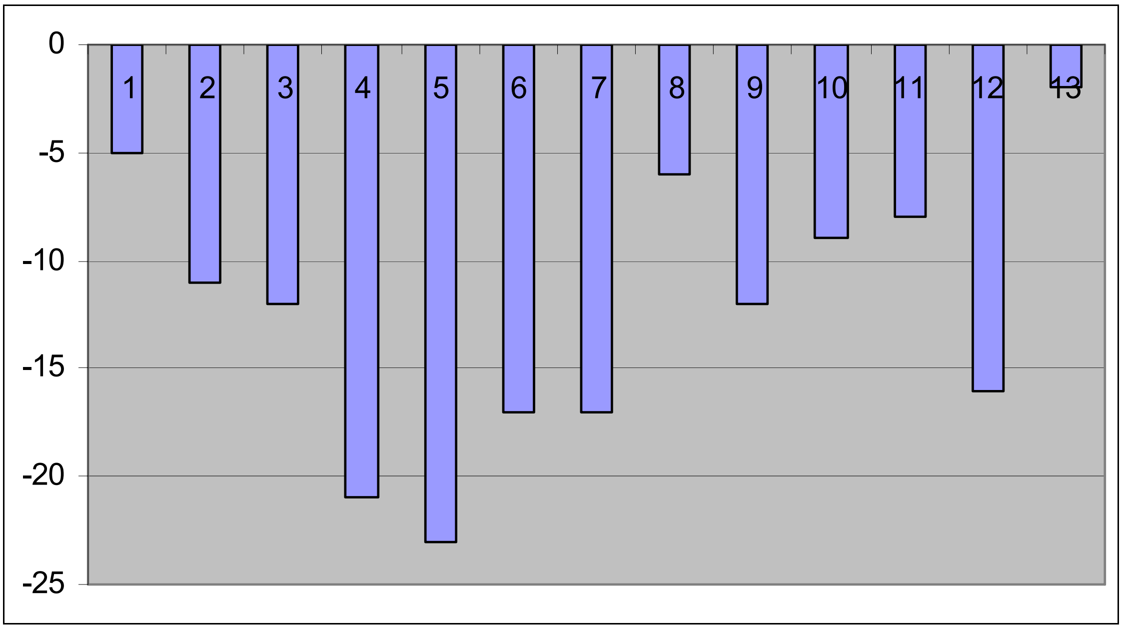


Figure 6.4 Overall environmental impacts per project

The **highest** environmental impacts are expected to be felt on the following alternatives:

- *Construction of Moamba-Major and Movene Dams (-23 points)*
- *Construction of Moamba-Major Dam (-21 points)*
- *Intake in the Maputo river at Salamanga (-17 points)*
- *Intake in the Maputo river at Catuane (-17 points)*
- *Desalination (-16 points)*

The **medium** impacts are expected to be felt on the following alternatives:

- *Intake at Massingir Dam (-8 points)*
- *Groundwater abstraction with artificial recharge (-9 points)*
- *Completion of Corumana Dam (-11 points)*
- *Groundwater north of Maracuene* and *Intake weir downstream of confluence of Sabie and Incomati (both with -12 points)*

6.4 Combined scoring

In this environmental screening of the alternative projects it is not possible to go beyond a qualitative analysis and all the socio-economic and environmental indicators were assumed to have the same weight. Based on this, Table 6.3 is a simple combination of Tables 6.1 and 6.2.

Table 6.3 Evaluation matrix of combined socio-economic and environmental impacts

		Environmental	Social	SUM
1	Intake at existing Corumana Dam	-5	1	**-4**
2	Completion of Corumana Dam	-11	-3	**-14**
3	Intake weir downstream of confluence of Sabie and Incomati	-12	-3	**-15**
4	Moamba Major Dam	-21	-10	**-31**
5	Moamba Dam combined with Movene Dam	-23	-15	**-38**
6	Intake in Maputo River in Catuane	-17	-1	**-18**
7	Intake in Maputo River, upstream Salamanga	-17	-1	**-18**
8	Groundwater in northern Maputo	-6	-8	**-14**
9	Groundwater intake north of Maracuene	-12	-2	**-14**
10	Groundwater field north of Maracuene with artificial recharge	-9	-7	**-16**
11	Intake at Massingir Dam	-8	-5	**-13**
12	Desalination	-16	-11	**-27**
13	Reuse of wastewater	-2	-8	**-10**

It can be seen that the project with less global socio-economic and environmental impact is alternative 1 – Intake at the existing Corumana Dam (-4 points), followed by alternative 13 – re-use of wastewater (-10 points). Close to the second alternative in terms of global impacts are alternatives 11 – intake at Massingir Dam (-13 points), 2 – completion of Corumana Dam, 8 – groundwater north of Maputo and 9 – groundwater north of Maracuene, all with -14 points.

The following alternatives in increasing global impacts are alternatives 3 – intake in the Incomati downstream of the confluence (-15 points), 10 – groundwater with artificial recharge (-16 points), 6 – intake in the Maputo river at Catuane (-18 points) and 7 – intake in the Maputo river at Salamanga (-18 points).

The worst alternatives in terms of global socio-economic and environmental impacts are alternatives 12 – desalination (-27 points), 4 – construction of Moamba-Major Dam (-31 points) and 5 – construction of Moamba-Major and Movene Dams (-38 points).

It must be noted that this comparison assumed that all alternatives would be able to deliver the required amount of water for the Greater Maputo water supply, which may not be the case, particularly for desalination, re-use of wastewater and the groundwater alternatives.

6.5 Use of environmental and social scoring

It is essential to note that the combined scores given in Table 6.3 are based on a relative scale without giving any weights to the different criteria. The approach was chosen to get overview of the relative difference in environmental and social impacts of the supply alternatives and it is important to understand that these results can not be used out of context.

It should be noted that a screening is limited to impacts. Most environmental and social impacts can be reduced through mitigation measures. The relative difference between the supply alternatives would probably be less after mitigation measures have been applied. Care should therefore be taken before using the scores in Table 6.3 as the only criterion for favouring or discarding an alternative.

For the chosen supply alternatives it is absolutely essential to conduct a full Environmental and Social Impact Assessment (ESIA), including identified mitigation measures.

7 COMBINED SCREENING OF SUPPLY ALTERNATIVES

7.1 Safe yields

Table 4.1 gives the estimated safe yields for the gross list of alternatives. These estimates are mainly based on the firm yields of the water balance analysis with the WRYM model, which gives the 100% safe yield. Although normally a lower yield than 100% is required, and there are uncertainties associated with the analysis, these estimates give an indication which alternatives are viable for the long-term water supply to the greater Maputo.

Figure 2.2 indicates that in the order of 125-150 Mm^3/year is needed to fully supply all domestic and irrigation requirements at 100% assurance by 2030, while the IIMA agreement stipulates a maximum of 87.6 Mm^3/year to be taken from either of the Incomati or Maputo Rivers.

As mentioned above the acceptable assurance of supply for urban supply and irrigation is set to 98% and 80%, respectively, which will reduce the required additional source of water. However, considering these assurances of supply, the additional amount of water required is probably still in the order of 100 Mm^3/year. Combining this with the fact that there are uncertainties in the success of reducing unaccounted for water, it is strongly recommended to develop a scheme that can fully utilise the 87.6 Mm^3/year allocated by the IIMA, or to utilise other abundant resources as the Limpopo River or desalinisation.

Smaller sources such as the Movene Dam, groundwater through natural recharge, reuse of water, or water demand management will not be sufficient on their own for solving the water supply situation for Maputo City and its metropolitan area. These smaller sources may, however, be effective additional supplies to a larger scheme.

7.2 Costs

Cost estimates have been made for all the gross supply alternatives in Table 4.1 and are summarised in Table 7.1. The basis for the Corumana, Moamba and Movene dams have been the previous studies by Lahmeyer and Associates (2003), Norconsult (2003) and SWECO and Associates (2005a), which all conducted detailed cost estimates. These costs have been escalated to 2009 price level by using a 10.1% rate per annum, based on actual escalations seen during the last seven years. A comparison with World Bank (2007a) shows similar costs with the estimates in Figure 7.1 being slightly higher. The reason for the higher costs is believed to be a higher escalation rate used in this study.

For the Maputo River, groundwater and Massingir alternatives new estimates have been made based on tentative designs of the abstraction and conveyance systems. Experience from Australia and South Africa has been used to guide the estimates for large desalination and recycling schemes.

Pipelines and pump stations generally comprise the largest part of the total costs of the schemes. Steel pipelines have been assumed for alternatives based on the experience from large water transfer schemes in South Africa. Unit prices for pipelines and pump stations have been taken from recent and on-going projects in South Africa with an additional allowance of 25% to make it applicable in Mozambique. Comparing with the World Bank (2007a) study the estimated pipeline costs presented in this report are considerably higher. The reason is probably because of difference in choice of pipeline type (e.g. reinforced PVC instead of steel), which has a large effects on the unit price per meter of pipeline. Recent estimates for glass-reinforced polyester pipes in Mozambique for diameters of one metre and smaller have shown considerably lower costs than have been used in this study. It is, however, argued that for the major transfer schemes of 40-90 Mm^3/year steel pipes are the most appropriate.

The cost estimates indicates that, except for the small-scale development of boreholes within northern Maputo, no new source would cost less than 0.55 USD per m^3. The developments of the transfers from Corumana/Moamba and Maputo River at Salamanga have similar costs being in the order of 0.55-0.65 USD/m^3. Desalinisation has by far the highest unit cost followed by the transfer of water from Limpopo and recycling of waste water.

			Dam storage		Abstraction		Conveyance Pipeline					Pumping		Treatment		Sub-Total	Operation Costs/year	Pumping Costs - transmission lines					Sub-Total	Total	
Supply Alternative	Safe Yield (Mm3/yr)	Assumed supply for Maputo (Mm3/yr)	Storage (Mm3)	Est. Cost MUSD	Description	Est. Cost MUSD	Pipeline (mm)	Length (km)	Design flow (m3/s)	Unit cost	Est. Cost MUSD	Pump station cost MUSD	kW required	Type	Cost MUSD	Cost (MUSD)	Maintenance of schemes & Operation of WTP (MUSD/yr)	Elevation difference (m)	Friction losses (m)	Total head (m)	Energy used (GWh/yr)	Cost energy (MUSD/yr)	Cost (MUSD/yr)	Discounted Cost (MUSD) over 30 years***	Unit Reference Value (URV) (USD/m3)
1 **Exisitng Corumana dam**	230-237	87.6	880	0	dam outlet	0.4	1800	91	3.75	3440	313	125	3900	conventional	113.5	552	6.00	0	90	90	25	1.14	7.14	590	**0.61**
2 **Completed Corumana dam**	250-256	87.6	1363	41	dam outlet	0.4	1800	91	3.75	3440	313	120	3500	conventional	113.5	588	6.00	-9	90	81	23	1.02	7.02	622	**0.64**
3 **Completed Corumana dam, Intake weir downstream of confluence of Sabie and Incomati**	>260	87.6	1363	41	weir on river	120	1800	79	3.75	3440	272	150	5400	conventional	113.5	697	7.00	45	78	123	35	1.58	8.58	739	**0.76**
4 **New multi-purpose dam at Moamba Major* on the Incomati upstream confluence with Sabie**	130-150	87.6	657	160	dam outlet	0.4	1800	57	3.75	3440	196	75	2300	conventional	113.5	545	5.50	0	52	52	15	0.67	6.17	572	**0.59**
5 **Moamba combined with Movene Dam**	additional 3-5 Mm3/year	87.6	678	180	dam outlet	2	1800	39	3.75	3440	134	80	2700	conventional	113.5	510	5.50	30	31	61	18	0.79	6.29	541	**0.56**
6 **An intake at the Maputo River at Catuane**	160-200	87.6	natural lake	0	Run-off river intake	3.5	1800	130	3.75	3440	447	145	5700	conventional	113.5	709	6.00	0	130	130	37	1.66	7.66	741	**0.77**
7 **An intake in the Maputo River upstream Salamanga**	160-200	87.6	18	43	Run-off river intake	3.5	1800	66.4	3.75	3440	228	135	3900	conventional	113.5	524	6.00	15	75	90	25	1.14	7.14	564	**0.58**
8 **Developed groundwater within northern part of Maputo south of Maracuene**	9	9	N/A	N/A	Borehole intake	2.1	400	2	0.3	1000	2	0.1	0	disinfection	0.2	4	0.01	Local distribution				0.05	0.06	5	**0.05**
9 **Developed groundwater north of Maracuene**	30	30	N/A	N/A	Borehole intake	4.7	1000	65	1.0	1292	84	108	1000	disinfection	0.7	197	4.00	15	70	85	6	0.29	4.29	230	**0.70**
10 **Artificial recharge from Incomati on the area north of Maracuene**	60	60	N/A	N/A	Borehole intake	5	1400	80	2.0	3300	264	178	3200	disinfection	1.2	448	6.50	45	90	135	21	0.93	7.43	497	**0.75**
11 **Intake at Massingir Dam**	>260	87.6	N/A	N/A	dam outlet	0.4	1800	231	3.75	3440	795	190	6100	conventional	113.5	1099	6.50	-90	230	140	40	1.78	8.28	1108	**1.15**
12 **Desalinisation plant north of Maputo****	Abundant	87.6	N/A	N/A	sea intake	0.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	reverse osmosis	1133	1134	41.20	N/A	N/A	N/A	N/A	N/A	41.20	1503	**1.55**
13 **Reuse of wastewater****	20% of used water	28	N/A	N/A	WWTW outlet	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	reverse osmosis and conventional	218	218	6.55	N/A	N/A	N/A	N/A	N/A	6.55	274	**0.89**

**Infrastructural cost of Moamba Major Dam calculated as a factor of total price, where the factor is defined as supply to Maputo City divided by water supplied to other new users (currently limited to 100 Mm3/yr for irrigation and 7 Mm3/yr for primary use by the IIMA). The total estimated price for Moamba Major Dam is 355 MUSD.*

*** Based on experince from Australia and South Africa*

**** Discount rate of 8%*

Table 7.1 Cost estimate for gross list of water supply alternatives in 2009 USD value.

7.3 Environmental concerns

Figure 7.2 shows a combined analysis of costs and environmental and social impacts of the supply alternatives.

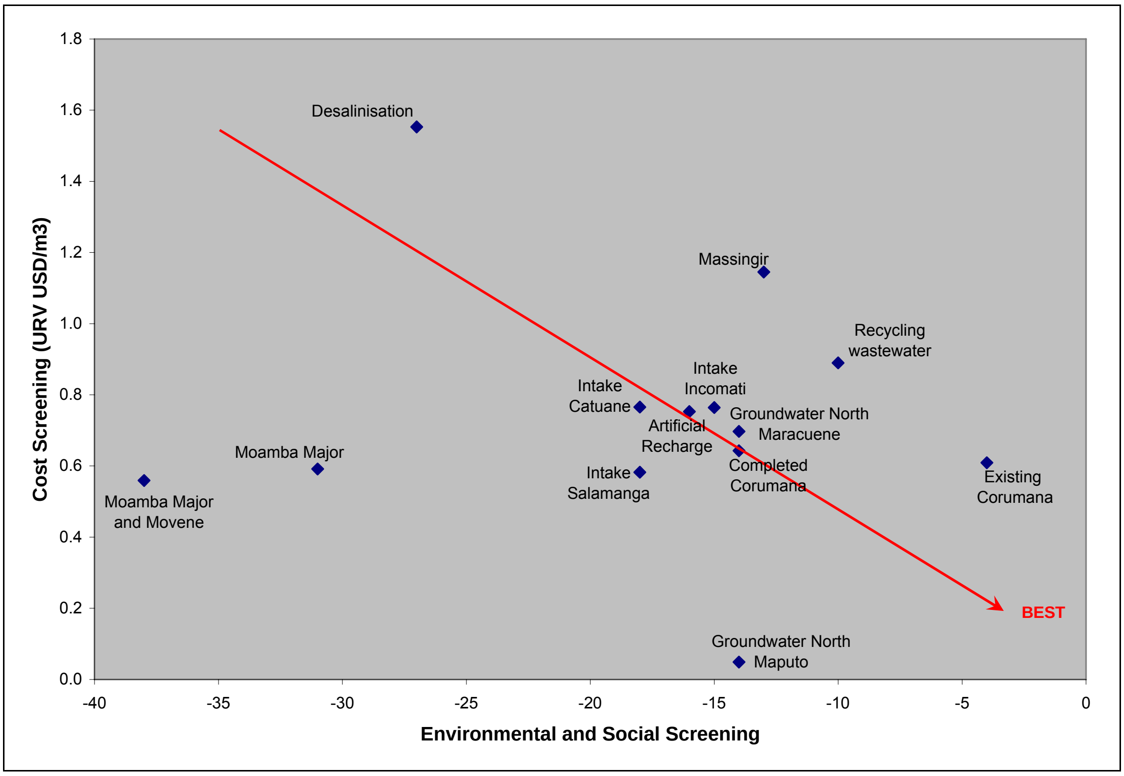


Figure 7.1 Cost estimate for gross list of water supply alternatives in 2009 USD value plotted against combined scores for environmental and social impacts.

The option of utilising the existing Corumana Dam as the source for Maputo water supply is the best option in terms of environmental and social impact.

Among the alternatives with reasonable unit costs (<0.8 USD/m^3), the completion of Corumana, transfers from Maputo River and the development of groundwater schemes all have moderately negative environmental and social impacts, while the Moamba options are less favourable. The combination of the Moamba Major and the Movene Dam has the largest negative impacts of all alternatives.

7.4 Timing and multi-purpose development

Besides the costs and environmental and social impacts other factors must also be taken into account to evaluate the different alternatives. The most notable factor is the possible use of the water supply schemes for other users than Maputo City.

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The Moamba Major has the most obvious multi-purpose function since it would augment the expansion of irrigation in the lower Incomati in Mozambique. The projected expansion of approximately 10,000 ha for irrigation below the confluence of Sabie and Incomati, may need additional storage to secure the 100 Mm^3/year, which is presently the maximum possible expansion according to the IIMA. The Moamba Major dam has also potential flood mitigation benefits for the lower Incomati area, which is prone to large floods.

Utilising the Corumana and/or Moamba dams for urban supply would also make it possible to secure water supply to the settlements along the EN4 that are rapidly expanding. A treatment work at Moamba would make it possible to deliver treated water directly to these settlements.

Similarly, abstraction from the Maputo River upstream Salamanga can supply water to the villages of Salamanga and Bela Vista, while the groundwater scheme north of Maracuene can supply both the Manhiça and Maracuene villages.

It should also be noted that considering the present development of the Maputo metropolitan area to the north and west this makes the supply sources from Incomati and groundwater aquifers north of Maracuene attractive. A source from the north does not need to connect to the existing treatment plant at Umbeluzi but can be connected to new distribution centres in the northwest part of the city.

Opposite to possible benefits of multipurpose functions, the time delay before being put into operation may limit the possible supply options. Figure 2.2 showed that the Maputo water supply needs to be augmented as soon as possible and that in 2015 there will be serious water deficits if the existing situation prevails. All supply options have different lead times because of required preparatory studies, sourcing of funding and construction times. Table 7.2 gives an estimate of the possible commissioning years for the gross list of supply alternatives.

Except for the development of small-scale groundwater in northern Maputo, the transfer from completed Corumana is the alternative that can be implemented first. The Corumana alternative has a short lead time because the World Bank has targeted funds for this alternative and is currently preparing technical studies for the completion of the Corumana Dam within the National Water Resources Development Project No. 1. On the other hand, the environmental issue raised by South Africa regarding possible negative environmental effects in the Kruger Park by the completion of the Corumana dam makes the start of operation uncertain.

Moamba Major has the longest lead time prior to being in operation. The reason is that due to its multi-purpose character an updated feasibility study is required and substantial funds needs to be sourced for the complete scheme, even if the part for Maputo water supply can be motivated and paid for.

The Moamba Major Dam, being a large dam also requires significant re-settlement as well as the relocation of the railway line that will mean long time for preparatory studies and construction.

Table 7.2 Estimated times for start of operation.

		Start of operation
1	Intake at existing Corumana Dam	2014
2	Completion of Corumana Dam	2014
3	Intake weir downstream of confluence of Sabie and Incomati	2015
4	Moamba Major Dam	2020
5	Moamba Dam combined with Movene Dam	2020
6	Intake in Maputo River in Catuane	2015
7	Intake in Maputo River, upstream Salamanga	2015
8	Groundwater in northern Maputo	2011
9	Groundwater intake north of Maracuene	2015
10	Groundwater field north of Maracuene with artificial recharge	2015
11	Intake at Massingir Dam	2017
12	Desalination	2017
13	Reuse of wastewater	2015

For both the groundwater schemes and the transfers from the Maputo River the size of the civil works are relatively smaller and the lead time thus becomes shorter. For the Maputo River substantial geotechnical investigations must, however, be conducted, which requires time. For the artificial recharge alternative it is also anticipated that pilot testing will be needed that will require longer preparatory studies compared to e.g. the Corumana.

Construction of pipelines for the required distances will take 1-2 years for the transfers from Incomati, Maputo or Maracuene groundwater scheme, which in practice prevents putting any of these into operation before 2014.

7.5 Risk considerations

All supply alternatives are to some extent related to risks. The main risks that are not implicitly taken into account in the above criteria are uncertainties in infrastructure design and cost, environmental and social impacts and lead times because of none or limited preparatory studies. Specifically the following risks are identified for the supply alternatives.

- The completion of the Corumana has relatively low risks related to the dam safety when filling up to the originally intended full supply level and the possible effects on the upstream Sabie River. Both issues will, however, be assessed in detail in upcoming studies funded under the NWRDP1 in beginning of 2010.

- The possible intake downstream of the Sabie and Incomati confluence is associated with considerable risks related to the infrastructure design. The river section in this area is generally wide and prone to erosion or sediment accumulation and no technical feasibility study has been conducted.

- The Moamba Major Dam has relatively low risks associated with the updating of the feasibility study from 2003. The existing feasibility study provides indications that Moamba Major is a potential option although the financial analysis needs to be updated.

- The Movene Dam has been principally designed based on only desk studies and thus involves considerable risks of changed costs and lead time.

- The Maputo River options (both Catuane and Salamanga) involve considerable risks related to the infrastructure design and costs. The tentative design and cost estimate of this study is based on a desk study without any field investigations. The principle design proposal is most likely viable but issues like salt water intrusion and geotechnical characteristics may change the detailed intake and off-channel storage sites and thereby affect the cost and lead time of these alternatives.

- The groundwater options are all principally designed on limited field investigations and groundwater modelling. Issues such as borehole yield and salt water intrusion must be studied in more detail and these options thus involve considerable risks both in terms of safe yield as well as in costs and lead time.

- Intake at Massingir has relatively moderate risk. On the one side it utilises an existent storage infrastructure. On the other side the recent structural failure in 2008 gives uncertainties in the possible yield of the dam, at least on the short-term. Furthermore, the long pipeline route has only been proposed on recognisance level in this study and therefore involves risks of changed costs.

- Desalination involves considerable risks with the infrastructural design and environmental impacts since this alternative has only been principally designed based on experience of other countries. However, even larger risk associated with desalinisation is the future cost of electricity required for the reversed osmosis, which comprise the major governing factor for the unit reference value of this alternative.

- Similarly, the unit reference value for treatment of waste water is totally dependent on the future electricity prices and thus also has considerable risks involved for the cost. This alternative has also been designed based on very little information on suitable sites, return flows and infrastructural design, which adds on to the risks involved.

All alternatives also include to varying degree an uncertainty of funding. The completion of the Corumana Dam has been secured through funding from the World Bank and involves the least risk in this regard. Also the search of funding for the Moamba Major Dam, pipeline from Corumana/Moamba and the treatment plant has been initiated by the Mozambican water authorities but no funding has yet been assured. Search for funding for all other alternatives have not been initiated and thus involves larger risk of extended lead time.

7.6 Choice of main strategies for supplying Greater Maputo

The results of the screening are summarised in Table 7.3, which displays all criteria for all the supply alternatives.

From the screening it can be concluded that a number of alternative options falls out from a cost perspective (see detailed cost estimates in Table 7.1):

- The use of desalinisation or reuse of wastewater are comparatively very expensive and are therefore not of interest as long as there are alternative sources.
- The piping from Massingir Dam in Limpopo is similarly too expensive relative to the options of retrieving water from the Incomati and/or Maputo Rivers.
- Artificial recharge is comparatively expensive relative to the possibility of taking the same amount of water from the Incomati system directly from Corumana.
- An intake at Catuane is comparatively more expensive than taking the water from a site upstream Salamanga, while having the same yield.

Since in all these cases alternatives exist that cannot be discarded based on other criteria, there is no motivation of studying these options further. With this background Table 7.4 gives advantages and disadvantages with the remaining alternatives.

The conclusion of the pros and cons is that none of the options of Table 7.4 can be discarded and should remain as possible options for the continued planning of the future water supply to the Maputo City. Considering the pros and cons it is however the consultant's recommendation to focus on the main strategies presented in Table 7.5, which will be further analysed in the coming chapters.

The basis for the choice of main strategies has been:

- The transfer from the Corumana Dam and the transfer from Maputo River upstream of Salamanga both have moderate costs, moderate environmental and social impacts and relatively short lead times, and should therefore be considered options.

- Although being the cheapest alternatives of the large transfer schemes the Moamba Major has not been considered on its own because of the long lead time. It would not be acceptable to have very low assurance of supply for a 10-year period up to 2020, when the Moamba Major dam can be in operation. However, because of it potential multi-purpose benefits and its possibility of being a long-term (after 2030) solution for Maputo water supply the Moamba Major Dam deserves to be included as an alternative sub-sequent to a first source that can be implemented within the coming five years.
- The existing Corumana dam option is not considered because it is already committed for irrigation in lower Incomati River. For the same reason it is neither judged viable to take the full amount of 87.6 Mm^3/year from the completed Corumana Dam.
- The intake on the Incomati downstream of the Sabie confluence is not considered because of its higher cost compared to taking water directly from Corumana, and because the weir on the Incomati River would require more maintenance to ensure siltation does not become a problem. It is also cheaper to pump stored water directly from Corumana to the treatment plant at Moamba, than it is to release the water and pump it from a weir, which is at a lower elevation and will have a higher pumping head.
- The Movene route option for the Moamba scheme is not considered because of the larger environmental and social impacts and because this option will not support water supply to the rapid urbanisation along the EN4.
- Groundwater in north Maputo and north of Maracuene are viable options with no competing users and should be developed, if needed, to augment the transfer schemes from Incomati and/or Maputo.
- Water demand management would in all cases be economically motivated and should be implemented as far as possible.

Risks due to lack of preparatory studies or large environmental and social impacts have been assumed to be solvable upon required detailed feasibility and ESIA to be conducted for all alternatives before implementation. These risks, however, motivate flexibility in the final strategy to be chosen to allow for future changed conditions after more detailed preparatory studies have been conducted.

	Criterion	**URV**	**Env Impacts**	**Social Impacts**	**Lead Time**	**Multi-purpose use**	**Safe yield**	**Risks**	**Funding**
	Unit	USD/m^3	*Relative*	*Relative*	*Year*		*Mm^3/year*		
1	**Existing Corumana dam**	0.61	-5	1	2014	Water supply along pipeline route along EN4	>87.6	Small	Search for funding of pipeline and WTP initiated
2	**Completed Corumana dam**	0.64	-11	-3	2014	Water supply along pipeline route along EN4	>87.6	Awaiting detailed dam safety and EIA study	Funding for completion secured. Search for funding of pipeline and WTP initiated
3	**Completed Corumana dam, Intake weir downstream of confluence of Sabie and Incomati**	0.76	-12	-3	2015	Water supply along pipeline route along EN4	>87.6	No feasibility or ESIA for intake made	Funding for completion secured. Search for funding of pipeline and WTP initiated.
4	**New multi-purpose dam at Moamba Major on the Incomati upstream confluence with Sabie**	0.59	-21	-10	2020	Irrigation, Power production, Flood control, Water supply along pipeline route along EN4	>87.6	Update of feasibility and ESIA studies required	Search for funding of dam, pipeline and WTP initiated. Funding of part of the dam for multi-purpose uses unclear.
5	**Moamba combined with Movene Dam**	0.56	-23	-15	2020	Irrigation, Power production, Flood control	>87.6	No feasibility or ESIA for Movene Dam made	Search for funding of dam, pipeline and WTP initiated. Funding of part of the dam for multi-purpose uses unclear.
6	**An intake at the Maputo River at Catuane**	0.77	-17	-1	2015	Water supply along pipeline to Salamanga and Bela Vista	>87.6	No feasibility or ESIA for intake and lake storage made	No search of funding initiated
7	**An intake in the Maputo River upstream Salamanga**	0.58	-17	-1	2015	Water supply along pipeline to Salamanga and Bela Vista	>87.6	No feasibility or ESIA for intake and off-channel storage made. Assessment of salt water intrusion needed to confirm intake site	No search of funding initiated
8	**Developed groundwater within northern part of Maputo south of Maracuene**	0.05	-6	-8	2011	None	9	Small	Funding partially secured through FIPAG program
9	**Developed groundwater north of Maracuene**	0.70	-12	-2	2015	Water supply along pipeline to Manica and Maracuene	30	No detailed GW modelling or test pumping made. Risk for salt water intrusion must be further investigated.	No search of funding initiated
10	**Artificial recharge from Incomati on the area north of Maracuene**	0.75	-9	-7	2015	Water supply along pipeline to Manica and Maracuene	60	No feasibility or ESIA for intake made. No detailed GW modelling or test pumping made.	No search of funding initiated
11	**Intake at Massingir Dam**	1.15	-8	-5	2017	Water supply along pipeline	>87.6	No feasibility or ESIA made	No search of funding initiated
12	**Desalinisation plant north of Maputo**	1.55	-16	-11	2017	None	>87.6	No feasibility or ESIA made. Risk for increased electricity prices.	No search of funding initiated
13	**Reuse of wastewater**	0.89	-2	-8	2015	None	28	No feasibility or ESIA made. Risk for increased electricity prices.	No search of funding initiated

Table 7.3 Summary of all criteria for the supply alternatives.

Table 7.4 Remaining alternatives after less cost-efficient alternatives have been discarded.

No.	Source	Pros and Cons
1	Existing Corumana dam	+ Has short lead time + No costs for storage + Environmentally and socially it has small impacts + Will provide water supply to the expanding urbanisation along the EN4 + Low risks - Probably means reduction of planned growth of irrigation in Incomati - Reduces power production at Corumana - Large distance to Maputo that means higher costs
2	Completed Corumana dam	+ Has short lead time since completion of dam will be possible even before the pipeline and new treatment plant are finalised + Gives 22 Mm^3/year extra safe yield to be used for Maputo + Funding secured for completion of dam + Will provide water supply to the expanding urbanisation along the EN4 - Possible negative effects for environment and will require limited resettlements - Large distance to Maputo that means higher costs
3	Intake weir downstream of confluence of Sabie and Incomati	Same as above but: + Gives additional yield compared to taking the water from directly from Corumana - More expensive than taking the water directly from Corumana or Moamba - Risks involved due to lack of preparatory studies of intake
4	New multi-purpose dam at Moamba Major on the Incomati upstream confluence with Sabie	+ Gives in combination with the Corumana Dam sufficient additional yield for both Maputo City and developed irrigation in Incomati. + Possible power production at the dam. + Possible flood mitigation in lower Incomati + Will provide water supply to the expanding urbanisation along the EN4 + Search for funding initiated - Negative effects for environment and will require resettlements - Long lead time. Will probably not be in place before 2020 - Requires co-financing by irrigators/power producers

Table 7.4 (Cont.) Remaining alternatives after less cost-efficient alternatives have been discarded.

No.	Source	Pros and Cons
5	Moamba combined with Movene Dam	Same as above but: + Gives additional 4 Mm^3/year in yield + Shorter pipeline route - Will not supply expanding urbanisation along the EN4 - Negative effects for environment and will require limited resettlements in the Movene dam area - Risks involved due to lack of preparatory studies of Movene Dam
7	An intake in the Maputo River upstream of Salamanga	+ No large storage dam is needed + No competition with irrigation + Moderate environmental and social impacts + Can provide water supply to Salamanga and Bela Vista - Risks involved due to lack of preparatory studies on infrastructural design and salt water intrusion - Large distance to Maputo City that means higher costs
8	Developed groundwater within northern part of Maputo	+ Can be implemented directly + Environmentally and socially it has small impacts - Yield only 9 Mm^3/year
9	Developed groundwater north of Maracuene	+ Relatively small construction costs for borehole schemes + No competition with irrigation + Moderate environmental and social impacts + Can provide water supply to Maracuene and possibly Manhiça - Risks involved due to lack of preparatory studies on borehole yield and salt water intrusion - Large distance to Maputo that means higher costs

Table 7.5 Chosen main alternatives for new supply sources based on the screening.

Main alternatives	Features
A Main source from Incomati River augmented by groundwater and WDM	• 43.8 Mm^3/year from completed Corumana Dam for period implemented as soon as possible. Pipeline for raw water to Moamba Village. Treatment plant at Moamba. Pipeline from Moamba to Maputo.
	• 87.6 Mm^3/year from Moamba Major from 2020 (Corumana pipe used only as emergency)
	• Immediate expansion of groundwater scheme in north Maputo.
	• Immediate WDM measures implemented (Leakage reduction already assumed in estimated water demand)
	• Development, if needed, of the groundwater source north of Maracuene.
B Sources from Incomati <u>and</u> Maputo River augmented by groundwater and WDM	• 43.8 Mm^3/year from completed Corumana Dam for period implemented as soon as possible. Pipeline for raw water to Moamba Village. Treatment plant at Moamba. Pipeline from Moamba to Maputo.
	• 43.8 Mm^3/year from Maputo River through an intake upstream Salamanga and an off-river-storage developed when needed. Feasibility studies to start immediately.
	• Immediate expansion of groundwater scheme in north Maputo.
	• Immediate WDM measures implemented (Leakage reduction already assumed in estimated water demand)
	• Development, if needed, of the groundwater source north of Maracuene.
C Main source from Maputo River augmented by groundwater and WDM	• 87.6 Mm^3/year from Maputo River through an intake upstream Salamanga and an off-river-storage implemented as soon as possible. Could also be phased by developing first 43.8 Mm^3/year and later, when needed, the remaining 43.8 Mm^3/year in a parallel pipeline.
	• Immediate expansion of groundwater scheme in north Maputo.
	• Immediate WDM measures implemented (Leakage reduction already assumed in estimated water demand)
	• Development, if needed, of the groundwater source north of Maracuene.

8 WATER BALANCE ANALYSIS OF MAIN ALTERNATIVES

8.1 Assessment of assurance of supply

The assurances of supply of water to the city of Maputo and irrigation in the Umbeluzi and Incomati were calculated for each of the main strategy alternatives in Table 7.5. The assurances of supply are primarily used to determine the suitable phasing of the development of new water sources. Ideally the development options should be implemented to ensure that the projected demands can be supplied at the required 98% and 80% assurances for urban supply and irrigation respectively. At the same time, the cost of developing new water sources is significant, and new developments are usually held back until the assurance of supply requires intervention.

In the case of Maputo City, the assurance of supply is already below 98% and the projection of rapid growth in urban and irrigation demands in the region, requires intervention sooner rather than later.

The water balance and assurance of supply exercise was conducted using the Water Resources Yield Model (WRYM). The WRYM is a monthly time step water balance model developed by South Africa's DWAF to model the yield and hydropower of a catchment or multiple catchments. The model utilises naturalised hydrology as input and simulates the catchment at a constant development level, i.e. water infrastructure, water demands and land use remain constant during a simulation. The model was thus set-up for a number of development levels up until 2030, namely 2007, 2010, 2020 and 2030. The naturalised hydrology of the most recent and up to date studies on the Umbeluzi, Incomati and Maputo Rivers was utilised. The Water balance report (SWECO and Associates, 2009c) provides more detail on the hydrology utilised.

Water demands, cross border flows and required estuary flows as per Chapter 3 were included for the development levels up to 2030.

The assurances of supply were calculated as the number of months that the demand was supplied as a percentage of the total months (900; 1925 to 1999). Any supply lower than a demand was considered as a failure.

To determine the appropriate phasing of the new water sources for the main strategy alternatives, the assurances of supply for various combinations of new water sources were determined up to 2030. The scenarios representing various combinations of water sources that constitute the different development phases of the main strategy alternatives A, B and C, are shown in Table 8.1.

Table 8.1 Scenarios included in the assurance of supply exercise to represent the development steps of the main strategies.

Scenario	Water sources	Description
1	Pequenos Libombos only	Represents the existing scenario to determine the current assurance of supply and the assurance of supply into the future should the existing situation persist.
2	Pequenos Libombos only	The same as scenario 1 but included to determine the assurance of supply of irrigation in the Incomati should Corumana continue to be utilised only for irrigation. Forms the base scenario for irrigation assurance in the Incomati.
3	Pequenos Libombos and completed Corumana	Pequenos Libombos and 43.8 Mm^3/year from the completed Corumana dam. This scenario was included as the first phase of either Strategy a or B.
4	Pequenos Libombos, completed Corumana and Moamba Major	Pequenos Libombos and the full 87.6 Mm^3/year from Moamba Major with Corumana becoming a secondary source should it be needed. This scenario represents the second phase of Strategy A.
5	Pequenos Libombos and Maputo River 44	Pequenos Libombos and 43.8 Mm^3/year from the Maputo River abstracted upstream of Salamanga (with a smaller off-channel storage dam). This scenario represents either the first phase of Strategy C should the 87.6 Mm^3/year from the Maputo River be phased.
6	Pequenos Libombos and Maputo River 88	Pequenos Libombos and 87.6 Mm^3/year from the Maputo River abstracted upstream of Salamanga (with an off-channel storage dam). This strategy represents Strategy C if the full 87.6 Mm^3/year is implemented without phasing.
7	Pequenos Libombos, completed Corumana and Maputo river	Pequenos Libombos and 43.8 Mm^3/year from the completed Corumana dam, and 43.8 Mm^3/year from the Maputo River. This scenario represents the 2nd phase of either Strategy B.

8.2 Results

The assurances of supply for the Maputo city, the Umbeluzi and Incomati irrigation, and the estuary environmental water requirements up to 2030, are shown in Table 8.2 for the various scenarios.

Table 8.2 Assurance of supply for the scenarios representing the development phases of the main water supply strategy alternatives

Assurance of Supply (%)						
	2007					
Scenario	Maputo City	Umbeluzi Irrigation	Incomati Irrigation	Estuary EWRs Incomati	Estuary EWRs Umbeluzi	Estuary EWRs Maputo
1	89	87	100	100	93	100
3	100	99	100	100	100	100
4	100	100	100	100	100	100
5	100	100	100	100	100	100
6	100	100	100	100	100	100
7	100	100	100	100	100	100
	2010					
Scenario	Maputo City	Umbeluzi Irrigation	Incomati Irrigation	Estuary EWRs Incomati	Estuary EWRs Umbeluzi	Estuary EWRs Maputo
1	85	68	100	100	91	100
3	98	96	100	100	98	100
4	100	100	100	100	100	100
5	99	98	100	100	100	100
6	100	100	100	100	100	100
7	100	99	100	100	100	100
	2020					
Scenario	Maputo City	Umbeluzi Irrigation	Incomati Irrigation	Estuary EWRs Incomati	Estuary EWRs Umbeluzi	Estuary EWRs Maputo
1	65	54	99	100	80	100
3	78	74	99	100	86	100
4	98	94	99	100	98	100
5	79	76	99	100	87	100
6	98	97	99	100	98	100
7	98	97	99	100	98	100
	2030					
Scenario	Maputo City	Umbeluzi Irrigation	Incomati Irrigation	Estuary EWRs Incomati	Estuary EWRs Umbeluzi	Estuary EWRs Maputo
1	51	43	99	100	74	100
3	59	57	99	100	76	100
4	73	68	99	100	83	100
5	60	58	99	100	77	100
6	73	69	99	100	83	100
7	73	69	99	100	83	100

The results show that the assurance of supply for Maputo City with only the Pequenos Libombos is already around 90% in 2007, and decreases significantly beyond 2010. Possible interventions that can provide 43.8 Mm^3/year will improve the assurance of supply in 2010, but shortages and a lower assurance of supply occur again in 2020. This shows that the implementation of a new water source providing 43.8 Mm^3/year is not sufficient in 2020, and either alternative sources, such as groundwater, need to be implemented in conjunction with a surface water development of 43.8 Mm^3/year, or the full amount of 87.6 Mm^3/year needs to be made available before 2020. Furthermore, neither the completed Corumana scheme nor the Maputo River sources can be implemented before 2014.

As such two additional scenarios were included in the water balance analysis to determine if possible groundwater interventions can improve the short term assurance of supply, and delay the need for development of the full 87.6 Mm^3/year.

Scenario 8 is the same as scenario 3 or 5, but also includes the 9 Mm^3/year from groundwater north of Maputo and 30 Mm^3/year of groundwater from north of Maracuene, to augment Pequenos Libombos and the 43.8 Mm^3/year from either the Incomati or Maputo. Scenario 9 is as per scenario 4, 6 or 7 and also includes the two groundwater sources to augment the Pequenos Libombos, and the 87.6 Mm^3/year from either the Incomati or the Maputo.

The assurances of supply for Maputo City for scenarios 1 to 7 and scenarios 8 and 9 are show graphically in Figure 8.1, and in Table 8.3.

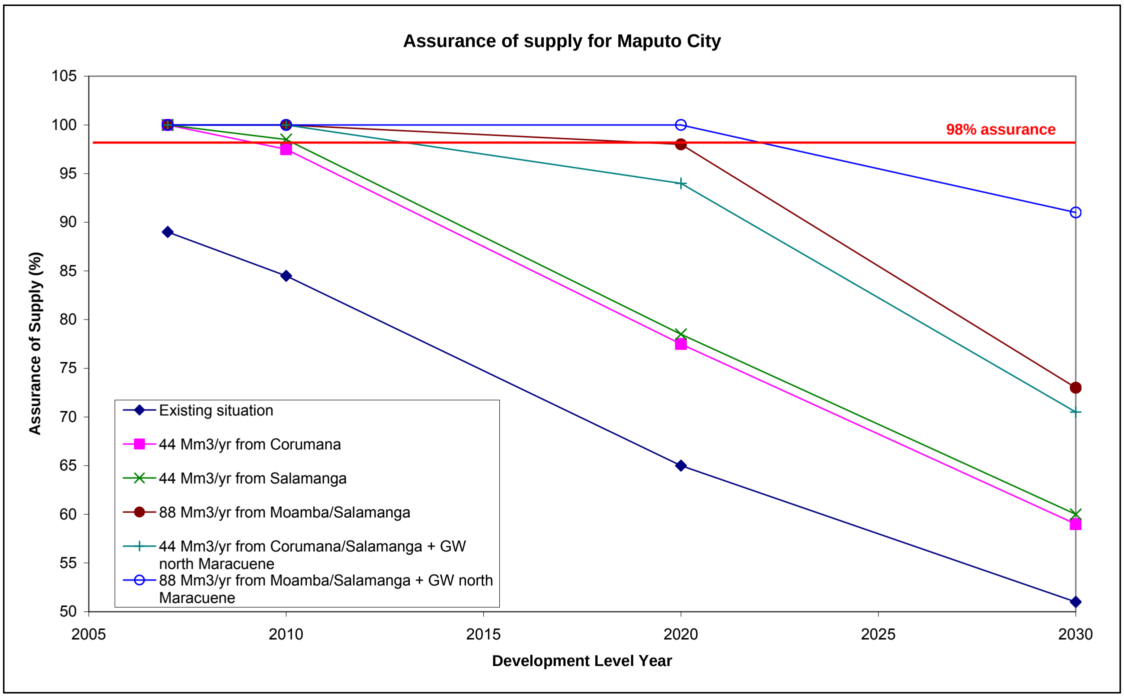

Figure 8.1 Assurance of supply for Maputo city

Table 8.3 Assurances of supply and associated deficits for Maputo City

Scenario	Maputo City Water Supply							
	2007		2010		2020		2030	
	Assurance of Supply	Deficit	Assurance of Supply	Deficit	Assurance of Supply	Deficit	Assurance of Supply	Deficit
	(%)	(Mm^3/yr)	(%)	(Mm^3/yr)	(%)	(Mm^3/yr)	(%)	(Mm^3/yr)
1	89	57	85	66	65	96	51	130
3	100	N/A	98	22	78	52	59	86
4	100	N/A	100	N/A	98	8	73	42
5	100	N/A	99	22	79	52	60	86
6	100	N/A	100	N/A	98	8	73	42
7	100	N/A	100	N/A	98	8	73	42
8	100	N/A	100	N/A	94	13	71	47
9	100	N/A	100	N/A	100	N/A	91	3

The inclusion of an additional 39 Mm^3/year from groundwater sources does improve the assurance of supply in 2020 and in 2030. However, in scenario 8 with the 43.8 Mm^3/year sourced from either the Incomati or Maputo, the assurance of supply beyond 2015 drops below 98%, and additional water sources are needed. This suggests that the full 87.6 Mm^3/year needs to be developed by approximately 2015 if assurances of supply of 98% or greater are to be maintained for Maputo City.

8.3 Discussion of water balance analysis

The water balance analysis shows that new water sources are required as soon as possible and that the growth in water demands requires the full implementation of an additional 87.6 Mm^3/year by approximately 2015 if new groundwater sources are utilised, and sooner if additional sources are not found.

8.3.1 Maputo City

Assessing the assurances of supply for Maputo City showed that both the additional 43.8 and/or 87.6 Mm^3/year could be reliably supplied from the Incomati or Maputo Rivers. However, even when implementing the full 87.6 Mm^3/year, the assurance of supply beyond 2020 is below 98% and drops to only 73% by 2030.

This is a result of Pequenos Libombos not being able to reliably supply the difference between the growing demand and the 87.6 Mm^3/year.

This is shown graphically in Figure 8.2. When Pequenos Libombos fails (shown in Figure 8.3), and the full demand cannot be supplied, the 87.6 million can still be reliably available from either the Incomati or the Maputo.

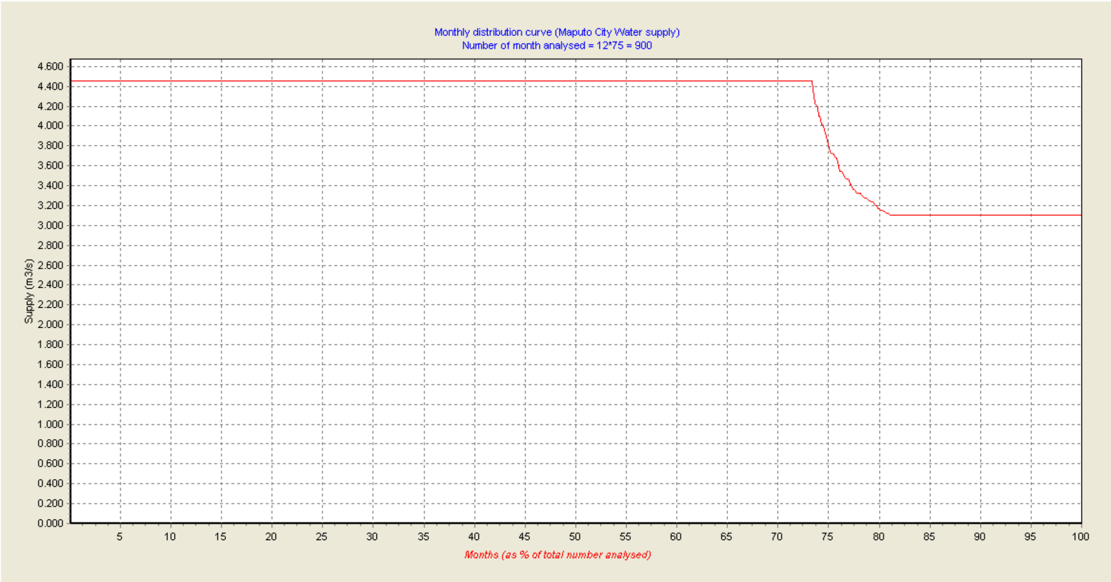

Figure 8.2 Assurance of supply for Maputo City in 2030 with additional 87.6 Mm³/year in new water sources implemented. 4.45 m³/s corresponds to the 2030 water demand and can be supplied fully during 73% of time. During close to 20% of the time only 97.6 Mm³/year (3.1 m³/s) can be supplied that corresponds to the new source plus 10 Mm³/year from local groundwater, i.e. the Pequenos Libombos yielding no supply at all.

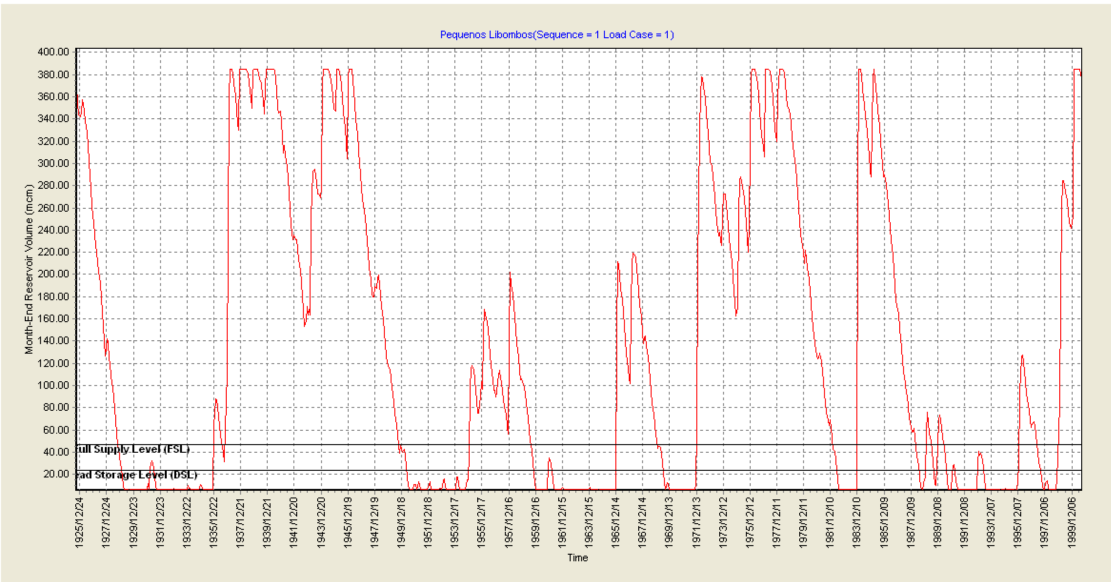

Figure 8.3 Water level trajectory of Pequenos Libombos in 2030 with additional 87.6 Mm³/year in new water sources implemented

8.3.2 Irrigation

Assurance of supply of irrigation in the Umbeluzi does improve as more water is sourced to augment Maputo City's supply. As more water is supplied to Maputo city from additional sources, the demand on Pequenos Libombos decreases, and the dam fails less often. This in turn increases the assurance of supply of water to Maputo city and the irrigation in the Umbeluzi.

The growth in irrigation in the Umbeluzi does put more strain on the Pequenos Libombos and this in turn does reduce the reliability of the water supply to the irrigation, as well as to Maputo City.

Assurance of supply of irrigation in the Incomati does not change for the various scenarios. The consistent assurance of supply of irrigation in the Incomati suggests that the existing Corumana Dam can support the planned growth in irrigation of an additional 100 Mm^3/year. Furthermore, if the Corumana Dam is completed, 43.8 Mm^3/year can be supplied to Maputo City and the planned irrigation can still be implemented without any additional water sources being necessary.

This fact prompted an additional analysis to determine the extent of Corumana's capacity to support both the planned growth in irrigation in the Incomati and supplement Maputo City's water supply.

A scenario was set up and tested whereby a completed Corumana supplied the full additional 87.6 million to Maputo City and also supplied the irrigation in the Incomati catchment. The assurance of supply to Maputo City would be 97%, and the irrigation in the Incomati, even up to the expanded 280 Mm^3/year, could be supplied at 80% assurance. The dam was however bordering on being over-utilised. The same was found for a scenario where the existing Corumana Dam could just supply 43.8 Mm^3/year to Maputo city at 98% and irrigation in the Incomati was still supplied at 80% assurance. Again the dam in the situation would be bordering on over-utilised.

Considering the uncertainty in system analysis modelling it is not recommended to choose a scenario in which the dams are bordering to be over-utilised. The Corumana Dam should therefore not be considered by its own as the long-term solution for the water supply to the Maputo City. Furthermore, the increased assurance of supply for irrigation would probably economically motivate a completion of the Corumana Dam even if the 80% assurance can strictly be met without the installation of the gates. The results of the water balance analysis for irrigation in the Incomati, however, indicate the need for an updated feasibility study of the Moamba Major dam, considering more optimised dam sizes.

8.3.3 Maputo River off-channel storage

As discussed in chapter 3.3.1, there are currently releases from Pongolapoort Dam which do increase the low flows in the in Maputo River. These releases are expected to continue for the foreseeable future. There is however no agreement associated with these releases and they are currently conducted for purposes within South Africa. As such it is possible that these releases may be discontinued for reasons that cannot be foreseen.

As such it was deemed necessary to assess the assurance of supply of the 87.6 Mm^3/year of water transferred from the Maputo River with and without the releases from Pongolapoort dam.

In both scenarios, off-channel storage was included to allow for limited periods when the flow in the river was too low to abstract the full required amount.

It was found that for both scenarios the full 87.6 Mm^3/year could be reliably transferred from the Maputo River. The difference between the scenarios is the capacity of off-channel storage required. When the releases from Pongolapoort were included, very little off-channel storage was required, and the off-channel storage dam essentially remained full. When, however, the releases from Pongolapoort were excluded, then the off-channel storage was utilised as some months a lower abstraction from the river was only possible.

Considering the need for a water supply strategy that is flexible and independent, it is suggested that the off-channel storage of 18 million m^3 is included in the alternative strategies that transfer 87.6 Mm^3/year from the Maputo River and that 8 Mm^3 in storage is included for transfers of 43.8 Mm^3/year from the Maputo River. Although much of this storage may not be needed if the releases from Pongolapoort dam continue, the cost of the off-channel storage is likely to be comparatively small compared to the pump stations and pipelines, and will decrease the risk associated with abstraction of water from the Maputo River during low flows.

8.4 Conclusions from water balance analysis

The results of the water balance analysis of the different combined water supply options can be concluded in the following bullets:

- Remaining with the existing situation would cause very serious constraints in the development of Maputo City. Significant water deficits would occur on a regular basis, in the 2030 situation every second year.

- 87.6 Mm^3/year can be reliably sourced and supplied from either the Incomati or Maputo Rivers.

- In 2025 the possible maximum augmentation of 87.6 Mm^3/year from Incomati and/or Maputo would not be sufficient to reach acceptable assurance of supply. As such other sources and/or water demand management will need to be developed and implemented.

- If the potential groundwater in northern Maputo and to the north of Maracuene is developed a phased implementation of the abstraction from Incomati and/or Maputo Rivers can be applied. Otherwise the full amount of 87.6 Mm^3/year is required already in 2010-2012. Even with the groundwater schemes developed the full amount of 87.6 Mm^3/year is needed approximately by 2015 to reach 98% assurance for urban water supply.

9 PRINCIPLE DESIGN FOR MAIN ALTERNATIVES

9.1 Main sources from Incomati River

This alternative provides for supplying half of the total required water from the Corumana Dam (i.e. 50% of 87.6 Mm^3/year = 43.8 Mm^3/year) for an interim period until the Moamba Major Dam is constructed, which will then supply the full 87.6 Mm^3/year. The pipeline from Corumana will then be used for emergencies.

The Corumana Dam is situated on the Sabie River about 40 km north of the planned Moamba Major Dam. The Corumana Dam comprises an earth-fill embankment with a gated spillway, an outlet works for river releases and for power generation and a saddle dam forming an emergency spillway. Construction commenced in 1983, but was curtailed in 1989 before the spillway gates could be installed and the saddle dam could be constructed. At present the dam operates at a FSL of 111 m.a.sl. The present yield from the Corumana Dam is not believed to accommodate a further water supply of 43.8 Mm^3/year to the City of Maputo as well as downstream planned irrigation in Incomati, unless the gates are installed and the saddle dam is constructed to raise the FSL to 117 m.a.sl.

The planned Moamba Major Dam is situated on the Incomati River about eight km north-west from the Moamba village. In the feasibility study by Norconsult (2003) a dam with full supply level (FSL) of 112 m.a.sl. was adopted, comprising a 2,600 m long rock-fill embankment with an asphalt core and a 415 m long concrete section towards the northern abutment to accommodate a gated spillway, a gated bottom outlet and a power station. The non-overspill crest of the dam is 36 m above river bed level.

The locations of the Corumana and the Moamba Major dams are shown in Figure 9.1 with the water supply pipeline routes to the City of Maputo. It is envisaged to provide a water treatment plant (WTP) on the right bank of the Incomati River at elevation 90 m.a.sl. three km north of Moamba Village and seven km downstream of the Moamba Major Dam.

Water can be supplied to the WTP directly from the outlet works at the Corumana Dam. The required length of the pipeline from Corumana Dam to the WTP at Moamba will be 48 km (see Figure 9.1).

The water levels in the Corumana Dam will vary from 100 m.a.sl. to the FSL of the completed dam at El 117 m.a.sl., with an average at 110 m.a.sl. This provides an average static head or fall of -20 m to the WTP with a maximum of -10 m.

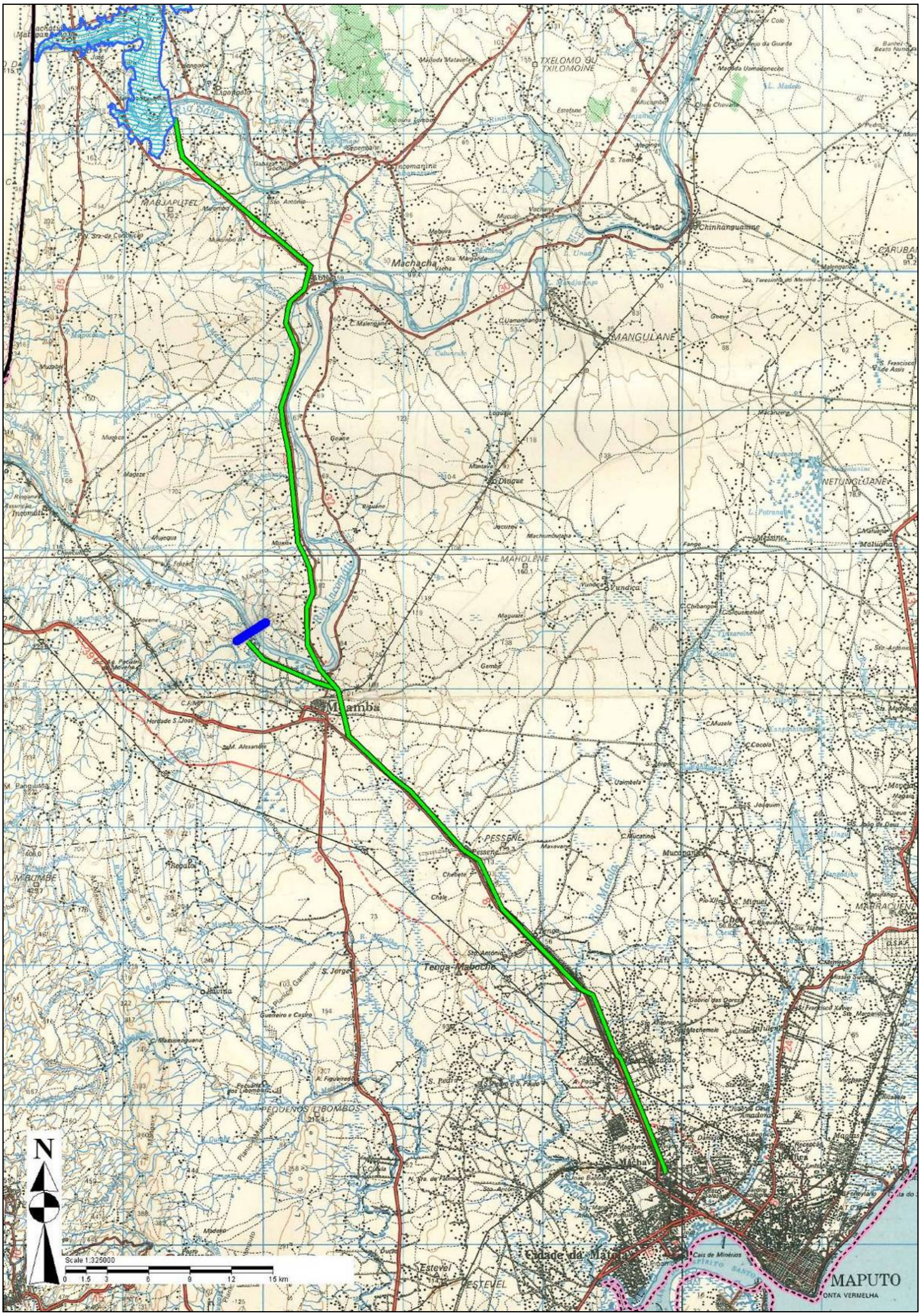

Figure 9.1 Water supply from Corumana and Moamba Major dams

The water levels in the Moamba Major Dam will vary from the lowest level at 95 m.a.sl. to the FSL at 112 m.a.sl. with an average at about 105 m.a.sl. It would be possible to deliver water from the Moamba Major Dam to the WTP under gravity.

The pipeline route from the WTP to the City of Maputo will be along the Moamba-Maputo main road (EN4) over a length of 43 km discharging at an elevation of 30 m.a.sl. The natural ground level along the route rises to a maximum level of 110 m.a.sl., halfway along the route.

The design capacity of the pipelines of the first phase from Corumana Dam will be 1.88 m^3/s, with a peak factor of 1.35. The pipeline from Moamba Major to the WTP for the second phase will have a design capacity of 3.75 m^3/s. It will be financially advantageous to build a second pipeline of design capacity 1.88 m^3/s from the WTP to the City of Maputo when Moamba Major Dam is constructed for the second phase.

The WTP near Moamba would require a design capacity of 162 Ml/d during the interim period and then duplicated later when Moamba Major Dam is constructed.

The risks involved with this option are small because of the already conducted preparatory studies. Although needing updates the Lahmeyer and Associates (2003) and Norconsult (2003) provide a good basis for the continued work. Lead time is the largest uncertainty because of the controversial environmental impacts in the Kruger Park by the completion of Corumana Dam and the need for co-financing the Moamba Major dam for other users.

9.2 Main sources from Maputo River

This alternative comprises direct water abstraction from the Maputo River some six km upstream of Salamanga, an off-channel storage dam in a small tributary of the Maputo River, and a pipeline to the existing distribution centre at water treatment works near Boane for a total required water supply of 87.6 Mm^3/year. The scheme is shown in as shown in Figure 9.2. This alternative was also considered in previous studies by SWECO and Associates (2005a) and PLANCENTER and Associates (2008), but without addressing the direct water abstraction from the Maputo River in any detail.

It is envisaged that direct water abstraction can be accomplished by pumps suspended from a bridge structure some distance into the river. A similar abstraction system designed for the Nile River is shown in Photograph 9.1. The low-lift pump station at the abstraction structure will deliver water to the off-channel storage dam (referred to as the Xembene Dam in the PLANCENTER Report of 2008 and sized for a storage volume of up to 36 Mm^3).

Photograph 9.1 Structure for direct water abstraction on the Nile River

It will not be practically possible to abstract more than about one fifth of the river flow, which implies that the design flow rate of 3.75 m^3/s can be abstracted when the river flow exceeds about 20 m^3/s. The 3.75 m^3/s is equal to the required average water supply of 2.78 m^3/s (87.6 Mm^3/year) multiplied by a summer peak factor of 1.35

Frequency analyses of the natural river flow (75 years of record) for durations of 1 month to 12 months have been carried out, without taking into account possible augmentation from the Pongolapoort Dam in South Africa. The probabilities of the river flow dropping below 20 m^3/s for different durations have been determined from the frequency analyses as shown in Table 9.1. The results show that lower abstraction rates will still be possible when the river flow drops to below 20 m^3/s. The required net off-channel storages shown in Table 9.1 are based on the differences between the required abstraction rate of 3.75 m^3/s and the actual abstraction rates for the duration under consideration. From the above it is provisionally concluded that a net storage of 12 Mm^3 will be required for the Xembene off-channel storage dam. Allowing for evaporation from the dam water surface and sedimentation, a gross storage volume of about 18 Mm^3 should be provided. The above estimated storage would need to be further investigated in more detail should this alternative be selected for development. A larger storage volume will be required if the dam has to also cater for irrigation.

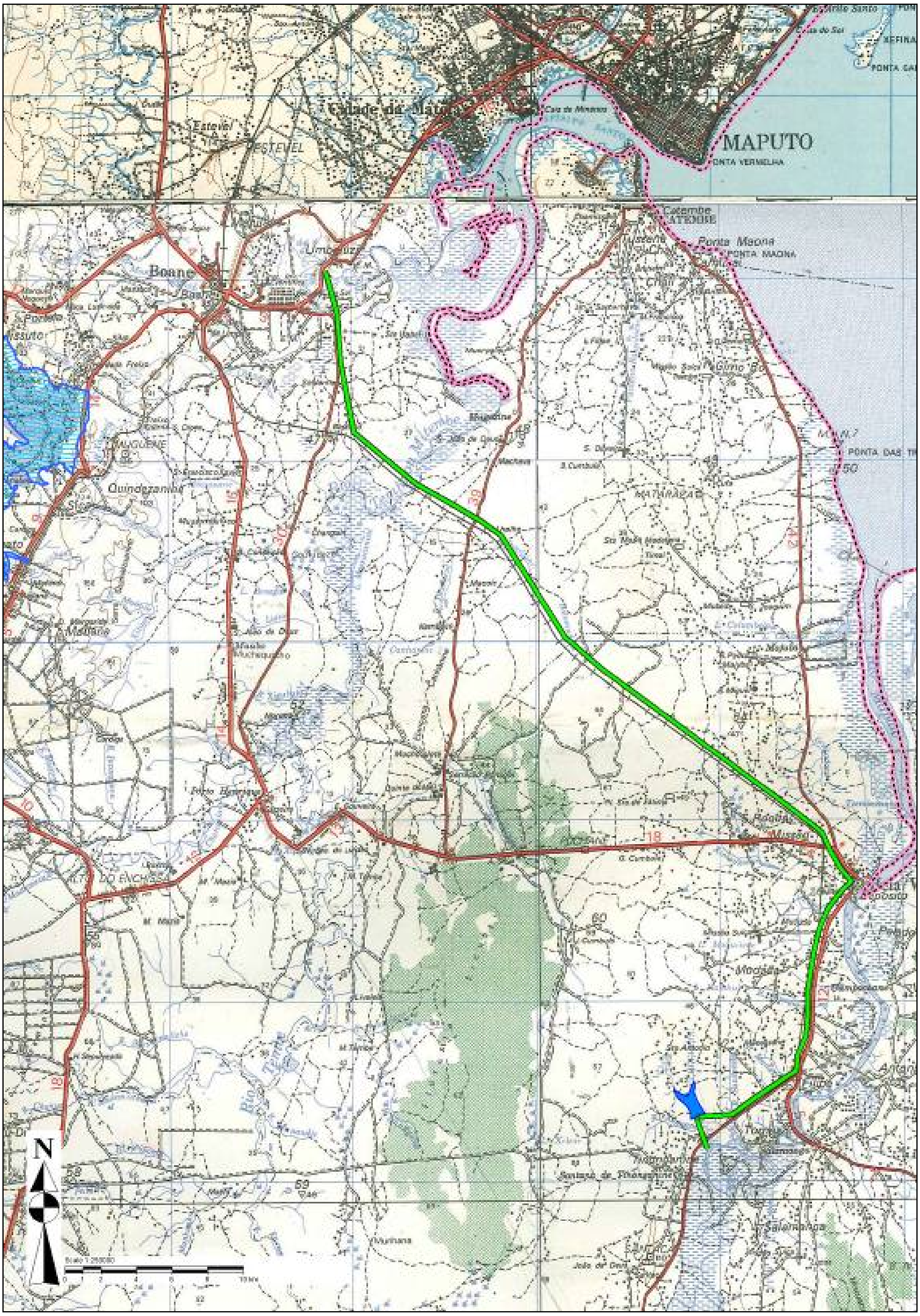

Figure 9.2 Water supply from Maputo River.

Table 9.1 Probabilities of low river flows and required off-channel storages for an abstraction of 3.75 m^3/s.

Duration (month)	Probability of average river flow lower than 20 m^3/s (%)	Average abstraction rate possible for given duration (m^3)	Off-channel storage required (Mm^3)
1 month	100%	2.2	4.1
2 months	80%	2.4	7.1
4 months	60%	2.7	11.0
6 months	40%	3.0	11.8
8 months	15%	3.2	11.6
12 months	1%	3.6	4.3

The Xembene Dam would be located 2.0 km north of the abstraction point on the Maputo River (Figure 9.3) The dam wall would comprise an earth-fill embankment about 22 m high with its crest at 28 m.a.sl. and 750 m long. The only spillway possible is a concrete lined overspill section and canal on either end of the embankment.

The low lift pump station at the abstraction point would have to be sized for an abstraction rate of 4.5 m^3/s (to compensate for periods when the required abstraction rate of 3.75 m^3/s cannot be met) and delivery against a static head of 25 m over a distance of 2.5 km to the Xembene Dam.

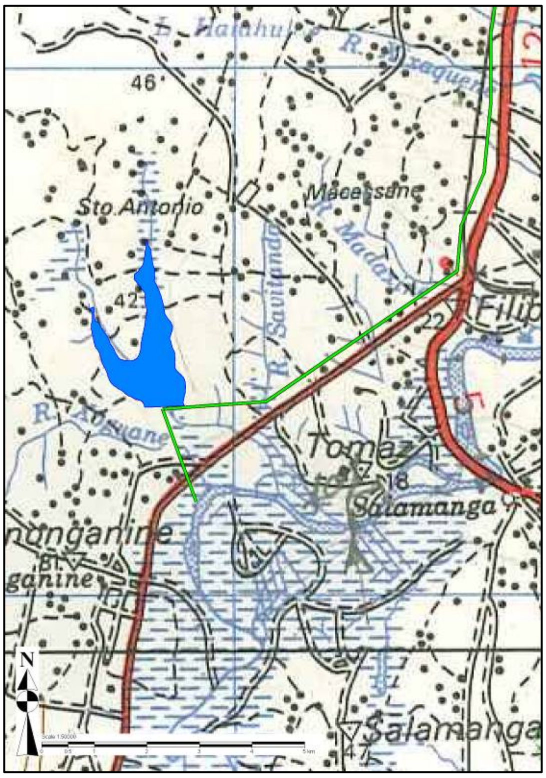

Figure 9.3

Location of the Xembene off-channel storage.

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A 64 km pipeline from the Xembene Dam to the existing distribution centre at the water treatment works near Boane could be routed along the road from Catuane to Bela Vista and then along the railway line to the existing water treatment plant near Boane. The beginning of the pipeline route at the Xembene Dam and the end at the existing water treatment plant are at the same elevation of 10 m.a.s.l. Halfway along the route the natural ground level rises to about 60 m.a.sl. A design flow rate of 3.75 m^3/s is required for the pipeline.

A water treatment works would be required with a design capacity of 324 Mℓ/d. It is preferred to locate the water treatment works with pre-sedimentation facilities at the Xembene Dam to avoid the pumping of sediment-laden water. Treated water could also then be supplied to villages along the route.

Risks with this alternative are mainly relating to the tentative design. Geotechnical investigations have been made for neither the suggested abstraction point nor the Xembene Dam site. The geological conditions are quite difficult with mostly flat flood plains (see Photograph 9.2). A comprehensive feasibility study is thus required to confirm the tentative design and update the cost estimates. A further risk with the intake in the Maputo River is possible salt water intrusion during times with high tide. Figure 9.4 indicates that the location, approximately 5 km upstream of Salamanga, is at the very tail of where the salt water content is too high for conventional treatment. Further, detailed measurements and modelling must therefore be conducted to confirm that the water's salt content is within acceptable limits. If not, alternative solutions, such as moving the intake upstream or building a salt water barrier, must be considered, which may increase the cost and environmental impacts.

Photograph 9.2 Typical river section in river stretch where the planned abstraction scheme would be located in the Maputo River.

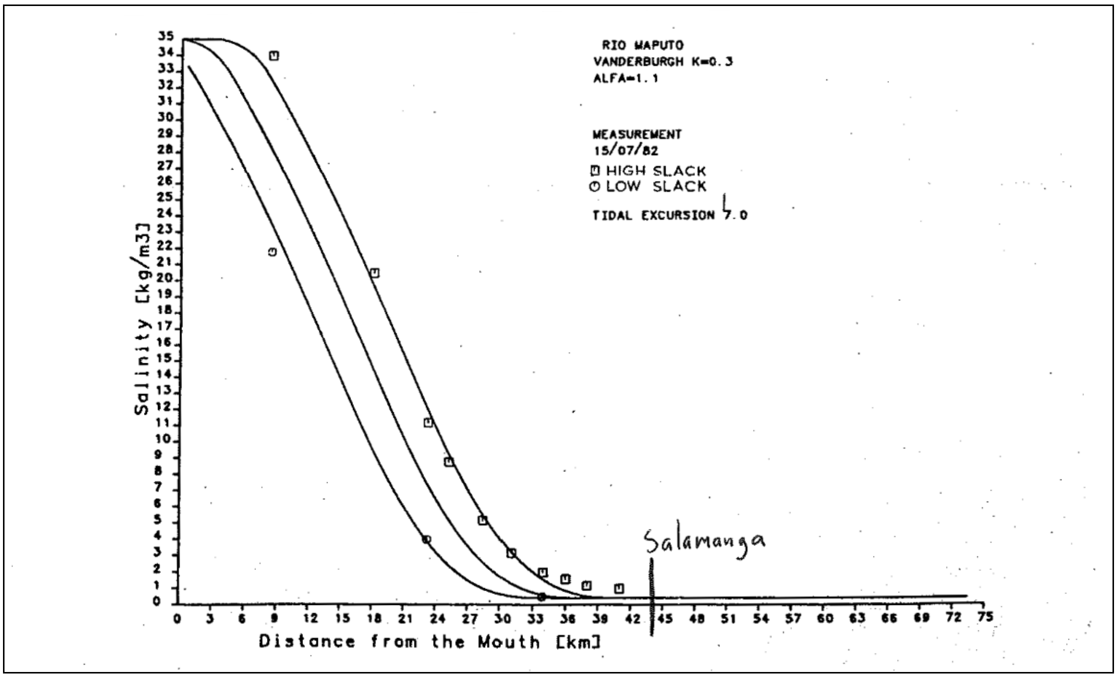


Figure 9.4 Calculated and measured salt intrusion in the Maputo River. Measurements were made on 15 July 1982. Source: Savenije (1986).

9.3 Combination of Maputo and Incomati Rivers

For this alternative half of the water requirement is supplied from the Corumana Dam and the other half from the Maputo River, each system delivering 43.8 Mm^3/year or at a design flow rate of 1.88 m^3/s for a peak factor of 1.35.

The conceptual layout of the supply from the Corumana Dam is the same as described above for in Chapter 9.1, while the conceptual layout for the supply from the Maputo River is similar to what is described in Chapter 9.2, except that the abstraction and pipeline capacities are halved.

Again assuming that only one fifth of the river flow can practicably be abstracted, the full 1.88 m^3/s can be abstracted when the river flow exceeds 10 m^3/s. The probabilities that the river flow drops to below 10 m^3/s are shown in Table 9.2.

The required net off-channel storages in Table 9.2 are based on the difference between the required abstraction rate of 1.88 m^3/s and the actual abstraction rate for the duration under consideration. Allowing for evaporation and siltation a gross storage volume of about 8 Mm^3 should be provided in the Xembene off-channel storage dam.

Table 9.2 Probabilities of low river flows and required off-channel storages for an abstraction of 1.88 m^3/s.

Duration (month)	Probability of average river flow lower than 20 m^3/s (%)	Average abstraction rate possible for given duration (m^3)	Off-channel storage required (Mm^3)
1 month	54%	1.0	2.3
2 months	40%	1.4	2.5
4 months	15%	1.6	2.9
6 months	4%	1.7	2.8
8 months	0%	1.88	0

The low lift pump station at the abstraction point would have to be sized for an abstraction rate of 2.25 m^3/s to compensate for periods when the required abstraction rate of 1.88 m^3/s cannot be met, and a the water would need to be pumped a distance of 2.0 km to the Xembene Dam with a static head of 20 m.

The pipeline route from the Xembene Dam to the existing WTP near Boane will be the same to that selected for taking all the water from Maputo River. A design flow rate of 1.88 m^3/s is required for the pipeline. A water treatment plant adjacent to the Xembene Dam would be required with a design capacity of 162 Mℓ/d.

Risks involved for this option are the same as discussed in chapters 9.1 and 9.2.

9.4 Groundwater schemes

The groundwater schemes that seems feasible to develop are

- The northern Maputo City area
- The area north of Maracuene

The north Maputo study area extends in the north/south direction from the present border of the high density urban and industrial area up to Maracuene (Figure 9.5). In the east/west direction the area extends from halfway between the Matola River and the catchment boundary between the Matola and Incomati rivers and up to the foot of the hills close to the Incomati River.

Groundwater in this area is presently being used by private water providers (POPS) that operate in the area. However, it is estimated that an additional 9 Mm^3/year would be available (SWECO and Associates 2009b). The groundwater supply is presently being further developed through the support of FIPAG. Some 19 wells have recently been established and more wells are planned. Wells are generally very successful (mean production 24 m^3/d) and water quality is generally good in the areas not too close to the Matola River. No high levels of chloride or sulphate have been reported.

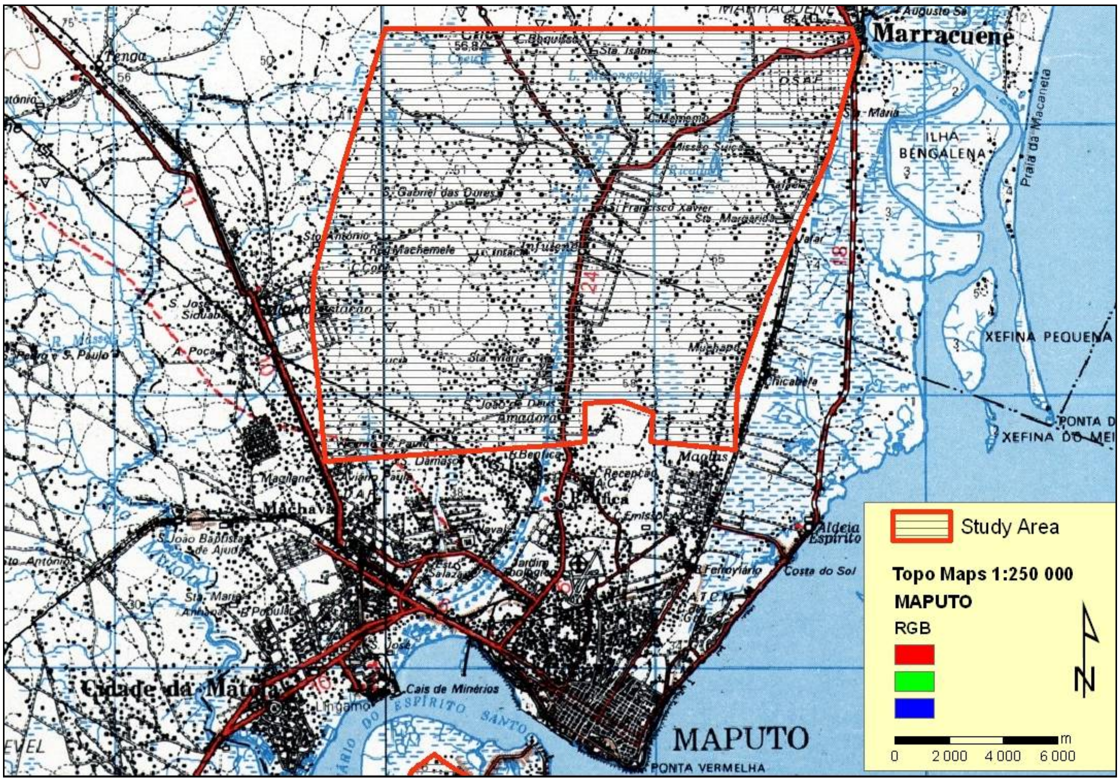


Figure 9.5 Area for development of small-scale groundwater.

Although being a relatively small source the groundwater of this area is recommended to be further utilised because of the low cost and short lead time. This should be conducted through intensifying the present programme run by FIPAG to develop boreholes for local distribution. The boreholes can either be linked to the FIPAG network or reduce water demand by supplying local sub-systems of the city.

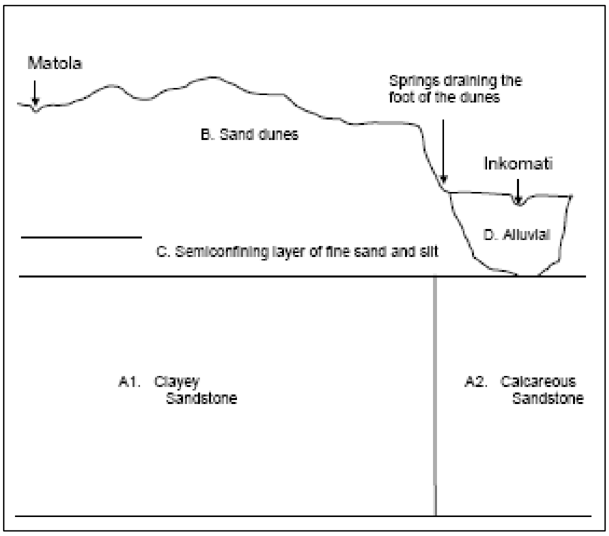
The area north of Maracuene (Figure 9.7) has larger potential according to SWECO and Associates (2004). The area between the two rivers Matola and Incomati is dominated by old sand dunes (Figure 9.6). The detailed investigation study by SWECO in 2004 indicated that the total natural groundwater recharge of the study area amounts to more than 30 Mm^3/year, which indicates possible abstraction of 1-1.5 m^3/s. An abstraction of 1.5 m^3/s corresponds to approximately 40 % of the natural recharge.

The groundwater will be abstracted through approximately 50 boreholes along the Incomati River between Maracuene and Manhiça as illustrated in Figure 9.7. The boreholes should be connected, through intermediate reservoirs, with a pipeline feeding water to a storage reservoir close to Maracuene where treatment would occur before conveyance of the treated water to a distribution centre in Maputo City. Since groundwater quality seems good it is anticipated that disinfection is sufficient for treatment.

Risks with this alternative are mainly related to water quality. There is a risk for salt water intrusion locally that must be investigated through test pumping of wells in a pilot scale project. It is further required that groundwater modelling is conducted to confirm the possible yield and to optimise the location of the boreholes. This modelling should be preceded with targeted drilling and geophysics. More detailed sampling of groundwater quality should further be conducted to determine the level of required treatment.

Figure 9.6

Profiles of area north of Maracuene showing the sand dunes that can be utilised for large-scale groundwater abstractions for Maputo City.



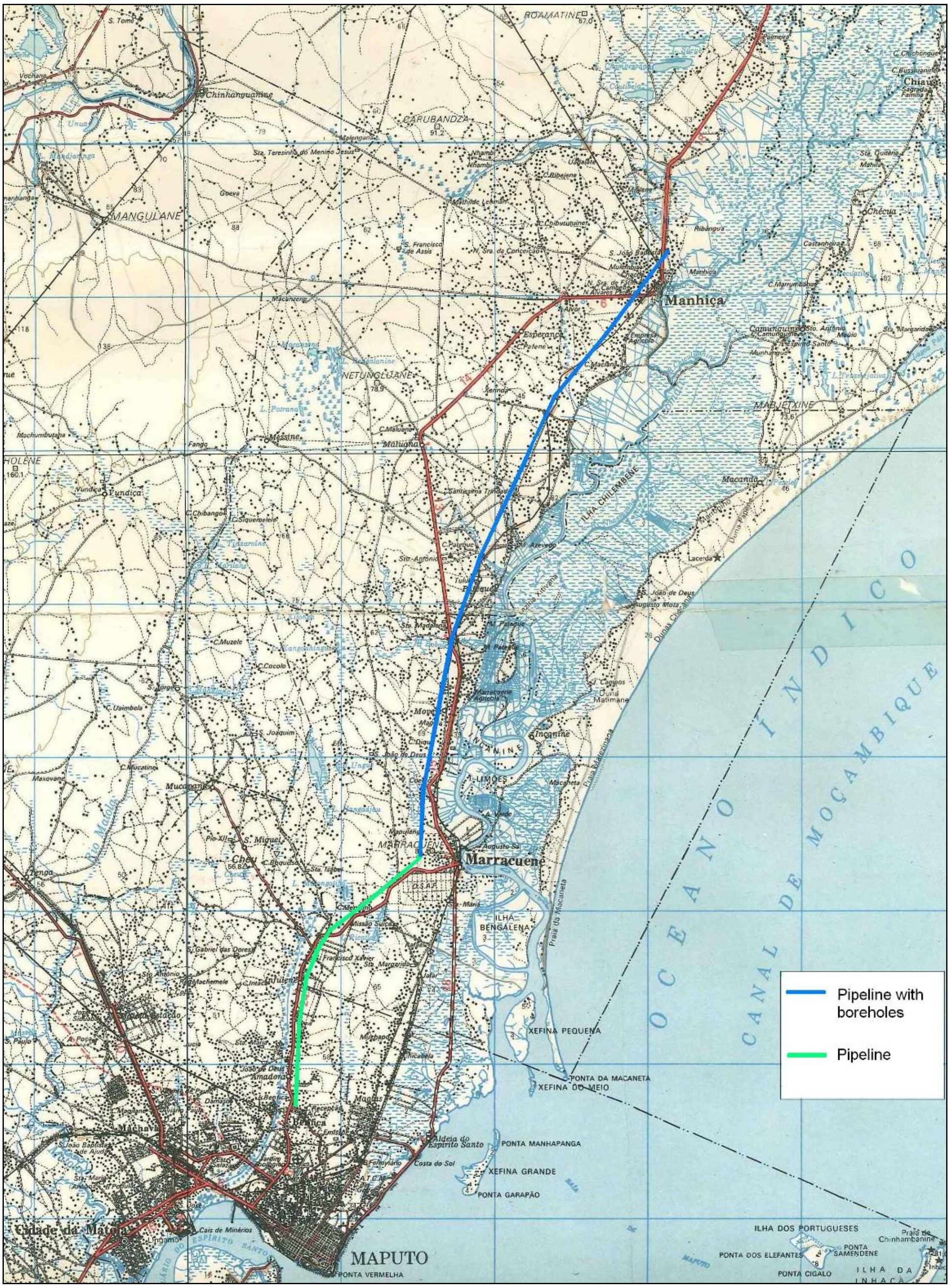


Figure 9.7 Groundwater scheme north of Maracuene.

9.5 Preparatory studies

Table 9.3 presents a list of necessary studies for the development of the main alternatives to augment the Maputo water supply.

Table 9.3 Gross list of preparatory studies needed.

Development	Necessary preparatory studies
Corumana Dam	• Updated feasibility study for the completion of the Corumana Dam and the pipeline, including detailed costing* • Updated EIA and SIA for the completion of the Corumana Dam, pipeline and treatment plant • Detailed design of the Corumana Dam, pipeline and treatment plant* • Tender documents for completion of the Corumana Dam and construction of the pipeline and treatment plant
Groundwater scheme north of Maracuene	• Updated groundwater yield assessment of the area north of Maracuene, including test pumping, water quality measurements and groundwater modelling. • Feasibility and detailed design of the borehole scheme north of Maracuene, reservoirs, pipelines and treatment • EIA and SIA for the development of the groundwater scheme north of Maracuene reservoirs, pipelines and treatment • Tender documents for groundwater scheme north of Maracuene, reservoirs, pipelines and treatment
Moamba Major Dam	• Updated feasibility study for the Moamba Major Dam, including detailed cost-benefit analysis for the multi-purpose use • Updated EIA and SIA for the Moamba Major Dam, including resettlement plans • Detailed design of the Moamba Major Dam and second pipeline • Tender documents for construction of Moamba Major Dam and second pipeline
Maputo River abstraction upstream Salamanga	• Intensive water quality measurements campaign and salt water intrusion modelling. • Feasibility and preliminary design of the abstraction scheme, off-channel storage, pipeline and treatment plant, including surveying and geotechnical investigations and detailed costing • Detailed design of the abstraction scheme, off-channel storage, pipelines and treatment plant • Tender documents for abstraction scheme, off-channel storage, pipelines and treatment plant
Maputo water supply network	• The Maputo Water Supply Network Master Plan**

** Partly covered by the NWRDP1 project on Technical Services and Dam Safety currently being procured by DNA*

***Currently procured by FIPAG*

Because this study is limited to a strategic level of detail the tentative design and cost estimates needs to be updated in more detail. Furthermore, the existing feasibility studies for Moamba Major and the completion of Corumana are to a certain extent outdated, and need to be updated with today's costs levels and the results of this report as a background.

Comprehensive feasibility studies, based on preliminary design, therefore need to be developed for all the schemes. To enable correct design and cost estimation of the pipeline and treatment plants it is also necessary to integrate the results from the coming Master Plan for the Maputo Water Supply network that FIPAG is currently procuring.

For the Maputo River and the groundwater schemes north of Maracuene, there is an urgent need to establish water quality monitoring to enable the feasibility study to have input data. Preferably water quality monitoring should start already in 2009 in the Maputo River to cover the low flow and high tide seasons.

For the Maputo River and the groundwater schemes north of Maracuene there are also needs for basic field investigations since no previous feasibility studies have been conducted. In the Maracuene area this involves test pumping and geophysics, which will give input to groundwater modelling for yield analysis and salt water intrusion assessment. For the Maputo River it involves detailed topographical surveying and geotechnical investigations of the abstraction and off-channel storage sites.

All pipeline routes for all alternatives must further be surveyed in detail to give input to optimisation of the design of the pipelines and pump stations.

Regardless of which alternative is selected, social and environmental impacts will be felt. Therefore, environmental and social impact assessments (ESIA) will be needed in order to determine which impacts will occur and how the social and biophysical environment will be affected. Projects which may potentially lead to population displacement will need particular attention, where a Resettlement Action Plan shall be implemented. Besides the potential impacts on the population due to the loss of normal life conditions, one should also take into consideration cultural aspects such as cultural and historical sites which may be found on the project site. The ESIA shall follow all necessary legal requirements and include any other aspect raised during the public participation process followed during the preparation of environmental and social impact studies.

When all technical and financial feasibility and ESIA studies are conducted, detailed design is required. It is also essential to take into account the lead time for tender documentation and procurement, as well as for time to source funding for the development projects.

9.6 Alternative implementation

The water balance analysis of the main alternatives have shown that the full amount of 87.6 Mm^3/year from Incomati and/or Maputo, as well as the development of groundwater north of Maputo, are required to give acceptable assurance of supply in 2020. The water balance has showed that both Incomati and Maputo Rivers have the capacity to yield 87.6 Mm^3/year on a permanent basis if the necessary infrastructure is built.

There are, however, different alternative implementation strategies. Through taking into account the lead time for preparatory studies, such as feasibility, environmental and social impact assessments and design studies, sourcing of funding and tendering procedures, as well as the results of the water balance analysis a number of alternatives can be formulated (Figure 9.8).

No activities in 2009 have been accounted for, although the National Water Resources Development Project No. 1 has recently launched the study on Technical Services and Dam Safety for the completion of the Corumana Dam.

Because FIPAG's present programme on development of groundwater in the northern part of Maputo is on-going, it is anticipated that no preparatory studies are needed. For the larger groundwater scheme north of Maracuene it is, however, needed to immediately source funding for the feasibility study and ESIA to be started in 2010. If feasible sources of funds are found, detailed design and tendering should be possible in 2012. That would make construction possible in 2013-2014, and operation to start in 2015. Because the groundwater source is needed to augment the limited transfer from Incomati and Maputo these activities are included in all alternatives.

Because funding is secured by the World Bank it is judged feasible to conduct the detailed design and tender document for the Corumana Dam scheme within 2010. The following year is needed for securing the funds and for the tender procedure for construction, which would enable construction to start in 2012. Construction of the pipeline will be the critical path and would probably take two years, allowing start of operation by 2014.

For the Moamba Major Dam funding needs to be raised for the updated feasibility study, ESIA, detailed design and tender documents, which will delay the start of the preparatory studies. Because of the large scheme size and the associated likely resettlement which requires a participatory process, the feasibility, ESIA and the detailed design are estimated to take three to four years. Because of the multi-purpose character of the dam, it is further believed that at least one additional year is needed to secure the funds. This would mean start of construction in 2017 and possible start of operation in 2020. The size of dam will further take approximately two years to fill, which may limit the yield the first years of operation.

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Alternative A: 44 Mm3/yr from Corumana and 88 Mm3/yr from Moamba	85	83	83	80	85	97	97	96	95	95	100	99	99	98	97	96	95	94	93	92	91
Development of groundwater North of Maputo																					
Feasibility and ESIA study for groundwater north of Maracuene																					
Financing and tendering for construction																					
Development of groundwater North of Maracuene																					
Detailed Design of Corumana completion and pipeline																					
Financing and tendering for construction																					
Completion of Corumana & dev. of pipeline for 44 Mm3/yr																					
Feasibility and ESIA study for Moamba Major																					
Detailed Design or Moamba Major																					
Financing and tendering for construction																					
Development of Moamba Major + pipeline																					
Alternative B: 44 Mm3/yr from Corumana and 44 Mm3/yr from Maputo River	85	83	83	80	85	97	97	96	100	100	100	99	99	98	97	96	95	94	93	92	91
Development of groundwater North of Maputo																					
Feasibility and ESIA study for groundwater north of Maracuene																					
Financing and tendering for construction																					
Development of groundwater North of Maracuene																					
Detailed Design of Corumana completion and pipeline																					
Financing and tendering for construction																					
Completion of Corumana & dev. of pipeline for 44 Mm3/yr																					
Feasibility and ESIA study for Maputo intake, off-shore storage and pipeline																					
Detailed Design or Maputo intake, off-shore storage and pipeline																					
Financing and tendering for construction																					
Development of Maputo intake, off-shore storage and pipeline for 44 Mm3/yr																					
Alternative C1: 88 Mm3/yr from Maputo River asap	85	83	83	80	80	100	100	100	100	100	100	99	99	98	97	96	95	94	93	92	91
Development of groundwater North of Maputo																					
Feasibility and ESIA study for groundwater north of Maracuene																					
Financing and tendering for construction																					
Development of groundwater North of Maracuene																					
Feasibility and ESIA study for Maputo intake, off-shore storage and pipeline																					
Detailed Design or Maputo intake, off-shore storage and pipeline																					
Financing and tendering for construction																					
Development of Maputo intake, off-shore storage and pipeline																					
Alternative C2: 44 +44 Mm3/yr from Maputo phased	85	83	83	80	80	97	97	96	100	100	100	99	99	98	97	96	95	94	93	92	91
Development of groundwater North of Maputo																					
Feasibility and ESIA study for groundwater north of Maracuene																					
Financing and tendering for construction																					
Development of groundwater North of Maracuene																					
Feasibility and ESIA study for Maputo intake, off-shore storage and pipeline																					
Detailed Design or Maputo intake, off-shore storage and pipeline																					
Financing and tendering for construction																					
Development of Maputo intake, off-shore storage and pipeline for 44 Mm3/yr																					
Development of pipeline for 44 Mm3/yr																					

97 Estimated assurance of supply from Maputo without WDM

Preparatory studies and fund sourcing

Construction

Maintenance and operation

Figure 9.8 Alternative implementation plans for the main alternatives for future augmentation of water supply to the Maputo City.

Because of the relatively limited civil works and low social impact, it is judged possible to conduct feasibility, ESIA and detailed design for the Maputo River alternative in two years starting from 2010. A key is sourcing funds for the preparatory studies. As with the Corumana option it is assumed that one year is needed for securing the funds and for the tender procedure for construction, which would enable construction to start in 2013. Again a two-year construction time is assumed because of the long pipeline, which would make the scheme in operation in 2015.

9.7 Water demand management

Figure 9.9 shows that all four alternatives for augmenting Maputo water supply during the period up to 2030, will result in water deficits. The short term assurance of supply will be low because of the lead time to put new sources into operation. During this period serious water deficits may occur since Pequenos Libombos is the only source. After 2020 the projected increase in water demand will further cause water deficits even if all the IIMA allocation and the groundwater is utilised. Table 8.3, however, shows that although not supplying the full requirements water secured from groundwater and transfers from the Incomati and/or Maputo would not give very large water deficits.

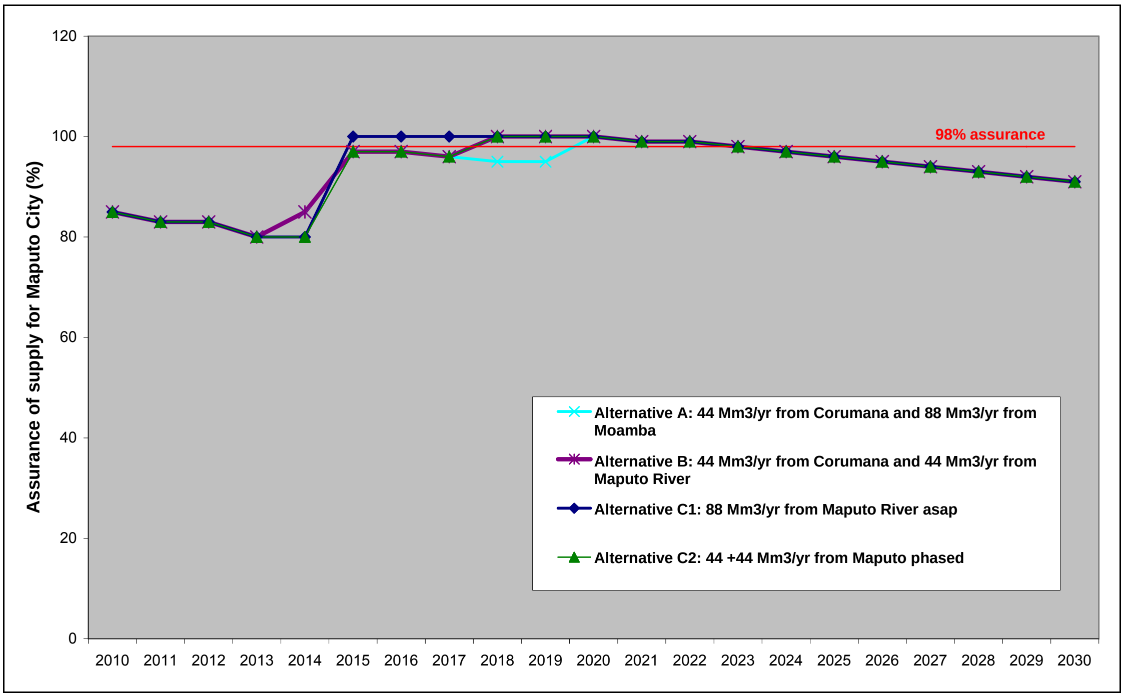


Figure 9.9 Estimated assurance of supply for Maputo City if no water demand management measures are implemented.

To support the new sources of water for Maputo City water demand management measures need to be implemented to mitigate the projected low assurance of supply.

The first and most important WDM measure for the City of Maputo is to ensure that the planned leakage reduction programme run by FIPAG to reduce losses down to 25%, is successful. This is absolutely critical for Maputo City to have acceptable assurance of supply since the projected water demand has already assumed this low loss rate. Support and funds must therefore be allocated to FIPAG to enable them to keep up the reduction of losses according to this high goal.

Chapter 5 indicated that, based on experience from Cape Town (DWAF 2007), further 29 Mm^3/year of the total water demand could potentially be reduced by other WDM measures than leakage reduction. Most of these measures are, however, related to more long-term programmes such as education and advocacy and installing of meters at consumers. Also implementation of pressure metering, water saving devices, grey water and rainwater harvesting systems will take time to implement.

On the short-term, to meet the possible water deficits for the period 2010-2015, water demand management should therefore focus on curtailment. Because of the relatively high risk of not supplying all the water demand during these years the water authorities must develop emergency plans, in which certain usages of water that can be curtailed are identified, and for which bylaws and enforcement measures are prepared, ready to be implemented if water scarcity occurs.

On the longer term focussing on the years 2020-2030 when minor deficits are foreseen, as shown by Figure 7.1, the suggested WDM in Chapter 5 should be initiated as soon as possible. It recommended that DNA and FIPAG initiate the following prioritised programmes:

1. Education and promotion of reduced water usage.
2. Compulsory installation of consumer meters at the users
3. Development of an improved tariff and billing system
4. Implementation of pressure management
5. Assessment of possibilities to install water saving devices, grey water and rainwater harvesting systems

Education and promotion of reduced water usage is relatively cheap and has no lead time. Since the effects of such WDM are seen on the long-term it is necessary to start this programme already in 2010. Steps 2-5 are more dependent on the general infrastructure level and network coverage and it is assumed that FIPAG, with their current leakage reduction programme, will only be able to initiate these programmes from 2015 and on-wards. WDM should, however, be an important part of the water supply master plan that FIPAG is currently developing.

Experiences and lessons learnt from the water demand management in South Africa, such as in Cape Town and Durban, should be used as input for the design of the WDM programmes.

10 COST ANALYSIS OF MAIN ALTERNATIVES

10.1 Storage Dams

A recent study of cost escalation of two major dams forming part of the Thukela Water Project in the South Africa revealed that the average cost increase over the last seven years amounted to 10.1% per annum. The construction industries in Mozambique and the South Africa are interrelated and it can be accepted with reasonable confidence that a similar escalation rate would have been applicable to Mozambique.

10.1.1 Moamba Major Dam

The cost estimates for Moamba Major Dam with a FSL of 112 m.a.sl. contained in the May 2003 report by Norconsult with a base date of 2002 have been escalated to 2009 (7 years) at a rate of 10% per year, as shown in Table 10.1.

Table 10.1 Moamba Major Dam – Project Cost Estimate (2009).

Item	Amount (MUSD)
1. Site & Basin Costs	3.9
2. River Diversion	3.3
3. Foundation Excavation	29.0
4. Foundation Preparation	21.1
5. Gravity Dam & Spillway/Stilling basin	46.9
6. Spillway Gates & Crane	35.2
7. Embankment Dam	47.5
8. Power Supply	0.2
9. Landscaping & Fencing	0.5
10. Access Roads	1.8
11. Railway Relocation	15.5
Sub-total	**204.9**
10% Miscellaneous	20.5
30% G&P	67.6
Sub-total	**293.0**
10% Contingencies	29.3
10% Professional Services	32.2
TOTAL PROJECT COST	**354.5**

Since the Moamba Dam would be a multipurpose dam the cost associated with the Maputo City water supply is calculated as the ratio of the water supplied to Maputo City and the water supplied to other users. The IIMA currently limits the development of irrigation and primary uses in the Incomati River to further 107 Mm^3/year, which would give the ratio of 0.45=88/(107+88). The cost of Moamba Dam for Maputo water supply is thus estimated to 160 MUSD.

10.1.2 Corumana Dam

The cost estimates for the completion of Corumana Dam as included in the March 2003 feasibility study by Lahmeyer and Associates with a base date of 2001 have also been escalated by 10% per annum to 2009 (8 years) as shown in Table 10.2. Considering that Maputo City will utilise all extra yield created by the completion it is judged reasonable that the full cost of the raising is accounted for.

Table 10.2 Completion of Corumana Dam – Project Cost Estimate (2009).

Item	Amount (MUSD)
A. Civil Works	
1. General requirements	5.3
2. Existing piers	0.7
3. Emergency spillway	16.5
4. Saddle dam	0.5
5. Grouting, etc	3.1
Sub-total: Civil Works	**26.1**
B Mechanical and Electrical	
1. Radial gates	5.2
2. Stoplogs	2.6
3. Miscellaneous	0.1
4. Standby generating set	0.1
5. Power supply	0.1
Sub-total: Mechanical and Electrical	**8.1**
Contingencies (10%)	3.4
Professional Services (10%)	3.8
Total Project Cost	**41.4**

10.1.3 Xembene Off-Channel Storage Dam

The Xembene Dam should be sized, for storages of 18 Mm^3 and 8 Mm^3 for Alternatives C and B respectively.

A storage volume of 36 Mm^3 was considered in the PLANCENTER Report of 2008 with a cost estimate of 42.3 MUSD at 2005 price levels. The 1:50 000 maps have been used for determining quantities and the cost estimates must be considered only as an indication of the cost. As such the dam's feasibility and size was confirmed, and a capacity curve was derived off a topological map generated with a 90m grid of spot elevations sourced from NASA.

It can be accepted that the cost of the dam will reduce to 70% and 33% of the 36 Mm^3 storage cost for 18 Mm^3 and 8 Mm^3 storage, respectively. This was confirmed as acceptable from the new topological map generated. Allowing for escalation of 10% per annum over four years, the project costs shown in Table 10.3 are considered appropriate for comparison purposes.

Table 10.3 Xembene off-channel storage – Project Cost Estimate (2009).

Alternative	Storage Volume (Mm^3)	Amount (MUSD)
B: Maputo and Incomati	8	20.4
C: Maputo the only source	18	43.4

10.1.4 Maputo River – Direct Water Abstraction Structure

The bridge structure required for direct water abstraction from the Maputo River comprises a steel framework supported on 20 m long concrete piles. Based on present day (2009) unit costs for bridge structures and allowing a 25% increase for Mozambique the project costs for Alternatives B and C have been estimated as shown in Table 10.4.

Table 10.4 Maputo River Direct Water Abstraction Structure (Alternative B & C).

Item	Rate (MUSD)	B: Maputo and Incomati		C: Maputo the only source	
		Quantity	Amount (MUSD)	Quantity	Amount (MUSD)
1. Preliminary & General	30%	1.83	0.55	1.30	0.39
2. Concrete piles	1,800	450	0,81	330	0.60
3. Steel structure	6,400/t	160	1.02	110	0.70
4. Sub-total			**2.38**		**1.69**
5. Miscellaneous	20%		0.48		0.32
6. Professional Services	10%		0.29		0.20
Total Project Cost			**3.15**		**2.21**

10.2 Pipelines

The sizing of the pipelines (pumping mains) to supply water to Maputo should be optimized on the basis of capital cost and energy cost over the life span of the project. However, for the purpose of this study a flow velocity of 1.5 m/s was assumed.

Water requirements are usually higher during the summer and lower during the winter. The design capacities of the pipelines should cater for the summer requirements, which are obtained by applying a peak factor of 1.35 to the average requirements, which is considered applicable to the conditions in the City of Maputo.

The design flow rates, pipeline diameters and lengths are shown in Table 10.5 for the three alternatives. It is to be noted that the natural ground level rises to 60 m.a.sl. along the route from Xembene Dam to the WTP near Boane and to 110 m.a.sl. along the route from the WTP at Moamba to the City of Maputo. It is possible to convey the water under gravity from these high spots to the city at flow velocities higher than 1.5 m/s. The reduction in the pipe sizes are minimal and have not been taken into account for the purpose of this study.

Table 10.5 Pipelines – Project Costs.

Alternative	Design Flow (m^3/s)	Diameter (mm)	Length (Km)	Unit Rate (USD/m)	Amount (MUSD)
Alternative A					
• Phase 1					
- Corumana to WTP at Moamba	1.88	1,250	48.0	2,060	98.88
- Moamba to City of Maputo	1.88	1,250	43.1	2,060	88.79
• Phase 2					
- Moamba Major to WTP at Moamba	3.75	1,000	7.5	3,440	25.8
- Moamba to City of Maputo	1.88	1,250	43.1	2,060	88.79
Alternative B					
• Phase 1					
- Corumana to WTP at Moamba	1.88	1,250	48.0	2,060	98.88
- Moamba to City of Maputo	1.88	1,250	43.1	2,060	88.79
• Phase 2					
- Maputo River abstraction to Xembene	2.25	1,400	2.0	2,580	5.12
- Xembene to WTP near Boane	1.88	1,250	64.4	2,060	132.66
Alternative C					
• Maputo River Abstraction to Xembene dam	4.50	2,000	2.0	3,870	7.74
• Xembene to WTP near Boane	3.75	1,800	64.4	3,440	221.54

The all inclusive unit rates for the pipelines given in Table 10.5 are based on analyses of pipelines in South Africa with an additional allowance of 25% to make it applicable to Mozambique conditions and an addition of 10% for professional services.

5.4.4 Pump Stations

The pump stations have been sized for the maximum required design flow rates given in Table 10.5 based on a peak factor of 1.35. The average conveyance throughout the year will be lower and pumped against a lower friction head, which should be used for determining the annual energy requirements. The details are shown in Table 10.6. The friction heads have been based on the Hazen-Williams flow formula with a discharge coefficient, C = 120, and an overall efficiency of 0.84 has been assumed for the pumps.

Table 10.6 Pump Stations – Project Costs and Annual Energy Costs.

Alternative	Flow rate (m^3/s)	Total head (m)	Pumps required (Mw)	Project Costs		Annual Operating	
				Civil (MUSD)	M&E (MUSD)	Energy (GWh/yr)	Cost (MUSD)
Alternative A							
• Phase 1							
- Corumana Pump Station	1.88	68	1.49	13.0	48.0	3.54	0.159
- Moamba Pump Station	1.88	63	1.38	13.0	47.0	6.31	0.284
• Phase 2							
- Moamba Major Dam	3.75	10	-	-	-	Operates under gravity	
- Moamba Pump Station	1.88	63	1.38	13.0	47.0	6.31	0.284
Alternative B							
• Phase 1							
- Corumana Pump Station	1.88	68	1.49	13.0	48.0	3.54	0.159
- Moamba Pump Station	1.88	63	1.38	13.0	47.0	6.31	0.284
• Phase 2							
- Maputo River Pump Station	2.25	23	0.60	8.0	35.0	3.93	0.153
- Xembene Pump Station	1.88	101	2.22	15.0	56.0	11.23	0.505
Alternative C							
• Maputo River Pump Station	4.50	27	1.42	13.0	47.5	8.18	0.368
• Xembene Pump Station	3.75	81	3.55	17.0	61.5	19.31	0.869

As for the pipelines, the total pump station costs have been based on South African all-inclusive unit costs in terms of MW and adjusted by 25% for Mozambique conditions and a further 10% addition for professional services.

The annual energy costs shown in Table 10.6 are based on pumping continuously for 24 hours per day and 7 days per week at South Africa's Eskom's short-term future price of 0.045 USD per kWh. The capital costs of power supply have not been included in the cost estimates.

10.3 Water Treatment Plants

The project costs of the water treatment plants have been based on the construction costs of such works in South Africa expressed in terms of the required capacity. These costs have been increased by 25% for Mozambique and a further 10% was added for Professional Services to obtain the total water treatment plant costs. The costs for different capacities of the water treatment works are shown in Table 10.7.

Table 10.7 Project costs of water treatment plants.

Alternative	Maximum Flow rate (m^3/s)	Capacity (Mℓ/d)	Project Costs (MUSD)
Alternative A			
- Phase 1	1.88	162	60.2
- Phase 2	1.88	162	60.2
Alternative B			
- Phase 1	1.88	162	60.2
- Phase 2	1.88	162	60.2
Alternative C	3.75	324	113.5

10.4 Maintenance Costs

The annual maintenance costs for the various components shown in Table 10.8 are based on acceptable cost models.

Table 10.8 Annual Maintenance Costs.

Component	Percentage of Capital Cost
Dams	
- Civil	0.25 % / year
- M & E	4 % / year
Pump Stations	
- Civil	0,25 % / year
- M & E	4 % / year
Pipelines	0.5 % / year
Maputo River Abstraction	
- Civil	0.5 % / year

10.5 Groundwater schemes

The cost estimates for the groundwater schemes north of Maputo and north of Maracuene are outlined in Tables 10.9 and 10.10, respectively.

Table 10.9 Estimated costs for the development of groundwater in north Maputo.

Assumptions:					
Demand	9,000,000	m3/year	0.285	m3/s	
Nº boreholes	25				
Productivity per borehole	0.011	m3/s			
Length area of boreholes	25	km			
Average depth borehole	40.0	m			
Costs:					
Complete Boreholes (40 m average)	15,000 USD	per unit	25		375,000 USD
Complete Wells	2,000 USD	unit	8	m	16,000 USD
Field tests	1,000 USD	unit	25		25,000 USD
Pumps and distribution connections	50,000 USD	per borehole	25		1,250,000 USD
Automatic (telemetric)Control systems	70,000 USD	total	1	set	70,000 USD
Fences/guard houses around boreholes	3,000 USD	per borehole	25		75,000 USD
Electrical connections	1,000 USD	per km for	25	km	25,000 USD
Pumping tests and evaluation of boreholes as-built					25,000 USD
TOTAL					**1,861,000 USD**

Table 10.10 Estimated costs for the development of groundwater north of Maracuene.

Assumptions:					
Demand	30,000,000	m3/year	0.951	m3/s	
Nº boreholes	50				
Productivity per borehole	0.019	m3/s			
Length area of boreholes	45	km			
Average depth borehole	40				
Average distance to Maputo	50	km			
Costs:					
Access roads and land clearance					250,000 USD
Complete Boreholes (40 m average)	15,000 USD	per unit	50		750,000 USD
Complete Wells	2,000 USD	unit	8	m	16,000 USD
Field tests	1,000 USD	unit	50		50,000 USD
Pumps and connections	2,000 USD	per borehole	50		100,000 USD
Reservoirs and main pipes to Maputo	1,676 USD	per m	50,000	m	83,800,000 USD
Pumps for conveyance to Maputo (M&E + Civil)					108,000,000 USD
Automatic (telemetric)Control systems					100,000 USD
Fences/guard houses around boreholes	3,000 USD	per borehole	50		150,000 USD
Electrical connections	1,000 USD	per km for	45	km	45,000 USD
Pumping tests of boreholes as-built					35,000 USD
TOTAL					**193,296,000 USD**

10.6 Preparatory studies

The following rough estimates have been used for the preparatory studies (Table 10.11). In addition a cost of 0.1 MUSD is estimated for the sourcing of funds and tendering for construction for each of the projects.

Table 10.11 Estimated costs for preparatory studies.

Studies	MUSD
Feasibility and ESIA study for groundwater north of Maracuene, including groundwater modelling.	1.0
Detailed Design of Corumana completion, pipeline and treatment plant	0.5
Feasibility and ESIA study for Moamba Major	2.5
Detailed Design for Moamba Major	1.0
Feasibility and ESIA study for Maputo intake, off-channel storage, pipeline and treatment plant	1.5
Detailed Design or Maputo intake, off-shore storage and pipeline	0.5

10.7 Comparison of project and implementation alternative costs

In order to undertake a relative comparison of each of the water supply alternatives, a number of assumptions have been made. These assumptions are listed below:

- The base year is 2009 and all figures are escalated and discounted accordingly.
- Capital costs are divided equally over the number of years indicated by the implementation schedule (Figure 9.8) and then escalated accordingly.
- Maintenance and operating costs commence in the year after completion of construction as per implementation schedule.
- Discount rates of 4%, 6% and 8% were used in order to arrive at Net Present Value (NPV) figures for each alternative.
- Discount rates were used to discount the water production to calculate the Unit Reference Value (URV) assuming all supplied water will generate income through sale of water.
- The NPVs were calculated for the period 2010 to 2030, i.e. a 21-year period.

Given these assumptions, a number of calculations were conducted in order to arrive at a capital, maintenance and operating cost for each alternative per year. These figures were then totalled per year, and discounted accordingly. Table 10.12 below displays the total NPV values for each alternative.

At each discount rate, alternative C1 comes out as the least-cost option, followed by alternative C2, then alternative B, followed lastly by alternative A.

Table 10.12 Net present value for the implementation alternatives for period 2010-2030.

	NPV @ 4%	NPV @ 6%	NPV @ 8%
A: 44 Mm^3/yr from Corumana and 88 Mm^3/yr from Moamba	954	848	759
B: 44 Mm^3/yr from Corumana and 44 Mm^3/yr from Maputo River	938	840	757
C1: 88 Mm^3/yr from Maputo River asap	744	672	611
C2: 44 +44 Mm^3/yr from Maputo phased	834	740	660

Note: Groundwater schemes north of Maputo and Maracuene included in all alternatives

Table 10.13 displays the total capital cost for each alternative in 2009 values.

Table 10.13 Total capital cost for the implementation alternatives.

	Total Capital Cost in 2009 (MUSD)
A: 44 Mm^3/yr from Corumana and 88 Mm^3/yr from Moamba	1,000
B: 44 Mm^3/yr from Corumana and 44 Mm^3/yr from Maputo River	940
C1: 88 Mm^3/yr from Maputo River asap	723
C2: 44 + 44 Mm^3/yr from Maputo phased	842

Note: Groundwater schemes north of Maputo and Maracuene included in all alternatives

Also in terms of total capital cost in 2009 values, alternative C1 is the cheapest with a total cost of 723 MUSD, followed by alternative C2 with 842 MUSD, alternative B with 940 MUSD and alternative A with 1,000 MUSD.

Table 10.14 displays the Unit Reference Values taking into account all preparatory studies and operation & maintenance, as well as discounted income from water sales.

Table 10.14 Unit Reference Values in USD/m^3.

	URV @ 4%	URV @ 6%	URV @ 8%
A: 44 Mm^3/yr from Corumana and 88 Mm^3/yr from Moamba	0.85	0.96	1.08
B: 44 Mm^3/yr from Corumana and 44 Mm^3/yr from Maputo River	0.79	0.90	1.02
C1: 88 Mm^3/yr from Maputo River asap	0.60	0.68	0.77
C2: 44 +44 Mm^3/yr from Maputo phased	0.73	0.82	0.92

Note: Groundwater schemes north of Maputo and Maracuene included in all alternatives

10.8 Water demand management measures

The costs for water demand management are based on the DWAF (2007) unit estimates for m^3 water reduction. It is assumed that a limited programme is appropriate for Maputo City focussing on education and advocacy for usage reduction, metering, tariffs and billing control, pressure management and water saving devices.

Assuming implementation of education and advocacy for usage reduction in 2010 and other measures from 2015 would give the following estimated cost in 2009 present value:

- 2010-2030: 0.1 MUSD/year
- 2015-2030: 1.5 MUSD/year

It is assumed in the above prices that meters at households will be fully covered by the consumers as is currently the practice in South Africa.

11 TRANSBOUNDARY ISSUES

The choice of the final strategy to secure sufficient water supply to the greater Maputo City is to a certain degree dependent on transboundary issues. Policymakers responsible for the water supply of the City of Maputo must for decision-making as far as possible avoid uncertainties in future border flows from South Africa and Swaziland.

In the present situation there are three major uncertainties related to the border flows:

1. Compliance of IIMA: The recent updated assessments of water demand have shown a number of cases where both South Africa and Swaziland already today exceed the allocated water use for irrigation or afforestation in the Incomati and Maputo Rivers and the projections of water demands indicate a deteriorating situation (cf. Table 3.6 and 3.7).

2. Lack of comprehensive water-sharing agreement between Swaziland and Mozambique for the Umbeluzi River. The estimated growth in water demand from 2007 to 2030 in Swaziland equals 90 Mm^3/year. This is one of the reasons that Pequenos Libombos, despite augmentation of the Maputo water supply from Incomati or Maputo and groundwater, has projected periods of running dry for close to a decade in the 2030 water demand situation (cf. Figure 8.3).

3. The interim status of the IIMA: The water balance analysis has shown that 87.6 Mm^3/year from either Incomati or Maputo will not be sufficient augmentation to secure the water supply to the City of Maputo, while at the same time excess water is available in both rivers up to 2030. It is, however, unclear if the 87.6 Mm^3/year is negotiable for the final comprehensive agreement.

The approach in this study has been, in accordance with the ToR, to assume that the existing bi-lateral and multi-lateral agreement will be complied. Under this assumption the City of Maputo will have serious problems to secure its water supply up to 2030 and the suggested strategies therefore require utilisation of less cost-efficient options such as the groundwater resources north of Maracuene.

A change in the pre-conditions for border flows into Maputo, such as a negotiated water-sharing agreement for Umbeluzi or a re-negotiated IIMA may change the preferred strategy and may make it possible to find more cost-efficient solutions.

It is therefore essential to include the process of transboundary river basin management in the water supply strategies and to opt for as flexible infrastructural solutions as possible.

The TPTC and the future Secretariat for Incomati and Maputo Rivers as well as the JWC for Umbeluzi River therefore have important roles in the implementation of the strategies. In parallel with immediate initiation of preparatory studies for development of infrastructure for the first phase of augmentation of Maputo water supply, the water authorities of the three countries must make efforts to reach agreements on the three pertinent issues relating to the Incomati, Umbeluzi and Maputo rivers listed above

TPTC has the following concrete activities to agree on relating to the water supply of the City of Maputo and its metropolitan area:

- To develop and agree on a plan for reaching compliance of the IIMA in terms of allocated water use and border flows.

- To agree on a final formulation of the IIMA relating to the allocation of water supply to the City of Maputo.

The latter point may include discussions on possible negotiations of increase of the allocation of 87.6 Mm^3/year (e.g. through reallocation from other uses within Mozambique), which would significantly augment the situation for the Maputo City water supply.

The Joint Water Commission for Umbeluzi River

- Should as soon as possible come to an agreement on water allocation for the Umbeluzi River basin.

This would allow both Swaziland and Mozambique to optimally develop the water resources within each country.

12 CHOICE OF FINAL TWO STRATEGIES

12.1 Basis for the choice

The final two strategies were chosen based on the findings in the previous chapters of this report and are presented in Tables 12.1 and 12.2.

The main principles for the choice were

- The two strategies should give the Mozambican water authorities the possibility to independently secure the water supply to the City of Maputo without further augmentation from the upstream countries than what is stipulated in the IIMA and the 1976 agreement for the Umbeluzi River.
- As much flexibility as possible should be built into the strategies to enable more cost efficient solutions, should the transboundary water-sharing agreements be updated or more detailed information becomes available after further preparatory studies.
- The two strategies should, as far as possible, follow the long-term strategic objectives of the Mozambican government to secure water supply to the City of Maputo as well as to other water users in southern Mozambique.

Based on the above principles it was concluded that none of the three main alternatives presented in Table 7.5 should be chosen to the letter as the proposed strategy. The reason is the uncertainties and risks involved because of the lack of feasibility and ESIA studies and the still on-going process of finalising the transboundary water-sharing agreements. The uncertainties and risks make it difficult for the Mozambican water authorities to decide on the long-term solution only based on the findings of this study.

However, the immediate water deficit that Maputo City faces already in the coming five years makes it of utmost importance to start implementation of at least one additional source as soon as possible. Both strategies are therefore structured with a first phase, the short-term strategy, focussing on preparation and implementation of infrastructure for a transfer of 43.8 Mm^3/year either from Incomati or Maputo before 2015 (Figure 12.1).

In parallel with the preparation for implementation of infrastructure for the short-term augmentation of Maputo water supply it is essential to conduct necessary technical and financial feasibility studies and ESIA for alternatives aiming for a long-term solution of water sources for the Greater Maputo and other users in southern Mozambique. It is also essential to finalise the negotiations for water-sharing agreements for all three rivers during the coming years.

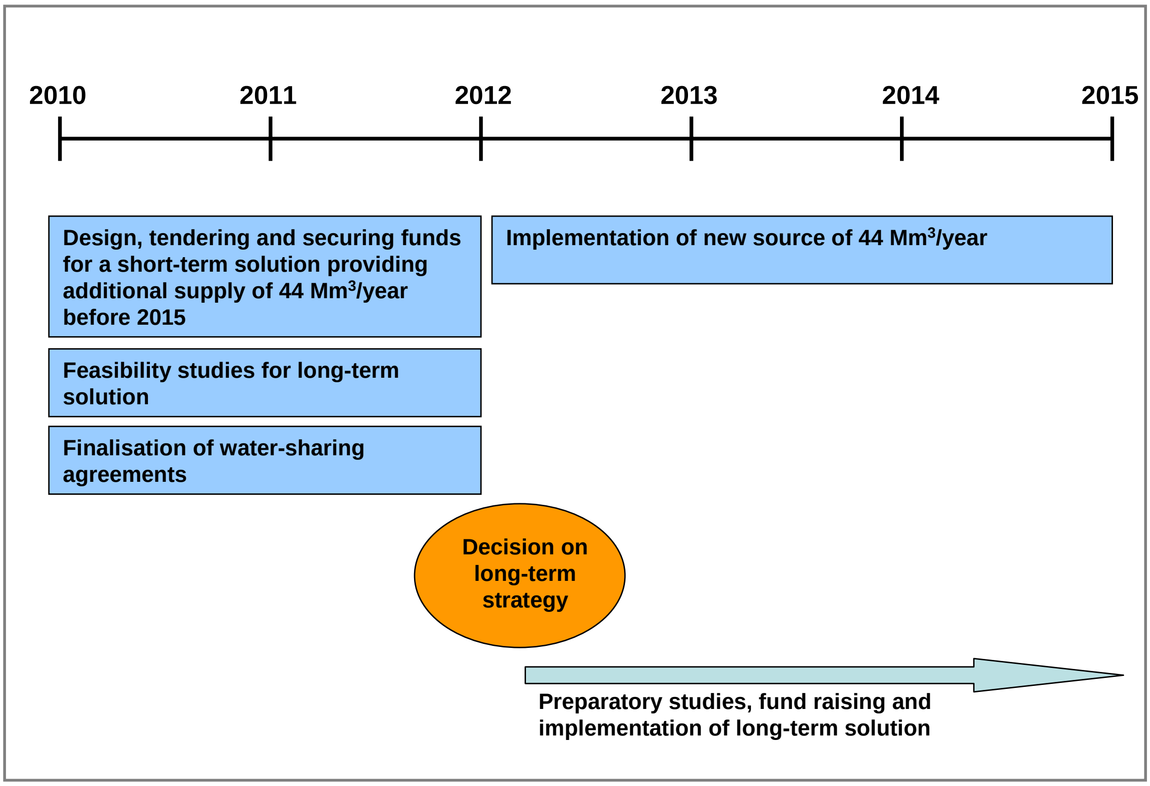


Figure 12.1 General structure of the proposed strategies.

With updated information from conducted feasibility studies for all main alternatives and with the boundary conditions set in agreed final water-sharing agreements the Mozambican Government should be able to take the final decision on the long-term solution for Maputo water supply. Alternatives for additional infrastructure to supplement the short-term source are the Moamba Major dam, groundwater north of Maracuene and further development of the Maputo River. Both strategies therefore include a second phase, which is open depending on the outcome of more studies on the alternatives and the strategic decisions of the Mozambican Government.

The more specific basis for the final choice is given below.

- The completed Corumana Dam option was chosen because the preparatory studies are already being initiated and the funding is partially secured, which makes it possible to implement within the coming five years. It thus probably provides the option that can be implemented first of all alternatives.
- The option of an intake and off-channel-storage in Maputo River close to Salamanga was chosen because it seems to be the most cost-efficient alternative and because the relatively lean infrastructural solution makes the lead time comparably short although no preparatory studies have yet been conducted.

- Due to the serious water scarcity in the Umbeluzi River, the IIMA stipulated 87.6 Mm^3/year from Incomati and/or Maputo rivers will not be sufficient, which is why a third source probably needs to be included also in the long-term strategy to be taken in 2012. The development of the groundwater schemes in north of Maputo and north of Maracuene has been found to be the most cost-efficient alternative and should thus be further studied with a detailed feasibility study starting in 2010.

- The need for set boundary conditions for the three rivers, Incomati, Umbeluzi and Maputo are essential for the Mozambican Government to set the final strategy for the long-term solution for Maputo water supply as well as supply to other economic activities in southern Mozambique. Because of the rapidly increasing water deficit, even with an additional 43.8 Mm^3/year supplied for the Maputo City it is important that the finalisation of the IIMA and the establishment of a comprehensive agreement on the Umbeluzi River basin are finalised by latest in 2011.

- None of the strategies will reach 98% assurance of supply because of the lead times to implement the transfers. Both strategies must therefore include Water Demand Management measures, such as emergency plans for curtailment in water scarcity situations. Also in the long-term water demand measurements are judged economically favourable and should be developed as far as possible.

- Although being a small additional source the continued development of groundwater in the northern part of Maputo City should be included because of its low unit reference value and because the programme has partly already been initiated by FIPAG.

- The coordination of activities and plans by FIPAG, DNA and ARA-Sul is fundamental for the optimisation of the different alternatives. The planned study on the Maputo Water Supply Network Master Plan must be conducted in parallel, and in coordination, with the feasibility and design of the transfer schemes from Incomati/Maputo and the Maracuene groundwater scheme.

Table 12.1 Strategy alternative no.1 for augmenting the water supply to the City of Maputo and its metropolitan area.

STRATEGY Alternative 1			
Description: ***Development of a transfer scheme for 43.8 Mm^3/year from the completed Corumana Dam to Maputo City in parallel with exploiting groundwater resources and implementing Water Demand Management measures, as well as feasibility studies for long-term solution and finalisation of water-sharing agreements.***			
Implementation Plan:			
Period	***Activity***	***Responsibility***	***Estimated cost (MUSD 2009)***

2010	• Develop an emergency plan to curtail water use through bylaws in case of serious water deficits
	• Enhance the programme to develop boreholes in the Northern Maputo Area
	• Procure and conduct the Technical Services and Dam Safety and ESIA projects under the NWRDP1 including updated feasibility and preliminary design of the completion of the Corumana Dam, pipelines and treatment plant for transferring water from Sabie River to Maputo City
	• Detailed design and tender documentation for the Corumana Dam completion.
	• Source funding for pipeline and treatment plant for transferring water from Corumana to Maputo City
	• Conduct the Master Plan for Maputo City water supply network preparing for additional sources from the Maputo River and the Maracuene groundwater scheme
	• Initiate the process of finalising Annex 1 of the IIMA including a final formulation of the allocation of first priority water allocation for the City of Maputo
	• Develop a plan for reaching compliance of the IIMA allocations in South Africa and Swaziland
	• Enhance the process of finalising a water-sharing agreement for the Umbeluzi River
	• Source funding, procure and initiate detailed feasibility studies and ESIA for the following long-term solution for Maputo water supply
	  • Updating the feasibility study for Moamba Major considering other more optimised dam sizes Groundwater scheme north of Maracuene and the transfer of treated water to Maputo City, including GW modelling and test pumping.
	  • Abstraction scheme, off-channel storage, pipelines and treatment plant for transferring water from Maputo River upstream Salamanga to Maputo City (including water quality monitoring at the proposed abstraction site in Maputo River 5 km upstream of Salamanga)
		DNA/FIPAG
		FIPAG
		DNA
		
		DNA/ARA-Sul
		DNA/ARA-Sul
		FIPAG
		TPTC
		TPTC
		Umbeluzi JWC
		DNA/ARA-Sul
			5

2011	• Detailed design and tender documentation for pipelines and treatment plant for transferring water from Sabie River to Maputo City • Procure contractors for the implementation of the Corumana Dam completion and the construction of pipelines and treatment plant for transferring water from Sabie River to Maputo City • Finalise the programme to develop boreholes in the Northern Maputo Area • Finalise the updated Annex 1 of IIMA and a water-sharing agreement for the Umbeluzi River • Finalise detailed feasibility studies and ESIA for the options of Moamba Major, Maputo River and groundwater at Maracuene for further augmentation of water supply to Maputo City • Develop a programme for education and advocacy of reducing water usage to be implemented in 2012-2030	DNA/ARA-Sul DNA/ARA-Sul FIPAG TPTC/Umbeluzi JWC DNA/ARA-Sul DNA/FIPAG	5
2012	• Start construction for the implementation of the Corumana Dam completion and the construction of pipelines and treatment plant for transferring water from Sabie River to Maputo City • Final decision on long term water-supply strategy for Maputo City and its metropolitan area and southern Mozambique	DNA/ARA-Sul DNA/ARA-Sul	100
2013-15	• Finalise the implementation of the Corumana Dam completion and the construction of pipelines and treatment plant for transferring water from Sabie River to Maputo City • Detailed update of the water demand forecast for the City of Maputo and its metropolitan area and the Maputo Water Supply Master Plan • Source funds, conduct detailed designs and tender documents for chosen infrastructural solutions following the decision on final strategy	DNA/ARA-Sul DNA/ARA-Sul/FIPAG DNA/ARA-Sul	310
2016-30	• Implement and finalise chosen infrastructural solutions following the decision on final strategy • Initiate and implement the comprehensive programme for Water Demand Management • Update water demand projections and the Maputo water supply Master Plan every 5 year.	DNA/ARA-Sul DNA/ARA-Sul/FIPAG DNA/ARA-Sul/FIPAG	540-610
		TOTAL CAPITAL COST:	***960-1,030***

Table 12.2 Strategy alternative no.2 for augmenting the water supply to the City of Maputo and its metropolitan area.

STRATEGY Alternative 2			
Description: ***Development of a transfer scheme for 43.8 Mm³/year from the Maputo River upstream of Salamanga in parallel with exploiting groundwater resources north of Maputo City and implementing Water Demand Management measures, as well as feasibility studies for long-term solution and finalisation of water-sharing agreements.***			
Implementation Plan:			
Period	**Activity**	**Responsibility**	**Estimated cost (MUSD 2009)**
2009	• Initiate water quality monitoring at the proposed abstraction site in Maputo River 5 km upstream of Salamanga	DNA/ARA-Sul	

2010	• Develop an emergency plan to curtail water use through bylaws in case of serious water deficits
	 • Enhance the programme to develop boreholes in the Northern Maputo Area
	 • Source funding, procure and conduct a feasibility study and ESIA for the abstraction scheme, off-channel storage, pipelines and treatment plant for transferring water (for both options of 44 and 88 Mm³/year) from Maputo River upstream Salamanga to Maputo City
	 • Conduct the Master Plan for Maputo City water supply network preparing for additional sources from the Maputo River and the Maracuene groundwater scheme
	 • Initiate the process of finalising Annex 1 of the IIMA including a final formulation of the allocation of first priority water allocation for the City of Maputo
	 • Develop a plan for reaching compliance of the IIMA allocations in South Africa and Swaziland
	 • Enhance the process of finalising a water-sharing agreement for the Umbeluzi River
	 • Source funding, procure and initiate detailed feasibility studies and ESIA for the following long-term solution for Maputo water supply
	     • Updating the feasibility study for Moamba Major considering other more optimised dam sizes
	     • Groundwater scheme north of Maracuene and the transfer of treated water to Maputo City, including GW modelling and test pumping.
		DNA/FIPAG
		 FIPAG
		 DNA/ARA-Sul
		
		 FIPAG
		 TPTC
		 TPTC
		 Umbeluzi JWC
		 DNA/ARA-Sul
			5

2011	• Detailed design and tender documents for the abstraction scheme, off-channel storage, pipelines and treatment plant for transferring 44 Mm³/year from Maputo River upstream Salamanga to Maputo City • Finalise the programme to develop boreholes in the Northern Maputo Area • Finalise the updated Annex 1 of IIMA and a water-sharing agreement for the Umbeluzi River • Finalise detailed feasibility studies and ESIA for the options of Moamba Major and groundwater at Maracuene for further augmentation of water supply to Maputo City • Develop a programme for education and advocacy of reducing water usage to be implemented in 2012-2030	DNA/ARA-Sul FIPAG TPTC/Umbeluzi JWC DNA/ARA-Sul DNA/FIPAG	5
2012	• Source funds and procure contractors for implementation of the abstraction scheme, off-channel storage, pipelines and treatment plant for transferring 44 Mm³/year from Maputo River upstream Salamanga to Maputo City • Final decision on long term water-supply strategy for Maputo City and its metropolitan area and southern Mozambique	DNA/ARA-Sul DNA/ARA-Sul	-
2013-2015	• Start and completion of construction of the abstraction scheme, off-channel storage, pipelines and treatment plant for transferring 44 Mm³/year from Maputo River upstream Salamanga to Maputo City • Detailed update of the water demand forecast for the City of Maputo and its metropolitan area and the Maputo Water Supply Master Plan • Source funds, conduct detailed designs and tender documents for chosen infrastructural solutions following the decision on final strategy	DNA/ARA-Sul DNA/ARA-Sul/FIPAG DNA/ARA-Sul	340
2016-30	• Implement and finalise chosen infrastructural solutions following the decision on final strategy • Initiate and implement the comprehensive programme for Water Demand Management • Update water demand projections and the Maputo water supply Master Plan every 5 year.	DNA/ARA-Sul DNA/ARA-Sul/FIPAG DNA/ARA-Sul/FIPAG	520-610
		TOTAL CAPITAL COST:	***870-960***

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12.2 Evaluation of the two strategies

The Terms of References does not require a prioritisation of the two chosen strategies. The consultant, however, would like to objectively present advantages and disadvantages of the two strategies based on the findings of this study.

The choice between the two strategies presented in Tables 12.1 and 12.2 is to a certain extent a choice between risk and cost:

- Strategy no. 1 with the development of a transfer from the completed Corumana Dam as a first phase is more expensive but comprises less risk. Construction-wise the Corumana transfer has already been indicated to be feasible (Lahmeyer and Associates 2003) and funding is secured for the completion of the dam through the World Bank (World Bank 2007b).

- Strategy no. 2, assuming Maputo River as the next source of the 43.8 Mm^3/year, is the cheapest alternative (estimated 70 MUSD less for the first phase) but also has the higher risk. The major risks involved with this strategy are the uncertainties regarding the infrastructural solutions and the water quality as well as the lack of secured funding. These risks may result in extended lead times or increased costs.

Strategy no. 1 would allow water supply to the smaller urban settlements along the EN4 and give more flexibility for FIPAG to optimise its distribution network by a new distribution centre in the north-west part of the city.

Strategy no.1, especially if followed by the Moamba Major Dam, would also give the Mozambican water authorities a larger flexibility to manage the water resources within the country in a drought emergency situation because of the provided large storages.

From a transfer failure perspective, such as pipeline failure or similar, a final strategy with many sources is, however, preferable. This would promote a strategy involving both the Incomati and Maputo rivers as sources.

There are risks involved in the development of the groundwater scheme north of Maracuene. The major uncertainties are lack of recent comprehensive hydrogeological studies and possible salt water intrusion, which may reduce the available yield. Water quality uncertainties may further increase treatment costs. Because of these uncertainties it is of utmost importance to finalise the water-sharing agreements for the Incomati, Maputo and Umbeluzi Rivers within the coming two years. If the groundwater yield north of Maputo City is not sufficient, the possible augmentation from the transboundary water allocation for the three rivers would be the only reasonable alternative, from a cost perspective, to secure the water supply to the City of Maputo and its metropolitan area.

Independent of the feasibility of the proposed transfers or possible augmentation from the transboundary water allocation for the three rivers, the consultant strongly advocates the implementation of Water Demand Management. On the long-term, measures such as education and promotion of usage reduction, proper tariffs and billing systems, pressure management and water saving devices are all financially advantageous, especially in a situation where the water sources need to be pumped from large distances giving high maintenance and operation costs, as is the case for the City of Maputo.

The costs for both chosen strategies are high compared to previous estimates. The main reason is the significantly increased costs for pipelines and pump stations during the recent years. Although being on the high side it is believed that the costs presented in this study are fair estimates since they are based on recent and on-going water transfer projects in South Africa, and thus more accurate than the previous studies. Emphasis should, however, be given in the updated feasibility studies to assess the possibilities of reducing the conveyance costs by e.g. using other material than steel for the pipelines. It should further be noted that a reduced conveyance cost would not change the choice of the two strategies and would still give Strategy no. 1 as the more expensive alternative.

Table 12.3 summarises the major advantages and disadvantages for the strategic choices to augment the water supply for the Maputo City and its metropolitan area. It also gives the necessary information needed before a final decision can be taken.

It should be noted that in Table 12.3 the cost estimates for the long-term alternatives are based on utilising the water allocation up to the present IIMA agreement. The results of this study have indicated that further yield can be obtained should the water-sharing agreements be revised, but this would incur higher capital costs.

For the long-term alternatives it is essential that the finalisations of the water-sharing agreements for both IncoMaputo and Umbeluzi Rivers are made in coordination with the updated feasibility studies and basic design since the allocated water is an essential input to find the most cost-efficient solution. For all alternatives the process of securing funds is essential to meet the expected year of commissioning.

Table 12.3 Summary of advantages and disadvantages with the different short-term and long-term solutions.

	Yield (Mm^3/year)	Cost (MUSD)	Major Advantages and Benefits	Major disadvantages	Required information / studies to be able to take a final decision	Expected Year to supply water
Short-term Alternatives						
Completed Corumana	43.8	410	• Short lead time • Funds for completion secured • Provides the new source in the NW expansion areas of Maputo	• High cost because of long pipeline transfer		2014
Maputo River	43.8	340	• Least cost	• Uncertainties in cost and lead times because of lack of preparatory studies	• Assessment of salt water intrusion • Feasibility Study and Basic Design	2015
Long-term Alternatives						
Moamba Major Dam	Additional 43.8	395	• Multi-purpose use • Large storage capacity which give independence in a drought situation	• Largest negative environmental and social impact • Long lead time • Relatively high cost	• Updated feasibility study and ESIA • Secured interest and funding for other uses • Finalised water-sharing agreements for IncoMaputo and Umbeluzi Rivers	2020
Maputo River	Additional 43.8	313	• Least cost	• Uncertainties in cost and lead times because of lack of preparatory studies • Small storage giving dependence of South Africa and Swaziland in a drought situation	• Assessment of salt water intrusion • Feasibility Study and Basic Design • Finalised water-sharing agreements for IncoMaputo and Umbeluzi Rivers	2017
Additional Sources						
Groundwater	39	193	• No competing users	• Uncertainties because of lack of preparatory studies	• Monitoring and modelling of yield and salt water intrusion • Feasibility Study and Basic Design	2015
WDM	29	9	• Low cost per m^3	• Difficulties to implement because of low coverage of piped water • Uncertain effect of measures	• More detailed study on possibility to implement larger WDM measures such as grey water system and rain harvesting	Gradually 2015-2030

13 UPDATING OF ANNEX 1 of IIMA

The Annex 1 of IIMA basically consists of six types of information:

1. Catchment areas of the Incomati and Maputo Rivers (Articles 2 and 3).
2. The natural water resources (MAR) of the Incomati and Maputo Rivers (Articles 2 and 3).
3. The amount of irrigation (areas and water demand) in 1991 of the Incomati and Maputo Rivers (Articles 2 and 3).
4. Key stations for monitoring flows in the Incomati and Maputo Rivers (Articles 2 and 3).
5. Agreed water usage (water allocation) for First Priority Supply, Irrigation and Afforestation for each of the three countries for the Incomati and Maputo Rivers (Articles 4 and 6).
6. Water Requirements of the Ecosystems for the Incomati and Maputo Rivers including e.g. border flows (Articles 5 and 7).

I further include clauses in Article 4 (1) and 6 (1) related to the water supply to the City of Maputo:

"The additional reserved water use of up to 87.6 million m^3/a is intended for the city of Maputo and will be drawn from the total water available from the further development of the Maputo (Incomati) watercourse. A similar quantity of water is reserved from the Incomati (Maputo) watercourse to provide for wider options of choice. The final details and options to meet the growing water requirements of the city of Maputo and the greater Maputo Metropolitan Area will follow from further studies. These will be recorded by the Parties as an amendment of this Annex in terms of Article 16 of the Agreement after the provisions of subArticle (7) have been complied with."

Sub-Articles 4(7) and 6(7) further give guidance regarding the studies to be conducted to assess the water supply to the City of Maputo:

"Mozambique shall perform further studies, including environmental impact assessments that also take account of any future transboundary impacts, approved by the TPTC to establish the water requirements of the city of Maputo, the supply capability of its existing sources of water. Mozambique shall notify the Parties through the TPTC of the findings of these studies in accordance with the procedures set out in Article 4(1) of the Protocol and Article 13 of the Agreement to enable the Parties to evaluate the same in own territories and for the TPTC to then recommend to the Parties the portion of the reserved quantity of water shown in subArticles (1) and (2) that is to be admitted in the respective subArticles"

The implementation of the recent river basin studies JMRBS (PLANCENTER and Associates 2008) and IWAAS (Water for Africa and Associates 2009) as well as the present study has resulted in updated information for Annex 1. Based on this the following update of Annex 1 should be conducted for the final agreement:

- Catchment areas and MAR should be updated in Articles 2 and 3 with the new information from the recent river basin studies (JMRBS, IWAAS).

- The amount of irrigation (areas and water demand) should be updated to 2004/2005 estimate based on the detailed assessment of the recent river basin studies (JMRBS, IWAAS).

After the final choice of the two presented water supply strategies, presented in Chapter 12, has been made by the Mozambican water authorities and the TPTC, and after negotiations of possible changes to the suggested allocation of 87.6 Mm^3/year for the City of Maputo, the following updates should be conducted for the final agreement:

- The clauses in Articles 4 (1) and 6 (1) related to the water supply to the City of Maputo should be removed and the First Priority Supplies should be updated according to the agreed strategy.

- Sub-Articles 4(7) and 6(7) should be removed.

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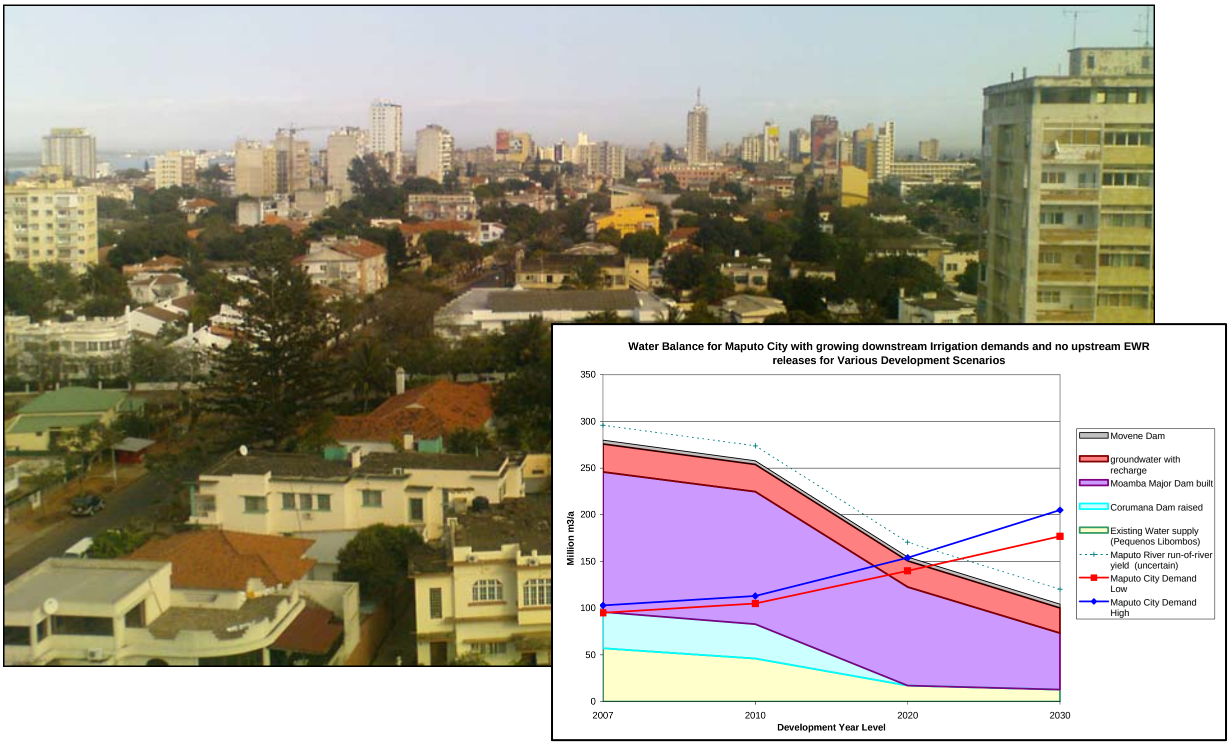
Augmentation of Water Supply to the City of Maputo and its Metropolitan Area



Water Balance Report

Draft 4 May 2009

SWECO International
DHI, BKS, CONSULTEC

Client:	**National Directorate of Water, Mozambique, on behalf of the Tripartite Permanent Technical Committee (TPTC) between Mozambique, South Africa and Swaziland**
Project:	**Progressive Realization of the IncoMaputo Agreement (PRIMA)**
Study:	**Augmentation of Water Supply to the City of Maputo and its metropolitan Area**
Title:	**Water Balance Report**
Sub title:	**-**
Status of report:	**Draft**
SWECO Project No:	**1989705**
Date:	**4 May 2009**
Project team:	**SWECO International AB, Sweden (lead)** **CONSULTEC Lda, Mozambique** **BKS, South Africa** **DHI Water, Environment, Health, Denmark**

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Augmentation of Water Supply to the City of Maputo and its Metropolitan Area

WATER BALANCE REPORT

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Appendices

SUMMARY

The Water Balance Report is a part of the project "*Augmentation of Water Supply for the City of Maputo and its Metropolitan Area*". The purpose of the water balance analyses is to assess the water requirements in the river system and compare that with the water availability.

The results showed that during normal conditions the water availability in the Umbeluzi River is sufficient to supply the Greater Maputo for a foreseeable future. However, secure urban water supply at a very high assurance has essential economic impacts for a society and the future water supply infrastructure cannot be designed based on normal conditions.

The analysis of drought conditions, expressed as the historic safe yield for the studied period of data (80-85 years), showed that the existing water available from the Pequenos Libombos Dam needs to be augmented with new sources of water as a water deficit is likely beyond 2007, with estimated shortages of between 130 to 150 million m^3/a in 2030.

The safe yields for the major development options in Mozambique, assuming no Environmental Flow Requirements (EWR) in South Africa and Swaziland, were estimated as follows:

- Completed Corumana Dam: 256 million m^3/a (2007) to 250 million m^3/a (2030)
- Moamba Major Dam: 150 million m^3/a (2007) to 133 million m^3/a (2030)
- Movene Dam: 5 million m^3/a
- Catuane Run-of-the river: 16.8 million m^3/month (2007) to 13.5 million m^3/month (2030)
- Artificial groundwater recharge: 30 million m^3/a.

Compliance with EWR in South Africa would considerably increase the yields in especially Moamba Major and Catuane. On the other hand, compliance with estuarine flow requirements would probably decrease the water that can be allocated to urban water supply to a similar order of magnitude.

The calculated safe yields in this study are significantly lower for the Moamba major and completed Corumana Dam compared to previous studies. The reason is a combination of increased water usage in South Africa and Swaziland in combination with reduced natural inflow series based on the latest updates.

Unless the Maputo River can be utilised in feasible way, the challenge is to balance water use between irrigation and urban water demand in Mozambique. The Completed Corumana and Moamba Major will only be sufficient to augment water supply to the City of Maputo and its Metropolitan Area if development of irrigation is frozen at the present level in the Incomati River basin.

Compliance of cross border flows in accordance with the existing IIMA and the 1976 agreement for Umbeluzi would augment the situation and allow for limited expansion of other uses in Mozambique while securing water supply to the Greater Maputo.

1 INTRODUCTION

1.1 Background

The project "*Augmentation of Water Supply for the City of Maputo and its Metropolitan Area*" aims to study in detail the forecasts of water requirements for the City of Maputo and its metropolitan area and the possibility of supplying these from the Umbeluzi River watercourse, augmented by new supplies from the Incomati and the Maputo river watercourses and/or groundwater resources and by increasing water use efficiencies and other water demand management measures.

Water balance analyses and water resources yield analyses are important tools to assess future water availability and deficits of the Greater Maputo area. It will give indications of current and future possible sources for water supply and give guidance to when necessary infrastructure projects need to be implemented.

The water resources available from the Umbeluzi, Incomati and Maputo rivers were assessed to determine how much water is available and where the water is available to supply the growing water requirements of the City of Maputo and the Greater Maputo Metropolitan Area.

1.2 Objective

The aim with this report is given in the Terms of Reference:

"*Presentation of the water balances for the city of Maputo and the Greater Maputo Metropolitan Area until the years 2027 with 5-year intervals based on the water availability and the projected water demands upstream of Maputo."*

The specific objectives of the activities related to the water balance component, given in the ToR, are:

- Providing water balances for Greater Maputo Area until the years 2027 with 5-year intervals, taking into account the river basins water resources availability, the projected water demands for Greater Maputo and the projected water demands upstream of Maputo.

- Assessing the foreseen water deficits for Greater Maputo Area, under normal hydrological conditions and under drought conditions.

At the Project Steering Committee meeting on the 9th March 2009 the years for presentation were set to 2007 (base year), 2010, 2015, 2020, 2025 and 2030. The reason for this change was that input data on water demand from previous studies were generally expressed for these years. Because of the approximately linear growth in water demands of the different users, only 2007, 2010, 2020 and 2030 are reported on in the tables.

The water balance component is also an important part of the Strategy formulation component. The specific objectives of this report have therefore also been extended to estimate the available water resources for the future potential sources of water supply for the Greater Maputo Area:

- Estimating safe yield for potential development projects to augment water supply to the City of Maputo and its metropolitan area.

2 WATER BALANCE ANALYSIS

2.1 Rationale for water balance analysis

System analysis is important to take into consideration the seasonal and inter-annual variation in available water resources (see Figure 2.1). Comparison of demand and supply is therefore made month by month in the analysis to assess the risk of failure of the system.

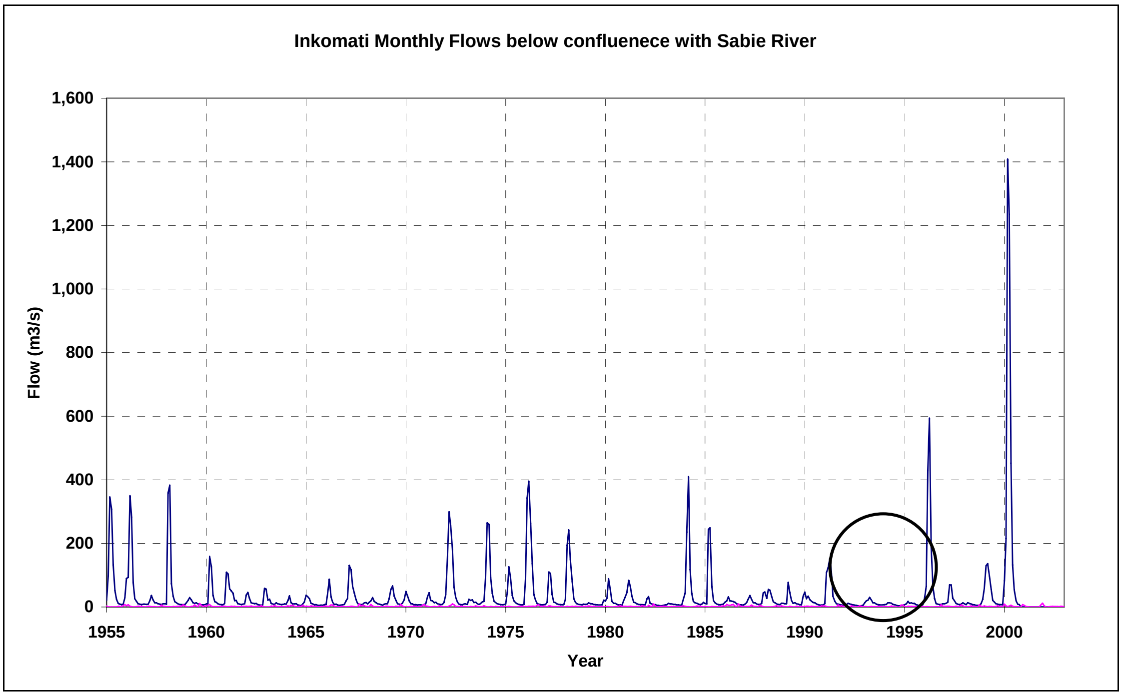

Figure 2.1 The long-term available water resources of the Inkomati River basin are governed by the dry periods. Analyses of the last 50-year record period, show that the critical years occurred in the early 1990s

The system analysis provides two essential results that are fundamental for the water management in a river basin:

- *Historic safe yield*: the maximum annual water volume that can be abstracted without failing once over the total hydrological record length.
- *Assurance of supply*: the percentage of time steps with fully satisfied water demand over the total hydrological record length

2.2 Required input data

The data required to calculate water balances at different points in the study area are natural river flows and water demands of the different users, including environmental flow requirements. In addition rainfall and evaporation data are required for the dams.

2.3 Modelling tools

The water resources yield model (WRYM) was used to determine water availability of the different surface water resources. The WRYM is a monthly time step water balance model developed by South Africa's DWAF to model yield and hydropower. The model utilises naturalised hydrology as input and simulates the catchment at a constant development level, i.e. water infrastructure, water demands and land use remain constant during a simulation.

The WRYM, through a user-defined penalty system, can prioritise water supply to higher priority users. The system can also assess a number of different water infrastructure scenarios and possible combinations of water resource developments.

For further information on the terms and procedures used in yield analysis, refer to the report entitled: Yield Analysis: Terms and Procedures (Department of Water Affairs and Forestry, South Africa, 1998)

3 STUDY FRAMEWORK

3.1 Study area

This study focuses on the water supply to the City of Maputo and its metropolitan area. Current water intake is located in the Umbeluzi River downstream of the Pequenos Libombos Dam. Potential sources for future water supply, however, also include the Incomati and the Maputo rivers in Mozambique.

Water balance analysis for future options must therefore include the three river basins, Incomati River, Umbeluzi River and Maputo River (Figure 3.1).

3.2 Legal setting

3.2.1 The Umbeluzi River

In 1976 Mozambique and Swaziland signed an agreement on water sharing in the Umbeluzi River basin. This agreement contains a general introduction and two articles:

- The first article defines that Mozambique should receive 40% of the flows measured at two hydrometric stations, GS3 and GS10 in the Umbeluzi River at the border between Swaziland and Mozambique.
- The second article defines conditions for a transition period, until the construction of the Pequenos Libombos Dam in Mozambique.

As the Pequenos Libombos Dam has been completed and started operating in 1988, the second article is not valid anymore and the agreement is thus limited to its first article.

The agreement does not refer to any kind of water use or water allocations in the two countries. There is no reference in the agreement to natural or virgin flows. The agreement also lacks any reference to minimum cross-border flows or how annual volumes agreed for cross-border flows should be distributed with time.

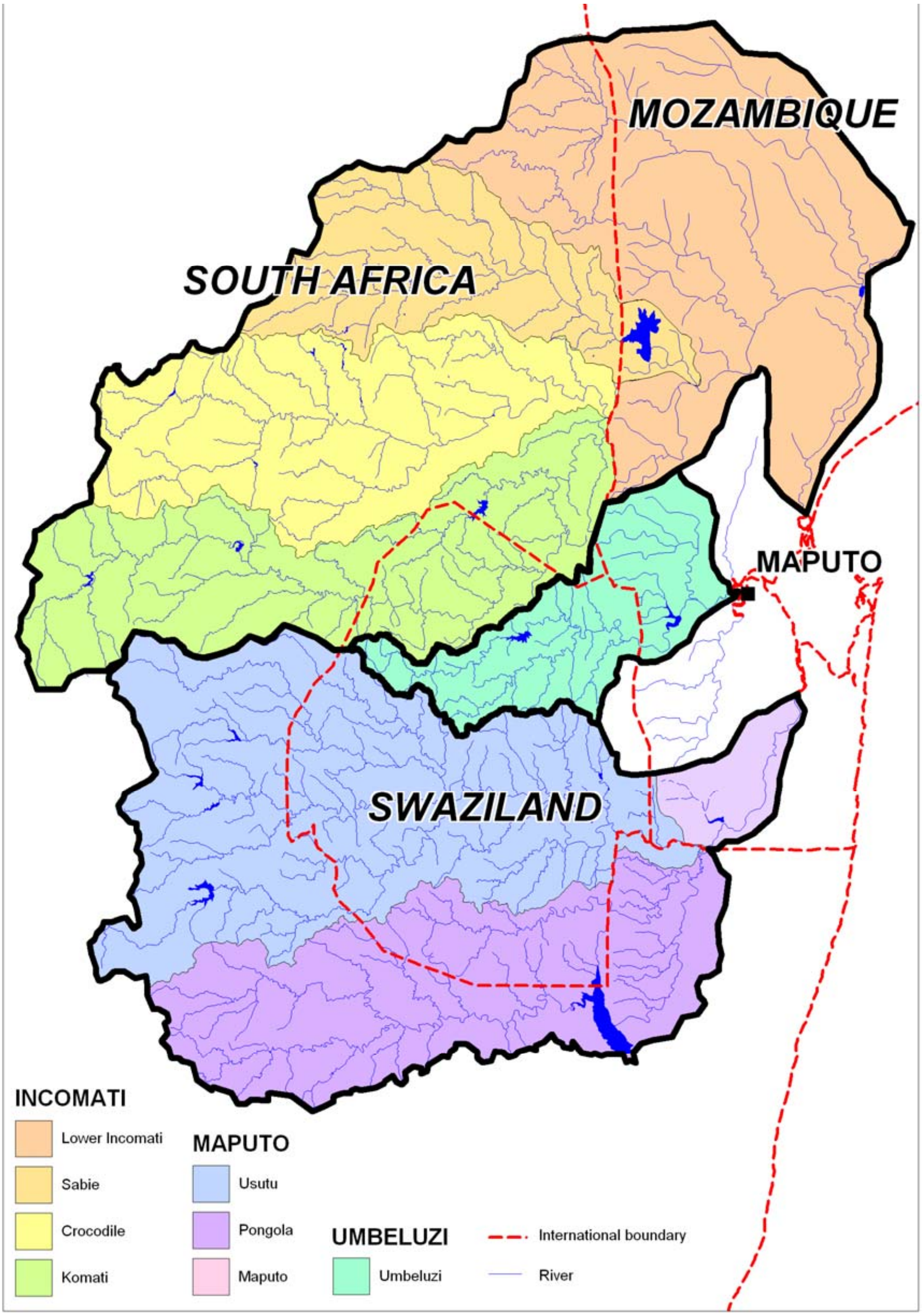

Figure 3.1 The study area comprises the three river basins of Incomati, Umbeluzi and Maputo rivers

3.2.2 The Incomati and Maputo rivers

In 2002 South Africa, Swaziland and Mozambique signed and agreed on water sharing in the Incomati and the Maputo River basin, the Interim IncoMaputo Agreement (IIMA). This agreement's general objective is to promote co-operation among the three countries to ensure protection and sustainable utilisation of the water resources within the basins. The joint body for co-operation between the countries shall be the Tripartite Permanent Technical Committee (TPTC) between Mozambique, South Africa and Swaziland.

Annex 1 of the agreement gives the natural mean annual runoff (MAR) for the two river basins (Table 3.1 and 3.2).

Table 3.1 Contribution of the sub-catchments of the Incomati River catchment to the total natural mean annual runoff (Source: IIMA).

Sub-catchment	**Contribution to natural MAR (million m³/a)**			
	Mozambique	**South Africa**	**Swaziland**	**Total**
Komati	0	955	475	1 430
Crocodile	-	1 225	-	1 225
Sabie	0	750	-	750
Massintonto	10	10	-	20
Uanetze	10	5	-	15
Mazimechopes	20	-	-	20
Incomati	130	0	-	130
Total	**170**	**2 945**	**475**	**3 590**

Table 3.2 Contribution of the sub-catchments of the Maputo River catchment to the total natural mean annual runoff (Source: IIMA).

Sub-catchment	**Contribution to natural MAR (million m³/a)**			
	Mozambique	**South Africa**	**Swaziland**	**Total**
Lusushwana	-	80	340	420
Mpuluzi	-	220	40	260
Usuthu	5	100	505	610
Ngwempisi	-	290	210	500
Mkhondvo	-	370	200	570
Ngwavuma	-	20	160	180
Pongola	-	1 100	60	1 160
Maputo	100	-	-	100
Total	**105**	**2 180**	**1 515**	**3 800**

The IIMA also state the allocated water for each country and sub-catchment (Tables 3.3 and 3.4).

Table 3.3 Allocated water use in the Incomati (Source: IIMA).

South Africa			
	First Priority	Irrigation	Afforestation
KOMATI SA	183	381	99
CROCODILE	73	307	247
SABIE	80	98	129
MASSINTONTO	0.3	0	0
UANETSE	0.3	0	0
Total	*337*	*786*	*475*
Swaziland			
	First Priority	Irrigation	Afforestation
KOMATI	22	261	46
Mozambique			
	First Priority	Irrigation	Afforestation
INCOMATI U/S SABIE	1.1	29	0
INCOMATI D/S SABIE	15.6	239	25
SABIE	0.5	12	0
MASSINTONTO	0.7	0	0
UANETSE	0.6	0	0
MAZIMCHOPE	0.5	0	0
Total	*19*	*280*	*25*

Table 3.4 Allocated water use in the Maputo (Source: IIMA).

South Africa			
	First Priority	Irrigation	Afforestation
Pongola	18	517	46
Ngwavuma	2	1.3	0
Mkhondvo	117	13.9	42
Ngwempisi	60	4.8	52
Usuthu	38	0	14
Mpuluzi	6	0.8	37
Lusushwana	1	0.2	7
Total	*242*	*538*	*198*
Swaziland			
	First Priority	Irrigation	Afforestation
Pongola	2	6.4	0.5
Ngwavuma	2.6	58.6	1.5
Usuthu	39.4	462	80
Total	44	527	82
Mozambique			
	First Priority	Irrigation	Afforestation
Maputo	6	60	0

In addition to the first priority allocation 87.6 Mm3/year was reserved for the city of Maputo and will be drawn from the total water available from the further development of the Maputo or Incomati watercourses.

Finally, the IIMA states the water requirements of the ecosystems of Incomati and Maputo (Table 3.5).

Table 3.5 Allocated water for the ecosystem (Source: IIMA).

Key Point		
	Annual minimum	Irrigation
	Mm3/year	*m3/s*
Incomati – Ressano Garcia	200	0.6
Sabie	290	2.6
Maputo - Salamanga	840	2.7

3.3 Possible future sources for Maputo water supply

Possible future water supply sources for the Greater Maputo area are:

- Surface water conveyed from the nearby Umbeluzi, Incomati and Maputo rivers;
- Groundwater from aquifers within or adjacent to the City of Maputo;
- Desalination of sea water; and
- Piped water from distant large sources such as the Limpopo or Zambezi rivers.

Transferring water from the Limpopo or Zambezi rivers was not considered as the estimate costs of piping the water are higher than the cost of desalination of seawater, which could provide an endless source for Maputo. Desalination of seawater is not discussed in any detail in this report.

Based on previous studies the following possible developments of surface and groundwater resources have been identified to augment the existing source at Pequenos Libombos Dam:

1. Water piped from the existing Corumana Dam (FSL = 111 m);
2. Water piped from the completed Corumana Dam (gates installed to FSL = 117 m);
3. Water piped from a future Moamba Major dam (FSL = 112 m);

4. Piped water from Moamba Major via Movene Dam, which will give a local additional source;

5. Piped water from run-of-the river intake in Maputo River at Catuane;

6. Development of natural groundwater resources north of Maputo; and

7. Development of an artificial groundwater recharge scheme fed by the Incomati River close to Maracuene.

In addition, it is assumed that Catembe and Inhaca will be locally supplied by groundwater, which is possible due to its low water demand.

4 REVIEW OF PREVIOUS STUDIES

4.1 Previously conducted water balance analyses

The following recent studies have conducted basin-wide water balance analyses of the Incomati, Umbeluzi and Maputo rivers and are summarised in Table 4.1.

Table 4.1 Recent studies related to water balance analyses in Incomati, Umbeluzi and Maputo Rivers

Title	Owner	Rivers
Joint Inkomati Basin Study, Phase II, CONSULTEC and BKS Acres (2002)	TPTC	Incomati
Raising of the Full Supply Level of Corumana Dam, Final Feasibility Study Report, Main Report, Lahmeyer International and Associates (2003)	DNA	Sabie
Feasibility Study for Moamba- Major Dam, Cost Estimate at IPL 2002, Revised May (2003), Norconsult	DNA	Incomati
3-Basin Study - National Water Resources Development Plans and Joint Water Resources Development Study of Maputo, Umbeluzi and Incomati River Basins, SWECO & Associates (2004)	DNA	Incomati, Umbeluzi and Maputo
Joint Umbeluzi River Basin Study, SWECO & Associates (2005)	DNA & DWA	Umbeluzi
Joint Maputo River Basin Study, Current and Potential Water Resources Developments, Combined Task Report 8.2-8.4 (2007), PLANCENTER & Associates	TPTC	Maputo
Incomati Water Availability Assessment Study (on-going)	DWAF	Sabie, Crocodile and Komati

4.2 Review of most recent previous analyses

The report on Water Availability completed as part of this study has included a review of previous studies on the Maputo, Umbeluzi and Incomati rivers. As such, the general assessment of the previous reports will not be repeated in this chapter. The focus of this report is on the modelling conducted by the most recent studies, and in particular the representative scenarios that simulate the water balances of the three basins at various potential development levels that correspond to future time slices.

Specific developments and water use within the upstream countries are of lesser importance as this study is focused on the most likely potential developments within

Mozambique, to serve the city of Maputo. The total effect of likely growth in water use in the upstream countries is, however, of importance, so as to determine the corresponding changes in yield of potential developments that could augment water supply to Maputo.

4.2.1 Joint Maputo River Basin Study (JIBS)

The JIBS was the first transboundary study of the three rivers feeding into the Maputo Estuary. It included a through assessment of the water resources and water demand of the Komati, Crocodile, Sabie and the Incomati Rivers. It was conducted during the 1990s and one of the first components was the hydrology. The hydrology of JIBS was therefore based on the records up to 1988. Although the water requirements were updated in the later stage of the study the system analysis was only conducted for the series up to 1988, thereby missing the critical dry years in the beginning of the 1990s. The results of the system analysis for Incomati reported in 2002 were the basis for the IIMA.

4.2.2 Feasibility studies for Corumana and Moamba

Following the JIBS studies were the feasibility studies for the completion of Corumana Dam (raising of the FSL to 117 m.a.sl) and the Moamba Dam. Both these studies conducted system analysis to assess yield and thus the financial viability of the dam development projects. The basic input data for the feasibility study was taken from the JIBS.

4.2.3 3-Basin Study

The 3-basin study was the first joint study on all three river basins. System analysis was made to assess different possibilities of augmenting water supply for the City of Maputo from the Incomati or the Maputo rivers. The study, however, was limited since it did not consider water demand and infrastructural development in Swaziland or South Africa. Hydrology was updated to 1999.

4.2.4 Joint Umbeluzi River Basin Study

The JURBS was the second comprehensive transboundary study of the three rivers. The purpose of the JURBS study was to produce the basis for a bi-lateral water-sharing agreement between Swaziland and South Africa. As part of the assessment, system analysis was conducted for the whole of Umbeluzi River basin including the City of Maputo.

4.2.5 Joint Maputo River Basin Study (JMRBS)

The JMRBS study constituted a comprehensive assessment of the water resources of the Maputo River for the purpose of integrated water resources management. This included updating of the hydrology with the latest land use data through the use of the WRSM2000 model, calculating yields using the WRYM for a number of different scenarios and also calculating water balances.

The water demands of the different water users in the basin were estimated for the current day (2005 level) and projected until the year 2030. Safe yields were calculated for all the major dams in the basin, and 1 in 5 year yields for each catchment. These catchment yields include the existing water use in each catchment as well as the additional yield available from the unused water at the outlet of each catchment. The yield per catchment was determined with, and without, Ecological Water Requirement (EWR) releases.

The JMRBS also assessed potential water resources developments such as irrigation schemes proposed in the IIMA. A total of 13 potential water resources developments were assessed using the WRYM.

4.2.6 Inkomati WAAS (Water Availability and Assessment Study)

The main objective of the yield analyses undertaken for the Inkomati WAAS was to assess the yield of the systems based on scenarios developed for the purpose of assessing a variety of situations. A number of scenarios were analysed over the course of the yield analysis process and the most important scenarios selected for inclusion. These scenarios are described below and address the following aspects:

- The impact of catchment developments at the 2004-development level which includes stream flow reduction (SFR) due to afforestation and alien invasive plants (AIP), irrigation, major and minor storage dams and interbasin water transfers;
- The impact of various water rights and allocations made to water users. Various allocations were reviewed and the largest allocation accepted. This scenario included SFR due to afforestation and alien invasive plants;
- The implementation of the ecological reserve and the impact of the associated ecological water requirements (EWR) on the available water resources in the system

5 WATER BALANCE ANALYSIS FOR MAPUTO CITY WATER SUPPLY

5.1 Specific objectives

The specific objectives with the water balance analysis is to

- estimate the yields from the existing infrastructure and future potential infrastructural developments in Mozambique that could serve the City of Maputo; and
- calculate water balances for the Greater Maputo Area for different scenarios

5.1.1 Potential water resource infrastructure developments

Potential infrastructure developments, identified and investigated as part of previous studies, and included in the analyses for this study are:

- Completion of Corumana Dam (raising the full supply level with gates);
- Construction of Moamba Dam;
- Construction of Movene Dam;
- Water supply from the Maputo River (run-of-river); and
- Water supply from groundwater recharged with water abstracted from the Incomati River (run-of-river).

5.2 Chosen approach

The water resources yield model (WRYM) discussed in chapter 2.3 was used to determine water availability from the various surface water resources. Existing WRYM configurations available from the studies described in chapter 4.2 were utilised and adapted for this study:

- The existing WRYM setup from the JURBS was used to assess the historic safe yield at Pequenos Libombos and a possible dam at Movene for the years 2007, 2010, 2020 and 2030 with upstream developments and demands updated accordingly.
- The WRYM setups from the Inkomati WAAS were used to determine the yields from the existing and raised Corumana Dam as well as for a possible dam at Moamba Major. Again the upstream water demands were updated to determine the yields with different levels of upstream development. A run of river yield was also determined on the Inkomati river to provide some information on the availability of water for groundwater recharge.

- Run-of-river yields were determined at specific points on the Maputo River utilising the existing WRYM setups from the JMRBS, again for the 2007, 2010, 2020 and 2030 upstream development levels.

The groundwater availability for supply to the Greater Maputo Area has been accepted as 10 million m^3/a (Water Availability Report, 2009). This information, together with the water requirements to be supplied from Pequenos Libombos to the Greater Maputo Area was used to determine the water balances for the years 2007, 2010, 2020 and 2030, both for high and low scenarios of water demands in the Greater Maputo Area.

5.3 Input data

5.3.1 Natural flow series

The natural flow series, determined as part of previous studies, were adopted for this study. The natural flow series determined in the JMRBS, the Inkomati WAAS and the Joint Umbeluzi River Basin Study were used for the Maputo, Inkomati and Umbeluzi Rivers respectively. The hydrology determined in these studies is assumed to be the most recent and up to date information available. More information on the natural MAR's for the three rivers utilised in this study are available in Water Availability Report (2009).

5.3.2 Current and projected water demands

The existing and projected future water demands, determined as part of previous studies, were also adopted for this study. The existing and future project water demands utilised in the water yield and water balance assessments are presented in the separate report for this study (Water Demand Report, 2009).

5.3.3 Environmental water requirements

The environmental water requirements (EWR) used in the latest available studies (JURBS, JRMBS and IWAAS) were also included in this study.

5.4 Scenarios

To meet the specific objectives of the analysis, given in Paragraph 5.1 above, the following scenarios were considered:

1) Historic safe yields from Pequenos Libombos Dam and water balances for the Greater Maputo Area:

Scenario	Assumption	Years	Description
1A	• Pequenos Libombos Dam is the only source of water. • Projected water demand development in Swaziland and Mozambique	2007 2010 2020 2030	No change from present day infrastructure. Only the water demands growth from the 2007-scenario to the 2030-scenario. This

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	• Existing (2007) infrastructure development in Swaziland • No environmental flow provided.		scenario gives a projection of future deficits if existing situation prevails
1B	• Pequenos Libombos the only source • Projected WD development in Swaziland and Mozambique • Future infrastructure development in Swaziland • No environmental flow	2007 2010 2020 2030	Gives a projection of future deficits if infrastructural development in Swaziland occurs to augment local water demand
1C	• Pequenos Libombos the only source • Projected WD development in Swaziland and Mozambique • Future infrastructure development in Swaziland • Environmental flow requirements in Swaziland only.	2007 2010 2020 2030	Gives the effects of implementation of environmental flow requirements
1D	• Pequenos Libombos the only source • Projected WD development in Swaziland and Mozambique • Future infrastructure development in Swaziland • Environmental flow requirements in Swaziland plus estuarine flow requirement in Mozambique (0.5 m^3/s)	2007 2010 2020 2030	Gives the effects of implementation of estuarine flow requirements

2) Safe yields for future surface water development projects

Scenario	**Assumption**	**Years**	**Description**
2A: Corumana	• Existing FSL of Corumana • EWR in South Africa enforced • Projected WD development in South Africa • Existing infrastructure in SA	2007 2010 2020 2030	Gives the yield of the existing dam with EWR releases for the Kruger National Park
2B: Corumana	• Existing FSL of Corumana • No EWR • Projected WD development in South Africa • Existing infrastructure in SA	2007 2010 2020 2030	Gives the yield of the existing dam with not EWR releases for the Kruger National Park
2C: Corumana	• Completed Corumana dam • EWR in South Africa enforced	2007 2010	Gives the yield of the completed dams with EWR

Scenario	Assumption	Years	Description
	• Projected WD development in South Africa • Existing infrastructure in SA	2020 2030	released for the Kruger National Park
2D: Corumana	• Completed Corumana dam • No EWR • Projected WD development in South Africa • Existing infrastructure in SA	2007 2010 2020 2030	Gives the effect of the dams in South Africa is used for other demands than environmental releases.
2E: Corumana	• Completed Corumana dam • EWR in South Africa enforced • Water demands in South Africa maximised according to IIMA • Existing infrastructure in SA	2007 2010 2020 2030	Gives the effect if South Africa utilises the IIMA to the limit in the future.
2F: Moamba	• FSL = 112 m • No EWR • Projected WD development in South Africa and Swaziland • Existing infrastructure in SA	2007 2010 2020 2030	Gives the yield for Moamba for the dam size proposed by Norconsult without environmental flows
2G: Moamba	• FSL = 112 m • EWR in South Africa enforced • Projected WD development in South Africa and Swaziland • Existing infrastructure in SA	2007 2010 2020 2030	Gives the yield for Moamba for the dam size proposed by Norconsult with enforced environmental flows.
2H: Moamba	• FSL = 112 m • No EWR • WD development in Crocodile maximised acc. to IIMA • Existing infrastructure in SA	2007 2010 2020 2030	Gives the yield for Moamba with the now too high use in Crocodile reduced to allowed volumes according to IIMA.
2I: Moamba	• FSL = 112 m • No EWR • WD development in Crocodile and Komati maximised IIMA • Existing infrastructure in SA	2007 2010 2020 2030	Gives the effect if South Africa and Swaziland utilises the IIMA to the limit in the future.
2J: Movene	• FSL: 80, 82 and 84 m • No EWR	2007 2010 2020 2030	Gives the yield of Movene with different FSLs
2K: Catuane	• Run-of-the river intake • No EWR • Projected WD development in Swaziland and South Africa • Existing infrastructure in SA and	2007 2010 2020 2030	Gives the yield of an intake in Catuane in Maputo without environmental flow and without any infrastructural development

Scenario	Assumption	Years	Description
	Swaziland		in Swaziland and South Africa
2L: Catuane	• Run-of-the river intake • EWR enforced • Projected WD development in Swaziland and South Africa • Existing infrastructure in SA and Swaziland	2007 2010 2020 2030	Gives the yield of an intake in Catuane in Maputo with enforced environmental flow and without any infrastructural development in Swaziland and South Africa
2M: Catuane	• Run-of-the river intake • EWR enforced • Projected WD development in Swaziland and South Africa • Developed infrastructure in SA	2007 2010 2020 2030	Gives the yield of an intake in Catuane in Maputo with enforced environmental flow and with infrastructural development in Swaziland and South Africa
2N: Catuane	• Run-of-the river intake • EWR enforced • WD development in Usutu and Pongola maximised acc. to IIMA • Developed infrastructure in SA	2007 2010 2020 2030	Gives the effect if South Africa and Swaziland utilises the IIMA to the limit in the future.
2P: Artificial recharge Incomati	• Run-of-the river intake in Incomati • EWR enforced • Projected WD development in Swaziland, South Africa and Mozambique • Existing infrastructure in SA and Swaziland	2007 2010 2020 2030	Gives the run-of the river yield for Incomati as a source for artificial recharge for groundwater north of Maputo.

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5.5 Results

5.5.1 Historic safe yields from Pequenos Libombos Dam

The historic safe yields from Pequenos Libombos Dam for the different scenarios are shown in Table 5.1.

Table 5.1 Historic safe yields from Pequenos Libombos Dam

Scenario	2007	2010	2020	2030
1A	88.3	82.0	68.9	63.9
1B	84.8	78.1	53.5	52.0
1C	90.0	83.8	59.0	57.0
1D	74.2	68.0	43.2	41.2

5.5.2 Water balances at Pequenos Libombos Dam

The water balances at Pequenos Libombos Dam for the high water demands for the Greater Maputo Area for the different scenarios are shown in Table 5.2.

Table 5.2 Water balances at Pequenos Libombos Dam for high water demands scenario

Scenario	2007	2010	2020	2030
1A	-3.4	-22.2	-76.4	-130.6
1B	-6.9	-26.1	-91.8	-142.5
1C	-1.7	-20.5	-86.3	-137.5
1D	-17.5	-36.2	-102.1	-153.3

The water balances at Pequenos Libombos Dam for the low water demands for the Greater Maputo Area for the different scenarios are shown in Table 5.3.

Table 5.3 Water balances at Pequenos Libombos Dam for low water demands scenario

Scenario	2007	2010	2020	2030
1A	3.3	-13.6	-61.7	-103.8
1B	-0.2	-17.5	-77.1	-115.7
1C	5.0	-11.8	-71.6	-110.7
1C	-10.8	-27.6	-87.4	-126.5

The water balances at Pequenos Libombos Dam for Scenario 1A for the Greater Maputo Area are reflected in Figure 5.1. For Scenario 1A the water availability and water demands for 2007 are more or less in balance. In 2030 the water demands exceed the water availability by between 104 million m^3 (low scenario) and 131 million m^3 (high scenario).

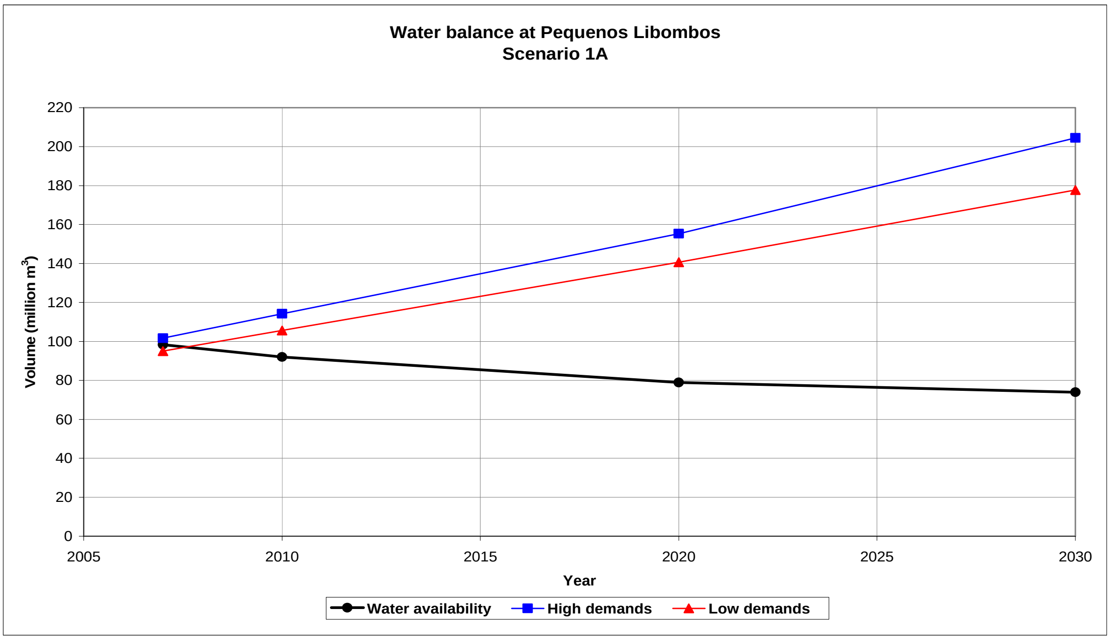

Figure 5.1 Water balance at Pequenos Libombos Dam for Scenario 1A

The scenarios reflecting infrastructural development in Swaziland and environmental flow requirements do not significantly change the pattern. In the worst case the water deficit for Maputo in 2030 is 127 million m^3/year (low scenario) and 153 million m^3 (high scenario).

The inclusion of dams in Swaziland means that more water will be used for upstream users during a dry period, which means less water flow cross the border. The total yield of the catchment will decrease because of the increased storage but since the dams are not operated jointly, the effect for the downstream Pequenos Libombos is a decrease in the safe yield.

The inclusion of environmental flows in Swaziland will augment the water supply source for Greater Maputo but the estuarine flow requirements will give an even larger negative impact, resulting in a lower safe yield for the Greater Maputo.

5.5.3 Historic safe yields from Corumana Dam

The historic safe yields from Corumana Dam for the different scenarios are shown in Table 5.4, and Figures 5.2 and Figure 5.3.

Table 5.2 Historic safe yields from Corumana Dam.

Scenario	**2007**	**2010**	**2020**	**2030**
2A	254	254	253	253
2B	237	235	232	230
2C	274	273	272	271
2D	256	254	251	250
2E	271			

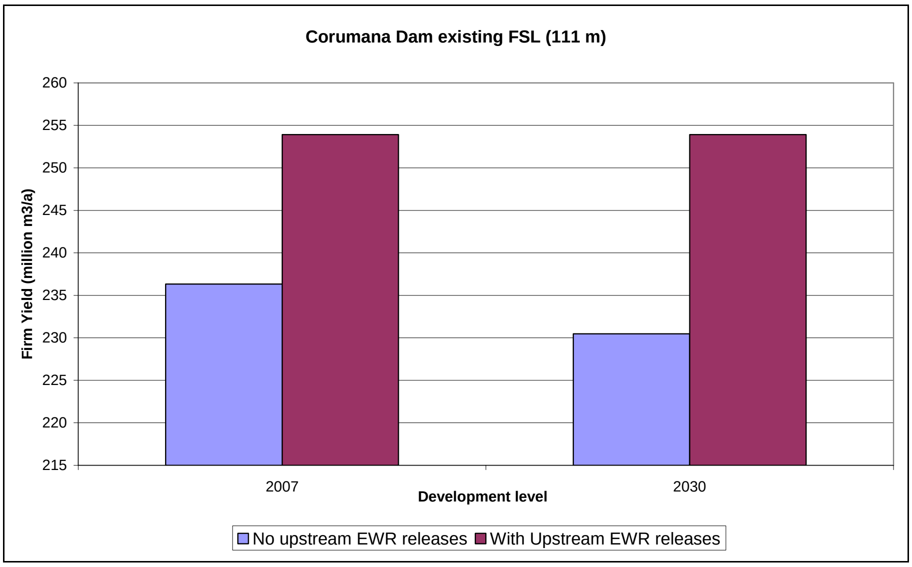

Figure 5.2 Corumana Dam historic safe yields for various development scenarios.

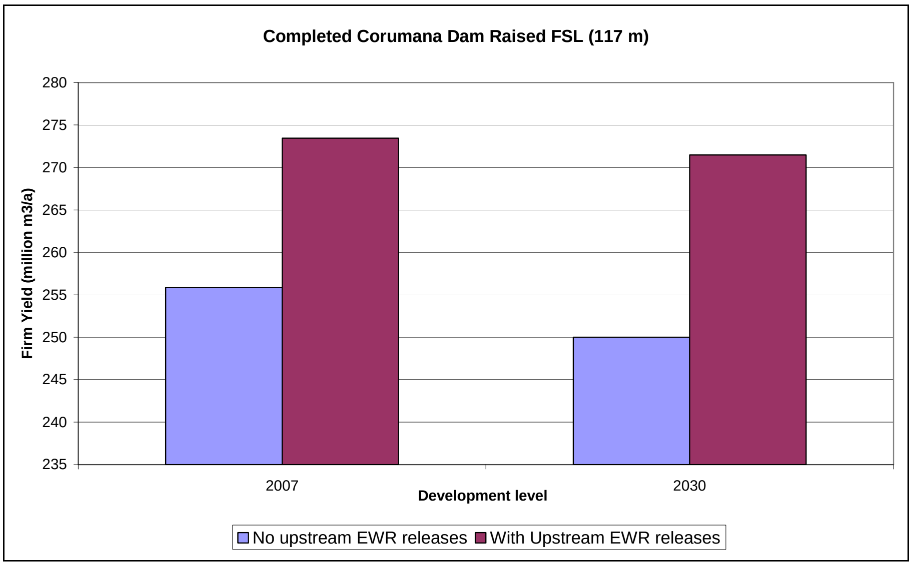

Figure 5.3 Completed Corumana Dam historic safe yields for various development scenarios.

The additional historic safe yield that results from the completion of Corumana Dam with the raised FSL is approximately 20 million m^3/a of water.

5.5.4 Historic safe yields from Moamba Major Dam

The historic safe yields from Moamba Major Dam for the different scenarios are shown in Table 5.5, and Figure 5.4

Table 5.5 Historic safe yields from Moamba Major Dam

Scenario	2007	2010	2020	2030
2F	150	142	135	133
2G	383	382	381	380
2H	385	383	382	381
2I	383			

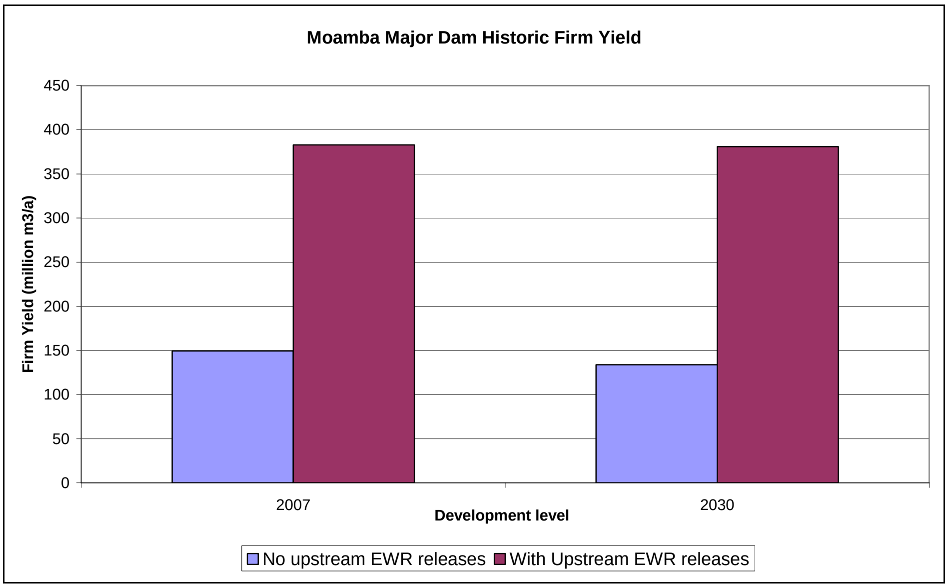

Figure 5.4 Historic safe yield of the potential Moamba Major Dam for various development scenarios

5.5.5 Historic safe yields from Movene Dam

The historic safe yields from Movene Dam (scenario 2J) for the different upstream development levels are shown in Table 5.6. The yields from Movene Dam were determined with no releases for environmental water requirements (EWR) to be supplied from the dam. The yields are the same for the different years due to no foreseen changes in land-use upstream of the dam.

Table 5.6 Historic safe yields from Movene Dam (Scenario 2J).

Full supply level (m)	**2007**	**2010**	**2020**	**2030**
80.0	3.37	3.37	3.37	3.37
82.0	4.19	4.19	4.19	4.19
84.0	5.13	5.13	5.13	5.13

5.5.6 Run-of-river yields from the Maputo River

The run-of-river yields of the Maputo River were determined by analysing the minimum flows in the Maputo River upstream of the estuary for different scenarios.

The results for the selected scenarios for 2007 and 2030 are shown in Table 5.7. Scenario 2N is not linked to a specific period as it shows the effect of the maximum allowed development, according to IIMA. The water demand growth and water infrastructure development in the catchment for the scenarios are summarised in Appendix B.

The minimum annual flow (run-of-river yield) in million m^3 in the Maputo River upstream of the estuary and the minimum monthly flow in brackets are given in Table 5.7. These yields do not allow for the estuary environmental requirements.

Table 5.7 Run-of-river yields (including flow to estuary) from the Maputo River (million m3/a). Minimum monthly flows are given in brackets.

Scenario	**2007**	**2030**
2K	735.9 (16.8)	565.5 (13.5)
2L	755.4 (20.3)	580.5 (13.5)
2M	820.0 (33.8)	663.2 (14.1)
2N	50.60 (7.2)	

The minimum annual Class C EWR for the Maputo Estuary, which has not been allowed for in these yields, is 390 million m^3 and the minimum monthly EWR is 15.3 million m^3.

Scenario 2K is the present day scenario without EWR releases. Scenario 2L shows the present day development with upstream EWR releases in South Africa and Swaziland. It is shown that the increase in the minimum annual flow, as a result of upstream EWR releases is less than 3%.

Scenario 2M shows an increase in the minimum flow in the Maputo River of approximately 9% if some proposed new dams in the upstream catchment are implemented. This is a result of water stored in the new dams being released for the EWR during dry periods, and increasing the minimum flow in the Maputo River.

The flow frequency duration curves (FDCs) for the four scenarios comparing the 2007 and 2030-level development level for Scenarios 2K, 2L and 2M, are given in Appendix A. The FDC for the scenario 2N shows the available flow before the Maputo Estuary if the maximum allowable development according to the IIMA is practised. The FDC for the Estuary Class C EWR has also been included in Appendix A.

5.5.7 Run-of-river yields from the Incomati River

The run-of-river yields from the Incomati River for the different upstream development levels are shown in Table 5.8. This yield is calculated just below the junction of the Sabie, and Crocodile and Komati rivers. No provisions were made for EWR's at the estuary. Moamba major Dam is not included in this scenario. Again, the yields in Table 5.8 are for the driest year in the record period, and the value in brackets is for the driest month.

Table 5.8 Run-of-river yields from the Incomati River Minimum monthly flows are given in brackets.

Scenario	2007	2010	2020	2030
2P	205.7 (9.13)	205.6 (9.13)	205.5 (9.12)	205.5 (9.12)

Growth in the downstream water requirements from the abstraction point on the Inkomati after the confluence with the Sabie River have been assumed to be supplied from the yield from Corumana Dam. The run of river yield could thus be available for the purpose of the abstraction was for groundwater recharge, and release to satisfy the downstream environmental water requirements. The capacity of the aquifer is in the region of 30 million m^3/a. The run of river yield appears to be sufficient to recharge the aquifer, although a more detail analysis with allocations of available water to downstream water demand growth for future scenarios would be valuable.

6 ASSURANCE OF SUPPLY TO GREATER MAPUTO AREA

The assurance of supply to the water users in the Greater Maputo Area was determined with the WRYM. The water requirements for the urban and industrial users were combined and the assurance of supply was calculated as:

$$\frac{\textbf{Number of months with 100\% supply}}{\textbf{Number of months (900)}} \; \mathbf{* \, 100}$$

The assurance of supply was determined for Scenarios 1A, 1B and 1D discussed earlier in this report.

6.1.1 Assurance of supply for Greater Maputo Area high demands scenario

The assurance of supply for the Greater Maputo Area for the high water demands for the different scenarios are summarised in Table 6.1.

Table 6.1 Assurance of supply for the Greater Maputo Area for the high water demands scenario

Scenario	**2007**	**2010**	**2020**	**2030**
1A	100	98	81	65
1B	100	97	77	61
1D	98	97	76	61

The average annual percentage of demand supplied for the Greater Maputo Area for the high water demands for the different scenarios are summarised in Table 6.2.

Table 6.2 Average annual % of demand supplied to the Greater Maputo Area for the high water demands scenario

Scenario	**2007**	**2010**	**2020**	**2030**
1A	100	99	84	72
1B	100	98	82	68
1D	99	98	80	68

6.1.2 Assurance of supply for Greater Maputo Area low demands scenario

The assurance of supply for the Greater Maputo Area for the low water demands for the different scenarios are summarised in the Table 6.3.

Table 6.3 Assurance of supply for the Greater Maputo Area for the low water demands scenario

Scenario	**2007**	**2010**	**2020**	**2030**
1A	100	99	85	71
1B	100	99	82	67
1D	99	99	79	67

The average annual percentage of demand supplied for the Greater Maputo Area for the low water demands for the different scenarios are summarised in Table 6.4.

Table 6.4 Average annual % of demand supplied to the Greater Maputo Area for the low water demands scenario

Scenario	**2007**	**2010**	**2020**	**2030**
1A	100	99	88	77
1B	100	99	86	73
1D	99	99	83	73

The results show that for the probable (low) and high scenarios assurance of supply is acceptable (>98%) up to approximately 2010, while in 2015 the risk of failure is too large.

7 DISCUSSION OF RESULTS

7.1 Normal contra drought conditions

The results expressed as safe yield gives the picture during the most severe drought that has occurred during the last 85 years, for which measurement of rainfall has been conducted in the study area. In a highly variable climate the design of first priority water use infrastructure needs to be designed based on the safe yield.

It is, however, important to note that the normal situation is much different. Average flow in Umbeluzi River at the Mozambican border is more than 200 million m^3/a even with the future development in Swaziland. In the normal situation the inflow is to Pequenos Libombos is therefore sufficient for supplying the Greater Maputo. This is also confirmed by the assurance of supply, which shows that even the high water demand scenario is supplied 61-65% of the time.

For urban water supply the reliability if a secure water source is, however, economically essential and therefore an assurance of supply of 98% is normally required.

7.2 Existing Pequenos Libombos Dam

The water demands for the City of Maputo and the yield from Pequenos Libombos Dam were more or less in balance in 2007. With the projected future water demands for the Greater Maputo Area shortages of between about 130 and 155 million m^3/a can be expected in 2030. Additional sources of water to supplement the existing supply from the Umbeluzi River to the Greater Maputo Area need to be implemented as a matter of urgency.

If no new water resources are developed to supplement water supply to the Greater Maputo Area, the assurance of supply in 2030 will only be between 67% and 71%, and only between 73% and 77% of the annual demand will be supplied for the low scenario of water demands.

If no new water resources are developed to supplement water supply to the Greater Maputo Area, the assurance of supply in 2030 will only be between 61% and 65%, and only between 68% and 72% of the annual demand will be supplied for the high scenario of water demands.

7.3 Possible future infrastructure and water resource developments

7.3.1 Corumana Dam

Corumana Dam currently supplies irrigation downstream of the dam, and generates hydropower. At the 2003 level, only a small fraction of the safe yield was being utilised for irrigation. The completion of Corumana could yield additional water that could be utilised for increasing irrigated agriculture, domestic water supply or a combination of both. A previous study utilising hydrology determined in the JIBS study, determined a safe yield of Corumana of 299.8 million m^3/a for the existing incomplete dam, and a safe yield of 321.9 million m^3/a if the dam were to be completed and the FSL raised to 117m (Lahmeyer International 2003). This is an increase in safe yield of approximately 22 million m^3/a.

The analyses of this study at the 2007 level determined the safe yield for to be between 254 and 237 million m^3/a for the not completed Corumana Dam, depending on whether upstream environmental water releases are made or not. The safe yield of the completed Corumana Dam was found to be between 274 and 256 million m^3/a, with and without upstream environmental water releases. If upstream environmental releases of water are made, the inflow into the dam is increased. Environmental releases will be predominantly a result of releases in South Africa intended for the Kruger National Park. It should, however be noted that the safe yields determined from Corumana Dam in this study do not include any releases from the dam for downstream environmental water requirements. A portion of this yield would most likely need to be assigned to the EWR downstream of the dam.

The safe yields determined in this study (2007) are appreciably lower than those previously found in 2002 (Lahmeyer International 2003); a reduction of between 45 and 62 million m^3/a for the dam without gates, and between 47 and 65 million m^3/a for the completed dam. The additional yield that is available as a result of raising the dam is however much the same; 22 million m^3/a in the previous study, and 20 million m^3/a in this study.

The reduction in safe yields can be attributed to the updated hydrology and water demands, whereby a mean annual inflow into the dam decreased from 555 million m^3/a from the previous analysis to between 426 to 438 million m^3/a in these analyses. The safe yield is governed by the critical period in the hydrology record. The previous study which utilised the hydrology from the JIBS included the period from 1920 to 1988. This study utilised a record period from 1925 to 1999 and included the dry period in the 1990's, which reduced the safe yield (Figure 7.1)

The yields do reduce further from the 2007 to the 2030 development level, but the reduction is small. The impact of upstream environmental water releases is much more significant than the increasing levels of water demand development up to 2030 on safe yield.

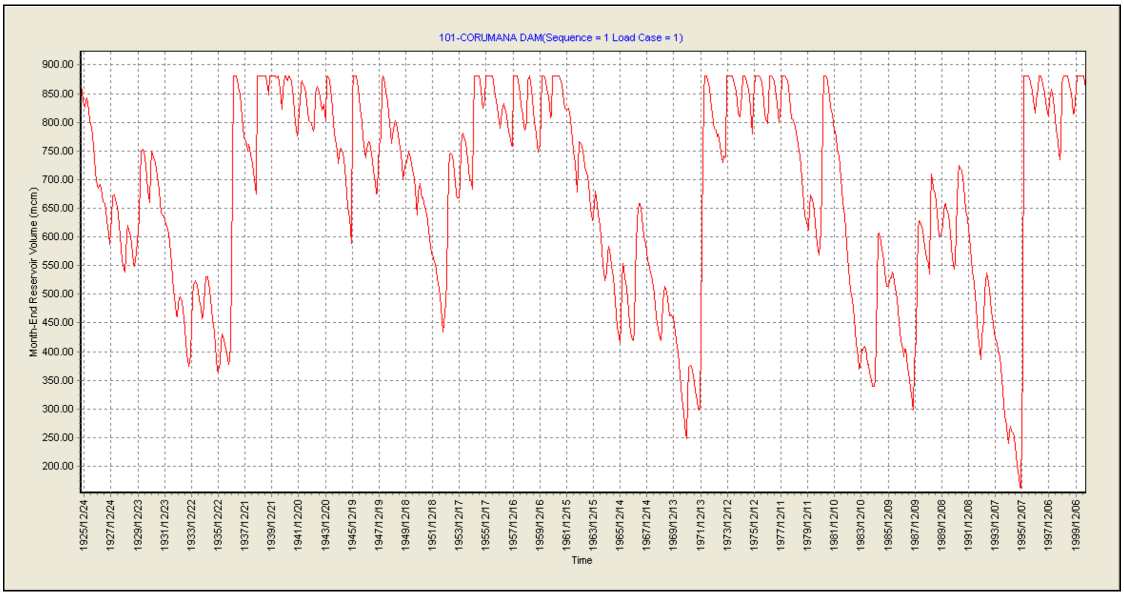

Figure 7.1 Graph of simulated water levels in Corumana showing that the inclusion of the 1990s natural inflow series decreases the safe yield.

As mentioned, the safe yield can be assigned to various water users downstream of Corumana Dam. The raising of Corumana Dam could yield an estimated additional 20 million m^3/a, which could be assigned to water supply to Maputo City. The yield currently available for the incomplete Corumana Dam is however not currently fully utilised by irrigated agriculture, for which its construction was intended, and some of this safe yield could also possibly be used for domestic water supply.

Table 7.2 presents the current and future water demands in the Incomati River that could be supplied water released from Corumana and possibly Moamba Major Dam to satisfy some if not all of the demand.

Table 7.2 Current and future water demands downstream of the existing Corumana Dam and the possible Moamba Major Dam.

	Water demand (million m^3/a)			
Incomati	2007	2010	2020	2030
Sabie below Corumana	4	4	67	109
Incomati below Moamba	2	2	2	2
Incomati below confluence of Sabie	211	211	211	211

7.3.2 Moamba Major Dam

The safe yield determined from the possible Moamba Major Dam is between 149 and 383 million m^3/a. The large range in yield is a result of environmental releases being included upstream in South Africa and Swaziland that increases the flow into the dam for the second scenario. If no environmental water releases are made, the inflow into the Moamba Major dam site is generally very low during the dry months. More detail in inflows into the dam sites can be found in the flow duration curves in Appendix A.

Again, these yields do not include water releases for downstream environmental water requirements in Mozambique.

Safe yields determined in this study are likely to be lower than those previously determined, again due to the updated water demands, and the hydrology with a longer record period including the critical period in the 1990's. The average inflow into Moamba Major for this study ranged from 861 to 986 million m^3/a, without and with upstream environmental water releases respectively. This is a reduction from hydrology of the JIBS where the average inflow was 1258 million m^3/a (Norconsult 2003).

The existing and projected future water demands below the possible Moamba Major Dam to the confluence with the Sabie River are small (Table 7.2). Growth in total water requirements below the Moamba and Corumana Dam sites is however appreciable, and the allocation of water to these demands from a combination of Corumana Dam, the possible Moamba Major Dam, ground water and river flows below the dams, has not been determined in this report. The allocation water to the growth in water demand from these various sources is important, as the potential surplus that could be transferred to augment the City of Maputo's growing demands will be affected.

7.3.3 Maputo run of river abstraction

The Maputo run of river yield was determined to assess the volume of water that could be abstracted from the Maputo River without the construction of a dam for water supply to Maputo City.

The JMRBS determined yields from the lower Maputo River near the outlets of the Maputo River. These yields are not directly comparable with this study as the JMRBS determined the 1:5 year yield, and this study only reports on historical yields.

The run of river yield determined in this study do not include environmental water requirements, and the volume of water that could be supplied to the City of Maputo will depend on the level of environmental water requirement chosen to be satisfied.

7.3.4 Incomati run of river abstraction for groundwater recharge

The run of river yield appears to be sufficient to recharge a groundwater aquifer of storage capacity of approximately 30 million m^3/a up until 2015 to 2020. More detail on the allocation of the available water to downstream water demands in particular the environmental requirements of the estuary are required.

7.4 Possible combination of sources

A combination of possible water resource developments to augment the existing water supply at Pequenos Libombos is need to offset the likely deficit of between 130 and 155 million m^3/a expected in 2030.

The likely timing of various new water resource developments is very important, and is dependant on the order in which new developments are implemented, as well as the implementation of remedial measures such as water demand management to improve water use efficiency.

What is also important is how increased irrigation is prioritised. If the assumed development of irrigation in the Sabie and Incomati Rivers, expressed by ARA-Sul, is given priority the Corumana and Moamba dams will not be sufficient for the all users more than until 2020 (Figure 7.2), which is probably just shortly after Moamba Major is possible to start operation. If irrigation is not allowed to grow any further from today's level the two dams will, however, secure water supply to Greater Maputo almost up to 2030 (Figure 7.3).

With the existing water rights for irrigation downstream of Pequenos Libombos and Corumana the completed Corumana Dam will only be sufficient to secure water to the Greater Maputo at the present situation. Already in 2010 the resource needs to be augmented by Moamba Major or another source is needed. Alternatively, the existing water allocation for irrigation must be decreased during dry conditions to allow for the first priority use.

Note that Figures 7.2 and 7.3 show one possible combination of development scenarios. The order in which the possible new water resource developments have been implemented has been randomly chosen. The various water resource developments could have been implemented in another order, such as utilising the groundwater with surface water recharge first, followed by the utilisation of Maputo river water and then the Moamba Dam. By changing the order, water resource planners can determine which developments could be implemented in a practical manner, and determine when the next development is necessary.

7.5 Compliance with IIMA and EWR

The assessment of water demand (Water Demand Report, 2009) indicated that the stated water allocation in IIMA had already been breached in the Crocodile River basin in South Africa. Even when comparing the future water demand in Swaziland and Mozambique for irrigation in Usutu and Incomati, respectively, the demand exceed the allocations in the IIMA. The system analysis (Scenario 2G and 2H), however, showed that decreasing the water demand for irrigation in Crocodile to IIMA levels gives only a small increase in safe yield of the Moamba Dam. The over-utilisation of irrigation in the Crocodile is thus not a major factor for the future water supply to the Greater Maputo, although is limit water usage in Mozambique.

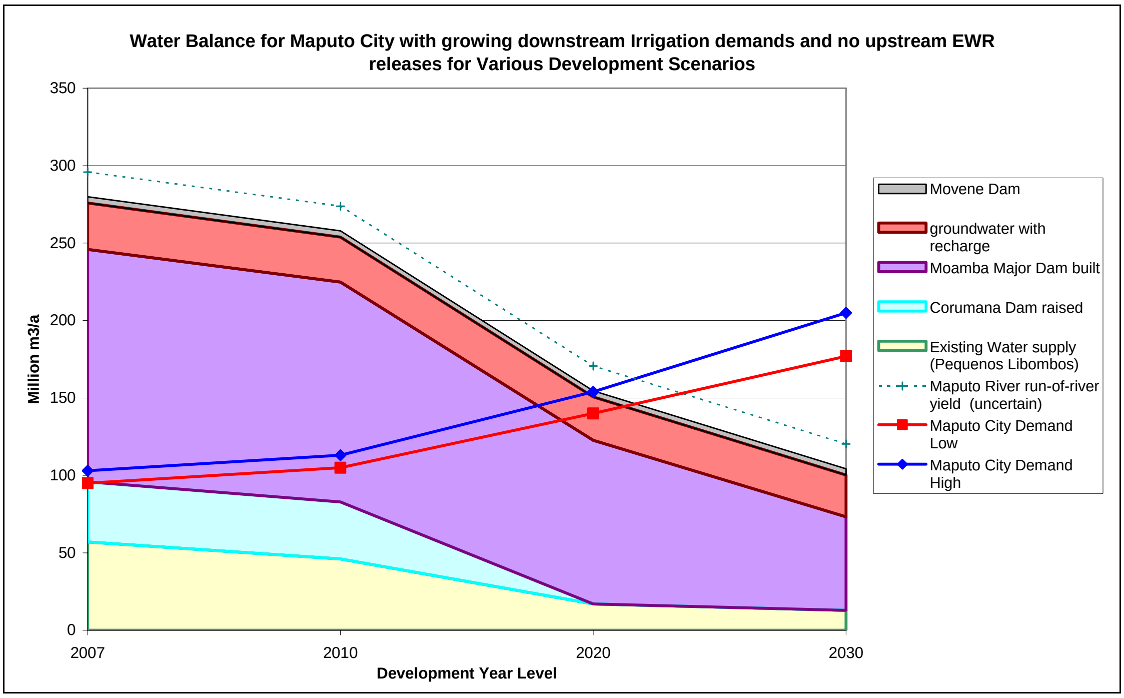

Figure 7.2 Cumulative water availability and water demand growth for Maputo city for possible new water sources if irrigation development in the Incomati and Sabie is giving priority.

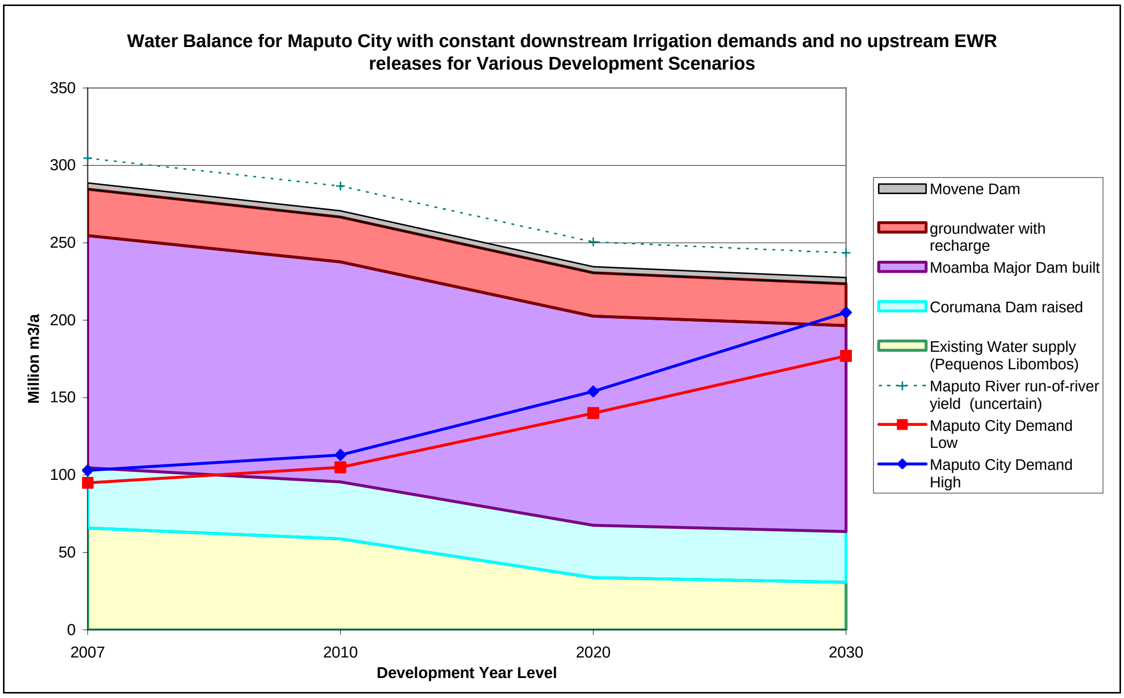

Figure 7.3 Cumulative water availability and water demand growth for Maputo city for possible new water sources if irrigation in the Incomati and Sabie is frozen at the current level.

A factor that effect the safe yield for Pequenos Libombos, Corumana and Moamba Major is the releases of minimum environmental flow stated in the IIMA. It should be noted that in the scenarios analysed in this report the ecological flow requirements at Ressano Garcia and Lower Sabie has not been taken into account if not EWR is assumed. This means that the border flows between South Africa and Mozambique is sometimes zero in the scenarios without EWR. Inclusion of the South African defined EWR, however, gives full compliance with the IIMA.

Similarly the 1976 agreement in the Umbeluzi River has not been taken into account in the system analysis for the Umbeluzi River basin. During the dry months the flow at the border between Swaziland and Mozambique is normally less than 40% of the flows at GS10 and GS3 on a monthly basis.

The reason for running scenarios where EWR is not complied within South Africa or cross border flows are complied in accordance to bi-lateral and tri-lateral agreements is that a control or enforcement system is not yet in place to guarantee this flow. For the future water supply strategy of the Greater Maputo it is therefore important to assess this worst case, while in parallel work to promote assurance of the agreed border flows.

8 CONCLUSIONS

The existing water available from the Pequenos Libombos Dam needs to be augmented with new sources of water as a water deficit is likely beyond 2007, with estimated shortages of between 130 to 150 million m^3/a in 2030.

The following possible future water resource developments were assessed:

- Completion of Corumana Dam;
- Construction of Moamba Dam;
- Construction of Movene Dam;
- Water supply from the Maputo River (run-of-river); and
- Water supply from groundwater recharged with water abstracted from the Incomati River (run-of-river).

The completion of Corumana Dam was estimated to increase the safe yield available by 20 million m^3/a, from between 230 and 250 million m^3/a to between 250 and 270 million m^3/a. The range of safe yields is a result of higher inflows into the dam should releases be made in South Africa and Swaziland for environmental water requirements. A significant portion of the safe yield of Corumana Dam (incomplete) is currently not being utilised for irrigated agriculture and a portion of this could be allocated along with the 20 million m^3/a should the dam be raised.

Moamba Major Dam can yield between 150 and 380 million m^3/a of water. Although growth in water demand for future development level is likely to reduce yields slightly, the impact of releases upstream for environmental water requirements has a significant impact on inflows to the dam and causes the large range in possible yield.

Movene dam provides little yield as a single development but is likely to be part of a phased development with Moamba Major, should the dam be constructed.

The quantity of water that could be supplied from the Maputo River as a run of river abstraction depends on the releases that should be made for the environmental requirements of the estuary. The lowest annual flow in the Maputo River near Catuane for the period analysed was approximately 750 million m^3/a in 2007 and 670 million m^3/a in 2030. More detail on the portion of the low flows that need to be assigned to the estuary's environmental water requirements is needed.

Water supply from groundwater recharged with surface water abstracted from the Inkomati River appears to be viable. Sufficient water may be available in the Inkomati to recharge the groundwater aquifer of approximately 30 million m^3/a if Corumana Dam can supply the water demands in the Inkomati river below the confluence with the Sabie River. The impact of Moamba Major Dam on this possible development has not been determined.

Analysis of different combinations of the possible water developments that may augment Maputo City's growing water demand will provide a better understanding of the impact of the order in which possible developments are implemented.

Remedial measures such as water demand management to improve water use efficiency should be included in further work as such measures are also likely to have an impact on the timing of future water resource developments to augment Maputo cities water supply.

9 REFERENCES

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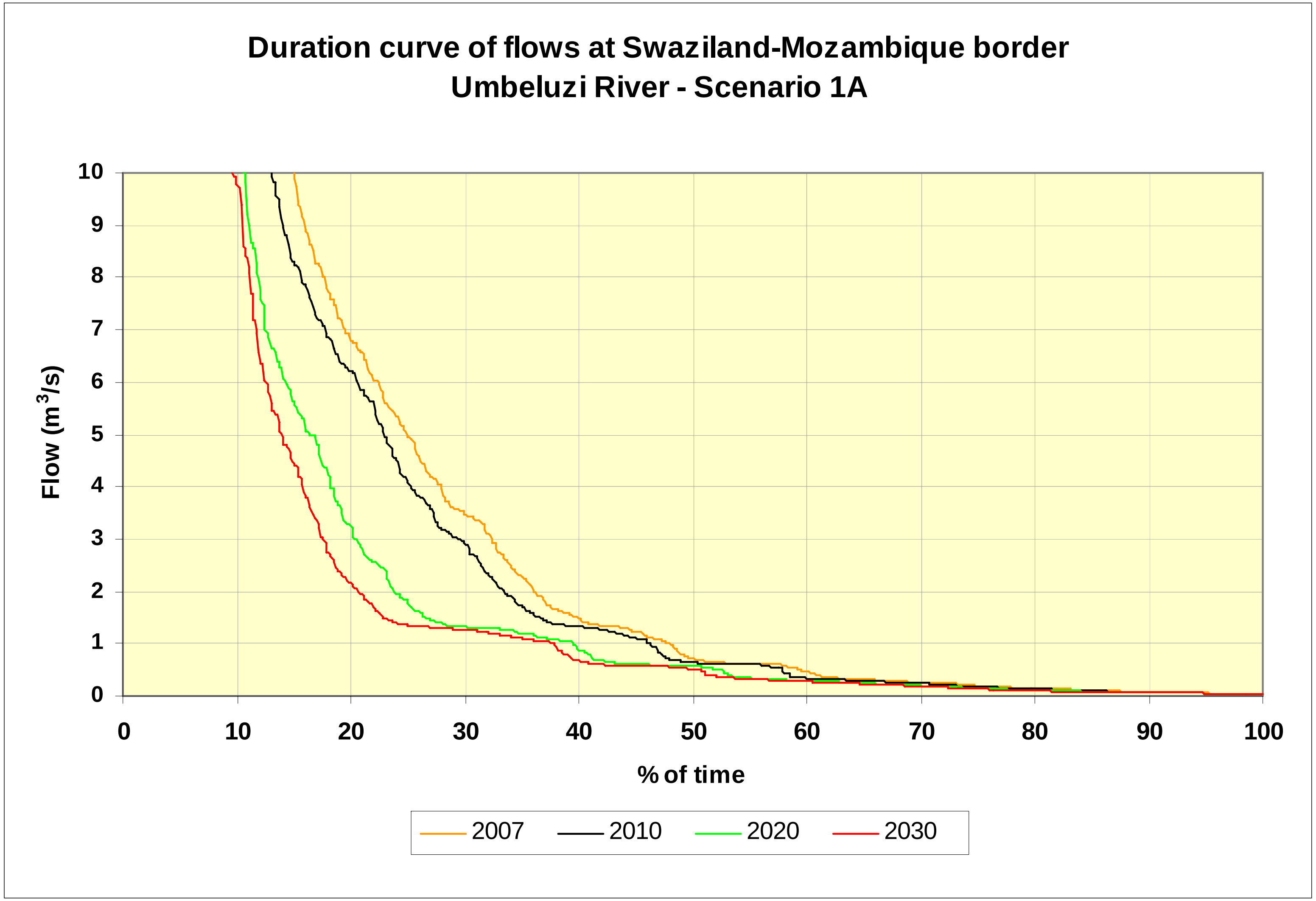
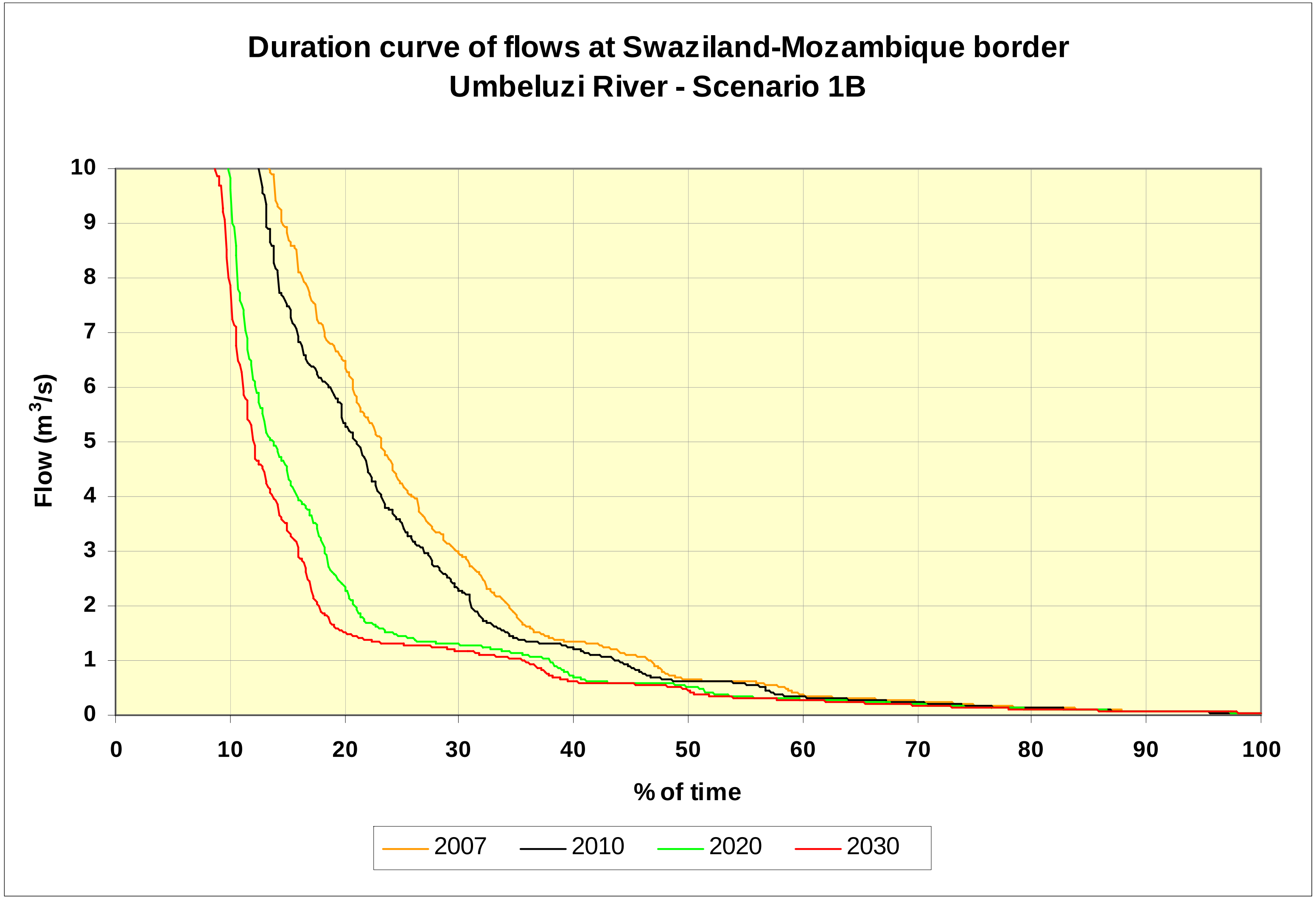
APPENDIX A

Duration curves for different scenarios

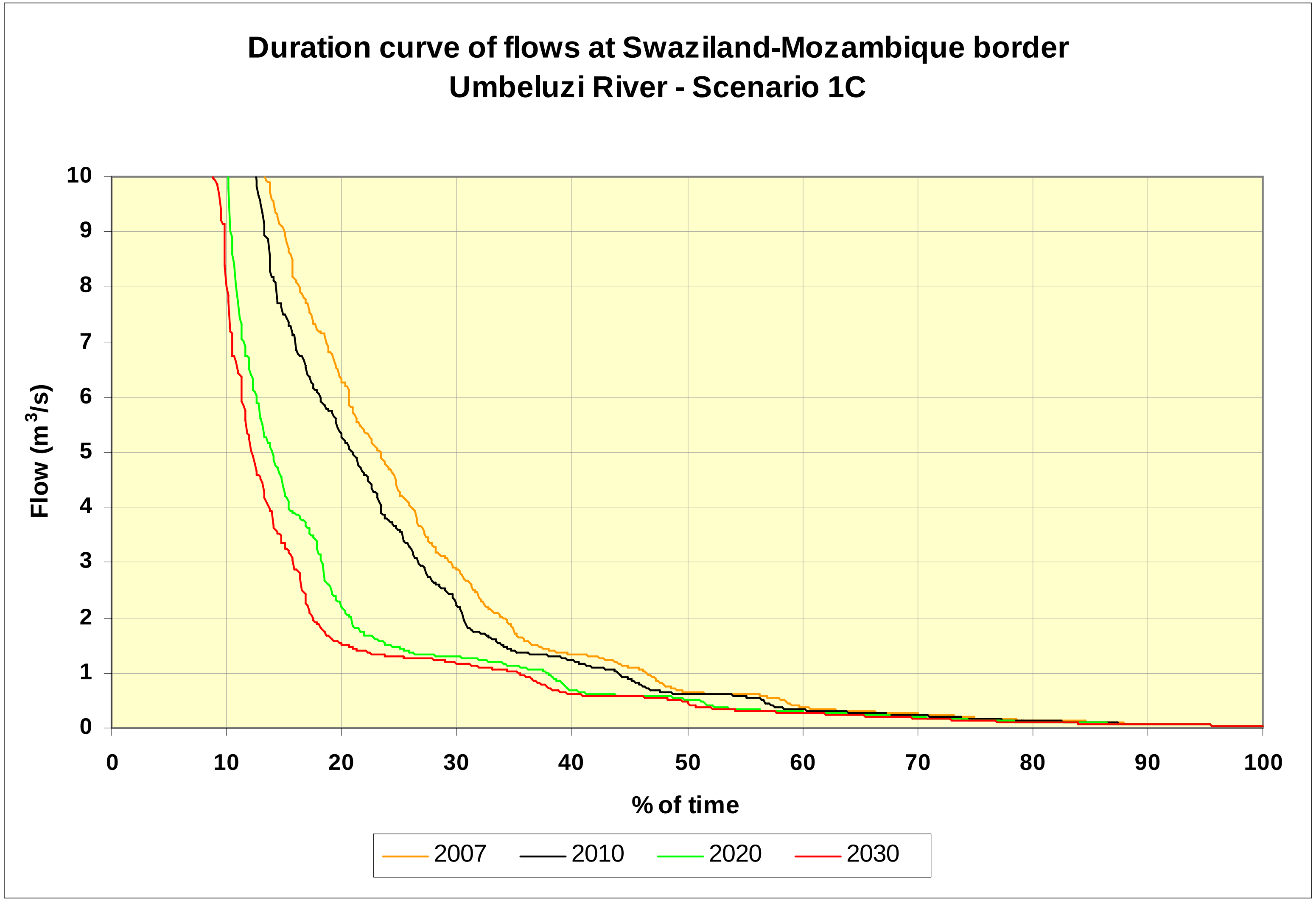
Scenario 1A - Duration curve of monthly flows at the Swaziland-Mozambique Border



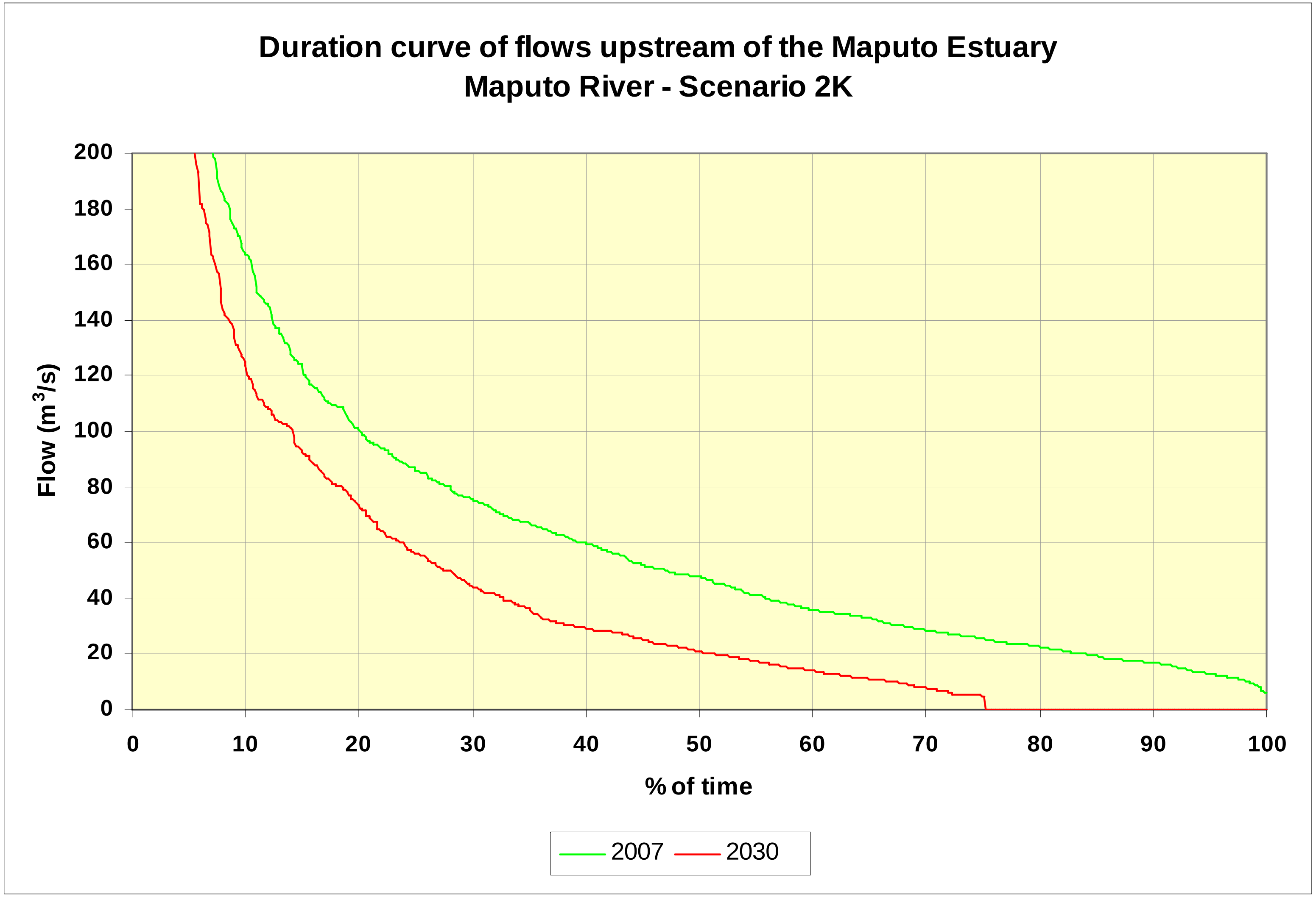
Scenario 1B - Duration curve of monthly flows at the Swaziland-Mozambique Border



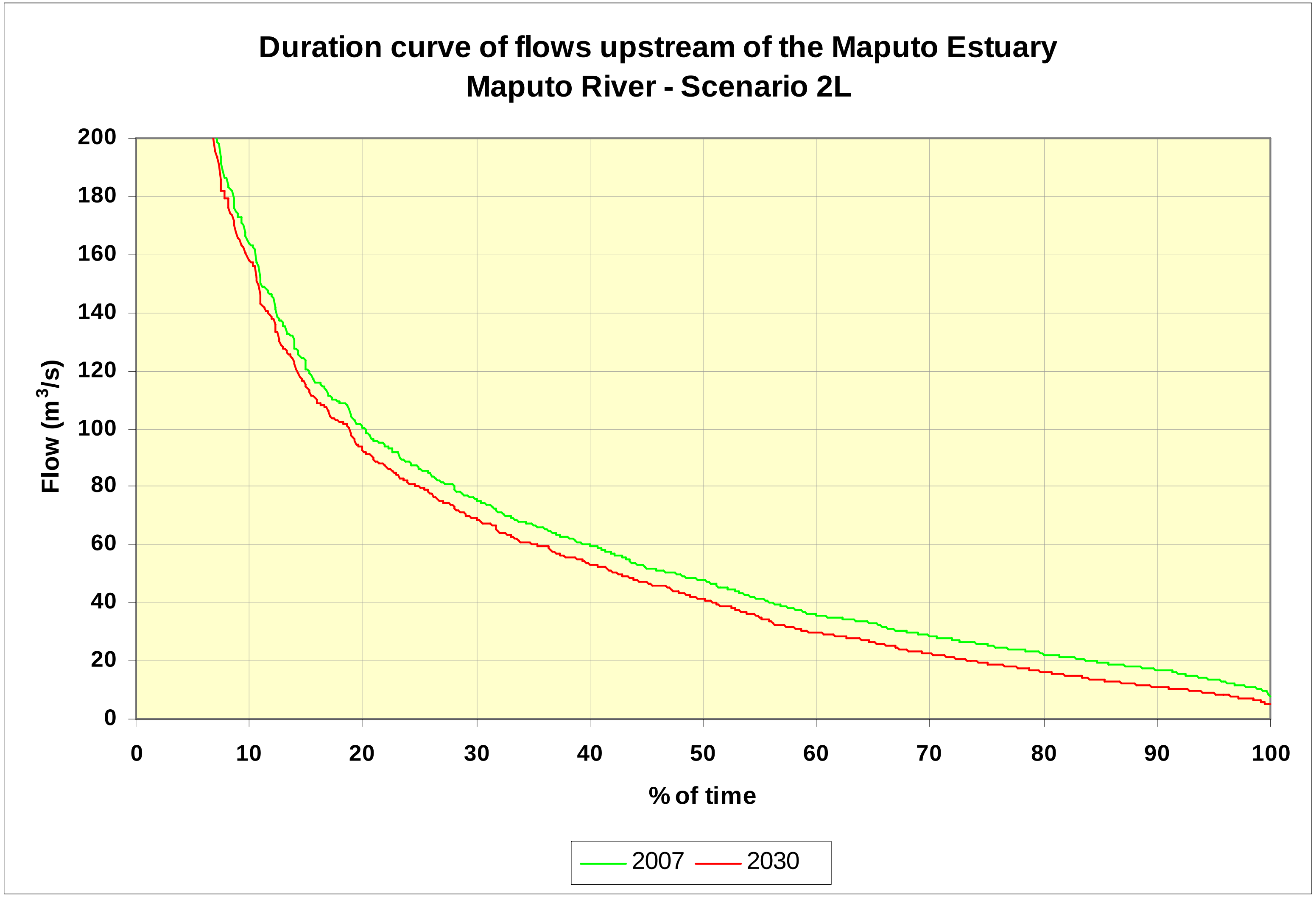
Scenario 1C - Duration curve of monthly flows at the Swaziland-Mozambique Border



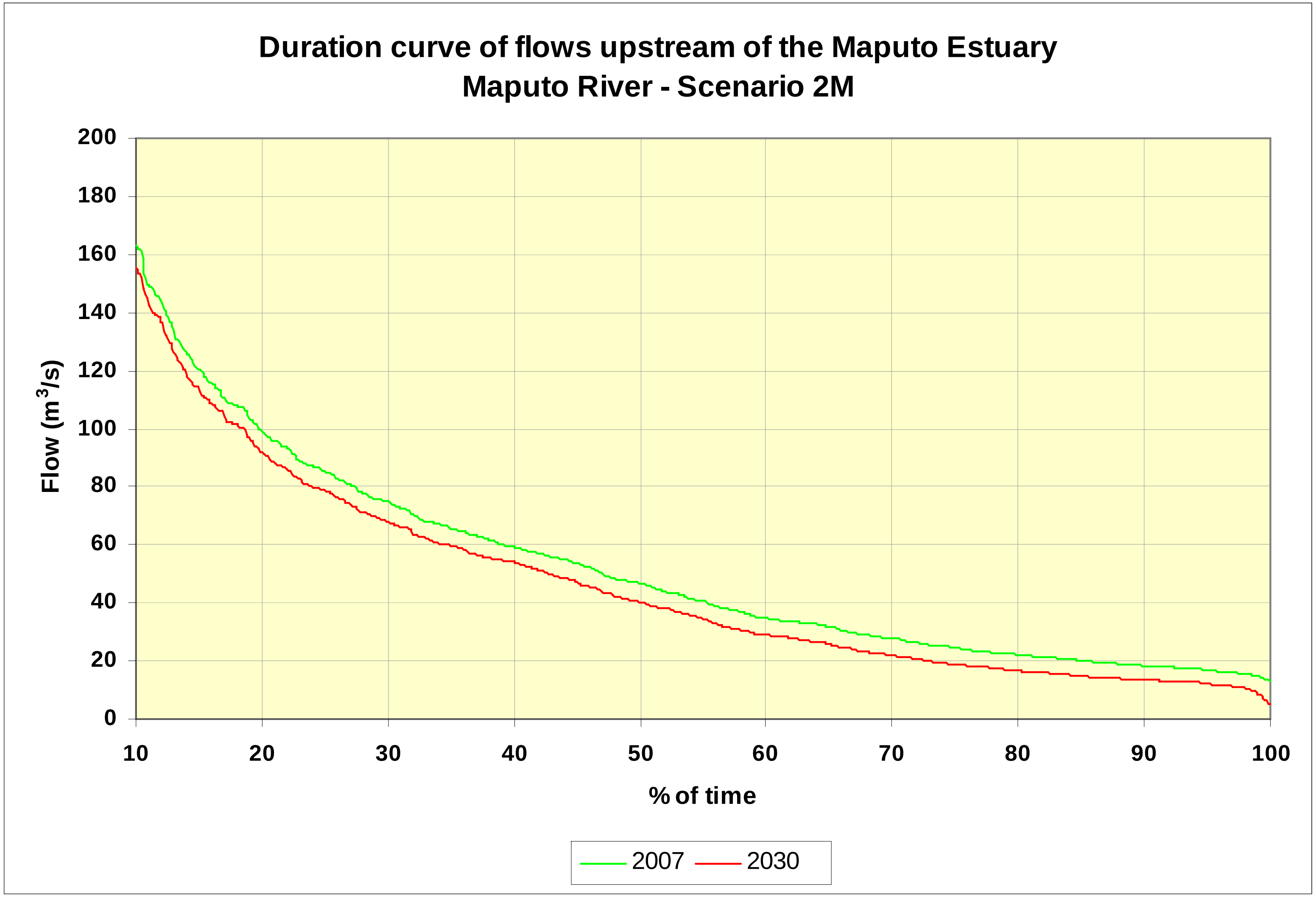
Scenario 2K - Duration curve of monthly flows upstream of the Maputo Estuary



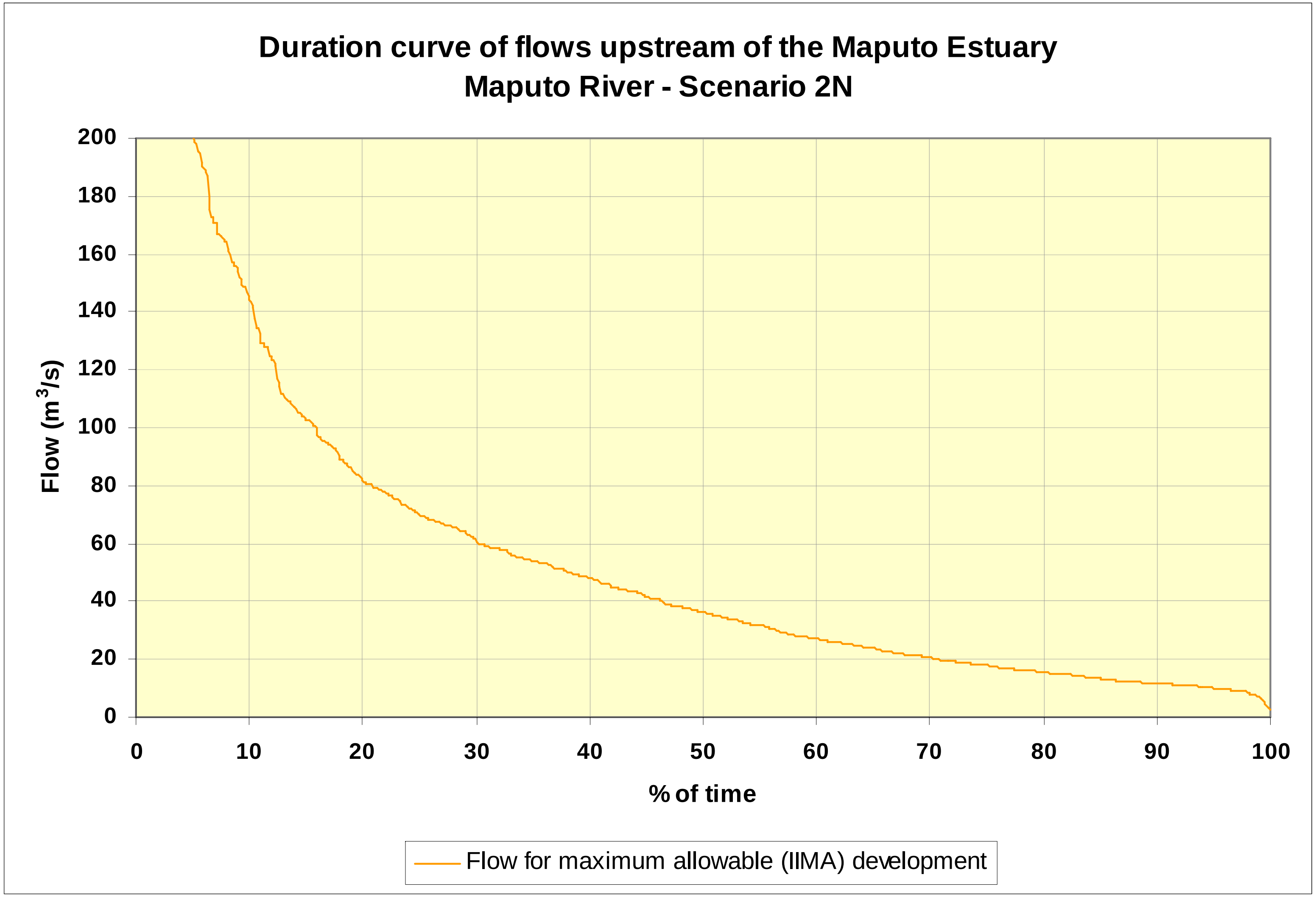
Scenario 2L - Duration curve of monthly flows upstream of the Maputo Estuary



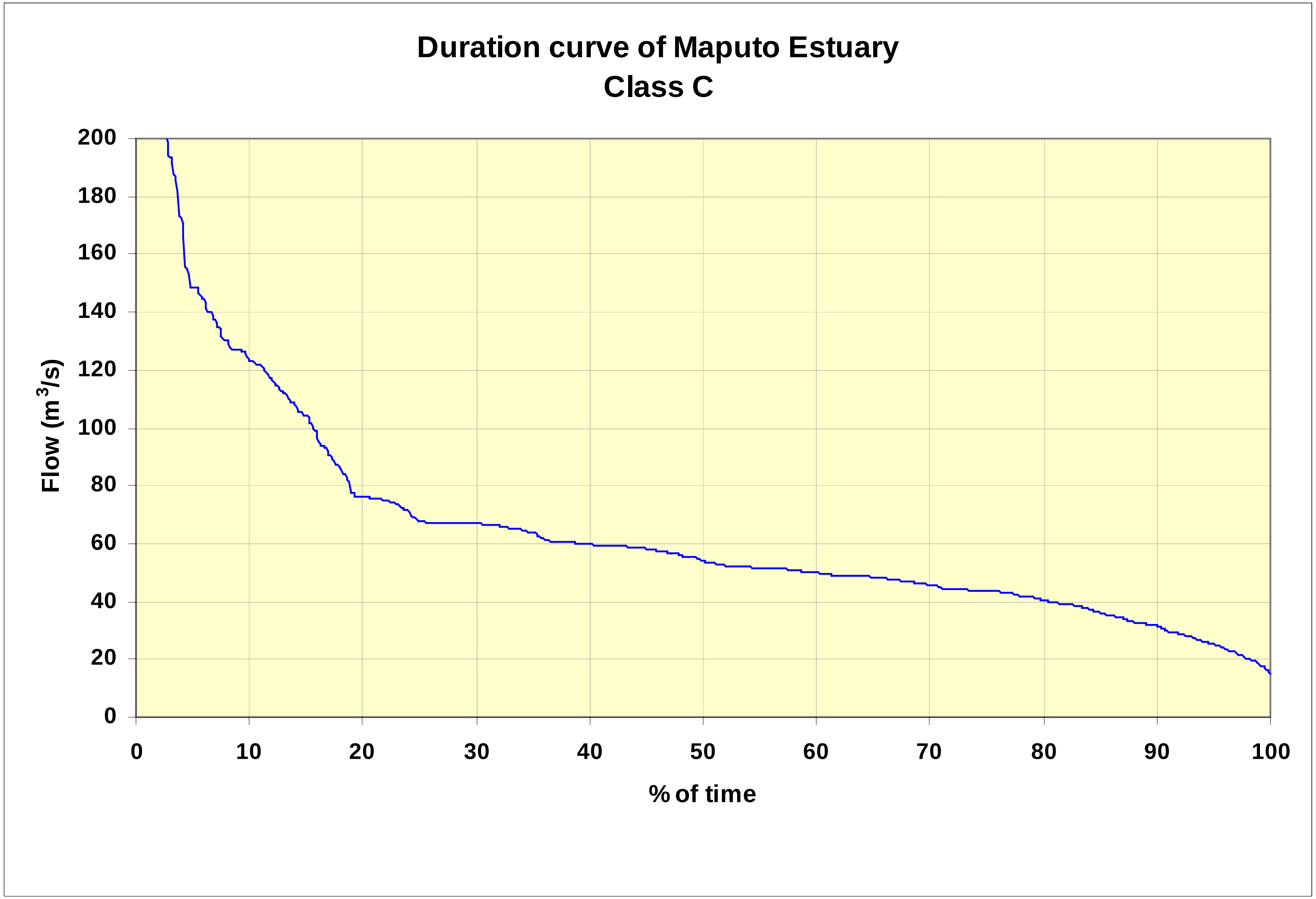
Scenario 2M - Duration curve of monthly flows upstream of the Maputo Estuary



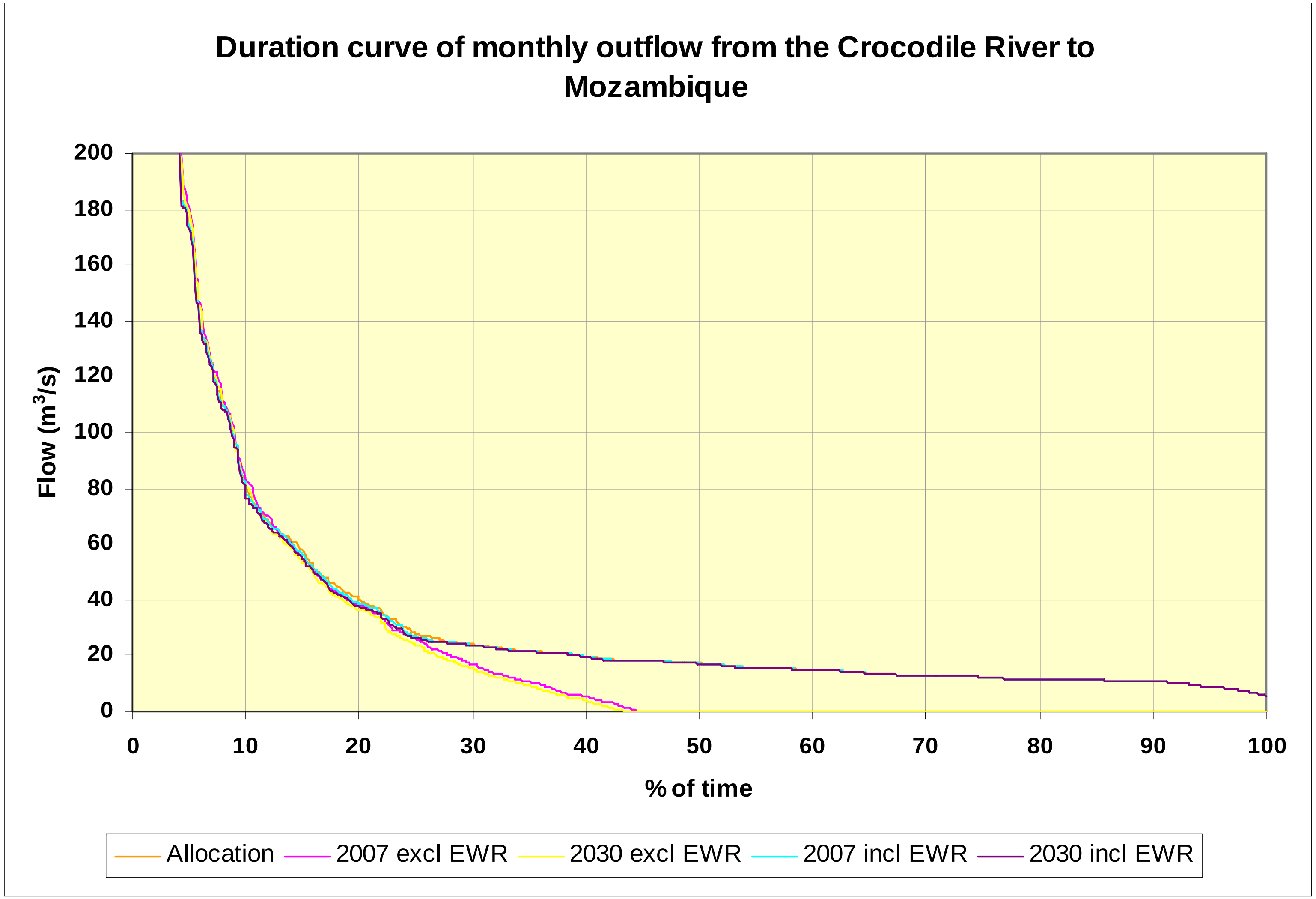
Scenario 2N - Duration curve of monthly flows upstream of the Maputo Estuary



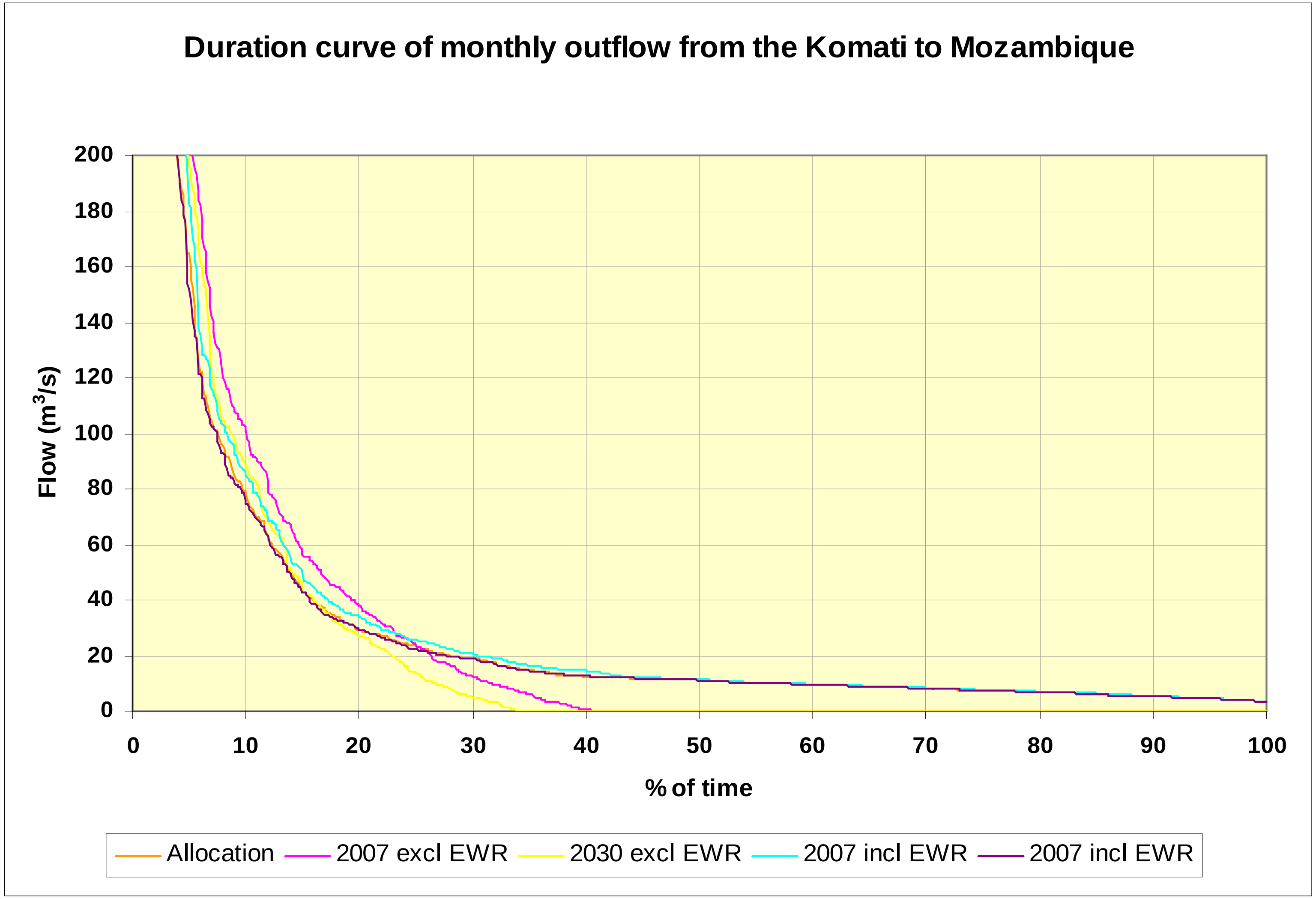
Scenario 1C - Duration curve of monthly flows at the Maputo Estuary



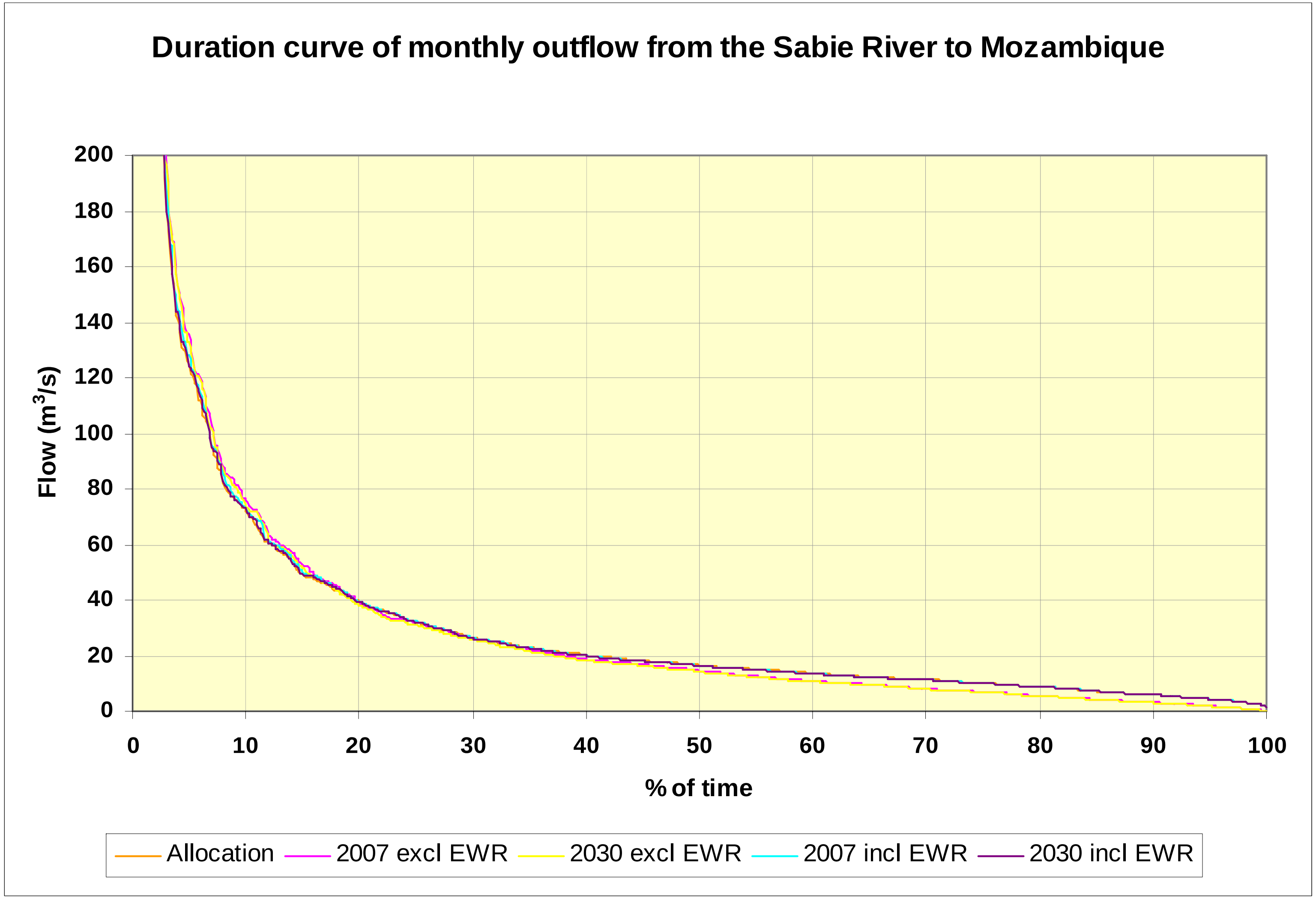
Scenario 2F-I - Duration curve of monthly flows in the Crocodile River into Mozambique



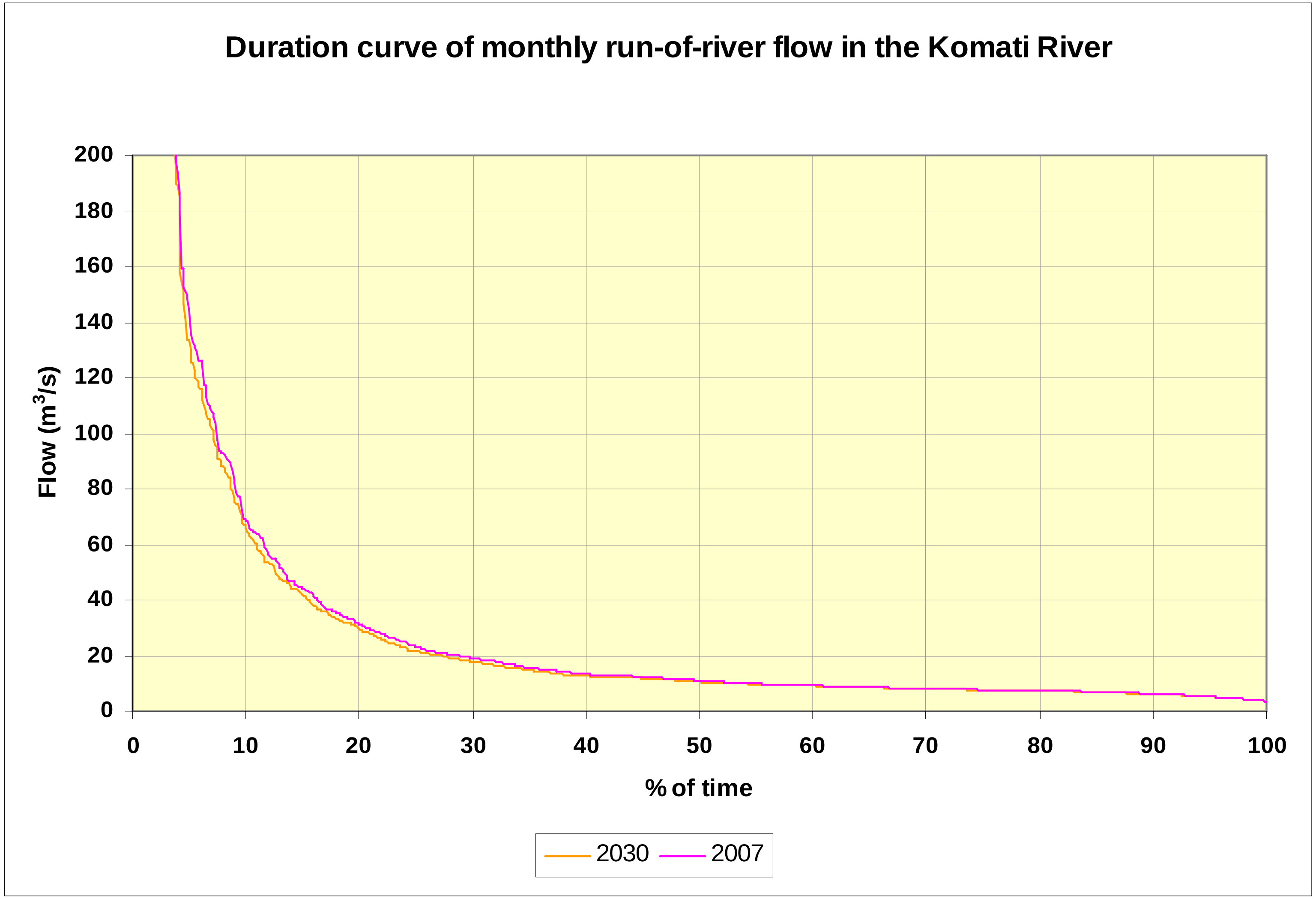
Scenario 2F-I - Duration curve of monthly flows in the Komati River into Mozambique



Scenario 2A-E- Duration curve of monthly flows in the Sabie River into Mozambique



Scenario 2P- Duration curve of monthly flows in the Inkomati River for possible abstraction to recharge groundwater

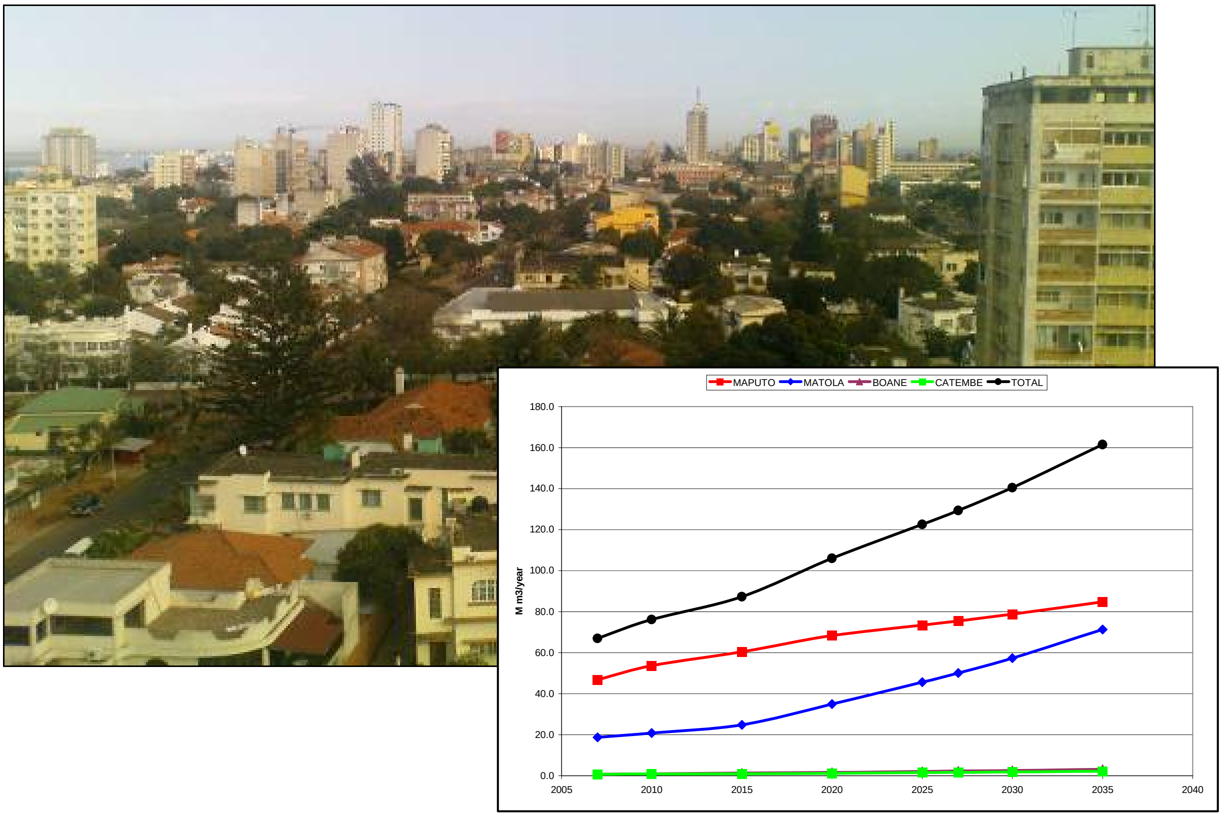


APPENDIX B

Water demand and infrastructure development different scenarios on the Maputo River

Quaternary	Sub-Area	Irrigation						Dams		Domestic					
		Channel number	WRYM file	Present demand	Present supplied	Growth factor (%)	2030 demand	Present	2030	Channel number	WRYM file	Present demand	Present supplied	Growth factor (%)	2030 demand
W55A to E	**Mpuluzi**														
		230	w5h11fd.dem	3.852		1.00	3.852	W5H011(230)	W5H011(230)					1.35	
W54A to D	**Upper Usuthu**													1.33	
		200	w5r2fd.dem	7.868		1.21	9.520	WESTOE(207)	WESTOE(207)						
								W5R002FD(200)	W5R002FD(200)						
								CHURCHILL WEIR(210)	CHURCHILL WEIR(210)						
W54E,F,G	**Middle Usuthu**														
		432	gs6-9ir.dem	25.801		1.09	28.123			451	min/max	12.000		1.35	16.200
W56A to F	**Lusushwana**							LAKE LUPHOHLO(303)	LAKE LUPHOHLO(303)						
		312	gs260.dem	15.415		1.09	16.802	NDNDVO(304)	NDNDVO(304)	449	min/max	7.000		1.33	9.310
		442	gs6-260.dem	1.206		1.09	1.315	KUBUTA(507)	KUBUTA(507)						
W52A,B,C W53A,B,C,D	**Upper Ngwempisi**														
		101	w5h5fd.dem	6.882		1.25	8.603	W5H026FD(140)	W5H026FD(140)	135	w5h26ams.de	3.840	2.240	1.28	4.915
		110	w5r3fd.dem	1.396		1.25	1.745	MERRIKLOOF(146)	MERRIKLOOF(146)						
		114	w5r3.DEM	2.586		1.25	3.233	W5H005FD(101)	W5H005FD(101)						
		140	w5h26fd.dem	9.363		1.25	11.704	ISHELELO (107)	ISHELELO (107)						
								W5R003 FD(110)	W5R003 FD(110)						
								MORGENSTOND(117)	MORGENSTOND(117)						
								JERICHO(131)	JERICHO(131)						
W52D W53E,F,G	**Lower Ngwempisi**					1.09	0.000							1.70	
								NGWADHL A B(153)	NGWADHL A B(153)						
W51A to D	**Upper Mkhondvo**														
		1	w5r4fd.dem	28.030		1.25	35.038	W5R007FD(3)	W5R007FD(3)	25	w5h22pt.dem	2.880	2.860	1.37	3.946
		20	w5h22fd.dem	3.163		1.25	3.954	HEYSHOPE(8)	HEYSHOPE(8)						
		7	w5r4ir.dem	7.675		1.25	9.594	W5H020FD(20)	W5H020FD(20)						
		27	w5h22ir.dem	10.873		1.25	13.591	BAKENKOP(30)	BAKENKOP(30)						
W51E to H	**Lower Mkhondvo**														
		43	gs7ir.dem	1.799		1.10	1.979	MAHAMBA A(31)	MAHAMBA A(31)					1.35	
		403	gs6-7ir.dem	1.799		1.10	1.979	LAGUBHU(49)	LAGUBHU(49)						
W57A to K	**Lower Usuthu**														
		602	e393ird.dem	153.526		1.70	260.994	VANECK&SIVUNGA(612)	VANECK&SIVUNGA(612)					1.50	
	Lower Usuthu / Swaziland					1.70	0.000	LUBOVANE (505)	LUBOVANE (505)						
		612	e393iru.dem	59.704		1.70	101.497								
		621	min/max	32.848		1.70	55.842								
		411	gs6-rir.dem	22.972		1.70	39.052								
W43A to F	**Ngwavuma**													1.30	
		862	gs8ir.dem	0.493		1.30	0.641								
		871	e06w43ir.dem	41.460		1.30	53.898								
W41A to G W42A to M	**Upper Phongola**							W4H004FD(800)	W4H004FD(800)						
		800	w4h4fd.dem	1.173		1.18	1.384	BIVANE(811)	BIVANE(811)	839	min/max	0.030		1.35	0.041
W44A to E	**Middle Phongola**														
		832	min/max	220.980		1.00	220.980			836	min/max	1.580		1.36	2.149
		829	min/max	32.980		1.00				829	incl irrrigation	5.000		1.36	6.800
W45A,B	**Lower Phongola**														
		842	mkhtnir.dem	29.979		1.25	37.474	NGWAVUMA(846)	NGWAVUMA(846)					1.33	
W70CX, W70DX	**Maputo /swaziland**													1.67	
		502	gs19irr.dem	4.512		6.10	27.523	MPAKENI(864)	MPAKENI(864)						
		703	e06cxir.dem	3.251		6.10	19.831	LOWER PONGOLA WMA D	LOWE PONGOLA WMA DUMMY(85)						
		709	e06dxir.dem	3.251		6.10	19.831								
		5													
	TOTAL			**734.837**			**989.977**					**32.330**			**43.360**
								ON	ON						
								OFF	OFF						
								UNDER CONSTRUCTION	BUSY BUILDING						

Augmentation of Water Supply to the City of Maputo and its Metropolitan Area



Water Demand Report

Final Report 22 July 2009

SWECO International
DHI, BKS, CONSULTEC

Client:	**National Directorate of Water, Mozambique, on behalf of the Tripartite Permanent Technical Committee (TPTC) between Mozambique, South Africa and Swaziland**
Project:	**Progressive Realization of the IncoMaputo Agreement (PRIMA)**
Study:	**Augmentation of Water Supply to the City of Maputo and its metropolitan Area**
Title:	**Water Demand Report**
Sub title:	**-**
Status of report:	**Final**
SWECO Project No:	**1989705**
Date:	**22 July 2009**
Project team:	**SWECO International AB, Sweden (lead)** **CONSULTEC Lda, Mozambique** **BKS, South Africa** **DHI Water, Environment, Health, Denmark**

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Augmentation of Water Supply to the City of Maputo and its Metropolitan Area

WATER DEMAND REPORT

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LIST OF ABREVIATIONS

AdeM	Águas de Moçambique
AdeP	Águas de Portugal
CRA	Conselho de Regulação do Abastecimento de Água (Water regulatory board)
DNA	National Water Directorate in Mozambique
DWA	Department of Water Affairs in Swaziland
DWAF	Department of Water Affairs and Forestry in South Africa
EFR	Estuarine Flow Requirements
FIPAG	Fundo de Investimento e Património de Abastecimento de Água, Mozambique
GDP	Gross Domestic Product
IIMA	Tripartite Interim Agreement for Co-operation on the Protection and Sustainable Utilization of the Incomati and Maputo Watercourses (Interim IncoMaputo Agreement)
INE	Instituto Nacional de Estatística, Mozambique
IWRM	Integrated Water Resources Management
IWAAS	Inkomati Water Availability Assessment Study
JIBS	Joint Incomati Basin Study
JMRBS	Joint Maputo River Basin Study
JURBS	Joint Umbeluzi River Basin Study
L/p/d	Litre per person and day
MAR	Mean Annual Runoff
Mm^3	Million Cubic Metres
PRIMA	Progressive Realization of the Incomati Maputo Agreement
RGP	General Population Census, Mozambique
SMAE	Autonomous Services of Water and Electricity, Mozambique
TPTC	Tripartite Permanent Technical Committee
UFW	Unaccounted fro Water
UNDP	United Nations Development Projects
WHO	World health Organisation
WRYM	Water Resources Yield Model

1 INTRODUCTION

In the methodology proposed by the Consultant, the estimate of the future water demand of the Greater Maputo area is central, as the strategies to be developed to guarantee the water supply to this large urban area have to respond to that demand, finding ways to balance it with the available surface and ground water resources.

The Greater Maputo area includes the cities of Maputo, Matola, Catembe and the towns in Boane district. Although only the town of Boane is within the boundaries of the Umbeluzi catchment, the Umbeluzi River basin has been for a long time the main source for the water supply system of the area. The Umbeluzi basin is shared essentially by Swaziland and Mozambique, with two major water users: irrigation in Swaziland and the Greater Maputo water supply in Mozambique.

The Greater Maputo total water requirements exceed the availability of the water resources of the Umbeluzi basin and this has been recognized for more than 40 years as it is documented in past studies. The solution considered for the augmentation of the water supply to Maputo was to transfer water from the Incomati River basin, where the Moamba-Major dam would be an essential component of the scheme. However, the understanding that the Incomati River basin was also becoming water stressed led to the execution of a joint study of the Incomati basin, JIBS, that created the basis for an interim agreement between Mozambique, Swaziland and South Africa of water allocation and other cooperation rules regarding the Incomati and the Maputo river basins, the IncoMaputo agreement.

In the agreement, a provision to reserve a volume for the Maputo water supply was included and that this volume of water could be drawn from the Incomati basin or from the Maputo basin or from both. Because this impacts on other water users of these two basins, the implementation of the IncoMaputo agreement required that the water demand estimates for the Greater Maputo water supply were reviewed as well as the water demand for the main existing and potential sources of water for the Maputo system: the Umbeluzi, Incomati and Maputo river basins.

Therefore, the present report deals in some detail with the water demand for the Greater Maputo water supply system and afterwards presents brief summaries of the water demands of other water users in the three river basins under consideration. For the Maputo water supply system, two scenarios have to be prepared: one with a normal economic growth (“most probable”) and another considering a high economic growth (“high scenario), to care for the uncertainty that surround the projections of water demand in the long term. Water demand is herewith interpreted as consumptive use, be it for domestic consumption, irrigation, afforestation, industry or other use. It does not include environmental water requirements as the instream flows that are required for conservation purposes in one section of the river can still be used further downstream. Evidently, this is not the case of the estuarine freshwater requirements. Due to its specific nature, environmental water requirements will be dealt with in a separate chapter in the present report.

2 WATER DEMAND OF THE GREATER MAPUTO AREA

2.1 The Greater Maputo Area

The definition of the Greater Maputo Area is not clear as sometimes different limits are assumed. For example, the Hydroplan report (Hydroplan 2008) refers that the "Grande Maputo" includes the cities of Maputo and Matola. The city of Maputo, on the other hand, includes the area of Catembe, on the south side of the Espírito Santo Estuary, and the island of Inhaca. Finally, the concession area of Águas de Maputo includes the cities of Maputo and Matola and the district of Boane. More recently, the area of Tsalala, between Matola and Moamba, and along the EN4 highway, has been also included.

For the present study, all those areas indicated above are considered, except Inhaca Island. This corresponds to the objectives of the study and its insertion in the broad framework of the PRIMA, where the Incomati and the Maputo basins are linked to the Maputo water supply as potential water sources.

Figure 2.1 presents the Greater Maputo area under this definition.

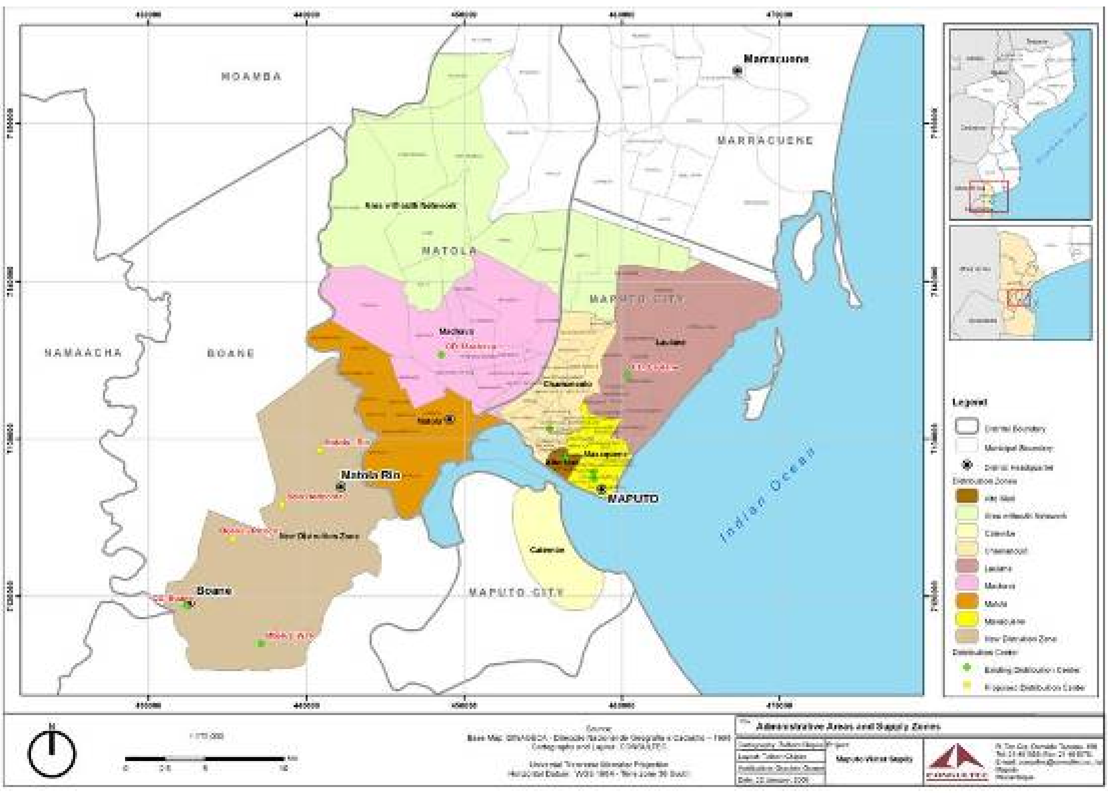

Figure 2.1 Greater Maputo Area for water supply

In terms of administrative divisions, the area of the Greater Maputo is then distributed by the Municipalities of Maputo and Matola and the District of Boane.

Each of the Municipalities is managed by a City Council, headed by a President and with a team of “vereadores”, under which work various specialized Directorates. The City Council is guided and supervised by the City Assembly. The President and the members of the City Assembly are elected in local elections held every five years.

The Districts, like Boane, are governed by an Administrator, appointed by the Government and working under the Provincial Governor. There is a District Government, with Directors for specific areas, working under the Administrator. At the central Government level, the supervision belongs to the Ministry of State Administration.

The reference to the Greater Maputo started to appear due to the ever increasing integration, initially between the cities and Maputo and Matola, and later with Catembe and Boane due to the continuous growth of the urban area. In fact, already from the colonial times, Maputo and Matola shared a number of essential urban services, mainly water and electricity, while some others (solid waste, sanitation, public transport, cemeteries) were left to the individual municipalities and others (telecommunications, for example) were taken by the central government.

However, in spite of the physical integration of the two cities, there were difficulties in integrated urban planning. A significant effort was made at the end of the 1990s when a consultant was brought in to prepare an Urban Master Plan for the joint and integrated development of Maputo and Matola. Unfortunately, the process of approval of this plan never came to a successful conclusion, may be due to the fact that it had to be approved by two separate Municipal Assemblies, and the plan was shelved.

In 2008, a new Master Plan has been prepared and approved for the City of Maputo only.

In more recent years, the lack of urban space in the city of Maputo for new urban developments, particularly for housing, led to a significant growth in other areas. The main directions of expansion are to the west of Matola, in the direction of Matola-Rio and Boane, and to the north of Maputo in the direction of Maracuene and Moamba. In a more limited scale, this is happening also in Catembe, where the development is hampered by the lack of a bridge over the estuary or, at least, of a reliable and safe ferry service.

2.2 Responsibilities for water supply provision

During the colonial period, the responsibility for the water supply was with the municipalities. For Maputo and Matola, this was taken care by SMAE (Autonomous Services of Water and Electricity).

After Mozambique became independent in 1975, the Government decided to split up the water and electricity services and, due to the weakness of the municipal institutions at that time, water supply became the responsibility of DNA that created for that purpose a state owned company, Águas de Maputo (with similar solutions for the provincial capitals), which was responsible for the whole water supply system for the areas of Maputo and Matola. Águas de Maputo functioned during the 1980s and 1990s and was responsible not only for the day-to-day operation of the system but also to manage, on behalf of DNA, some large investment programs with donor support.

This situation changed after the Government adopted the National Water Policy (1995) and the legal framework for delegated management (1998). Under this new legal framework, two para-statal institutions were created – FIPAG and CRA.

FIPAG (Fund for Investment and Asset Management in Water Supply) received from the Government the water supply infrastructures of the main urban centres, including naturally Maputo and Matola. FIPAG became responsible to negotiate and manage investments and for the operation, maintenance and expansion of the systems, either directly or by concession or contract management with a private operator, coordinating its plans with the municipalities. The Greater Maputo water supply was given in concession to a consortium of foreign and Mozambican companies, Águas de Moçambique, presently led by Águas de Portugal.

CRA is a regulator for the urban water supply, with the main objective of keeping an adequate balance between the interests of the private operator and of the public at large, in parallel with the good maintenance of the systems.

In this system, FIPAG and Águas de Moçambique (AdeM) have now the major role in planning the expansion of the water supply system.

Besides AdeM, which is by far the major water provider in the area, there are some other providers:

- Private investors, with small distribution systems, supplied by one or more boreholes
- Small systems in peri-urban areas, with investments made by FIPAG, managed by private operators under contract with FIPAG

There are also water vendors but the scale of the business is rather small.

Private investors created their systems during the years when the peri-urban areas were expanding while there was no increase in the water supply network. Therefore, they represented a social service for the population in those areas. Nowadays, there are a number of problems with at least some of these systems:

- Water quality control is not regular. Some of the boreholes draw water from aquifers that are not very deep and that can be contaminated by drainage and sewerage.
- There are high water losses in the system. However, in general the meters are located near the borehole and not at the consumer's house, so the losses along the way are paid directly by the consumer.
- Water costs are on average higher than those of AdeM for the same level of service.

Although it is difficult to estimate correctly the total number of people serviced by these systems, it appears to be about 140,000, representing almost 20% of the presently served population.

FIPAG is now in a process of trying to register all these private water providers and get them to follow general rules in terms of the services provided.

Another private investor, MozaBusiness, is interested in becoming a provider in the area of Tsalala. This is still in the process of negotiations with FIPAG.

2.3 Main types of water uses

According to AdeM data of 2007, they had almost 100,000 connections, with the following distribution:

- Domestic – 93%
- Commerce and services – 4%
- Public and industrial – 2%
- Standposts – 1%

The small private operators had about 70% of domestic (housing) connections and 30% of standposts.

Domestic consumption is thus the dominant type of water use in the Greater Maputo, in spite of this region being the most developed industrial area in the country.

Data of 2007 regarding volumes of water invoiced by AdeM indicated a much higher percentage for non-domestic water use, in the order of 25% of total demand or about 1/3 of the domestic demand. This percentage will tend to decrease with the expected large increase in domestic supply.

In terms of the abstracted volumes, they were in 2006 approximately:

- From the Umbeluzi River – 186,000 m^3/d
- Small systems using groundwater – 6,500 m^3/d
- Catembe (also using groundwater) – 900 m^3/d

A large part of the water abstracted becomes water losses. AdeM estimated that the total water losses in the system amounted in 2006 to about 60% of the abstraction, with the following distribution:

- Treatment – 5%
- Transmission – 28%
- Distribution – 23%
- Commercial – 5%

The commercial losses correspond to water distributed to the consumer but that is not invoiced, so they are not physical losses.

Even so, a percentage of water losses in the order of 50-55% is excessively high and FIPAG devised investment plans and ensured the financing specifically aimed towards a significant reduction of physical losses to something in the order of 25%.

There are no significant fluctuations of water consumption along the year, although some increase in consumption could be expected during the hot season (December to February).

Tourism in the Greater Maputo area does not introduce any major changes in water consumption the same way it does in other regions like Inhambane Province. This is due to the fact that, on one hand, the tourism-linked water consumption (in hotels and restaurants) is quite small as indicated previously; on the other hand, most of the occupation of the hotels are related to business people and not to tourism geared toward beaches where the seasonal effect is more important.

2.4 Review of information and recent studies

The essential information for the present study on water demand is about population and the historical of water consumption in the area.

Population data is available from the 1997 and 2007 Census that were executed by INE – National Institute of Statistic. The data from the 2007 Census is still being processed but some of the more global information can already be consulted.

AdeM has detailed records of the water abstracted, treated, distributed and invoiced and this has been used in a number of recent reports prepared by various consultants for FIPAG or for AdeM.

The most relevant and updated reports are the following ones:

- Maputo water supply project, Component 2 – Hydroplan in association with Connex, Salomon and PDNA, June 2008
- Plano Director do sistema de abastecimento de água na área de cessão da Águas de Moçambique (Master Plan for the water supply system in the concession area of Águas de Moçambique) – Águas de Portugal / Águas de Moçambique, September 2007
- Maputo water supply project, Component 1 – Mott MacDonald, July 2008

The Mott MacDonald report deals essentially with projects to increase water production and transmission, focusing on the Umbeluzi water treatment works and transmission mains for the various distribution centres. For that purpose, it makes use of water demand estimates from other reports, mainly from SWECO & Associates (2005b), as well as raw data from AdeM and ARA-Sul.

The report of AdeP / AdeM extrapolates water demand until 2014. Its approach is based on the number of connections and not so much in terms of volume of water, which is understandable as their service is to take the water unto the consumer.

The most relevant report is the one prepared by Hydroplan and associates, which has recently been approved by the client, FIPAG. This report uses the most recent data from AdeM and from INE (census of 2007, 1997 and before), with a sound methodology, presenting the best estimates of present and future water demand. This report is used as a basis and the most probable scenario of water demand is taken from it.

2.5 Future water demand in the Greater Maputo area

2.5.1 Population in the Greater Maputo Area

The Census of 2007 gave lower than expected figures for population growth in Mozambique. The annual growth rate was 1.8%, with several sources like UNDP, World Bank and WHO linking it to the impact of AIDS/HIV. Present estimates of the Ministry of Health are that 16% of adults between the ages of 15–49 are living with HIV/AIDS. The AIDS epidemic causes higher death and infant mortality rates, and lowers life expectancy.

Mozambique, like most African countries, is undergoing rapid urbanization. The urban population represents about 30 percent of the national total and is growing at about 5 percent per year. By 2020 more than half of Mozambicans will live in urban areas. By 2010, the urban population of Maputo City is expected to increase from 1.3 million to 1.7 million, more than twice the size of Beira, the second largest city.

Recent studies show that over half of the urban population can be considered poor, using consumption-based indicators. An important aspect to consider is that, while urban poverty is slightly less (52 percent) than in rural areas (55 percent), the difference is small; notably poverty has also fallen more rapidly in rural than urban areas due to post-war agricultural gains. In Maputo, the capital city and single largest population centre, there has been no decrease in poverty since 1997 despite the overall economic growth.

Over 70 percent of the urban population in Mozambique lives in settlements that are informal and have slum characteristics including dense unregulated growth: a lack of common infrastructure services such as water, sanitation, drainage and electricity; and homes made of precarious materials. Even the "cement city" {originally the planned colonial urban core) of the main cities of Mozambique has seen very limited investment or maintenance since Independence in 1975 leaving drainage systems inoperative, a major solid waste crisis, inadequate water and sanitation services and an almost complete lack of physical planning. Unplanned settlements are also often built on unsuitable terrain that is prone to flooding, erosion, and the accumulation of solid waste.

Maputo contributes over 40 percent of the national Gross Domestic Produce having an estimated GDP per capita of US$ 1,250 compared to a National GDP per capita of US$ 310 in 2005. It is also a city of extreme and growing inequality. Approximately 70 percent of Maputo City's residents live in informal settlements and 54 percent live below the poverty line of US$1.50 per day. The low level of investments in urban areas over many years has reduced the quality and quantity of service delivery, especially in the maintenance of existing infrastructure.

Population in the Greater Maputo Area to be served by the water supply system was estimated by Hydroplan to be about 1.8 million people, with the following distribution:

- Maputo city – 1.1 million
- Matola city – 0.65 million
- Boane district – 0.05 million

Detailed population data before 1997 is available for Maputo City only, essentially from the general population census (RGP) of 1970 and 1980. This information was used to assess the past development trends observed within Maputo area. For the whole area (Maputo, Matola and Boane) census figures are available for the years 1997 and 2007 only. The census figures enabled computation of the historical growth rates for each “bairro”.

Figure 2.2 presents the development of population and annual growth rate in Maputo city.

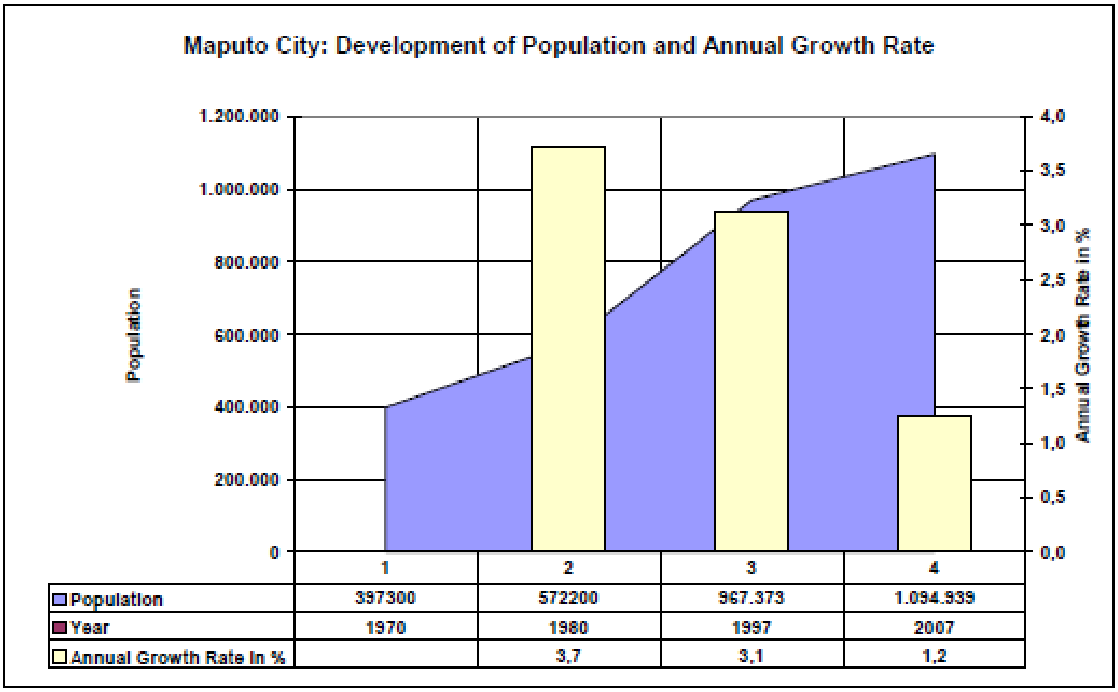

Figure 2.2 Population and growth rate for Maputo City (source: Hydroplan 2008)

During the decade of 1997 to 2007, the annual growth rate in Maputo City was only 1.2% while in Matola City it was 4.9%. A number of factors are contributing for this low growth rate in Maputo City in comparison with neighbouring areas:

- Saturation of occupation of urban land, particularly in urban districts 1, 2 and 3
- Lifting of the pressure created by the civil war, when people took refuge in the city even when living conditions were very poor. When the war ended, these people looked for better alternatives.
- Increasing value of houses and flats in the cement city. This led to a process where poorer and larger families living in those houses and flats sold or rent them to more affluent and usually smaller families or even to commercial or services use, moving to peri-urban areas, to Matola and to other urban expansion areas.

The higher growth rates in Matola and Boane (and to a much lesser scale, to Catembe) were also caused, besides being an alternative to Maputo City, by new urban and industrial developments, particularly in Matola. Details of growth rates are given in Table 2.1 (“This Report” is the report by Hydroplan and Associates, 2008).

Table 2.1 Details of population growth rates (source: Hydroplan 2008)

	1997 -2007		2006	2008
Annual Growth Rate in %	**Average**	**Variation**	**AdeM**	**This Report**
Districts of Maputo City				
District 1	-2.10	-4.5 – +0.1	1.0	1.0
District 2	-0.50	-1.8 – +0.1	1.0	1.0
District 3	0.60	-0.3 – +1.8	1.0	1.2
District 4	2.40	±0.0 – +12.0	2.0	2.5
District 5	3.40	-1.2 – +9.0	2.0	2.0
Catembe	2.10	+0.5 – +5.2	2.0	2.6
Inhaca	-1.60	N/A	N/A	1.4
Maputo City Average	**1.20**			**1.8**
Districts of Matola City				
Posto Administrativo de Infulene	6.50	±0.0 – +30.2	3.0	3.7
Posto Administrativo de Machava	6.10	+0.2 – +14.4	3.0	3.5
Posto Administrativo de Matola	2.40	-1.6 – +15.1	3.0	3.1
Matola City Average	**4.90**			**3.5**
District of Boane				
Boane	3.70	+2.6 – +4.4		5.1
Boane Average	**3.70**			**5.1**
Total project area	**2.50**			**2.5**

Table 2.1 shows negative growth rates in urban districts 1 (essentially, the old “cement city”) and 2 of Maputo City. The last two columns represent the growth rates adopted respectively by AdeM and Hydroplan in their projections.

In both reports, no negative growth rates were adopted, the reason being that the causes for the negative growth rates in urban districts 1 and 2 of Maputo City had already made their impact and had no continuation. On the opposite, some small growth would occur in those areas. For example, in urban district nº 1 it can be expected that the plots still available will be developed and that old houses will be replaced by higher buildings, corresponding to a process of densification. Similarly, a densification process can be expected also in districts nº 2 and 3.

It can be expected also that Matola will have in some of its districts a similar situation to what happened in Maputo in terms of saturation of the urban space. Therefore in both reports more moderate, although still high growth rates, have been adopted to estimate future population to be served.

A higher growth rate was assumed by Hydroplan for Matola-Rio and Boane, basically because served population is still very small and new urban developments in those areas are being planned and implemented.

Globally, the annual growth rate in the period 1997-2007 for the Greater Maputo Area was 2.6%. Hydroplan used the same global growth rate, although with large differences between the various areas, to estimate the population in the various areas for 2010 and from then on until 2035 in intervals of five years, as can be seen in Figure 2.3.

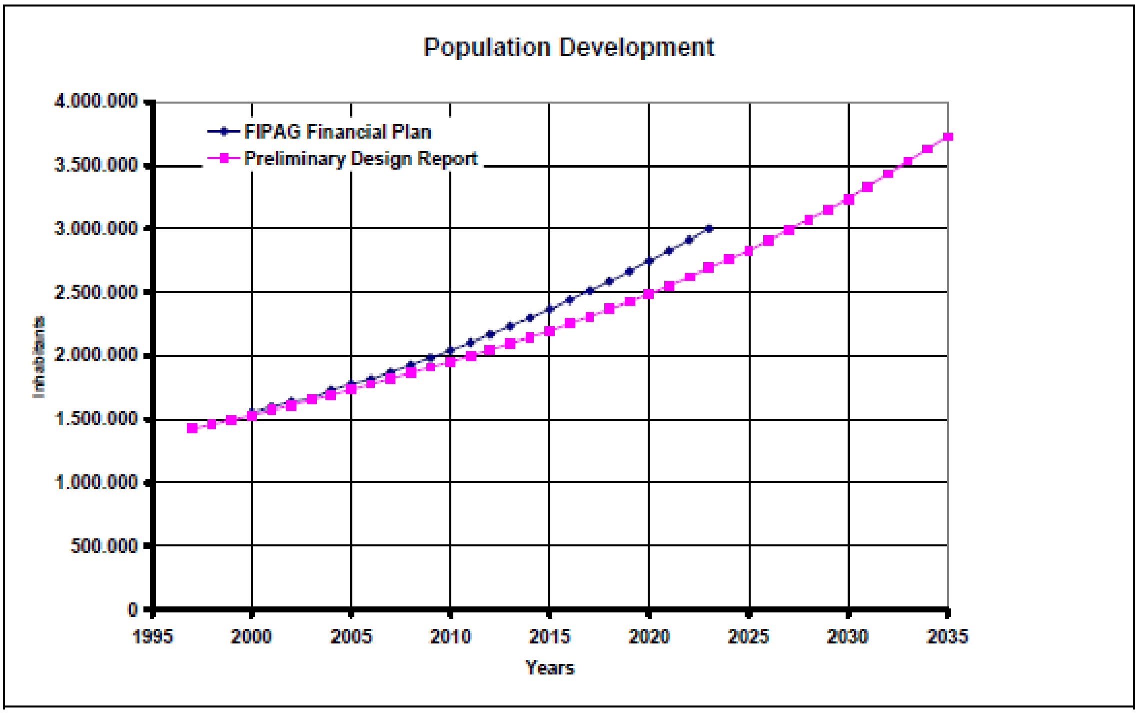

Figure 2.3 Population growth in the Greater Maputo Area until 2035 (source: Hydroplan 2008)

The adopted annual growth rates were 1.8% for Maputo, 3.5% for Matola and 5.1 for Boane.

Hydroplan obtained for Catembe an increase in served population from about 20,000 people in 2007 to about 41,000 in 2035, which seems to be a very modest growth for such an extended period. Catembe is one of the best potential urban expansion areas for Maputo. However, its development is being hampered by a very deficient transport system, the alternatives being an unreliable and not very safe ferry service or a long detour via a gravel road. It can be expected that, with pressure mounting for areas for urban development that are relatively close to the centre of Maputo City, a bridge will be built and, before that, a well organized, reliable and safe ferry service. When this happens, there will certainly be an explosive development in Catembe. Presently, however, it is difficult to forecast what it will mean in terms of population growth and the corresponding water demand.

Figure 2.4 presents the population projections in accordance with the growth rates adopted in the Hydroplan report. These projections indicate that the population of Matola will be almost equal to Maputo in 2035 due to the significant difference in growth rates. The population is distributed for the various Distribution Centres (existing and planned) that supply the “bairros”. Table 2.2 presents the evolution of the percentages of the total population corresponding to each DC, from 2007 to 2035, with figures for intermediate years being interpolated. It shows how the relative weight of each sub-area and main area may evolve in the future

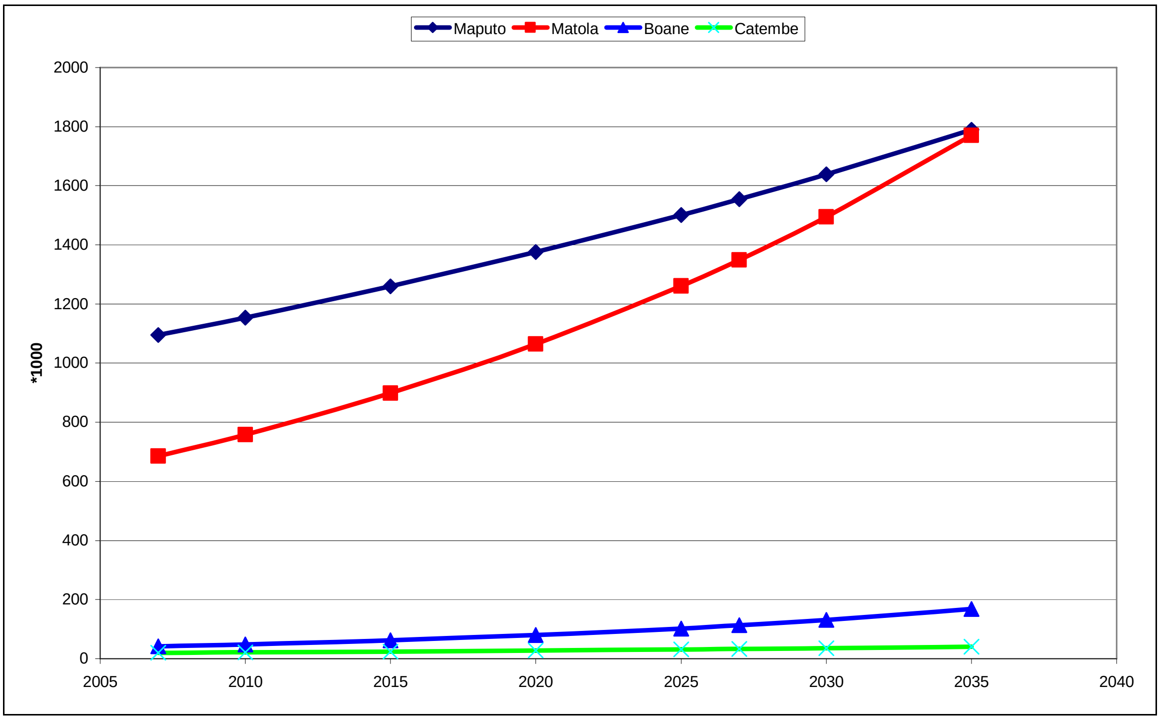

Figure 2.4 Population growth in Maputo, Matola, Boane and Catembe

Table 2.2 Evolution of the percentages of the total population associated with each Distribution Centre

	2007	**2035**
Chamanculo	21.8	15.7
Alto-Maé	2.4	1.7
Maxaquene	15.3	10.7
Laulane	22.2	21.4
Matola	16.1	21.8
Machava	18.2	21.5
Matola-Rio	1.0	2.2
Boane	1.7	3.6
Catembe	1.3	1.4

The projections prepared by Hydroplan can be considered as the “most probable” scenario. A “high” scenario will be presented and discussed later in this chapter.

2.5.2 Water Demand Estimates

To estimate future water demand, the following variables have to be taken into consideration:

- Population growth in the various areas to be served
- Unit consumptions in domestic use based on various levels of supply
- Evolution of coverage rate
- Non-domestic water uses (industrial, public, commercial and services)
- Water losses

Population growth

Population growth has already been dealt with in the previous item.

Unit consumption

Unit consumptions to be adopted in the design of public water supply systems are defined in the “Regulamento dos Sistemas Públicos de Distribuição de Água e Drenagem de Águas Residuais de Moçambique” (RSPDADARM – Mozambique Regulations for Public Systems of Water Supply and Wastewater Drainage), adopted in 2002. They are, in L/p/d:

- House connections in areas with more than 2,000 inhabitants – 125
- Yard connection – 50
- Standpost – 30

The unit consumption for a house connection is less than in cities of developed countries, where it stays in the range of 150-250 L/p/d.

The AdeM report indicates somewhat lower unit consumptions, in the order of 100 L/p/d for house connections and 20 L/p/d for standposts. However, yard connections show a higher value, possibly because water is sold to neighbours, considering the low coverage rate in the “bairros” where this has been detected.

The Hydroplan report considered the figures for the various “bairros” in relation to the type of occupation and socio-economic characteristics. Table 2.3 presents the unit consumption, in L/p/d, for domestic use adopted by Hydroplan in relation to the various Distribution Centres that supply the different “bairros”. In the table, the first figure is the consumption in 2007, the second in 2035, for the intermediate years the figures are interpolated.

Table 2.3 Unit consumptions (L/p/d) adopted by Hydroplan according to the level of supply

	House connection	Yard connection	Standpost
Chamanculo	120-130	60-80	25-30
Alto-Maé	130-150	60-80	20-30
Maxaquene	120-140	70-80	20-30
Laulane	120-135	60-80	20-30
Matola	120-135	60-80	20-30
Machava	120-135	60-80	20-30
Matola-Rio	120-180	60-80	20-30
Boane	120-135	60-80	20-30
Catembe	120-135	60-80	20-30

There is no apparent justification for the high unit consumption adopted for Matola-Rio (180 L/p/d in 2035). In the following calculations, this figure has been reduced to 135 L/p/d.

Coverage rate

Regarding the evolution of the coverage rate (“service level” in the terminology of the Hydroplan report), the objective of the Government is to achieve full coverage in urban areas. This has been adopted by Hydroplan for the year 2035 when non-covered population is reduced to 5% or less. The exception is the district of Boane where only the established urban settlements are considered to be connected to the water supply network.

Table 2.4 presents the evolution of the coverage rate from 2007 to 2035, the two figures in each column corresponding to those first and last years. It is assumed that values will be interpolated for intermediate years.

Table 2.4 Evolution of the coverage rate, figures in percentage.

	House connection	Yard connection	Standpost	Non-served population
Chamanculo	15-35	15-40	20-20	50-5
Alto-Maé	50-75	10-20	20-5	20-0
Maxaquene	45-65	15-20	15-15	25-0
Laulane	30-50	15-30	25-15	30-5
Matola	15-35	15-35	15-25	55-5
Machava	10-35	15-40	25-20	50-5
Matola-Rio	20-60	10-25	10-10	60-5
Boane	25-25	10-10	10-10	55-55
Catembe	15-35	15-35	10-25	60-5

Using the information included in Figure 2.4 and Tables 2.2-2.4, domestic water requirements can be computed, which are presented in Table 2.5.

Table 2.5 Domestic water requirements (Mm^3/year)

	2007	2010	2015	2020	2025	2027	2030	2035
Chamanculo	3.9	4.9	6.6	8.5	10.2	10.9	12.0	13.9
Alto-Maé	1.0	1.2	1.4	1.7	1.9	2.0	2.1	2.3
Maxaquene	5.8	6.6	8.0	9.5	10.6	11.1	11.8	13.1
Laulane	6.3	7.5	9.8	12.7	15.4	16.5	18.4	21.8
Matola	2.7	3.6	5.5	8.1	10.9	12.3	14.6	19.3
Machava	2.7	3.7	5.7	8.4	11.7	13.0	15.1	19.4
Matola-Rio	0.2	0.3	0.5	0.8	1.2	1.4	1.7	2.4
Boane	0.4	0.5	0.6	0.9	1.1	1.2	1.4	1.8
Catembe	0.2	0.3	0.4	0.6	0.8	0.9	1.0	1.3
TOTAL	23.2	28.4	38.6	51.2	63.8	69.2	78.1	95.4

Non-domestic water consumption

Non-domestic water consumption includes commercial, services, public and industrial water use. Statistics provided by AdeM indicated that in the years 2005-2007, the percentage of non-domestic water consumption was in the range of 25-30% of the total water consumption or between 33 and 40% of the domestic water consumption. Hydroplan assumed that these figures would decrease slightly with the significant increase planned for domestic water consumption, as presented in Table 2.6 (figures are percentage of domestic water consumption in 2007 and 2035).

Table 2.6 Evolution of non-domestic as a percentage of domestic water consumption

	Non-domestic consumption
Chamanculo	40-25
Alto-Maé	50-30
Maxaquene	50-30
Laulane	30-20
Matola	50-30
Machava	50-30
Matola-Rio	50-30
Boane	50-30
Catembe	50-30

The values assumed by Hydroplan seem reasonable: it can be expected that the level of consumption for public, commercial and services uses will remain proportional to the domestic use while some decrease can be expected in the proportion of the industrial use as the new industrial areas will consider obtaining raw water directly from ARA-Sul and introduce the level and type of water treatment required for the specific group of industries.

With the information of Tables 2.5 and 2.6, the water requirements for non-domestic water use can be computed (Table 2.7).

Table 2.7 Non-domestic water requirements (Mm^3/year)

	2007	2010	2015	2020	2025	2027	2030	2035
Chamanculo	1.6	1.9	2.3	2.8	3.1	3.2	3.3	3.5
Alto-Maé	0.5	0.6	0.6	0.7	0.7	0.7	0.7	0.7
Maxaquene	2.9	3.2	3.5	3.9	3.9	4.0	4.0	3.9
Laulane	1.9	2.2	2.7	3.2	3.6	3.8	4.0	4.4
Matola	1.4	1.7	2.5	3.3	4.1	4.4	4.9	5.8
Machava	1.3	1.7	2.5	3.4	4.4	4.6	5.1	5.8
Matola-Rio	0.1	0.1	0.2	0.3	0.4	0.5	0.6	0.7
Boane	0.2	0.2	0.3	0.4	0.4	0.4	0.5	0.5
Catembe	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.4
TOTAL	10.0	11.7	14.8	18.2	20.9	21.9	23.4	25.7

Water Losses (UFW - Unaccounted for Water)

Water losses of UFW are at present extremely high in the Maputo water supply system, in the order of 60% of the total abstracted water in 2006, of which 55% are physical losses and 5% are commercial losses.

The Maputo Water Supply Project, being developed by FIPAG with support from the European Bank of Investment and other donors, has the specific objective of reducing the UFW to about 35% until 2014. For this purpose, specific investments are being planned, including:

- Improvements in the transmission, storage and distribution networks
- Bulk and zone metering
- Leak detection program with immediate repair capacity

in parallel with improved management and a concerted effort with the authorities for a great reduction in illegal connections.

Hydroplan proposed in their study to further reduce UFW to 25% in 2035. The progress of reduction of UFW is schematized as follows:

- For the areas with new water supply networks (Laulane, Matola-Rio, Boane), UFW is assumed as 25% as the network is new and the operator can provide good maintenance and operation
- For the other areas, linear reduction from 56% (2007) to 32% (2015) and linear reduction to 25% until 2035.

It must be noted that the target of 25% is not easy to achieve. It implies investments but also good maintenance of the infrastructure and an institutional set-up for its management that really allows for rapid interventions when leakages are detected. However, it is feasible, as the examples of the cities of Inhambane and Maxixe, also under FIPAG management and that benefited recently from investments to rehabilitate and expand the water supply networks, show – both are working with UFW below 20%.

With the information above and the results presented in Tables 2.5 and 2.7, the UFW in the various Distributions Centres can be computed, see Table 2.8.

Table 2.8 Unaccounted for water (Mm^3/year)

	2007	2010	2015	2020	2025	2027	2030	2035
Chamanculo	7.0	8.5	8.8	8.7	7.9	7.5	6.9	5.8
Alto-Maé	1.9	1.5	1.0	1.0	1.0	1.0	1.0	1.0
Maxaquene	11.1	12.5	11.4	10.3	8.7	8.1	7.2	5.7
Laulane	2.7	3.2	4.2	5.3	6.3	6.8	7.5	8.7
Matola	5.2	4.7	3.8	5.0	6.0	6.4	7.1	8.4
Machava	5.1	4.8	3.9	5.1	6.4	6.8	7.4	8.4
Matola-Rio	0.1	0.1	0.2	0.4	0.6	0.6	0.8	1.1
Boane	0.2	0.2	0.3	0.4	0.5	0.6	0.6	0.8
Catembe	0.4	0.4	0.3	0.4	0.4	0.4	0.5	0.6
TOTAL	33.8	36.0	33.9	36.6	37.8	38.2	39.0	40.4

Projections of total water requirements

Table 2.9 presents the estimates of total water demand by Distribution Centre and aggregated for Maputo, Matola, Boane and Catembe.

Table 2.9 Estimates of total water demand (Mm^3/year)

	2007	2010	2015	2020	2025	2027	2030	2035
Chamanculo	12.5	15.3	17.7	20.1	21.1	21.6	22.2	23.2
Alto-Maé	3.5	3.2	3.0	3.4	3.7	3.7	3.8	4.0
Maxaquene	19.9	22.3	23.0	23.6	23.2	23.1	22.9	22.7
Laulane	10.9	12.9	16.7	21.2	25.4	27.1	29.8	34.9
MAPUTO	*46.8*	*53.6*	*60.4*	*68.3*	*73.4*	*75.4*	*78.8*	*84.8*
Matola	9.3	10.1	11.7	16.4	21.0	23.1	26.7	33.5
Machava	9.1	10.2	12.1	17.0	22.5	24.4	27.6	33.7
Matola-Rio	0.4	0.6	1.0	1.5	2.2	2.5	3.1	4.2
MATOLA	*18.8*	*20.8*	*24.8*	*34.9*	*45.6*	*50.1*	*57.3*	*71.4*
BOANE	*0.7*	*0.9*	*1.2*	*1.6*	*2.1*	*2.2*	*2.5*	*3.1*
CATEMBE	*0.7*	*0.8*	*0.9*	*1.2*	*1.5*	*1.6*	*1.8*	*2.2*
TOTAL	***67.0***	***76.1***	***87.3***	***106.0***	***122.5***	***129.3***	***140.5***	***161.5***

The results in the table show minor differences in relation to the results included in the Hydroplan report. Figure 2.5 shows the evolution of the water demand. It is interesting to notice that the curve of the total water demand shows a smaller slope until 2015 due to the effect of the large reduction in UFW.

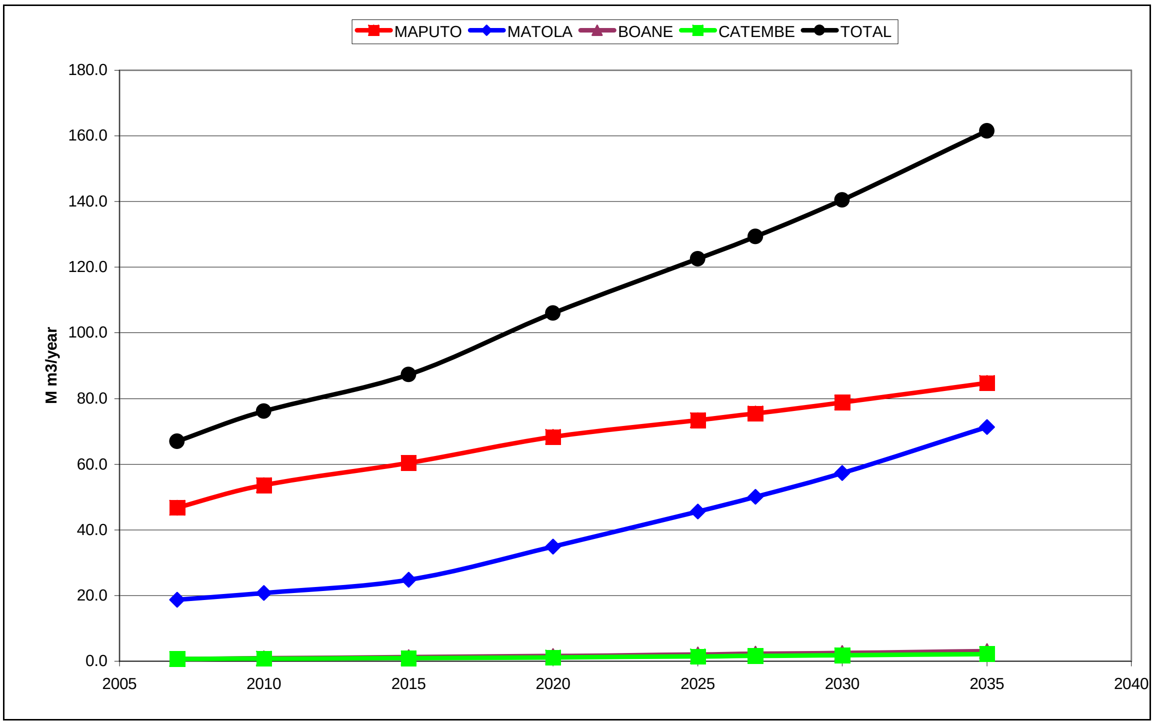

Figure 2.5 Evolution of water demand (Mm^3/year)

This scenario of future water demand can be accepted as the “most probable”. FIPAG has already secured funding from the GOM and from donors that ensure that implementation of the priority programs proposed for Components 1 (Increase of Water Production and Transmission) and Component 2 (Expansion of the water supply network and reduction of the UFW).

Projects that are included in those Components are:

- Increase of the capacity of water intake and treatment at the Umbeluzi plant (ETA) from the present 6,000 m^3/h to 10,000 m^3/h (87.6 Mm^3/year)
- Extension of the water supply network to new areas (Boane, Picoco, Belo Horizonte, Matola-Rio)
- Extension and rehabilitation in existing areas
- Rehabilitation of transmission mains and Distribution Centres
- Bulk metering

All these projects are to be implemented until 2015.

2.6 High Scenario of Water Demand

There are many uncertainties when the future urban development of the Greater Maputo area is considered. Just to illustrate with a few examples:

- What will be the impact of a safe and reliable crossing of the Espírito Santo estuary in terms of development of Catembe? And how would Catembe's development reflect on the other urban areas of the Greater Maputo?
- What if the population growth is higher than what has been considered?
- If the economic development of Mozambique accelerates, how will this be translated in terms of level of service and unit consumption?

One way to consider these questions is to create alternative scenarios of water demand and evaluate its impacts on the strategy for water supply. A high and a low scenario can be considered – the high scenario corresponding to high economic growth, higher population growth, higher unit consumptions, etc; on the opposite, the low scenario would correspond to low economic growth (for example, related to a global economic crisis, reduction of donor support and less private investments), resulting in reduced coverage and lower unit consumptions.

Scenarios are not forecasts – they are possible futures for which one needs to be prepared if these scenarios are realistic. The low scenario is less relevant for the development of a strategy because it does not put an additional stress on the physical system – usually, it would lead to a slower development of the planned projects and infrastructures. However, it can create other type of problems, related to public health and social unrest.

The high scenario is more important to consider in the development of the strategy to guarantee the future water supply to the Greater Maputo area. It stresses the system, from the water sources to the infrastructure (intake, treatment, transmission, storage and distribution), to ensuring the investments needed and to provide an adequate management capacity.

Therefore, a high scenario has been developed to be considered in comparison with the "most probable" scenario that has been presented previously. The same methodology that has been presented for the most probable scenario is also followed here. We considered that until 2015 the high scenario is the same as the "most probable" one. From 2016, the following differences exist:

- The global population annual growth rate is 3% instead of 2.6 %
- Increase of domestic unit consumption by 10%
- Larger population growth in Catembe

The resulting water demand is given in Table 2.10 and represented in Figure 2.6.

Table 2.10 Estimates of water demand for the high scenario (Mm^3/year)

	2007	2010	2015	2020	2025	2027	2030	2035
Chamanculo	13.8	17.0	20.1	23.0	24.7	25.4	26.5	28.5
Alto-Maé	3.8	3.6	3.4	4.0	4.3	4.4	4.6	4.9
Maxaquene	21.9	24.8	26.1	26.2	26.3	26.4	26.5	27.0
Laulane	11.9	14.3	18.9	24.5	30.1	32.3	36.0	42.9
MAPUTO	*51.4*	*59.7*	*68.5*	*77.6*	*85.3*	*88.5*	*93.6*	*103.3*
Matola	10.2	11.2	13.3	18.6	24.5	27.2	31.8	40.7
Machava	10.0	11.3	13.7	19.6	26.6	29.1	33.3	41.4
Matola-Rio	0.4	0.6	1.1	1.7	2.6	3.0	3.7	5.1
MATOLA	*20.6*	*23.2*	*28.1*	*40.0*	*53.6*	*59.3*	*68.7*	*87.2*
BOANE	*0.8*	*1.0*	*1.4*	*1.8*	*2.3*	*2.5*	*2.9*	*3.6*
CATEMBE	*0.8*	*0.9*	*1.0*	*1.3*	*1.7*	*1.8*	*2.1*	*2.6*
TOTAL	***73.7***	***84.7***	***99.0***	***120.7***	***142.9***	***152.1***	***167.3***	***196.7***

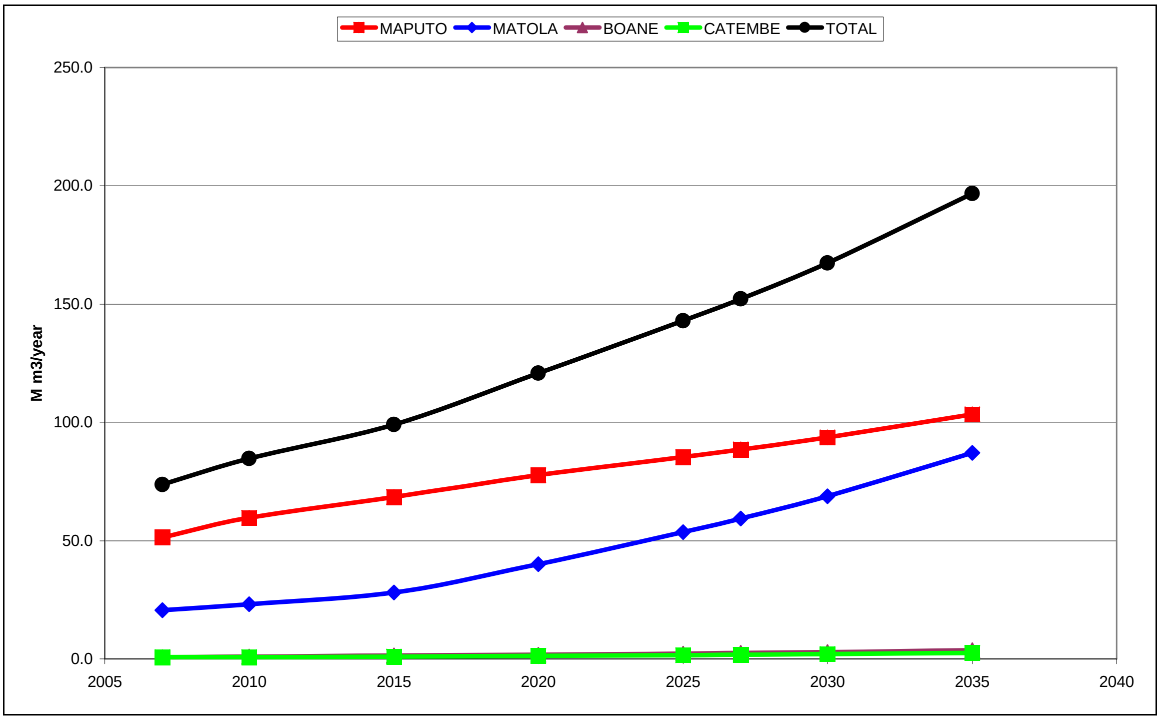

Figure 2.6 Evolution of water demand for the high scenario

Some comments can be made about these results:

- The high scenario represents an increase in water demand of about 18% in the year 2027 and of about 22% in 2035.
- Maputo and Matola represent about 97% of the total water demand, so the requirements of Boane and Catembe are minor in comparison.

- Even with a population growth rate of almost 6%, the water demand for Catembe is small, about 1.8 Mm^3/year in 2027 for the high scenario.
- While present water demand of Matola is about 40% of that of Maputo, it will rise to about 67% in both scenarios in the year 2027 and to 84% in the year 2035,
- There is a need to regularly update the forecasts of future water demand, based on reliable data of water abstracted, treated and distributed in the various distribution centres.
- In the most probable scenario, the total water demand in 2015 will be about 87 Mm^3/year, which corresponds almost to the full capacity of the water treatment works (ETA Umbeluzi) when the capacity expansion projects are finished. Therefore, bringing in another water source is vital to allow for the expansion of the water supply network.
- In the year 2027, the two scenarios give values of total demand of 129 and 152 Mm^3/year. The additional to what can be taken from the Umbeluzi and eventually from groundwater is still less than the amount reserved for Maputo water supply under the IncoMaputo agreement.
- The same happens in the most probable scenario in the year 2035. Only with the high scenario, with a total demand of 197 Mm^3/year the additional 87.6 Mm^3/year are not sufficient to cover the water requirements.

3 WATER DEMAND FOR OTHER USERS

3.1 Other water users

The water supply system of Maputo is essentially based on the surface water resources of the Umbeluzi River and, in a much lesser degree, on groundwater resources for the supply of peri-urban areas and in Catembe and Inhaca.

However, it is well known that the water resources of the Umbeluzi River basin are limited and subject to intensive use, in Mozambique and in Swaziland, mostly for irrigation, which is the major water user in this river basin.

For more than 40 years, there were plans in Mozambique to transfer water from the Incomati River basin to the Umbeluzi basin to augment the water supply to the city, with the Moamba-Major dam as the main pillar of the scheme. Therefore, the water supply to the Greater Maputo area became part of joint studies of the Incomati basin (JIBS, completed in 2001) and of the Maputo basin (JMRBS, completed in 2008). Particularly the JIBS was used as a basis for the IIMA agreement, signed by Mozambique, South Africa and Swaziland in 2002, where a reserve of 87.6 Mm^3/year to be provided by water resource development is kept in both the Incomati and the Maputo basin to be used, if necessary, to the Maputo water supply.

Water transferred to the Umbeluzi basin and used in the Maputo water supply system is obviously not available for other water users in the Incomati and the Maputo basin. For this reason, the water balance has to integrate the three basins (Umbeluzi, Incomati, and Maputo) and consider all the water requirements from the different users in those basins to check how the water demand of Maputo can be accommodated.

The water demand for other users is based on previous reports, namely:

- Joint Incomati Basin Study (JIBS), Consultec and BKS (2001)
- Three Basins Study, SWECO and Associates (2005a)
- Joint Umbeluzi River Basin Study (JURBS), SWECO and Associates (2005b)
- Joint Maputo River Basin Study (JMRBS), PLANCENTER and Associates (2008)

Details of the water demand estimates can be found in these reports.

3.2 Catchment subdivision

To enable input to the water balance analysis and to give a distributed picture of the water demand, the demand data have been compiled for sub-catchments. The appropriate level chosen was the tertiary river basins as defined by DWAF for South Africa and Swaziland. A corresponding subdivision of the Mozambican part of the three river basins was conducted. Figure 3.1 illustrates the subbasins for which water demand data are presented in this report.

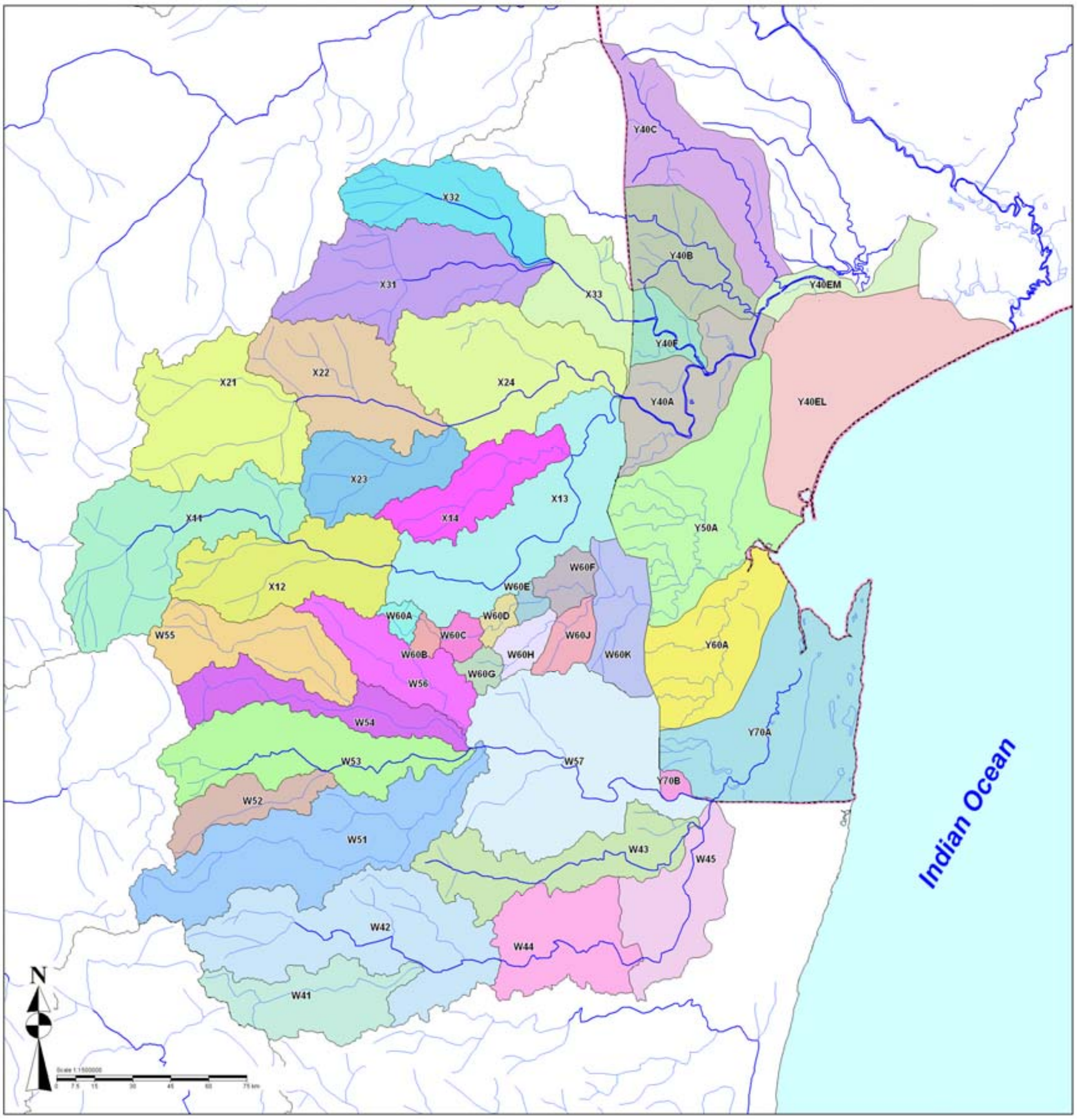

Figure 3.1 Sub-catchments of the Incomati River Basin.

3.2.1 Incomati River Basin – present and future water demand

The JIBS report was produced in a first phase in 1995, with limited inputs from Mozambique, and then completed in 2001. The various components of water demand that were analysed included domestic and municipal use, irrigation, industry and mining, afforestation, livestock, water transfers, fisheries. For each type of use, the present and future water requirements in each country (South Africa, Swaziland and Mozambique) were estimated. Table 3.1 gives a summary of the water requirements in the Incomati River basin referred to the year 1991.

Table 3.1 Water demand (1991) for various uses in the three countries in the Incomati basin

COUNTRY	DOMESTIC	IRRIGATION	INDUSTRY	AFFORE-STATION	LIVE-STOCK	WATER TRANSFER	TOTAL	
	Mm^3/year	Mm^3/year	Mm^3/year	Mm^3/year	Mm^3/year	Mm^3/year	Mm^3/year	%
South Africa	55	594	21.4	473	8.5	132	1282	76
Swaziland*	3.8	175	0	45	1.9	7.8	234	14
Mozambique	2.8	85	10.6	75	0.9	0	174	10
TOTAL	61	853	32	593	11	139	1689	

**The irrigation water requirements in Swaziland include a water transfer from the Komati basin to the Umbeluzi basin.*

Estimates for the year 2005 indicate that the total amount of water consumption increased to about 2,000 Mm^3/year, of which about 1,500 in South Africa, 300 in Swaziland and 200 in Mozambique. The JIBS report estimated the following future water demand in the three countries (Table 3.2):

Table 3.2 Future water demand for various uses in the three countries in the Incomati basin according to JIBS.

COUNTRY	DOMESTIC	IRRIGATION	INDUSTRY	AFFORE-STATION	LIVE-STOCK	WATER TRANSFER	TOTAL	
	Mm^3/year	Mm^3/year	Mm^3/year	Mm^3/year	Mm^3/year	Mm^3/year	Mm^3/year	%
South Africa	206.9	820.55	21.4	472.64	8.45	131.47	1661.41	60
Swaziland*	14.98	250.01	0	45.48	1.94	7.8	320.21	11
Mozambique	11.42	614.96	10.6	75	1.15	94.1	807.23	29
TOTAL	233.3	1685.52	32	593.12	11.54	233.37	2788.85	100

**The irrigation water requirements in Swaziland include a water transfer from the Komati basin to the Umbeluzi basin.*

While the total future water demands in Table 3.2 are quite similar to the values defined in the IIMA for South Africa and Swaziland (totals of 1,598 and of 329 Mm^3/year compared with 1,661 and 320), the total for Mozambique is much lower – 324 compared with 807 Mm^3/year, with the most significant reduction in irrigation (280 Mm^3/year allocated while the JIBS report refers to about 615). The figure of 324 Mm^3/year does not include the amount of 87.6 Mm^3/year that has been reserved for Maputo water supply.

For the part of the catchment in South Africa and Swaziland, the Consultant derived detailed data from an on-going study (Incomati Water Availability Assessment Study, IWAAS) for the year 2004. These demands where then escalated for 2007 and up to 2030 (Table 3.4). The projections in South Africa were made assuming no expansion in irrigation and afforestation because of the limitation of water availability, while domestic use was increased in accordance with the National Water Resources Strategy. In Komati in Swaziland the irrigation was escalated in accordance with the rates used in the JMRBS for the Usutu keeping in mind the IIMA limitations. The figures were aggregated and distributed by the tertiary catchments. For Mozambique, it is planned to expand irrigation in the Sabie catchment with another 10,000 ha.

Table 3.3 and Figure 3.2 present a summary of the water demand by country.

Table 3.3 Evolution of water demand in each country in the Incomati River basin, excluding any transfer to Maputo City (Mm^3/year).

TOTALS	**Year**					
	2007	**2010**	**2015**	**2020**	**2025**	**2030**
SOUTH AFRICA	1,581	1,585	1,592	1,598	1,604	1,610
SWAZILAND	258	277	291	306	306	306
MOZAMBIQUE	217	217	277	317	317	317
TOTAL	**2,056**	**2,079**	**2,166**	**2,221**	**2,227**	**2,233**

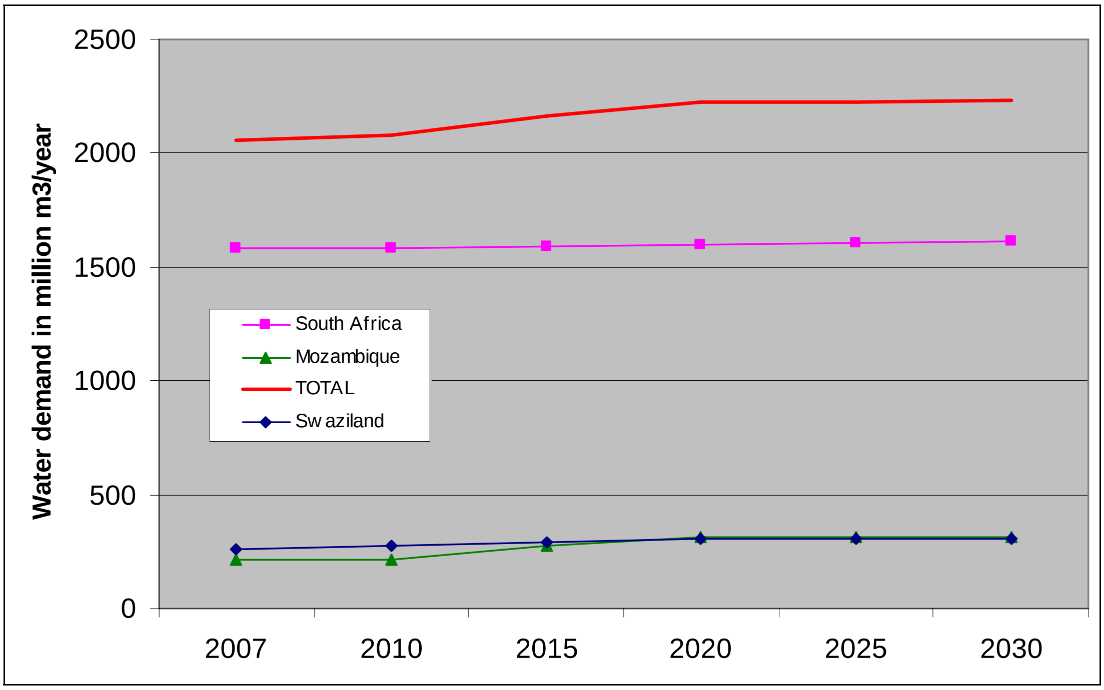

Figure 3.2 Development of water demand within the Incomati River basin, excluding any transfer to Maputo City.

Table 3.4 Estimates of present (2007) and future water demand in the Incomati catchment, excluding any transfer to Maputo City.

Million m3/year		2007						
Tertiary catchment	Quats	**Domestic**	**Industry**	**Mining**	**Irrigation**	**Forestry**	**Transfers out**	**Total**
X11	X11A - X11K	0.62	0.00	0.10	13.83	31.10	105.00	151
X12	X12A - X12K	4.29	0.00	0.00	3.54	39.30	0.00	47
X13	X13A - X13L	12.05	0.56	0.00	385.68	18.40	121.83	539
X14	X14A - X14H	5.09	0.00	0.00	99.58	28.50	7.80	141
X21	X21A - X21K	1.74	13.37	0.00	22.93	52.00	0.00	90
X22	X22A - X22K	40.43	0.00	0.00	182.28	65.80	0.00	289
X23	X23A - X23H	0.00	0.00	0.00	90.58	39.70	0.00	130
X24	X24A - X24H	8.05	8.98	0.00	218.47	0.40	0.00	236
X31	X31A - X31M	18.53	0.00	0.00	82.81	85.80	6.48	194
X32	X32A - X32J	2.35	0.00	0.00	17.29	3.90	0.00	24
X33	X33A - X33D	0.00	0.00	0.00	0.00	0.00	0.00	0
Total Swaziland and South Africa		**93**	**23**	**0**	**1117**	**365**	**241**	**1839**
Y40A	N/A	1.02	0.00	0.00	1.00	0.00	0.00	2
Y40F	N/A	0.00	0.00	0.00	4.00	0.00	0.00	4
Y40B	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0
Y40C	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0
Y40D	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0
Y40EM	N/A	0.50	5.30	0.00	100.00	0.00	0.00	106
Y40EL	N/A	0.00	5.30	0.00	75.00	25.00	0.00	105
Total Mozambique		**2**	**11**	**0**	**180**	**25**	**0**	**217**
TOTAL INKOMATI		**95**	**34**	**0**	**1297**	**390**	**241**	**2056**
		2010						
Tertiary catchment	Quats	**Domestic**	**Industry**	**Mining**	**Irrigation**	**Forestry**	**Transfers out**	**Total**
X11	X11A - X11K	0.65	0.00	0.10	13.83	31.10	105.00	151
X12	X12A - X12K	4.48	0.00	0.00	3.54	39.30	0.00	47
X13	X13A - X13L	12.55	0.56	0.00	403.12	18.40	121.83	556
X14	X14A - X14H	5.31	0.00	0.00	100.98	28.50	7.80	143
X21	X21A - X21K	1.81	13.37	0.00	22.93	52.00	0.00	90
X22	X22A - X22K	42.19	0.00	0.00	182.28	65.80	0.00	290
X23	X23A - X23H	0.00	0.00	0.00	90.58	39.70	0.00	130
X24	X24A - X24H	8.40	8.98	0.00	218.47	0.40	0.00	236
X31	X31A - X31M	19.34	0.00	0.00	82.81	85.80	6.48	194
X32	X32A - X32J	2.45	0.00	0.00	17.29	3.90	0.00	24
X33	X33A - X33D	0.00	0.00	0.00	0.00	0.00	0.00	0
Total Swaziland and South Africa		**97**	**23**	**0**	**1136**	**365**	**241**	**1862**
Y40A	N/A	1.04	0.00	0.00	1.00	0.00	0.00	2
Y40F	N/A	0.00	0.00	0.00	4.00	0.00	0.00	4
Y40B	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0
Y40C	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0
Y40D	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0
Y40EM	N/A	0.51	5.30	0.00	100.00	0.00	0.00	106
Y40EL	N/A	0.00	5.30	0.00	75.00	25.00	0.00	105
Total Mozambique		**2**	**11**	**0**	**180**	**25**	**0**	**217**
TOTAL INKOMATI		**99**	**34**	**0**	**1316**	**390**	**241**	**2079**
		2015						
Tertiary catchment	Quats	**Domestic**	**Industry**	**Mining**	**Irrigation**	**Forestry**	**Transfers out**	**Total**
X11	X11A - X11K	0.69	0.00	0.10	13.83	31.10	105.00	151
X12	X12A - X12K	4.77	0.00	0.00	3.54	39.30	0.00	48
X13	X13A - X13L	13.35	0.56	0.00	416.55	18.40	121.83	571
X14	X14A - X14H	5.66	0.00	0.00	102.06	28.50	7.80	144
X21	X21A - X21K	1.93	13.37	0.00	22.93	52.00	0.00	90
X22	X22A - X22K	44.93	0.00	0.00	182.28	65.80	0.00	293
X23	X23A - X23H	0.00	0.00	0.00	90.58	39.70	0.00	130
X24	X24A - X24H	8.95	8.98	0.00	218.47	0.40	0.00	237
X31	X31A - X31M	20.59	0.00	0.00	82.81	85.80	6.48	196
X32	X32A - X32J	2.61	0.00	0.00	17.29	3.90	0.00	24
X33	X33A - X33D	0.00	0.00	0.00	0.00	0.00	0.00	0
Total Swaziland and South Africa		**103**	**23**	**0**	**1150**	**365**	**241**	**1883**
Y40A	N/A	1.07	0.00	0.00	1.00	0.00	0.00	2
Y40F	N/A	0.00	0.00	0.00	64.00	0.00	0.00	64
Y40B	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0
Y40C	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0
Y40D	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0
Y40EM	N/A	0.53	5.30	0.00	100.00	0.00	0.00	106
Y40EL	N/A	0.00	5.30	0.00	75.00	25.00	0.00	105
Total Mozambique		**2**	**11**	**0**	**240**	**25**	**0**	**277**
TOTAL INKOMATI		**105**	**34**	**0**	**1390**	**390**	**241**	**2160**

Table 3.4 (Cont.) Estimates of present (2007) and future water demand in the Incomati catchment, excluding any transfer to Maputo City.

Million m3/year		**2020**						
tertiary catchment	Quats	**Domestic**	**Industry**	**Mining**	**Irrigation**	**Forestry**	**Transfers out**	**Total**
X11	X11A - X11K	0.73	0.00	0.10	13.83	31.10	105.00	151
X12	X12A - X12K	5.06	0.00	0.00	3.54	39.30	0.00	48
X13	X13A - X13L	14.15	0.56	0.00	429.98	18.40	121.83	585
X14	X14A - X14H	6.00	0.00	0.00	103.13	28.50	7.80	145
X21	X21A - X21K	2.05	13.37	0.00	22.93	52.00	0.00	90
X22	X22A - X22K	47.66	0.00	0.00	182.28	65.80	0.00	296
X23	X23A - X23H	0.00	0.00	0.00	90.58	39.70	0.00	130
X24	X24A - X24H	9.49	8.98	0.00	218.47	0.40	0.00	237
X31	X31A - X31M	21.85	0.00	0.00	82.81	85.80	6.48	197
X32	X32A - X32J	2.77	0.00	0.00	17.29	3.90	0.00	24
X33	X33A - X33D	0.00	0.00	0.00	0.00	0.00	0.00	0
Total Swaziland and South Africa		**110**	**23**	**0**	**1165**	**365**	**241**	**1904**
Y40A	N/A	1.10	0.00	0.00	1.00	0.00	0.00	2
Y40F	N/A	0.00	0.00	0.00	104.00	0.00	0.00	104
Y40B	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0
Y40C	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0
Y40D	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0
Y40EM	N/A	0.54	5.30	0.00	100.00	0.00	0.00	106
Y40EL	N/A	0.00	5.30	0.00	75.00	25.00	0.00	105
Total Mozambique		**2**	**11**	**0**	**280**	**25**	**0**	**317**
TOTAL INKOMATI		**111**	**34**	**0**	**1445**	**390**	**241**	**2221**
		2025						
tertiary catchment	Quats	**Domestic**	**Industry**	**Mining**	**Irrigation**	**Forestry**	**Transfers out**	**Total**
X11	X11A - X11K	0.77	0.00	0.10	13.83	31.10	105.00	151
X12	X12A - X12K	5.33	0.00	0.00	3.54	39.30	0.00	48
X13	X13A - X13L	14.90	0.56	0.00	430.22	18.40	121.83	586
X14	X14A - X14H	6.32	0.00	0.00	103.15	28.50	7.80	146
X21	X21A - X21K	2.16	13.37	0.00	22.93	52.00	0.00	90
X22	X22A - X22K	50.20	0.00	0.00	182.28	65.80	0.00	298
X23	X23A - X23H	0.00	0.00	0.00	90.58	39.70	0.00	130
X24	X24A - X24H	10.00	8.98	0.00	218.47	0.40	0.00	238
X31	X31A - X31M	23.01	0.00	0.00	82.81	85.80	6.48	198
X32	X32A - X32J	2.92	0.00	0.00	17.29	3.90	0.00	24
X33	X33A - X33D	0.00	0.00	0.00	0.00	0.00	0.00	0
Total Swaziland and South Africa		**116**	**23**	**0**	**1165**	**365**	**241**	**1910**
Y40A	N/A	1.14	0.00	0.00	1.00	0.00	0.00	2
Y40F	N/A	0.00	0.00	0.00	104.00	0.00	0.00	104
Y40B	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0
Y40C	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0
Y40D	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0
Y40EM	N/A	0.56	5.30	0.00	100.00	0.00	0.00	106
Y40EL	N/A	0.00	5.30	0.00	75.00	25.00	0.00	105
Total Mozambique		**2**	**11**	**0**	**280**	**25**	**0**	**317**
TOTAL INKOMATI		**117**	**34**	**0**	**1445**	**390**	**241**	**2227**
		2030						
tertiary catchment	Quats	**Domestic**	**Industry**	**Mining**	**Irrigation**	**Forestry**	**Transfers out**	**Total**
X11	X11A - X11K	0.81	0.00	0.10	13.83	31.10	105.00	151
X12	X12A - X12K	5.60	0.00	0.00	3.54	39.30	0.00	48
X13	X13A - X13L	15.64	0.56	0.00	430.46	18.40	121.83	587
X14	X14A - X14H	6.64	0.00	0.00	103.17	28.50	7.80	146
X21	X21A - X21K	2.27	13.37	0.00	22.93	52.00	0.00	91
X22	X22A - X22K	52.74	0.00	0.00	182.28	65.80	0.00	301
X23	X23A - X23H	0.00	0.00	0.00	90.58	39.70	0.00	130
X24	X24A - X24H	10.50	8.98	0.00	218.47	0.40	0.00	238
X31	X31A - X31M	24.17	0.00	0.00	82.81	85.80	6.48	199
X32	X32A - X32J	3.06	0.00	0.00	17.29	3.90	0.00	24
X33	X33A - X33D	0.00	0.00	0.00	0.00	0.00	0.00	0
Total Swaziland and South Africa		**121**	**23**	**0**	**1165**	**365**	**241**	**1916**
Y40A	N/A	1.18	0.00	0.00	1.00	0.00	0.00	2
Y40F	N/A	0.00	0.00	0.00	104.00	0.00	0.00	104
Y40B	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0
Y40C	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0
Y40D	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0
Y40EM	N/A	0.58	5.30	0.00	100.00	0.00	0.00	106
Y40EL	N/A	0.00	5.30	0.00	75.00	25.00	0.00	105
Total Mozambique		**2**	**11**	**0**	**280**	**25**	**0**	**317**
TOTAL INKOMATI		**123**	**34**	**0**	**1445**	**390**	**241**	**2233**

3.3 Maputo River basin – present and future water demand

The Joint Maputo River Basin Study (JMRBS) was finalized in 2009. Present (2005) and future water demands were estimated for the three countries, considering domestic urban and rural water supply, irrigation, forestry, industry and bulk water uses and water transfers. Table 3.6 summarises the estimates of future water demands in the Maputo basin based on the JMRBS.

Table 3.5 and Figure 3.3 present a summary of the water demand by country.

Table 3.5 Evolution of water demand in each country in the Incomati River basin, excluding any transfer to Maputo City (Mm^3/year).

TOTALS	**Year**					
	2007	**2010**	**2015**	**2020**	**2025**	**2030**
SOUTH AFRICA	746	748	749	750	752	753
SWAZILAND	649	697	801	803	805	808
MOZAMBIQUE	7	14	25	25	25	25
TOTAL	**1,402**	**1,458**	**1,575**	**1,578**	**1,582**	**1,586**

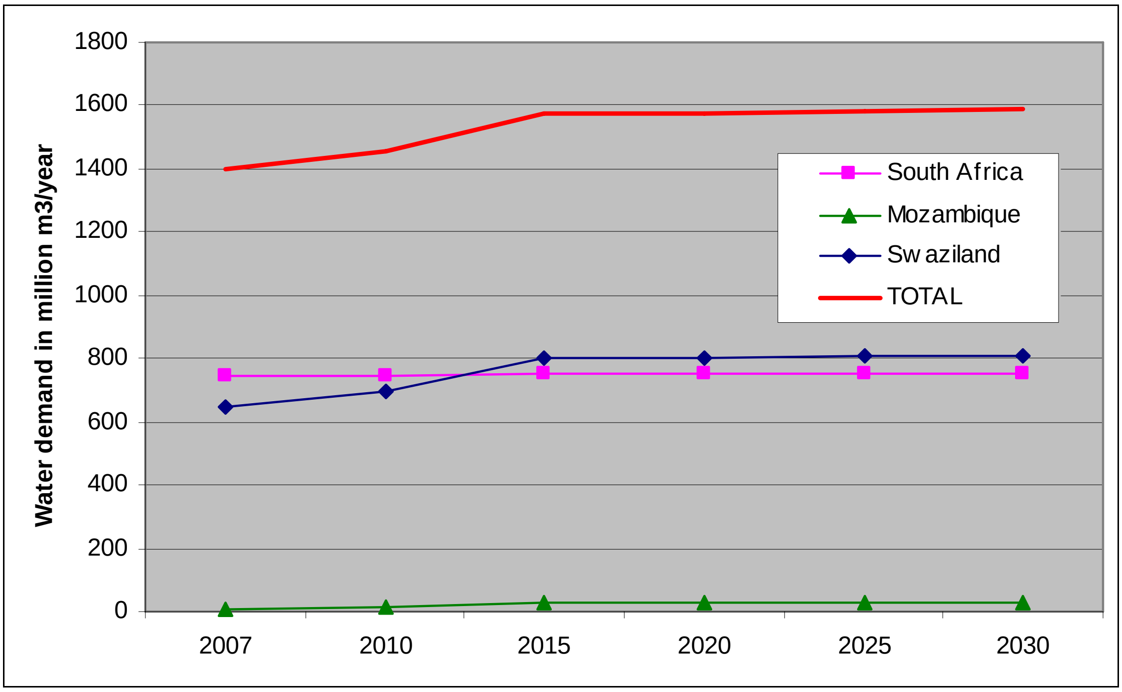

Figure 3.3 Development of water demand within the Maputo River basin, excluding any transfer to Maputo City.

Table 3.6 Estimates of present (2007) and future water demand in the Maputo River basin, excluding any transfer to Maputo City (Mm^3/year).

Million m3/year		2007							
Tertiary catchment	Quats	**Domestic**	**Industry**	**Mining**	**Irrigation**	**Forestry**	**Transfers out**	**Livestock**	**Total**
W41	W41A - G	0.83	0.00	0.01	0.86	29.30	0.00	0.92	32
W42	W42A - M	3.01	0.04	0.00	10.79	68.41	0.00	2.71	85
W43	W43A - F	1.41	0.16	0.00	42.30	3.90	0.00	2.29	50
W44	W44A - E	1.01	2.50	0.00	205.52	0.00	33.00	2.04	244
W45	W45A - B	2.23	0.00	0.00	69.68	0.00	0.00	1.34	73
W51	W51A - H	2.15	3.69	0.00	7.40	84.70	60.00	2.59	161
W52	W52A - D	0.36	0.19	0.24	1.08	35.90	0.00	0.50	38
W53	W53A - G	1.02	0.13	0.00	3.06	55.80	71.00	2.05	133
W54	W54A - G	1.17	24.56	0.00	17.90	51.40	0.00	1.29	96
W55	W55A - E	1.34	0.09	0.00	0.94	68.50	0.00	1.68	73
W56	W56A - F	16.23	4.17	0.00	23.39	55.10	0.00	1.29	100
W57	W57A - K	2.53	3.75	0.00	300.08	0.10	0.00	3.53	310
Total Swaziland and South Africa		**33**	**39**	**0**	**683**	**453**	**164**	**22**	**1395**
Y70B	N/A	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0
Y70A	N/A	0.16	0.00	0.00	6.90	0.00	0.00	0.00	7
Y60A	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Total Mozambique		**0**	**0**	**0**	**7**	**0**	**0**	**0**	**7**
TOTAL MAPUTO		**34**	**39**	**0**	**690**	**453**	**164**	**22**	**1402**
		2010							
Tertiary catchment	Quats	**Domestic**	**Industry**	**Mining**	**Irrigation**	**Forestry**	**Transfers out**	**Livestock**	**Total**
W41	W41A - G	0.86	0.00	0.01	0.88	29.30	0.00	0.92	32
W42	W42A - M	3.12	0.04	0.00	11.09	68.41	0.00	2.71	85
W43	W43A - F	1.46	0.16	0.00	42.53	3.90	0.00	2.29	50
W44	W44A - E	1.05	2.50	0.00	205.67	0.00	33.00	2.04	244
W45	W45A - B	2.31	0.00	0.00	69.72	0.00	0.00	1.34	73
W51	W51A - H	2.23	3.69	0.00	7.61	84.70	60.00	2.59	161
W52	W52A - D	0.37	0.19	0.24	1.11	35.90	0.00	0.50	38
W53	W53A - G	1.06	0.13	0.00	3.14	55.80	71.00	2.05	133
W54	W54A - G	1.22	24.56	0.00	18.20	51.40	0.00	1.29	97
W55	W55A - E	1.39	0.09	0.00	0.94	68.50	0.00	1.68	73
W56	W56A - F	17.02	4.17	0.00	23.75	55.10	0.00	1.29	101
W57	W57A - K	2.62	3.75	0.00	346.43	0.10	0.00	3.53	356
Total Swaziland and South Africa		**35**	**39**	**0**	**731**	**453**	**164**	**22**	**1445**
Y70B	N/A	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0
Y70A	N/A	0.16	0.00	0.00	13.46	0.00	0.00	0.00	14
Y60A	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Total Mozambique		**0**	**0**	**0**	**13**	**0**	**0**	**0**	**14**
TOTAL MAPUTO		**35**	**39**	**0**	**745**	**453**	**164**	**22**	**1458**
		2015							
Tertiary catchment	Quats	**Domestic**	**Industry**	**Mining**	**Irrigation**	**Forestry**	**Transfers out**	**Livestock**	**Total**
W41	W41A - G	0.90	0.00	0.01	0.92	29.30	0.00	0.92	32
W42	W42A - M	3.25	0.04	0.00	11.51	68.41	0.00	2.71	86
W43	W43A - F	1.51	0.16	0.00	42.95	3.90	0.00	2.29	51
W44	W44A - E	1.09	2.50	0.00	205.71	0.00	33.00	2.04	244
W45	W45A - B	2.41	0.00	0.00	69.72	0.00	0.00	1.34	73
W51	W51A - H	2.32	3.69	0.00	7.97	84.70	60.00	2.59	161
W52	W52A - D	0.39	0.19	0.24	1.17	35.90	0.00	0.50	38
W53	W53A - G	1.09	0.13	0.00	3.28	55.80	71.00	2.05	133
W54	W54A - G	1.26	24.56	0.00	18.72	51.40	0.00	1.29	97
W55	W55A - E	1.45	0.09	0.00	0.94	68.50	0.00	1.68	73
W56	W56A - F	17.94	4.17	0.00	24.38	55.10	0.00	1.29	103
W57	W57A - K	2.71	3.75	0.00	447.38	0.10	0.00	3.53	457
Total Swaziland and South Africa		**36**	**39**	**0**	**835**	**453**	**164**	**22**	**1550**
Y70B	N/A	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0
Y70A	N/A	0.17	0.00	0.00	24.41	0.00	0.00	0.00	25
Y60A	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Total Mozambique		**0**	**0**	**0**	**24**	**0**	**0**	**0**	**25**
TOTAL MAPUTO		**37**	**39**	**0**	**859**	**453**	**164**	**22**	**1575**

Table 3.6 (Cont.) Estimates of present (2007) and future water demand in the Maputo River basin, excluding any transfer to Maputo City (Mm^3/year).

Million m3/year		2020							
Tertiary catchment	Quats	**Domestic**	**Industry**	**Mining**	**Irrigation**	**Forestry**	**Transfers out**	**Livestock**	**Total**
W41	W41A - G	0.92	0.00	0.01	0.95	29.30	0.00	0.92	32
W42	W42A - M	3.32	0.04	0.00	11.83	68.41	0.00	2.71	86
W43	W43A - F	1.53	0.16	0.00	43.24	3.90	0.00	2.29	51
W44	W44A - E	1.12	2.50	0.00	205.73	0.00	33.00	2.04	244
W45	W45A - B	2.46	0.00	0.00	69.72	0.00	0.00	1.34	74
W51	W51A - H	2.36	3.69	0.00	8.31	84.70	60.00	2.59	162
W52	W52A - D	0.40	0.19	0.24	1.22	35.90	0.00	0.50	38
W53	W53A - G	1.11	0.13	0.00	3.42	55.80	71.00	2.05	133
W54	W54A - G	1.29	24.56	0.00	19.02	51.40	0.00	1.29	98
W55	W55A - E	1.48	0.09	0.00	0.94	68.50	0.00	1.68	73
W56	W56A - F	18.78	4.17	0.00	24.65	55.10	0.00	1.29	104
W57	W57A - K	2.75	3.75	0.00	447.92	0.10	0.00	3.53	458
Total Swaziland and South Africa		**38**	**39**	**0**	**837**	**453**	**164**	**22**	**1553**
Y70B	N/A	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0
Y70A	N/A	0.17	0.00	0.00	24.41	0.00	0.00	0.00	25
Y60A	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Total Mozambique		**0**	**0**	**0**	**24**	**0**	**0**	**0**	**25**
TOTAL MAPUTO		**38**	**39**	**0**	**861**	**453**	**164**	**22**	**1578**

		2025							
Tertiary catchment	Quats	**Domestic**	**Industry**	**Mining**	**Irrigation**	**Forestry**	**Transfers out**	**Livestock**	**Total**
W41	W41A - G	0.94	0.00	0.01	0.98	29.30	0.00	0.92	32
W42	W42A - M	3.39	0.04	0.00	12.17	68.41	0.00	2.71	87
W43	W43A - F	1.56	0.16	0.00	43.53	3.90	0.00	2.29	51
W44	W44A - E	1.14	2.50	0.00	205.66	0.00	33.00	2.04	244
W45	W45A - B	2.52	0.00	0.00	69.68	0.00	0.00	1.34	74
W51	W51A - H	2.41	3.69	0.00	8.67	84.70	60.00	2.59	162
W52	W52A - D	0.40	0.19	0.24	1.27	35.90	0.00	0.50	39
W53	W53A - G	1.12	0.13	0.00	3.56	55.80	71.00	2.05	134
W54	W54A - G	1.32	24.56	0.00	19.33	51.40	0.00	1.29	98
W55	W55A - E	1.51	0.09	0.00	0.94	68.50	0.00	1.68	73
W56	W56A - F	19.64	4.17	0.00	24.94	55.10	0.00	1.29	105
W57	W57A - K	2.80	3.75	0.00	448.72	0.10	0.00	3.53	459
Total Swaziland and South Africa		**39**	**39**	**0**	**839**	**453**	**164**	**22**	**1557**
Y70B	N/A	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0
Y70A	N/A	0.17	0.00	0.00	24.41	0.00	0.00	0.00	25
Y60A	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Total Mozambique		**0**	**0**	**0**	**24**	**0**	**0**	**0**	**25**
TOTAL MAPUTO		**39**	**39**	**0**	**864**	**453**	**164**	**22**	**1582**

		2030							
Tertiary catchment	Quats	**Domestic**	**Industry**	**Mining**	**Irrigation**	**Forestry**	**Transfers out**	**Livestock**	**Total**
W41	W41A - G	0.95	0.00	0.01	1.01	29.30	0.00	0.92	32
W42	W42A - M	3.47	0.04	0.00	12.50	68.41	0.00	2.71	87
W43	W43A - F	1.58	0.16	0.00	43.83	3.90	0.00	2.29	52
W44	W44A - E	1.17	2.50	0.00	205.58	0.00	33.00	2.04	244
W45	W45A - B	2.58	0.00	0.00	69.65	0.00	0.00	1.34	74
W51	W51A - H	2.45	3.69	0.00	9.03	84.70	60.00	2.59	162
W52	W52A - D	0.41	0.19	0.24	1.33	35.90	0.00	0.50	39
W53	W53A - G	1.13	0.13	0.00	3.70	55.80	71.00	2.05	134
W54	W54A - G	1.35	24.56	0.00	19.63	51.40	0.00	1.29	98
W55	W55A - E	1.54	0.09	0.00	0.94	68.50	0.00	1.68	73
W56	W56A - F	20.51	4.17	0.00	25.23	55.10	0.00	1.29	106
W57	W57A - K	2.84	3.75	0.00	449.53	0.10	0.00	3.53	460
Total Swaziland and South Africa		**40**	**39**	**0**	**842**	**453**	**164**	**22**	**1561**
Y70B	N/A	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0
Y70A	N/A	0.17	0.00	0.00	24.41	0.00	0.00	0.00	25
Y60A	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Total Mozambique		**0**	**0**	**0**	**24**	**0**	**0**	**0**	**25**
TOTAL MAPUTO		**40**	**39**	**0**	**866**	**453**	**164**	**22**	**1586**

3.4 Umbeluzi River basin – present and future water demand

Although South Africa has a small area within the Umbeluzi River basin, it has taken mostly the role of observer and the basin water resources are in fact allocated between Swaziland and Mozambique.

Water demand estimates for the future were prepared and presented in the JURBS report, finalized in 2005. They included:

- Swaziland – urban water supply to Mbabane and other towns, rural water supply, irrigation, industry, livestock and game
- Mozambique – urban water supply to the Greater Maputo area, rural water supply, irrigation, forestry, industry.

In Swaziland, the major water user by far is irrigation, with a large area dedicated to sugar cane. In Mozambique, the major water user is the Greater Maputo water supply system.

Table 3.8 summarises the water demand estimates in the Umbeluzi River basin. The estimates of domestic water demand in Mozambique have been changed in relation to the JURBS report, considering the figures derived for the most probable scenario for the Greater Maputo water demand and recent data from ARA-Sul concerning other water users.

Table 3.7 and Figure 3.4 present a summary of the water demand by country.

Table 3.7 Evolution of water demand in each country in the Umbeluzi River basin (Mm^3/year).

TOTALS	**Year**					
	2007	**2010**	**2015**	**2020**	**2025**	**2030**
SWAZILAND	260	271	294	313	332	350
MOZAMBIQUE (other uses)	25	34	34	44	44	45
Maputo City	67	76	87	106	123	141
TOTAL	**352**	**381**	**415**	**462**	**498**	**535**

Table 3.8 Estimates of present (2007) and future water demands in the Umbeluzi River basin (Mm3/year)

Million m3/year	**2007**					
Tertiary catchment	**Domestic**	**Industry**	**Irrigation**	**Forestry**	**Livestock**	**Total**
W60A	7.85	0.00	0.00	0.00	0.00	8
W60B	0.43	0.00	0.00	0.00	0.66	1
W60D	0.00	0.00	5.88	0.00	0.00	6
W60E	0.00	0.00	89.35	0.00	0.00	89
W60F	0.00	0.00	139.33	0.00	0.00	139
W60G	0.29	0.00	0.00	0.00	0.65	1
W60J	0.00	0.00	0.71	0.00	0.00	1
W60K	3.51	11.41	0.00	0.00	0.00	15
Total Swaziland	**12**	**11**	**235**	**0**	**1**	**260**
Y50A	0.70	2.00	19.20	3.00	0.00	25
Y60A	0.00	0.00	0.00	0.00	0.00	0
Maputo City	67.00					67
Total Mozambique	**68**	**2**	**19**	**3**	**0**	**92**
TOTAL UMBELUZI	**80**	**13**	**254**	**3**	**1**	**352**

	2010					
Tertiary catchment	**Domestic**	**Industry**	**Irrigation**	**Forestry**	**Livestock**	**Total**
W60A	8.58	0.00	0.00	0.00	0.00	9
W60B	0.52	0.00	0.00	0.00	0.73	1
W60D	0.00	0.00	5.88	0.00	0.00	6
W60E	0.00	0.00	94.06	0.00	0.00	94
W60F	0.00	0.00	144.14	0.00	0.00	144
W60G	0.35	0.00	0.00	0.00	0.72	1
W60J	0.00	0.00	0.71	0.00	0.00	1
W60K	3.76	13.31	0.00	0.00	0.00	17
Total Swaziland	**13**	**13**	**245**	**0**	**1**	**271**
Y50A	0.90	2.00	27.90	3.00	0.00	34
Y60A	0.00	0.00	0.00	0.00	0.00	0
Maputo City	76.10					76
Total Mozambique	**77**	**2**	**28**	**3**	**0**	**110**
TOTAL UMBELUZI	**90**	**15**	**273**	**3**	**1**	**381**

	2015					
Tertiary catchment	**Domestic**	**Industry**	**Irrigation**	**Forestry**	**Livestock**	**Total**
W60A	9.79	0.00	0.00	0.00	0.00	10
W60B	0.66	0.00	0.00	0.00	0.83	1
W60D	0.00	0.00	5.88	0.00	0.00	6
W60E	0.00	0.00	101.89	0.00	0.00	102
W60F	0.00	0.00	152.15	0.00	0.00	152
W60G	0.44	0.00	0.00	0.00	0.83	1
W60J	0.00	0.00	0.71	0.00	0.00	1
W60K	4.16	16.47	0.00	0.00	0.00	21
Total Swaziland	**15**	**16**	**261**	**0**	**2**	**294**
Y50A	1.10	2.00	27.90	3.00	0.00	34
Y60A	0.00	0.00	0.00	0.00	0.00	0
Maputo City	87.30					87
Total Mozambique	**88**	**2**	**28**	**3**	**0**	**121**
TOTAL UMBELUZI	**103**	**18**	**289**	**3**	**2**	**415**

Table 3.8 (Cont.) Estimates of present (2007) and future water demands in the Umbeluzi River basin (Mm3/year)

Million m3/year	2020					
Tertiary catchment	**Domestic**	**Industry**	**Irrigation**	**Forestry**	**Livestock**	**Total**
W60A	11.43	0.00	0.00	0.00	0.00	11
W60B	0.96	0.00	0.00	0.00	0.98	2
W60D	0.00	0.00	5.88	0.00	0.00	6
W60E	0.00	0.00	109.73	0.00	0.00	110
W60F	0.00	0.00	160.16	0.00	0.00	160
W60G	0.64	0.00	0.00	0.00	0.98	2
W60J	0.00	0.00	0.71	0.00	0.00	1
W60K	4.74	16.47	0.00	0.00	0.00	21
Total Swaziland	**18**	**16**	**276**	**0**	**2**	**313**
Y50A	1.55	2.00	37.20	3.00	0.00	44
Y60A	0.00	0.00	0.00	0.00	0.00	0
Maputo City	106.00					106
Total Mozambique	**108**	**2**	**37**	**3**	**0**	**150**
TOTAL UMBELUZI	**125**	**18**	**314**	**3**	**2**	**462**

	2025					
Tertiary catchment	**Domestic**	**Industry**	**Irrigation**	**Forestry**	**Livestock**	**Total**
W60A	13.06	0.00	0.00	0.00	0.00	13
W60B	1.26	0.00	0.00	0.00	1.13	2
W60D	0.00	0.00	5.88	0.00	0.00	6
W60E	0.00	0.00	117.57	0.00	0.00	118
W60F	0.00	0.00	168.16	0.00	0.00	168
W60G	0.84	0.00	0.00	0.00	1.13	2
W60J	0.00	0.00	0.71	0.00	0.00	1
W60K	5.31	16.47	0.00	0.00	0.00	22
Total Swaziland	**20**	**16**	**292**	**0**	**2**	**332**
Y50A	2.00	2.00	37.20	3.00	0.00	44
Y60A	0.00	0.00	0.00	0.00	0.00	0
Maputo City	122.50					123
Total Mozambique	**125**	**2**	**37**	**3**	**0**	**167**
TOTAL UMBELUZI	**145**	**18**	**330**	**3**	**2**	**498**

	2030					
Tertiary catchment	**Domestic**	**Industry**	**Irrigation**	**Forestry**	**Livestock**	**Total**
W60A	15.67	0.00	0.00	0.00	0.00	16
W60B	1.51	0.00	0.00	0.00	1.24	3
W60D	0.00	0.00	5.88	0.00	0.00	6
W60E	0.00	0.00	123.45	0.00	0.00	123
W60F	0.00	0.00	176.57	0.00	0.00	177
W60G	1.01	0.00	0.00	0.00	1.24	2
W60J	0.00	0.00	0.71	0.00	0.00	1
W60K	6.37	16.47	0.00	0.00	0.00	23
Total Swaziland	**25**	**16**	**307**	**0**	**2**	**350**
Y50A	2.50	2.00	37.20	3.00	0.00	45
Y60A	0.00	0.00	0.00	0.00	0.00	0
Maputo City	140.50					141
Total Mozambique	**143**	**2**	**37**	**3**	**0**	**185**
TOTAL UMBELUZI	**168**	**18**	**344**	**3**	**2**	**535**

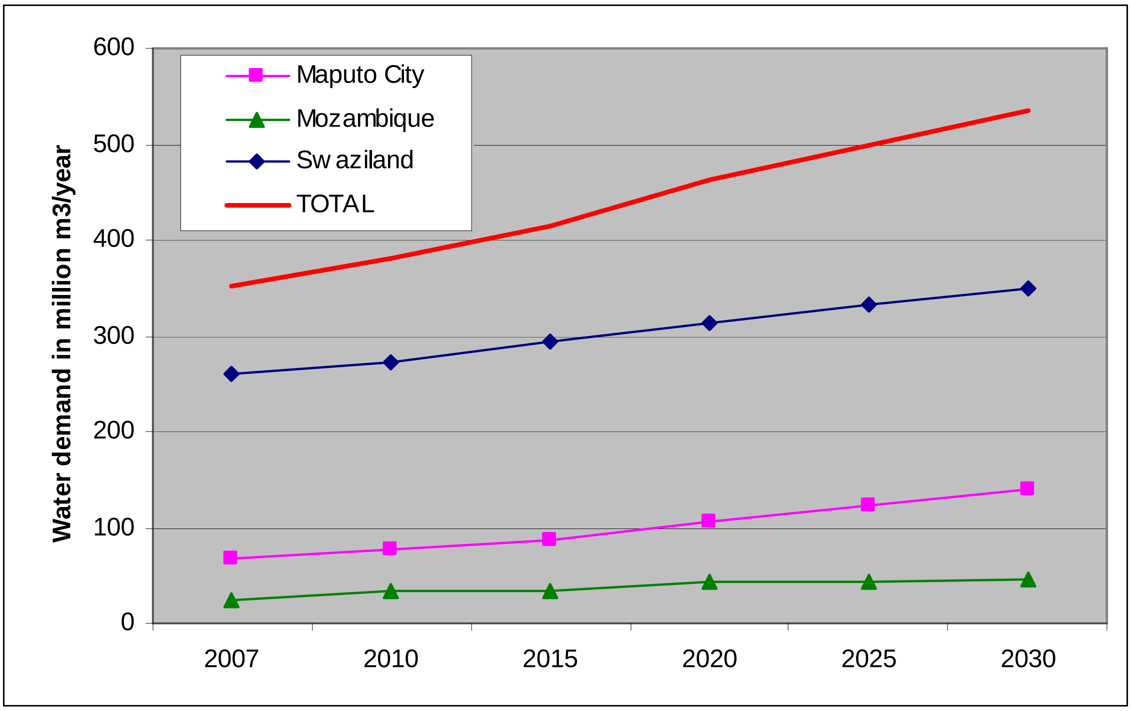

Figure 3.4 Development of water demand within the Umbeluzi River basin.

4 ENVIRONMENTAL FLOWS

4.1 Introduction

4.1.1 Methodology and Objectives

This chapter summaries the detailed review made by Brown and Reinecke (2008). The approach adopted for the environmental flow assessment was mainly to review previous studies of environmental flow requirements and determinations. Both published and unpublished studies have been reviewed.

The objective with the review was the following:

- Evaluate the ecological condition of the Incomati, Umbeluzi and Maputo Rivers and the Maputo, Espirito Santo and Incomati estuaries
- Come up with recommendations for environmental flows in the studied rivers.
- Assess environmental flow recommendations for estuaries around the world and thereafter give recommendations for the Maputo, Espirito Santo and Incomati estuaries.

Time constraints, and the fact that much of the literature is unpublished, means that the reports assembled are not a comprehensive list of all estuarine environmental flow studies undertaken. There is also a bias towards studies from southern and eastern Africa. Nonetheless, in our opinion, they are sufficient to provide an overview of environmental flow recommendations and degree of implementation for estuaries. The full list of reports and papers read is given in Reference chapter, regardless of whether or not they were eventually referred to in this report.

4.1.2 Definition of Environmental flow

Environmental Flows may be defined as an allocation of water with a prescribed distribution in space and time, and of a specific quality, that is deliberately left in a river, or released into it, to manage river health and the integrity of ecosystems and communities sustained by river flows (Watson, 2006; adapted from SADC, 2002).

4.2 Ecological Condition of the Incomati, Umbeluzi and Maputo Rivers

There are several reports and datasets that provide estimates of the ecological condition of the studied rivers. For the purposes of this assessment, a selection of those conducted in the last decade, *viz*. since 1999, was considered.

These selected studies included:

AfriDev (2000)	The First Phase of a Cumulative Environmental Impact Assessment for the Inkomati River Basin.
AfriDev (2005)	Resource Unit Report. Komati Catchment Ecological Water Requirements Study
Brown (1997)	Instream Flow Requirements for the Bivane River.
DWAF (2005)	Desktop GIS based estimates of ecological status for the mainstream rivers in the quaternary catchments in South Africa, generated by DWAF.
DWAF (2008)	Preliminary Reserve and Resource Class Determination undertaken for the Usutu River, Cumulative at the outlet of Quaternary Catchment W57K.
Godfrey (2002)	Ecological Reserve Determination for the Crocodile River Catchment, Incomati System, Mpumalanga.
Louw (2007)	Maputo River Intermediate Environmental Flow Requirements Assessment Task Report.
Louw & Koekemoer (2007)	Maputo River Intermediate EcoClassification of four EFR sites.
Paterson (2008)	Long Term Implications of Freshwater Abstraction on the Maputo Estuary and Bay.
Sengo *et al*. (2005)	Valuing environmental water pulses into the Incomati estuary.
SWECO and Ass. (2005b)	Joint Umbeluzi River Basin Study. Final Report.

The ecological condition assessments in each of the reports vary slightly depending on the method used and the level of detail considered. Ecological condition also differs between the instream and riparian portions of the rivers, with the instream portion generally in better condition than the riparian portion. The bulk of the reports reported ecological condition in accordance with the South African ecological condition categories as summarized in Table 19. Where this was not the case, we used the information in the reports to estimate the ecological condition category, and have marked the reference with an asterisk to denote this.

4.2.1 Incomati River Basin

The ecological condition estimates for the main rivers in the Incomati catchment are summarised in Table 4.1.

Table 4.1 Ecological condition for the rivers in the Incomati catchment

River	River-Reach	Ecological condition	Reference
Komati	Inkomati-Upper	Largely natural-Moderately modified	AfriDev (2005)
	Inkomati-Lower	Seriously modified	
	Gladdespruit	Largely modified	
	Seekoespruit	Largely natural	
	Teespruit	Largely natural	
	Mlumati	Largely natural	
	Lomati	Largely modified	
Crocodile	Crocodile-Upper	Largely natural-Moderately modified	Godfrey (2002)
	Crocodile-Middle	Moderately modified	
	Crocodile-Lower	Moderately modified	
	Kaap	Moderately modified	
Sabie	Sabie-Upper	Largely natural	Louw (2002)
	Sabie-Kruger	Largely natural	
	Sabie-Lower	Largely natural	
	Marite	Largely natural	
	Mutlumuvi	Largely natural-Moderately modified	
	Sand River	Largely natural	
Incomati	Incomati-Lower	Moderately modified	Afridev (2000)*
	Estuary	Moderately modified	Sengo *et al*. (2005)*

**Ecological condition category estimated by authors from information in report.*

4.2.2 Umbeluzi River

The SWECO study divided the Umbeluzi River into Preliminary Resource Units (PRUs; Figure 4.1) and these are used in the summary of the ecological condition of the main rivers in the Umbeluzi catchment (Table 4.2).

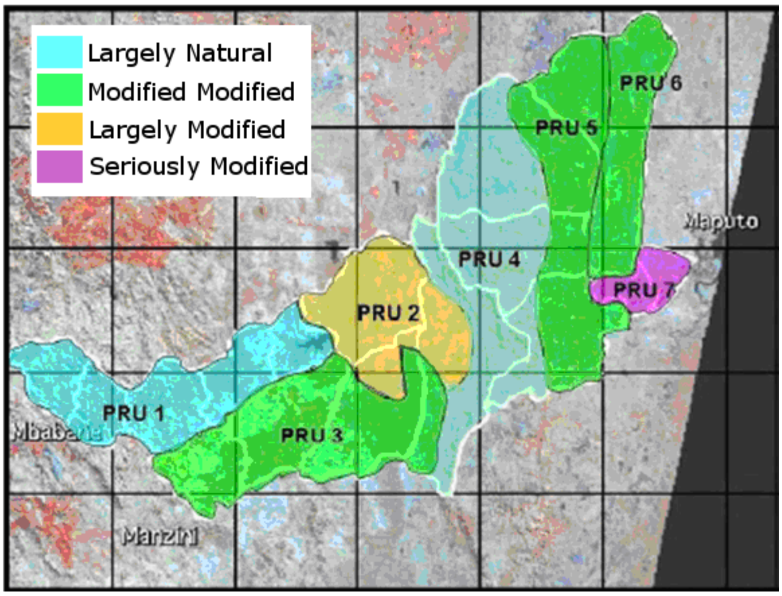

Figure 4.1 Ecological conditions for PRUs in the Umbeluzi River (from SWECO, 2005b).

Table 4.2 Ecological condition for the rivers in the Umbeluzi Catchment

River	**River-Reach**	**Ecological condition**	**Reference**
Umbeluzi	PRU 1	Largely natural	SWECO (2005b)
	PRU 2	Largely modified	
	PRU 3	Moderately modified	
	PRU 4	Largely natural	
	PRU 5	Moderately modified	
	PRU 6	Moderately modified	
	PRU 7	Seriously modified	

4.2.3 Maputo River

The ecological condition estimates for the main rivers in the Maputo catchment are summarised in Table 4.3.

Table 4.3 Ecological condition for the rivers in the Maputo Catchment

River	**River-Reach**	**Ecological condition**	**Reference**
Pongola	Pongola-Upper	Largely natural	Brown (1997)
	Pongola-Lower	Moderately modified-Largely modified	DWAF (2005)
	Bivane-Upper	Largely natural-Moderately modified	Brown (1997)
	Bivane-Lower	Unknown	-
Usutu	Mainstream	Largely natural	DWAF (2008)
	Ngwempisi-Upper	Moderately modified-Largely modified	Louw and Koekemoer (2007)
	Ngwempisi-Lower	Moderately modified	
	Mkondvo-Upper	Moderately modified-Largely modified	
	Mkondvo-Middle	Moderately modified	
	Mkondvo-Lower	Moderately modified	
Maputo	Maputo-Upper	Moderately modified-Largely modified	Louw and Koekemoer (2007)
	Maputo-Middle	Moderately modified	
	Maputo-Lower	Moderately modified	
	Estuary	Moderately modified	Paterson *et al.* (2008)

4.3 Environmental Flow Recommendations for the Incomati, Umbeluzi and Maputo Rivers

Most of the environmental flow work undertaken in these rivers has been in the South African and Swaziland portions of the catchments. The Incomati catchment has received a considerable amount of attention, partly because it was the focus of much of the early developmental work that was done in the build up to the 1998 Water Act (NWA 1998). Much of the work done in the 1990 was, however, repeated once the procedures for the determination of the Ecological Reserve (NWA 1998; DWAF 1999) became established. Thus, for the purposes of this review, we concentrated on the more recent studies, as these tend to be more uniform in their approach and in their outputs.

The available recommended environmental flows (as a percentage of MAR) for the maintenance of present ecological condition and, where applicable, for the recommended ecological condition, in the rivers are provided in Table 4.4.

The environmental flow determinations were done at using various methods involving varying levels of effort and resolution. Details of the methods used can be found in the references provided. The levels of effort expended in determining the environmental flows requirements are summarized as follows:

Rapid: *c*. 2 person days per site, including a site visit to visually assess ecological condition. Uses monthly hydrological data (usually WR90) and no hydraulic cross-sections. Determinations done using the standard extrapolated relationships in the Desktop Model (Hughes and Hannart, 2003). This is synonymous with the DWAF (1999) Rapid II Procedures for Reserve determinations.

Medium: *c*. 2 person weeks per site, including a one-day site visit and data collection. Daily or monthly site-specific hydrological data used in conjunction with hydraulic cross-sections. Determinations arrived at through consensus among a full specialist team. This is synonymous with the DWAF (1999) Intermediate Procedures for Reserve determinations.

Detailed: *c*. 3-5 person weeks per site, including two to three one-day site visits and data collection covering at least two seasons. Daily site-specific hydrological data used in conjunction with hydraulic cross-sections. Determinations arrived at through consensus among a full specialist team. This is synonymous with the DWAF (1999) Comprehensive Procedures for Reserve determinations.

Research: Research activities targeted at a particular aspect of ecosystem functioning, e.g., saltwater intrusion in estuaries, which provides some guidance on environmental flows but is not a complete environmental flow assessment.

Also, most of the South African Reserve determinations do not stipulate floods with a return period of two years or greater, even although these are usually required if these rivers are to be maintained in their target conditions, and should be added to the overall requirements (Brown and Magoba, 2008). Addition of these floods to the requirement would increase the percentage MAR requested.

Table 4.4 Recommended environmental flows for the study rivers

Catchment	River	Condition	Percentage MAR	Effort	Reference
Incomati	Komati	Largely natural/ Moderately modified	21.2%	Detailed	AfriDev (2005)
	Komati	Moderately modified	14.6%	Detailed	AfriDev (2005)
	Mlumati	Moderately modified	18.1%	Detailed	AfriDev (2005)
	Komati	Largely modified	28.8%	Detailed	AfriDev (2005)
	Gladdespruit	Largely modified	25.5%	Detailed	AfriDev (2005)
	Teespruit	Moderately modified	36.5%	Detailed	AfriDev (2005)
	Lomati	Largely modified	11.8%	Detailed	AfriDev (2005)
	Crocodile-Upper	Largely natural	39.8%	Medium	Godfrey (2002)
		Largely natural	51.8%	Medium	Godfrey (2002)
	Crocodile-Middle	Moderately modified	29.3%	Medium	Godfrey (2002)
	Crocodile-Lower	Largely natural	20.0%	Medium	Godfrey (2002)
	Sabie	Largely natural	32.0%	Rapid	Hughes (undat.)
	Elands	Largely natural	38.8%	Detailed	Hill (2005)
		Moderately modified	25.0%		
		Largely natural	34.0%	Detailed	Hill (2005)
		Moderately modified	19.3%		
Umbeluzi		Largely natural	42.2%	Rapid	SWECO (2005b)
		Largely modified	16.5%	Rapid	SWECO (2005b)
		Moderately modified	22.1%	Rapid	SWECO (2005b)
		Largely natural	-	Rapid	SWECO (2005b)
		Moderately modified	-	Rapid	SWECO (2005b)
		Moderately modified	19.5%	Rapid	SWECO (2005b)
		Seriously modified	15.1%	Rapid	SWECO (2005b)
Maputo	Usutu (Upper)	Largely natural	43%	Rapid	DWAF (2008)
	Ngwempisi-Lower	Largely natural/ Moderately modified	31.3%	Medium	Louw (2007)
		Moderately modified	26.3%		
	Mkondvo-Upper	Largely Natural/ Moderately modified	24.8%	Medium	Louw (2007)
		Moderately modified	21.8%		
	Mkondvo-Lower	Moderately modified	19.2%	Medium	Louw (2007)
	Maputo-Lower	Largely natural/ Moderately modified	24.3%	Medium	Louw (2007)
		Moderately modified	21.1%		
	Bivane-Upper	Largely natural/ Moderately modified	22.1%	Medium	Brown (1997)
	Bivane-Lower	Largely natural/ Moderately modified	31.3%	Medium	Brown (1997)

4.4 Review of Environmental flow recommendations for Estuaries

'*Estuaries are semi-enclosed coastal bodies of water which have a free connection with the open sea and within which sea water is measurably diluted with freshwater from land drainage*' (Pritchard, 1967 cited in Olson *et al*., undated).

Freshwater inflow to estuaries is a fundamental part of estuarine physics and chemistry, morphology and biology. The mixing of fresh- and saltwater and the materials they contain create and sustain a unique type of environment that is among the most productive of any on earth (Nixon *et al.*, 2004; and others).

The amounts, duration and intensity of freshwater events influence estuarine geomorphology, water temperature, salinity, pH, turbidity, nutrient status, organic inputs, dissolved oxygen concentrations, olfactory cues, mouth status, tidal prism, habitat diversity, primary and secondary productivity, fish recruitment, food availability and competition. Changes in all or a combination of these factors can have a direct effect on vertebrate and invertebrate abundance and distribution within the system (Whitfield, 1996, 2005 cited in Paterson *et al*., 2006).

This is because ecological processes in estuaries occur along gradients of salinity and other water quality features, and are influenced by river and seawater inflows. Because seawater is denser than fresh water, water entering from the rivers usually forms a layer of fresh water over the heavier seawater (Pritchard, 1967). Therefore the deeper water of an estuary may be saline, while the upper layers are fresh, or nearly so. Wind, the volume of freshwater inflows and the geometry of the estuary all influence the degree of mixing between freshwater and seawater.

The duration and frequency with which the estuary is open to the sea depends on river flows, the state of the tide, the degree of mouth protection, and the size and shape of the system. These factors influence the numbers and types of estuarine plants and animals that occur in an estuary, and hence its overall condition. Reduced flooding leads to less scouring, so an estuary may silt up and the mouth remain closed for longer periods than is natural, thus changing the connectivity with the marine environment, the salinity gradients, and ultimately the animal and plant species that live there (Brown and Magoba, 2008).

4.4.1 The Ecological Effects Changes in Freshwater Inflow to Estuaries

Freshwater inflows to an estuary fluctuate in a response to surface runoff from tributary catchments. The abstraction of water and/or construction of major dams in upstream catchment areas reduce both the volumes of freshwater runoff and the freshwater flushing of estuaries. In times of drought, freshwater inflows may be absent, or may consist principally of the constant discharge of sewage effluent and other wastewaters.

The potential impacts of a change in quantity, quality and timing of freshwater inflows to estuaries will depend to some extent on the location and nature of the estuary but, in general, comprise those listed in Table 4.5.

Table 4.5 The potential effects of reduction in the volume, and changes in the timing, of freshwater inflows to estuaries (from Olsen et al., undated; Paterson et al., 2006; Whitfield, 1998; Whitfield and Harrison, 2003)

Type of change to freshwater inflow	Potential impacts on estuary functions	Potential human impacts
Reduction in quantity (volume) of freshwater inflow.	Increased salinity; die-offs of salinity sensitive plants, e.g., mangroves; reductions in crustacean populations; reductions in salinity-sensitive fish. Reduced nutrient inputs; reduced plant and animal productivity. Reduced sediment recharge; loss of wetland habitat. Increase in marine deposits, upsetting the sediment balance in the lower reaches and reducing tidal flow into the estuary. Reduced tidal flux resulting in hypersaline conditions and decreased productivity. Reduced flushing leading to longer residence times and accumulation of pollutants. Erosion as a result of loss of tidal damping. Loss of sea connection resulting in fundamental change in the functioning of the estuary.	Reduced harvests of economically important fish and shellfish. Changes for estuary-dependent human populations including loss of livelihood for fishing communities. Reduction in area of habitats with tourist appeal. Reduction in recreational value of waters and in real-estate value of surrounding lands. Health risks associated with poor water quality. Property losses as a result of flooding or bank erosion.
Changes in timing	Destruction or degradation of habitats that are adapted to seasonal pulses of freshwater and seasonal changes in salinity. Reductions in population of organisms adapted to seasonal pulses of freshwater.	

4.4.2 Flow-related Recommendations for the Maputo Bay Estuaries

The Maputo Bay estuaries have a strong marine linkage, large mangroves and varied (year-on-year) inflow patterns (Monteiro and Matthews, 2003, Paterson *et al*., 2008). They also play a vital support role for coastal fisheries in the bay (Monteiro and Matthews, 2003) and migrant bird populations (Sengo *et al*., 2005). Useful summaries of the characteristics of the individual estuaries and their socio-economic importance can be found Paterson *et al*. (2008; Maputo Estuary), Sengo *et al.* (2005, Incomati Estuary).

Most reports on the Maputo Bay estuaries make reference to the deleterious effects of reduced freshwater inflows, with specific reference to the loss of:

- 'small' floods (e.g., AfriDev, 2000; Louw, 2007; Paterson, 2008; Sengo, 2003; Sengo *et al*., 2005, Van der Zaag and Carmo Vaz, 2003), as these seasonal freshwater pulses cause the modest flooding of the floodplains that enhances the yield of shrimps, fish, fuel wood and other goods and services (Sengo *et al*. 2005); and,

- dry season low flows (Paterson, 2008; Sengo, 2003) as reduce inflow results in salinity intrusion.

There have been no detailed studies of the Maputo Bay estuaries, although every report reviewed made some sort of a recommendation that a detailed study should be undertaken (e.g., AfriDev, 2000; Louw, 2007; Paterson, 2008; Sengo *et al*. 2005). Dr Paterson also makes the point that 'there is no shortage of sediment in Maputo Bay and possibility exists for a net influx of sediments into the estuaries, thus it would be useful to determine the vulnerability of the Maputo Estuary to mouth closure (Dr Angus Paterson, SAEON, personal communication). There are, however, one or two research projects that provide insight into the likely magnitude of portions of the environmental flows.

Incomati: The minimum recommended river flow required to prevent saltwater intrusion upstream of 20 km is 35 m^3/s (Brockway *et al*., 2005). This would constitute *c*. 28% of the MAR.

Umbeluzi In the Joint Umbeluzi Basin Study (SWECO and Associates, 2005b) the environmental flow allocations for the estuary focused on floods and requested a flood with a magnitude of 30 Mm^3 once every two years. This was based on environmental flow work done for the assessment of the Pequenos Libombos Dam. Presumably this was in addition to the 15.1% MAR requested for the river immediately upstream of the estuary. Thus, according to the provisions made in (SWECO and Associates, 2005), the total environmental flows from the Umbeluzi River for the Espirito Santo Estuary would be in the order of 21.6% of MAR.

Maputo: A minimum monthly flow rate of 21 m^3/s is said to prevent saltwater intrusion upstream of 30 km from the mouth (DNA, 1982). This would constitute *c*. 19% of the MAR.

Maputo Bay: Recommendations from the Catchment2Coast project (C2C; Monteiro, *et al*., 2006) for the protection of Maputo Bay suggest that that the volume of flow required in the wet seasons from the Incomati River is 500 Mm^3, i.e., 13% of MAR, and from the Maputo River is 250 Mm^3, i.e., 7% of MAR Maputo River. A flood release of freshwater combined with a minimum flow requirement to maintain the salinity below 20 was regarded as being the best way in which to maximise the resilience of ecosystem services. 13% and 7%, respectively, seem low for the environmental flows of such an important system. It is, however, difficult to know exactly what the exact objectives were of these flows or if any other portions of the flow regime were recommended as only the abstract and not the main report was available for this study.

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INKOMATI WATER MANAGEMENT AREA

PRESENT WATER USE (DEMAND)

	Domestic, industry, mining, transfer out					Irrigation					Forestry					TOTAL				Transfer	
Catch-	IWAAS	MWS		IIMA		IWAAS	MWS		IIMA		IWAAS	MWS		IIMA		IWAAS	MWS		IIMA	IWAAS	M
ment	2004	2007	2027	RSA	Swazilan	2004	2007	2027	RSA	Swazilan	2004	2007	2027	RSA	Swazilan	2004	2007	2027		2004	2007
X11	80.6	79.4	79.5				13.9	13.9			27.3	31.1	31.1				124.4	124.4		79.6	78.7
X12	4.2	8.6	10.9				3.4	3.4			31.5	39.3	39.3				51.3	53.6			
X13	133.1	137.9	182.9				452.1	489.7			12.6	18.4	18.4				608.4	691.0		117.7	117.7
X14	12.1	12.9	15.0				138.2	196.6			26.1	28.5	28.5				179.6	240.1		7.2	7.8
Komati	**230.0**	**238.8**	**288.3**	**183.0**	**22.0**	**565.0**	**607.6**	**703.5**	**381.0**	**261.0**	**97.5**	**117.3**	**117.3**	**99.0**	**46.0**	**892.5**	**963.6**	**1109.1**	**992.0**	**204.5**	**204.2**
X21	15.1	15.3	15.7				21.3	21.3			48.5	52.0	52.0				88.5	89.0			
X22	39.0	12.5	15.8				149.0	149.0			71.4	65.8	65.8				227.4	230.7			
X23	-4.2	0.0	0.0				91.7	91.7			35.1	39.7	39.7				131.4	131.4		-7.2	
X24	13.5	50.9	63.7				192.4	192.4			0.3	0.4	0.4				243.8	256.5		-6.4	-6.4
Crocodile	**63.3**	**78.7**	**95.2**	**73.0**		**482.0**	**454.4**	**454.4**	**307.0**		**155.2**	**157.9**	**157.9**	**247.0**		**700.6**	**691.0**	**707.5**	**627.0**	**-13.7**	**-6.4**
X31	7.5	7.8	9.8				66.7	66.7			90.3	85.8	85.8				160.2	162.3		6.4	18.4
X32	9.8	0.0	0.0				9.8	9.8			3.2	3.9	3.9				13.7	13.7			
X33	0.0	0.0	0.0				0.0	0.0			0.0	0.0	0.0				0.0	0.0			
Sabie	**17.3**	**7.8**	**9.8**	**80.0**		**77.0**	**76.5**	**76.5**	**98.0**		**93.5**	**89.7**	**89.7**	**129.0**		**187.8**	**173.9**	**176.0**	**307.0**	**6.4**	**18.4**
TOTAL	**310.6**	**325.2**	**393.3**	**336.0**	**22.0**	**1124.0**	**1138.4**	**1234.4**	**786.0**	**261.0**	**346.2**	**364.9**	**364.9**	**475.0**	**46.0**	**1780.9**	**1828.5**	**1992.6**	**1926.0**	197.3	216.2
				358.0					**1047.0**					**521.0**							

over estimated

under estimated

within WMA

internal-n

IWAAS _Inkomati Water Availability Assessment Study

MWS - Maputo Water Availability Assessment Study

IIMA- Interim IncoMaputo Agreement

s
WS
2027
78.7
159.65
8.61
247.0
-6.4
-6.4
18.4
18.4

259.0

ot counted

TPTC

Progressive Realisation of the IncoMaputo Agreement

Augmentation of Water Supply for the City of Maputo and Metropolitan Areas – IAAP 4

TPTC

Progressive Realisation of the IncoMaputo Agreement

Augmentation of Water Supply for the City of Maputo and Metropolitan Areas – IAAP 4

Fact Sheet

1 – Objective of Project

Overall objective

To study in detail the **forecasts of water requirements for the City of Maputo and its metropolitan area** and the possibility of supplying these from the **Umbeluzi River watercourse**, **augmented by new supplies** from the Incomati and the Maputo watercourses and/or groundwater resources and by increasing water use efficiencies and other water demand management measures.

Specific objective

To **provide details and options** to meet the **growing water requirements** of the city of Maputo and the greater Maputo Metropolitan Area, to be approved and considered by Mozambique, South Africa and Swaziland **to enable an amendment of Annex 1** of the Interim Agreement for the Incomati and the Maputo rivers (IIMA).

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Progressive Realisation of the IncoMaputo Agreement

Augmentation of Water Supply for the City of Maputo and Metropolitan Areas – IAAP 4

Fact Sheet

2 – Implementing Consortium

SWECO International AB, Sweden (lead); CONSULTEC Lda, Mozambique; BKS, South Africa; DHI Water, Environment, Health, Denmark

3 – Implementation Period

1 October 2008 until 31 December 2009

4 – Contract Value

Euro 433,069.-

5 – Deliverables

The following reports have been produced (both in English and Portuguese):

- Inception Report
- Water Demand Report
- Water Availability Report
- Water Balance Report
- Water Supply Strategies for Greater Maputo Area until 2030
- Final Project Report

- 6 Workshops of which 4 in Maputo, 1 in South-Africa and 1 in Swaziland
- 3 Two-day training courses in Maputo

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Progressive Realisation of the IncoMaputo Agreement

Augmentation of Water Supply for the City of Maputo and Metropolitan Areas – IAAP 4

Main Conclusions

Proposed Strategies for the short-term (up to 2015) are:

Strategy 1 –

Development of a transfer scheme for 43.8 Mm^3/year from the **completed Corumana Dam** to Maputo City in parallel with:

- Exploiting groundwater resources north of Maputo City and;
- Implementing Water Demand Management measures, as well as;
- Feasibility studies for long-term infrastructural solutions and;
- Finalisation of water-sharing agreements.

Corumana Dam option because:

- Preparatory studies are already being initiated and
- Funding is partially secured, which make it possible to implement before 2014. *(The option that can probably be implemented first of all alternatives)*

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Progressive Realisation of the IncoMaputo Agreement

Augmentation of Water Supply for the City of Maputo and Metropolitan Areas – IAAP 4

Main Conclusions

Proposed Strategies for the short-term (up to 2015) are:

Strategy 2 –
Development of a transfer scheme for 43.8 Mm^3/year from the **Maputo River upstream of Salamanga** in parallel with:

- Exploiting groundwater resources north of Maputo City and;
- Implementing Water Demand Management measures, as well as;
- Feasibility studies for long-term infrastructural solutions and;
- Finalisation of water-sharing agreements.

Option of intake and off-channel-storage dam in Maputo River close to Salamanga because:

- It seems to be the most cost-efficient alternative and
- The relatively lean infrastructural solution makes the lead time comparably short, although no preparatory studies have yet been conducted.

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Augmentation of Water Supply for the City of Maputo and Metropolitan Areas – IAAP 4

Main Conclusions

Both **short-term strategies** are followed by the implementation of infrastructure in 2016-2020 for the **long-term solution**.

Alternatives are:
Moamba Major dam;
Groundwater north of Marracuene and
Further development of the Maputo River.

The **final choice** of the **long-term solution** must therefore be made in 2012, following the **finalisation of the water sharing agreements** and **updated preparatory studies**, to allow preparatory works and tendering procedures.

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Augmentation of Water Supply for the City of Maputo and Metropolitan Areas – IAAP 4

Way Forward

In parallel with the preparation for the **short-term solution**, it is essential:

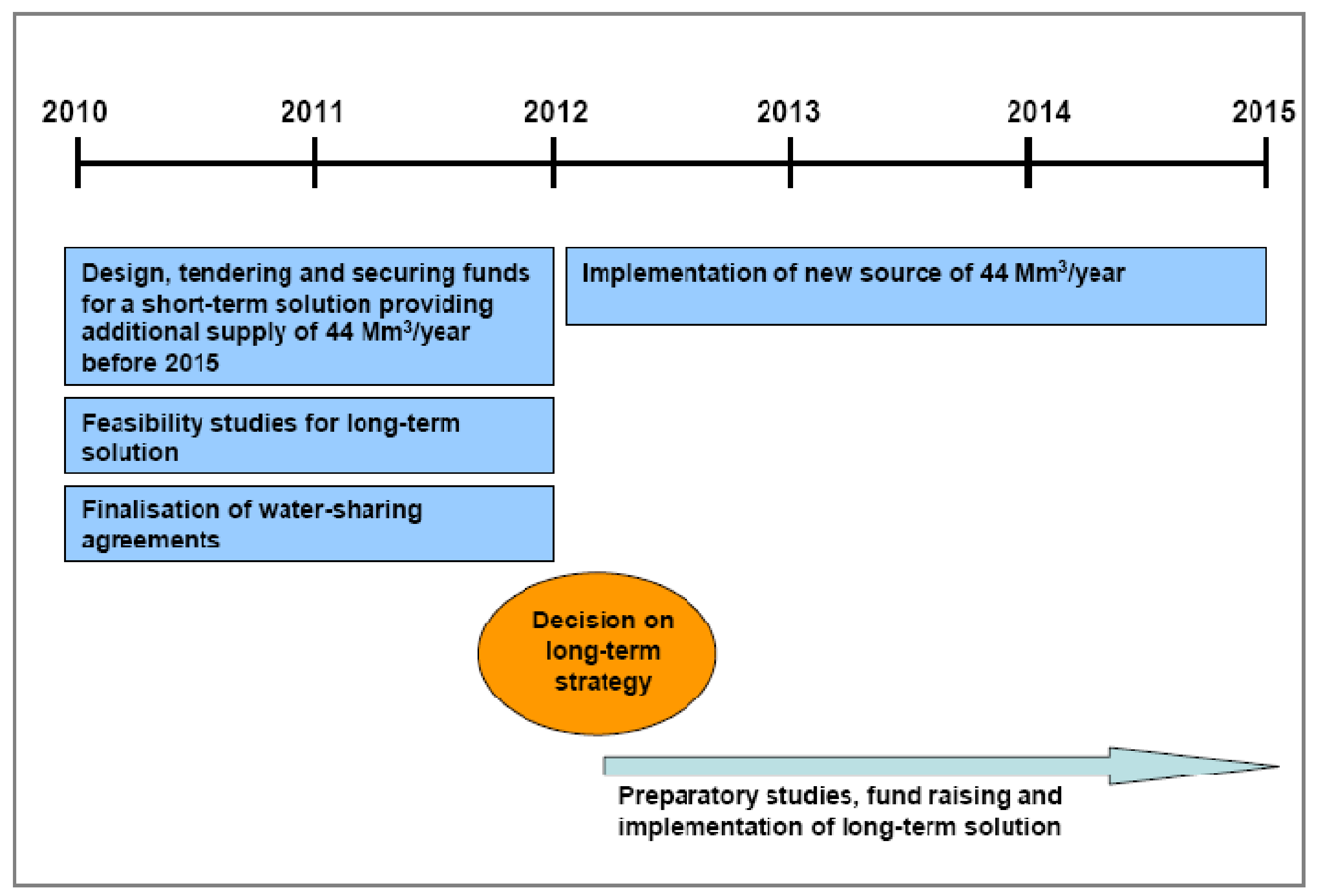
- To conduct ***Feasibility studies and ESIA*** for long-term solution and;
- To ***finalize the negotiations for water sharing agreements*** for all three rivers during the coming years.

This should enable the Mozambican Government to take the final decision on the **long-term strategy** for the Maputo water supply.

Progressive Realisation of the IncoMaputo Agreement

Augmentation of Water Supply for the City of Maputo and Metropolitan Areas – IAAP 4

Objective of CB&T Plan



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Progressive Realisation of the IncoMaputo Agreement

Augmentation of Water Supply for the City of Maputo and Metropolitan Areas – IAAP 4

Proposed Studies

- Develop a plan for ***reaching compliance of the IIMA allocations*** in South Africa and Swaziland;
- Finalize the ***updated Annex 1 of IIMA*** and a ***water-sharing agreement for the Umbeluzi River***;
- ***Updated feasibility and ESIA study*** for the multi-purpose ***Moamba Major Dam***;
- ***Feasibility and ESIA study*** for ***groundwater scheme north of Marracuene***, including GW modelling and test pumping;
- ***Feasibility and ESIA study*** for ***Maputo River intake***, off-shore storage, pipeline and WTP, incl. water quality monitoring;
- ***Final decision on long term water-supply*** strategy for Maputo City and southern Mozambique

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Progressive Realisation of the IncoMaputo Agreement

Augmentation of Water Supply for the City of Maputo and Metropolitan Areas – IAAP 4

Next Steps

- Approval / Endorsement of ***Report on Water Supply Strategies for Greater Maputo Area until 2030*** by TPTC;
- Approval / Endorsement of the ***Final Project Report*** by TPTC;
- Role of PRIMA? Implementation of (part of) the proposed studies?

TPTC

Progressive Realisation of the IncoMaputo Agreement

Project on Augmentation of Water Supply for the City of Maputo and Metropolitan Areas – IAAP 8

Thank you for your Attention

Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

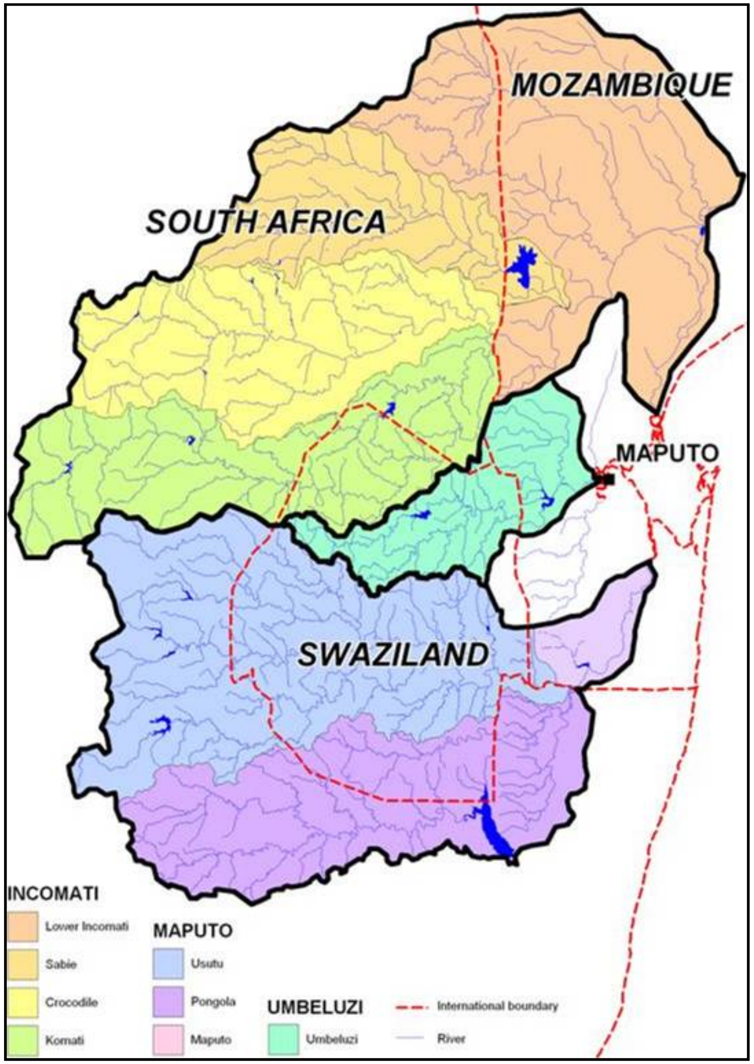
Half-day Workshop 3 August 2009, Pretoria

Water Supply Strategies for Greater Maputo until 2030

OVERALL OBJECTIVE

- *Project water requirements for the City of Maputo*
- *Possibility of supplying these from the Umbeluzi River*
- *Possibility to augment by*
  - *Incomati and Maputo watercourses*
  - *Groundwater resources*
  - *Water demand management measures*

Study Area


MOZAMBIQUE
SOUTH AFRICA
MAPUTO
SWAZILAND
INCOMATI
Lower Incomati
Sabie
Crocodile
Komati
MAPUTO
Usutu
Pongola
Maputo
UMBELUZI
Umbeluzi
International boundary
River

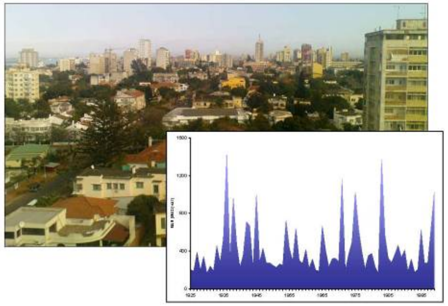
Basic info

Programme:	Progressive Realisation of the IncoMaputo Agreement (PRIMA)
Client:	Tripartite Permanent Technical Committee (TPTC) of Mozambique, Swaziland and South Africa
Consultant:	SWECO International, DHI, BKS, CONSULTEC
Time:	Oct 2008 – Sep 2009
Funds:	Dutch Government

WORK DONE PREVIOUSLY IN THE PROJECT

Tripartite Permanent Technical Committee (TPTC) between Mozambique, South Africa and Swaziland
Progressive Realization of the IncoMaputo Agreement (PRIMA)

Augmentation of Water Supply to the City of Maputo and its Metropolitan Area



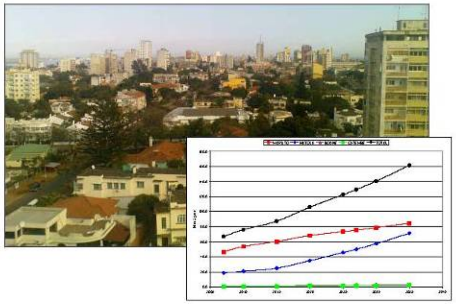
Water Availability Report

Final Report 22 July 2009

SWECO International
DHI, BKS, CONSULTEC

Tripartite Permanent Technical Committee (TPTC) between Mozambique, South Africa and Swaziland
Progressive Realization of the IncoMaputo Agreement (PRIMA)

Augmentation of Water Supply to the City of Maputo and its Metropolitan Area



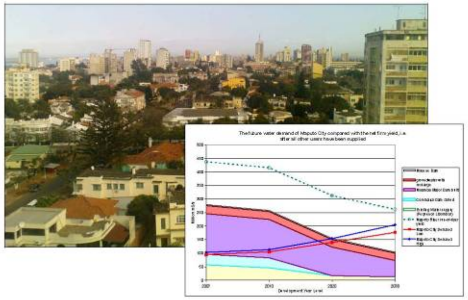
Water Demand Report

Final Report 22 July 2009

SWECO International
DHI, BKS, CONSULTEC

Tripartite Permanent Technical Committee (TPTC) between Mozambique, South Africa and Swaziland
Progressive Realization of the IncoMaputo Agreement (PRIMA)

Augmentation of Water Supply to the City of Maputo and its Metropolitan Area

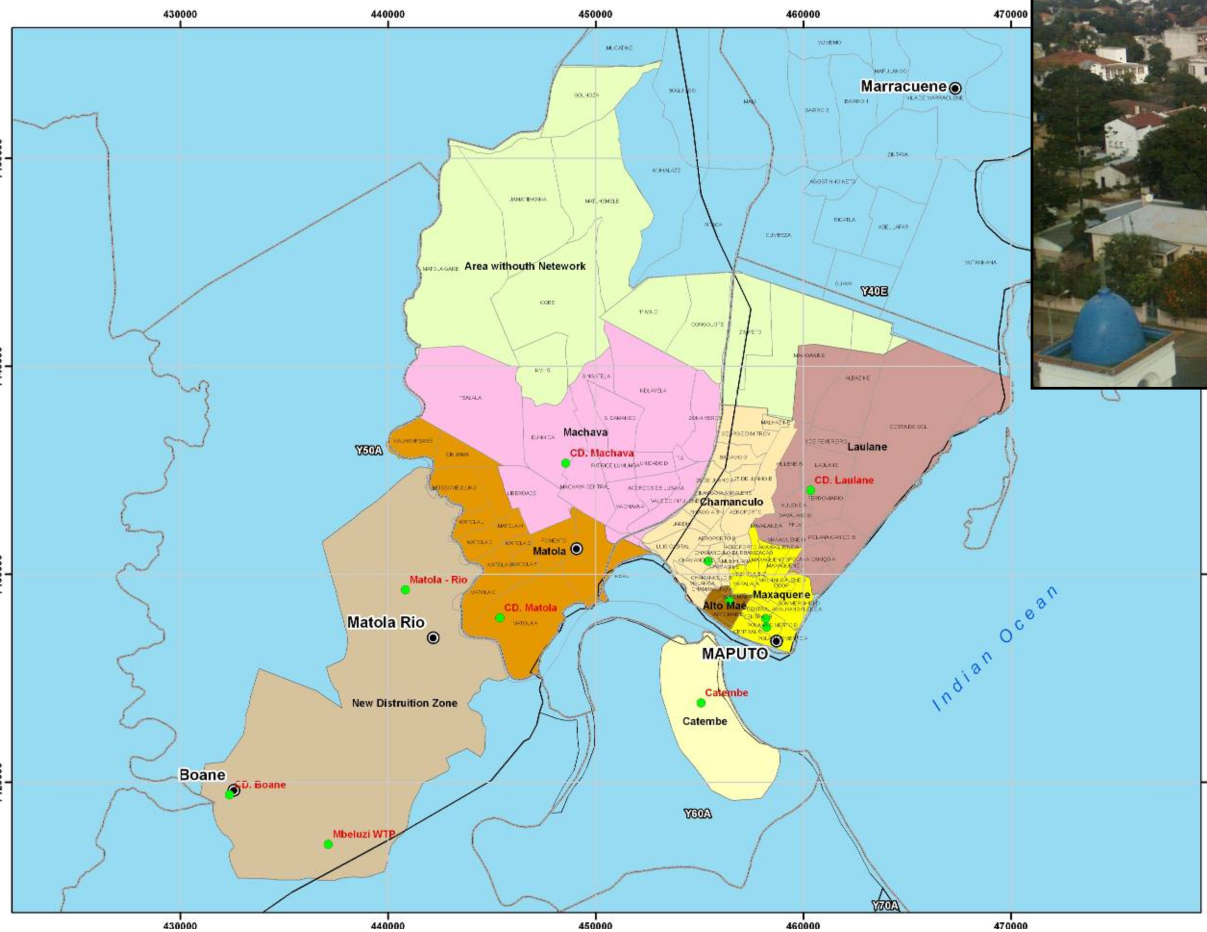


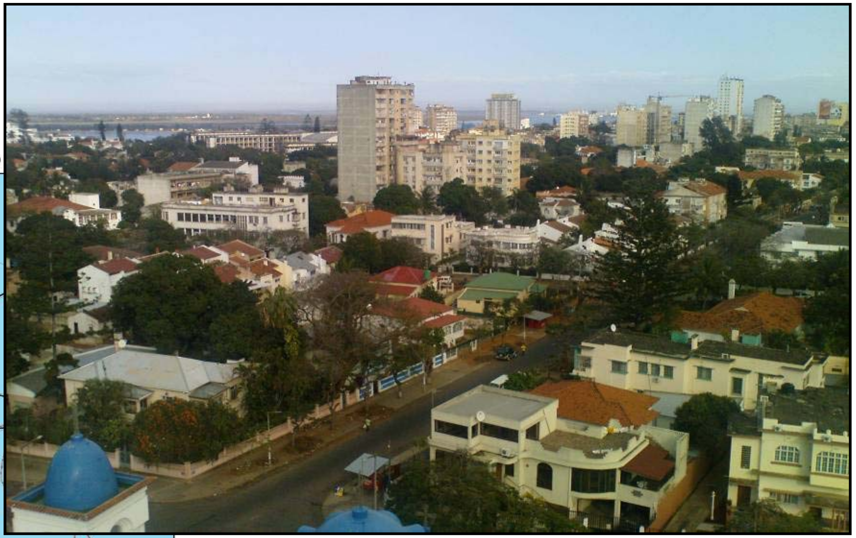
Water Balance Report

Final Report 22 July 2009

SWECO International
DHI, BKS, CONSULTEC

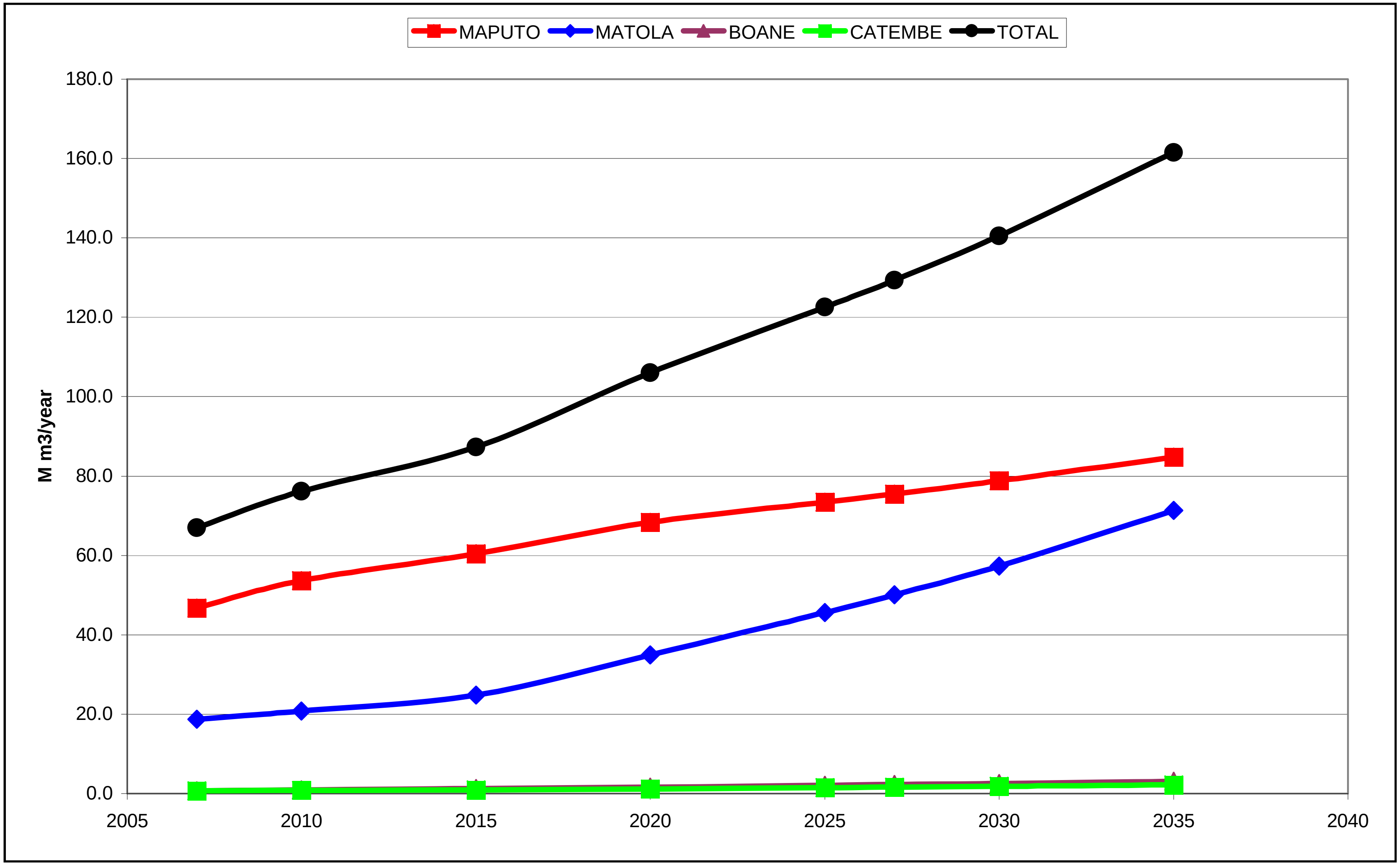
Augmentation of Water Supply for the City of Maputo and its Metropolitan Area



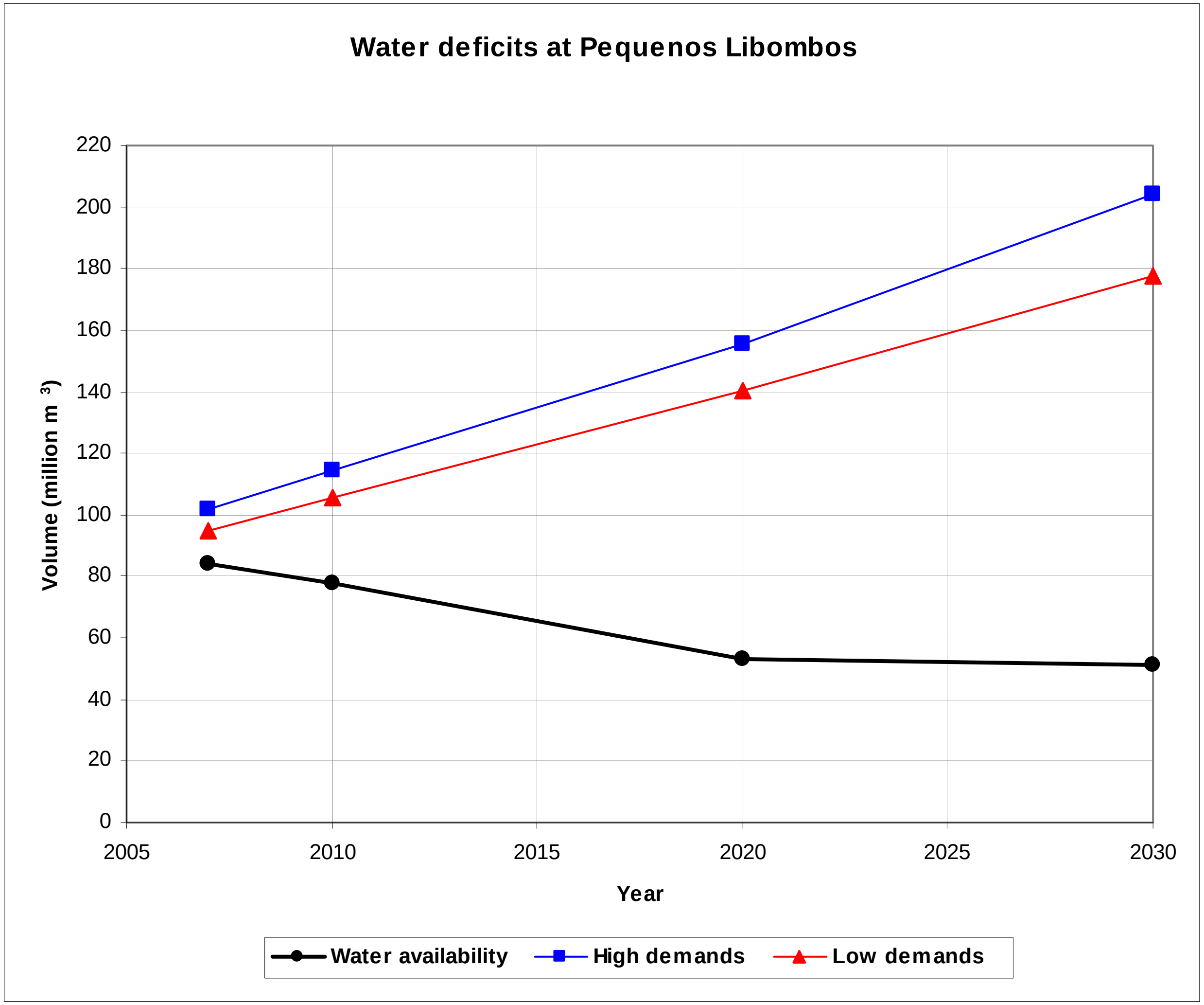


GREATER MAPUTO IS GROWING!

Augmentation of Water Supply for the City of Maputo and its Metropolitan Area



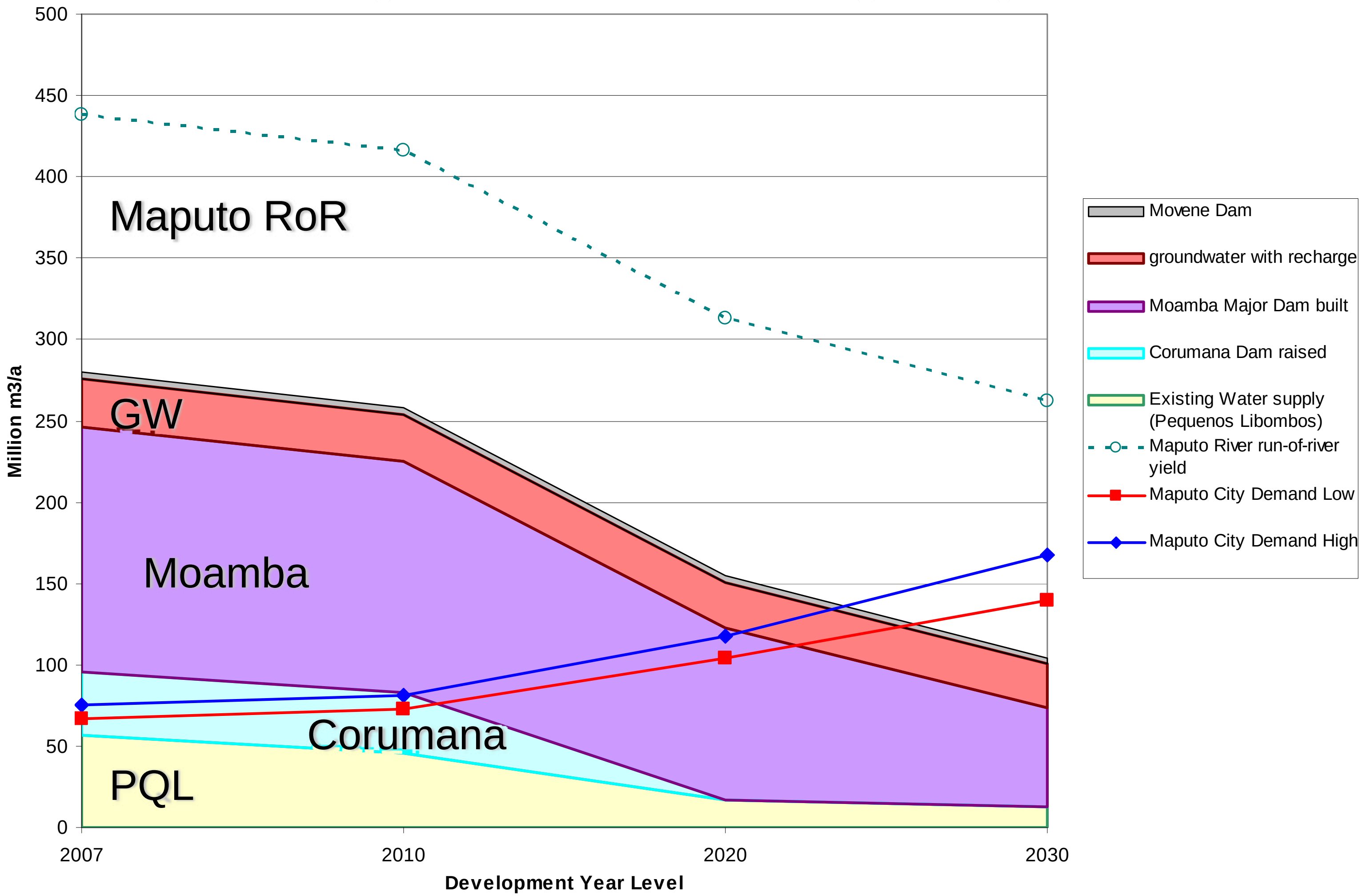
Augmentation of Water Supply for the City of Maputo and its Metropolitan Area



Deficit for PQL in 2030: 125-150 Mm³/year

Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

Maputo demand compared with net firm yield (after other users)



LIMITATIONS

- ***IIMA does not allow to take all water***
- ***Physical constraints to use Maputo run-of-river yield***

→ Priorities between users must be taken into account

→ Different levels of assurance of supply must be used

FORMULATION OF STRATEGIES

1. *Setting of boundary conditions*
2. *Screening to find main alternatives*
3. *Water demand management*
4. *Water balance analysis of main alternatives*
5. *Tentative design of infrastructure and costing*
6. *Financial analysis of main alternatives*
7. *Tranboundary issues affecting choice of strategies*
8. *Formulation of 2 final strategies*

BOUNDARY CONDITIONS

1. *Compliance with multilateral agreements*

   - IIMA

   - *Water allocation in each country*
   - *Ecological border flows acc. to IIMA (i.e. no SA EWR)*

   - 1976 agreement for Umbeluzi

   - *Minimum flows set to 40% of monthly minimum flows at GS3 and GS20*

2. *98% assurance for urban supply, 80% for irrigation*
3. *Most probable projections of water demand and infrastructural development in SA and Swaziland*

IIMA Compliance

2007

SOUTH AFRICA									
	First Priority		Irrigation		Afforestation		TOTAL		
	Allowed	Actual	Allowed	Actual	Allowed	Actual	Allowed	Actual	%
SABIE	80	27	98	100	129	90	307	217	71%
CROCODILE	73	73	307	514	247	158	627	745	119%
KOMATI	183	131	381	406	99	82	663	619	93%
USUTU/PONGOLA	242	161	538	330**	198	342	978	833	85%
							2575	*2414*	*94%*
SWAZILAND									
KOMATI	22	4	261	219*	46	35	329	258	78%
USUTU/PONGOLA	44	64	527	387	82	111	653	562	86%
							982	*820*	*84%*
MOZAMBIQUE									
INKOMATI	19	12	280	180	25	25	324	217	67%
MAPUTO	6	0.3	60	7	0	0	66	7.3	11%
							390	*224.3*	*58%*

**Interbasin-tranfer to Umbeluzi for sugar cane irrigation included*

***Interbasin-tranfer to Mkuze for sugar cane irrigation included*

IIMA Compliance

2030

SOUTH AFRICA									
	First Priority		Irrigation		Afforestation		TOTAL		
	Allowed	Actual	Allowed	Actual	Allowed	Actual	Allowed	Actual	%
SABIE	80	34	98	100	129	90	307	224	73%
CROCODILE	73	88	307	514	247	158	627	760	121%
KOMATI	183	131	381	406	99	82	663	619	93%
USUTU/PONGOLA	242	163	538	334**	198	342	978	839	86%
							2575	*2442*	*95%*
SWAZILAND									
KOMATI	22	4	261	267*	46	35	329	306	93%
USUTU/PONGOLA	44	69	527	541	82	111	653	721	110%
							982	*1027*	*105%*
MOZAMBIQUE									
INKOMATI	19	18	280	280	25	25	324	323	100%
MAPUTO	6	0.3	60	24	0	0	66	25	37%
							390	*347.7*	*89%*

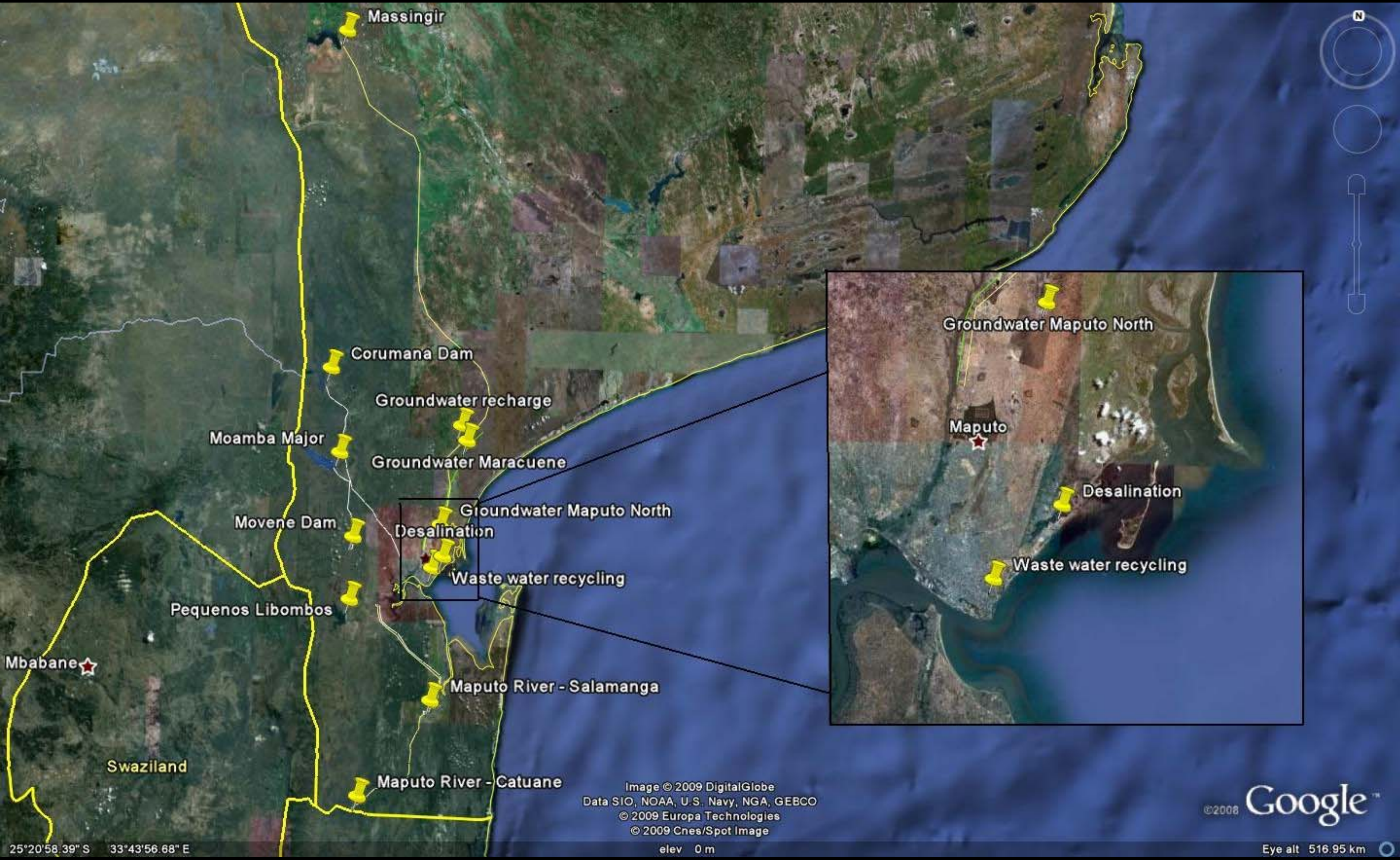
**Interbasin-tranfer to Umbeluzi for sugar cane irrigation included*

***Interbasin-tranfer to Mkuze for sugar cane irrigation included*

SCREENING OF SUPPLY ALTERNATIVES

1. ***Safe yield***
2. ***Environmental screening***
3. ***Social screening***
4. ***Unit cost per cubic metre***
5. ***Multipurpose use***
6. ***Lead time before operation***

Augmentation of Water Supply for the City of Maputo and its Metropolitan Area



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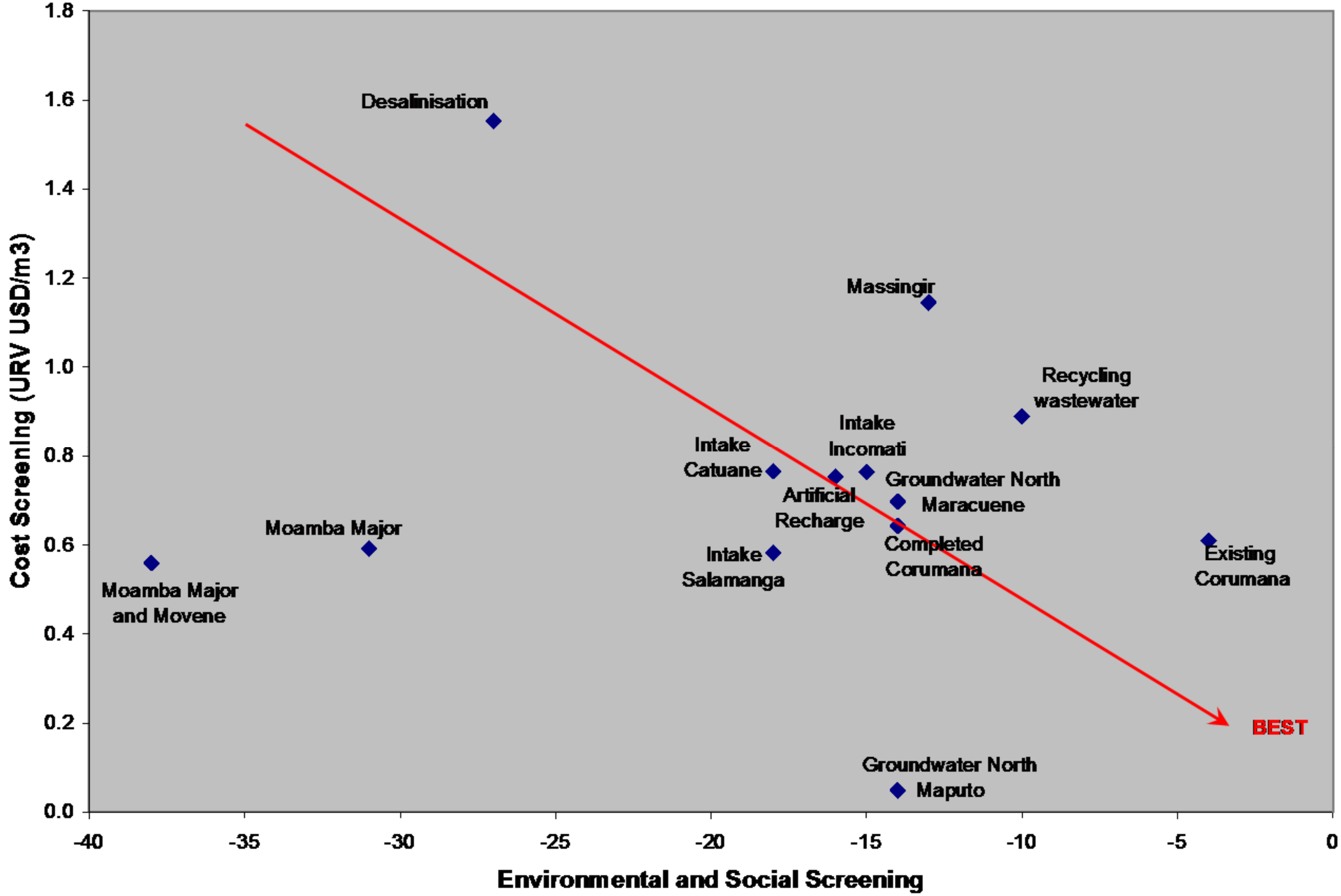
Augmentation of Water Supply for the City of Maputo and its Metropolitan Area



Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

		Start of operation
1	Intake at existing Corumana Dam	2013
2	Completion of Corumana Dam	2013
3	Intake weir downstream of confluence of Sabie and Incomati	2014
4	Moamba Major Dam	2020
5	Moamba Dam combined with Movene Dam	2020
6	Intake in Maputo River in Catuane	2014
7	Intake in Maputo River, upstream Salamanga	2014
8	Groundwater in northern Maputo	2011
9	Groundwater intake north of Maracuene	2013
10	Groundwater field north of Maracuene with artificial recharge	2015
11	Intake at Massingir Dam	2017
12	Desalination	2017
13	Reuse of wastewater	2015

WATER DEMAND MANAGEMENT

Based on Cape Town, Durban and India case studies

	POTENTIAL WDM	Cost (MUSD/year)	Annual Savings (Mm^3)
Water wastage reduction	•Pressure management •Grey water systems •Rainwater harvesting •Metering, tariffs and billing control	7.96	16.4
Water usage reduction	•Water saving devices •Education and advocacy	0.68	12.6
Total		8.64	29.0

Note: Leakage reduction down to 25% losses already accounted for in water demand projections

MAIN ALTERNATIVES

A: INCOMATI

- Phase1: 44 Mm^3/yr from Corumana
- Phase2: 88 Mm^3/yr from Moamba Major
- Complementary GW
- WDM

B: INCOMATI/MAPUTO

- Phase1: 44 Mm^3/yr from Corumana
- Phase2: 44 Mm^3/yr from Maputo River at Salamanga
- Complementary GW
- WDM

C: MAPUTO

- 88 (44+44) Mm^3/yr from Maputo River at Salamanga
- Complementary GW
- WDM

COSTING

- *Based on experience of transfer schemes in SA*
- *10% escalation per year (observed in SA)*
- *25% extra for Mozambique*
- *Steel pipes assumed because of large transfer volumes*

COSTING

• GW scheme north of Maracuene	193 MUSD
• 44 Mm^3/year from Corumana	410 MUSD
• 44 Mm^3/year from Moamba	395 MUSD
• 44 Mm^3/year from Maputo River	335 MUSD
• 88 Mm^3/year from Maputo River	528 MUSD

COSTING

	Total Capital Cost in 2009 (MUSD)
A: 44 Mm^3/yr from Corumana and 88 Mm^3/yr from Moamba	1,022
B: 44 Mm^3/yr from Corumana and 44 Mm^3/yr from Maputo River	960
C1: 88 Mm^3/yr from Maputo River asap	743
C2: 44 + 44 Mm^3/yr from Maputo phased	862

Groundwater schemes north of Maputo and Maracuene included in all alternatives

NET PRESENT VALUE (MUSD)
(all costs up to 2030)

	NPV @ 4%	NPV @ 6%	NPV @ 8%
A: 44 Mm^3/yr from Corumana and 88 Mm^3/yr from Moamba	954	848	759
B: 44 Mm^3/yr from Corumana and 44 Mm^3/yr from Maputo River	938	840	757
C1: 88 Mm^3/yr from Maputo River asap	744	672	611
C2: 44 +44 Mm^3/yr from Maputo phased	834	740	660

Groundwater schemes north of Maputo and Maracuene included in all alternatives

UNIT REFERENCE VALUE (USD/m^3)

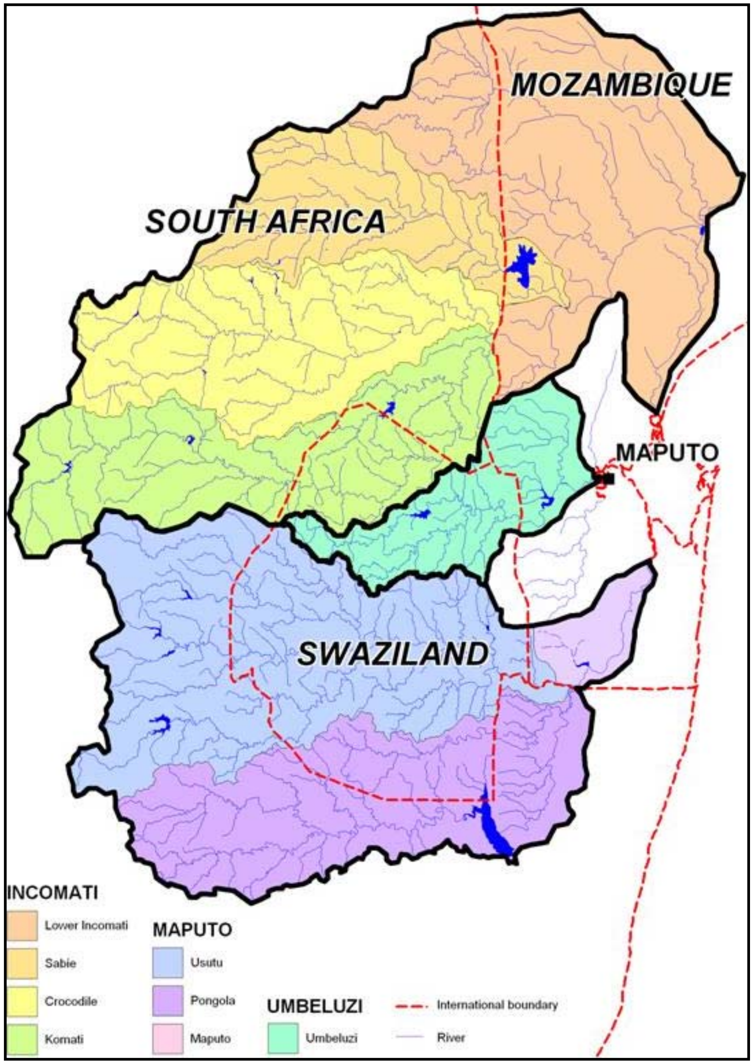
	URV @ 4%	URV @ 6%	URV @ 8%
A: 44 Mm^3/yr from Corumana and 88 Mm^3/yr from Moamba	0.85	0.96	1.08
B: 44 Mm^3/yr from Corumana and 44 Mm^3/yr from Maputo River	0.79	0.90	1.02
C1: 88 Mm^3/yr from Maputo River asap	0.60	0.68	0.77
C2: 44 +44 Mm^3/yr from Maputo phased	0.73	0.82	0.92

Groundwater schemes north of Maputo and Maracuene included in all alternatives

TRANSBOUNDARY ISSUES

UNCERTAINTIES:

1. Compliance of IIMA
2. No agreement for Umbeluzi
3. Interim status of IIMA



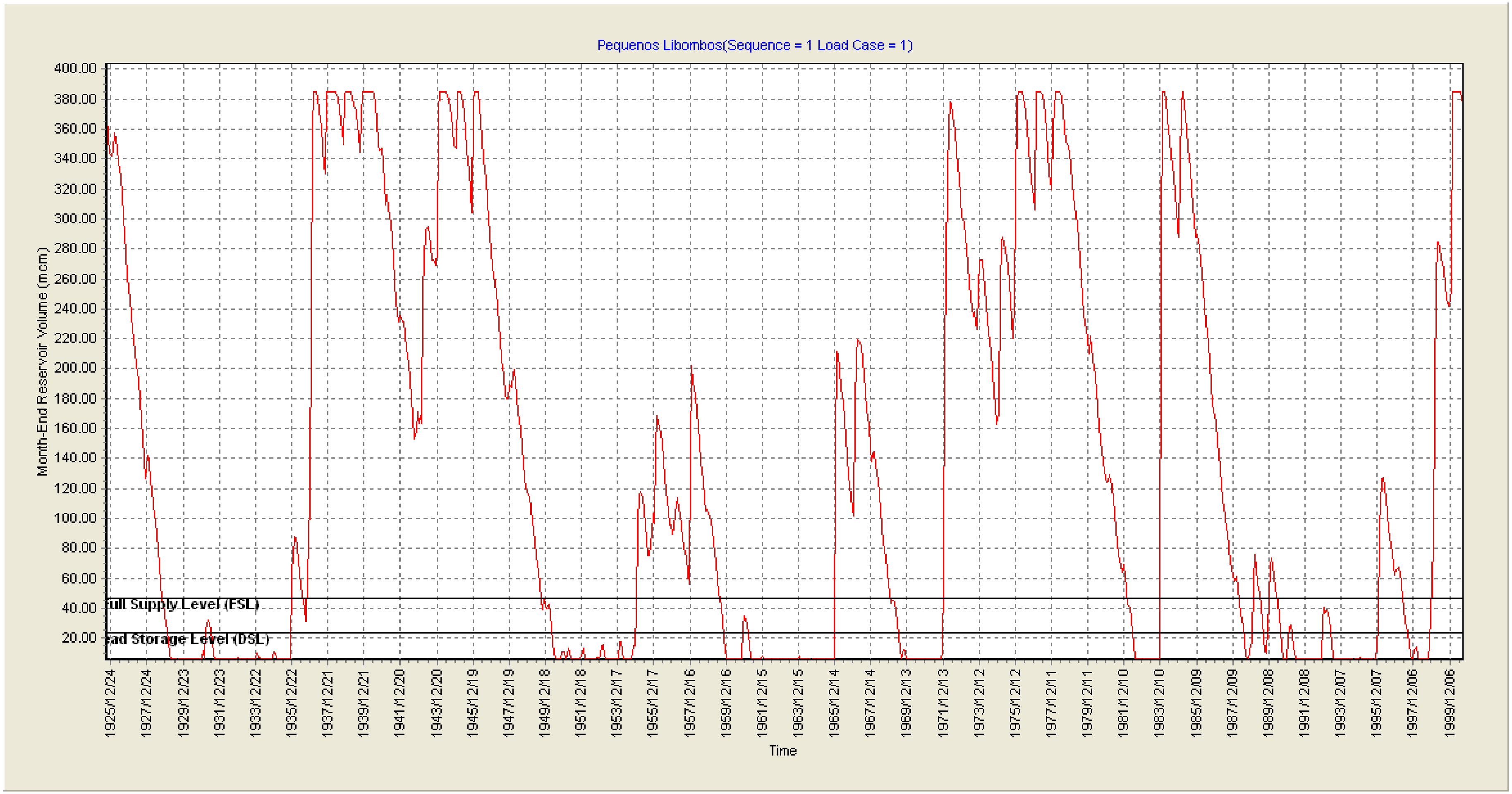
TRANSBOUNDARY ISSUES

- *When and how can irrigation in Crocodile be decreased?*
  - ➲ *Uncertainty for Moamba Major inflow*

- *Projected increase of water demand in Umbeluzi in Swaziland from 2007-2030 is 90 Mm^3/year.*
  - ➲ *PQL failing for long periods in the 2030 situation – means that full supply must come from other sources*

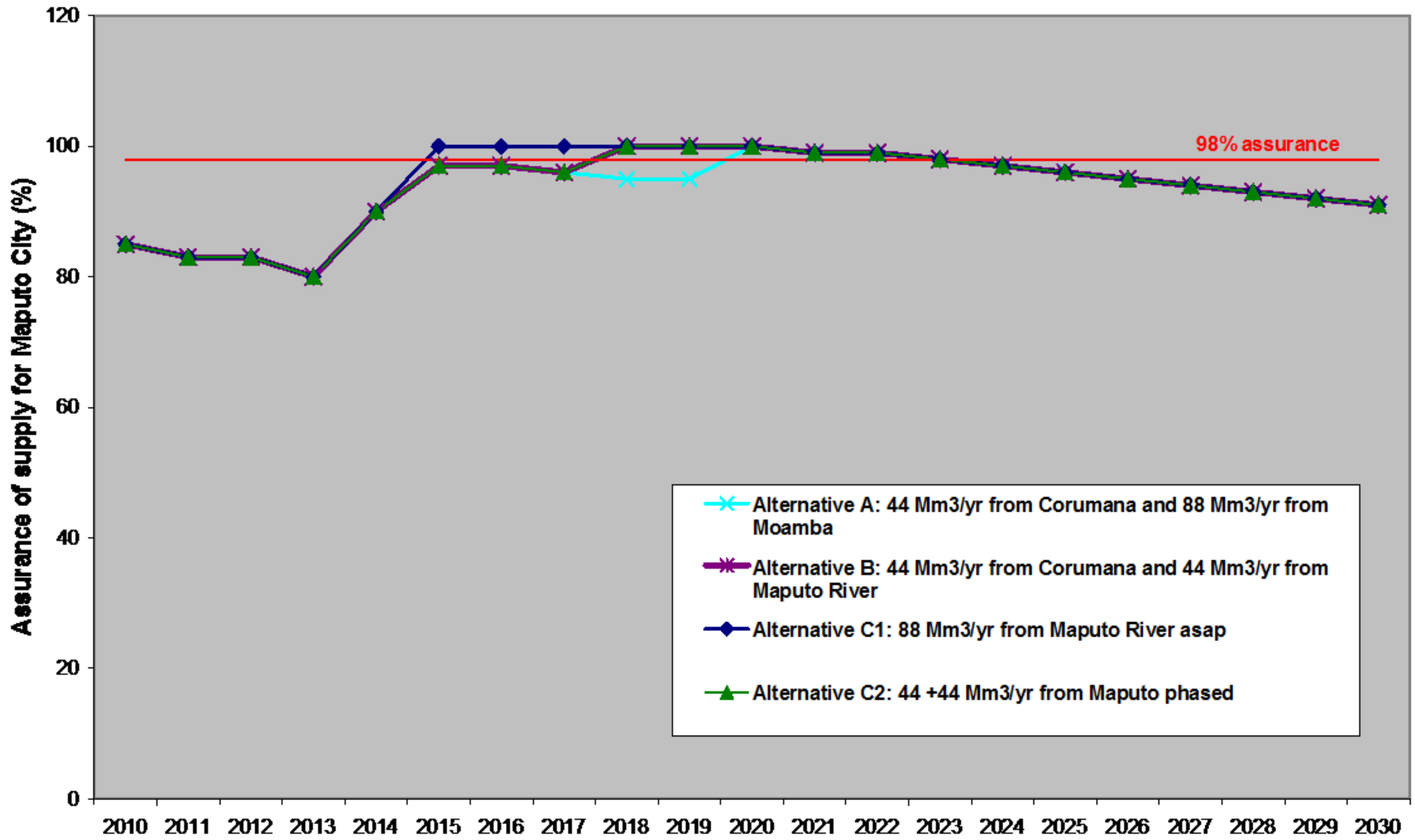
- *How to interpret the clause of 88 Mm^3/year for Maputo City? Can it be renegotiated in the final agreement?*

➔ **TPTC activities must be part of the Strategies**



Pequenos Libombos dam in 2030 situation

Augmentation of Water Supply for the City of Maputo and its Metropolitan Area



Assurance of Supply for Maputo with the main alternatives implemented

WDM MUST BE PART OF STRATEGIES

1. *Preparations for emergency curtailment 2010-2015*
2. *Initiate Education and Advocacy campaign asap*
3. *Support FIPAG in leakage reduction programme*
4. *Initiate from 2015*
   - *Improved tariff and billing control*
   - *Meters at households*
   - *Water saving devices*
   - *Pressure management*

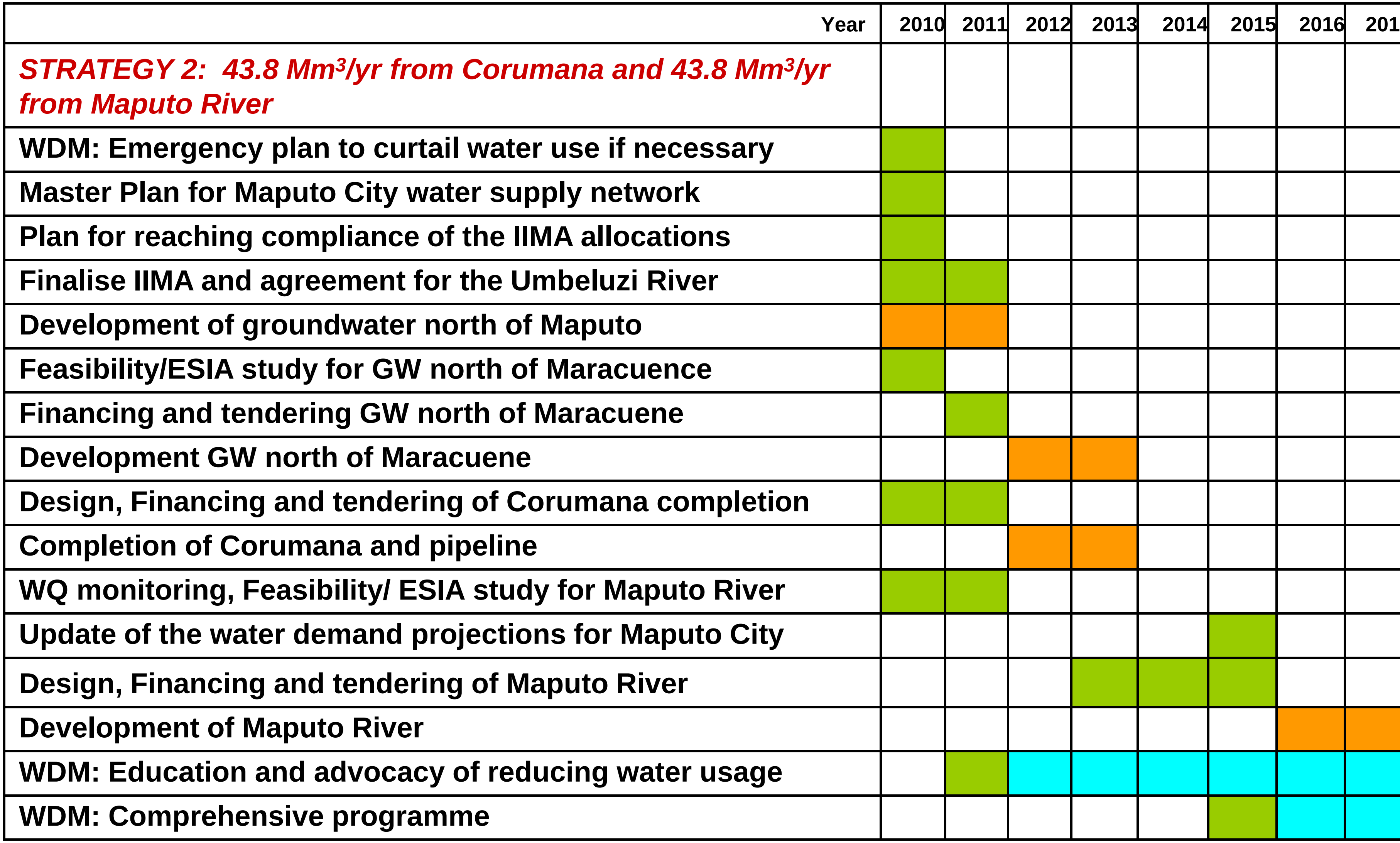
BASIS FOR CHOICE OF STRATEGIES

1. *Either the Incomati River or the Maputo River, or a combination of the two, augmented by other sources.*
2. *Give the Mozambican water authorities the possibility to independently secure the water supply to the City of Maputo without further augmentation from the upstream countries than IIMA and the 1976 agreement for the Umbeluzi River.*
3. *As much flexibility as possible should be built into the strategies to enable more cost efficient solutions, should the transboundary water-sharing agreements be updated.*

Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

Year	2010	2011	2012	2013	2014	2015	2016	2017
STRATEGY 1: ***87.6 Mm³/ from Maputo River upstream Salamanga***								
WDM: Emergency plan to curtail water use if necessary								
Master Plan for Maputo City water supply network								
Plan for reaching compliance of the IIMA allocations								
Finalise IIMA and agreement for the Umbeluzi River								
Development of groundwater north of Maputo								
Feasibility/ESIA study for GW north of Maracuene								
Financing and tendering GW north of Maracuene								
Development GW north of Maracuene								
WQ monitoring, Feasibility/ ESIA study for Maputo River								
Design, Financing and tendering of 1st phase of Maputo River								
Development of 1st Phase of Maputo River								
Update of the water demand projections for Maputo City								
Design of the 2nd phase of Maputo River								
Development of 2nd Phase of Maputo River								
WDM: Education and advocacy of reducing water usage								
WDM: Comprehensive programme								

Augmentation of Water Supply for the City of Maputo and its Metropolitan Area



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PROS AND CONS

STRATEGY 1:

- *Cheapest*
- *Less competition amongst water users*
- *Uncertainty in infrastructure solution and funding*

STRATEGY 2:

- *More expensive*
- *Funding partly secured*
- *Little risk, shortest lead time*
- *Gives higher security for pipeline/dam failures*

Water Balance and Assurance of Supply

1. Assurances of supply conducted for 3 alternate strategies.

2. Assurances calculated for both Maputo city supply and irrigation in the Umbeluzi and Incomati rivers.

3. Used to determine required timelines for phasing of developments in the different strategies

Water Balance and Assurance of Supply - Scenarios

1. Each alternate strategy comprises one or more phased developments of different possible sources.

2. Scenarios were set up to represent all possible development combinations representing each phase of the three alternative strategies

3. Total of 7 scenarios.

Scenarios

Scenario	Water sources	Description
1	Pequenos Libombos only	Represents the existing situation and calculates assurances should it persist.
2	Pequenos Libombos only	The same as scenario 1 but included to determine the assurance of supply of irrigation in the Inkomati
3	Pequenos Libombos and completed Corumana 43.8	Pequenos Libombos and 43.8 Mm3/year from the completed Corumana dam. This scenario was included as the first phase of either Strategy A or B.
4	Pequenos Libombos, completed Corumana and Moamba Major	Pequenos Libombos and the full 87.6 Mm3/year from Moamba Major with Corumana becoming a secondary source should it be needed. This scenario represents the second phase of Strategy A.
5	Pequenos Libombos and Maputo River 43.8	Pequenos Libombos and 43.8 Mm3/year from the Maputo River. This scenario represents either the first phase of Strategy C should the 87.6 Mm3/year from the Maputo River be phased.
6	Pequenos Libombos and Maputo River 87.6	Pequenos Libombos and 87.6 Mm3/year from the Maputo River. This strategy represents Strategy C if the full 87.6 Mm3/year is implemented without phasing.
7	Pequenos Libombos, completed Corumana and Maputo river	Pequenos Libombos and 43.8 Mm3/year from the completed Corumana dam, and 43.8 Mm3/year from the Maputo River. This scenario represents the 2nd phase of either Strategy B.

Water Balance Assessment

- Assurances of supply analysed for each scenario up to 2030
- Conducted using the WRYM and the latest model set-ups for the Incomati, Umbeluzi and Maputo Rivers.
- The WRYM is a static state model (constant level of development)
- Time steps chosen of 2007, 2010, 2020 and 2030.

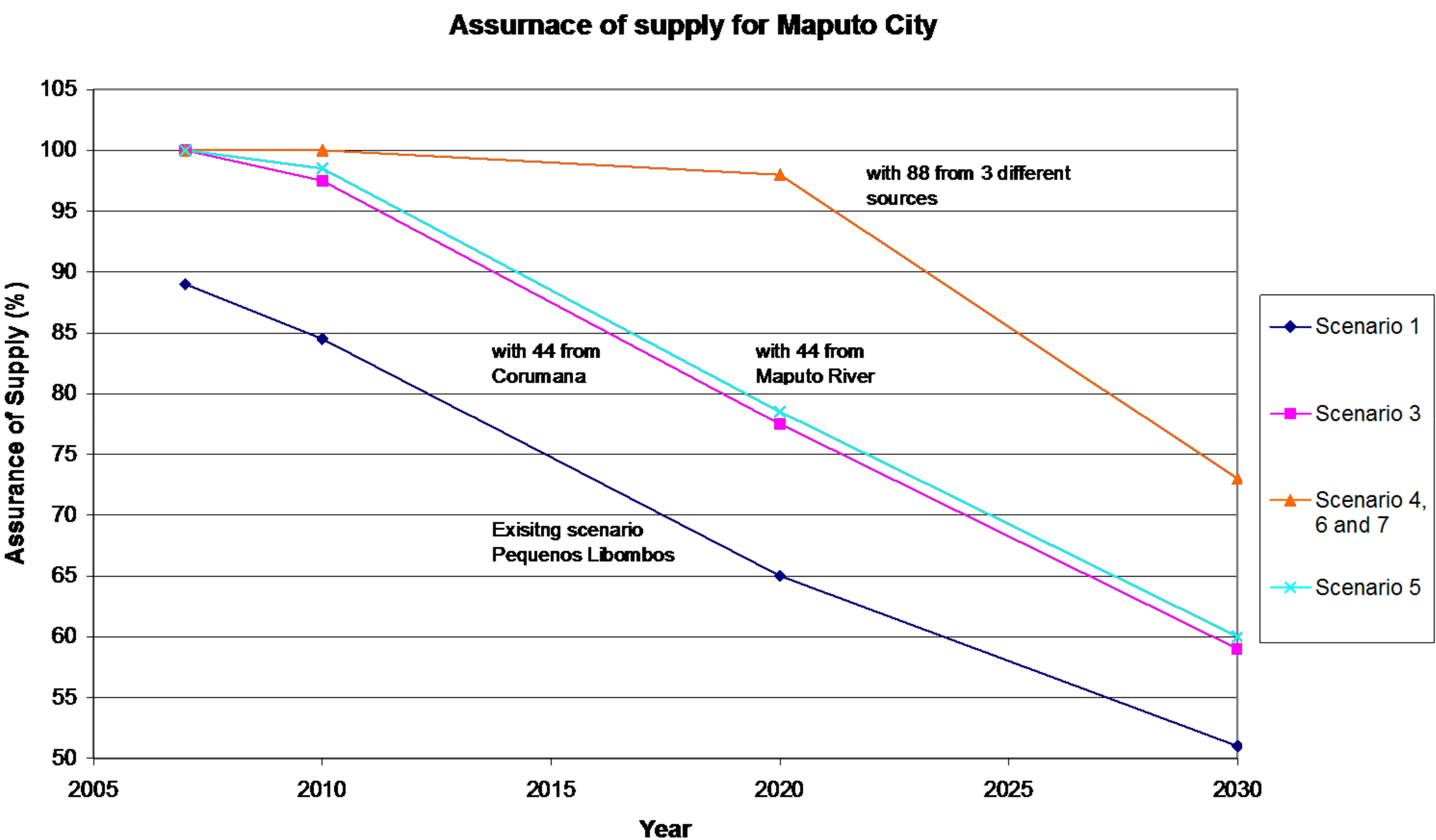
Border flows and Water Demands

Incomati and Maputo

- Environmental flow requirements at the borders and estuaries included as stipulated in the IIMA.
- Existing and future projected water use limited to the water allocated for irrigation and afforestation

Umbeluzi

- Environmental flows at the border based on 1976 agreement and assumed to be a minimum flow for each month equal to 40% of the lowest combined flow recorded in that month


Assurnace of supply for Maputo City
Assurance of Supply (%)
105
100
95
90
85
80
75
70
65
60
55
50
2005
2010
2015
2020
2025
2030
Year
with 88 from 3 different sources
with 44 from Corumana
with 44 from Maputo River
Exisitng scenario Pequenos Libombos
Scenario 1
Scenario 3
Scenario 4, 6 and 7
Scenario 5

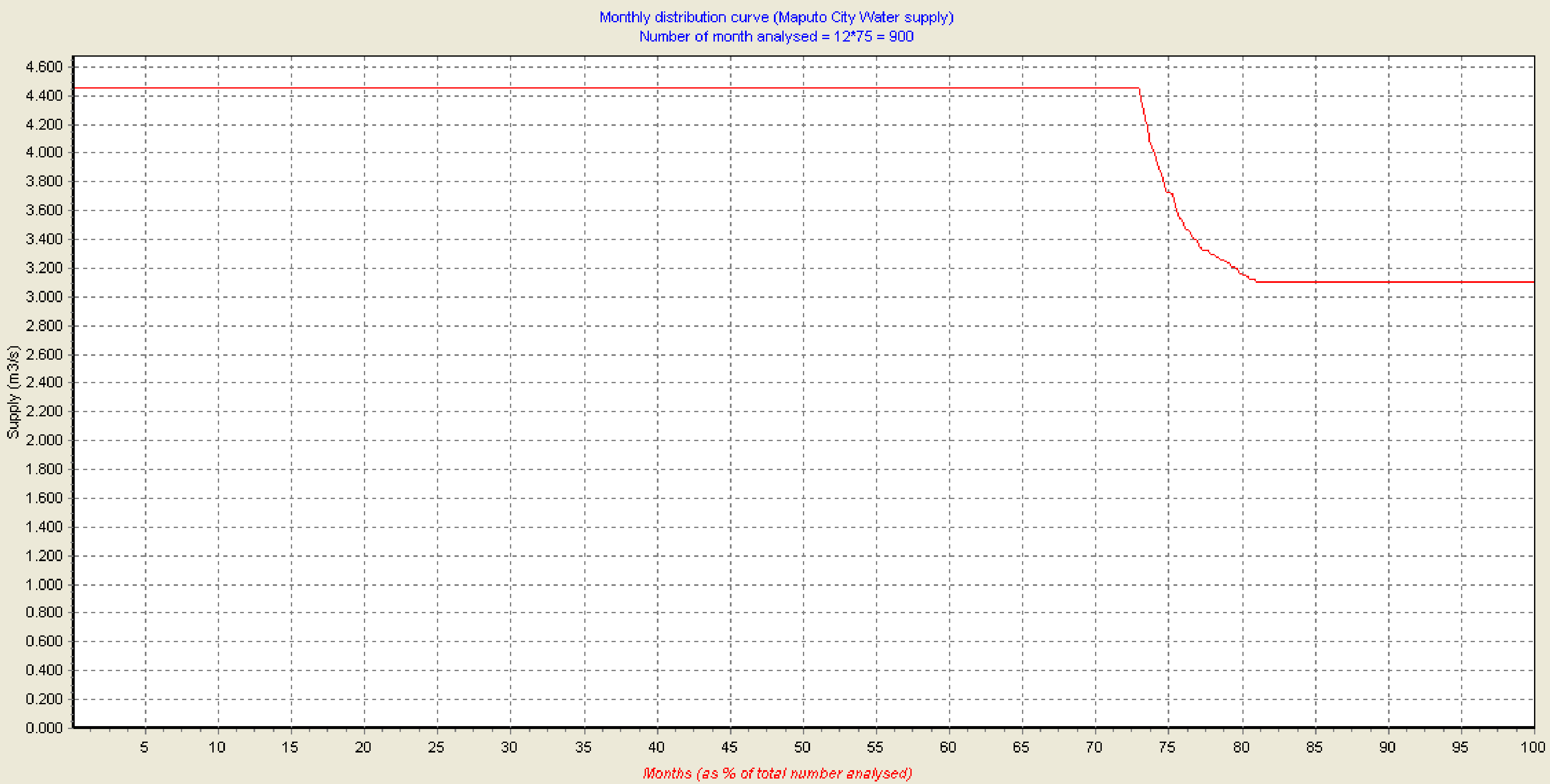
Results (1)

- The assurance of supply for existing Pequenos Libombos is already about 90% and decreases significantly beyond 2010
- Assurances of supply of scenarios with an additional 44 Mm^3/year are the same and the additional 44 Mm^3/year can be reliably supplied from both the Maputo River or the Corumana Dam
- Assurances of Supply of the scenarios with an additional 88 Mm^3/year are the same an this additional amount can also be reliably supplied from either the Maputo River or the Corumana and Moamba Major dams

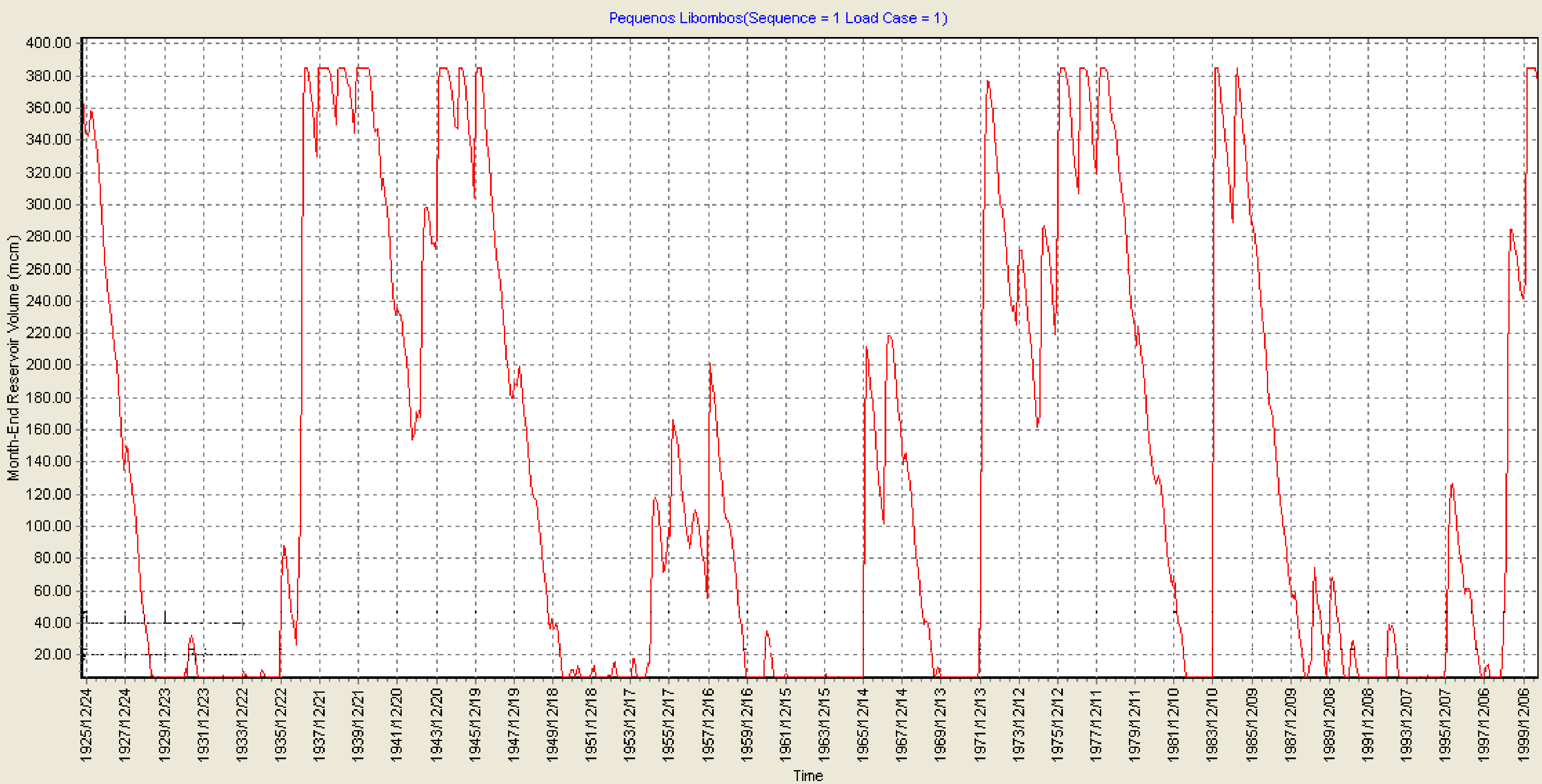
Results (2)

- Although up to 88 Mm^3/year can be reliably supplied from either the Maputo or Incomati Rivers, the assurance of supply of Maputo city is still below 98% for the short term and again beyond 2020.
- The short term problem is that no new water sources can be developed before 2013 and not much beyond 2010, an additional Mm^3/year will not be sufficient.
- The long term problem is due to the fact that the portion of Maputo city's demand that will not be supplied by the additional 88 Mm^3/year, cannot be reliably supplied by Pequenos Libombos

Maputo City Assurance of Supply

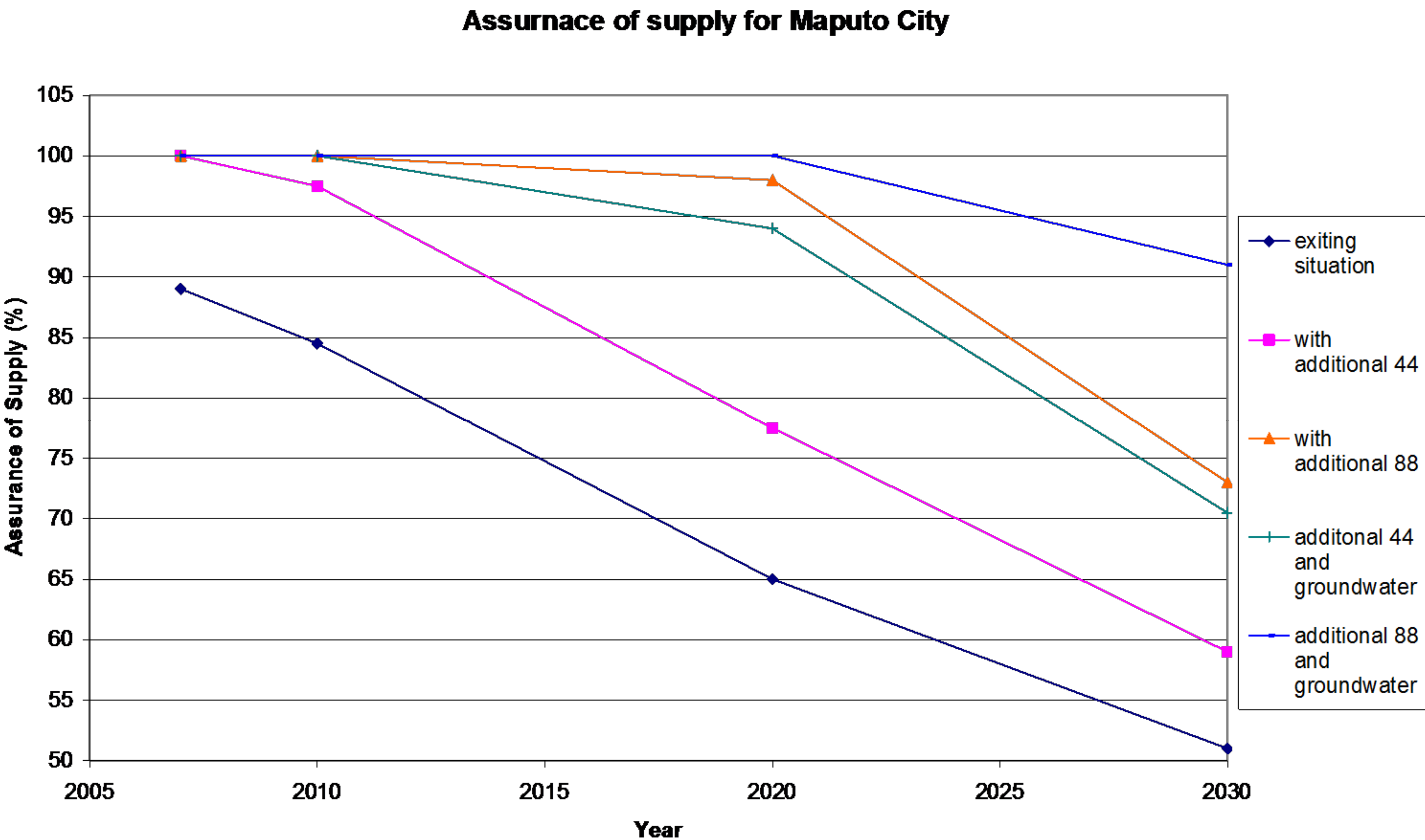


Pequenos Libombos Dam Trajectory



Groundwater

- To improve short term assurances of supply and to possibly postpone the need to implement the full 88 Mm^3/year, an additional source is needed.
- Groundwater appears to be the only additional source that can be implemented in a relatively short time.
- Comprises of two sources, an additional 9 Mm^3/year from north of Maputo and additional 30 Mm^3/year from north of Maracuene.


Assurnace of supply for Maputo City
Assurance of Supply (%)
105
100
95
90
85
80
75
70
65
60
55
50
2005
2010
2015
2020
2025
2030
Year
exiting situation
with additional 44
with additional 88
additonal 44 and groundwater
additional 88 and groundwater

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Results - Groundwater

- From strategies with 44 and 88 Mm^3/year from surface water, the inclusion of an additional 39 Mm^3/year does improve the assurances of supply.

- The full 88 Mm^3/year does however still need to be implemented beyond 2015 if assurances of supply are to be maintained at or above 98%.

Results – Assurance of supply to Irrigation

- Assurances of supply to irrigators in the Umbeluzi decreases into the future as Pequenos Libombos becomes more stressed, but does increase as more water is augmented from new sources.
- Assurance of supply for irrigation in the Incomati is the same for all scenarios and only drops to 99 % in 2030.
- This suggests that the Corumana Dam can support the planned expansion in irrigation in the Incomati, even if some water is assigned to urban supply.

Results – Corumana and Moamba Major

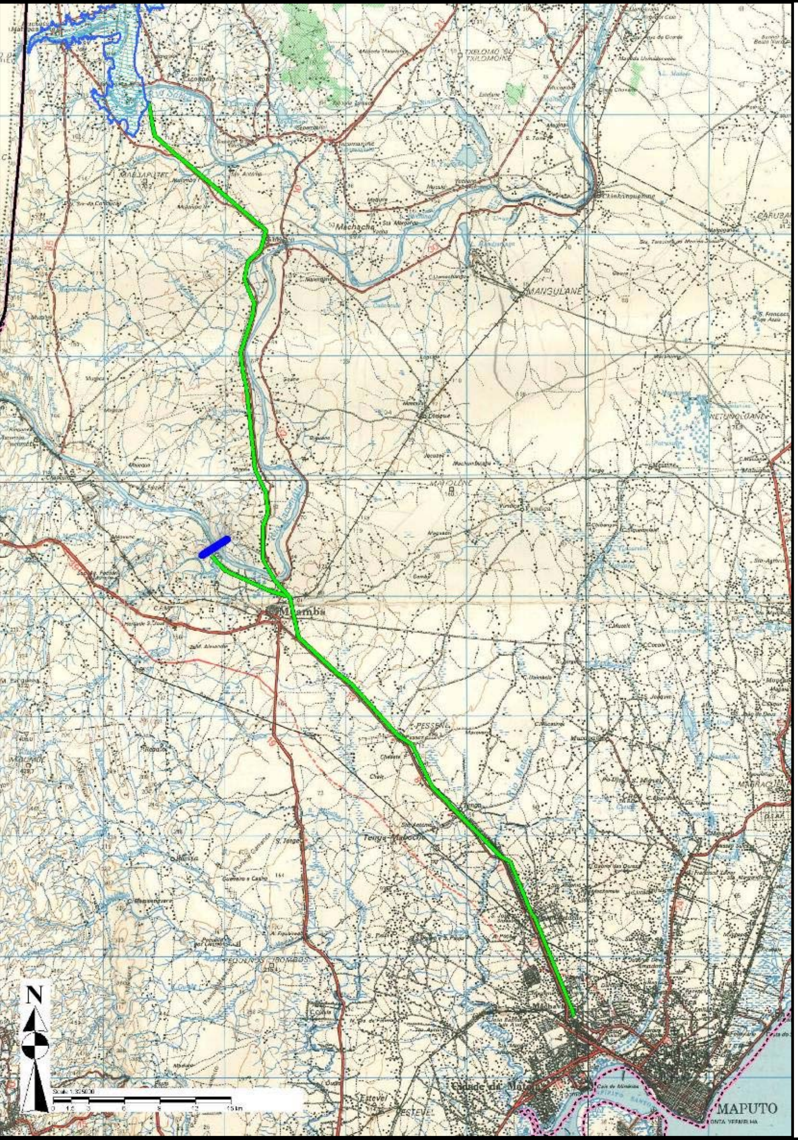
- Additional scenarios confirmed this and showed that the existing dam can support the planned irrigation and close to 44 Mm^3/year to Maputo, and a raised dam can support the planned growth in irrigation and supply close to 88 Mm^3/year to Maputo.
- These results don't necessarily suggest that Corumana dam should become the focus of the strategies, but shows that the need for Moamba Major as a multi-purpose scheme is limited as that even if all 88 Mm^3/year is supplied from the Incomati, a much smaller Moamba Major is required that proposed.

Results – Maputo River

- With the assumption that a 5th (20%) of the flow in the Maputo River can be reliably abstracted, the full 88 Mm^3/year can be supplied to Maputo if some off-channel storage is provided for to compensate for the low flow periods.
- More storage is required if the releases from Pongolapoort Dam are not considered, where as virtually no storage is required if the releases are considered to be reliably available.
- For the purpose of this study, the releases are not considered as part of the strategy, and off-channel storage of 15 Mm^3 will be included for the abstraction of the full 88 Mm^3/year.

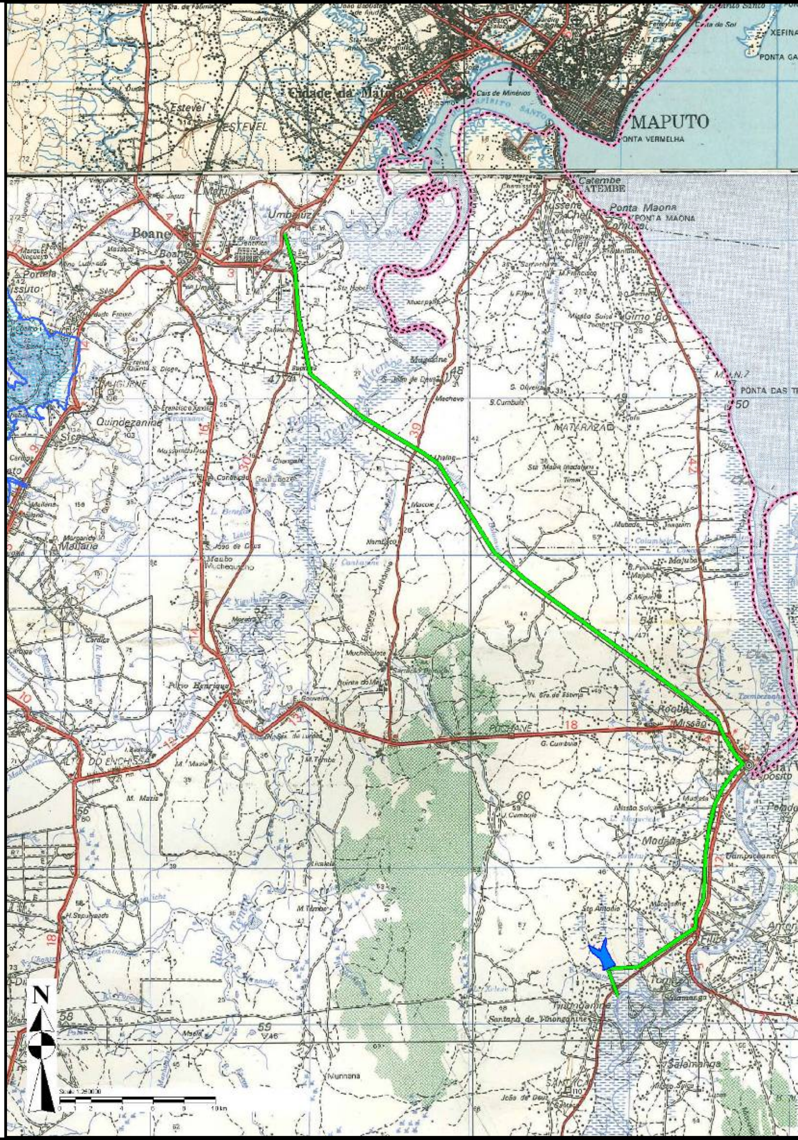
Preliminary Design for Main Alternatives

Augmentation of Water Supply for the City of Maputo and its Metropolitan Area



Inkomati transfers

Maputo transfers



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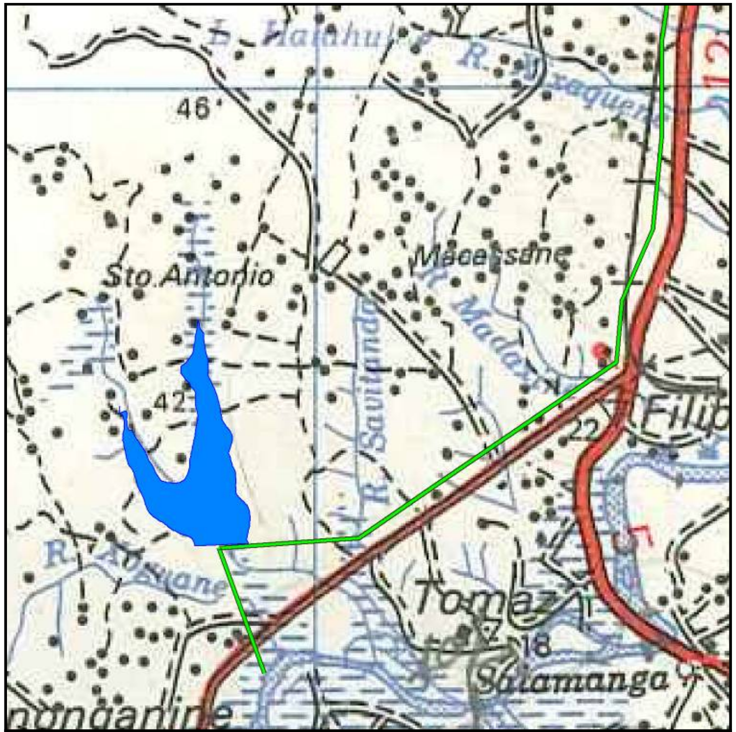
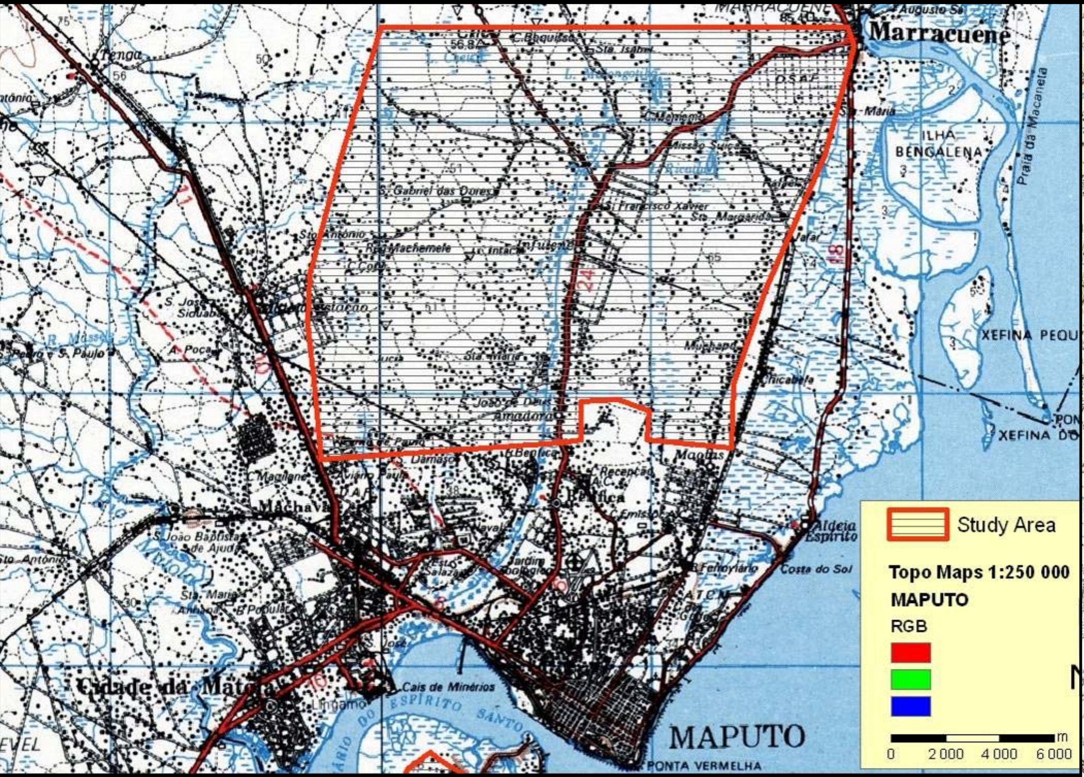
Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

Duration (month)	Probability of average river flow lower than 20 m^3/s (%)	Average abstraction rate possible for given duration (m^3)	Off-channel storage required (Mm^3)
1 month	100%	2.2	4.1
2 months	80%	2.4	7.1
4 months	60%	2.7	11.0
6 months	40%	3.0	11.8
8 months	15%	3.2	11.6
12 months	1%	3.6	4.3

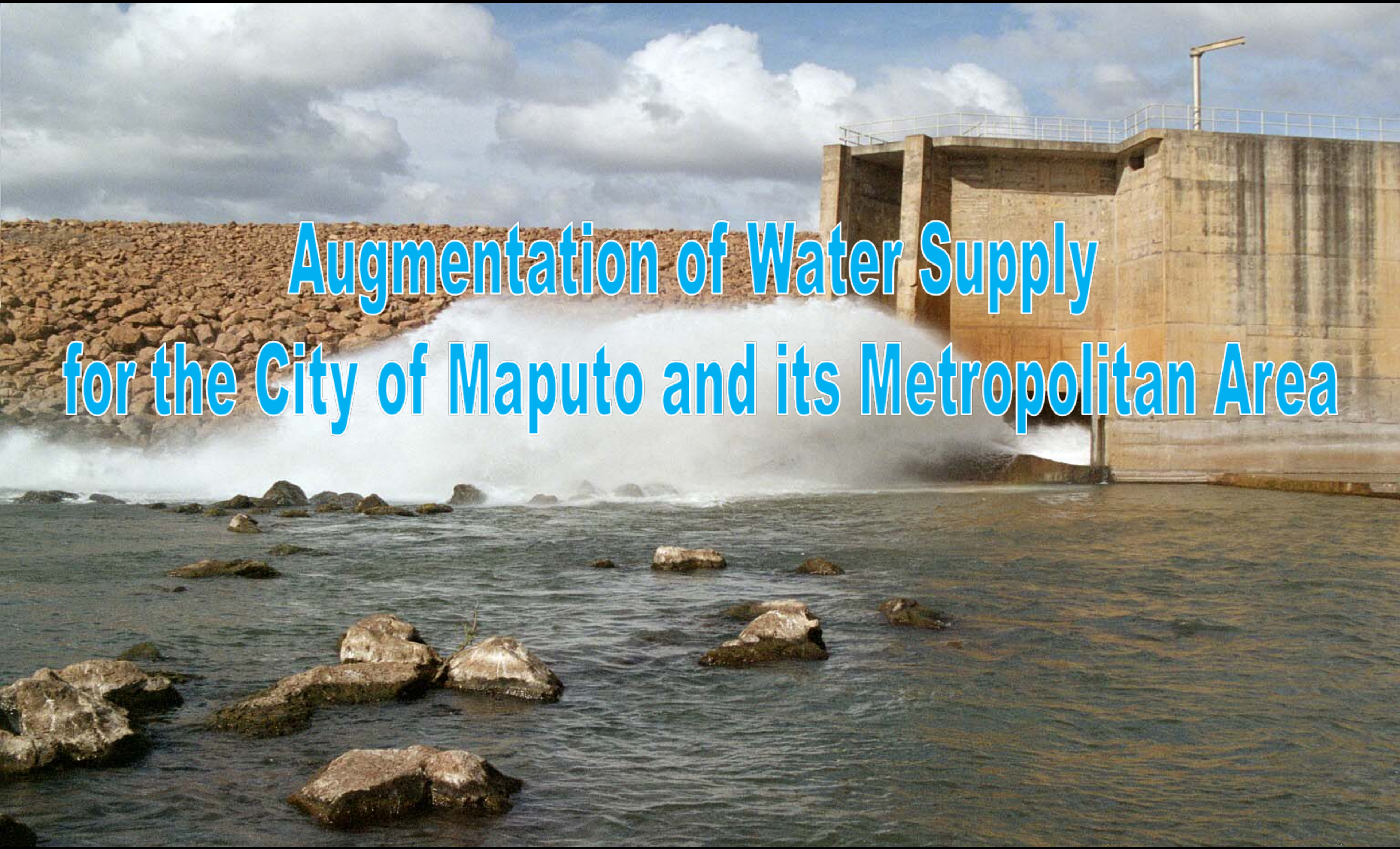


Augmentation of Water Supply for the City of Maputo and its Metropolitan Area



Groundwater from north of Maputo city – suited to local supply

Groundwater piped from boreholes along the Inkomati river road to Maputo city for distribution


Augmentation of Water Supply
for the City of Maputo and its Metropolitan Area

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Progressive Realisation of the IncoMaputo Agreement

PRIMA

Seminar with stakeholders on water demand

Maputo, 28 January 2009

Objective: Presentation of water demand scenarios and feedback from the Client and stakeholders

Client: Tripartite Permanent Technical Committee (TPTC)

Consultant: SWECO International, DHI, BKS, CONSULTEC

OBJECTIVES FOR THE MAPUTO WATER DEMAND COMPONENT

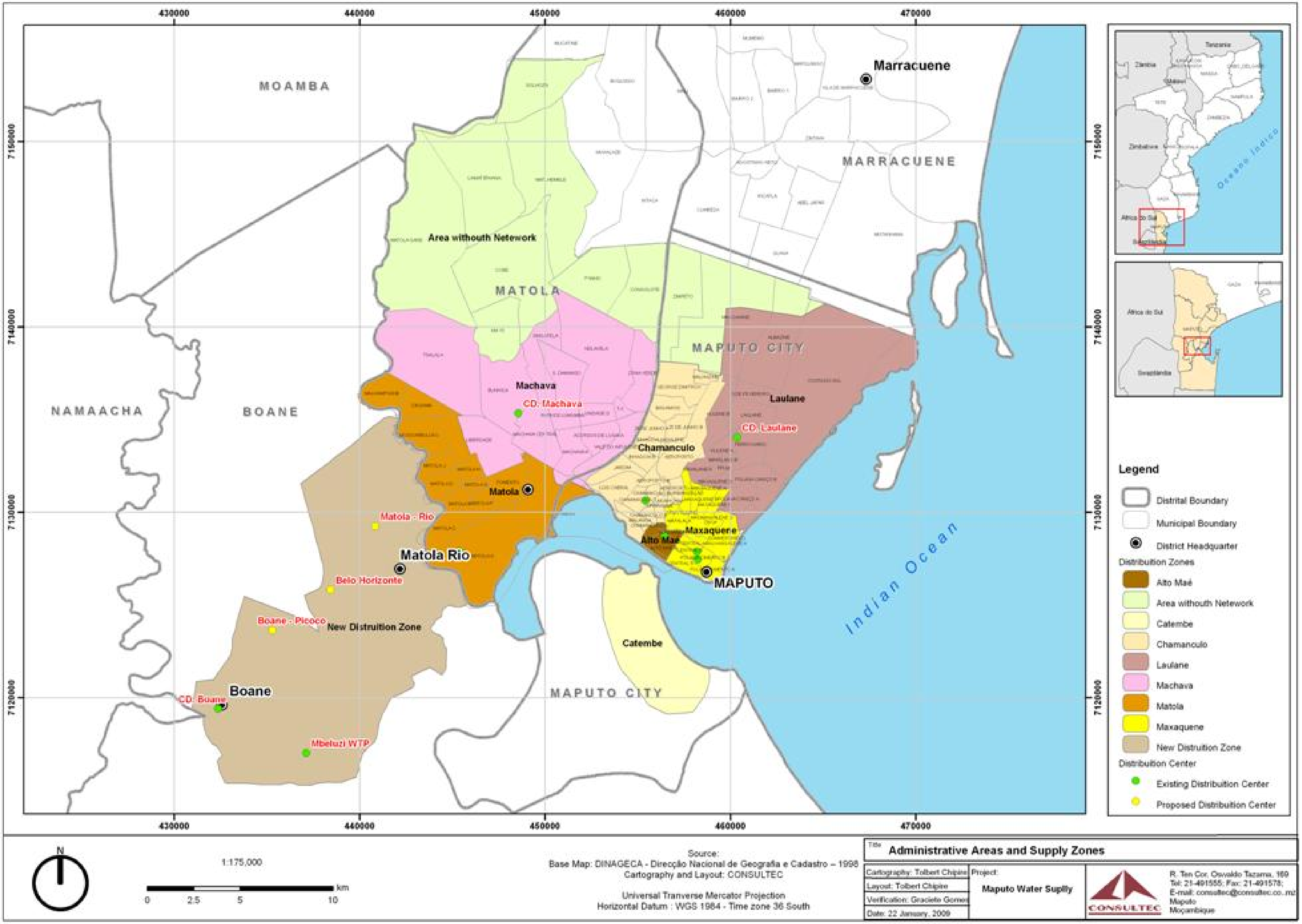
- Establish present water consumption in the water supply system of the Greater Maputo area
- Prepare two scenarios (probable and high) of future water demand for the various categories of water use in the Great Maputo water supply system

METHODOLOGY

- GREATER MAPUTO WATER SUPPLY SYSTEM
  - Review the most recent reports prepared for FIPAG and Águas de Moçambique
  - Analyse projections of water demand in these reports
  - Check with FIPAG the underlying assumptions and the planned investment programme
  - Discuss and agree with FIPAG and other stakeholders on the two scenarios of future water demand for a horizon of 20 years and the evolution of demand in periods of 5 years

AREAS COVERED BY THE GREATER MAPUTO WATER SUPPLY SYSTEM

- City of Maputo (includes Catembe and Inhaca island)
- City of Matola (includes Machava, Belo Horizonte)
- District of Boane
- Tsalala



430000
440000
450000
460000
470000
7150000
7140000
7130000
7120000
MOAMBA
Marracuene
MARRACUENE
Area withouth Netework
MATOLA
MAPUTO CITY
Laulane
Machava
CD. Machava
NAMAACHA
BOANE
CD. Laulane
Chamanculo
Matola
Matola - Rio
Maxaquene
Alto Mae
Matola Rio
MAPUTO
Belo Horizonte
Boane - Picoco
New Distruition Zone
Indian Ocean
Catembe
Boane
CD. Boane
MAPUTO CITY
Mbeluzi WTP
Oceano Indico
Legend
Distrital Boundary
Municipal Boundary
District Headquarter
Distribution Zones
Alto Maé
Area withouth Netework
Catembe
Chamanculo
Laulane
Machava
Matola
Maxaquene
New Distrution Zone
Distribution Center
Existing Distribuition Center
Proposed Distribuition Center
N
1:175,000
0 2.5 5 10 km
Source:
Base Map: DINAGECA - Direcção Nacional de Geografia e Cadastro – 1998
Cartography and Layout: CONSULTEC
Universal Tranverse Mercator Projection
Horizontal Datum : WGS 1984 - Time zone 36 South
Title
Administrative Areas and Supply Zones
Cartography: Tolbert Chipire
Layout: Tolbert Chipire
Verification: Gracieto Gomes
Date: 22 January, 2009
Project:
Maputo Water Suplly
CONSULTEC
R. Ten Cor. Osvaldo Tazama, 169
Tel: 21-491555; Fax: 21-491578;
E-mail: consultec@consultec.co.mz
Maputo
Moçambique

WATER SUPPLY RESPONSIBILITIES AND PROVIDERS

- Responsibility lies with FIPAG
- Main provider is Águas de Moçambique, concession contract with FIPAG
- Other providers
  - private investors, with small distribution systems, using boreholes
  - small systems in peri-urban areas, investment by FIPAG, managed by private operators under contract with FIPAG
  - MozaBusiness (project for Tsalala)

REPORTS AND OTHER INFORMATION

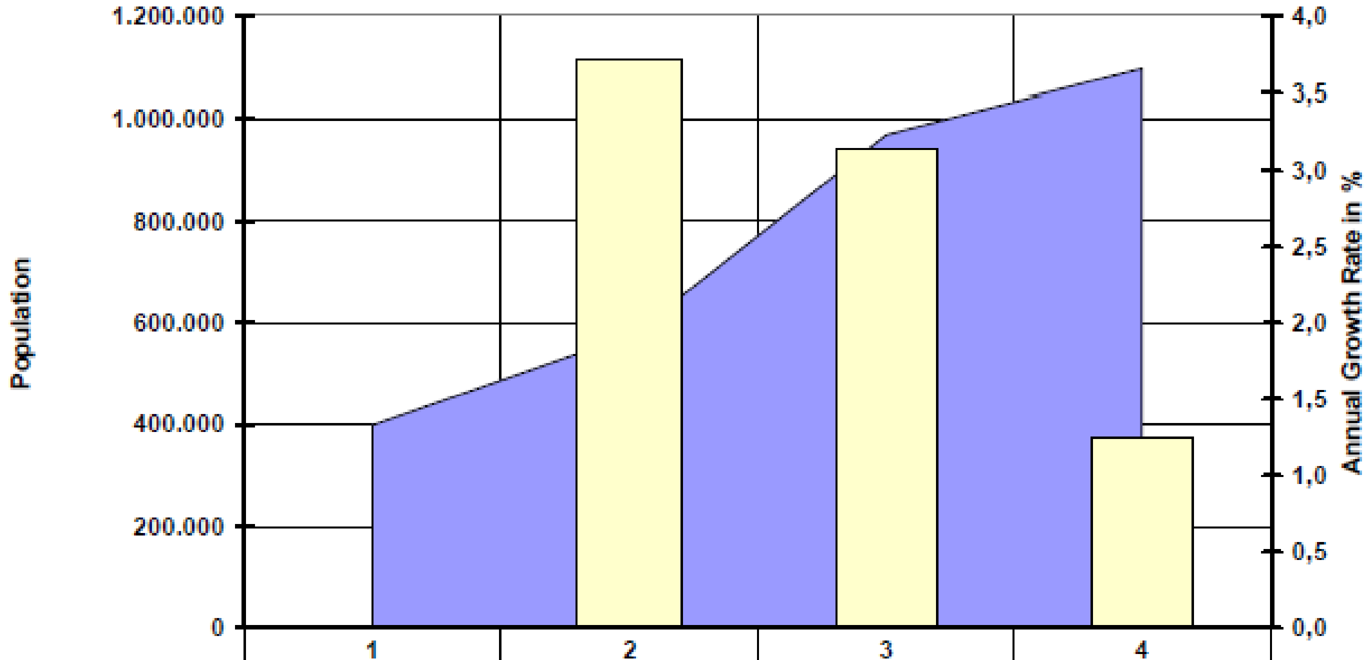
- Main reports
  - Maputo water supply project, Component 2 – Hydroplan in association with Conex, Salomon and PDNA, June 2008
  - Plano director do sistema de abastecimento de água na área de cessão da Águas de Moçambique – Águas de Portugal / Águas de Moçambique, September 2007
  - Maputo water supply project, Component 1 – Mott MacDonald, July 2008
- Information from the 1997 and 2007 Census – INE, 2008

REPORTS AND OTHER INFORMATION

- Mott MacDonald report deals with increase of water production and transmission, uses water demand estimates from other reports
- AdeP / AdeM report extrapolates water demand until 2014, approach based on number of connections
- Hydroplan and associates report is the most recent, with a sound methodology, using data from the INE (census of 2007, 1997 and before) and from AdeM – best estimate of present and future water demand

POPULATION GROWTH IN MAPUTO CITY

Maputo City: Development of Population and Annual Growth Rate



	1	2	3	4
Population	397300	572200	967.373	1.094.939
Year	1970	1980	1997	2007
Annual Growth Rate in %		3,7	3,1	1,2

source: Hydroplan report

POPULATION GROWTH RATES

Factors that may have influenced the low growth rate in Maputo city

- no decrease in poverty level at the city during the past decade, more significant improvements in rural areas
- impact of AIDS
- lifting of the pressure created by the civil war
- saturation of occupation or urban land, particularly in urban districts 1, 2 and 3
- increasing distances between house and work place

POPULATION GROWTH RATES

Much higher growth rates in Matola and Boane, possibly due to:

- saturation of the urban space in Maputo city
- urban and industrial developments in Matola and Boane

POPULATION GROWTH RATES

	1997 -2007		2006	2008
Annual Growth Rate in %	**Average**	**Variation**	**AdeM**	**This Report**
Districts of Maputo City				
District 1	-2.10	-4.5 – +0.1	1.0	1.0
District 2	-0.50	-1.8 – +0.1	1.0	1.0
District 3	0.60	-0.3 – +1.8	1.0	1.2
District 4	2.40	±0.0 – +12.0	2.0	2.5
District 5	3.40	-1.2 – +9.0	2.0	2.0
Catembe	2.10	+0.5 – +5.2	2.0	2.6
Inhaca	-1.60	N/A	N/A	1.4
Maputo City Average	**1.20**			**1.8**
Districts of Matola City				
Posto Administrativo de Infulene	6.50	±0.0 – +30.2	3.0	3.7
Posto Administrativo de Machava	6.10	+0.2 – +14.4	3.0	3.5
Posto Administrativo de Matola	2.40	-1.6 – +15.1	3.0	3.1
Matola City Average	**4.90**			**3.5**
District of Boane				
Boane	3.70	+2.6 – +4.4		5.1
Boane Average	**3.70**			**5.1**
Total project area	**2.50**			**2.5**

Source: Hydroplan report

POPULATION PROJECTIONS

- Population projections prepared by Hydroplan with the adopted growth rates for the horizon of 2035 in 5 years intervals
- Period until 2015 corresponds to investments that are already guaranteed by FIPAG
- Population supplied to increase from present 880,000 to about 1,550,000
- These projections taken to be the most probable scenario

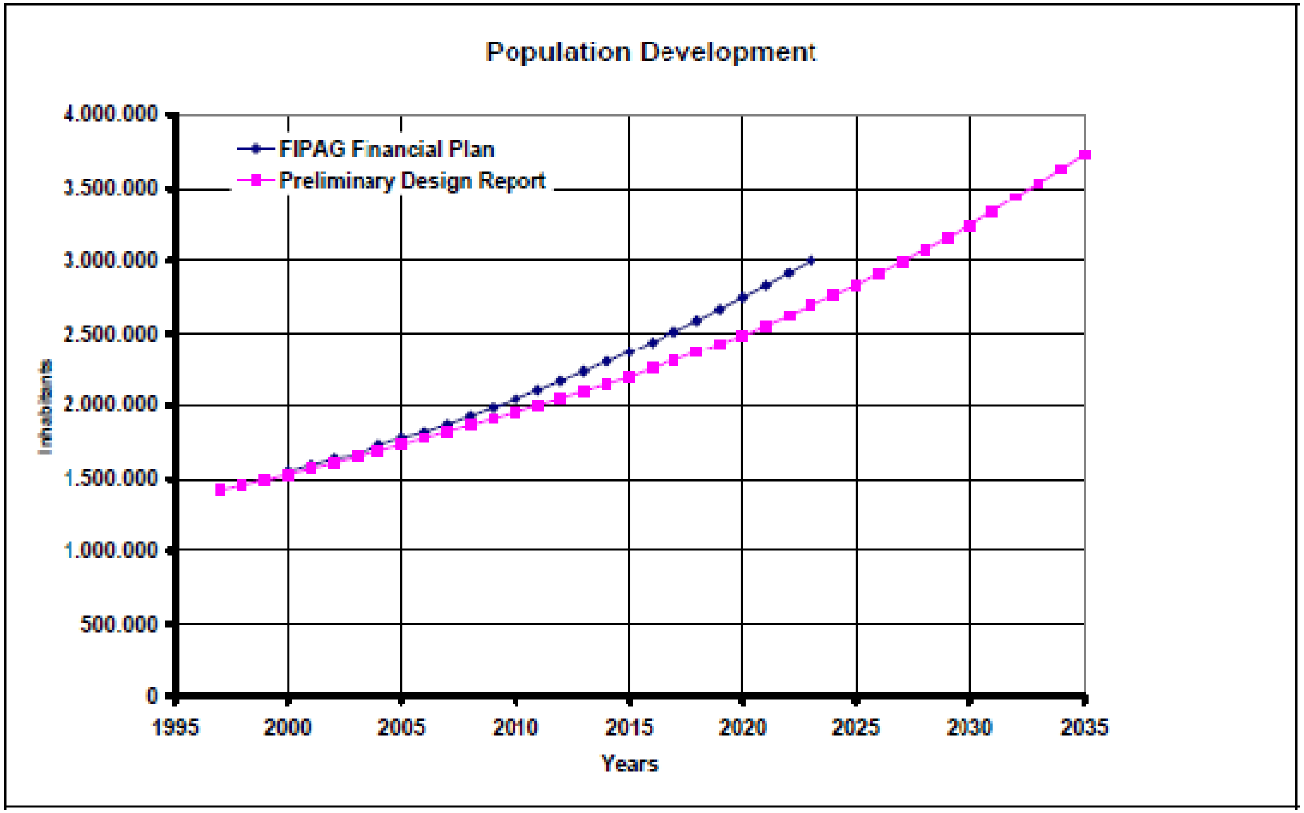
POPULATION PROJECTIONS

Source: Hydroplan report

Actual annual growth rate computed for the period 1997 – 2007	Adopted growth rates applied for the future population forecasts
Rates below 1.0 %	Minimum 1.0 %
Rates between 1.0 and 4.3 %	Actual growth rates as computed for the period 1997 to 2007 are applied (refer to Annex 2)
Rates above 4.3 %	Maximum 4.3 %
District Vila de Boane 4.4 % District Matola-Rio 2.6 %	5.1 %[4]

POPULATION PROJECTIONS

Source: Hydroplan report – population in year 2027: 3 millions



POPULATION PROJECTIONS

- average growth rate for 1997-2007: 2.5%, same growth rate assumed for the period 2007-2035
- average growth rates assumed for the period 2007-2035:
  - Maputo city – 1.8%
  - Matola city – 3.5%
  - Boane – 5.1%
  - Catembe – 2.6%
- In 2035: Maputo city – 1.75 M, Matola city and district – 1.77 M, Catembe – 41,000
- Development of Catembe could accelerate if a reliable and fast crossing is built

WATER DEMAND

- water demand computation by Hydroplan – most probable scenario
- considered
  - population distribution and growth patterns
  - domestic use based on various levels of supply (house connection, yard connection, standpost) and historical data at the various ”bairros”
  - evolution of coverage rate
  - industrial and other non-domestic water uses
  - water losses

WATER DEMAND

- **RSPDADARM considers the following unit consumptions (L/p/d)**
  - **house connections in areas with more than 2000 inhabitants – 125 (much less than in cities of developed countries, 150-250)**
  - **yard connection – 50**
  - **standpost – 30**
- **study by Sustém (2001) found somewhat lower figures**
- **non-domestic water consumption taken as a percentage of domestic (presently, about 1/3 of domestic consumption – source: AdeM)**

WATER DEMAND

Source: Hydroplan report - unit consumption rates adopted

Type of Connection:	House connection (HC)	Yard connection (YC)	Public Tap (PT)	Non Domestic in % of domestic demand
Distribution Centre	l/c/d	l/c/d	l/c/d	
Alto Maé	130 150	60 80	20 30	50 30
Chamanculo	120 – 130	60 – 80	25 – 30	40 – 25
Laulane	120 – 135	60 – 80	20 – 30	30 – 20
Maxaquene	120 – 140	70 – 80	20 – 30	50 – 30
Machava, Matola, Boane, Catembe	120 – 135	60 – 80	20 – 30	50 – 30
Matola – Rio Belo Horizonte	120 – 180	60 – 80	20 – 30	50 – 30

Note: First figure is for the year 2007; last figure the level to be reached in 2035. The values in between will be interpolated

WATER DEMAND

Source: Hydroplan report – evolution of coverage and UFW

BENCH MARK INDICATORS	Base Year	Year					
	2007	2010	2015	2020	2025	2030	2035
Population served	879.865	1.100.907	1.531.707	1.751.021	2.011.397	2.322.227	2.695.239
Population not served	640.143	514.007	261.593	250.390	234.047	210.779	178.211
Population served; coverage in percentage	58	68	85	87	90	92	94
Per capita water demand for the population served (l/c/d)	71	77	87	88	91	94	96
Unaccounted for water (%)	51	44	33	30	29	27	25

WATER DEMAND

Source: Hydroplan report – level of supply

Type of connection:	House connection (HC)	Yard connection (YC)	Public Tap (PT)	Not Served Population
Distribution Centre	Percentage of total population			
Alto-Maé	50 – 75	10 – 20	20 – 5	20 – 0
Chamanculo	15 – 35	15 – 40	20 – 20	50 – 5
Laulane	30 – 50	15 – 30	25 – 15	30 – 5
Machava	10 – 35	15 – 40	25 – 20	50 – 5
Matola	15 – 35	15 – 35	15 – 25	55 – 5
Maxaquene	45 – 65	15 – 20	15 – 15	25 – 0
Catembe	15 – 35	15 – 35	10 – 25	60 – 5
Boane	25 – 25	10 – 10	10 – 10	55 – 55
Matola – Rio Belo Horizonte	20 – 60	10 – 25	10 – 10	60 – 5

Note: First figure is for the year 2007; last figure the level to be reached in 2035,

WATER DEMAND

- UFW is presently very high, above 50%
- Objective: reduce to 25% in 2035 through:
  - improvements in the transmission, storage and distribution networks,
  - bulk and zone metering,
  - leak detection program with immediate repair capacity,
  - improved management,
  - great reduction in non-authorized connections
- Large investment program by FIPAG to be implemented until 2015

WATER DEMAND

Source: Hydroplan report – water demand estimate, average domestic consumption 74 L/p/d

Year	2007	2010	2015	2020	2025	2030	2035
	in million m^3/ year						
Total water provision	**67.1**	**76.7**	**99.4**	**109.2**	**125.0**	**142.5**	**159.6**
Unaccounted for water	34.5	33.3	32.4	33.1	35.9	38.8	39.9
Domestic water demand	22.9	30.8	48.5	56.2	67.2	79.9	94.3
Non-domestic water demand	9.8	12.7	18.5	19.9	21.9	23.8	25.4

INVESTMENTS PLANNED AND IMPLEMENTED

- FIPAG secured funds to invest in infrastructure
- Implementation to take place until 2015
- Capacity of water intake and treatment at ETA Umbeluzi to increase from the present 6,000 m3/h to 10,000 m3/h (87.6 M m3/year)
- Other investments are in extension of network to new areas (Boane, Picoco, Belo Horizonte, Matola-Rio) and extension and rehabilitation in existing areas; reahabilitation of transmission mains and distribution centers; and bulk metering

REASONS TO CONSIDER OTHER SCENARIOS

- Until 2015 – no other scenarios, investment program being implemented; after 2015 – other scenarios can be considered, high and low
- High scenario
  - high economic growth
  - population growth rate higher than 2.5%, same coverage (95%)
  - increase in average unit consumption
- Low scenario
  - low economic growth
  - decrease of external support, less investment capacity
  - resulting in reduced coverage and lower unit consumption in 2035

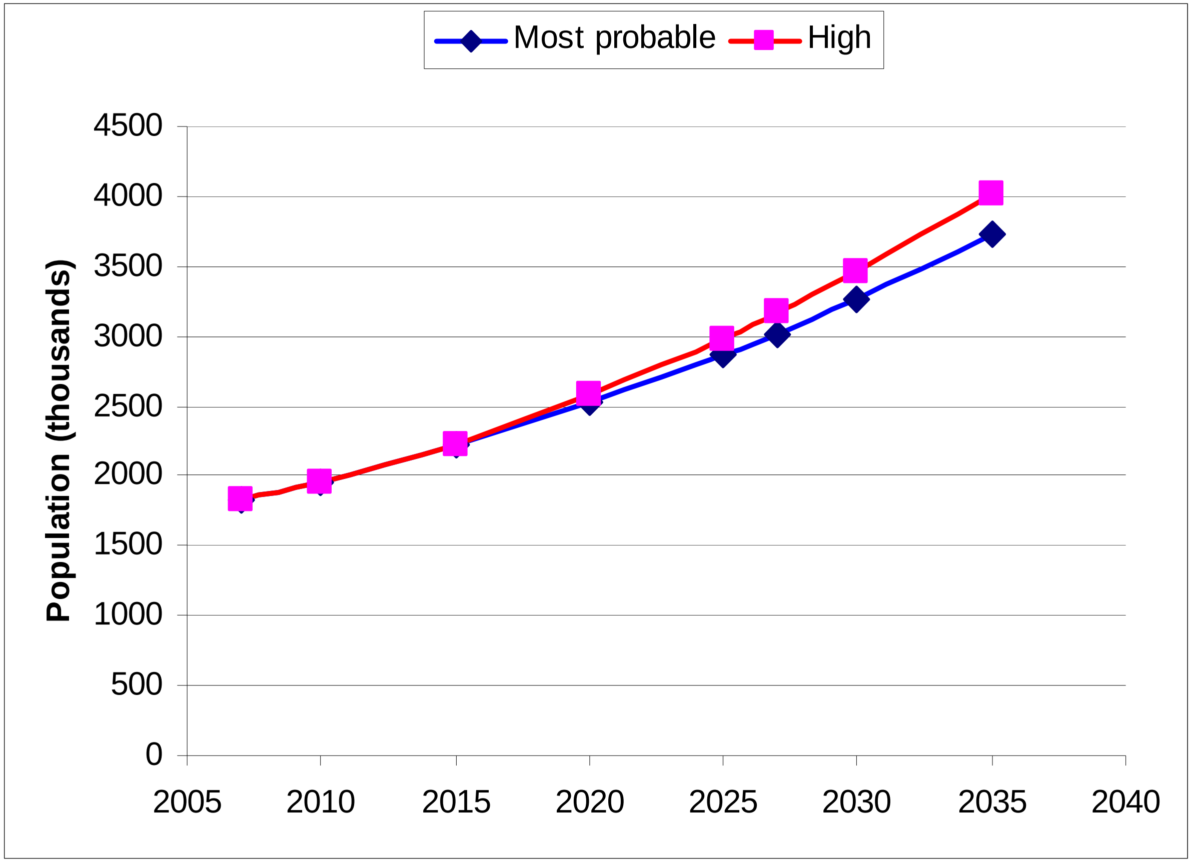
DEALING WITH OTHER SCENARIOS

- Uncertainties on how the urban area, the population and the economic activities will evolve in the mid- and long-term future
- Need to regularly update the projections
- Low scenario is less relevant, it does not put an additional stress in the physical system (although it can create other type of problems – social, health, political)
- The high scenario creates additional stress in the physical system – water source, infrastructure, investments, management

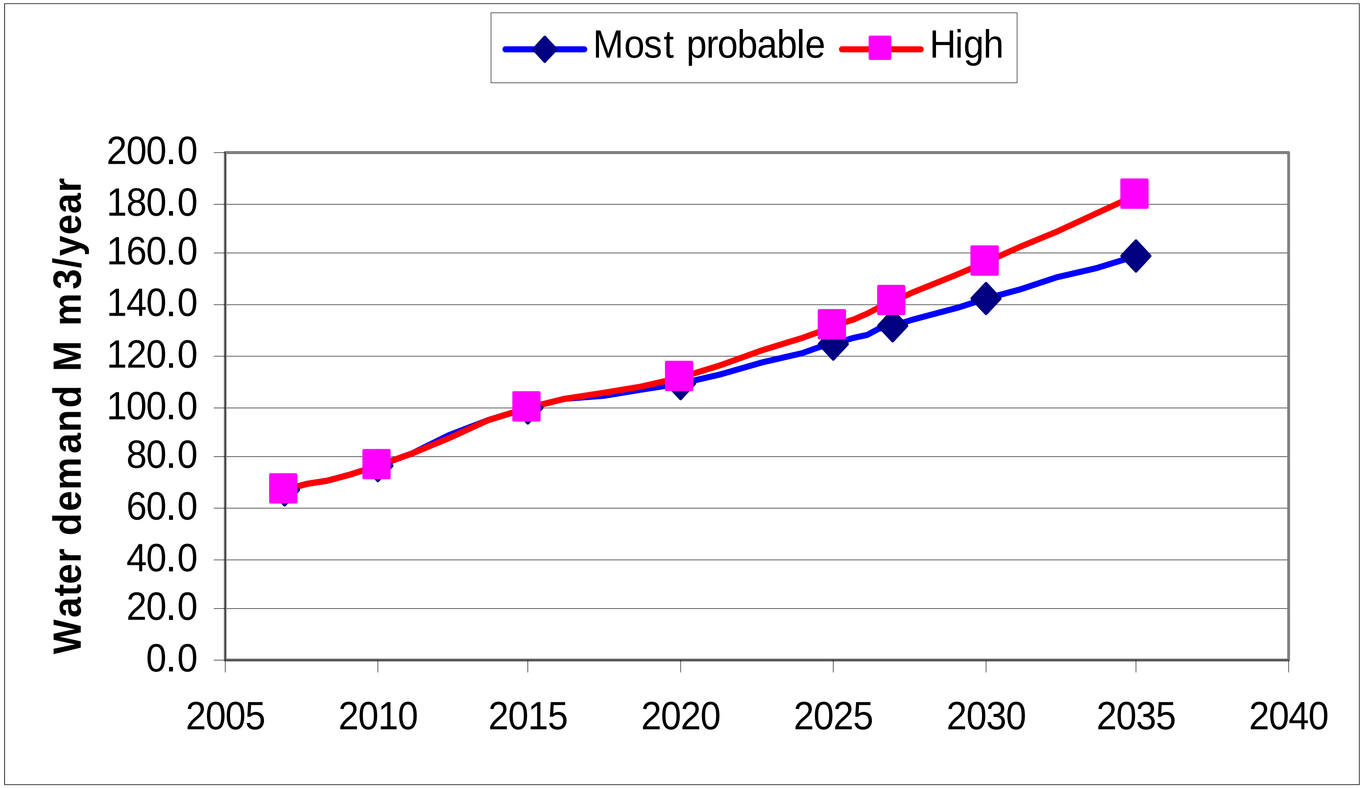
HIGH SCENARIO

- Similar approach to that followed by Hydroplan and associates, no changes until 2015
- From 2016, population growth rate of 3%, same coverage evolution, same reduction of UFW
- Average domestic unit consumption rate increased to 80 L/p/d
- Larger growth in Catembe (5.5% per year)

COMPARING THE TWO SCENARIOS - POPULATION



COMPARING THE TWO SCENARIOS – WATER DEMAND



OBSERVATIONS

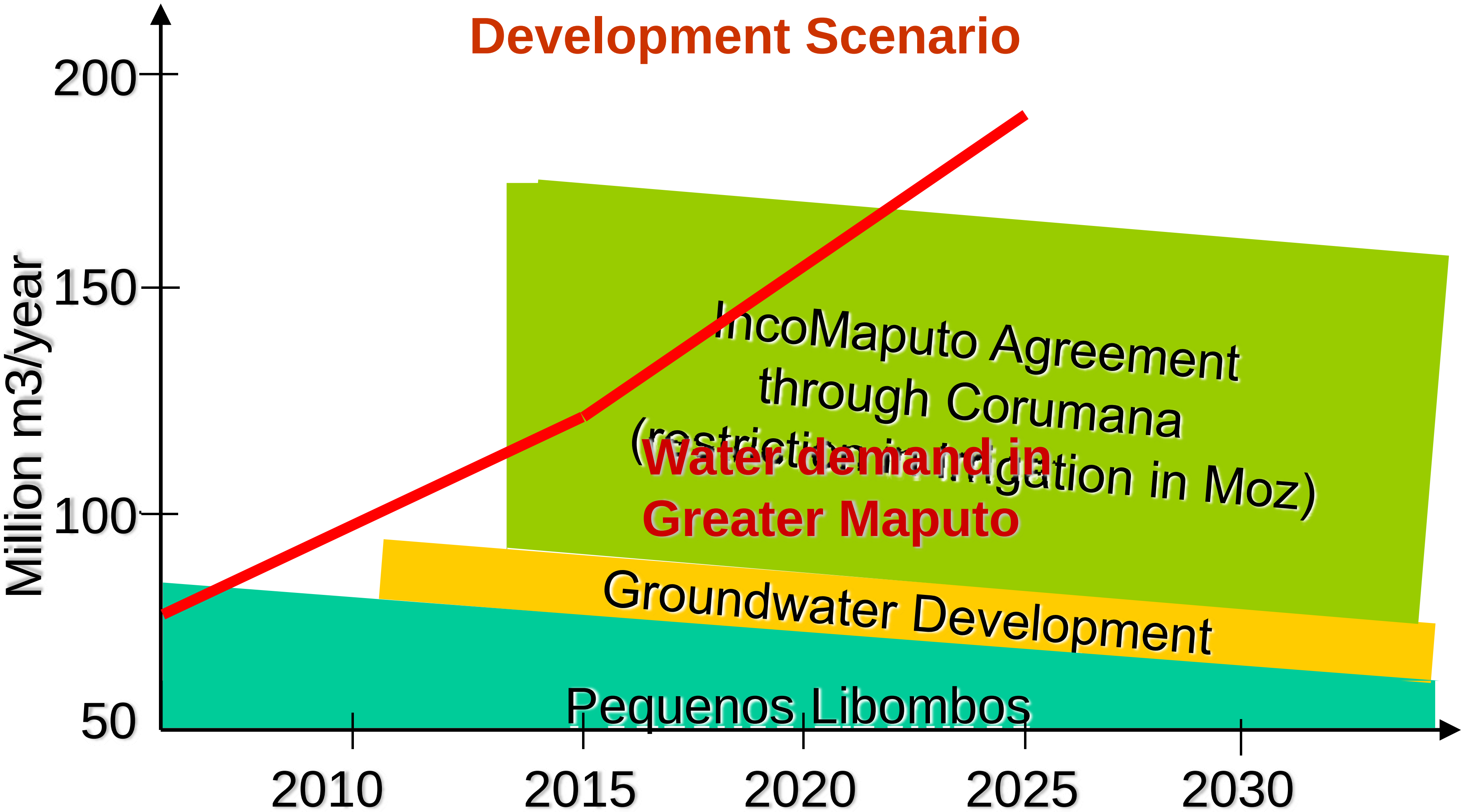
- The high scenario gives more 15% in terms of water demand in relation to the most probable scenario for the year 2035
- The target of 25% for UFW is difficult to achieve
- Almost 95% of the water demand in both scenarios correspond to the cities of Maputo and Matola; Boane and Catembe take about 6%
- The water demand in Catembe is low even considering a population growth rate of 5.5% during 20 years
- While present water demand of Matola is about 63% of Maputo, it will become the same in 2035 in both scenarios

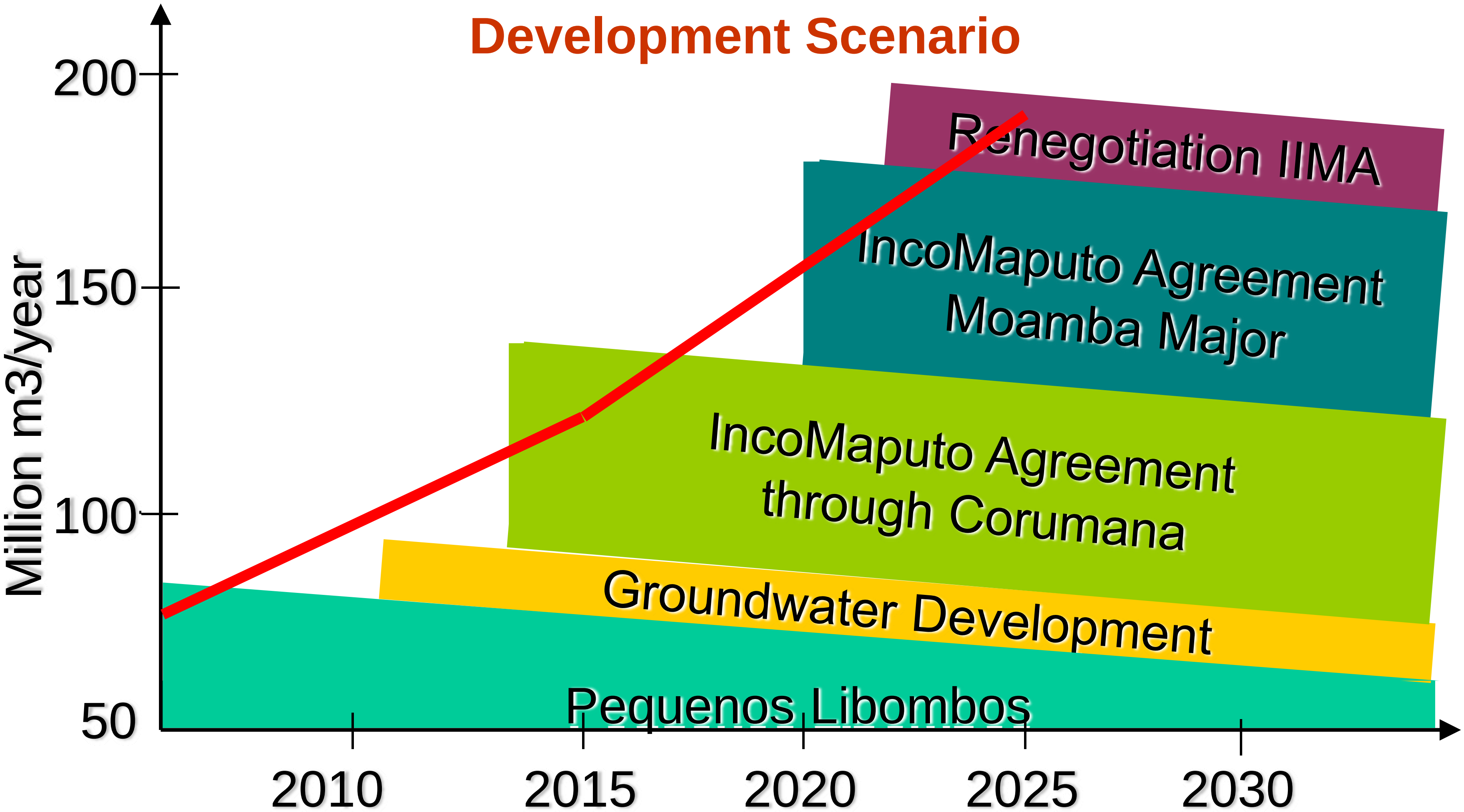
WATER CONSERVATION AND WATER DEMAND MANAGEMENT

Experience from other cities in southern Africa

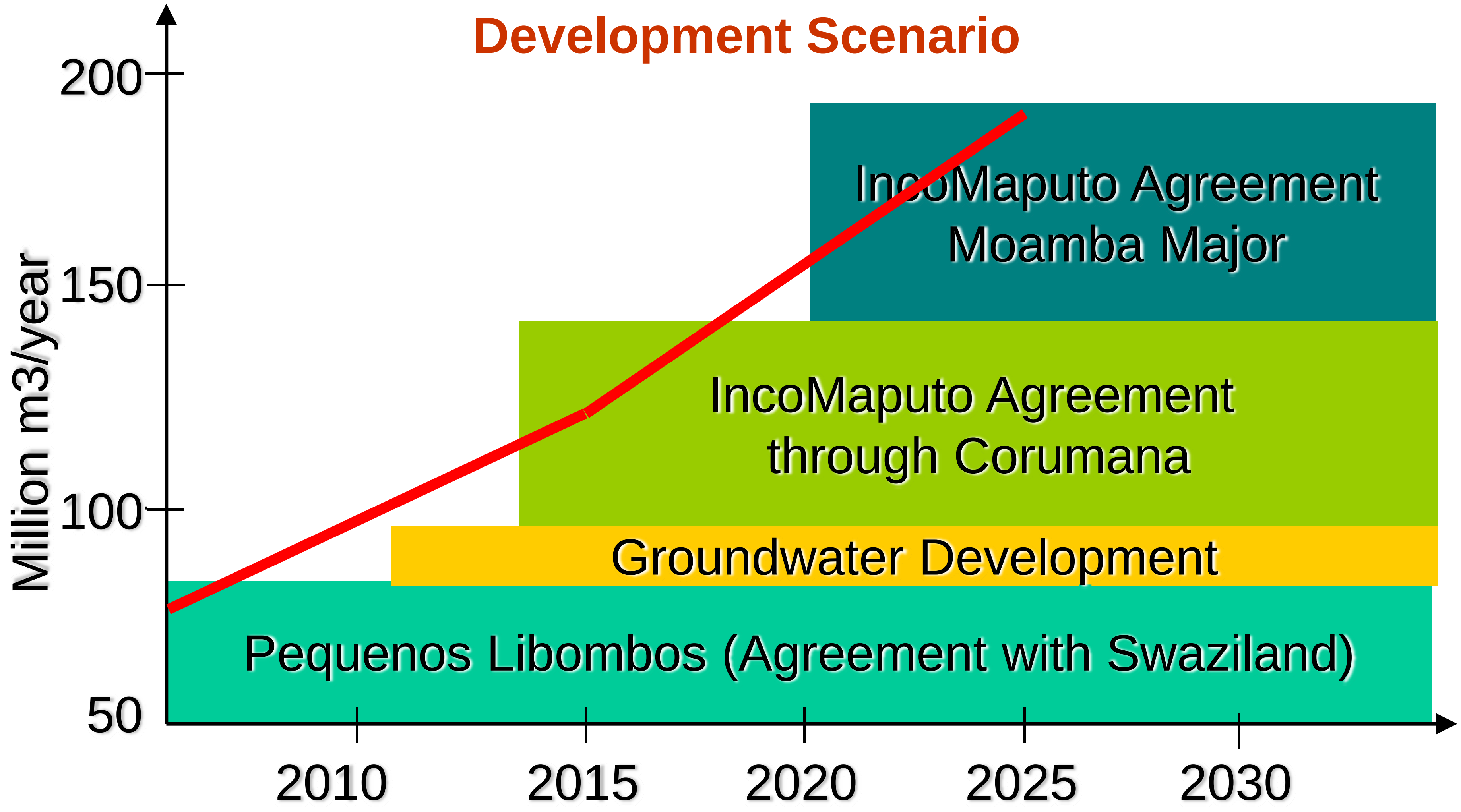
Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

Development Scenario




Development Scenario
Million m3/year
200
150
100
50
Renegotiation IIMA
IncoMaputo Agreement
Moamba Major
IncoMaputo Agreement
through Corumana
Groundwater Development
Pequenos Libombos
2010
2015
2020
2025
2030

SWECO


Development Scenario
200
150
100
50
Million m3/year
IncoMaputo Agreement
Moamba Major
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Groundwater Development
Pequenos Libombos (Agreement with Swaziland)
2010
2015
2020
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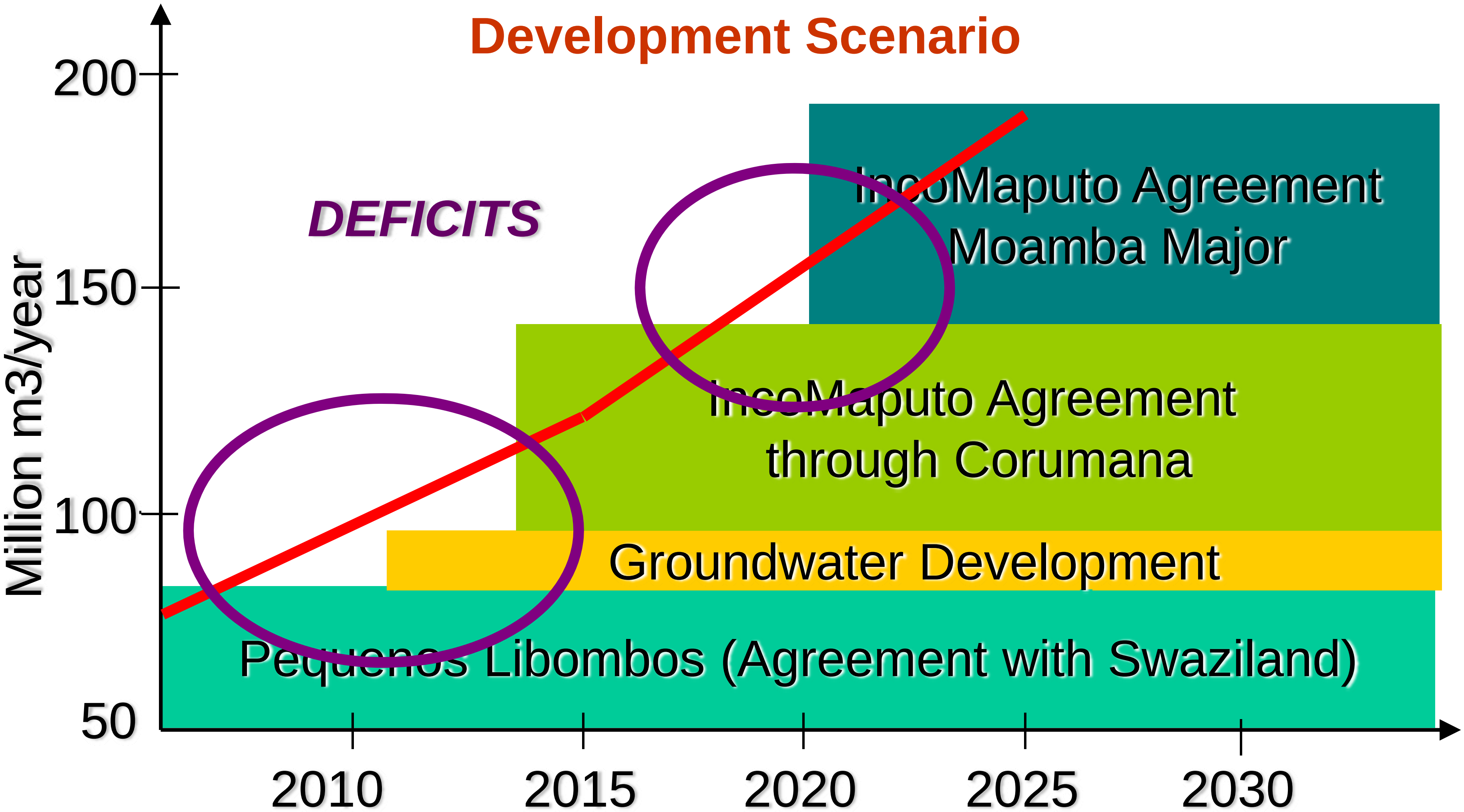
SWECO


Development Scenario
Million m3/year
200
150
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DEFICITS
IncoMaputo Agreement
Moamba Major
IncoMaputo Agreement
through Corumana
Groundwater Development
Pequenos Libombos (Agreement with Swaziland)
2010
2015
2020
2025
2030

SWECO

THE ONLY WAY TO AVOID WATER DEFICITS IS TO REDUCE WATER DEMAND!

Water Conservation & Water Demand Management

- **To minimise losses in distribution**
- **To encourage or enforce efficient use of water**
- **To reuse grey or sewage water**

- Permanent basis, or
- Drought mitigation

Examples from Cape Town

- **To minimise losses**
  - **Leakage repair**
  - **Pressure management**
  - **Improved metering**

Examples from Cape Town

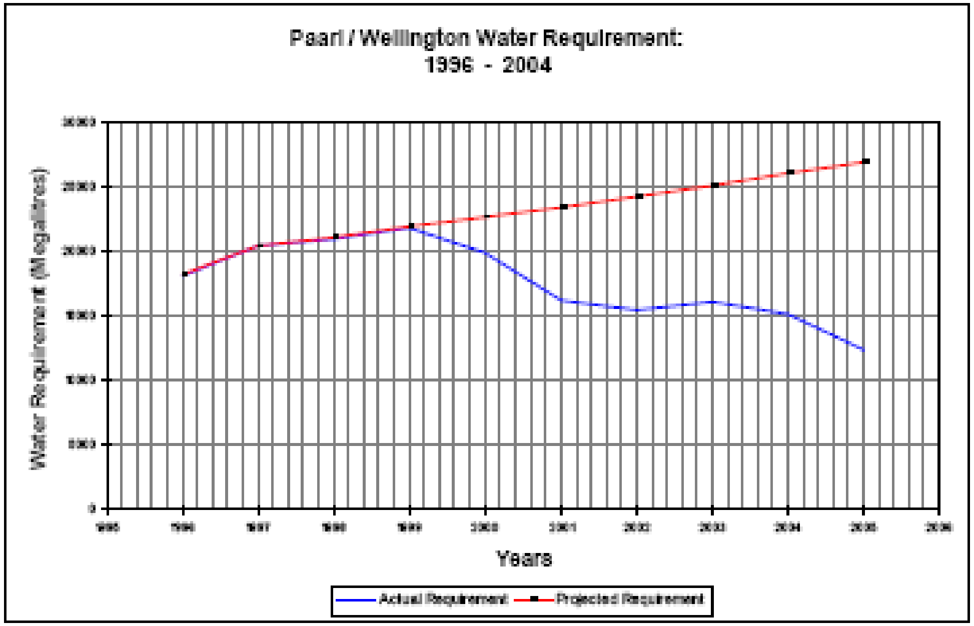
- **To encourage or enforce efficient use of water**
  - **Water Awareness programmes**
  - **Partnership with Dept. of Education**
  - **Elimination of Automatic Flush Urinals**
  - **Three-step water tariff**
  - **Promotion of water efficient fitting**
  - **Direct contact with large users**

Special by-laws during drought 2004/05

Examples from Cape Town

- To reuse grey or sewage water
  - Promotion of grey water for garden watering
  - Municipal use of treated sewage water for watering of parks and sport fields

Examples from Cape Town

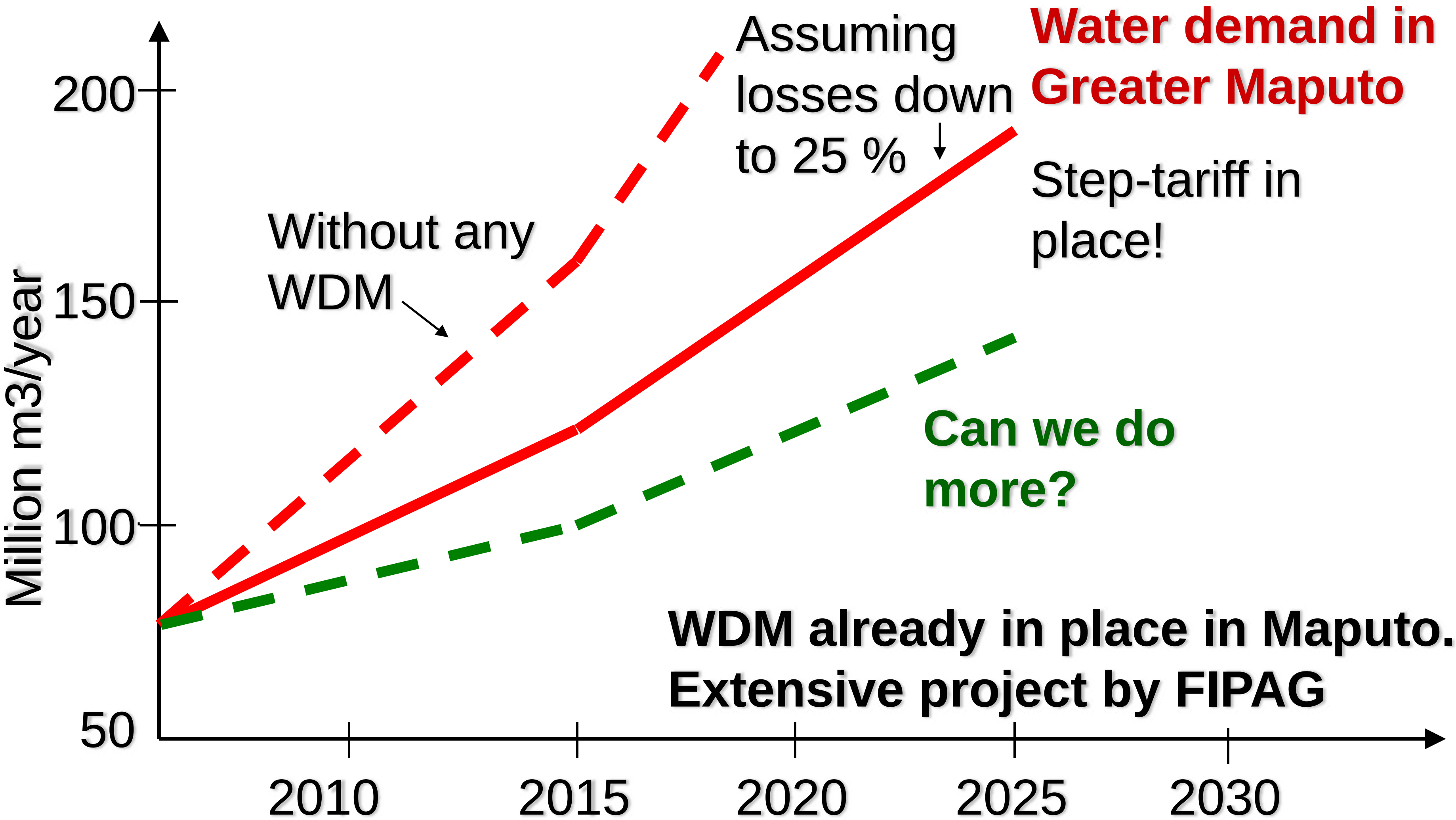


Significant reduction observed in certain areas

Similar results in Namibia!

SWECO

Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

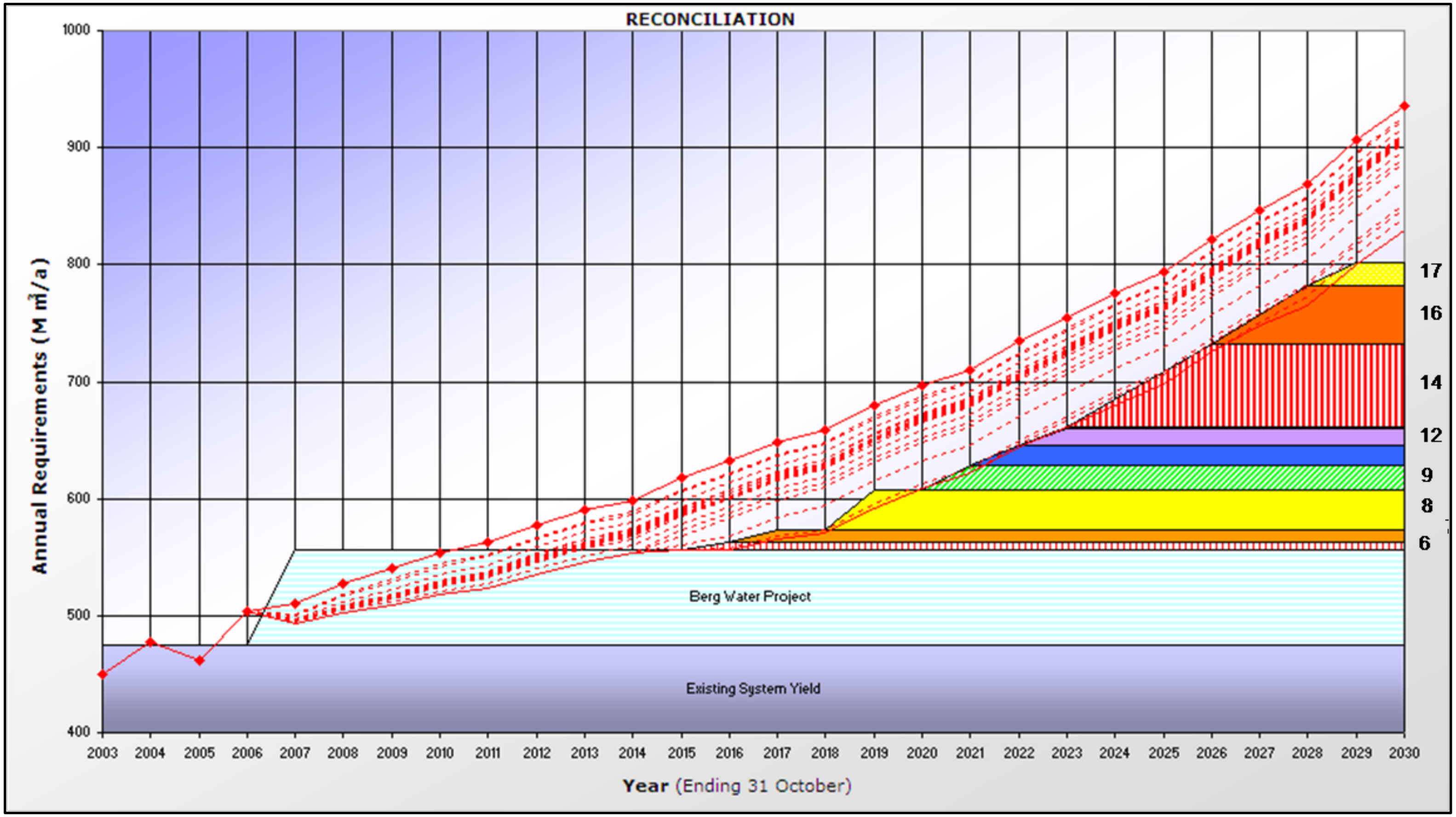


SWECO

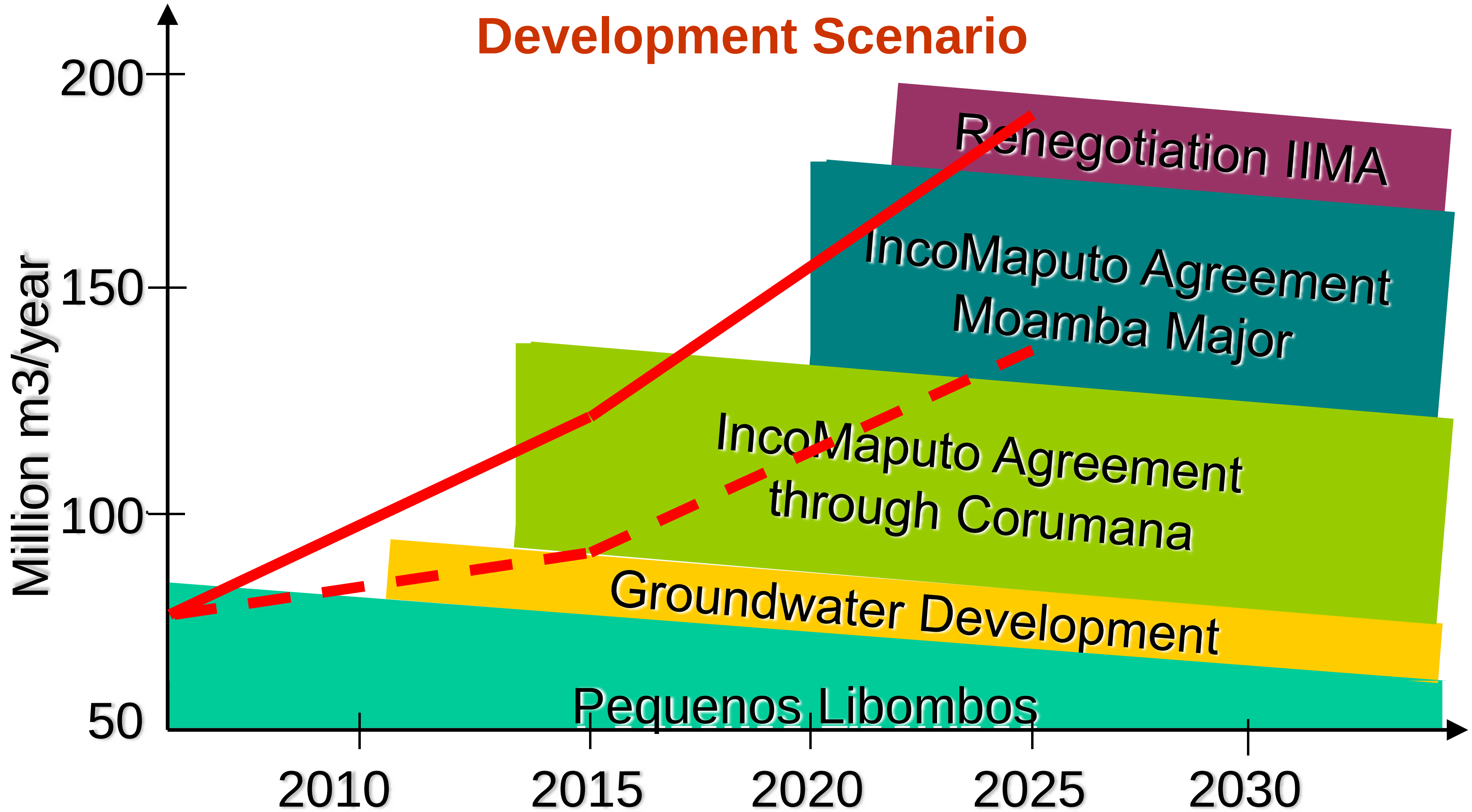
Costs (Examples from Cape Town)

Pressure Management	0.40	rand/m^3
User Education	0.70	rand/m^3
Elimination of Automatic Flushing Urinals	0.26	rand/m^3
Leakage Repair	0.31	rand/m^3
Introduction of Water Efficient Fittings	0.60	rand/m^3
Promotion of Grey Water Use	1.05	rand/m^3

Examples from Cape Town – WDM as part of strategy



SWECO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2010
2015
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2030

Plano de Estrutura Urbana
Do Município
de

Assembleia Municipal – Seminário de Apresentação

Maputo, Novembro de 2008

O Plano de Estrutura Urbana do Município de Maputo (PEUMM)

- constituído por **orientações e propostas expressas em peças desenhadas e escritas**
- instrumento orientador e coordenador da ocupação do solo
- **materializa-se através de planos de urbanização e de pormenor**

Natureza jurídica do PEUMM

Tem a natureza jurídica de regulamento administrativo por força do seu REGULAMENTO.

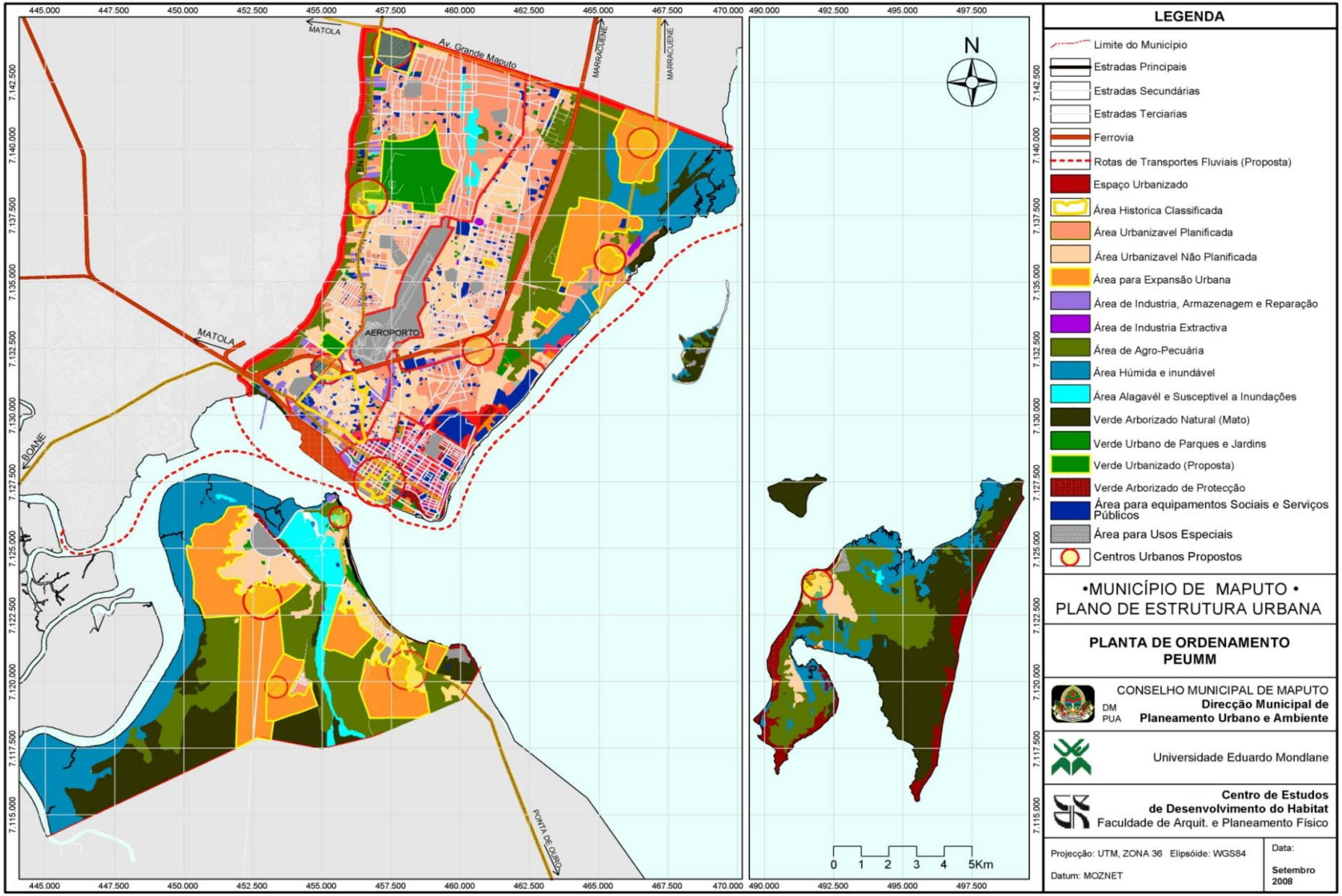
Documentos principais do PEUMM

- A planta de Ordenamento
- A planta de Condicionantes
- O regulamento

Documentos complementares do PEUMM

- As razões e filosofia
- O relatório de fundamentação das opções
- A analise da situação actual
- As plantas e cartas que explicitam e argumentam aos opções

A Planta de Ordenamento – Uso do Solo



A Planta de ordenamento indica e define:

- AS CLASSES E CATEGORIAS DO DO ESPAÇOS
- USO DOMINANTE DO SOLO

CLASSES E CATEGORIAS DO ESPAÇOS - USO DOMINANTE DO SOLO

Classes de Espaço

- Espaço Urbanizado;
- Espaço Urbanizáveis;
- Espaço para Actividade Industrial, de Armazenagem e Reparação;
- Espaço para Actividade Agrícola;
- Espaço Afecto à Estrutura Ecológica;
- Espaço para Equipamento Social e Serviços Públicos.
- Espaço para Redes de Infra-estruturas;

ESPAÇOS URBANIZADOS

São espaços localizados em **tecidos urbanos construídos, já estabilizados ou em fase de estabilização,** em que se verifica simultaneidade de usos e de actividades.

ESPAÇOS URBANIZADOS

O regulamento do PEUMM, do artigo 27 ao artigo 37 apresenta as regras que regem a construção ou alterações.

- Condições de incompatibilidade
- Alterações ao uso
- Condições de edificabilidade
- Logradouro
- Excepções à edificabilidade
- Estacionamento privativo
- Regime especial de estacionamento privativo
- Alinhamento e cérceas
- Regime de cedências

ESPAÇOS URBANIZÁVEIS

São áreas estrategicamente localizadas, **com capacidade construtiva, capazes de assegurar a expansão urbana** a curto e a médio prazo, e que correspondem geralmente à evolução dos espaços urbanos já consolidados.

O espaço urbanizável é o solo susceptível de vir a adquirir as características do solo urbano.

ESPAÇOS URBANIZÁVEIS

Destino de uso dominante

As áreas englobadas nos espaços urbanizáveis destinam-se à **localização predominante de actividades residenciais, complementadas com outras actividades,** nomeadamente comerciais, de equipamento, de serviços e industriais ou armazenagem, desde que não criem condições de incompatibilidade com a função residencial.

ESPAÇOS URBANIZÁVEIS

O regulamento do PEUMM, apresenta as regras que regem a construção ou alterações tais como:

- **Implementação do Plano**
- **Restrições gerais**
- **Condições de incompatibilidade**
- **Índices urbanísticos**
- **Padrões de ocupação**
- **Condições de edificabilidade**
- **Infra-estruturas viárias**
- **Estacionamento público**

ESPAÇOS URBANIZÁVEIS

- Nas áreas a ocupar por edifícios habitacionais, os Planos de Urbanização ou de Pormenor que venham a ser elaborados devem destinar 75% da mesma à habitação multifamiliar e 25% a habitação unifamiliar
- **Nas áreas destinadas a habitação, 60% da mesma deve ser destinada a construção de habitação social.**
- Os índices estabelecidos para as diversas classes, zonas e categorias de espaços serão respeitados nos Planos de Urbanização, Planos de Pormenor ou operações de loteamento a elaborar.

ESPAÇOS URBANIZÁVEIS

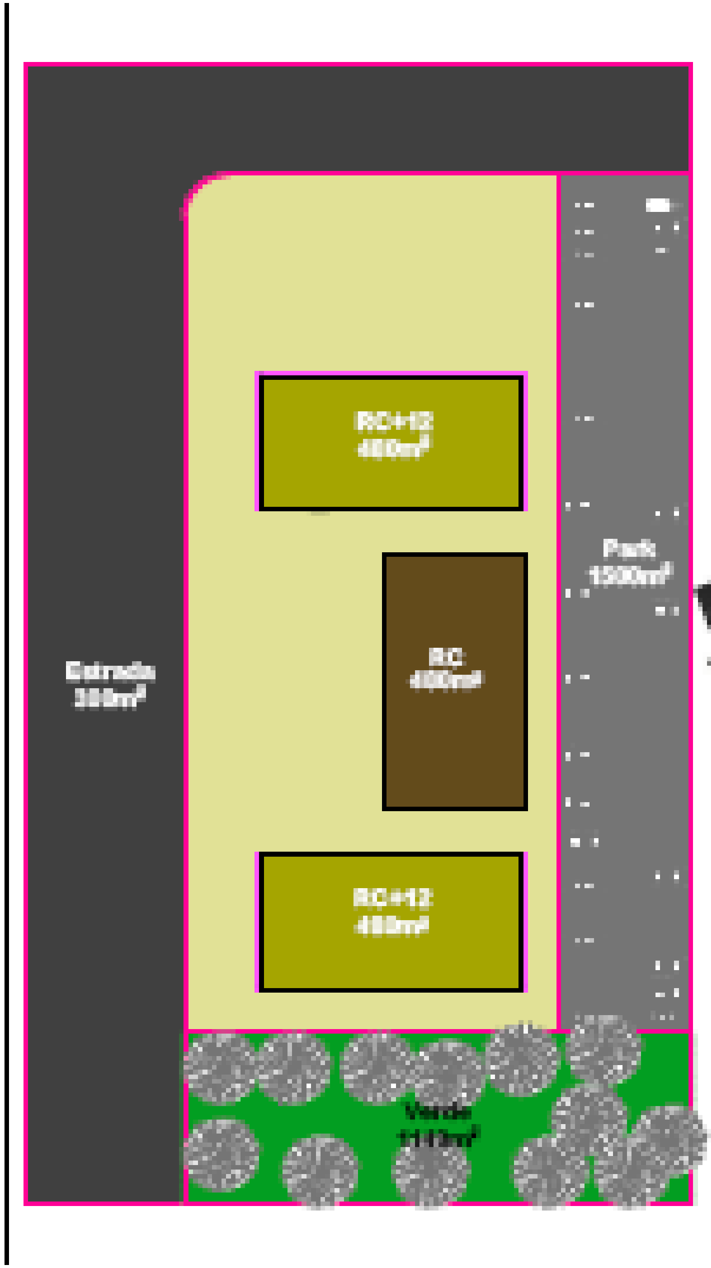
Índices urbanísticos

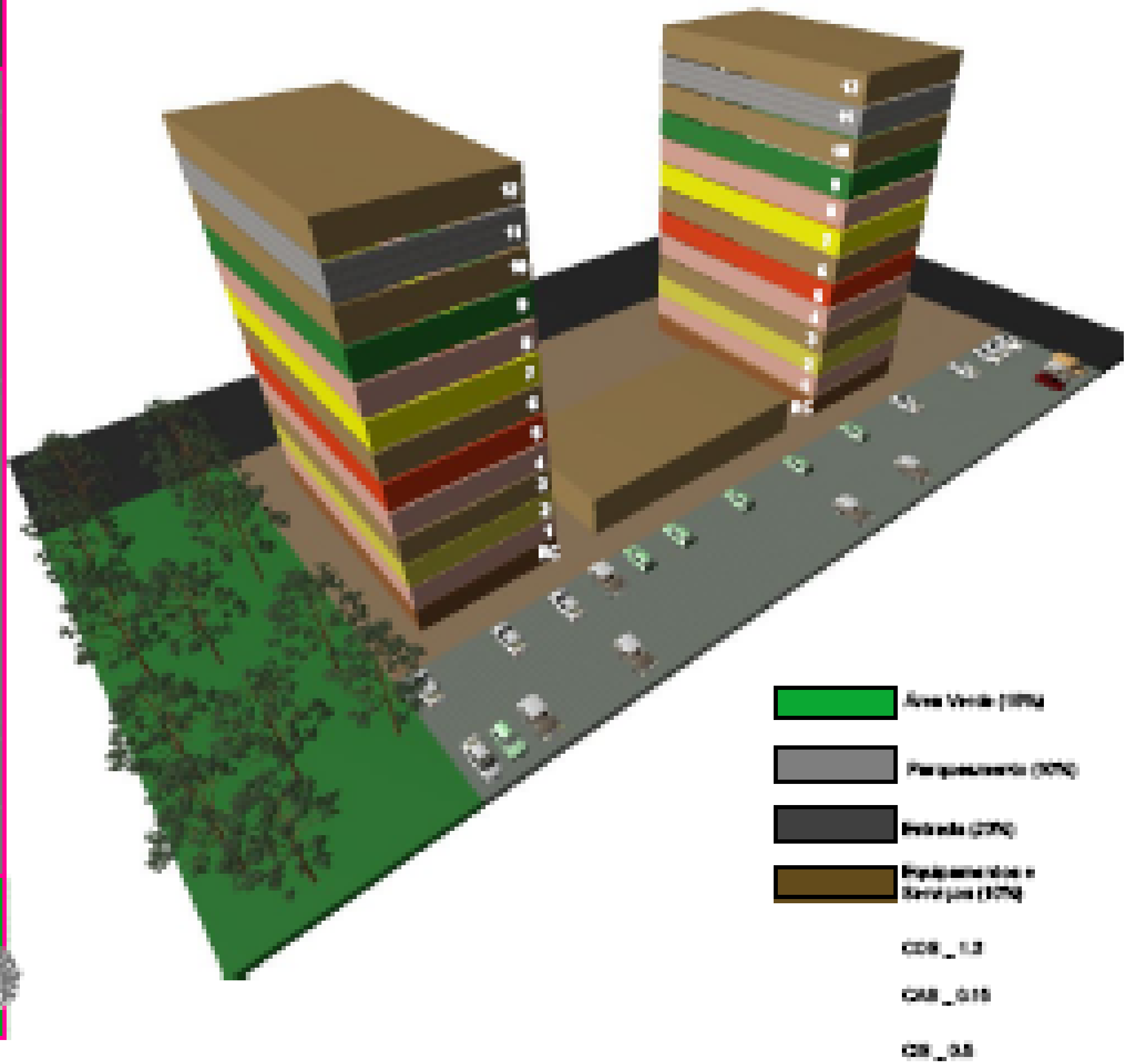
Para áreas de uso predominantemente habitacional de alta densidade (Plurifamiliar) – mais de 60 residências por hectare

- Densidade Populacional **– 500 hab/ha**
- Coeficiente de Afectação do Solo (CAS) **- 0,2**
- Coeficiente de Ocupação do Solo (COS) -**1,2**
- Coeficiente de Impermeabilização do Solo (CIS) – **0,5**
- Percentagem de área para Espaços Verdes de Utilização Colectiva – **15 %**
- Percentagem de área para Equipamentos – **15 %**

ESPAÇOS URBANIZÁVEIS

Índices urbanísticos



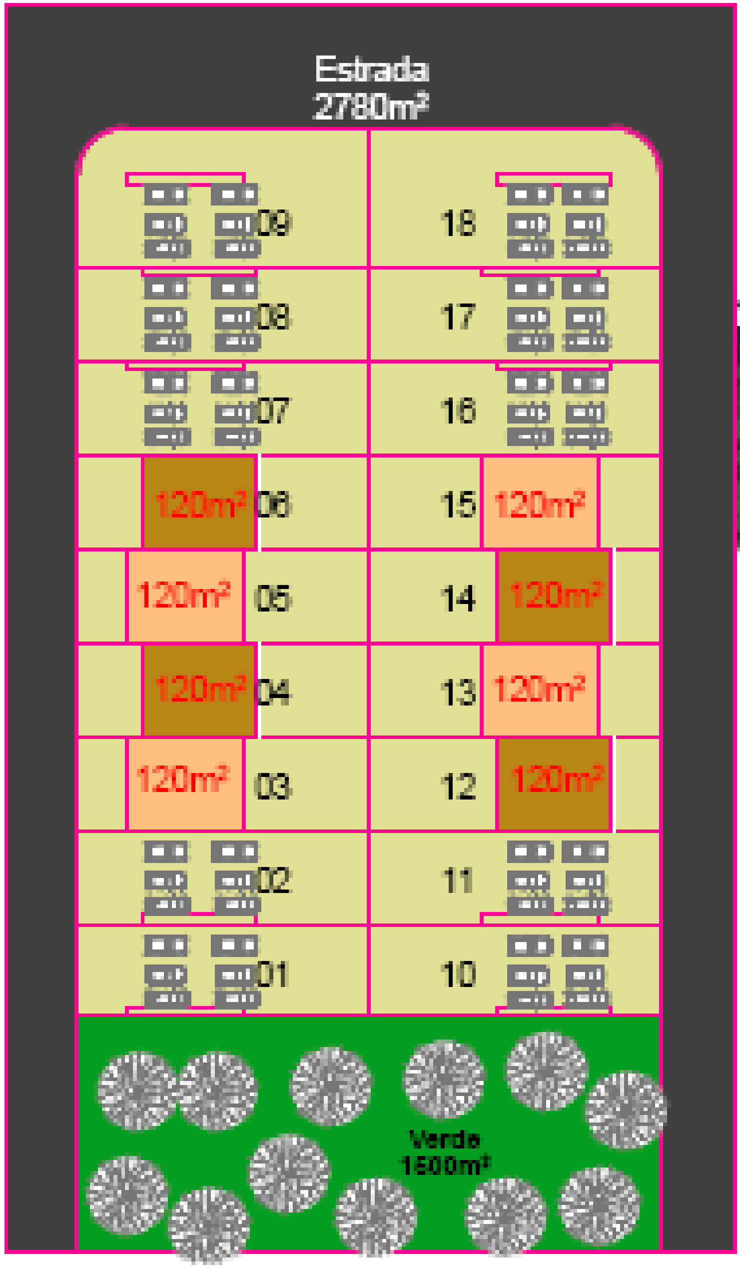


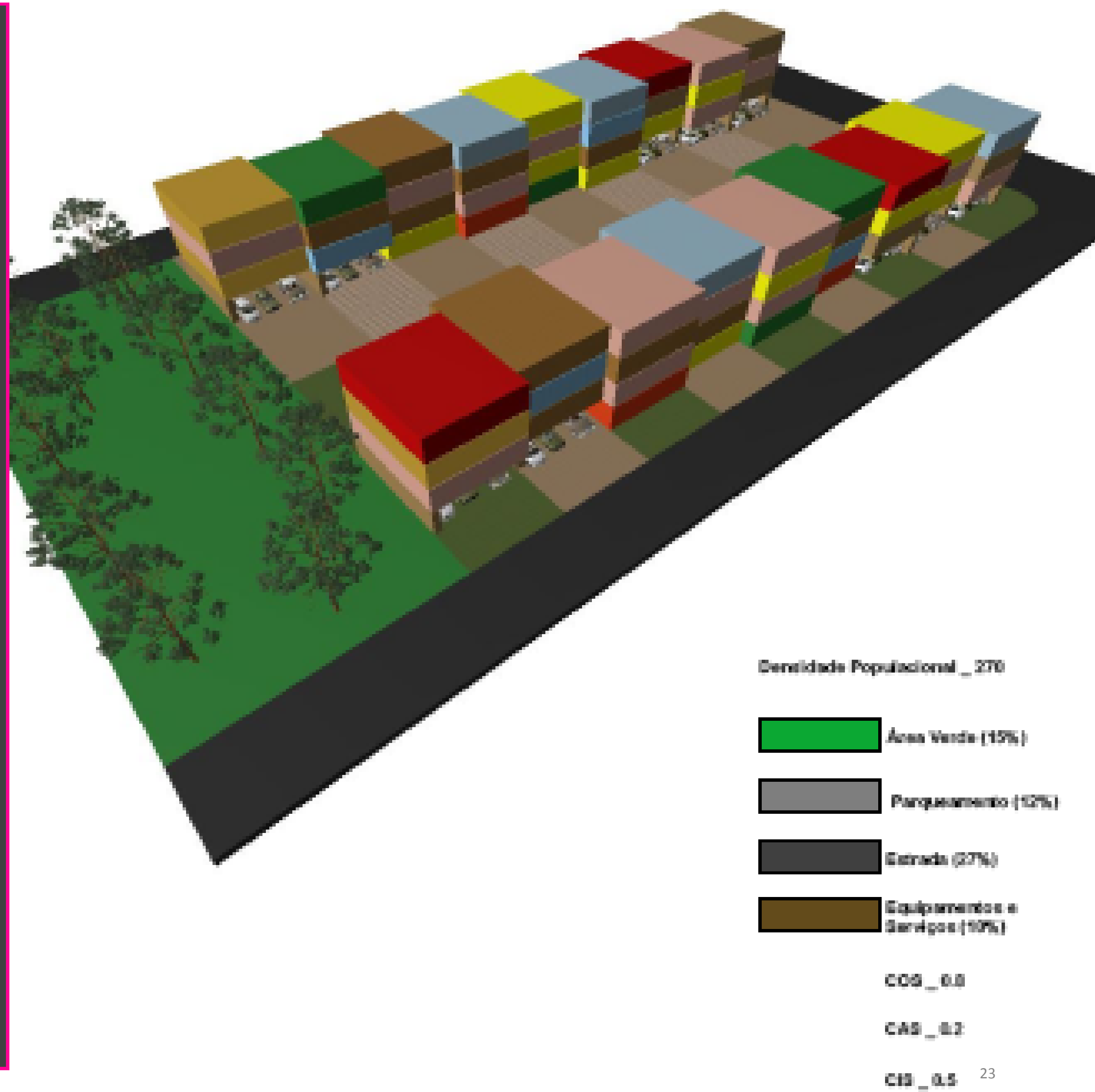
Regulamento do PEUMM

Para áreas predominantemente residenciais de média densidade (Plurifamiliar) entre 20 e 60 residências por hectare

- **Densidade Populacional – 240 hab/ha**
- **Coeficiente de Afectação do Solo (CAS) - 0,2**
- **Coeficiente de Ocupação do Solo (COS) -0,8**
- **Coeficiente de Impermeabilização do Solo (CIS) – 0,5**
- **Percentagem de área para Espaços Verdes de Utilização Colectiva – 15%**
- **Percentagem de área para Equipamentos – 15%**

Regulamento do PEUMM



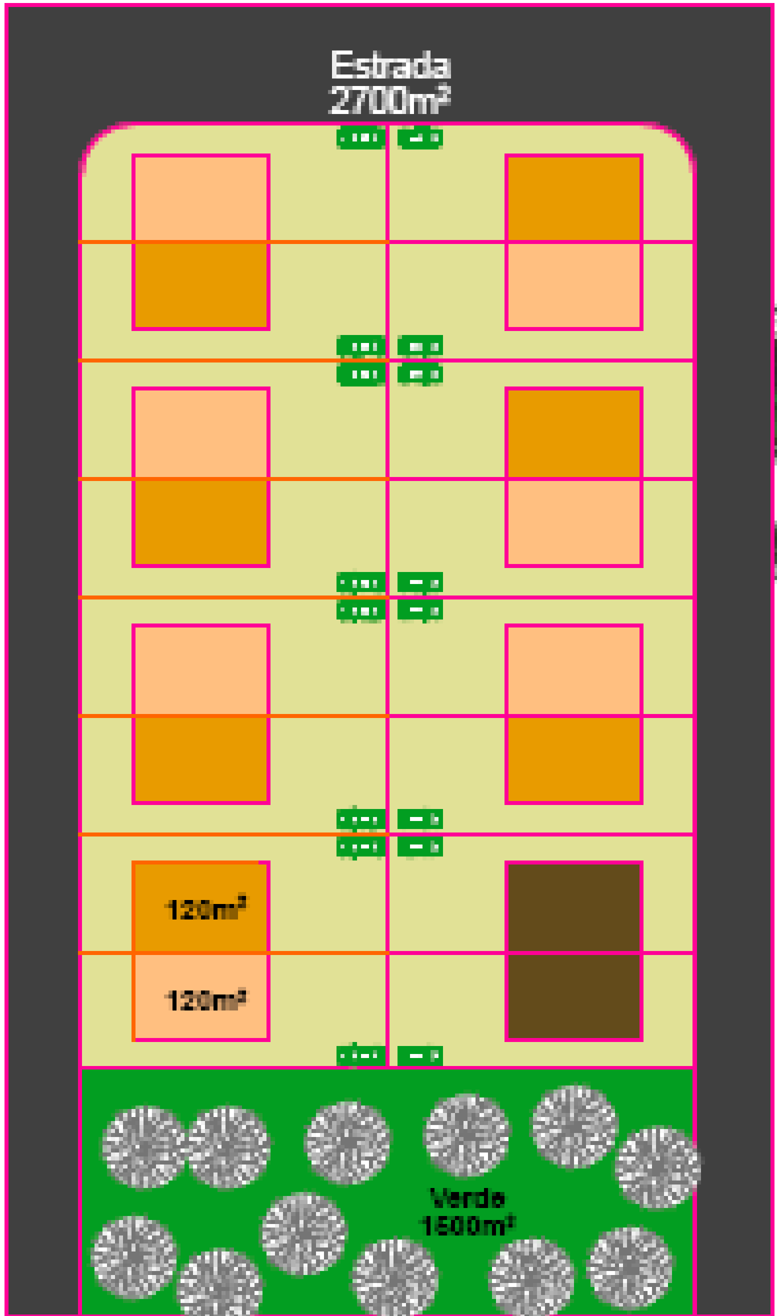


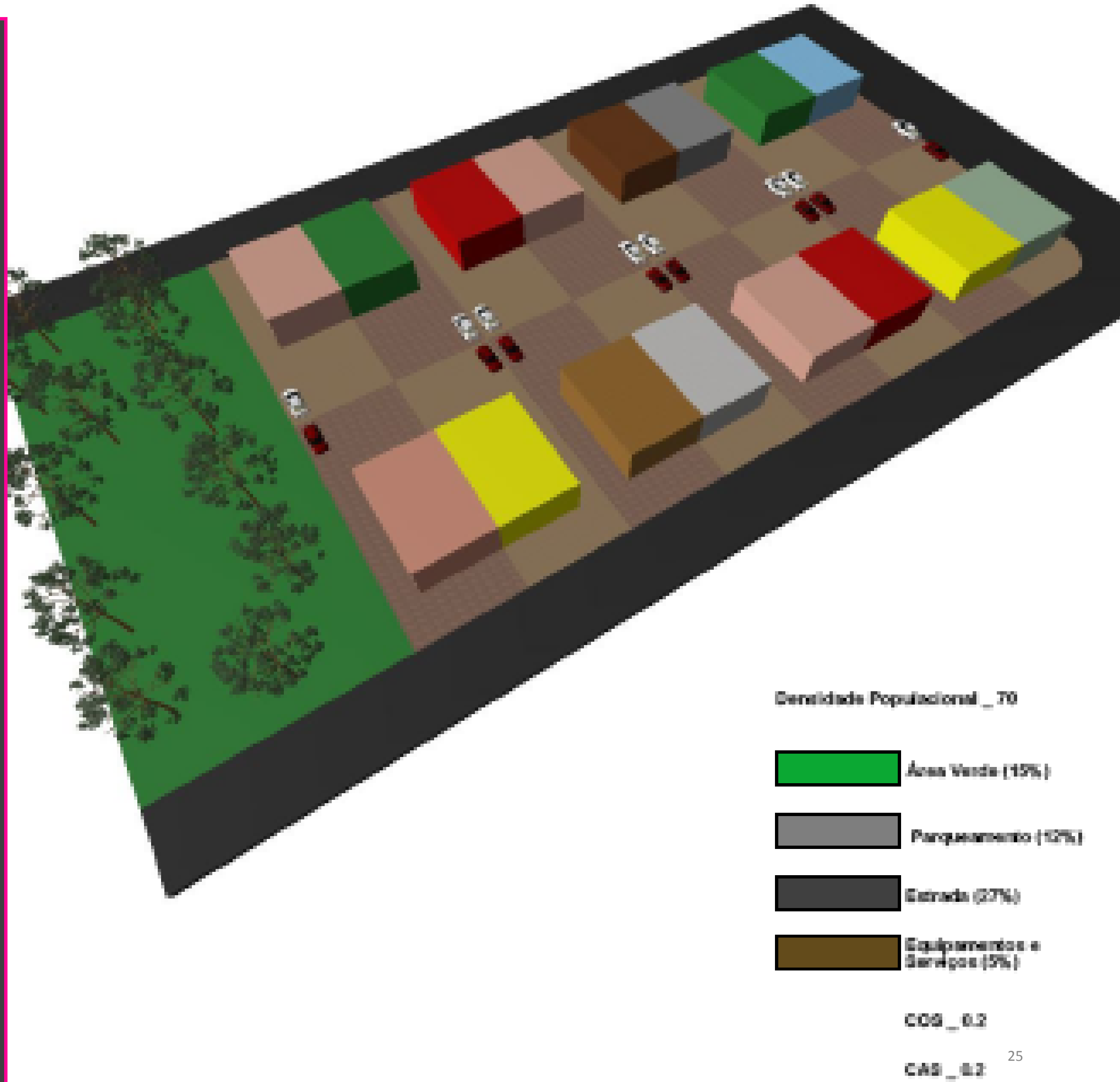
Regulamento do PEUMM

Para áreas de uso predominantemente habitacional de baixa densidade (Unifamiliar) – menos de 20 residências por hectare

- Densidade Populacional – 80 hab/ha
- Coeficiente de Afectação do Solo (CAS) - 0,3
- Coeficiente de Ocupação do Solo (COS) - 0,6
- Coeficiente de Impermeabilização do Solo (CIS) – 0,5
- Percentagem de área para Espaços Verdes de Utilização Colectiva – 15%
- Percentagem de área para Equipamentos – 10%
- Parqueamento – um lugar por apartamento

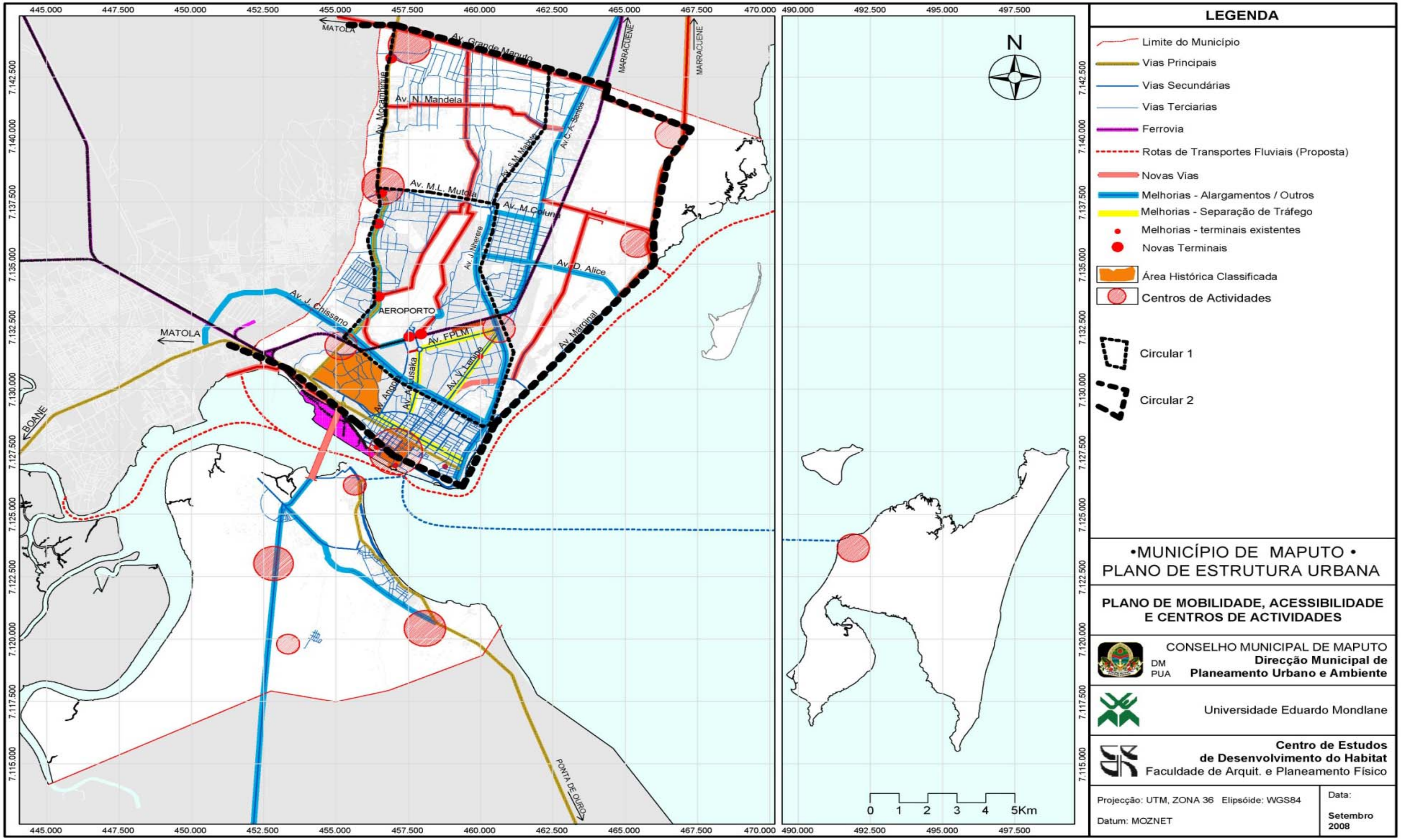
Regulamento do PEUMM





Planta de Ordenamento

Proposta de Mobilidade e Acessibilidade



Mobilidade e Acessibilidade

Os principais temas a abordados pelo PEUMM são:

- **Apostar nas obras de manutenção de infra-estruturas viárias;**
- **Densificação dos acessos e da rede viária nas áreas menos servidas (áreas periurbanas)**
- **Introdução de medidas de gestão da circulação viária, para aliviar áreas específicas de congestionamento;**
- **Desenvolvimento de esquemas funcionais para o transporte de passageiros;**
- **Desenvolvimento de meios alternativos para o transporte de passageiros e mercadorias a nível interurbano;**
- **Desenvolvimento de um Programa específico de Transportes**

As Condicionantes

Tem por objectivos :

- **A segurança dos cidadãos;**
- O funcionamento e ampliação das infra-estruturas e equipamentos;
- **O enquadramento e defesa do património cultural e ambiental;**
- A execução de infra-estruturas programadas ou já em fase de projecto.

As Condicionantes

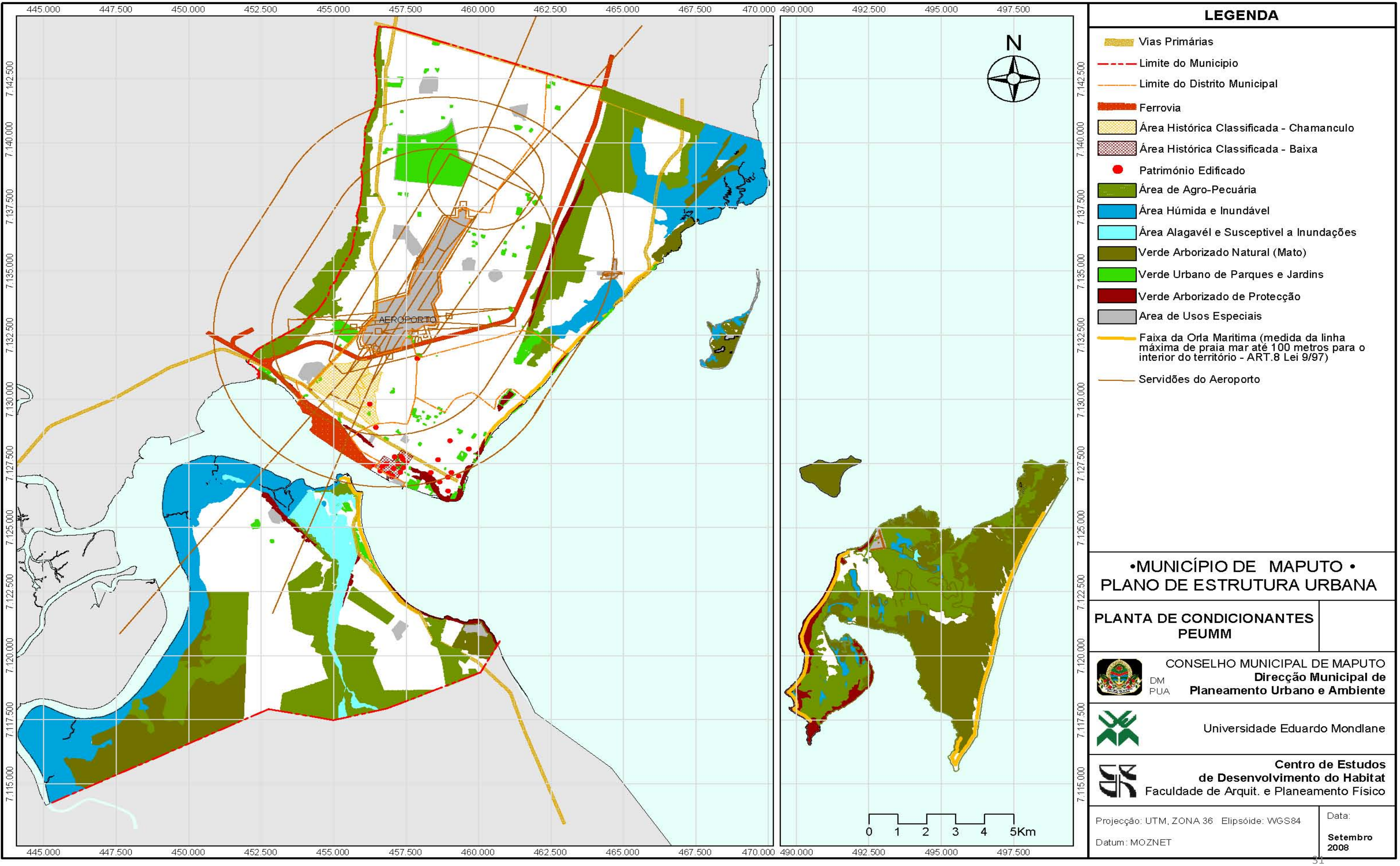
Foram identificadas:

- as servidões administrativas e restrições de utilidade pública
  - **Área de protecção da rede viária**
  - **Via-férrea e sua zona de protecção**
  - **Sistemas de captação e adução de água potável**
  - **Sistema de drenagem e tratamento de esgotos**
  - **Linhas de transporte de energia eléctrica**
  - **Telecomunicações**
  - **Gasoduto**
  - **Zona de protecção do Aeroporto de Maputo**

As Condicionantes

- **Espaço para actividade agrícola;**
- **Espaços afectos à estrutura ecológica do Município;**
  - Terra húmida e inundável;
  - Área alagável ou susceptível a inundações;
  - Verde Arborizado de Protecção;
- **Património Arquitectónico e Urbanístico;**
- Zonas de segurança e protecção de elementos, equipamentos e **instalações especiais**
  - **Instalações militares**
  - **Cemitérios**
  - **Lixeira**

Planta de Condicionantes do PEUMM



Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

Stakeholder Workshop 28 January 2008

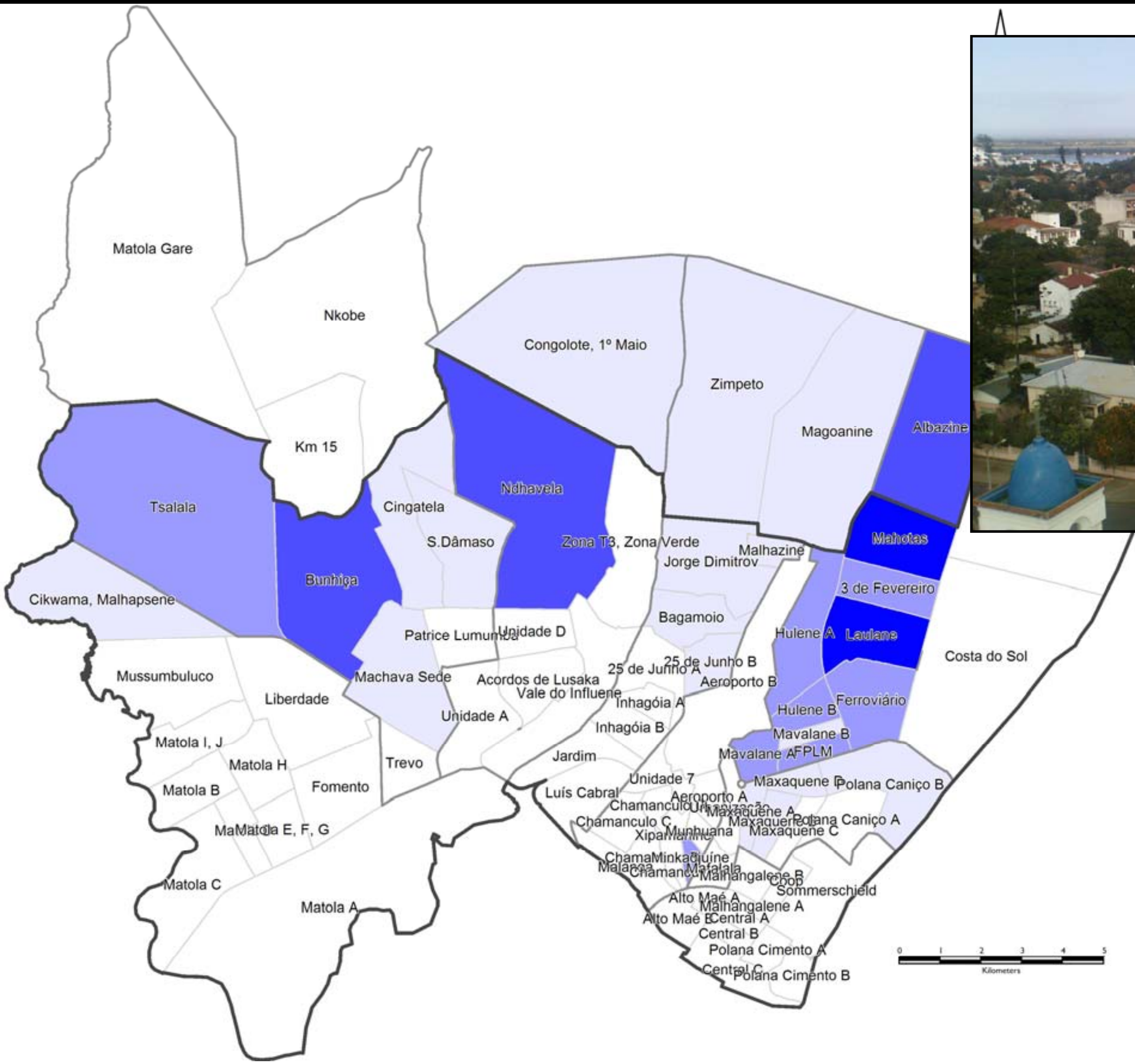
Future Water Demand in the Greater Maputo Area

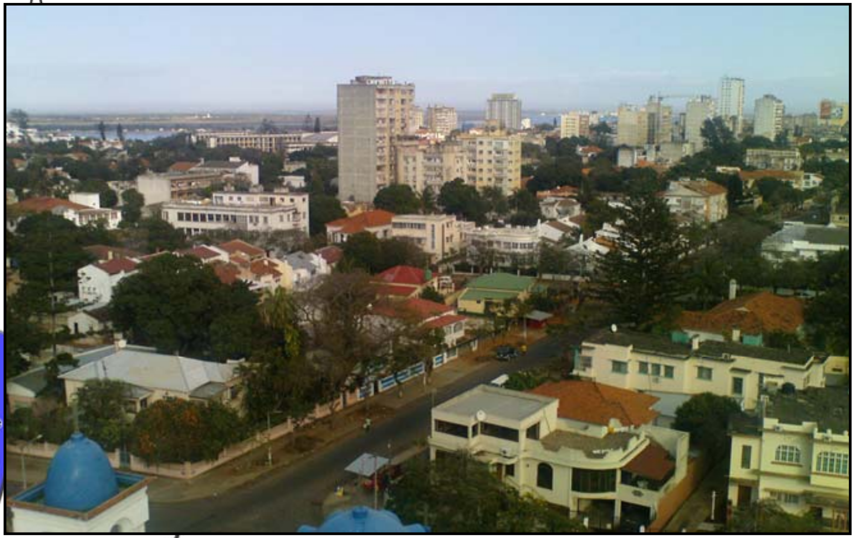
INTRODUCTION

(Rikard Lidén, Team Coordinator)

1. Background to the project
2. Purpose and Scope of Work
3. Work done so far (Inception Report)
4. Objective of this workshop

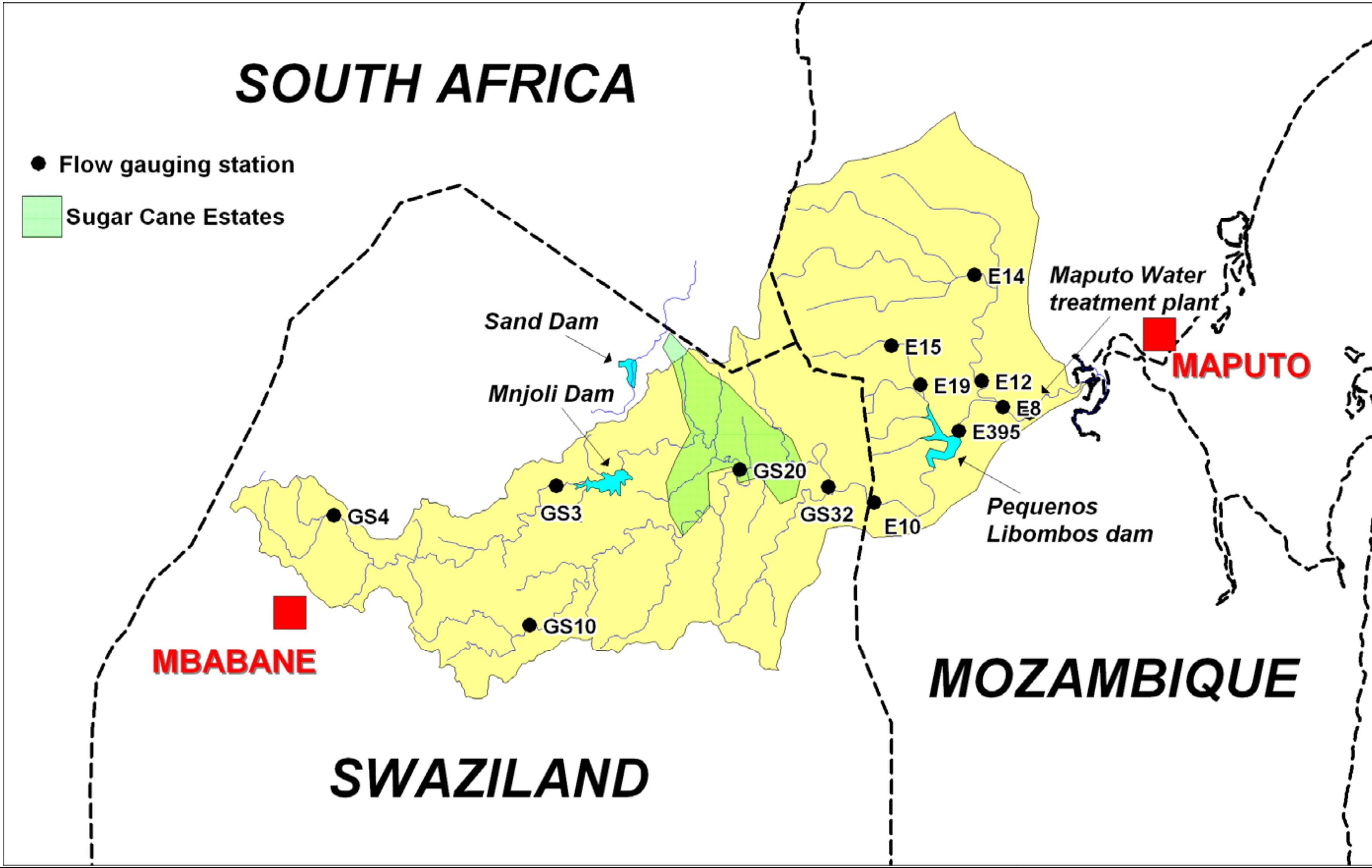
Augmentation of Water Supply for the City of Maputo and its Metropolitan Area



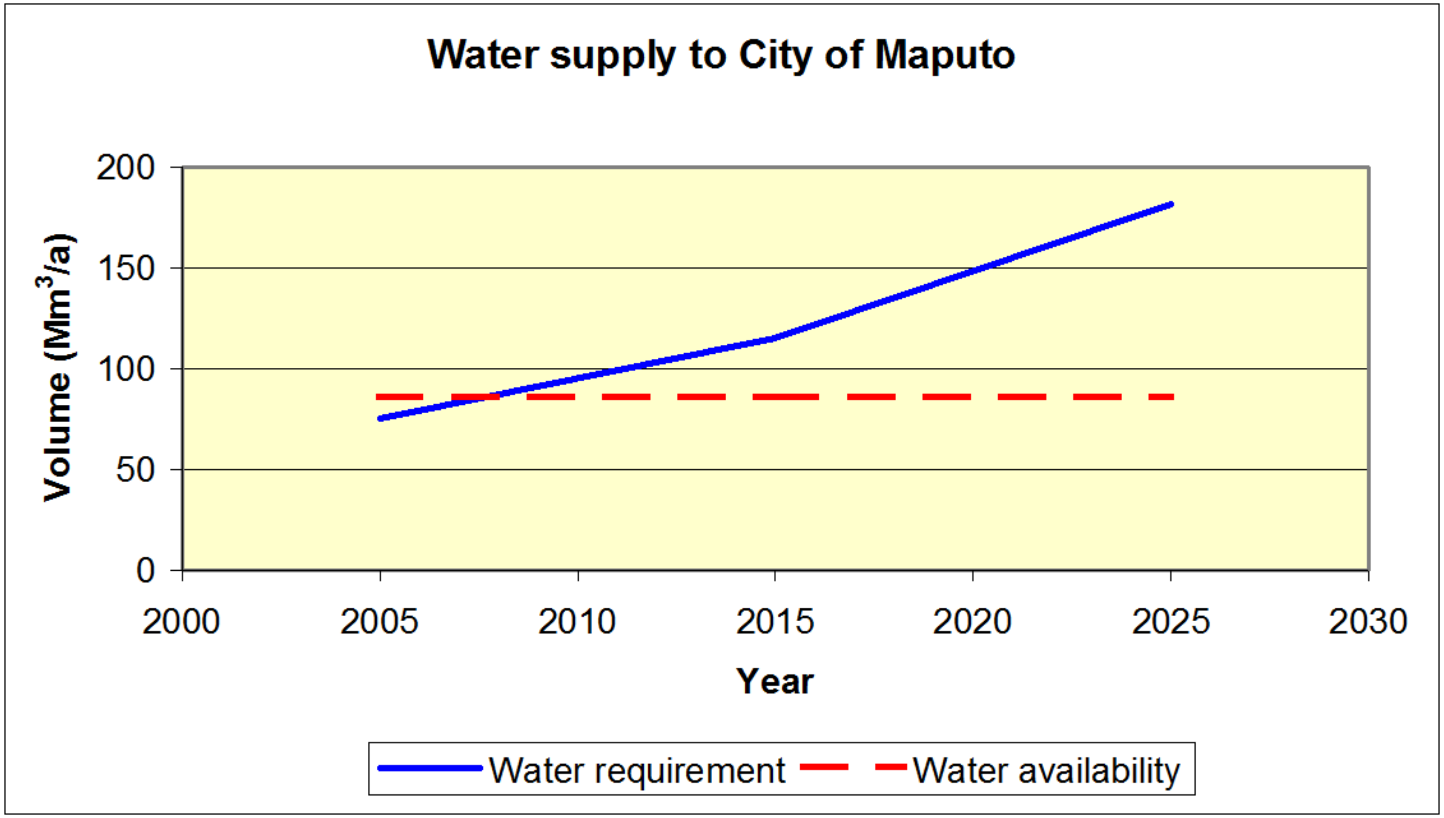


GREATER MAPUTO IS GROWING!

Augmentation of Water Supply for the City of Maputo and its Metropolitan Area

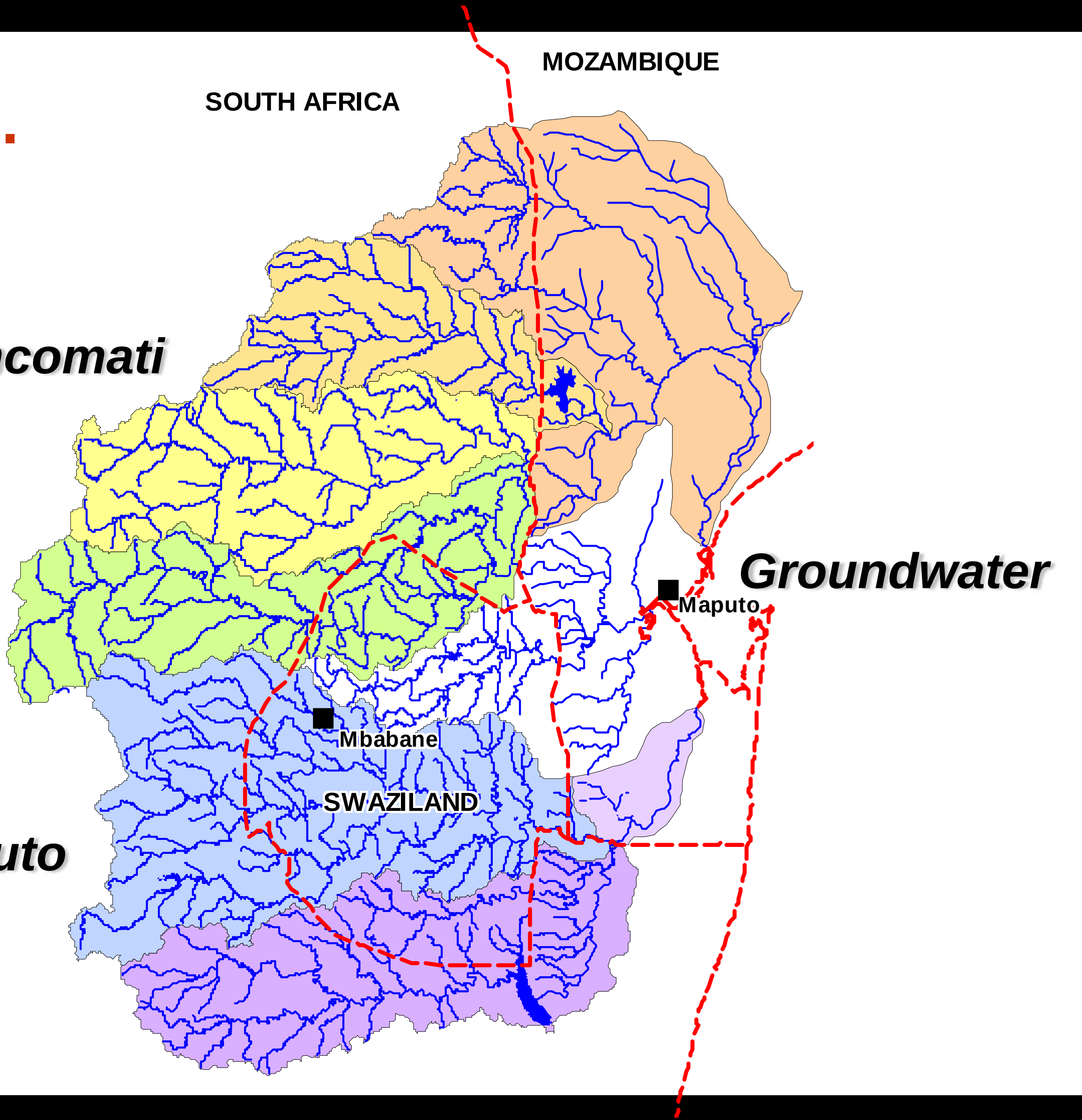


Maputo requirements will soon exceed safe yield at the intake site



JURBS Study (2005)

Other sources……….



The IncoMaputo Agreement……..

…up to 87,6 million m3/a is reserved water for the city of Maputo and will be drawn from the total water available from the further development of the Incomati watercourse. A similar quantity of water is reserved from the Maputo watercourse to provide for wider options of choice.

Basic info

Programme: Progressive Realisation of the IncoMaputo Agreement (PRIMA)

Client: Tripartite Permanent Technical Committee (TPTC) of Mozambique, Swaziland and South Africa

Consultant: SWECO International, DHI, BKS, CONSULTEC

Time: Oct 2008 – Sep 2009

Funds: Dutch Government

Objective

***...study in detail the forecasts of water requirements for the City of Maputo and its metropolitan area and the possibility of supplying these from the Umbeluzi River watercourse, augmented by new supplies from the Incomati and the Maputo watercourses and/or groundwater resources and by increasing water use efficiencies and other water demand management measures*.**

Scope of work

- Comprehensive and Detailed Study of the Water Requirements for the City of Maputo and its Metropolitan Area
- Future Water Requirements in the three riparian countries
- Water Availability in the Umbeluzi, Incomati, and Maputo Rivers
- Evaluation and formulation of future Water Supply Strategies for the Water Supply to the City of Maputo taking into account
- Assessment of consequences from future Water Supply Strategies for the Water Supply to the City of Maputo

Schematics

WORK SO FAR

- INCEPTION
- WATER DEMAND STUDY
- WATER RESOURCES
  - Groundwater
  - Surface Water
- ENVIRONMENTAL FLOW REQUIREMENTS

Inception

- 3-half day workshops
- Compilation of studies and data
- Focus of the study
- Outstanding issues

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

Progressive Realization of the IncoMaputo Agreement (PRIMA)

Augmentation of Water Supply to the City of Maputo and its Metropolitan Area

Inception Report

Draft 26 Nov 2008

SWECO International
DHI, BKS, CONSULTEC

Inception Report - Some feedback

- Important study
- Open mind in terms of water supply strategies
- Water Demand Management as separate option
- Include climate change and water quality issues
- Do not make interpretation of IncoMaputo Agreement

Inception Report - Focus

- **Review of previous studies for**
  - Water Resources & Infrastructure development
  - Environmental flow requirements
  - Water demand in upstream countries
- **Emphasis on**
  - Distributed water demand for Maputo City and its metropolitan area and water demand management
  - Joint water balance modelling
  - Water resources strategy
  - Joint training for understanding of methods and results

Inception Report - Outstanding issues

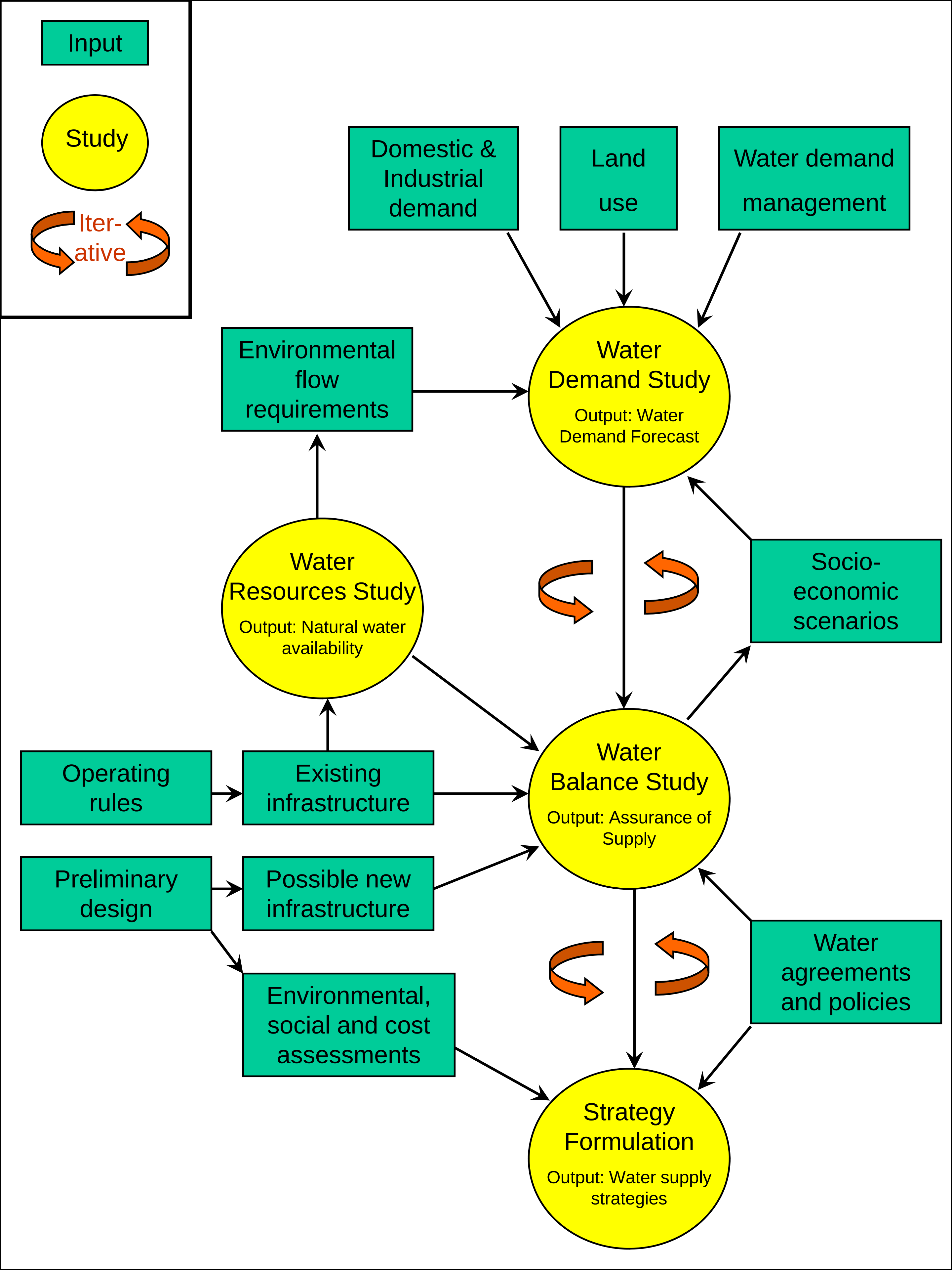
1. Parallel on-going studies provide important inputs → essential to adjust time schedule to accommodate these inputs
2. Indications of considerable changes in inflow from Inkomati compared to JIBS
3. Difficult to find information on the Raising of Corumana and Tchumene Water Supply Project

Stakeholder Workshop 28 January 2008

Future Water Demand in the Greater Maputo Area

- Get inputs on the Structure Plan for central Maputo, Catembe and Inhaca
- Present tentative results on water demand forecast for the Greater Maputo Area
- Assess the possibilities for water demand management for reducing future urban water demand

FEEDBACK FROM STAKEHOLDERS!



Input
Study
Iter-
ative
Domestic & Industrial demand
Land use
Water demand management
Environmental flow requirements
Water Demand Study
Output: Water Demand Forecast
Water Resources Study
Output: Natural water availability
Socio-economic scenarios
Operating rules
Existing infrastructure
Water Balance Study
Output: Assurance of Supply
Preliminary design
Possible new infrastructure
Water agreements and policies
Environmental, social and cost assessments
Strategy Formulation
Output: Water supply strategies