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

LITERATURE REVIEW REPORT

FINAL

AUGUST 2012

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

LITERATURE REVIEW REPORT

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

LITERATURE REVIEW REPORT

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Literature Review Report

1 INTRODUCTION

1.1 BACKGROUND

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

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

Intensive irrigation farming is practised in the upper parts of the Klein Letaba River catchment (upstream and downstream of the Middle Letaba Dam), the Groot Letaba (downstream of the Tzaneen Dam) and Letsitele rivers, as well as in the upper Luvuvhu River catchment. Vegetables (including the largest tomato production area in the country), citrus and a variety of sub-tropical fruits such as bananas, mangoes, avocados and nuts are grown. Large areas of the upper catchments have been planted with commercial forests in the high rainfall parts of the Drakensberg escarpment and on the Soutpansberg. The area, particularly the Groot Letaba sub-area, is a highly productive agricultural area with mixed farming, including cattle ranching, game farming, dry land crop production and irrigated cropping. Agriculture, with the irrigation sector in particular, is the main base of the economy of the region. Large scale utilization of the groundwater resource occurs mostly downstream of the Albasini Dam in the Luvuvhu catchment, where it is used by irrigators as well as in the vicinity of Thohoyandou where it is used to supply rural communities. The limited mineral resources in the Luvuvhu basin are dominated by deposits of cooking coal in the northeast near Masisi. In addition to irrigation water supply from the dams in the study area, towns, villages and rural settlements are also supplied with potable water.

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

1.2 MAIN OBJECTIVES OF THE STUDY

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

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

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

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

1.3 STUDY AREA

The study area comprises of the water resources of the catchment of the Luvuvhu, Mutale, Letaba and Shingwedzi rivers linked to adjacent systems as indicated by the inter-basin transfers on **Figure 1.1**. This area represents the entire WMA 2 and includes tertiary catchments A91, A92, B81, B82, B83 and B90. Adjacent areas supplying water to this WMA or getting water from this WMA are also part of the study area.

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

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

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

The two main branches of the Letaba River, the Klein and Groot Letaba, have their confluence on the western boundary of the Kruger National Park. The Letaba River flows into the Olifants River just upstream of the border with Mozambique (Figure 1.1).

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

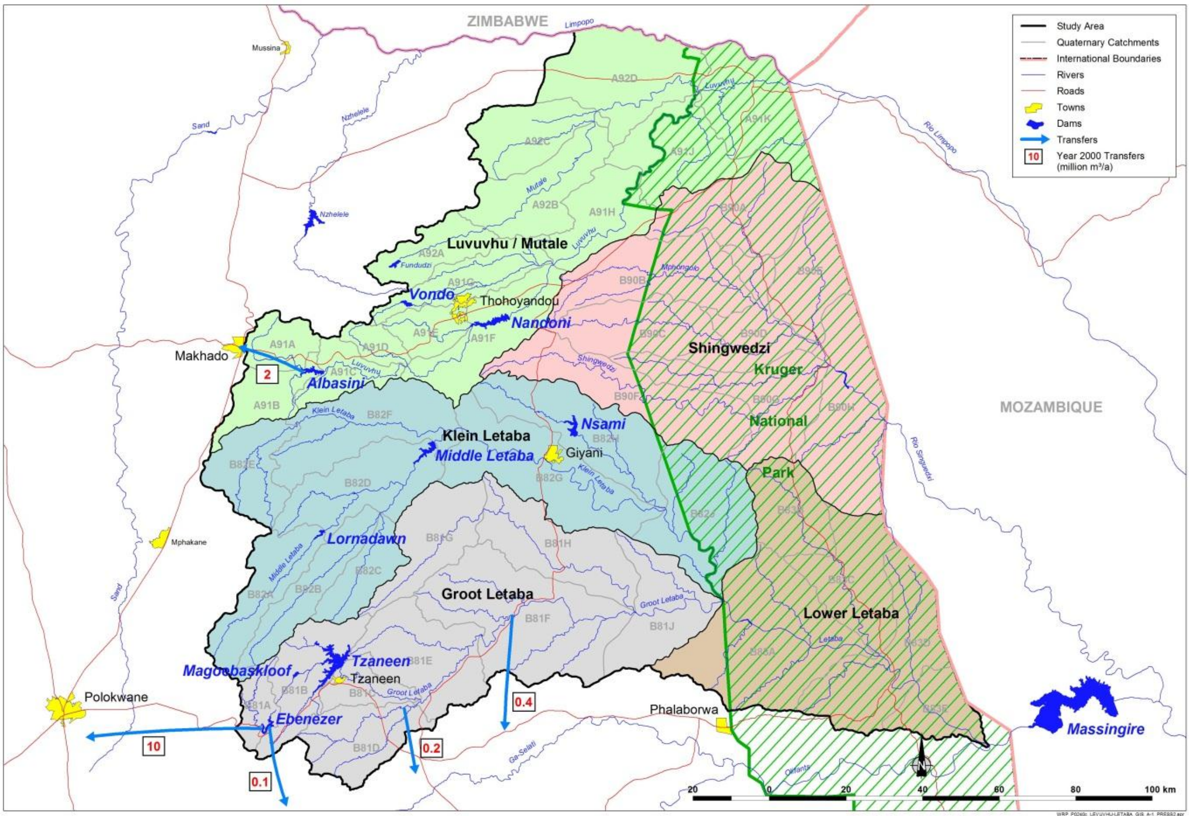


Figure 1-1 Study area

Along the western escarpment rainfall can be well over 1 000 mm per year, while in the Lowveld region in the eastern parts of the water management area rainfall decreases to less than 300 mm per year and the potential evaporation is well in excess of the rainfall. Grassland and sparse bushveld shrubbery and trees cover most of the terrain, marked by isolated giant Boabab trees.

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

1.4 PURPOSE OF THE REPORT

The Literature Review Report lists and briefly describes past reports that were reviewed with the aim of capturing relevant information that can be used in the current study and to prepare a list of augmentation schemes, management measuresand planned bulk infrastructure options that were investigated in the past. The aim with the information review task was to collate information from previous studies and assessments that are relevant for the development of the reconciliation strategies for the Luvuvhu and Letaba water supply system.

1.5 INFORMATION SOURCES

The reports that were reviewed originated from several studies of which the most important are listed below:

1. Water resources planning of the Luvuvhu River basin
2. Kruger National Park Rivers researchprogram, Water for Nature: Hydrology, Luvuvhu River
3. Water Resources Planning of the Letaba River Basin Study of development Potential and Management of the Water Resources
4. Kruger National Park Rivers Research Program, Water for Nature: Hydrology, Letaba River.
5. Albasini Dam (a9r001) hydrology
6. Letaba water resource development pre-feasibility study
7. Luvuvhu River Dam Feasibility Study
8. Groot Letaba Water Resource Development Feasibility Study
9. Mutale River Water Resources Investigation: Stuation Assessment, Management, and development potential of water resources
10. Luvuvhu Government Water Scheme: Bulk Water Supply Preliminary Designs
11. Luvuvhu River Government Water Scheme
12. A Reconnaissance Study to Augment the Water Resources of the Klein Letaba River Catchments
13. Middle Letaba Water Supply Scheme: WC/WDM Situation Assessment
14. Luvuvhu/Letaba Water Resource Situation Assessment
15. Natural Water Resource Strategy

16. Internal strategic perspective:Luvuvhu/Letaba water management area
17. Luvuvhu River system annual operating analysis
18. Letaba Catchment Reserve Determination Study
19. Letaba River system annual operating analysis
20. Department Of Agriculture Resis Programme (Strategic Plan 2005 / 2006)
21. Real Time Operation Of The Letaba River System
22. Groot Letaba river water development project
23. Water Resources Systems Development Business Support Phase 3
24. Socio-Economic and Ecological Impacts of Water Restrictions in the Letaba catchment
25. The Development of a Comprehensive WC/WDM Strategic Business plan for the Limpopo WMA
26. The Development of a Comprehensive WC/WDM Strategic Business Plan For The Luvuvhu/Letaba WMA Bulk Resources Planning; Luvuvhu Government Water Scheme

Studies currently being undertaken by the DWA include:

27. Development of Reconciliation Strategies for All Towns in the Northern Region (on going)
28. Establishment of Drought Operating Rules for Stand Alone Dams and Schemes Typical of Rural/Small Municipal Water Supply Scheme (Northern Region)
29. Validation and Verification of Water Use in the Luvuvhu-Letaba Water Management Area
30. Letaba Groundwater Reserve
31. Development of a first order water conservation and water demand management strategy and business plan for various municipalities under the DWA rapid response programme : Limpopo

In totalof almost 200reports wereidentified and sourced where available, as listed in **Table 1.1** below, and were grouped according to the above-mentioned studies and listed in chronological order within each group. In Table 1.1, the reports in red are those that were not available for review.

Table 1.1: List of reports reviewed

No	Title	Document No.	Author	Date	Comments
1.1 Reports: Water Resources Planning of the Luvuvhu River Basin 1990					
1 2	Volume 1:Executive Summary Volume 2: Main Report	PA 900/00/0190 PA 900/00/0290-	Hill Kaplan Scott	1990	Complete
3	Volume 3: Physical Characteristics Appendix 1: Topography & Climate	PA 900/00/0390	Hill Kaplan Scott	1990	Complete
4	Volume 3: Physical Characteristics Appendix 2: Geology	PA 900/00/0490	Hill Kaplan Scott	1990	Complete
5	Volume 3: Physical Characteristics Appendix 3: Vegetation, Wildlife & Ecology	PA 900/00/0590	Hill Kaplan Scott	1990	Complete
6	Volume 4: Land Use Appendix 4: Land use Capability	PA 900/00/0690	Hill Kaplan Scott	1990	Complete
7	Volume 4: Land Use Appendix 5: Existing Land use	PA 900/00/0790	Hill Kaplan Scott	1990	Complete
8	Volume 4: Land Use Appendix 6: Population	PA 900/00/0890	Hill Kaplan Scott	1990	Complete
9	Volume 4: Land Use Appendix 7: Infrastructure	PA 900/00/0990	Hill Kaplan Scott	1990	Complete
10	Volume 5: Water Infrastructure	PA 900/00/1090	Hill Kaplan Scott	1990	Complete
11	Volume 6: Water Requirements Appendix 9: Water Requirements	PA 900/00/1190	Hill Kaplan Scott	1990	Complete
12	Volume 6: Water Requirements Appendix 10: Water Rights and Allocations	PA 900/00/1290	Hill Kaplan Scott	1990	Complete
13	Volume 7: Water Resources Appendix 11: Hydrology: Records and Calibration	PA 900/00/1390	Hill Kaplan Scott	1990	Complete
14	Volume 7: Water Resources Appendix 12: Hydrology Runoff Simulation	PA 900/00/1490	Hill Kaplan Scott	1990	Complete
15	Volume 7: Water Resources : Appendix 13: Hydrology Floods and droughts	PA 900/00/1590	Hill Kaplan Scott	1990	Complete
16	Volume 8: Water Resources (cont.) Appendix 14: Geohydrology	PA 900/00/1690	Hill Kaplan Scott	1990	Complete
17	Volume 8: Water Resources (cont.) Appendix 15: Water Quality	PA 900/00/1790	Hill Kaplan Scott	1990	Complete
18	Volume 8: Water Resources (cont.) Appendix 16: Sedimentation	PA 900/00/1890	Hill Kaplan Scott	1990	Complete

No	Title	Document No.	Author	Date	Comments
19	Volume 9: Dam Sites Appendix 17	PA 900/00/1990	Hill Kaplan Scott	1990	Complete
20	Volume 9: Dam Sites Appendix 18: Mashawane Dam	PA 900/00/2090	Hill Kaplan Scott	1990	Complete
21	Volume 9: Dam Sites Appendix 19: Mashawane Geology	PA 900/00/2190	Hill Kaplan Scott	1990	Complete
22	Volume 9: Dam Sites Appendix 20: Paswane Dam	PA 900/00/2290	Hill Kaplan Scott	1990	Complete
23	Volume 9: Dam Sites Appendix 21: Paswane Geology	PA 900/00/2390	Hill Kaplan Scott	1990	Complete
24	Volume 10: Dam Sites continued Appendix 22: Tshikonelo Dam	PA 900/00/2490	Hill Kaplan Scott	1990	Complete
25	Volume 10: Dam Sites continued Appendix 23: Tshikonelo Geology	PA 900/00/2590	Hill Kaplan Scott	1990	Complete
26	Volume 10: Dam Sites continued Appendix 24:Tshaphele Dam	PA 900/00/2690	Hill Kaplan Scott	1990	Complete
27	Volume 10: Dam Sites continued Appendix 25: Tshaphele Geology	PA 900/00/2790	Hill Kaplan Scott	1990	Complete
28	Volume 10: Dam Sites continued Appendix 26: Xikundu Dam	PA 900/00/2890	Hill Kaplan Scott	1990	Complete
29	Volume 10: Dam Sites continued Appendix 27: Xikundu Geology	PA 900/00/2990	Hill Kaplan Scott	1990	Complete
30	Volume 10: Dam Sites continued Appendix 28:Upper Mbwedi Dam	PA 900/00/3090	Hill Kaplan Scott	1990	Complete
31	Volume 10: Dam Sites continued Appendix 29:Upper Mbwedi Geology	PA 900/00/3190	Hill Kaplan Scott	1990	Complete
32	Volume 10: Dam Sites continued Appendix 30: Mbwedi Sites 1 & 2 Geology	PA 900/00/3290	Hill Kaplan Scott	1990	Complete
33	Volume 11: Water Resources Management Appendix 31: Systems Analysis	PA 900/00/3390	Hill Kaplan Scott	1990	Complete
34	Volume 11: Water Resources Management Appendix 32: Research and Monitoring Needs	PA 900/00/3490	Hill Kaplan Scott	1990	Complete
35	Volume 11: Water Resources Management Appendix 33: Legal and Institutional Needs	PA 900/00/3590	Hill Kaplan Scott	1990	Complete
36	Volume 11: Water Resources Management Appendix 34: Development	PA 900/00/3690	Hill Kaplan Scott	1990	Complete

No	Title	Document No.	Author	Date	Comments
	Possibilities				
1.2 Reports: Kruger National Park Rivers Research Program, Water for Nature: Hydrology, Luvuvhu River.					
37	Kruger National Park - Luvuvhu River – Hydrology	PA 900/00/3790	Hill Kaplan Scott	1990	Complete
1.3 Reports: Water Resources Planning of the Letaba River Basin Study of development Potential and Management of the Water Resources					
38	Executive Summary	PB 800/00/0190	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete
39	Basin Study Report	PB 800/00/0290	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete
40	Annexure 1: Catchment Description	PB 800/00/0390	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete
41	Annexure 2: Demography	PB 800/00/0490	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete
42	Annexure 3: Existing Dams and Major control works	PB 800/00/0590	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete
43	Annexure 4: Domestic and Industrial Water Usage	PB 800/00/0690	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete
44	Annexure 5: Irrigation	PB 800/00/0790	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete
45	Annexure 6: Afforestation	PB 800/00/0890	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete
46	Annexure 7: Ecology Maintenance	PB 800/00/0990	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete
47	Annexure 8: Inter Basin Water Transfer	PB 800/00/1090	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete

No	Title	Document No.	Author	Date	Comments
48	Annexure 9: Hydrology: Gauge Station Details	PB 800/00/1190	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete
49	Annexure 10: Hydrology: Catchment Model Calibration	PB 800/00/1290	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete
50	Annexure 11: Hydrology: Flow Generation	PB 800/00/1390	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete
51	Annexure 12: Hydrology: Floods	PB 800/00/1490	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete
52	Annexure 13: Ground Resources	PB 800/00/1590	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete
53	Annexure 14: Environmental Aspects	PB 800/00/1690	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete
54	Annexure 15: Water Quality	PB 800/00/1790	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete
55	Annexure 16: Sediment	PB 800/00/1890	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete
56	Annexure 17: Water Losses	PB 800/00/1990	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete
67	Annexure 18: Surface Water Resources Development	PB 800/00/2090	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete
68	Annexure 19:Ground Water Resource Development	PB 800/00/2190	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete
69	Annexure 20: Development Options	PB 800/00/2220	Steffen, Robertson and Kirsten inc and	1990	Complete

No	Title	Document No.	Author	Date	Comments
			the RSA DWA		
70	Annexure 21: Operation of Major Water Control Structures	PB 800/00/2390	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete
71	Annexure 22: Institutional Aspects	PB 800/00/2490	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete
72	Annexure 23: Monitoring And Research Needs	PB 800/00/2590	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete
73	Annexure 24: Book of Drawings	PB 800/00/2690	Steffen, Robertson and Kirsten inc and the RSA DWA	1990	Complete
1.4 Reports: Kruger National Park Rivers Research Program, Water for Nature: Hydrology, Letaba River.					
74	Kruger National Park – Letaba River – Hydrology	PB 800-00-2890	Steffen, Robertson and Kirsten Consulting Engineers	1990	Complete
1.5 Reports: Albasini Dam (A9R001) Hydrology 1993					
75	Leweringsontleding: Volume 1: Verslag	….	EA Nel and JA Du Plessis	1993	Complete
76	Leweringsontleding: Volume 2: Bylae	…	EA Nel and JA Du Plessis	1993	Complete
77	Stogastiese Leweringsontleding	…..	HS Swart and JA Du Plessis	1993	Complete
1.6 Reports: Letaba Water Resource Development Pre-Feasibility Study 1994					
78	Executive Summary	PB 800/00/0194	BE Wijers, BJ Middleton and AC White	1994	Complete
79	Main Report	PB 800/00/0294	BE Wijers, BJ Middleton and AC White	1994	Complete
80	Tzaneen Dam Raising	PB 800/00/0394	BE Wijers, BJ Middleton and AC White	1994	Complete
81	Study area	PB 800/00/0494	BE Wijers, BJ Middleton and AC White	1994	Complete
82	Hydrology and Water Resource	PB 800/00/0594	BE Wijers, BJ	1994	Complete

No	Title	Document No.	Author	Date	Comments
			Middleton and AC White		
83	Development and Management Proposals	PB 800/00/0694	BE Wijers, BJ Middleton and AC White	1994	Complete
84	Factors Affecting Development	PB 800/00/0794	BE Wijers, BJ Middleton and AC White	1994	Complete
85	Proposed Development: Technical description	PB 800/00/0894	BE Wijers, BJ Middleton and AC White	1994	Complete
86	Nondweni Weir	PB 800/00/0994	BE Wijers, BJ Middleton and AC White	1994	Complete
1.7 Reports: Luvuvhu River Dam Feasibility Study 1997					
87	Main Feasibility Report	PB A900/00/3990	LDC	1997	Complete
88	ANNEXURE 1: Engineering : Feasibility design Reports Volume 1: a)Engineering design of proposed dams in the Luvuvhu River and Lutanandwa River	PB A900/00/4090	Consultburo, HKS Law Gibb Laubscher & Smith also known as Luvuvhu Development Consultants(LDC)	1997	Complete
89	ANNEXURE 1: Engineering : Feasibility design Reports Volume 1: b)Beraming van vloedspitse te Mutoti terrein in Luvuvhu rivier	PB A900/00/4190	Consultburo, HKS Law Gibb Laubscher & Smith also known as Luvuvhu Development Consultants(LDC)	1997	Complete
90	ANNEXURE 1: Engineering : Feasibility design Reports Volume 1: c)Beraming van vloedspitse te Lutanandwa terrein	PB A900/00/4290	Consultburo, HKS Law Gibb Laubscher & Smith also known as Luvuvhu Development Consultants(LDC)	1997	Complete
91	ANNEXURE 1: Engineering : Feasibility design Reports Volume 2: a)Mutoti dam : Leengebied ondersoek	PB A900/00/4390	LDC	1997	Complete
92	ANNEXURE 1: Engineering : Feasibility design Reports Volume 2: b)Mutoto dam sites: Thohoyandou district: First engineering geological	PB A900/00/4490	LDC	1997	Complete

No	Title	Document No.	Author	Date	Comments
	reconnaissance report				
93	ANNEXURE 1: Engineering : Feasibility design Reports Volume 2: c)Lutanandwa damterrein: Distrik Soutpansberg: eerste ingenieurs geologiese verkenningsondersoek	PB A900/00/4590	LDC	1997	Complete
94	ANNEXURE 1: Engineering : Feasibility design Reports Volume 3: Preliminary design of Water purification works	PB A900/00/4690	LDC	1997	Complete
95	ANNEXURE 2: Water Resources System Analysis of the Luvuvhu River	PB A900/00/4790	LDC	1997	Complete
96	ANNEXURE 3: Biophysical aspects ROIP and IFR Reports Volume 1: ROIP 2 of the proposed Mutoti Dam in the Luvuvhu River	PB A900/00/4890	LDC	1997	Complete
97	ANNEXURE 3: Biophysical aspects ROIP and IFR Reports Volume 2: a)ROIP 1 of bulk water distribution infrastructure	PB A900/00/4990	LDC	1997	Complete
98	ANNEXURE 3: Biophysical aspects ROIP and IFR Reports Volume 2: b)Botanical survey of the Mutoti Dam site	PB A900/00/5090	LDC	1997	Complete
99	ANNEXURE 3: Biophysical aspects ROIP and IFR Reports Volume 2: c)Botanical survey of the Lutanandwa Dam site	PB A900/00/5190	LDC	1997	Complete
100	ANNEXURE 3: Biophysical aspects ROIP and IFR Reports Volume 2: d)Pilot study of mammals and herpetofauna of the Mutoti and Lutanadwa Dam sites	PB A900/00/5290	LDC	1997	Complete
101	ANNEXURE 3: Biophysical aspects ROIP and IFR Reports Volume 3: Report on Luvuvhu River IFR Workshop, July 1994	PB A900/00/5390	LDC	1994	Complete
102	ANNEXURE 3: Biophysical aspects ROIP and IFR Reports Volume 4: a)Report on IFR monitoring protocol for the Luvuvhu River	PB A900/00/5490	LDC	1997	Complete

No	Title	Document No.	Author	Date	Comments
103	ANNEXURE 3: Biophysical aspects ROIP and IFR Reports Volume 4: b)Report on IFR refinement for the Lutanandwa River	PB A900/00/5590	LDC	1997	Complete
104	ANNEXURE 4: Sociological aspects: SIA ReportsVolume 1: Social impact assessment of proposed dams in the Luvuvhu River and Lutanandwa	PB A900/00/5690	LDC	1997	Complete
105	ANNEXURE 4: Sociological aspects: SIA ReportsVolume 2:Archaeological impact assessment of proposed dams in the Luvuvhu River and Lutanandwa	PB A900/00/5790	LDC	1997	Complete
106	ANNEXURE 5: Water Quality of the Luvuvhu River	PB A900/00/5890	LDC	1997	Complete
107	ANNEXURE 6: Agriculture Development associated with a dam on the Luvuvhu River	PB A900/00/5990	LDC	1997	Complete
108	ANNEXURE 7: Economic and Financial aspects of development in the Luvuvhu River	PB A900/00/6090	LDC	1997	Complete
1.8 Reports: Groot Letaba Water Resource Development Feasibility Study 1998					
109	Volume 1: Main Report	PB B810/00/0298	Consultburo and BKS	1998	Complete
110	Volume 2: Water Requirement and System Analyses	PB B810/00/0398	Consultburo and BKS	1998	Complete
111	Volume 3: Instream flow requirements	PB B810/00/0498	Consultburo and BKS	1998	Complete
112	Volume 4: Relevant environmental impact prognoses	PB B810/00/0598	Consultburo and BKS	1998	Complete
113	Volume 5: Water quality and riparian vegetation	PB B810/00/0698	Consultburo and BKS	1998	Complete
114	Volume 6: Legal and institutional aspects	PB B810/00/0798	Consultburo and BKS	1998	Complete
115	Volume 7: Public involvement and social impacts	PB B810/00/0898	Consultburo and BKS	1998	Complete
116	Volume 8: Preliminary design	PB B810/00/0998	Consultburo and BKS	1998	Complete
117	Volume 9: Financial and economic evaluations	PB B810/00/01098	Consultburo and BKS	1998	Complete
1.9 Reports: Mutale River Water Resources Investigation: Situation Assessment, Management, and					

No	Title	Document No.	Author	Date	Comments
Development Potential of the Water Resources 1999					
118	Annexure 1: Catchment characteristics	A920/00/0198	Africon	1999	Complete
119	Annexure 2: Socio-economic assessment	A920/00/0298	Africon	1999	Complete
120	Annexure 3: General Infrastructure	A920/00/0398	Africon	1999	Complete
121	Annexure 4: Economic geology and mining	A920/00/0498	Africon	1999	Complete
122	Annexure 5: Afforistation	A920/00/0598	Africon	1999	Complete
123	Annexure 6: Livestock, game and fisheries	A920/00/0698	Africon	1999	Complete
124	Annexure 7: Irrigation	A920/00/0198	Africon	1999	Complete
125	Annexure 8: Water transerfs	A920/00/0798	Africon	1999	Complete
126	Annexure 9: Environmental aspects	A920/00/0198	Africon	1999	Complete
127	Annexure 10. Archaeological aspects	A920/00/0898	Africon	1999	Complete
128	Annexure 11: Legal aspects	A920/00/0998	Africon	1999	Complete
129	Annexure 12: Water requiments	A920/00/01098	Africon	1999	Complete
130	Annexure 13: Surface water hydrology	A920/00/01198	Africon	1999	Complete
131	Annexure 14: Surface water quality aspects	A920/00/01298	Africon	1999	Complete
132	Annexure 15: Groundwater resources and quality	A920/00/01398	Africon	1999	Complete
133	Annexure 16: Sedimentation	A920/00/01498	Africon	1999	Complete
134	Annexure 17: Dams	A920/00/01598	Africon	1999	Complete
135	Annexure 18: System yield analysis	A920/00/01698	Africon	1999	Complete
1.10 Reports: Luvuvhu Government Water Scheme: Bulk Water Supply Preliminary Designs 1999					
136	Executive Summary	PB 900/00/6199	Consultburo and BKS	1999	Complete
1.11 Reports: Luvuvhu River Government Water Scheme 2000					
137	Design of the first phase of the Nandoni water treatment plant	A900/00/0100	GFJ and Burotech	2000	Complete
138	Preliminary pipe route of bulk pipes from Albasini dam to elim/waterval	A900/00/0200	Africon	2000	Complete

No	Title	Document No.	Author	Date	Comments
	and vleyfontein				
139	Social impact assessment of alternative routes	A900/00/0103	Mothopo Technologies/ Sego-Dolo Development	2000	Complete
1.12	**Reports: A Reconnaissance Study to Augment the Water Resources of the Klein Letaba River Catchments**				
140	Executive Summary	PB B800/00/3003	WSM	2003	
141	Main Report	PB B800/00/3103	WSM	2003	Complete
142	Annexure 1: Macro and socio-economic overview and legal aspects	PB B800/00/3203	WSM	2003	Complete
143	Annexure 2: Natural Environment and Water Quality	PB B800/00/3303	WSM	2003	complete
144	Annexure 3: Domestic and Agricultural Water Requirements	PB B800/00/3403	WSM	2003	Complete
145	Annexure 4: Surface Runoff Hydrology	PB B800/00/3503	WSM	2003	Complete
146	Annexure 5: Surface Water Resource Development Potential	PB B800/00/3603	WSM	2003	Complete
147	Annexure 6: Regional Geology and Groundwater Resources	PB B800/00/3573	WSM	2003	Complete
148	Annexure 7: Engineering Geology of Dam site on the Klein Letaba	PB B800/00/3583	WSM	2003	Complete
149	Annexure 8: Preliminary Design and costing of augmentation schemes	PB B800/00/3593	WSM	2003	Complete
1.13	**Reports: Middle Letaba Water Supply Scheme: WC/WDM Situation Assessment 2003**				
150	Middle Letaba Water Supply Scheme: Water Conservation and Water Demand Management Situation Assessment Study	…	Tlou and Matji (Pty) Ltd	2003	Complete
1.14	**Reports: Luvuvhu/Letaba Water Resource Situation Assessment 2003**				
151	Main Report	P02000/00/0101	WSM	2003	Complete
1.15	**Reports: National Water Resource Strategy 2003**				
152	Luvuvhu and Letaba water Management Area Overview Of Water Resources Availability And Utilization	P WMA 02/000/00/0203	Ms Basson, JD Rossouw	2003	Complete
1.16	**Reports: Internal Strategic Perspective: Luvuvhu/Letaba Water Management Area 2004**				
153	Internal Strategic Perspective:	P WMA	Goba Moahloli	2004	Complete

No	Title	Document No.	Author	Date	Comments
	Luvuvhu/Letaba Water Management Area	02/000/00/0304	Keeve Steyn (Pty) Ltd in association with Tlou and Matji, Golder Associates Africa and BKS		
1.17	**Reports: Luvuvhu River System Annual Operating Analysis 2005**				
154	Development of a Decision Support System and executing of the 2005/2006 annual operating analysis	PNMA 02/000/00/0305	WRP & DMM	2005	Complete
1.18	**Reports: Letaba Catchment Reserve Determination Study 2006**				
155	Inception Report	RDM/B800/00/CON/COMP/0404	R.G Heath	2006	Report not yet available
156	Main Report	RDM/B800/01/CON/COMP/1304	R.G Heath	2006	Complete
157	Briefing document	RDM/B800/01/CON/COMP/1304	R.G Heath	2006	Report not yet available
158	Groundwater scoping report	RDM/B800/02/CON/COMP/0504	R.G Heath and Sami K	2006	Complete
159	Wetland scoping report	RDM/B800/03/CON/COMP/0604	Marneweck GC	2006	Complete
160	Resource units report	RDM/B800/00/CON/COMP/0704	R.G Heath	2006	Report not yet available
161	EWR report quality	RDM/B800/01/CON/COMP/0804	Scherman	2006	Complete
162	EWR report quality	RDM/B800/01/CON/COMP/0904	R.G Heath and RW Palmer	2006	Complete
163	Ecological consequences of flow scenarios	RDM/B800/01/CON/COMP/1004	R.G Heath	2006	Complete
164	Hydrology support and water resource elevation	RDM/B800/01/CON/COMP/1104	K Haumann	2006	Complete
165	Eco specs and monitoring report	RDM/B800/01/CON/COMP/1204	R.G Heath	2006	Complete
166	Capacity building	RDM/B800/01/CON/COMP/1404	R.G Heath	2006	Report not yet available
167	Socio-economics flow scenarios	RDM/B800/01/CON/COMP/1504	T Tlou	2006	Complete
168	Ecological Data	RDM/B800/01/CON/COMP/1604	R.G Heath	2006	Complete
1.19	**Reports: Letaba River System Annual Operating Analysis 2006**				
169	Letaba River System Annual Operating Analysis 2005/06	WMA 02/000/00/0406	Semenya Furumele	2006	Complete

No	Title	Document No.	Author	Date	Comments
			Consulting		
1.20 Reports: Department of Agriculture Resis Programme 2006					
170	Strategic plan	….	Limopo Province Department Of Agriculture	2006	Complete
1.21 Reports: Real Time Operation of the Letaba River System 2008					
171	Data Collection and Monitoring	2006-44	Beason Mwaka	2008	Complete
172	Estimate Loss Dependant Variables With Water Balance	2006-44	Beason Mwaka	2008	Complete
1.22 Reports: Groot Letaba River Water Development Project 2009					
173	Environmental Impact Assessment: Annexure A - Water Quality Specialist Study	P 02/B810/00/0708/ vol 2, Annexure A	Dr Martin van Veelen	2009	Complete
174	Environmental Impact Assessment: Annexure B - Terrestrial Ecology Specialist Study	P 02/B810/00/0708/ vol 2, Annexure B	Graham Deall, Warren McCleland and Peter Hawkes	2009	Complete
175	Environmental Impact Assessment: Annexure C - Social Impact Assessment	P 02/B810/00/0708/ vol 2, Annexure C	Ms Anita Bron and Ms Portia Mnisi	2009	Complete
176	Environmental Impact Assessment: Annexure D - Economic Specialist Study	P 02/B810/00/0708/ vol 2, Annexure D	Nanja Churr	2009	Complete
177	Environmental Impact Assessment: Annexure F - Air Quality Specialist Study	WP9090	Airshed Planning Professionals (Pty) Ltd	2009	Complete
178	Environmental Impact Assessment:Annexure G - Visual Impact Assessment	P 02/B810/00/0708/ vol 2, Annexure G	Keran James	2009	Complete
179	Environmental Impact Assessment: Annexure H1 - Aquatic Ecology Specialist Study	P 02/B810/00/0708/ vol 2, Annexure H1	Golder Associates Africa	2009	Complete
180	Environmental Impact Assessment: Annexure H2 - Aquatic Ecology Desktop Study	P 02/B810/00/0708/ vol 2, Annexure H2	Golder Associates Africa	2009	Complete
181	Environmental Impact Assessment: Annexure I - Noise Impact Assessment	P 02/B810/00/0708/ vol 2, Annexure I	Jongens Keet Associates	2009	Complete
182	Environmental Impact Assessment: Annexure J - Heritage Resource Specialist Study	P 02/B810/00/0708/ vol 2, Annexure J	Dr J A van Schalkwyk	2009	Complete
183	Environmental Impact Assessment: Annexure K - Health Impact Assessment	P 02/B810/00/0708/ vol 2, Annexure K	Andrew Dickson/ Margot Saner/ Dr Lorraine Hodge	2009	Complete

No	Title	Document No.	Author	Date	Comments
184	Environmental Impact Assessment: Annexure L - Traffic Impact Assessment	P 02/B810/00/0708/ vol 2, Annexure L	ILISO Consulting	2009	Complete
185	Environmental Impact Assessment: Annexure M - Sedimentation Impact Assessment	P 02/B810/00/0708/ vol 2, Annexure M	ASP Technology (Pty) Ltd	2009	Complete
186	Environmental Impact Assessment: Annexure N - Draft Pre Construction EMP	P WMA 02/B810/00/0608/ 2	Deon Esterhuizen and Terry Barker	2010	Complete
187	Environmental Impact Assessment: Annexure O - Generic Construction EMP	P WMA 02/B810/00/0708/ 2	Terry Baker, Martin van Veelen and Melissa Naidoo	2010	Complete
188	Environmental Impact Assessment Report	P WMA 02/B810/00/0708/ 2	Terry Baker, Martin van Veelen and Melissa Naidoo	2010	Complete
189	Technical Study Module: Vol 1 Technical Study Module Main Report	P WMA 02/B810/00/0608/ 01	Aurecon	2010	Complete
190	Technical Stud Module: Vol 2 Review of Water Requirements	P WMA 02/B810/00/0608/ 02	Aurecon	2010	Complete
191	Technical Study Module: Vol 3 Groundwater	P WMA 02/B810/00/0608/ 03	Aurecon	2010	Complete
192	Technical Study Module: Vol 4 Hydrology	P 02/B810/00/0608/ 04	Aurecon	2010	Complete
193	Technical Study Module: Vol 5 Water Resource Analysis Report	P 02/B810/00/0608/ 05	MA kilick and A Sparks	2010	Complete
194	Technical Study Module: Vol 6 Annex 1 Nwamita Dam Preliminary Design –Appendices	P WMA 02/B810/00/1110/ 01	Aurecon	2010	Complete
195	Technical Study Module: Vol 6 Annex 2 App B Part 1 Geotechnical Investigation	P WMA 02/B810/00/1110/ 02	Aurecon	2010	Complete
196	Technical Study Module: Vol 6 Annex 3 App B Part 2 Geotechnical Investigations	P WMA 02/B810/00/1110/ 03	Aurecon	2010	Complete
197	Technical Study Module: Vol 6 Annex 4 Appendix H Drawings	P WMA 02/B810/00/1110/ 04	Aurecon	2010	Complete
198	Technical Study Module: Vol 6 Nwamitwa Dam Preliminary Design Report	P WMA 02/B810/00/0608/ 06	Aurecon	2010	Complete

No	Title	Document No.	Author	Date	Comments
199	Technical Study Module: Vol 7 Raising of Tzaneen Dam Preliminary Design Report	P WMA 02/B810/00/0608/07	Aurecon	2010	Complete
200	Technical Study Module: Vol 8 Annexure 1 Bulk Infrastructure- Appendices A-K	P WMA 02/B810/00/1110/05	Aurecon	2010	Complete
211	Technical Study Module: Vol 8 Bulk Infrastructure	P WMA 02/B810/00/0608/08	Aurecon	2010	Complete
1.23 Reports: Water Resources Systems Development Business Support Phase 3 2010					
212	Incorporation of a Transfer Option from Nandoni Dam to Giyani into the DSS for the Luvuvhu and Letaba	WP10016 – P0240c	WRP	2010	Complete
1.24 Reports: Socio-Economic and Ecological Impacts of Water Restrictions in the Letaba catchment 2010					
213	Guideline Document for Incorporating into Socio-Economic Impacts into future Water Restrictions	PWMA 02/B810/00/1009/6	Toriso Tlou	2010	Complete
214	Inception Report	PWMA 02/B810/00/1009/1	Toriso Tlou	2010	Complete
1.25 Reports: The Development of a Comprehensive WC/WDM Strategic Business plan for the Limpopo WMA					
215	Limpopo Water Management Area: Development of a Comprehensive WC/WDM Strategy and Business Plan	……..	Cain Chunda,	2010	Complete
1.26 Reports: Luvuvhu/Letaba WMA Development of a Comprehensive WC/WDM Strategy and Business Plan					
216	Luvuvhu-Letaba Water Management Area: Development of a Comprehensive WC/WDM Strategy and Business Plan	……	Cain Chunda	2010	Complete
1.27 Reports: Development of Reconciliation Strategies for All Towns in the Northern Region (on going)					
217	Current study				No reports yet available
1.28 Reports: Establishment of Drought Operating Rules for Stand Alone Dams and Schemes Typical of Rural/Small Municipal Water Supply Scheme (Northern Region) (ongoing)					
218	Current study				No reports yet available
1.29 Reports: Validation and Verification of Water Use in the Luvuvhu-Letaba WMA (on going)					
219	Current study				No reports yet available

1.6 REPORT LAYOUT

Chapter two of this report describes pertinent information form the reports of past studies, covering each study under a main heading. The sub-sections give a concise description of each of the reports with the focus on the conclusions and recommendations that were made in the report.

Chapter three provides a summary of the most important information that need to be considered in the tasks of the current study for the development of the reconciliation strategy.

2 SUMMARY OF PERTINENT INFORMATION FROM THE REPORTS

2.1 WATER RESOURCES PLANNING OF THE LUVUVHU RIVER BASIN (1990)

2.1.1 Overview

The WaterResources Planning of the Luvuvhu River Basis was initiation by the department of Water Affairsdue to the need for the establishment of a coherent and reliable data base for careful planning and resource management, which should be based on a thorough understanding of the catchment's characteristics, as well as an assessment of the basin's water resource needs and development possibilities.

The major objectives of the study were to:

- Provide information and data to assist in the effective utilization, development, management and control of the water resources of the catchment
- Provide information required to evaluate the impact of various development scenarios on the basin
- Provide guidelines on the management need of the basin's water resources
- Identify problems and their possible solutions in the short, medium and long term
- Provide the information needed to make an initial assessment of the feasibility of proposed schemes
- Provide scenarios of development possibilities
- Identify and monitor research needs to address any current shortage in information

The water resource planning of the Luvuvhu river basin was divided into 36 reports as reviewed in the following sub-sections.

2.1.2 Volume 1: Executive Summaryand Volume 2: Main Report

Report Title: WATER RESOURCES PLANNING OF THE LUVUVHU RIVER BASIN: Executive

Summary. Report No. PA900/00/0190, Main Report. Report No. PA 900/00/0290. Department of Water Affairsin association with the Republic of Venda and Gazankulu.Prepared by HKS (Hill Kaplan Scott Inc.November 1990.

This report was commissioned in order to develop a data base and resource inventory which could be used in the planning process. The primary objectives was thus to first collate information on the natural and human resource of the study area. Secondly, the current and projected water utilization by the various users sectors was determined, following which the available water resources were estimated based on hydrological information. Finally various development opportunities to match demand and supply were investigated and guidelines on the management of the water resource of the region were developed.

One of the most significant findings of the report is that there is extensive utilization of run-of-river flow which severely depletes the river flow, particularly during the critical months of August to October. There are however considerable undeveloped water resources which could be harnessed by the construction of large storage dams in the catchment.

It also became apparent that the existing fragmented management of the water resource of the basin was an obstacle in the depth of resolving the problems in the basin. Hand-in-hand with this were serious problems concerning the legal status of some of the water users, particularly the Kruger National Park.

The main recommendations of the study were the need for the establishment of a Water Advisory Body, the need for a land use management strategy for the basin, the need for further investigation of dam sites and improvement in the monitoring of data pertinent to the water resource of the basin.

2.1.3 Volume 3: Physical Characteristics

Report Title: WATER RESOURCES PLANNING OF THE LUVUVHU RIVER BASIN – STUDY OF DEVELOPMENT POTENTIAL AND MANAGEMENT OF THE WATER RESOURCES: Volume 3 - Physical Characteristics. Report No’s. PA 900/00/0390, PA 900/00/0490 and PA 900/00/0590.Department of Water Affairs in association with the Republic of Venda and Gazankulu.Prepared by HKS (Hill Kaplan Scott Inc.) November 1990.

2.1.3.1 **Scope and extent**

The physical characteristics of the Luvuvhu River Basin were identified and assessed in this report. Appendix 1 of the report covers the topography and climate, Appendix 2 the geology and Appendix

3 the vegetation, wildlife and ecology of the basin. Conclusions were drawn and recommendations were made with respect to the establishment of rainfall and evaporation stations within the basin.

2.1.3.2 **Topography**

The Luvuvhu River Basin covers an area of approximately 3 568 km^2. The most prominent features of the basin are the Soutpansberg Mountains and the Luvuvhu River Gorge. The Luvuvhu River deeply divides the basin. This feature is particularly pronounced in the east, where the 56 km long Luvuvhu Gorge cuts through the sandstones of the eastern tip of the Soutpansberg.

The topography varies from Soutpansberg Mountains in the northwest to the flat low lying flood plains of the Limpopo River in the north east. Elevations range from 1587 m.a.s.l in the Soutpansberg Mountains in the northwest to 232 m.a.s.l at the Limpopo River confluence in the east. The marked change in topography gives rise to varied climatic conditions.

2.1.3.3 **Climate**

The climate of the Luvuvhu Basin is largely influenced by the topography of the area and ranges from high rainfall humid areas in the mountainous northwest with a MAP of some 1 800 mm/a, to low rainfall hotter areas in the north-eastern lowveld with a MAP of 400 mm/a. The average MAP over the basin is 800 mm/a. The combination of wetter, cooler conditions and steep slopes in the northwest results in this region providing the major component of the basin's water resources.

The Luvuvhu River Basin falls within the eastern summer rainfall region of Southern Africa. The distribution of rainfall through the year shows a highly seasonal characteristic. Most of the rainfall occurs during the summer months. The peak rainfall period is December to February when the average rainfall is typically 50 – 60 % of the MAP. Lower rainfall areas in the catchment generally experience greater variability than the higher rainfall areas.

The seasonality of rainfall together with the variability between years typifies the problems related to surface water development in Southern Africa. The large variation in the amount, type and distribution of the rainfall also has, together with temperature and hence evaporation potential, a significant effect on the natural vegetation in the basin.

Temperature increases from the mountains in the west to the plains in the east of the basin. At Louis Trichardt the average daily temperature is approximately 21 deg C while the winter average temperature is 15 deg C. In the central basin (Levubu and Gouldville) these temperatures are approximately 2 deg C higher and in the lower basin (Punda Maria) 4 deg C higher.

The average annual A-pan evaporation ranges from approximately 1 700 mm/a in the mountainous areas to just above 2050 mm/a in the low lying areas, in accordance with the variation with the variation in altitude and temperature.

There are three relative humidity station located within or near the basin. The location and relative humidity statistics for the stations are given in the report. Wind data is available for two stations within the basin. Seasonal wind roses for the stations and wind data are given in the report.

It was recommended that new rainfall stations be established in the central and north-eastern regions of the basin where there is a sparsity in rainfall stations. It was further recommended that a network of evaporation stations be established in the basin at existing and potential dam sites and at the larger irrigation schemes.

2.1.3.4 **Geology**

The geology of the Luvuvhu River Basin was identified and assessed. Aspects that were considered in the report are the regional physical geology and geological structure, engineering geology, seismicity, the minerals and mines within the basin and mineral claims and leases. Conclusions were made and are given in the report.

The physical geology comprises of three main groups of rock, namely the Basement Rocks, the Soutpansberg Group and the Karoo Sequence (from lowest to highest). Each of these groups can gain be divided into a number of sub formations.

The Basement Rocks are mainly granitoid gneisses and underlie most of the upper 80 km length of the basin. They form the lowveld area to the south of the Soutpansberg. The Luvuvhu River cuts through the mountainous area of the Soutpansberg Group of rocks between 80 km and 135 km downstream of its source. The rocks consist of interlayered conglomerates, sandstones, quartzites, shale’s and basalt. The last 35 km of the river basin is underlain by the Karoo Sequence comprising sandstone, shale, grit, conglomerate and basalt.

The engineering geological aspects of the rocks within the basin are of importance as regards infrastructural development. The engineering geology of the three groups of rocks (Basement Rocks, the Soutpansberg Group and the Karoo Sequence) is discussed to some extent in the report.

Seismicity does not appear to be a problem in the basin but individual verification would be necessary as part of the detail design of dams.

Minerals that occur in the basin include coal, copper, cobalt, corundum, phosphate and vermiculite. Coal is mined but the other minerals occur only in small quantities and are not mined.

The following conclusions were made in the report:

- It appears that collapsing soils can be expected south of Thohoyndou.

- There is potentially expansive clay soils in the Basement Rock region and in the Karoo basalts.
- Sand and course aggregate for construction purposes should be readily available in the basin.
- Seismicity does not appear to be a problem in the basin.

2.1.3.5 **Vegetation, wildlife and ecology**

The vegetation, wildlife and ecology of the Luvuvhu River Basin was identified and assessed. The objective of the study was to provide the data and information on which the optimal development and utilization of the water resources of the basin can be based. Aspects that were considered in the report are the physical environment, the vegetation, the wildlife and the ecology of the basin. Conclusions were made and are given in the report.

Aspects of the physical environment that were considered in the report included geology, topography, climate, hydrology, the soils, sediments and land use, ecosystems, areas of aesthetic quality and unique resources.

There is diverse endemic vegetation in the basin. The main veld types are Mopane Forest, Dry Ironwood Forest, Tree Savannah (bushveld, most dominant) and Arid Sweetveld. The veld throughout the basin is in very good condition and there is little evidence of erosion. This implies a good retention of rainfall without the occurrence of large scale wash runoff.

The ecology of the Luvuvhu River Basin is considered in terms of the Upper Basin, The Central Basin, the Lower Basin and the Luvuvhu River. The Upper Basin is developed to a large extent to afforestation and dry land and irrigated crops. The dynamics of the ecosystem have been considerably altered from the natural state. The Central Basin is the one most likely to experience dramatic ecological change. The Lower Basin is a wilderness area of great ecological diversity. This diversity is in part responsible for the ecological stability of the area under the variable conditions of rainfall. The Luvuvhu River is tending from being perennial to being a more static, annual system in which the life components are diminishing. The general trend is towards anoxic conditions and nutrients are not displaced downstream. Increasing river abstractions from run-of-river flow has had the effect of changing the river from being strongly perennial to being a more seasonal system.

Stocks of large wild animals are almost exclusively confined to the Kruger National Park. The newly established Makuya Park carries a lower biomass of ungulates. In the central and upper basin areas there are some bushbuck and duiker, as well as crocodile in the main river reaches.

The study resulted in a number of conclusions made. Conclusions were made with respect to the physical environment, the vegetation, the wildlife and ecology of the basin. The conclusions are identified and itemized in the report.

The investigation and review of the ecological components of the basin yielded substantial information. However, a consideration of the data and information available indicates the need for further in depth studies of certain aspects. The further aspects that require in depth study are river biology, ecosystems, resource utilization, disease ecology and sosio-economics. Details of the required in depth studies are given in the report.

2.1.4 Volume 4: Land use

Report Title: WATER RESOURCES PLANNING OF THE LUVUVHU RIVER BASIN – STUDY OF DEVELOPMENT POTENTIAL AND MANAGEMENT OF THE WATER RESOURCES: Volume 4 – Land Use. Report No. PA 900/00/0690, No. PA 900/00/0790, No. PA 900/00/0890 and No. PA 900/00/0990. Department of Water Affairs in association with the Republic of Venda and Gazankulu.Prepared by HKS (Hill Kaplan Scott Inc.) November 1990.

2.1.4.1 **Scope and extent**

The land use capability of the Luvuvhu River Basin was assessed with emphasis on irrigation, dry land farming and afforestation suitability. The two essential determinants of the capability of water related land use, soils and topography, were investigated in detail.

Forestry occurs in the high rainfall, mountainous areas, intensive tropical fruit and vegetable farming is done where rainfall is good and irrigation can augment watering. Pastoral farming is done in the largest part of the more densely populated areas.Appendix 4 of the report covers the Land use Capability of the catchment, Appendix 5 the Existing Land use, Appendix 6 the Population of the catchment and Appendix 7 the Infrastructure of the catchment. Conclusions were drawn and recommendations were made with respect each of these topics.

2.1.4.2 **Existing Land use**

An overview of the existing land uses in the catchment at the time of the study is given in Appendix 5. Land uses includes towns, collected villages, traditional family units, cultivated lands, forests, Nature Reserves and National Parks

The upper basin (the south-western section) is comprised mainly of commercial farms and forestry estates. Louis Trichardt, located on the catchment boundary, is the service and industrial centre for this portion of the basin. In the central basin (old Venda and Gazankulu) the development pattern at the time of the study was villages serving nearby collected (not collective) agricultural plots. This development hinges around the burgeoning government and industrial centre of Thohoyandou. In the northeast of the central basin there is a transition from villages and agricultural plots to the traditional family subsistence agriculture. In the north-eastern section (Kruger and Makuya National Parks) the land is used almost exclusively for recreation and nature conservation

Urban development use to be divided into the RSA, Venda and Gazankulu. Thohoyandou (1985 population 13000) is the only proclaimed town in the Luvuvhu River Basin. There are a number of urban settlements or collected villages in both the former Venda and Gazankulu portions of the basin. A total of 128 settlements occur in the catchment which covers 128 km^2.

Significant shifts in population have occurred within the basin over the 15 year period from 1970 to 1985. There was considerable relocation of people from the Soutpansberg District to Venda. As a percentage of total basin population the Venda portion has grown from 65% to 78%. Louis Trichardt (1985 population 8800) and Malamulele (1985 population 2000) are located immediately outside the basin but derive a large portion of their water supplies from the basin. The total population depending on water from the Luvuvhu catchment were 317000 in 1985.

The agriculture of the basin consists of dry land, irrigation and livestock farming. A certain amount of game farming also takes place. The wide range of climatic conditions of the basin results in a rich diversity of agricultural production. There is substantial irrigation farming; mainly from farm dams, in the upper reaches of the river. The central basin has primarily subsistence farming on dry land. Run- of-river and borehole irrigation is also widely practised.

A total of 36100 ha of dry land under cultivation (10.4% of the catchment) were measured during this study. In the dry Doring River catchment there is some corn, sorghum and potato production under borehole irrigation.

Some 9 900 ha of land (2.8% of the basin) was measured as being under irrigation during this study. On the well- established irrigation schemes in the upper south-western portion of the basin, the crops produced are primarily subtropical fruit, including bananas, mangoes, litchis, pawpaw’s, kiwi fruit and various nuts.

The basin also supports a substantial livestock population including cattle sheep and goats. Animal husbandry ranges from the traditional pastoral type to stud farming.

The total forestry area in the basin is 14600 hectares. This is 4.2% of the total basin area. Most of the commercially forested land lies on the northern edge of the basin, in the western and central sections. Commercial forestry has existed in the basin since 1911. Most of the existing forestry areas are in the RSA part of the basin. These forests had been established by 1947. Records before this date are sparse. The Thate Vondo Forest of Venda was started in 1950 and the portion within the study area had been completed by 1958.

The forest area was constant until 1972 when further forestry expansion in the Luvuvhu River Basin was halted in terms of the Forestry Act of1968. The area within the RSA has been declared as Class I status under that Act. This means that further expansion of forestry within the RSA portion of the basin has been halted. According to Von den Busche (personal communication) only two permits were issued for a total of 59 ha during the five years to 1988.

There has been a large scale conversion of commercial plantations to agricultural crops during the same period. The total area of commercial plantations on RSA land in the Luvuvhu Basin decreased by nearly 18% (or 2300 ha) during this period. On the RSA State forest portion of Roodewal some 250 ha commercial plantations were removed and natural vegetation was re-established. There are some remaining indigenous forests on the Soutpansberg, mainly in the Entabeni Nature Reserve.

Industry was in the early stages of development in the basin at the time of the study. There were industries at Thohoyandou and Louis Trichardt. The Venda Development Corporation (VDC) gives the main impetus to industry in the basin. There was no industrial development in the Gazankulu portion of the basin.

There are some coal, copper, cobalt, corundum, phosphates and vermiculite to be found in the Basin. Mines have been established to exploit some of these deposits. At the time of the study. The Venda administration granted ISCOR prospecting and mining rights over much of the coal bearing areas in Venda. ISCOR has established a mine on the watershed between the Mutate and Luvuvhu rivers at Tshikondeni. The mine is capable of producing 4 000 tons of coking coal a month. There were plans for expanding this operation, including the construction of a railway line running to the north or the Luvuvhu River Basin. General Mining (Gencor) at the time of the study also showed interest in acquiring rights to the mining of copper and cobalt, also within the Makuya area. There is a vermiculite mine at Nat Kruit, in the extreme southwest corner of the study area. Current indications were that there is little other potential for mining in the basin.

The Kruger National Park, the Makuya Wilderness Park and the Ben Lavin Nature Reserve are primarily nature conservation areas. These areas are mainly non-consumptive protected land. The resources of these areas are not allowed to be used by tribe’s people. Some utilization of the resource does however occur.

In summary the existing land use in the Basin at the time of the study can be summarized as in **Table 2.1**.

Table 2.1:Summary of the land use in the Luvuvhu River Basin (1990)

Land use	Area (Ha)	% of Catchment	RSA (Ha)	Venda (Ha)	Gazankulu (Ha)
Urban/Villages	9 720	2.7	-	8 200	1 520
Cultivation: Dry Land	36 090	10.1	15 600	15 000	5 490
Irrigated	9 850	2.8	6 700	2 950	200
Forestry	14 570	4.1	12 930	1 600	40
National Parks	103 980	29.2	85 980	18 000	-
Nature Reserves	2 080	0.6	2 080	-	-
Natural/Livestock	180 310	50.6	42 410	113 850	24 050
Total	356 800	100.0	165 700	159 600	31 300

2.1.4.3 **Soil**

Soil mapping of the basin was undertaken by carrying out investigations to rationalize existing data. Soils augers, soil pits and natural exposures were used. Field investigations were also carried out using 1:100 000 soil maps and air photos (1977) with a nominal scale of 1:50 000 as a basis. Field demarcations were transferred from working bases to 1:50 000 topographical maps. In addition two detailed surveys of the Vuwani and Tshivase areas with soil maps at a scale of 1:5 000 were obtained and used. These had been produced by RF Loxton, Venn and Associates in 1982 and 1984.

Soils were then classified according to the Binomial System. Soil categories were grouped according to depth and clay activity to produce a logical sequence. Topographic factors were also taken into account in certain cases. The Maps of the basin soils were then produced and are contained in the report.

2.1.4.4 **Land Use Capability**

The soil categories were graded according to their potential for sustained use. Combining these with topographical detail, land use capability subgroups were mapped on 1:50 000 maps.

2.1.4.5 **Irrigation Potential**

Irrigation potential is determined by the combination of A and B soils with slopes of no more than 16% whilst taking into account the proximity to water and economic conditions. The areas with potential were then determined for the sub catchments of the basin and prioritised according to soils, proximity to water and topography. The list of these areas is contained in the report and is not reproduced here. An area of 68 885 hectares of the 356 600 hectares was determined to have irrigation potential, which represent about 20% of the basin sub catchments. The figures exclude the Kruger National Park.

2.1.4.6 Forestry Potential

Timber plantations respond to improved soil and moisture conditions. However, on economic grounds plantations are frequently relegated to areas of lower potential soils or more severe topography. The limiting factor for timber is rainfall. A mean annual rainfall of 1 000 mm is considered a threshold below which forestry potential becomes marginal. The significant parts of the Luvuvhu Basin sub catchments have rainfall in excess of 1 000 mm/a. even the worst combination of slopes and soils will have some forestry potential given adequate rainfall. It's only the worst Landuse Capability Group (D4) that needs to be excluded.

The areas with high forestry potential in the basin were therefore determined to be 602.8 km^2. The existing forestry area was only 146 km^2, with 129.37 km^2 being in South Africa, 16.93 km^2 in Venda and 0.4 km^2 in Gazankulu.

2.1.4.7 Industry

Industry was in the early stages of development in the basin. The industries were at Thohoyandou and Louis Trichardt. There was no industrial development in Gazankulu.

2.1.4.8 Mining

The basin has coal, copper, cobalt, corundum, phosphates and vermiculite minerals and some mines have been established to exploit these deposits. ISCOR was granted coal prospecting and mining rights, and established a mine at Tshikondeni capable of producing 4000 tons of coking coal a month. There was a vermiculite mine at Nat Kruit, in the extreme southwest corner of the basin.

2.1.4.9 Protected land

The Kruger National Park, Makuya Wilderness Park and the Ben Lavin, Matiwa and Entabeni Nature Reserves are mainly non-consumptive protected land within the basin. The extent of the Nature Reserves is 20.8 km^2 and is 1039.8 km^2 for the National Parks.

2.1.4.10 Land Tenure

Most of the land in Venda and Gazankulu is tribally owned. The district of Elim in Gazankulu is administered by South African Development Trust. The farms of Soutpansberg District in South Africa are mostly held in freehold by private individuals and companies. Many of the forests in this district are state controlled by the Department of the Environment.

2.1.4.11 **Summary of land uses**

The land use summary is provided in **Table 2.1**.

2.1.4.12 **Infrastructure**

Appendix 7of**Volume 4** of the study reports addresses the state of development of infrastructure within the Luvuvhu River Basin, including settlements, transportation, power supply and communication systems, but excluding water infrastructure which is dealt with separately in **Volume 5** of the study reports (see **Section 2.1.5**).

The following conclusions were made in the report:

- In the upper section of the Luvuvhu River Basin (RSA), the infrastructure is generally well developed to meet the needs of agricultural and forestry developments in the area.
- In the central section of the Luvuvhu River Basin (Venda and Gazankulu), the infrastructure is developing rapidly to cope with an increasing population.
- The lower section of the Luvuvhu River Basin (Kruger and Makuya National Parks) is a wilderness area that has a low level of infrastructural development.

2.1.5 Volume 5: Water Infrastructure

Report Title: WATER RESOURCES PLANNING OF THE LUVUVHU RIVER BASIN – STUDY OF DEVELOPMENT POTENTIAL AND MANAGEMENT OF THE WATER RESOURCES: Volume 5 – Water Infrastructure. Report No. PA 900/00/1090. Department of Water Affairs in association with the Republic of Venda and Gazankulu.Prepared by HKS (Hill Kaplan Scott Inc.) November 1990.

2.1.5.1 **Scope and extent**

The existing bulk water infrastructure on the Luvuvhu River Basin was identified and assessed. Aspects that were considered in the report are the main river tributaries and sub catchments of the river basin, the existing dams in the basin, the water supply and sewage disposal schemes and the water transfers within the basin as well as out of the basin. Conclusions were made and are given in the report.

2.1.5.2 **Infrastructure**

The major existing dams in the Luvuvhu Basin are the Vondo, Albasini, Tshakuma, and Mambedi Dams. The Mambedi Dam on the Mambedi Stream is a privately owned by the Sapekoe Tea Company and the catchment of the dam is mostly on the Sapekoe property. There are approximately 80 smaller agricultural dams in the basin, most of them in the Upper Basin area.

There are three major water supply schemes, a number of government irrigation schemes and a large number of privately owned irrigation development in the basin.

The major water supply schemes are the following:

- The Albisini Government Water Scheme. The scheme comprises of the Albisini Dam, four weirs on the Luvuvhu River and the Latonyanda and Barotta Streams, a system of irrigation canals and a water treatment works downstream of the dam with a pipeline to the town of Louis Trichardt. The scheme provides domestic and industrial water to Louis Trichardt, water for irrigation and water for the Sapekoe Estate.
- The Vondo Regional Water Supply Scheme. The scheme is supplied from the Vondo Dam. Water is supplied from the dam under gravity to the Phiphidi water treatment works (current capacity 40 Ml/d). Treated water is then pumped to a number of reservoirs from where it is distributed to the scheme under gravity flow. The scheme supplies water the Thohoyandou and the areas surrounding Thohoyandou. Irrigation water is also supplied to the Tshivase Tea Estate.
- The Malamulele Regional Water Supply Scheme. The scheme comprises of a weir on the Levuvhu River, a water treatment works, a supply system to reservoirs in the town of Malamulele and distribution pipework downstream of the reservoirs. Treated water is distributed to areas both within and outside of the Luvuvhu Basin. The scheme relies on run-of-river flow.
- Smaller irrigation schemes. There are a number of existing and proposed irrigation schemes in the Luvuvhu Basin

The major sewage treatment works within the Luvuvhu Basin are the following:

- The Thohoyandou Sewage Treatment Works. The works comprises a conentional treatment process and serves a large area that includes Thohoyandou, its industrial township, Sibasa, Makwarela, Shayandima and Tshilidzina Hospital
- The Donald Fraser Hospital Scheme. The hospital has a sewage treatment works that serves only the hospital. The works is based on the activated sludge process.
- The Venda prison and William Eadie Hospital Schemes. Separate small treatment works at the prison and hospital treats effluent from these facilities.

The following conclusions were made in the report:

- There are well developed domestic/industrial water supply schemes serving the towns of Louis Trichardt, Thohoyandou and Malamulele. There is also well a developed infrastructure to supply domestic water to rural areas in the Central Basin and in Venda and Gazankulu.

- There is a need for the development of a water supply infrastructure to supply domestic water to the rural areas in Venda and Gazankulu downstream of the Luvuvhu/Mutshindudi confluence.
- There is extensive irrigation development in the Upper Basin, supplied from dams and from run-of-iver flow. The development makes considerable use of the water supplies of the Upper Basin.
- In the Central Basin area, there are numerous small to medium sized irrigation schemes that rely on run-of-river flow for their water supply. The only scheme in the Central Basinthat is supplied from a dam is the Tshivase Tea Estate, which is supplied from the Vondo Dam.
- There are no other water use sectors in the basin for which there is a developed water infrastructure.
- There are water transfers out of the Luvhu Basin to adjacent basins, of which the main transfers are to Louis Trichardt (Sand River Basin) and the Malamulele District (Shingwedzi River Basin)

2.1.6 Volume 6: Water Requirements

Report Title: WATER RESOURCES PLANNING OF THE LUVUVHU RIVER BASIN – STUDY OF DEVELOPMENT POTENTIAL AND MANAGEMENT OF THE WATER RESOURCES: Volume 6– Water Requirements. Report No. PA 900/00/1190. Department of Water Affairs in association with the Republic of Venda and Gazankulu.Prepared by HKS (Hill Kaplan Scott Inc.) November 1990.

2.1.6.1 Scope and extent

The current (1990) and potential future water requirements for all water use sectors in the LuvuvhuRiver Basin were determined and assessed.

2.1.6.2 Water Requirements

Water requirements in the Luvuvhu River Basin can be grouped into two major categories, direct and indirect water use sectors. The direct use sectors consist of urban, industrial and power, irrigation, livestock and mining. The indirect use sectors consist of forestry, recreation, ecology, other (dry land farming, river losses, and fisheries).

A review of the water requirements indicated in 1985, using the census figures, about 317 000 people were dependent on the Luvuvhu River water. Due to possible population growth and water consumption rates of the various areas in the basin, two levels of future water requirements up to 2010 were estimated.

The total water requirements in 1985 amounted to 192 million m^3/a and the projected water requirements from 1985 to 2010 are shown in **Table 2.2**. The estimated ecological water requirements were considered the most unreliable due to available techniques at the time. The detailed irrigation requirements breakdown per sub catchment and scheme is contained in the above-mentioned Report Title.

Table 2.2: Summary of Projected Water Requirements of the Luvuvhu River Basin (1985 to 2010)

Sector	1985	1990	1995	2000	2005	2010
	(million m^3/a)					
Domectic/Industrial						
Low Growth						
Louis Trichardt	1.44	1.67	1.94	2.24	2.60	3.02
Upper Basin Rural	0.24	0.24	0.24	0.24	0.24	0.24
Vondo Scheme	6.94	7.58	8.79	10.19	11.81	13.70
Rural Venda	0.61	0.68	0.75	0.83	0.91	1.01
Malamulele Scheme	1.46	1.46	1.46	1.46	1.46	1.46
Total Domestic (Low)	10.69	11.63	13.18	14.96	17.02	19.43
High Growth						

Sector	1985	1990	1995	2000	2005	2010
	(million m^3/a)					
Louis Trichardt	1.44	1.84	2.35	2.99	3.82	4.88
Vondo Scheme	6.94	8.03	10.25	13.09	16.70	21.32
Rural Venda	1.02	1.24	1.51	1.84	2.24	2.72
Malamulele Scheme	1.46	1.57	1.69	1.83	1.97	2.12
Total Domestic (High)	11.26	13.12	16.28	20.2	25.28	31.62
Irrigation (Low)	82.1	82.1	82.1	82.1	82.1	82.1
(High)	82.1	90.4	98.7	107.0	115.3	123.6
Forestry	18.5	18.5	18.5	18.5	18.5	18.5
Mining	0.0	0.0	0.0	0.0	0.0	0.0
Livestock	0.2	0.2	0.2	0.2	0.2	0.2
Ecology	80.0	80.0	80.0	80.0	80.0	80.0
Total Usage (Low)	191.5	192.4	194.0	195.8	197.8	200.2
(High)	192.1	202.2	213.7	226.0	239.3	253.9

2.1.7 Volume 7: Water Resources

2.1.7.1 Hydrology – Record Calibration

Report Title:WATER RESOURCES PLANNING OF THE LUVUVHU RIVER BASIN: Water Resources: Appendix 11: Hydrology: Records and Calibration: Report Number P.A 900/00/1390.

The RSA Department of Water Affairs.Prepared by Hill Kaplan and Scot Inc. November 1990.

This report examined the available rainfall and hydrological data in the basin. The density, duration and reliability of the data are discussed together with the physical factors of the basin which affect the hydrology. The available rainfall records were patched (the filling in of missing data) and a rainfall map of the area was produced. The available streamflow records were naturalized (adjusted for water abstractions) and patched. The adjusted records were used to calibrate the Pitman runoff simulation model, so that runoff can be simulated at places and times in the river basin where no records exist.

The Luvuvhu River Basin is located in the north-eastern corner of South Africa. It rises near to Louis Trichardt and flows in a north-easterly direction to its junction with the Limpopo River near to Pafuri. The study area is approximately 3568 km^2. The Mutale River was excluded from the analysis. The catchment shape is very elongated: the longest channel is some 250 km long; the catchment width varies between 8 km and 35 km. The catchment was sub-dived into 24 sub-catchments for reporting purposes and based on the river structure.

Regarding the rainfall used in the study – very detailed information regarding all rainfall data records used during this study was captured, including patched rainfall values. Summaries of all the available data were provided, including patched MAP's altitude and record length as well as maps of the data distributions.

There were 45 rainfall stations in and adjacent to the river basin that had significantly long duration of data (15 years) to be considered reliable. It was noted that there are a large number of stations in the upper basin but very few in the lower basin. Most stations showed significantly below average MAP during the 1940s, the 19605 and 1980s, with contrasting above MAP values during the 1920s, 1950s and 1970s.

The PATCH program was used to patch the records. The method is a statistically and time-series based regression analysis of monthly data. Each rainfall station was initially correlated with a number of other stations in a broad radius around the target station. A significance test indicated which stations were the most highly correlated. These stations (usually 1, 2 or 3 stations) were then used as controls to patch the gaps in the target records. . It was possible to achieve a higher correlation in the upper portion or the basin than in the lower basin due to the greater density of available stations. It was noticeable that stations at similar altitudes are usually more highly correlated than those closer together but at different altitudes. The effect of topography is thus evident.

The 45 rainfall stations were patched from October 1920 to September 1984 (i.e. 64 complete years of record). Analysis of the rainfall pattern shows that the MAP on the peaks of the

Soutpansberg is 2 068 mm per annum. This reduces to 440 mm in the northeast of the study area. The MAP data was mapped using MAP Isohyets. The average October to March rainfall varied from 81% to 89% of the MAP. The peak rainfall period is December to February when the average rainfall is 50% to 60% of the MAP.

Regarding the evaporation simulated evaporation data was been produced for the study area and a detailed description of the process is provided.

Regarding the flow gauging data used during the study – Seven flow gauging stations were used during the analysis. Six of the stations were measuring weirs and one was a dam (Albasini Dam). The Department of Water Affairs did an evaluation of the station's data as input to the study. Detailed analyses were done for each of the stations describing:

- History of ownership of the station
- Type of recording and how it changed over time
- Time-step of the recordings and length of good record.
- Capacities of the measuring weirs
- Concerns and overall quality of data

The longest period for which streamflow data was usable was from 1952 – 1985 and other stations had shorter periods. The observed streamflow data was initially patched by adding the average daily flows of the days immediately prior to and after the missing period.

Streamflow records were naturalized by adding back the abstractions. However, many users do not keep any record of their water use. Thus where no records exist it becomes necessary to estimate the abstractions by some means. The detailed methodology and data used during the naturalization process is provided.

Detailed Afforestation data is provided by gauging weir incremental area, however he naturalization and patching was done without accounting for forestry usage. As the available information indicated constant areas of forestry over the period of patching and calibration, it was considered that no undue trend was being imposed on the data during the patching stage. The effects of forestry on runoff could be accounted for during the calibration stage.

There were few records of irrigation abstraction, in most of the measured catchments in the Luvuvhu Basin, except where irrigation water has been taken off at the weirs themselves. Attempts to obtain records from irrigators proved fruitless and it was thus necessary to estimate abstractions by an irrigation demand algorithm. No return seepage was allowed for. Each of the main sub-catchments was discussed in detail to describe what was taken into account as well as what the sources of the data was.

The naturalized records contain missing periods of data. It is necessary to fill in these periods before calibration is carried out, so that a continuous record is available. The PATCH program (Pegrarn, 1985) was used for patching the records. This is a regression analysis that uses the flows at other streamflow and/or rainfall stations to estimate the missing records. Only 4 of the observed streamflow records were finally used during the calibration process due to problems with appropriate correlations between the streamflow stations.

The naturalized and patched records of the remaining 4 stations were deemed reliable to be used to calibrate the Pitman model so that the model can be used to synthesize records for similar catchments. Individual calibrations were carried out on these catchments. All the statistics, graphs and Pitman parameters were provided in the report.

In areas where no calibration was done some correlation between rainfall, relief and vegetation in the basin was investigated. It was however decided to restrict the possible zonation of the basin to rainfall alone. The calibration was thus utilized for areas ill the study area where the rainfall exceeded 1 200 mm per annum (The Wet Zone). There are no reliable streamflow records in the Luvuvhu Basin that can be used to calibrate the catchments with a lower rainfall than the above catchments. The above calibration could not be reliably used for the dryer catchments in the Luvuvhu Basin.

It was thus necessary to seek calibrated parameters in similar catchments to the dryer zones of the study area. Reference was made 10 the calibrations done for the adjacent Letaba River Basin After consultation with Dr Pitman it was decided to use the Letaba 'Semi-Arid Zone' calibration for rainfall areas less than 600 mm per annum.

Some of the recommendations (which weren’t discussed above) of the study were:

- Future hydrological studies will require more rainfall data and it is recommended that new rainfall stations be established more extensively than at present in the central and lower parts of the basin.
- There are only 3 evaporation stations in the basin, ail located close together in the upper basin. Further evaporation stations should be established, particularly in the central and lower basin areas.
- The records of the used observed streamflow stations proved to be sufficiently reliable to use for calibration purposes. These monitor predominantly forested, high rainfall mountain catchments. There are no reliable records for the dryer portions of the catchment. Other measuring stations should be established on the Luvuvhu River:

- On the Luvuvhu and Mutshindudi rivers immediately upstream of their joint confluence
- Between the Luvuvhu/Mutale confluence and the Luvuvhu floodplain.

- A detailed investigation of the small dams in the catchment and the monitoring of water abstractions from these dams are recommended.
- Monitoring of water use for irrigation, possibly by remote sensing, is also recommended for the improvement of future hydrological estimates.
- Some of the stream gauges should be automated and the capacities of the weirs should be improved. Albasini and Vondo Dams monitoring should be improved.

2.1.7.2 **Hydrology – Runoff Simulation**

Report Title:WATER RESOURCES PLANNING OF THE LUVUVHU RIVER BASIN: Water Resources: Appendix 12: Hydrology: Runoff Simulation: Report Number P.A 900/00/1490. The RSA Department of Water Affairs.Prepared by Hill Kaplan and Scot Inc. November 1990.

This report describes the simulation of runoff for the sub-catchments and dam sites in the basin. The Pitman model was used to simulate runoff at the various sites for various scenarios, principally the virgin and present day condition (1987) scenarios, taking into account forestry, irrigation and existing dams.

Parameters, rainfall and evaporation derived from the report described under the previous section were used to simulated runoffs for the 24 catchments. For the present day scenario the land uses identified in other reports of this project was used to configure the Pitman Model Present Day Scenarios. The estimated runoff reduction due to Afforestation was estimated to be 18.52 $10^6 m^3/a$. The total Natural MAR of the catchment (excluding the Mutale) was calculated to be 395 $10^6 m^3/a$ while the Present Day runoff was 315 $10^6 m^3/a$. The simulated inflow to 4 dams and several dam sites were also calculated as well as the flows at international borders.

The recommendations stated that that the runoff simulations was reliable and can be used for short and medium term decisions. As the basin develops however it would be necessary to revise these estimates. Calibration will have to be revised as more observed streamflow and land use data becomes available.

2.1.7.3 **Hydrology – Floods and Droughts**

Report Title:WATER RESOURCES PLANNING OF THE LUVUVHU RIVER BASIN: Water Resources: Appendix 13: Hydrology: Floods and Droughts: Report Number P.A 900/00/1590. The RSA Department of Water Affairs.Prepared by Hill Kaplan and Scot Inc. November 1990.

This Appendix of the Water Resources Report includes the analysis of floods and droughts in the Luvuvhu River Basin. The analyses of droughts were conducted for the simulated records for sub catchments of the Luvuvhu River Basin (Appendix 12) with the current hydrological records (Appendix 11). The yield analysis results for the existing as well as the potential dam sites are presented **Table 2.3** and **Table 2.4** respectively.

Table 2.3: Existing dams in the Luvuvhu River Basin

Dam	**River**	**Owner**	**Capacity (million m^3/a)**	**MAR (million m^3/a)**		**Yield (million m^3/a)**	
				Virgin	**Net**	**Firm**	**90% Assured**
Vondo	Mutshindudi	Venda	5.3	30.8	30.8	8.0	12.2
Albasini	Luvuvhu	DWA	25.6	18.8	18.8	6.1	8.3
Tshakhuma	Barotta	Venda	2.1	7.0	7.0	1.7	2.7
Mambedi	Mambedi	Sapekoe	7.0	2.9	2.9	0.6	1.1
Total			**40.0**	**59.5**	**55.1**	**16.4**	**24.3**
MAR and Yields are based on simulated flow records (1920 to 1985)							

Table 2.4: Potential Dam Sites in the Luvuvhu River Basin

Dam	River	Catchment Area (km^2)	Net* MAR (million m^3/a)	Yield for a dam of capacity = 1 MAR of site (million m^3/a)	
				Firm	90% Assured
Xikundu	Luvuvhu	2233	261.3	88.0	178.0
Tshikonelo	Luvuvhu	1675	163.9	56.4	104.4
Paswane	Mutshindudi	402	90.6	43.0	65.0
Mashwane	Luvuvhu	970	81.6	25.0	51.5
Tshaphele	Mutshindudi	215	44.0	21.8	30.5
Vondo (Phase 2)	Mutshindudi	51	30.8	17.8	21.9
Mid Dzindi	Dzindi	57	26.0	9.4	17.5
UpperMbwedi	Mbwedi	39	12.4	6.4	9.6
Roodewal	-	50	11.3	4.8	7.2
Latonyanda	Latonyanda	45	14.5	4.4	6.5
* Excludes any discharge from Albasini, Vondo and Mambedi Dams. Yields assume that none of the other potential dams are built upstream. Note that 1 MAR dam is not necessarily the most optimal size for each dam.					

It was recommended that greater certainty should be established on the hydrology of the basin for future planning and development of the rivers water resources, which will require an expansion and improvement of the gathering of hydrological and associated data. The following priorities were identified:

- The establishment and maintenance of automated continuous streamflow gauging stations along the central and lower reaches of the Luvuvhu River and its major tributaries and at major dams in the catchment.
- The extension of rainfall measuring network in the central and lower portions of the basin.

- A detailed investigation of the small dams in the catchment and monitoring of water abstractions from these dams.
- Monitoring of the irrigation water use over time should be conducted, possibly by remote sensing methods. This would need to be accompanied by a parallel groundwater abstraction assessment where large scale use of surface water is used for irrigation.

There was insufficient data available from the Luvuvhu Basin for the analysis of flood frequencies and provisional estimates of flood peaks were made from empirical and deterministic methods. Decades of sufficient data capturing will be required for accurate analysis of flood frequencies to be made. The methods used for the analysis were the Regional Maximum Flood method of Kavocs and the Unit graph Method. The Regional Maximum Flood method of Kavocs was regarded as the most reliable and the flood peaks estimates for dam sites in the basin based on this method were presented.

2.1.8 Volume 8: Water Resources (Continued)

Appendix 15 of the report describes the water quality requirements for various water users in the catchment as well as setting out purified effluent quality requirements in terms of the General and Special effluent standards. Limited water quality results are given for:

- Malamulele Water Treatment Works (WTW) and Sewage Treatment Works (STW);
- Phiphidi WTW;
- Thohoyandou STW;
- Donald Fraser Hospital STW; and
- Venda Prison and William STW.

Limited water quality trends and potential pollution sources are described. Water quality analysis including the following parameters: colour, turbidity, suspended solids, pH, dissolved solids, sodium, magnesium, calcium, fluoride, chloride, nitrate and nitrite, sulphate, phosphate, total alkalinity, silica, potassium and ammonia, for nine sites (Albasini Dam, A9M05, A9M01, A9M07, A9M06, A9Q01, A9Q02, A9Q03 and A9Q04) for varying periods from 1966 are included.

The water quality requirements for the various water users, the General and Special standards requirements as well asthe actual water quality data presented is very dated.

2.1.9 Volume 9: Dam Sites

Report Title: WATER RESOURCES PLANNING OF THE LUVUVHU RIVER BASIN – STUDY OF DEVELOPMENT POTENTIAL AND MANAGEMENT OF THE WATER RESOURCES: Volume 9 – Dam Sites. Department of Water Affairs in association with the Republic of Venda and Gazankulu.Prepared by HKS (Hill Kaplan Scott Inc.) November 1990.

Volume 9 comprise of:

- Appendix 17: Dam Sites — Report No PA 900/00/1990
- Appendix 18: Mashawane Dam — Report No PA 900/00/2090
- Appendix 19: Mashawane Geology — Report No PA 900/00/2190
- Appendix 20: Paswane Dam — Report No PA 900/00/2290
- Appendix 21: Paswane Geology — Report No PA 900/00/2390

2.1.9.1 **Scope**

Appendix 17 deals with the future development and management of the water resources of the Luvuvhu River Basin. It reports on a reconnaissance level study of potential dams in the basin. Existing dams were not investigated, as these are either of considerable storage volume with respect to their runoff and are therefore unlikely to be raised or are currently the subject of detailed study by others. Nineteen undeveloped sites were selected for investigation, of which fourteen were newly investigated for this report.

The sites were compared with each other based on location, construction cost, unit reference value of the cost of water, yield, storage capacity, etc. The most promising sites for development were identified and further investigated. Conclusions were made and are given in the report. Recommendations were given as to further feasibility studies for three of the most promising dam sites.

Appendices 18, 19, 20 and 21 are all in support of **Appendix 17**. The reports deal with each dam site in particular. Aspects that are considered are general design and construction aspects, hydrology and design floods and dam foundation conditions. Cost estimates, conclusions and recommendations for each dam site are also given.

2.1.9.2 **Existing and Potential Dams**

The existing dam development is in the upper reaches of the Luvuvhu Basin. The existing large dams are the Vondo, Albisini, Tshakuma, and Mambedi Dams. The Mambedi Dam on the Mambedi Stream is privately owned by the Sapekoe Tea Company and the catchment of the dam is mostly on the Sapekoe property. Pertinent dam parameters for the above dams are given in the report (Capacity, MAR, yield).

Potential dam sites were initially identified from 1:50 000 topographical maps, 1:5 000 orthophoto maps and aerial photographs of the area. Nineteen undeveloped sites were selected for study.

The dam sites selected for investigation were the following:

- Luvuvhu River: - Mashawane Dam
  - Gandlanani Dam
  - Tshikonelo Dam
  - Xikundu Dam
  - Dongadziva Dam
- Mitshindudi River: - Tshaphele Dam
  - Paswane Dam
- Mambedi River: - Mambedi Dam (1)
  - Mambedi Dam (2)
  - Upper Mambedi Dam
- Tshinane River - Tshinane Dam (1)
  - Tshinane Dam (2)
  - Tshinane Dam (3)
- Albisini catchment: - Roodewal Dam
- Dzindi River: - Sterkstroom Dam
- Latonyanda River: - Latonyanda Dam
- Barotta River: - Tshakhuma Dam

The sites were investigated and observations on the geology and available construction materials were made. No soil sampling and testing were done and no surveys were done. With the information gained, a preliminary assessment was made of the possible type and size of dam that could be built at each site and a cost estimate was done.

A first approximation to the hydrology of each site was determined. An effective storage equivalent of 1 MAR was used for initial sizing of each dam. Allowance was made for 40 years of sediment storage in the total storage volume. The regional maximum flood was determined for each site and the spillway for each dam sized accordingly. Three types of dams were considered for each site (Earth fill/rock fill embankment, mass gravity concrete or roll Crete dam, Composite structure comprising a mass gravity concrete/roll Crete overflow section with earth fill/rock fill embankments on the flanks). Material volumes were calculated and preliminary cost estimates and unit reference values prepared.

It was concluded, that except for the Paswane Dam on the Mutshindudi River, the most favourable dam sites are all located on the Luvuvhu River. The Mashawane dam site has a relatively low unit water cost and are only 16 km away from Thohoyandou. The dam site is strategically placed to supplement water supplies to the Vondo Scheme (supplying Thohoyandou and surrounding areas and irrigation water to the Shivase Tea Estate) and to Louis Trichardt.

It was recommended that further investigations, at a feasibility stage level of detail, be carried out for three of the most promising dam sites. The three sites are for the Paswane Dam, the Mashawane Dam and the Xikundu Dam. It was recommended that the investigations should include detail investigations of foundations and construction materials, potential uses for the water, distribution system costs, environmental factors and detailed design proposals.

2.1.10 Volume 10: Dam Sites (Continued)

Report Title: WATER RESOURCES PLANNING OF THE LUVUVHU RIVER BASIN – STUDY OF DEVELOPMENT POTENTIAL AND MANAGEMENT OF THE WATER RESOURCES: Volume 10 – Dam Sites (Continued). Department of Water Affairsin association with the Republic of Venda and Gazankulu.Prepared by HKS (Hill Kaplan Scott Inc.) November 1990.

Volume 10 comprise of:

- Appendix 22: Tshikonelo Dam Report No PA 900/00/2490
- Appendix 23: Tshikonelo Geology Report No PA 900/00/2590
- Appendix 24: Tshaphele Dam Report No PA 900/00/2690
- Appendix 25: Tshaphele Geology Report No PA 900/00/2790
- Appendix 26: Xikundu Dam Report No PA 900/00/2890
- Appendix 27: Xikundu Geology Report No PA 900/00/2990
- Appendix 28: Upper Mbwedi Dam Report No PA 900/00/3090
- Appendix 29: Upper Mbwedi Geology Report No PA 900/00/3190
- Appendix 30: Mbwedi Sites 1 & 2 Geology Report No PA 900/00/3290

2.1.10.1 **Scope**

The above appendices are all in support of **Volume 9 –** Dam Sites, **Appendix 17**, Report No PA 900/00/1990. The reports deal with each dam site in particular. Aspects that are considered are general design and construction aspects, hydrology and design floods and dam foundation conditions. Cost estimates, conclusions and recommendations for each dam site are also given.

2.1.11 Volume 11: Water Resources Management

2.1.11.1 Appendix 31: System Analysis

Report Title:WATER RESOURCES PLANNING OF THE LUVUVHU RIVER BASIN: Water Resources: Appendix 31: System Analyses. Report Number P.A900/00/3390 The RSA Department of Water Affairs. Prepared by Hill Kaplan and Scot Inc. November 1990.

The report examined the operation of the water resources system of the Luvuvhu River Basin. This included the current water resources development within the basins as well as the availability and use of water. The ability of the system to meet the demands was also examined as well as the effect of water resources development and abstraction on the remaining river flows. The Mutale River, a major tributary of the Luvuvhu River was not covered in the study area of this study and gross flow estimates were obtained from a previous study (Chunnett Fourie, 1984).

The details of the components listed below were summarised in the report:

- **Existing Dams:** The capacity, net MAR and usage of the Albasini, Mambedi, Tshakhuma and Vondo dams are summarised. There are many other smaller dams in the catchment that were not included in the system analyses due to their expected minor effect.
- **Water Supply Schemes**: The supply source and distribution or users of the Albasini Government Water Scheme, Vondo Regional Water Supply Scheme and Malamulele Regional Water Supply Scheme were indicated.
- **Existing Water Demands**: The existing domestic/industrial, irrigation and the ecological water requirements were shown.
- **Return Flows:** Only one significant return flow into the Luvuvhu River Basin exists, which is the effluent discharge from the Thohoyandou Sewage Purification works that discharges into the lower end of the Dzindi River. The return flow form Louis Trichardt and Malamulele discharge into adjacent catchments. No allowance was made for irrigation return flows.
- **Operating Rules:** The operating rules of the Albasini Dam, Vondo Dam and remainder of the basin were summarised.

System analyses were conducted for both the existing conditions and possible future conditions by using the HEC-3 computer programme produced by the US Army Corps of Engineers. The system was modelled for the 24 sub catchments that the study area was divided into and the previously simulated runoff records for the period 1920 to 1984 were used as local inflows.

The various assumptions included in the two system analysis scenarios (existing conditions and possible future conditions) are documented in the report. For the possible future conditions scenario, assumptions were also made with regards to the future water requirement projections and the required assurance of supply for the different water users as well as the most feasible future water supply development options (Raising of Vondo Dam, Mashawane Dam, Paswane Dam and Xikundu Dam were identified as the key dam sites in the central basin). Future dam combination scenarios were analysed the yields of the various combinations are presented.

The system analyses results can be summarised as follows:

- The analysis of the existing Luvuvhu River System indicated that the irrigated areas upstream of the Albasini Dam rely on sources other than run-of-river flow. Farm dams and groundwater are their main sources of water.
- The Albasini GWS is over extended and cannot supply all the water allocations linked to the dam. The irrigation areas are affected the most because Lois Trichardt has priority on the water in the dam.
- The demand on the water supply from Mambedi Dam is also over extended.
- The Vondo Dam operates at an assurance too low for domestic/industrial supply and the raising of the dam is required.
- The river flow through the Kruger National Park has deteriorated substantially from the virgin conditions, especially over the months from August to November, which coincides with the natural time of low runoff and the critical irrigation season.
- The low flows of the Kruger National Park and the projected domestic/industrial demands of the year 2010 can be met by dam construction in the catchment. Future irrigation developments could also be accommodated, depending on the selection of dams constructed.

The following recommendations were made:

- No further increase in water resources abstraction from run-of-river should occur in the Luvuvhu River without the provision of a major storage facility. Although high assurance of supply could occur from any run-of-river scheme, the effect on the flows for the Kruger National Park would be severe.
- A detailed system analysis of the Albasini Dam should be carried out, which will require a detailed survey of the existing irrigation and small farm dams as this level of detail is currently not available.
- Operating rules for the Vondo Dam are required.
- In order to understand he conditions at the Luvuvhu Flood Plain (at the Limpopo

confluence), it will be necessary to incorporate information of the existing runoff from the Mutale River. This information was not available and a study on the current water resource usage in the Mutale River is thus recommended.

2.1.11.2 **Appendix 32: Research and Monitoring Needs**

Report Title:WATER RESOURCES PLANNING OF THE LUVUVHU RIVER BASIN: Water Resources: Appendix 32: Research and Monitoring Needs. Report Number P.A900/00/3490 The RSA Department of Water Affairs. Prepared by Hill Kaplan and Scot Inc. November 1990.

The report describes the research and monitoring needs required in areas where sufficient knowledge and data is lacking in fields such as climate, hydrology, water utilisation, groundwater, water quality and sedimentation.

The following recommendations were made for each of the seven fields:

A. Climate

- A scarcity of rainfall stations was identified in the central and north eastern portions of the basin and it was recommended that new stations be established in these areas, especially in areas with high irrigation potential.
- A network of evaporation stations should be established in the basin at the existing and potential dam sites and at the larger irrigation schemes.

B. Hydrology

- The study of hydrology indicated a need for additional automated streamflow stations, especially in the lower reaches of the Luvuvhu, which include the drier portions of the catchment. The installation sites were indicated.
- As the basin is developed, the runoff estimates should be revised using adjusted parameters, especially where areas under afforestation and irrigation are altered. Further system analyses should be undertaken to assess the implications on the overall water characteristics, using updated hydrological and water utilisation data prior to the development of new dams as these revisions may lead to different conclusions concerning the development options.

C. Groundwater

- The geohydrology of the basin should be investigated in greater detail. Investigations should include groundwater usage, data collection on lithology, hydraulic tests on boreholes to determine water levels, yields, recovery curves and water quality in order to develop a groundwater plan.

D. Water Quality

- The quality of surface and groundwater was generally adequate for irrigation and conventional treatment for domestic supply and it was recommended that measures are implemented to ensure that it is maintained as such.
- A regular streamflow water quality sampling program should be initiated to monitor pH, electrical conductivity, sodium and phosphates while bacteriological samples are taken in areas where specific problems arise.
- The Tshikondeni coal mine is located on the Luvuvhu/Mutale Watershed, which is a potential pollution source to the lower Luvuvhu flood plain in the Kruger National Park. Proper control of runoff from the workings should be maintained and monitored to prevent pollution.
- The quality of groundwater should be monitored at regular intervals to ensure that timeous responses can be made to deteriorations in water quality to maintain health needs as groundwater forms the basis for a large proportion of primary users.

E. Sedimentation

- Little information was available on sediment loads and regular reservoir surveys should be undertaken on all dams greater than 10 million m^3 to establish volumes of trapped silt which will allow for determination of available regionalized sediment yield indices.
- The increase in population and agricultural activity should be monitored using remote sensing methods in order to timeously implement conservation practices in order to reduce the impact of erosion and sediment loads as a result of the increased activities.

F. Wildlife and Ecology

- An assessment of the vulnerability of the various habitats and ecosystems to potential changes in the basin should be conducted. Specific attention should be given to the water needs of the ecology in the Kruger National Park in order to determine water allocations and releases from present a future storage dams.

G. Water Utilization

- The monitoring of water abstractions from farm dams and run-of-river schemes for irrigation should be updated regularly to revise the water use projections. Automation of data capture through remote sensing methods was recommended. The collection of information on the population growth and domestic water requirements and losses should be conducted together with the above. This would greatly assist future revisions of hydrology and estimates of water utilisation in the basin.

2.1.11.3 **Appendix 33: Legal and Institutional Needs**

Report Title: WATER RESOURCES PLANNING OF THE LUVUVHU RIVER BASIN: Water Resources: Appendix 33: Legal and Institutional Needs. Report Number P.A900/00/3590 The RSA Department of Water Affairs. Prepared by Hill Kaplan and Scot Inc. November 1990.

This report provides an overview of the effect that the institutional and legal development has on the water resources development in the Luvuvhu River Basin. Recommendations for future institutional and legal development were also made. These are summarized below.

- It was proposed to establish a Water Advisory Body composed of the different water regulatory authorities.
- It would be desirable to investigate the Government Water Control Area, to determine whether successful water regulation can be achieved or not. The RSA Department of Water Affairs should be responsible for this.
- It is considered essential that the water rights for tribal and state owned land are established. This would be the responsibility of the RSA and Venda Departments of Water Affairs.
- The RSA Department of Water Affairs should ensure that provision is made in the Water Act for the water rights of the ecology.

2.1.11.4 **Appendix 34: Development Possibilities**

Report Title: WATER RESOURCES PLANNING OF THE LUVUVHU RIVER BASIN: Water Resources: Appendix 34: Development Possibilities. Report Number P.A900/00/3690 The RSA Department of Water Affairs. Prepared by Hill Kaplan and Scot Inc. November 1990.

This report provides scenarios of development possibilities required in the Luvuvhu River Basin. The results of the report can be summarised as follows:

- The potential for additional water supply from run-of-river abstraction is restricted due to the effect on the river flows during critical periods.
- There is however substantial potential for the increase in water supply by the construction of dams in the catchment.
- There is insufficient information available to provide a definitive assessment of the groundwater potential.

The goals, objectives and key strategies for water resources management in the Luvuvhu River

Basin were summarised in the report. The constraints associated with the development of the Luvuvhu River Basin according to the identified objectives were also documented, which included financial, institutional, social, technical environmental and legal constraints.

The individual sectoral water supply problems in the basin, how each could be satisfied by the development of individual sources and the strategies for development are documented in the report.

The main component in the development of the Luvuvhu River Basin water resources are the major dams. Based on the discussions of the sectoral water supply problems the Vondo Dam (raising), Mashawane Dam, Paswane Dam and Xikundu Damare are the key large dam sites in the central basin and smaller dams with good potential are the Upper Mbwedi and Mid-Dzindi Dams.

Analyses of the water requirement scenarios and water supply options indicated that:

- At least one new large dam is required (in addition to Vondo Dam) in order to provide for the needs of the Kruger National Park.
- Development scenarios are heavily dependent on the assumed or required rate of irrigation development.
- There are insufficient suitable small dams to provide the same potential yield as the large dams.

Three broad scenario options were identified (in addition to the raising of Vondo Dam):

- High rate of irrigation development (more than 100ha/annum)
  - Short Term: Paswane Dam
  - Medium/Long Term: Xikundu and Mashawane Dams
- Low rate of irrigation development (less than 50ha/annum)
  - Short Term: Xikundu Dam for KNP low flows
  - Medium Term: Small Dams for individual irrigation schemes (eg. Mid-Dzindi and Upper Mbwedi Dams).
  - Long Term: Mashawane Dam for domestic/industrial supply
- No further irrigation development
  - Short Term: Xikundu Dam
  - Long Term: Mashawane Dam for domestic industrial supply

Recommendations: Existing Water Supply Schemes

A. Albasini Government Water Scheme

The scheme would benefit from additional development of water resources in order to improve the assurance of water supply to the scheme. There would not be much advantage in raising Albasini Dam, as little additional yield would result. It would be more beneficial to develop some of the catchments which are not yet dammed, particularly the Latonyanda Stream. The cost of any such development and means of funding it would require careful evaluation.

A detail study which investigates the water supply to Louis Trichardt should be undertaken.

This would include consideration of alternative supplies from other river basin. Potential new sources within the Luvuvhu River Basin that may be considered are:

- Mashawane Dam (in Venda).
- Latonyanda Dam (supply to irrigation, thus releasing more of Albasini's water supply for Louis Trichardt).
- Roodewal Dam (reduces runoff to Albasini Dam).

This is required to timeously resolve the future water supply of Louis Trichardt.

B. Vondo Regional Water Supply Scheme

The most practical solution to the short/medium term water supply needs of this scheme is to raise Vondo Dam. This is required as soon as possible because the existing water demand has outstripped the firm yield of the existing dam.

Implementation is urgent and the longer term needs of the scheme could be supplied from the potential Mashawane Dam.

C. Malamulele Regional Water Supply Scheme

When the water demand for this scheme increases, or there is a significant upstream abstraction of water resources, the potential Mashwane Dam would become necessary to provide an adequate assurance of supply for this scheme.

Recommendations: Water Resources Development

- In general it was recommended that no further irrigation development or other water abstraction scheme should occur in the Luvuvhu Basin without the provision of new storage facilities, as the run - of- river supply has been exploited to the limit and any further attempts to abstract more water from run -of - river supply will prevent existing downstream users (including the Kruger National Park) from receiving their water requirements.

- Feasibility studies should be carried out for the Paswane, Mashawane and Xikundu dam sites, in order to confirm the viability of these sites for development. These are required to determine priorities and requirements for development and t investigate solutions.

2.2 KRUGER NATIONAL PARK RIVERS RESEARCHPROGRAM, WATER FOR NATURE: HYDROLOGY, LUVUVHU RIVER (1990)

2.2.1 Overview

The Department of Water Affairs and the Water Research Commission embarked upon a study which had the objective of establishing the water requirements of the natural systems in rivers. This study focused on the rivers which flow through the Kruger National Park, where it is known that the natural systems have been adversely affected by development of the water resources upstream of the park.

The study details aspects of the hydrology of the Luvuvhu River, which flows through the Kruger National Park at its northern end.The portion passing through the Kruger National park is at the river's most downstream end. Upstream development of water resources usage has seriously affected the flow in the river at the downstream end.

One report was sourced and reviewed in the Kruger National Park River study.

2.2.2 Kruger National Park – Luvuvhu River – Hydrology

Report Title: KRUGER NATIONAL PARK RIVERS RESEARCH PROGRAM, WATER FOR NATURE: Hydrology, Luvuvhu RiverReport No. PA 900/00/3790. Department of Water Affairs.Prepared by HKS (Hill Kaplan Scott Inc.) November 1990

The hydrological data has been taken from the Luvuvhu River Basin Study. Further analyses have been carried out in order to present the data in a manner that might be of greater use to the natural scientists working on the study, than the unanalysed data would be.

A comprehensive understanding of the hydrology of the river requires that a range of development conditions be considered. Various analyses were carried out on each of the runoff records for the scenarios below so that a variety of perspectives could be gained:

- Natural, Undeveloped Conditions ('Virgin Runoff).

- Conditions of development that occurred at various historical periods.
- Current conditions of afforestation.
- Current development of all water resources.
- Possible future development scenarios.

The river was divided into nine reaches but only four of these reaches have been analysed (other two reaches required the Mutale River which was not included in the Hydrological Analysis). The runoff record is for the reach outlet. These are:

- Reach 3: The Luvuvhu River immediately upstream of the Mutshindudi River confluence.
- Reach 4: The Luvuvhu River at the Kruger National Park upstream boundary.
- Reach 5: The Luvuvhu River immediately upstream of the Mutale River Confluence.
- Reach 9: The Mutshindudi River at its confluence with the Luvuvhu River.

There was some limitation to the original Hydrology: most of the observed data for the catchment was situated in the upper parts of the catchment and only simulations could be done for the lower parts, which makes the cumulative flow at the end of the river of low confidence.

A broad overview was provided on the history of the population and growth in land use in the basin. Detailed dates of the major events were provided. For the purposes of analysis, a few significant dates were chosen to coincide with significant changes, such as the construction of a damn, or the start or end of a water scheme development. These dates are 1920, 1936, 1952, 1962, 1972, 1982 and 1987.

Detailed land and water use figures were provided per reach for these dates. These included irrigation and afforestation development, domestic and industrial water supply and major dams natural inflows, capacities, yields and dates commissioned. The natural flows for each river reach were provided as well as the corresponding change of MAR for the decision dates.

Monthly runoff sequences were generated under various catchment conditions at four key points at the outlet of the main reaches. The sequences were for a 64 year period, each under fixed development conditions. The detailed time series were provided. The daily variation inflow in the river was not addressed. It was however addressed with the instantaneous low flow requirements of the natural system compared to the monthly data.

The following statistical analyses were done for each of the scenario sequences:

- Statistical summaries
- Low flow occurrence

- Drought flow sequences
- Comparisons with 70% assurance of flows

The critical point in the river, when the needs of nature are concerned, is at the Kruger National Park upstream boundary. This is the downstream end of Reach 4. Comparisons of the desired and minimum required flows to the virgin and existing conditions at Reach 4 indicate that there has been a depletion of the flows in the river, with the most severe impact over the critical period of August to November.

The main findings was that the status of development of the water resources of the Luvuvhu River Basin may be described as being relatively low in comparison to the total water resources of the basin. However, there is a significant use of the critical low period flows by run-of-river abstraction, because there is insufficient dam storage with respect to the extent of abstraction.

Thus further development of water abstraction schemes which rely on run-of-river flow will require that storage dams be constructed before they could proceed.

2.3 WATER RESOURCES PLANNING OF THE LETABA RIVER BASIN STUDY OF DEVELOPMENT POTENTIAL AND MANAGEMENT OF THE WATER RESOURCES (1990)

2.3.1 Overview

The basin study involves an in investigation of all water related matters in the study areas including water use and demands, water resources, development and management of the water resources.The water resource planning of the Letaba river basin study is divided into 26 reports and 3 of these reports are not available.

2.3.2 Executive Summaryand the Basin Study Report

Report Title: WATER RESOURCES PLANNING OF THE LETABA RIVER BASIN: STUDY OF DEVELOPMENT POTENTIAL AND MANAGEMENT OF THE WATER RESOURCES: Executive Summaryand Basin Study Report. Report No. PB 800/00/0190, and Report No.PB 800/00/0290.Prepared for: Department of Water Affairs and Forestry. Prepared by Steffen Robertson and Kirsten inc and the RSA Department of Water Affairs, 1990.

The study aimed to obtain a thorough understanding of the complex interactive processes in the study area and their impact on the water industry. This was achieved by examining and assessing the historical and current situation regarding all hydro related matters in the basin. Possible future development scenarios were also examined.

The study involved:

- Evaluation of available data
- Evaluation of mathematical tools currently in use
- Evaluation of existing management
- Evaluation of factors affecting development
- Assessing the short, medium and long term problems
- Evaluation and assessment of the interaction of water on other primary and secondary resources

Review of possible development options by combining, integrating and moulding the various elements or processes into possible development scenarios

The following were noted as recommendations that need required urgent attention:

- A water authority be created.
- The water resources be jointly developed, controlled, and managed.
- The efficiency of water use by the irrigation sector be improved.
- Data collection, processing and dissemination be improved.

The recommendations from the study were as follows:

- The hydro meteorological data network should be improved. Rain gauges should be installed to improve the spatial coverage and the flow of gauging network should be expanded by constructing additional stations. The operation of existing river flow gauging stations should be improved
- Operating rules for water supply schemes in the basin should be refined and these should be implemented in order to maximise the supply of water to all users
- Detailed studies of development possibilities be undertaken for
    - Letsitele catchment
    - Lower Groot Letaba catchment
    - Molototsi catchment
    - Klein Letaba catchment
    - Augmentation of flows for the Kruger National Park
    - Water transfer to Pietersburg and environs

- Water quality management objectives should be set for all rivers in the basin
- The data compiled in this study should be fully integrated onto the Geographic Information System of the Department of water Affairs and Forestry, and the system should be utilised for the management of the water resources
- The impact of changing land-use and water utilisation should be monitored and evaluated on an on-going basis.
- As a priority, the relevant authorities should be requested to investigate means of reducing the population growth in the catchment
- Institutional arrangements should be initiated to achieve on-going co-operation between the various regional authorities and interest groups that deal with water resource development and management. The Letaba River Basin Steering Committee, which serves as a forum for the exchange of information, debate and communication on matters of common interest concerning water resources, should be replaced by a suitable organisation with broad representation

2.3.3 Annexure 1: Catchment Description

Report Title: WATER RESOURCES PLANNING OF THE LETABA RIVER BASIN STUDY OF DEVELOPMENT POTENTIAL AND MANAGEMENT OF THE WATER RESOURCES – Annexure 1 – Catchment Description. Report No. PB 800/00/0390.Department of Water Affairs.Prepared by SRK, 1990.

The natural characteristics of the Letaba River basin have a major influence on the development potential and water use. The degree and extent of the infrastructure in the area also impacts on the water industry. This report therefore aims to give a review and assessment of the natural characteristics. Details with regard to the present land use of the study area and existing infrastructure are also presented. Aspects addressed in this report include topography, drainage, geology, climate, soils, vegetation, wildlife, archaeology, present land use and land use potential.

2.3.3.1 **Topography and drainage**

The Letaba River and Shingwedzi River catchments are located in the north-eastern part of South Africa. The Letaba River catchment measures about 13 500km^2 and the Shingwedzi River catchment measures about 6000 km^2. The catchments lie partly in the Republic of South Africa (RSA), the former Gazankulu, Veda, Lebowa and Mozambique. A large portion of the area, located in the RSA lies in the Kruger National Park (KNP).

Development of the area started about the turn of the century. Developments were initially in terms of agriculture and afforestation. Service industries were subsequently established. More recently, steps were taken to stimulate industrial growth in the area to promote decentralization of industry in South Africa. During the past two decades, most areas in the catchment have experienced extraordinary population growth. These developments have placed tremendous pressure on the available resources. In recent times, awareness has also grown as to the importance of nature conservation. Water is needed to maintain the ecology in and near to the rivers. In some cases, such as the lower Groot Letaba River, the quantity of water is significant. The requirement is estimated to be greater than is available in the river system at present.

The study area comprises the Letaba River and Shingwedzi River catchments. This area is located in the north-eastern part of South Africa in the vicinity of Tzaneen, Phalaborwa and Punda Maria. The Letaba and Shingwedzi Rivers are two of the major rivers draining the eastern escarpment of the former Transvaal. The two catchments generally lie on a west-east axis, the headwaters being formed by the Transvaal Drakensberg mountain range. The study area can broadly be divided into three zones of relief:

- mountainous zone
- low mountainous and foothill zone
- plains zone

The mountainous zone forms the headwaters of the Groot Letaba River and its major tributaries, viz. Klein Letaba, Middle Letaba, Koedoes and Brandboontjies Rivers. This zone includes the northern portion of the Transvaal Drakensberg mountain range which lies on a north-south axis.

The topography of the mountainous zone rises steeply from about 900 m in the vicinity of the towns Tzaneen, Duiwelskloof and Waterval to a general level of about 2 000 m in the vicinity of Haenertsburg and Dap Naude Dam. The general topography north of the headwaters of the Middle Letaba River is at a lower level, viz. about 1 300 m. The low mountains and foothill zone lies between the Drakensberg mountain range in the west and the-plains to the east. The surface of this area rises gently from about 600 m to 900 m. The plains zone covers most of the study area. Slopes are flat rising from about 200 m in the east to about 600 m in the west.

The study area is drained by the Letaba River and the Shingwedzi River. Both river systems are well defined having several major tributaries which include the Klein Letaba, Middle Letaba, Koedoes, Mlototsi and Letsitele Rivers. The river courses are strongly influenced by several major geological fault lines which strike in a north-easterly direction.

2.3.3.2 **Present land use**

Extensive development has occurred within the Letaba and Shingwedzi catchments which have led to the exploitation of water resources.

2.3.3.2.1 Urban and Industrial Development

The study area has a population of over 710 000 people. More than 90% of the population stay in villages and settlements that are located in the central and eastern regions. Many of the settlements have populations in excess of 5 000. **Table 2.5** summarises the location, population, and characteristics of the large towns.

Table 2.5: Development characteristics of large towns

Town	Location	Population	Comment
Tzaneen	Upper reaches of Groot Letaba River	7 000	Water pumped directly from Groot Letaba river. Industries of manufacturing and processing.
Nkowakowa	15 km east of Tzaneen	6 500	Water pumped directly from Groot Letaba river. Industries of light manufacturing and processing
Lenyenye	20 km south-east of Tzaneen	6 000	Serves as dormitory to Nkowakowa industrial area.
Ga-Kgapene	25 km north of Tzaneen	5 000	Acts as service centre to other settlements in region
Giyani	Northern bank of Klein Letaba River	7 800	Administrative capital of Gazankulu. Acts as service centre to other settlements in region.
Malamulele	35 km north of Giyani	2 400	Well-developed infrastructure. No rail link.

2.3.3.2.2 Infrastructure

The main roads in the area include:

- R71 from Pietersburg to Letaba Rest Camp, via Haenertsburg, Tzaneen, Letsitele and Phalaborwa
- R36 from Louis Trichardt to Lydenburg via Mooketsi, Duiwelskloof, Politsi, Tzaneen, Nkowakowa and Lenyenye
- R524 from Louis Trichardt to Punda Maria via Thohoyandou
- From Punda Maria to Letaba Rest Camp via Munnik and Mooketsi

The railway network consists of one line in a NW-SE direction. The towns of Pietsburg/Louis

Trichardt, Phalaborwa, Soekemoer, Mooketsi, Duiwelskloof, Politsi, Tzaneen, Nkowakowa and Letsitele are linked by the railway line.

The western and central parts of the study area have an extensive electricity network. Power is brought from Louis Trichart and Phalaborwa. Giyani, Tzaneen and Junction contain mayor substations.

The initial water supply network was designed to meet the domestic needs of Tzaneen and the irrigation requirements along the Groot Letaba River. The system was later expanded to supply Pietersburg, and urban centres in Gazankulu, Lebowa and Venda. Characteristics of the major bulk water supply systems are shown in **Table 2.6**.

Table 2.6: Bulk water supply systems

Name	Capacity (mill m^3)	Supply (mill m^3/annum)	Recipient	Method of delivery
Dap Naudé Dam	2.1	5.6	Pietersburg	Pipeline under gravity
Ebenezer Dam	70	2	Tzaneen domestic	Pipelines and canals
		13.9	Irrigators between Ebenezer Dam and Fanie Botha Dam	
		5.9	Pietersburg	
Magoebaskloof Dam	4.9	0.9	Domestic and industrial users in Politsi, Duiwelskloof and Ga-Kgapane	Pipeline, canal or released into Politsi River for abstraction downstream
		6.8	Irrigation in the vicinity	
Fanie Botha Dam	158.7	3.4	Domestic and industrial users in Nkowakowa, Ritavi 2 district, Letaba Citrus Processors, Koedoe Co-operative and Consolidated Murchison	

Name	Capacity (mill m^3)	Supply (mill m^3/annum)	Recipient	Method of delivery
			Mines	
		57	Irrigation users along Groot Letaba River downstream of Fanie Botha dam	Pumped directly from river
		48.2		Diverted from river and conveyed in Letaba Noord, N & N and Masalal canals
Magoboya Ramadike Dam	2.8	1.3	Domestic users in numerous villages in the Naphuno 1 district of Lebowa	From purification works near dam through two pipelines
Middle Letaba and Hudson Ntsanwisi Dams	184.2 24.2	1.1	Domestic	Water purified at Hudson Ntsanwisi dam and conveyed in pipelines to supply numerous villages
			Irrigation	Canal links Middle Letaba Dam with Hudson Ntsanwisi Dam for irrigation
Luvuvhu River		0.8	Domestic needs in Malamulele district	Extensive pipe network
Vondo Dam		<0.1	Village 30 km north-west of Giyani	

2.3.3.2.3 Mines

The following minerals are the main economically viable minerals:

- Gold
- Antimony
- Beryllium
- Zinc
- corundum
- Barites
- Magnesite
- Nickel
- Kyanite

Of these minerals, gold is the most economically viable mineral. It is mined in the Klein Letaba Gold Field where there are six operating gold mines. **Table 2.7** lists the operating mines and prospective mines in the area.

Table 2.7: Gold mines in Klein Letaba Gold Field

Operating mines	Prospective mines
Fumani Gold Mine	Horseshoe
New Union Gold Mine	Roodepoort
Lois Moore Gold Mine	Ophir
Klein Letaba Gold Mine	Courtenay
Franke Gold Mine	Nebulous
Birthday Gold Mine	Gemsbok
	Ben d'or
	Ennis

2.3.3.2.4 Agriculture

At least 11% of the total area is used for agriculture (153 000 ha). Land is used for forestry, tea plantations, sub-tropical crops, grazing and ranching, amongst other uses. **Table 2.8** is a reproduced table showing the area of land used for the different agricultural practices.

Table 2.8: Area of land under different agricultural practices

Type of Cultivation	Area (m^2)	% of cultivated area	% of catchment
Irrigation	34 000	22	2.5
Dry land	22 600	15	1.5
Grazing	96 000	63	7.0
Total	152 600	100	11.0

2.3.3.2.5 Afforestation

In areas where the mean annual precipitation is greater than approximately 900 mm, exotic forests are present. The distribution of exotic forests is:

- RSA 44 000 ha
- Venda 400 ha
- Lebowa 3 200 ha
- Gazankulu 100 ha

2.3.3.2.6 Recreation and Nature Conservation

The Kruger National Park and the Escarpment are two major tourist attractions in the area. The following are existing recreational areas:

- 5 public nature reserves
- 5 private nature reserves
- 9 forest reserves
- 1 botanical reserve
- 1 wilderness area

In addition, three public reserves are proposed which are associated with new dams, namely:

1. Middle Letaba Dam Reserve

2. Hudson Ntsanwisi Dam Pleasure Resort and Reserve
3. Thabina Dam Reserve

2.3.3.3 **Land use potential**

2.3.3.3.1 Mining

The potential for mining of coal, corundum, antimony and Gold is considered high in the catchment. Agricultural development potential Agriculture in the Letaba-Shingwedzi catchment forms the basis of the economy and there is considerable development potential based on the following:

- Primary industrial development is not likely to occur in the foreseeable future due to the distance of this area from major consumer areas and sources of basic raw materials.
- Agriculture is the chief way in which the people of the national states can make a viable living.
- Agricultural development can create employment opportunities either in primary production, or in the processing industries.
- There is still high potential land available, for both irrigable and dry- land agriculture, for agricultural expansion.
- Grazing and stock raising

Low veld quality and low carrying capacities characterise most of the area and it is already overgrazed. There is little potential for extensive development. However, there is probably high potential for Government-subsidised or private intensive schemes such as feed lot beef production, chicken farms

2.3.3.3.2 Fish Farming

Commercial fish production has an extremely potential for development, both in existing dams and in future schemes since water supply is likely to be a limiting factor for the expansion of irrigation agriculture and stock raising.

2.3.3.3.3 Afforestation

The potential for further forest development in the Letaba-Shingwedzi catchment is about 10 000 ha. This is based on a review of areas having suitable climatic and pedogenic conditions to support viable forest operations. The area suitable for development is mainly located downstream of Ebenezer Dam, with 3 000 ha located the Klein Letaba catchment and 1 000 ha located upstream of Fanie Botha Dam.

2.3.3.3.4 Recreation and nature conservation

The study area has a high potential for recreation development due to the following factors:

- Intrinsic scenic beauty;
- Increased pressure on facilities near the PWV area;
- Increased population within and nearby the study area;
- Increased leisure time and spending power of the public.

The main areas with development potential for tourism extends from Duiwelskloof in the north, southwards along the escarpment and the area to the southern catchment boundary. The other core development area is located in the vicinity of the Merensky Nature Reserve. The proximity of several private nature reserves to the south lends the possibility of extending the Nature Reserve area to the north and south.

New dam schemes could benefit recreation-related developments considerably, as has been demonstrated by the proposed new nature reserves associated with the Middle Letaba, Hudson Ntsanwisi and Thabina dams.

The growing demand for water is putting increased pressure on existing supplies. The quantity of water in a river and its flow regime are largely controlled by land-use activities within the catchment. The need to control land use is paramount in the long term management of water resources. The study recommended that several conservation areas should be established in the upper catchments of all the rivers in the study area in order to control land use.

Increased exploitation of water resources in the catchment for both consumptive and non-consumptive uses will lead to a decrease in river flow in the Kruger National Park, even if the water schemes are carefully controlled. The study concluded that the management of the river flows in the KNP was not acceptable and therefore the water needs of nature conservation should play a major role in limiting future water resource development.

2.3.4 Annexure 2: Demography

Report Title: WATER RESOURCES PLANNING OF THE LETABA RIVER BASIN STUDY OF DEVELOPMENT POTENTIAL AND MANAGEMENT OF THE WATER RESOURCES – Annexure 2 – Demography. Report No. PB 800/00/0490.Department of Water Affairs.Prepared by SRK, 1990.

Annexure 2 which provides demography of the Letaba River Basin Study, produced in 1990, entailed:

- Providing a historical overview of the population in terms of size, growth rate and settlement pattern
- Population statistics in terms of: urban, semi-urban, and rural; on sub-catchment boundaries; and on national boundaries
- A 25-year horizon (1985-2010), scenarios of future population size, growth rates and anticipated settlement patterns
- A present and possible future hierarchy of towns in the catchment area

The data sources utilised include: Central Statistical Services (RSA), Development Bank of Southern Africa, Republic of Venda (Department of Statistics), research from Plankonsult, and the Tzaneen Guide Plan.

The study emphasised that within South Africa various data sources exist which are not comparable with one another due to differences in the purpose and method of enumeration. The solution identified was to make use of the most comprehensive source of data, namely the census.

To provide a meaningful analysis of the population, the population was divided into two main components, namely: those residing within South Africa, and those within the national states. This was due to the differing characteristics between the two components. The RSA community is described as a consumer or ‘developed society’ with generally higher per capita incomes and high expenditure patterns, while the national states inhabitants are more of a ‘developing society’ with low per capita incomes and expenditure on consumer goods and services. The RSA has maintained a much lower birth rate; most of the industrial activities take place in the RSA, and the standard of infrastructure differ considerably between the RSA and the national states. Consequently considerable differences in water consumption patterns can be expected.

The population is further sub-divided into twelve sub-catchments. The figures for both historical and future population are provided for each sub catchment under the headings of developed and developing population (and further into urban and rural) and are later also split according to the states forming part of the sub catchment. Detailed definitions for the terminology utilised is also provided.

The current population density per magisterial district in 1985 is also provided. The total population was 760 996 people in a total area of 35 932 km^2 with an average density of 21 persons per km^2. The density was noted as remarkably higher in the southern part of the study area, due to closer proximity to job opportunities and transport infrastructure. On the other hand, the densities in the districts containing predominantly developed populations are very low, which is mainly attributed to extensive farming activities and a small number of urban concentrations.

Future population assumptions included that semi-urban population will grow at the same rate as the rural population and general growth trends in the study area which are higher than for RSA will continue. This was in the main due to Tzaneen growing in importance as the main service centre and towns such as Giyani and Nkowankowa steadily attracting industrial and other commercial activities.

Three future population scenarios were developed: a low growth rate (similar to national average over the period 1980 – 1985), a probable growth rate reflecting a decline in present growth rates in the area, and a high growth rate which represents a continuation of present trends. The growth rates used in forecasting the population in the study area are shown in **Table 2.9**.

Table 2.9: Population forecast in the Letaba River basin (1990)

Period and scenario	Developed population		Developing population		
	Urban	Rural	Urban	Semi-urban	Rural
1985 to 1990					
Low	3.0	1.9	4.7	2.9	2.9
Probable	4.7	2.8	5.8	3.8	3.8
High	5.5	3.0	6.7	5.4	5.4
1990 -2010					
Low	2.5	1.1	3.7	2.0	2.0
Probable	3.6	1.4	4.5	2.2	2.2
High	4.8	1.5	5.6	2.4	2.4

Using these growth rates, the population for the different sub-catchments were estimated for 1990 and 2010 as shown in **Table 2.10**.

Table 2.10: Population estimation for 1990 and 2010 (1990)

Target year	Urban	Semi-urban	Rural	Total
1990	60 656	433 629	432 215	926 500
2010	174 515	699 179	693 009	1 566 703

The study expected the urban population to almost treble from 1990 to 2010. The growth is noted to mostly take place in the towns of the developing community with drastic increase in demands for infrastructure. Similarly the semi-urban population was also expected to increase by almost 266000 persons which also implies increased demand for infrastructure and significant increases in water consumption. It was also expected that a large proportion of the population given as rural will actually fall in the semi-urban group fairly soon.

The study further determined a hierarchy for all the towns and semi-urban settlements. The formulation used was a sum of government authorities in the town (divided by government authorities in the region), plus shops in town (divided by shops in the region), plus schools (divided by schools), churches, hospitals and clinics, hotels, and other services, etc. This index produced the following hierarchy of towns: Tzaneen, Duiwelskloof, Giyani, Nkowakowa, Ga-Kgapane, Haenertsburg, Malamulele, Letsitele, Lenyenye, Senwanmakgope, and Lulekani. Based on estimating the future hierarchy of the towns, all semi-urban establishments were included in the analysis. The validity of the estimation was based on the assumption that the towns/settlements will develop to the point where the availability of services correlates with the population size. If this were to happen, the study notes that the first five positions will be taken up by semi-urban settlements in 1990 and the first formal town in the hierarchy will be Giyani. Tzaneen is expected, according to the estimate, to drop to the 14th position. In the year 2010, Giyani occupies the first position and Tzaneen the 8th.

The study concludes with:

- The developed population is growing considerably higher than the average growth rate for the rest of the country with growth rates of 4.4% per annum compared to 1.7% for the country and 5.8% for the developing community compared to 2.3% for the country
- A lack of stability in population settlement patterns is noted with a considerable degree of internal migration
- External influences, such as Mozambique refugees, influence the population growth rate
- Urbanisation is expected to accelerate
- The 2010 population is expected to increase to 1.53 million, i.e. at an average growth rate of 2.6% over the 20 year period

2.3.5 Annexure 3: Existing Dams and Major control works

Report Title: WATER RESOURCES PLANNING OF THE LETABA RIVER BASIN – STUDY OF DEVELOPMENT POTENTIAL AND MANAGEMENT OF THE WATER RESOURCES: Annexure 3 – Existing Dams and Major Water Control Works. Report No. PB 800/00/0590.Department of Water Affairs in association with the Republic of Venda, Lebowa and Gazankulu.Prepared by Steffen, Robertson and Kirsten Inc. Consulting Engineers (1990).

This report identifies and describes the existing dams and major water control works within the Letaba River and Shingwedzi River catchments. The main objective of the report is to provide detailed information of all the major dams and major water control works in the study area in order to facilitate the process of making adjustments to the management and control of the dams and thus improve water availability. Information provided in the report includes height-storage-surface area relationships, yield, spillway details; outlet works details, catchment area, mean annual precipitation and evaporation.

The first major water works were constructed in the study area in the 1950's and several hundred more dams have since been commissioned. At least 21 of these structures have a height greater than 12 m and are categorised as major water works.

Data sheets were prepared for every major dam and all the other water control structures which were identified and considered of importance in terms of the Letaba-Shingwedzi River Basin study. These data sheets are presented in alphabetical order as Appendix A in the report. Each data sheet contains details of the structure's location, ownership, control, design, hydrology and were available a table of the height-area-capacity characterises of the basin. Additional information provided includes a locality map, a schematic diagram showing the distribution network, water users, and layout plans of the structure, cross sections and outlet works.

Details of the 21 major existing dams in the study area are summarised in the report as reproduced below as **Table 2.11**.

Table 2.11: Reproduction of Table 3.1: Major Existing Dams

Dam Name	Capacity		Yield at 10% Risk (x 10^6 m^3/a)	Dam Height (m)	Ownership
	Gross Storage (x 10^6 m^3)	% Virgin MAR			
Altenzur	0.9	30	0	20	Private
Damara	0.6	10	2	112	Private
Dap Naudé	2.1	18	59	27	Pietersburg Munipality
Duiwelskloof	0.1	25	0	16	Duiwelskloof Municipality
Ebenezer	70.0	125	45	50	DWA
Engelhardt	3.8	1	0	13	KNP
Fanie Botha	159	73	92	50	DWA
Fish Eagle	0.6	?	0	12	Private
Fry	4.8	100	0	21	Private
Hudson Ntsanwisi	24.4	500	0.7	24	Gaz. Dept. of Works
Jachtpad	2.5	23	0	15	Private
Leeudraai	0.25	?	0	13	Private
Lorna Dawn	12.0	280	?	23	Private
Magoboya Ramodike	2.8	13	5.8	50	Lebowa DWA
Magoebaskloof	5.0	15	19.0	37	DWA
Makuleke	13.0	400	1.2	16	Gazankulu DWA
Middle Letaba	184	290	14.0	39	Gazankulu DWA

Dam Name	Capacity		Yield at 10% Risk ($\times 10^6$ m^3/a)	Dam Height (m)	Ownership
	Gross Storage ($\times 10^6$ m^3)	% Virgin MAR			
Pioneer	2.2	147	0.9	12.5	KNP
Van Zyl	2.2	41	0	18	Private
Vergelegen	0.3	Small	0	12.7	DWA
Welgevonden	0.2	18	2.6	15	Private

More than 100 minor dams were identified in the study area and these are listed per sub-catchment in **Table 3.2** in the **Annexure 3** of the report. The report further discusses the existing major dams and minor dams in each of the following sub-catchments:

- Groot Letaba River Catchment Upstream of Fanie Botha Dam
- Letsitele River Catchment
- Groot Letaba River Catchment Downstream of Fanie Botha Dam
- Middle Letaba River Catchment
- Klein Letaba River Catchment
- Molototsi River Catchment
- Shingwedzi River Catchment

The impact of the existing dams on the stream flow characteristics and the scope for further water resources development in each of the above sub-catchments is also discussed in this section of the report.

The following conclusions were made in the report:

- There are 21 existing dams that are categorised as being major in the study area.
- The combined gross storage of the major dams is about 490 million m^3 and is equivalent to about 94% of the virgin MAR.
- The total combined yield of the existing major dams is about 193 million m^3/annum and this is about 80% of the exploitable yield from the study area.

- There are more than 100 existing minor category dams in the study area, which have a combined gross storage capacity of about 40 million m^3.
- The storage capacity of the existing dams in each of the major sub-catchments is as follows:
  - Groot Letaba Upstream of Fanie Botha Dam (230 x 10^6 m^3 = 107% of MAR)
  - Groot Letaba Downstream of Fanie Botha Dam (21 x 10^6 m^3 = 50% of MAR)
  - Letsitele (8 x 10^6 m^3 = 7% of MAR)
  - Molototsi (2 x 10^6 m^3 = 17% of MAR)
  - Middle Letaba (211 x 10^6 m^3 = 336% of MAR)
  - Klein Letaba (25 x 10^6 m^3 = 20% of MAR)
  - Shingwedzi (27 x 10^6 m^3 = 50% of MAR)
- The Letsitele, Molototsi and Klein Letaba catchments are relatively undeveloped.

2.3.6 Annexure 4: Domestic and Industrial Water Usage

Report Title: WATER RESOURCES PLANNING OF THE LETABA RIVER BASIN: Domestic and Industrial Water Usage: Annexure 4. Report Number P.B800/00/0690 The RSA Department of Water Affairs. Prepared by Steffen, Robertson & Kirsten Inc. 1990.

The domestic and industrial water usage was investigated and presented in this report. The following conclusions were made:

- The total combined 1985 domestic, industrial and stock water use was about 25 million m^3/a (includes 6.9 million m^3/a exported to Pietersburg)
- The 1985 water usage in each major sub catchment was:
  Shingwedzi: 1.8 million m^3/a
  Klein Letaba: 3.9 million m^3/a
  Middle Letaba: 1.8 million m^3/a
  Letsitele: 4.6 million m^3/a
  Groot Letaba: 13.2 million m^3/a
- There are several regional water supply schemes transferring water out of the study area:
  Dap Naude Dam and Ebenezer Dam supply Pietersburg and environs (6.9 million m^3/a)
  Direct pumping from the Groot Letaba River to Murchison Gold Mine (1.0 million m^3/a)
  Magoboya Ramadike Dam supplies water to Sedan in Lebowa (0.2 million m^3/a)

- There are several schemes transferring water into the study area:
  Pumping from Luvuvhu River to Malamulele district (0.8 million m^3/a)
  Supply to a single village in Vuwani (Venda) from Vondo Dam (0.1 million m^3/a)
- The domestic and industrial water demand in the study area is expected to increase my 4.6% per annum and the total future (2010) domestic/industrial demand is expected to be about 87 million m^3/a.

It was recommended that:

- Water supply to the domestic/industrial users and selected villages be metered.
- A survey should be undertaken annually or 2-yearly in each of the centres receiving water to establish the number of people served with water and the type of water supply system in use.

2.3.7 Annexure 5: Irrigation

Report Title: WATER RESOURCES PLANNING OF THE LETABA RIVER BASIN STUDY OF DEVELOPMENT POTENTIAL AND MANAGEMENT OF THE WATER RESOURCES – Annexure 5 – Irrigation. Report No. PB 800/00/0790. Department of Water Affairs. Prepared by SRK, 1990.

The total irrigated area (1985) measures about 34 000 ha. These area occur mainly along the Groot Letaba River and its tributaries, the Middel Letaba. Lower Klein Letaba and the Letsitele Rivers. Permanent fruit crops (47%) and vegetable and grain cash crops (53%) are cultivated.

Irrigation application methods used are sprinkler (55% of area), microjet and drip (35%) and flood (10%). Irrigation water requirements are 220 million m^3/annum which equals 70% of all water used in the study area.

The only Government Water Control Area is situated along the Grot Letaba River and Politsi River, upstream of the Fanie Botha Dam. Water Resource development and water use in such areas are regulated in terms of the water act.

Water restrictions of up to 50% were instituted in the Groot Letaba valley during the drought of the 1980's. Economic disaster was avoided by more efficient irrigation such as the installation of microjet system.

2.3.8 Annexure 6: Afforestation

Report Title: WATER RESOURCES PLANNING OF THE LETABA RIVER BASIN STUDY OF DEVELOPMENT POTENTIAL AND MANAGEMENT OF THE WATER RESOURCES – Annexure 6 – Afforestation. Report No. PB 800/00/0890.Department of Water Affairs.Prepared by SRK, 1990.

2.3.8.1 **Introduction**

Indigenous and exotic forests occur in the study area in areas having a mean annual precipitation greater than about 900 mm. Forests are therefore confined mainly to the upper reaches of the Groot Letaba, Letsitele, Middle Letaba and Klein Letaba River catchments .There are no forest areas in the Shingwedzi River catchment. The indigenous forests occur in steep inaccessible ravines and mountainous areas. Exotic forests were established on accessible areas previously covered by veld. Exotic forests comprise mainly pines (Pinus spp) and gum (Eucalyptus).

Indigenous forests cover an area of about 23 000 ha and the exotic forests about 47 000 ha. This amounts to about 1.0% and. 2.0% respectively of the study area. Forests are a major user of water in the study area. Afforestation however makes a positive contribution to the development of the catchment and its inhabitants in that it is a substantial source of revenue, provides work opportunities and reduces soil erosion.

In view of the importance of afforestation in terms of availability of water and the future development of the catchment, various aspects regards to afforestation were investigated. The results of this investigation are given in this chapter and include details regarding distribution of forests, history of forest development, forest water use and forest development potential.

2.3.8.2 Distribution of forests

The afforested areas include:

- the area upstream of Fanie Botha Dam on the Groot Letaba River and includes Dap Naude Dam, Ebenezer Dam and Magoebaskloof Dam catchments,
- the Upper Letsitele River catchment;
- the Upper Thabina River catchment;
- the Upper Middle and Klein Letaba River catchments;
- the Upper Nwanedzi River catchment.

A. <u>Indigenous</u>

The indigenous forests cover an area of 23 000 ha and occur mainly upstream of Fanie Botha Dam, i.e. in the Broederstroom, Helpmekaar and Upper Groot Letaba River catchments. Concentrations of indigenous forests also occur in the Letsitele and Thabina River catchments. A significant percentage of this latter area consists of dense invader bush.

Indigenous forests in the study area occur on relatively poor soils and in many cases in inaccessible ravines and steep mountainous areas. Indigenous forests as a consequence seldom cleared to make the land available for other use. For practical purposes it can be considered that the area of indigenous forest has remained more or less constant for the last 50 years.

B. Exotic Forests

The exotic forests comprise mainly pine and gum plantations. The plantations occur mainly in the upper reaches of the Groot Letaba River, Letsitele, and Middle Letaba River and Klein Letaba River catchments. There are also two small wattle plantations upstream of Ebenezer Dam.

Forest development in the Letaba Basin resulted mainly from the increasing demand for mining timber, pulp and paper timber as well as fuel used in the silicon smelting works near Pietersburg. The first plantations in the Letaba catchment were established by the Department; of Forestry between 1903 and 1911 at Wood bush and De Hoek, located in the Dap Naude Dam and Magoebaskloof Dam catchments. Further plantations were developed by the Department in the 1920's and 1930's. Several Mining Houses and other private individuals also became actively involved with timber production in the 1920's and particularly after 1940’s. At present, about 75% of the afforested area in the study area is privately owned.

The total area covered by exotic forests at present (1986) in the study area is about 47 000 ha. About 44 000 ha (94%) of this area occurs in the RSA. The remainder occurs in the former Venda, Lebowa and Gazankulu. Venda has about 400 ha plantations and woodlots. The plantations occur in the Klein Letaba River catchment. Lebowa has 3 200 ha plantations and wood-lots. About 50% of the area occurs in Bolobedu district and about 50% in Naphuno 1 district. Gazankulu has no large scale planted forests in the study area. There are however, about 150 ha of wood-lots (DBSA).

Table 2.12: Indigenous Forests in the Study Area in the Letaba river Basin (1990)

Sub Catchment	Catchment Area (Ha)	Indigenous Forest Area (Ha)
Dap Naude Dam	1 400	290
Between Ebenezer and Dap Naude Dam	15 600	2 000
Magoebaskloof Dam	6 400	3 400
Between Fanie Botha Dam and Ebenezer Dam and excluding Magoebaskloof Dam	41 800	7 100
Letsitele River excluding Thabina River	25 500	4 950
Thabina River	20 800	2 600
Middle Letaba River catchment includes Koedoes River and Brandboontjies River catchments	180 000	1 900
Klein Letaba River catchment upstream of confluence with Middle Letaba River	109 700	600
Remainder of study area includes Nwanedzi River catchment	1 547 400	300
TOTAL CATCHMENT	**1 948 600**	**23 140**

The areas covered by afforestation in the various sub-catchments for different time periods are given in the table below.

Table 2.13: Exotic Forests in the Study Area

Sub-catchment	Types Of Trees	Catchment Area (Ha)	Area Afforested (Ha)				
			1940's	1950's	1960's	1970's*	1980's
Dap Naude Dam	Predominantly Pine	1 400	1 000	1 000	1 000	1 000	1 000
Between Ebenezer and Dap Naude Dam	Pine, more recently Gum	15 600	-	-	-	7 100	7 500
Magoebaskloof Dam	More than 50% gum	6 400	1 000	1 450	2 200	2 250	2 250
Between Fanie Botha Dam and Ebenezer Dam and excluding Magoebaskloof Dam	Mostly gum, recently cleared 900ha for tea	41 800	-	-	-	-	19 550
Letsitele River excluding Thabina River	Predominantly gum	25 500	-	-	-	3 800	3 800
Thabina River	No Information	20 800	-	-	-	1 200	1 200
Middle Letaba River catchment		180 000	-	-	-	-	5 600
Klein Letaba River catchment upstream of confluence with Middle Letaba River		109 700	-	-	-	-	1 850
Remainder of study area		1 547 400	-	-	-	-	4 500
TOTAL		**1 948 600**	**-**	**-**	**-**		**47 250**

2.3.8.3 Impacts of forests on runoff

It is difficult to quantify water usage theoretically in view of the large number of variables which include climate, vegetation factors, soil factors and catchment physiography. Estimates of water usage are therefore based on empirical formulae, such as the Pitman (1973) and Van der Zel (1975) methods.

Van der Zell Curves were used to estimate the amount of runoff reduction due to afforestation. From the results of this study, it was estimated that exotic forests in the Letaba catchment use about 64 x 10^6 m^3 of water per annum. Indigenous forests use about 37 x 10^6 m^3 of water per annum.

It was also noted from the synthetic flow record generated for each afforested catchment, that the forest had the marginal effect of lagging runoff. Under virgin conditions about 63% of the runoff occurred during the six wet summer months (October to March). Under afforested conditions this was reduced to about 60% with the remainder occurring during the winter months.

2.3.8.4 **Development potential**

An investigation by van der Zel (1981, 1987) has revealed that an additional 10 000 ha has the potential for forest development in the study area. That is, the climatic and pedogenic conditions in that area are suitable to support viable forest operations. From this study it was noted that, although only about 4% of the Letaba River and Shingwedzi River catchments is afforested, about 60% of the afforested area in the study area lies upstream of Fanie Botha Dam. This part of the catchment yields about 47% of the total runoff of the study area and the forests use nearly 25% of this runoff. Afforestation therefore has a significant impact on the water resources of the study area.

2.3.8.5 **Information availability**

Information regarding afforested areas is inadequate. Available information is in the form of 1: 50 000 maps and aerial photographs.

2.3.9 Annexure 7: Ecology Maintenance

This report estimated the water requirements of the aquatic ecosystems in the Letaba and Shingwedzi Rivers. The impact that upstream development would have on the flow regime was also reviewed. All assumptions used to achieve the recommendations are outlined in detail in the report.

2.3.9.1 **Proposed Flow Regimes**

The average annual water requirements for nature conservation along the Shingwedzi River in the Kruger National park is reproduced in **Table 2.14** below.

Table 2.14: Shingwedzi River Average Annual Water Requirements (1990)

Water consumed	Volume of water required ($10^6 m^3$)	
	Scenario A	Scenario B
Humans and animals	1	1
Flow maintenance for fry growth	8	0
Fish spawning and migration	6	6
Evaporation	3	2
Evapotranspiration	10	7
Seepage	5	6
Absolute minimum flow total	33 (60% MAR)*	22 (40% MAR)*
Plus additional flow for maintenance of flora and fauna	16	0
Desired total flow	**49 (89% MAR)**	**22 (40% MAR)**

* It is assumed that floods with a five-year return period would not be materially affected by abstraction. Therefore these percentages should be significantly higher, as the five year return period floods are included in calculation of the MAR.

The average annual water requirements for nature conservation along the Letaba River in the Kruger National park is reproduced in **Table 2.15** below.

Table 2.15: Letaba River average annual water requirements (1990)

Water consumed	Volume of water required (10^6m^3)
Humans and animals	1
Flow maintenance for biota that require currents	16
Fish spawning and migration	27
Evaporation	4
Evapotranspiration	22
Seepage	6
Flushing flows (20 x 10^6m^3 every 3 years and 35 x 10^6m^3 every 5 years)	14
Absolute minimum flow total	90 (13% MAR)*
Plus additional flow for maintenance of flora and fauna	32
Desired total flow	**122 (17% MAR)**

* See footnote to Table 2.14.

2.3.9.2 **Recommendations**

The report identified information needs, research needs and monitoring needs that must be addressed as a matter of urgency.

The information needs include the collection or calculation of aspects broadly listed below:

- Evapotranspiration
- Groundwater
- Baseline checkpoints
- Minimum flows
- Floods

- Scouring and flushing capacities of floods
- Attenuation
- Sediment
- Vegetation
- Winter distribution of large animals in relation to permanent surface water

Research is required to address the following topics:

- Biota of the Shingwedzi River and its tributaries
- Water requirements of Shingwedzi riparian vegetation
- Flows required in Letaba river for fish migrations
- Survival characteristics of fauna after cessation of flow
- Annual temperature/flow relationship of the Letaba river
- Quantities studies of reedbed dynamics
- Biological responses of Letaba River
- Continuing surveillance of Letaba and Shingwedzi rivers after recommendations are implemented.

The above mentioned studies would allow baseline information to be obtained. Thereafter on-going monitoring should be applied on the following aspects:

- Flows
- Water quality
- Piezometric level
- Vegetation
- The effect of managed flow regimes

2.3.9.3 **Consequences of failure to meet flow requirements**

If current water use and abstraction is followed by further development, then the minimum flow requirements cannot be met. The consequences of this are detailed in the report.

2.3.10 Annexure 8: Inter Basin Water Transfer

Report Title:WATER RESOURCES PLANNING OF THE LETABA RIVER BASIN: Inter Basin Water Transfer: Annexure 8. Report Number P.B800/00/1090 The RSA Department of Water Affairs. Prepared by Steffen, Robertson & Kirsten Inc. 1990.

The study report investigated the inter basin water transfers and concluded the following:

- About 11.3 million m^3/a is transferred out of the study area to meet domestic/industrial water requirements in the Olifants River Catchment and in the Pietersburg area.
- About 0.8 million m^3/a is transported into the study for domestic water requirements.
- Several transfer schemes transfer water between sub catchments of the study area. About 2.8 million m^3/a is transferred to meet domestic water needs and about 19.6 million m^3/a to meet irrigation needs.
- Future water transfers out of the basin could amount to 29.5 million m^3/a.
- Future water transfers into the basin could amount to 1.7 million m^3/a.

2.3.11 Annexure 9: Hydrology: Gauge Station Details

Report Title: WATER RESOURCES PLANNING OF THE LETABA RIVER BASIN STUDY OF DEVELOPMENT POTENTIAL AND MANAGEMENT OF THE WATER RESOURCES – Annexure 9 – Hydrology: Gauge Station Details. Report No. PB 800/00/1190.Department of Water Affairs.Prepared by SRK, 1990.

2.3.11.1 **Introduction**

Surface water is a scarce commodity in the Letaba River Basin and is likely to be a major limiting factor for the development of the region. It is therefore essential to have information regarding aspects such as the extent of water availability, variability of runoff with time and river flow abstractions. This information is obtained through the process of river flow monitoring.

An extensive river flow monitoring network comprising 37 stations has been developed in the Letaba River Basin, details of which are given in this report. This report also examines what is required of a gauging network, how the existing network fulfils these needs and considers possible improvements to the existing network.

2.3.11.2 **Location and details**

There are 37 gauging stations located in the Letaba Basin and their position is indicated on a map. These gauging stations show a distinct spatial pattern. The majority of structures are located in the

Upper Groot Letaba River. There is a lack of structures on the Klein Letaba and Middle Letaba Rivers and also along the lower reaches of the Groot Letaba River. The network of gauging stations on the Shingwedzi River is more evenly distributed, but these gauges have only been installed recently and thus record lengths tend to be short.

A list of the 37 gauging stations as well as primary details is provided in the report. Details given include station name and number, location, type of data recorded and period of record. A comprehensive data sheet of each of the gauging stations as well as a locality map, section details and recorded flow data is also provided.

In order to gauge the usefulness of anyone station, it is necessary to focus on the data available from these structures. The major criterion available to inspection is the length of available record. Information on data accuracy is also considered to be an essential criterion in the evaluation of that gauging station's effectively. The third criterion used for the evaluation of these gauging stations is the percentage of time the gauge has been exceeded. A scoring system was developed to rate the station's data with.

From the data available, none of the gauging stations were considered to have a "very good" score. This is partially due to the lack of information available on the quality of the data. As more information becomes available, so should the overall scores of stations increase. Only 7 structures were evaluated as being of a "good" standard, and 3 were classed as "fair" and the remainder as "poor". The evaluation results are provided in the table below. 50% of the "good" gauging stations are located in the Upper Groot Letaba River reaches. A further 25% are along the middle reaches of the Groot Letaba River. If the "fair" gauging stations are also studied, these all occur in the Upper Groot Letha River area.

Table 2.16:Flow gauging data availability that rated fair to good

Station	Period of Record	Missing Data (Yrs)	Longest Continuous Record (Yrs)	Gaps in Data (%)	Accuracy %	Breakdowns %of time	% Time Exceeded	Evaluation
B8M01	1930·1964	9.4	17	29	12-17	29	15-22	13
B8M04	1948-1960	4.6	13	10	10	No info	0	23
B8M05	1948-1956	-	8	3	No info	No info	0	14
B8M08	1959-1987	3	26	11-38	8-20	No info	13-22	16
B8M09	1960-1987	-	26	6	10	No info	0.3-5	24
B8M10	1960-1987	-	26	11/4	8-12	No info	8	22
B8M11	1960-1987	6	12	23	8-12	no info	0-1	23
B8M14	1968-1987	-	18	a	5-10	No info	1	23
B8M17	1979-1987	-	8	16	15	No info	0	18
B9M01	1960-1987	10	10	16-37	15	No info	0	21

EVALUATION SCORES:

>25 - Very good

18 - 25 - Good

13-17 - Fair

<13 - Poor

2.3.11.3 **Recommendation for the monitoring network**

From the results of this study it was recommended that flow gauging stations be established:

- in the upper Klein Letaba river reach
- at the confluence of the Klein Letaba and Middle Letaba Rivers
- on the Middle Letaba River
- on the lower Koedoes River
- on the upper Brandboontjies River
- in the upper Letsitele River valley
- on the Molototsi River.

The following existing stations are improved:

- B8M08 (Letaba Ranch)
- B8M10 (Mohlabas Location)
- B8Mll (Shingwedzi/Letaba Rd.)
- B8Ml8 (Engelhardt Dam)
- B8R07 (Middle Letaba Dam)

It was also recommended that river abstractions be monitored.

2.3.12 Annexure 10: Hydrology: Catchment Model Calibration

Report Title: WATER RESOURCES PLANNING OF THE LETABA RIVER BASIN STUDY OF DEVELOPMENT POTENTIAL AND MANAGEMENT OF THE WATER RESOURCES – Annexure 10 – Hydrology: Catchment Model Calibration. Report No. PB 800/00/1290.Department of Water Affairs.Prepared by SRK, 1990.

2.3.12.1 **Introduction**

This report gives details of the catchment; model and it's method of application to the study area. Details include an assessment of its input data, i.e. distribution of monthly rainfall, mean monthly evaporation, and abstractions for domestic, industrial and agricultural use. A description of application of the model, to the study area includes the process of calibration. This involves the division of the study area into zones containing similar runoff characteristics, the selection of gauged catchment representative of conditions in each zone; and the adjustment of parameters controlling the functions of the model. The summary of results and a discussion of problems encountered in the calibration are followed by recommendations emanating from the work carried out in this section of the study.

2.3.12.2 **Assessment of input data**

A. <u>Rainfall</u>

There are approximately 120 rainfall stations with records varying in length from 3 to 60 years in the study area. 75% of these stations are situated to the west of the Ritavi, Bolobedu and Vuwani district borders, and the remaining 25% are spread out along the Groot Letaba and Shingwedzi rivers. Approximately 30 stations have been in operation for periods longer than 50 years and approximately 53 stations have been in operation for longer than 30 years. Stations having long records tend to exist mainly in the south-western region of the study area. It should also be noted that only 52 stations were still recording rainfall data in 1987. MAP for catchments throughout the study area has been determined from a map showing lines of equal precipitation (rainfall isohyet map). Catchment monthly rainfall patterns were calculated from a selection of rainfall stations within a particular catchment or at least close to it. Periods of missing data were patched. The patching procedure involved the selection of stations surrounding the station with missing data. Regression techniques are then applied to guess the missing values.

B. <u>Observed Runoff</u>

The nature of the nine stations which have continuous records of greater than 15 years is such, that three contain periods of gauge exceedance for more than 10% of their record length, and four contain periods of missing data for more than 10% of their record length. Their error in measurement; ranges from 0 to 20%. Therefore, only three structures in the study area provide a continuous runoff record of greater than 15 years in length, and in which less than 10% of data is uncertain due to gauge exceedance or malfunction. Two of these structures are dams. The stations are B8M14, B8ROl and B8R03.

It is evident that all three of the above mentioned structures are located upstream of Fanie Botha Dam, and that in general gauging structures are located in the upper Groot Letaba River and are lacking in the downstream reaches of the Groot Letaba and the whole of the Klein Letaba system. The Shingwedzi catchment has a much more evenly distributed gauging network; although gauges have only recently been installed and records were not available.

If one relaxes the requirement for a 15 year observed record in favour of a 10 year record the distribution of the twelve structures having continuous runoff records of greater than 10 years, is again restricted mainly to the upper Groot Letaba River The three exceptions being B8M08, B8M11 and B9M01, which are located on the lower Groot Letaba, Tsende and Shisha Rivers, respectively.

After the division of the study area into runoff zones it was evident that not all runoff regimes in the study area were adequately monitored. It seems that whilst perennial rivers have been purposely gauged, drier rivers are gauged only where the requirement for a structure has been to serve another purpose. Such as impoundments or river diversion for irrigation or ecology. Therefore, the monitoring system as a whole is geared towards the assessment of water resources in the wetter areas of the catchment. Whilst neglecting the fact that measurement of periods of low flow in the drier areas, can serve to indicate the lack of water resources in those areas.

C. Evaporation

Six stations record evaporation in the Letaba catchment, and one station in the Shingwedzi catchment. Five of the seven stations are located at or upstream of Tzaneen and the Fanie Botha Darn. The remaining two are the Letsitele and Shingwedzi stations, which are situated close to the river flow gauging stations B8Ml0 and B9M01, respectively. There are no official facilities recording evaporation in the Klein Letaba catchment or lower Groot Letaba catchment. Evaporation records range from 9 years to 27 years. Records are reliable and complete with the exception of Letsitele, Fanie Botha Dam and Dap Naude Dam, which have significant periods of missing data. The recorded information is considered unsuitable for use in the model in view of its sparcity. Evaporation input to the model was therefore derived from the maps of mean monthly Symons pan evaporation.

D. Domestic, Industrial and Agricultural Water Usage

Information regarding abstractions for domestic, industrial, irrigation, afforestation and other users was obtained from various sources. This information has been analysed to yield monthly or annual water abstractions from each of the calibration catchments.

2.3.12.3 **The Hydrological Model**

The Pitman model is a physically based lumped mathematical model, requiring an input of monthly rainfall and evaporation to generate a simulated time series of monthly runoff. A detailed account of its structure is given in Pitman (1973). Essentially the model attempts to route rainfall to runoff through storages of interception and soil moisture, whilst deducting losses caused by the processes of evaporation and transpiration. A detailed description of the model's working is then provided.

2.3.12.4 **Calibration of the model**

The purpose of the model is to generate synthetic monthly runoffs at various locations within the study area. This would be achieved through a process of calibration, which involves the adjustment of model parameters to achieve a generated sequence of runoffs similar in character to those of an observed record. The choice of runoff zones and their catchments as well as the model calibration parameters and the method of calibration were discussed in detail.

A. Runoff records used

Having identified the catchments to be used in the calibration procedure, an examination of the observed river flow records was made River flow gauging station B9M01 (Shisha catchment) contains two periods of record. The first from 1960 - 1970 and the second from 1980 - 1988. River flow was not recorded during the period 1970 to 1980. Although the available record contains no gauging exeedances, 16% of months contain missing data. Accuracy of measurement was not established. This catchment lies entirely in the KNP and therefore no catchment development has taken place. In view of the relatively short period of continuous record available and taking cognizance of the need to utilize as much of the available record as possible, two periods of record were adopted for calibration purposes, i.e. 1960 -71. and 1980 - 87. Unfortunately the two periods of available record occurred during relatively dry years.

The record at station B8M11 (Tsende) also contains two periods of record, from 1960 - 1973 and from 1979 - 1988. River flow was not recorded for the period 1973 to 1979. Gauge exceedance occurred 1% of months on record and missing data occurred in 4% of months. Accuracy of measurement is estimated to be between 8 - 12%. However, according to the DWA river flow schedules, the weir was reported to be leaking up to 1973, although no mention of this is made in the DWA assessment of the various flow gauging stations. This catchment is also located entirely within the KNP and therefore no catchment development has taken place. Two periods of record were adopted for calibration purposes, i.e. 1960 - 71 and 1980 - 87. Again, the two periods of available record occurred during relatively dry years.

Station B8R06 (Dap Naude Dam) has a 4 year (1971 - 85) period of reservoir levels and releases from which the inflow record has been calculated. However, its reliability for the period 1971 to 1977 is poor due to uncertainties in the values of reservoir releases. The history of upstream catchment development is known and could therefore be incorporated into the Pitman Model. Despite some uncertainties, it was decided to use the full period of available record for calibration of the model, as this included both a cycle of wet am dry periods of rainfall.

Station B8R01 (Ebenezer Dam) has a 28 year (1960 - 88) record of reservoir levels and releases from which the inflow record has been calculated. Its accuracy is considered to be good. The history of upstream development has been adequately documented. However, due to the presence of Dap Naude Dam in the upper reaches of the Ebenezer Dam catchment, the record used for calibration was limited to the period of observed records common to both dams, i.e. 1971 to 1985. This constraint was necessary because the spillage from Dap Naude Dam would need to be taken into account; when calibrating Ebenezer Dam. Again the observed record contained a cycle of wet and dry period of rainfall.

Station B8R03 (Magoebaskloof Dam) has a 15 year (1971 - 86) record of reservoir levels and releases. However, 7% of months have missing data and 2% have inaccurate data due to uncertainties in measurements. Upstream catchment development has been adequately recorded. The 14 year period of record (1971 - 85) was used in the calibration procedure with patching of missing records. Again the available record covered a cycle of both wet and dry periods of rainfall.

Station B8M10 (Letsitele River) has a 28 year record of river levels for the period 1960 to 1988. 11% of months contain missing data and 8% of river levels have exceeded the gauge capacity. The relationship between river level and flow is such that estimates of flow will have an accuracy of 5%. After inspection of the record, it was decided to adopt the period 1974 to 1985 for the calibration, as this contained the most reliable period of flow which included both wet and dry periods of rainfall.

Station B8R07 (Middle Letaba Dam) has a four year (1984 - 1988) record of water levels and releases. Releases have not been accurately gauged and therefore the accuracy of the calculated inflow record is questionable (Eksteen et al, 1988). Upstream catchment development has been established. All four years of data were used in the calibration procedure. Unfortunately this period of record occurred during a relatively dry period of rainfall.

B. Model input data

Rainfall and evaporation are the two primary inputs to the model, and it is important that this data be representative of conditions throughout the catchment for which runoff is to be generated. Also required is the extent of catchment development in terms of afforestation and irrigation.

In view of the sensitivity of the model to changes in MAP, the production of a mean annual rainfall map using all available information was felt to be an important requirement. Evaporation records were found to be reasonably good, but their position was again unevenly distributed over the study area. This, catchment evaporation was measured from small scale maps of isopleths (lines of equal evaporation) and adjusted. Potential evaporation is considered to be less variable over the flatter areas in the eastern sector of the study area, and therefore the lack of recorded data in these areas was not of great significance in causing errors in the generation of runoff.

The third input required by the model is the extent of catchment development. Areas under afforestation were defined with reasonable accuracy, although there were difficulties in differentiating between actual planted areas, indigenous bush, service roads and firebreaks. Records of development were available in most areas, and an idea of increases in afforested area could be determined.

Irrigation areas proved more difficult to define due to being a less obvious feature on aerial photographs and maps. A further difficulty was in determining the source of irrigation water, be it from groundwater or surface water. The relevant information was obtained from reports, discussions and. questionnaires. Together with the area under irrigation, details of management practices and months in which irrigation took place were required. Where irrigation requirements were abstracted by a diversion weir and canal, the volume was usually recorded and could therefore be accounted for directly and independently of the model. In other cases a routine in the catchment model was used to account for irrigation abstractions.

2.3.12.5 **Results of the calibration**

Calibration of the Pitman Model was carried out on seven catchments covering four runoff zones. No information conducive to the calibration of the model for runoff zone 3 could be found. The results from the calibration of the model in each of the four runoff zones (1, 2, 4 and 5) were provided. A graphical representation of the errors in the agreement between river indices, seasonal distribution of flows, yield-storage curves and time series of observed and generated runoff are also provided.

The results showed that MAR is overestimated by 20% at B8R01, overestimated by <5% at B8R03 and underestimated by 35% at B8R06 in zone 5. MAR is underestimated by 10% in zone 4 (as indicated by the results of the Letsitele), and overestimated by >50% in zones 1 and 2 (if extreme event excluded). The variability of flow as measured by the coefficient of variation is overestimated by >5% at B8R01, overestimated by 10% at B8R03 and overestimated by more than 50% at B8R06 in zone 5. The coefficient of variation in zone 4 is overestimated by 10% and overestimated by 20% in zone 1 (if extreme event excluded) and underestimated by 50% in zone 2.

The yield-storage relationship in zone 5 at B8R01 is underestimated by 5%, at B8R03 it is underestimated by 5% and at B8R06 it is underestimated by 3O%. In zone 4 at B8M10 it is underestimated by 5% and at B8R07 it is underestimated by 50%. Finally, in zone 1 it is underestimated by between 15 and 50%, and in zone 2 it is underestimated by between 5 and 25%, depending on the period of the record.

Detailed discussion followed on the problems related to the calibration in terms of input data and deficiency of observed data as well as summaries of the calibration parameters. There were also discussions related to the model's irrigation routine - the volume of modelled irrigation demand did not agree with the reported water use by farmers in the study area. The model tended to underestimate irrigation use quite drastically. Parameters of the catchments were regionalized based on the calibration results for the different runoff zones.

2.3.12.6 **Conclusions**

Rainfall station records in the Middle and lower reaches of the Klein Letaba, whole of the Nwanedzi, Molototsi and Shingwedzi catchments are inadequate for use in the Pitman Model. There are too few stations and existing records are too short. The distribution of evaporation stations is too concentrated in the Upper Groot Letaba region. There is a need for stations in the. Middle and Klein Letaba area and also along the lower Groot Letaba and Letaba River areas.

There is a need for a more comprehensive record of catchment development such as irrigation and afforestation, both in terms of its areal extent and management. With the exception of those areas upstream of Fanie Botha Dam, the existing river flow gauging network is inadequate for the purposes of evaluating surface water resources. Either by direct analysis of observed records or through their indirect use in calibrating a catchment model. Existing river flow records are either too short or unreliable.

2.3.12.7 **Recommendation**

Recommendation emanating from this part of the Letaba Basin study is mainly in terms of improvement to the existing monitoring network for hydrological and climatological data. The recommendations are for:

River flow Gauging Network:

- The construction of 4 purpose built structures
- The reinstatement and improvement of 2 former gauging stations
- Increase the gauge capacity of 2 gauging stations
- Improve the management of data recording at 6 gauging stations
- Upgrade structures at 6 existing stations

Rainfall Station Network

- Establish 3 new rainfall stations
- Reinstate 2 former rainfall stations

Evaporation station Network.

- Establish 4 new evaporation stations
- Reinstate 1 farmer evaporation station

Catchment Modelling

- Improve and maintain database of catchment; development.
- Research the modelling of different irrigation and afforestation management practises.
- Increase the application of remote sensing in the provision of catchment data for water-resource studies.

2.3.13 Annexure 11: Hydrology: Flow Generation

Report Title: WATER RESOURCES PLANNING OF THE LETABA RIVER BASIN STUDY OF DEVELOPMENT POTENTIAL AND MANAGEMENT OF THE WATER RESOURCES – Annexure 9 – Hydrology: Flow Generation. Report No. PB 800/00/1390.Department of Water Affairs.Prepared by SRK, 1990.

2.3.13.1 **Introduction**

The aim of this chapter is the determination of how much water is available in natural streams and. what proportion is usable. The availability of water's defined as the maximum amount of runoff obtainable from the catchment. This would occur from a catchment in an undeveloped (virgin) state. The volume of water which can effectively be drawn from the catchment i.e. the usable proportion is considered to be a function of land use in the catchment such as afforestation and irrigation, and the variability and seasonality of stream flow .Stream flow variability is also modified by abstractions for domestic and industrial water use. Usable water is therefore the amount of runoff occurring from a developed catchment.

This section describes the surface water resource in time and space and gives details of the stream flow characteristics under the following catchment conditions:

- undeveloped (virgin)
- afforested
- present development, accounting for water use by domestic, industrial and irrigation sectors.

The evaluation of surface water resources could not be achieved through the use of currently available observed river flow data. Recourse to the generation of synthetic river flow records using a mathematical catchment model was therefore necessary. In view of its relatively simple data requirements and the success with which it has been used throughout South Africa, the flow generation model chosen for use in this study was that of Pitman (1981). A final discussion will contain information regarding the impact of catchment development on the amount, of usable water available. Also presented will be information for use in formulating development proposals for the study area.

2.3.13.2 **Methodology**

The period for which synthetic runoff records were generated was from 1933 to 1987. This period of record was available for most rainfall stations in the study area and included a balance of wet and dry periods of rainfall. Runoff records have been generated at all confluences of major rivers, all sites of major water works and most nature reserve, national park, homeland and international boundaries. Points at which runoff has been generated were identified by a Department of Water Affairs numbering system, based on what may be termed tertiary catchments.

Information regarding the areal extent and management of catchment development, such as afforestation and irrigation, is a required input for the generation of runoff records for developed and undeveloped catchment conditions. Also required is information on direct abstractions from river channels and reservoirs, together with any significant return flow. Afforested areas are reasonably well documented but are not as well defined due to its diffuse nature. Direct abstractions for irrigation were not always monitored. The source of irrigation water often alternated between surface and groundwater sources depending on the time of year and management practise. Domestic and industrial water abstractions were also not always monitored.

Underestimates of irrigation and afforested areas together with point abstractions would, lead to an overestimate of usable water. However the errors due to inaccuracies in this respect were considered to be lost when compared with the 10% error sometimes experienced in modelling MAR and similar errors in modelling the yield-storage characteristics of a catchment. Errors included by a lack of information on water use, will however have a significant impact on the accuracy of information regarding periods of low flow. Detailed land-use, water abstraction, dam and other development data is provided in appendices of the report.

The method of generating sequences of monthly runoffs was through the use of Pitman monthly mathematical catchment model. The study area has been divided into three runoff zones, i.e. humid, intermediate and semi-arid. Calibration parameters were derived for each zone.

2.3.13.3 **Flow generation and results**

Flow generation was carried out for three catchment conditions. The first assumed no catchment development in terms of irrigation or afforestation (virgin runoff conditions), the second assumed only catchment development in terms of afforestation (afforested runoff conditions), and the third assumed catchment development in terms of afforestation, irrigation, and domestic and industrial water use abstracted from reservoirs (developed runoff). Output was produced in the form of a time series of monthly runoff.

Several summaries, maps and graphs were produced on the simulated flows which included:

- mean annual runoffs for virgin and developed catchment conditions,
- relative runoff contribution to the total runoff at the study area outlet,
- expected runoff in the major rivers of the study area,
- summaries of additional statistics of runoff under virgin catchment conditions at major dams and catchment outlets,
- water use by irrigation and afforestation,
- curves of MAP/MAR,
- flow duration curves of runoff for undeveloped catchment conditions at a selection of points throughout the study area,
- deficient-flow-duration frequency (DDF) analyses on a sample of catchment to achieve regional DDF plots for the humid, intermediate and semi-arid zones,
- coaxial plot of Draft-Storage Frequency-Time of Year (CSFT),
- relationship between catchment MAP and catchment Runoff, and

- the seasonal variability of virgin runoff that is expected in each of the three runoff zones.

A summary of the results are as follow:

- Highest virgin runoffs occur upstream of the Fanie Botha Dam in the Groot Letaba catchment where runoff depths of over 800mm occur
- Lowest virgin runoffs occur close to the Mozambique border where runoff depths are less than 5 mm.
- The virgin mean annual runoff in the study area is as follows:
    - Outlet of the Letaba catchment on the Mozambique border 556 x $10m^3$ per year.
    - Outlet of the Shingwedzi catchment on the Mozambique border 57 x $10m^3$ per year.
    - Western border of the KNP on the Groot Letaba (including the Klein Letaba) is 537 x $10m^3$ per year.
    - Western border of the KNP on the Shingwedzi 6 x $10m^3$ per year, and on the Phugwane it is 4 x $10m^3$ per year and on the Mphongolo it is 7 x $10m^3$ per year.
    - Groot Letaba River upstream of Klein Letaba River 420 x $10m^3$ per year
    - Klein Letaba River upstream of Groot Letaba River confluence 125 x $10m^3$ per year.
- 75% of virgin runoff reaching the Mozambique border is generated by the Groot Letaba River.
- 47% of virgin runoff reaching the Mozambique border is generated by the Groot Letaba upstream of the Fanie Botha Dam.
- 17% of virgin runoff reaching the Mozambique border is generated by the Letsitele/Thabina catchment.
- 23% of virgin runoff reaching the Mozambique border is generated by the Klein Letaba River.
- Afforestation has reduced the runoff reaching the KNP via the Letaba River by 15% and via the Klein Letaba by 3%.
- There is no afforestation in the Shingwedzi catchment.
- The combined effect of irrigation, afforestation and the construction of dams have been to reduce the runoff at the KNP border in the Letaba catchment by 45% and by 34% in the Klein Letaba.
- The runoff upstream of the Fanie Botha Dam has been reduced by 33% due to catchment

development.

- Irrigation is insignificant in the Shingwedzi catchment and the construction of dams has not had a significant effect on its overall runoff.
- Runoff reaching the KNP under present levels of catchment development from the:
  - Groot Letaba River is approximately 230 x $10m^3$ per year.
- The Klein Letaba River is approximately 80 x $10m^3$ per year
- Approximately 325 million x $10m^3$ per year reach the Mozambique border via the Letaba River under present levels of catchment development.
- It is envisaged that the results presented here will change as the available database improves both in terms of its length and location. Therefore hydrological predictions are very much a function of time and will require continual update.

2.3.13.4 **Recommendations**

From this study we recommend that:

- improvements to the monitoring of runoff and meteorological parameters should be carried out as soon as possible,
- it will be necessary to coordinate the network improvements on a regional basis and with a hierarchy of station standards,
- with increasing attention given to ecology, the assessment of hydrology in drier areas will require a similar priority to that of catchments with development potential in wetter areas.
- improvements in the documentation of existing and future catchment development i.e. irrigation and afforestation, is an additional requirement for a competent assessment of water resources.
- It must be stressed that without an adequate database the assessment of a catchment hydrology requires an input based on extrapolations rather than fact, and. may lead to the over design or under design of water works.

2.3.14 Annexure 12: Hydrology: Flood

2.3.14.1 **Introduction**

This report calculated the flood frequencies at points were future development may take place and where it may be of general interest. Flood frequencies were calculated for return periods of 5, 10, 20, 50, 100, and 200 years, as well as the Probable Maximum Flood (PMF) and the Regional

Maximum Flood (RMF).

Previous calculations of flood peaks in the study area are noted in the report. **Table 2.17** summarises the findings of previous flood peaks.

Table 2.17: Historical peak flood estimations in the Ietaba River Basin (1990)

Units	Fanie Botha Dam (1957)	Ebenezer Dam (1985)	Letsitele Dam (1975)	Nondweni Weir (1986)	Middle Letaba Dam (1980)	Hudson Ntsanwisi Dam (1980)
Q_{10} (m^3/s)	573	250	236			215
Q_{20} (m^3/s)		350	360	1500	910 (320)*	292
Q_{50} (m^3/s)		500	496	2300	1230 (490)*	405
Q_{100} (m^3/s)	1202		630	3100	1500 (650)*	513
Q_{200} (m^3/s)	1436	750		3800	1780 (840)*	
Q_{PMF} (m^3/s)		1800	3440		7500 (3750)*	
Q_{RMF} (m^3/s)		1300				

*Attenuated flood peak outflow

Each method to calculate flood peak frequencies are appropriate in specific instances and have various constraints. Throughout the study area, the methods that were used were the Rational, HRU1/74, catchment parameter, FPPD, KovacsKovacs and the Roberts TPA methods.

2.3.14.2 **Results**

The catchment characteristics and storm rainfall are discussed in detail in the report.**Table 2.18**, **Table 2.19**, **Table 2.20**, and**Table 2.21**are reproductions of the results given in the report of representative flood peaks and volumes for the study area.

Table 2.18: Representative flood peaks and volumes for the Upper Groot Letaba Catchment (1990)

Sub-catchment	Area (km^2)	Flood Peak (m^3/s)								Flood Volume ($\times 10^6 m^3$)		
		5 Yrs	10	20	50	100	200	PMF	RMF	10 Yrs	100	PMF
B801V19	1358	380	540	700	960	1200	1720	9760	4610	31.8	76.3	641.3
B801D13	867	260	380	470	560	725	1120	6960	3720	17.8	38.2	366.6
B801C13 F Botha (I)	652	160	280	450	800	1140	1600	4620	3240	13.3	54.3	166.8
B801V13 F Botha (O)	652	30	40	80	170	280	660	4620	3240	1.4	9.9	166.8
B801D12	59	110	160	230	350	460	600	1340	1023	2.8	8.0	23.2
B801D11	127	160	240	340	510	650	840	2580	1480	6.6	18.0	71.2
B801D09	123	110	190	270	410	540	680	2130	1460	5.3	14.9	58.9
B801D05	347	60	90	250	490	690	930	3030	2400	4.8	37.0	162.4
B801D01-3 Ebenezer (I)	170	140	210	290	430	560	710	1930	1700	10.6	28.5	98.1
B801D01-3 Ebenezer (O)	170	0	0	110	280	430	600	1930	1700	0	16.2	85.8
B801D02	140	120	170	240	360	460	580	1680	1550	8.5	23.0	83.7
B801D03	30	60	90	140	200	270	350	960	740	1.3	4.1	14.6
B801D01 Dap Naude	14	40	60	80	120	160	200	520	2470	1.3	3.7	12.1

Sub-catchment	Area (km^2)	Flood Peak (m^3/s)								Flood Volume (x 10^6 m^3)		
		5 Yrs	10	20	50	100	200	PMF	RMF	10 Yrs	100	PMF
(I)												
B801D01 Dap Naude (O)	14	40	60	80	120	160	200	520	2470	1.3	3.7	12.1
B801D18	491	290	440	620	920	1200	1550	4500	2830	17.8	48.3	181.2
B801D17	250	200	300	430	660	860	1100	3000	5790	9.0	5.7	89.7
B801D15	227	170	260	370	550	720	930	2580	5660	8.6	23.6	84.4

Table 2.19: Representative flood peaks and volumes for the Klein and Middle Letaba Catchments

Sub-catchment	Area (km^2)	Flood Peak (m^3/s)								Flood Volume (x 10^6 m^3)		
		5 Yrs	10	20	50	100	200	PMF	RMF	10 Yrs	100	PMF
B803D03	520	230	360	530	800	1060	1400	2850	2910	8.6	25.4	68.3
B803D02	430	200	300	440	660	880	1150	2330	2660	13.5	39.6	247.1
B803D01	85	110	170	240	380	500	660	1330	1220	7.4	21.7	57.7
B803D07	1085	380	600	880	1350	1820	2400	7930	4140	29.5	89.4	389.6
B803D04-5	210	160	260	390	600	810	1050	2500	1880	8.4	26.5	81.9
B803V06	730	310	500	700	1100	1430	1900	4200	3420	24.2	69.2	203.3
B802D01	225	140	220	340	540	730	980	2710	1950	8.3	27.8	103.0
B802D03	790	330	530	780	1230	1680	2200	5140	3560	22	70.0	214.0

Sub-catchment	Area (km^2)	Flood Peak (m^3/s)								Flood Volume ($x\ 10^6\ m^3$)		
		5 Yrs	10	20	50	100	200	PMF	RMF	10 Yrs	100	PMF
B802D05	385	170	270	400	630	850	1130	3200	2520	11.4	36.1	136.1
B802D04	195	120	200	290	470	630	850	2250	1820	8.8	27.8	99.4
B805V01	2875	380	600	990	1900	2660	3640	13920	6610	40.9	181.9	1117.3
B802D08 M Letaba (I)	1800	490	780	1150	1750	2340	3100	11120	5280	47.9	143.6	717.5
B802D08 M Letaba (O)	1800	0	200	640	1350	1990	2790	11120	5280	11.2	75.6	649.5
B802V08	1525	500	780	1150	1750	2360	3100	10300	4870	40.1	121.3	607.9
B802D07	735	290	460	620	1060	1420	1850	4490	3430	21.1	65.2	206.3
B802D06	290	210	330	480	740	1000	1300	3010	2200	5.7	17.3	52.2
B805D02	3836	160	440	960	1850	2640	3640	12380	6890	22.5	136.7	820.1
B805V05	4620	160	440	960	2050	2930	4100	13600	7750	31.2	209.2	1264.4
B805D04	790	100	170	350	770	1160	1600	4560	3180	6.6	44.7	175.7
B805D03 Hudson Nt (I)	362	180	280	420	650	880	1150	3910	2170	10.9	34	151.2
B805D03 Hudson Nt (O)	362	0	0	100	400	660	950	3910	2170	0	18.5	135.7

Sub-catchment	Area (km^2)	Flood Peak (m^3/s)								Flood Volume ($x\ 10^6\ m^3$)		
		5 Yrs	10	20	50	100	200	PMF	RMF	10 Yrs	100	PMF
B805D06	5406	130	390	1030	2250	3250	4500	14700	8150	28.8	239	1341.4

Table 2.20: Representative food peaks and volumes for the lower Groot Letaba and Letaba Catchments (1990)

Sub-catchment	Area (km^2)	Flood Peak (m^3/s)								Flood Volume ($x\ 10^6\ m^3$)		
		5 Yrs	10	20	50	100	200	PMF	RMF	10 Yrs	100	PMF
B801D19	2002	480	700	930	1360	1670	2500	8940	4470	40.5	104.3	768.9
B801D22	2619	480	710	990	1460	2000	2900	10200	5120	27.1	125.4	919.4
B801D25	3151	510	770	1080	1660	2180	3240	11200	5610	30.1	142.1	978.5
B804D04	1080	350	560	830	1300	1750	2400	6580	3290	23.0	72.0	346.3
B806V01	4231	650	970	1380	2060	2760	3900	1300	6500	40.4	188	1240.9
B806D02	4827	670	1020	1480	2260	2970	4200	13900	6950	54.2	259.3	1625.3
B807V01	10233	670	1030	1710	3510	4720	6500	20100	10100	32.6	392.3	1940.0
B807D02	432	180	290	430	700	940	1250	3160	2080	8.5	27.9	93.7
B807D03	937	280	450	680	1100	1480	2000	6120	3060	17.8	58.5	288.7
B807D01	11503	600	1060	1810	3610	4870	6600	21400	10700	69.1	372.3	1983.6
B807V04	12394	640	1110	1960	3810	5060	7000	22300	11100	73.6	324.9	2146.1
B807D05	13468	670	1170	2020	3920	5100	7100	23200	11600	79.8	358.7	2323.1

Table 2.21: Representative flood peaks and volumes for the Shingwedzi Catchment (1990)

Sub catchment	Area (km^2)	Flood Peak (m^3/s)								Flood Volume ($x 10^6 m^3$)		
		5 Yrs	10	20	50	100	200	PMF	RMF	10 Yrs	100	PMF
B902D02	775	300	450	640	940	1210	1550	3840	2780	17.2	46.3	147.1
B902D01	220	160	240	330	490	640	810	2050	1480	6.3	16.9	54.3
B902D05	1746	470	700	970	1420	1860	2300	8430	4180	31.9	84.9	384.7
B902D04	910	340	500	700	1050	1350	1700	5720	3020	19.9	53.6	226.9
B902D03	648	290	430	600	900	1150	1450	3980	2550	15.9	42.6	147.3
B901D07	780	310	460	650	950	1250	1550	4000	2790	17.7	47.7	153.8
B901D05	240	220	310	410	580	720	890	2380	1550	8.3	19.4	64.2
B902V07	2526	590	880	1220	1800	2310	2900	10000	5030	43.7	114.6	524.3
B902D06	490	240	360	500	750	970	1250	3050	2210	11.2	30.4	95.5
B902D07	3053	660	980	1350	2000	2590	3250	11000	5530	58.7	155.2	669.2
B902V10	4598	810	1200	1700	2500	3210	4100	13600	6780	78.2	209.3	934.4
B901D03	1180	380	570	800	1200	1530	1950	6250	3430	23.8	63.9	261.2
B901D02	810	310	460	640	940	1250	1500	3830	2850	17.8	48.4	148.3
B901D01	375	250	340	430	580	830	1020	2700	1940	9.8	24.4	79.7
B902D10	5578	770	1200	1700	2500	3210	4100	15000	7470	78.2	209.3	1030.0
B902D09	1545	440	560	920	1350	1740	2200	7430	3930	19.5	77.2	329.5
B901D04	340	270	360	460	620	740	880	2360	1840	7.8	21.4	68.2
B901D06	538	250	380	540	800	1030	1300	3390	2320	8.9	36.7	120.8

Sub catchment	Area (km^2)	Flood Peak (m^3/s)								Flood Volume (x 10^6 m^3)		
		5 Yrs	10	20	50	100	200	PMF	RMF	10 Yrs	100	PMF
B902D05	1685	470	700	980	1425	1840	2300	8200	4100	21.2	83.2	381.0

2.3.14.3 **Discussion**

The results of the study were in good agreement with previous study results. In some sub catchments there was however, a large difference in the results of the different methods used. Reasons for the differences are detailed in the report.

The Ebenezer, Magoebaskloof, Fanie Botha, Middle Letaba, and Hudson Ntsanwisi Dams are the only structures that are influencing the flood flows with return periods between 5 and 200 years that are entering the Kruger National Park. In the Shingwedzi catchment the only influencing structure is the Makuleke Dam.

The study concluded the following:

- The upstream reaches of the Groot Letaba, Klein Letaba and Middle Letaba Rivers have much greater flood producing potential the downstream reaches of the same rivers. The Ebenzer
- The 5 year flood peak inflows are attenuated by between 30% and 100% in the Ebenezer, Magoebaskloof, Fanie Botha, Hudson Ntsanwisi and Middle Letaba dams. The 200 year flood peak inflows of the same dams attenuate by between 5% and 55%. At the Kruger National Park, the dams reduce the 5 year flood peak by about 50%, while the 200 year flood peak is reduced by about 10%.

It is unfeasible to build structures to generate flood events that are larger than 5 year return period magnitude floods.

2.3.15 Annexure 13: Ground Resources

The purpose of this report was to investigate the contribution groundwater could make to the available water resources of the area. The report consisted of a desk study from available borehole data, of which 2496 were identified. Borehole data was summarised according to districts and hydrogeological regions. 8 distinct hydrogeological regions were identified these are:

- Drakensberg escarpment
- Drakensberg foothills and valleys
- Bandelierkop
- Soutpansberg
- Giyani/Gravelotte
- The plains
- Lebombo
- Alluvium

For each region aquifer types are described in general, with coarse information on borehole yields. No information is provided on the volumes of groundwater available. An estimate of recharge for each administrative district serves as the only source of data on exploitable groundwater volumes.

Based on factors such as MAP, slopes, the presence of intrusive geological features and structures, and the estimated depth of weathering, a crude groundwater potential map were derived in terms of low, medium and high groundwater potential.

2.3.16 Annexure 14: Environmental Aspects

The downstream ecology of rivers is negatively impacted by development. Development alter flow regimes by changing the runoff volume, temperature and silt loads.

The main rivers affected by development are the Middle Letaba, lower Klein Letaba, and Lower Groot Letaba Rivers.

Areas where rare plant or animal species occur are highly sensitive to development. These are the upper reaches of the Klein Letaba River catchment, upper reaches of the Groot Letaba River catchment, upper reaches of the Letsitele River catchment, and the Shingwedzi, Phugwane, Shisha and the Letaba rivers in the KNP. There are archeological sites along the lower reaches of the Groot Letaba River.**Error! Reference source not found.** shows a map of the environmental ensitive areas.

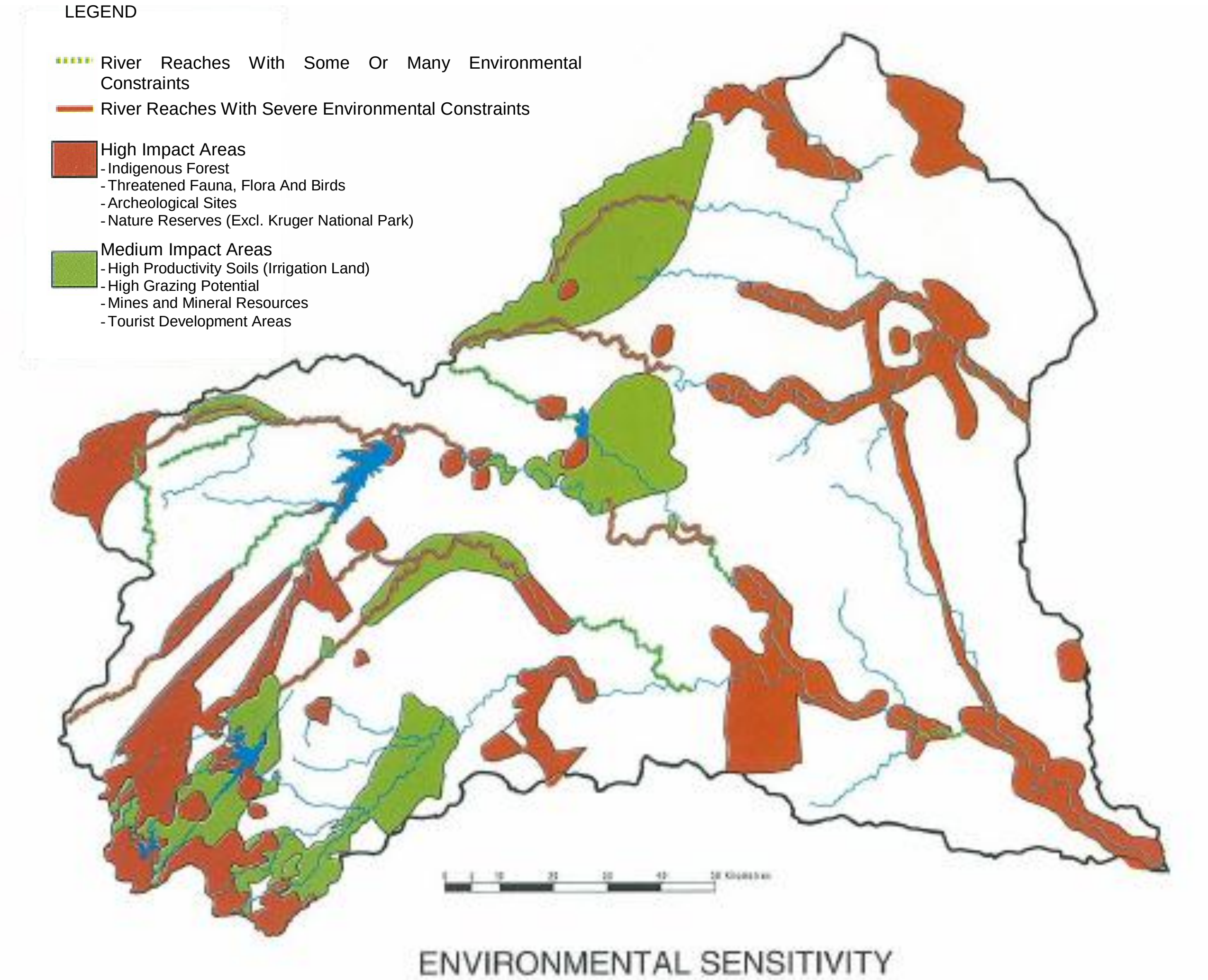


Figure 2-1 Environmental sensitive areas

1.1.1.1. Upper Klein Letaba River catchment

The catchment has had extensive population growth, and has a conservation status of 62%. The Klein Letaba and its tributaries are unregulated, and 85% of the catchment still has natural vegetation. The river has a score of 85%, while the biotica has a score of 43%.

1.1.1.2. Middel Letaba River catchment

The conservation status of this river is 52%, which is the lowest of the Letaba catchment. The sub-catchment has been extensively degraded due to large residential development. The valleys are under severe grazing pressure, although large areas are relatively unspoilt.

1.1.1.3. Lower Klein Letaba River catchment

The average RCS score for the river is 56%, and the RCS for the catchment is 68%. Increased population, increased volume of total abstraction, and increased river regulation are responsible for the defreadation. Nearly 3000 ha has been developed for agriculture.

1.1.1.4. Groot Letaba River upstream of Fanie Botha Dam

With an RCS score of 71%, this area is the least degraded of the study area. There is a high percentage of natural vegetation, diverse habitat, and clean fast flowing rivers.

1.1.1.5. Letsitale River Catchment

The upper third of the catchment is relatively pristine, while the two-thirds have been more degraded. Despite the pristine upper third, the catchment has a score of 56% due to the development.

1.1.1.6. Molotsi River Catchment

The catchment has a conservation score of 60%. The degradation is due to overgrazing, high population densities, erosion, and siltation.

1.1.1.7. Lower Groot Letaba River Catchment

The average river conservation status is 58%. The catchment contains some of the most developed areas. The lower reaches of the catchment still have natural vegetation, especially in the Hans Merensky Nature Reserve.

1.1.1.8. Letaba River Catchment in the KNP

The major negative attributes of the catchment is the amount of river abstraction, number of towns, population density, erosion, and clearance of vegetation. The most positive attributes are found within the KNP, and includes the importance of the river to surrounding ecosystems.

1.1.1.9. Shingwedzi River Catchment

The overall conservation status of the catchment is 91%, which is the highest catchment score. A wide range of habitats, and biotic coupled with no forestry and little farming or urban development is responsible for the high score. The river is rated as being in pristine state, however the catchment contains 20% of the dams in the KNP, which are causing severe impact on the ecology.

2.3.17 Annexure 15: Water Quality

Report Title: WATER RESOURCES PLANNING OF THE LETABA RIVER BASIN: Annexure 15: Water Quality. Report Number P.B800/00/1790 The RSA Department of Water Affairs. Prepared by Steffen, Robertson & Kirsten Inc. 1990.

The main objective of this part of the Luvuvhu River Basin Study was to evaluate both the surface and ground water quality within the Letaba and Shingwedzi Catchments, to make informed future predictions on the likely impacts of developments and to make recommendations for future water quality monitoring.

Eleven (11) surface water monitoring sites existed within the catchment at the time. Seven (7) of these were along tributaries of the Groot Letaba river, three (3) on the Groot Letaba River and one (1) on Middle Letaba Dam. Due to the unavailability of sufficient surface water quality data, various sources were used to patch the data. A comparison was made against SABS 241 1984 specification. The available data indicated that samples generally fell below the lowest reported criteria and chemically fit for domestic use. However, periodic increases in EC, Na, Cal and Total alkalinity were observed at certain sites. High PO4 as P levels were noted, which could be attributed to both point and non-point sources. Besides four (4) monitoring points, all sites had no microbiological records. There was a general deterioration in water quality in a downstream direction and a number of water borne diseases (Gastro-enteritis and Typhoid) prevalent in the study area.

Using Sharp's procedure, a refined monitoring network was established which included the elimination of certain monitoring sites on the Groot Letaba River and the addition of more sites on both the Klein and Middle Letaba Rivers.

No ground water monitoring sites and data, monitored by the DWA, existed at the time prior to this study. These had to be obtained from the Development Bank of South Africa (DBSA) (4), the Council of Scientific and Industrial Research (CSIR) (9) and Steffen, Robertson and Kirsten Incorporated (SRK) (5). Additional samples were also collected. A comparison was made against SABS 241 1984 specification. Although little information was available for ground water quality, the available data reflected generally good chemical quality trends. However, high nitrate values were evident and sewage contamination was likely to be the cause. It was recommended that boreholes intended for domestic use should be situated away from areas of possible sewage seepage and that treated water should be piped to consumers.

Generally, a Water Quality Management (Integrated Water Quality Management) approach was suggested for implementation for both surface and ground water in the Letaba and Shingwedzi catchments. Data should also preferably be accessible from one central source, such as a Geographical Information System.

The latter recommendations have been implemented with great success, although data availability might be limited.

2.3.18 Annexure 16: Sediment

Sediment deposition in dams can reduce the storage significantly, and may increase the turbidity in rivers.

In the lower reaches of rivers, dams with small capacities have almost entirely silted up. Sedimentation yield is mostly affected by land-use. The silt load on rivers is affected by land tillage, afforestation, and urbanisation.

The Klein Letaba and Molototsi Dams may be seriously impacted by sedimentation. The sediment yield from selected catchments is shown in Table 2.22.

Table 2.22: Sediment Yield from Selected Catchments

DAM	MAR ($10^6 m^3$)	CATCHMENT SIZE (km^2)	ESTIMATED MAXIMUM YIELD ($t/km^2/year$)	STORAGE LOSS OVER 50 YEARS (million m^3)
Klein Letaba	36,7	2 900	310	33,3
Molototsi	9,0	660	330	8,1
Nwanedzi	7,0	220	320	2,6
Thabina	29,0	150	350	1,9
Letsitele	41,0	170	360	2,3

The report suggests that a site specific study should be undertaken in these areas by re-surveying the dams. Suitable dams for this study would include Ebenezer, Magoebaskloof, Fanie Botha, Hudson Ntsanwisi, Middel Letaba, Lorna Dawn and Pioneer Dam. These dams should be re-surveyed every 10 years. Mkuleke dam should also be included in the survey programme.

2.3.19 Annexure 17: Water Losses

Report Title:WATER RESOURCES PLANNING OF THE LETABA RIVER BASIN: Water Losses: Annexure 17. Report Number P.B800/00/1990 The RSA Department of Water Affairs. Prepared by Steffen, Robertson & Kirsten Inc. 1990.

This study report identified and quantified the major water losses in the study area. The report confirmed that the water resources in the study area are limited and that future water resources development and planning should not only be aimed at quantitative improvement, but equally importantly at the improved productivity of this limited resource.

The water losses in the study area occur from the catchment itself, from bulk water storage dams, bulk water conveyance systems and at different user groups. From the results of this study the water losses can be summarised as follows:

- Resource water losses amount to 93% of the total precipitation volume.
- River conveyance losses occur mainly along the Groot Letaba River and amount to 22 million m^3/a.
- Canal conveyance losses amount to 9 million m^3/a.
- Pipeline conveyance losses amount to 1 million m^3/a.
- Irrigation user group losses amount to 32 million m^3/a.
- Domestic and industrial losses amount to 5 million m^3/a.

From the results of the study the following recommendations were made:

- Water use by alien vegetation should be investigated.
- The impact of improved cultivation on runoff should be investigated.
- The operation of major reservoirs should be investigated with the view of improving the total yield.
- Future dams should be located in the relatively low net evaporation areas.
- River conveyance losses along the Groot Letaba River downstream of the Fanie Botha Dam should be investigated.
- The implementation of alternative low loss conveyance systems should be investigated.
- George's Valley and Masala irrigation canal systems should be upgraded where necessary.
- The use of more efficient irrigation methods should be promoted. This may be achieved by re-evaluating existing quotas and introducing appropriate water tariffs.
- The basis for the selection of crops should be reviewed.

2.3.20 Annexure 18: Surface Water Resources Development

Report Title:WATER RESOURCES PLANNING OF THE LETABA RIVER BASIN: Surface Water Resources Development: Annexure 18. Report Number P.B800/00/2090. The RSA Department of Water Affairs.Prepared by Steffen, Robertson & Kirsten Inc. 1990.

Surface water availability in the catchment amounted to 250 million m^3/a in 1985. Additional water could be made available by further developing the surface water resources in the catchment. Significant potential for water resources development occurs in the following sub-catchments:

- Klein Letaba River
- Letsitele River
- Groot Letaba River

The Middle Letaba River catchment is overdeveloped. The construction of large dams in the Groot Letaba River is restricted by the lack of suitable dam sites and by intensive development along the river that would be inundated.

The maximum volume of water that could be made available from fully developed groundwater and surface water resources was estimated as 432 million m^3/a (337 million m^3/a) from existing and possible future dams and the remainder from groundwater).

2.3.21 Annexure 19: Ground Water Resource Development

Report Title:WATER RESOURCES PLANNING OF THE LETABA RIVER BASIN: Groundwater Resources Development: Annexure 19. Report Number P.B800/00/2190. The RSA Department of Water Affairs.Prepared by Steffen, Robertson & Kirsten Inc. 1990.

This annexure identified groundwater resources which could be exploited. The report identifies 4 regions that could be exploited for groundwater:

- The north eastern Malamulele area
- The central western Mooketsi district (already significantly developed)
- The south western area (already significantly developed)
- The north western area

Potential locations for well fields and approximate yields are provided.

The total volume of exploitable groundwater is 105 million m^3/a, of which 22 million m^3/a occurs in the Kruger National Park and will probably not be developed. About 35 million m^3/a can be extracted from groundwater resources by using existing facilities and a further 48 million m^3/a through further development.

The full exploitation of groundwater resources could be achieved by establishing a number of well fields. Numerous dispersed borehole developments comprising of 1 to 3 boreholes would also contribute to the total yield.

The groundwater yield in the Middle Letaba River catchment and along the middle reaches of the Groot Letaba River is over exploited.

2.3.22 Annexure 20: Development Options

Report Title: WATER RESOURCES PLANNING OF THE LETABA RIVER BASIN: Development Options: Annexure 20. Report Number P.B800/00/2290. The RSA Department of Water Affairs.Prepared by Steffen, Robertson & Kirsten Inc. 1990.

This section of the study identifies and discusses possible water resource development options that could be implemented to meet the projected water requirements in the study area. The total surface and groundwater availability in 1985 was about 240 million m^3/annum. It is estimated that by constructing additional dams and developing groundwater well fields, water availability could be increased to about 400 million m^3/annum.

The combined storage capacity of the existing dams in the study area amounts to approximately 500 million m3, and nearly half of this storage occurs in the Upper Groot Letaba catchment. Each of the major sub-catchments was evaluated and the potential for storage development was determined. Considerable potential for storage development occurs in the Klein Letaba River, Groot Letaba River and Letsitele River catchments. The Nwanedzi River and Molototsi River catchments have a lesser potential for development, whilst the Middle Letaba River and part of the Shingwedzi River catchments are considered to be fully developed. Based on the hydrology of the study area and environmental considerations, potential dam sites on major streams were identified and these are shown in Figure 2.2 below. A further preliminary selection of six dam sites was made from these potential sites for the development of additional storage that would yield a total of 120 million m^3/annum, as shown in **Table 2.23**.

Table 2.23: Details of Preliminary Selected Dam Sites (1990)

Catchment	Dam No.	MAR** ($x10^6$ m^3)	Storage		Yield		Cost	
			(% MAR)	($x10^6$ m^3)	(% MAR)	($x10^6$ m^3/a)	(R Million)	(c/m^3)
Upper Klein Letaba River	KL11A	44.0	300	132	70	31.0	30.8	7
Upper Groot Letaba River	Fanie Botha*	212.0	103	218	52	110.0	-	-
Letsitele River	LET6A LET12	46.0 9.0	300 300	138 27	86 81	39.8 7.3	83.6 21.7	14 20
Nwanedzi River	GR12	10.1	300	30	54	5.5	16.1	20
Lower Groot Letaba River	GR32A	11.1***	-	50	-	21.0	35.0	12
Molototsi River	GR29	7.8	300	23	40	3.1	13.2	30

* Existing dam rose.

** Water use by exotic forests and ad hoc irrigation accounted for.

*** Off-channel storage

No sites were considered to be suitable in the Lower Klein Letaba River catchment in view of the high evaporation and low run-off from the catchment (excluding contributions from upstream catchments), and the negative impact that construction of a dam on this river would have on the ecology of the Letaba River in the Kruger National Park.

No other sites were considered in the upper Groot Letaba due to poor basin characteristics, besides the raising of the Fanie Botha Dam by means of fitting gates to the spillway.

The available water resources in the Middle Letaba River are not sufficient to meet the water requirements in the area, and the construction of additional dams in the upstream areas of the catchment will negatively impact the yield of the already stressed Middle Letaba Dam.

The Klein Letaba River catchment is presently stressed due to high population and large irrigation development. The construction of a dam on the Klein Letaba River will only partly satisfy the water needs in the catchment and the dam will also impact on run-off to the Kruger National Park.

The Shingwedzi River is in balance. Groundwater reserves are considered to be in excess of the potential demand, but the transfer of the groundwater to other catchments may prove to be uneconomical.

The Letsitele River catchment appears to have the potential to meet local requirements. There are possible sites on the upper Thabina River and Letsitele River.

The Molototsi River is practically undeveloped at this stage, but there are possible dam sites in this area. However, the topography is relatively flat and sedimentation in the dam basins may be severe.

The Groot Letaba River is stressed, particularly in the lower reaches, and factors negating the construction of dams on the Groot Letaba River downstream of the Fanie Botha Dam include the intensive farming activity along the river, lack of suitable sites, high evaporation loss and excessive distance from major demand centres. The construction of off-channel storage was identified as a possible solution to these factors.

It was recommended that detailed studies for the following development possibilities should be undertaken:

- Letsitele catchment
- Lower Groot Letaba catchment
- Molototsi catchment
- Klein Letaba catchment
- Augmentation of flows for the Kruger National Park
- Water transfer to Pietersburg and environs

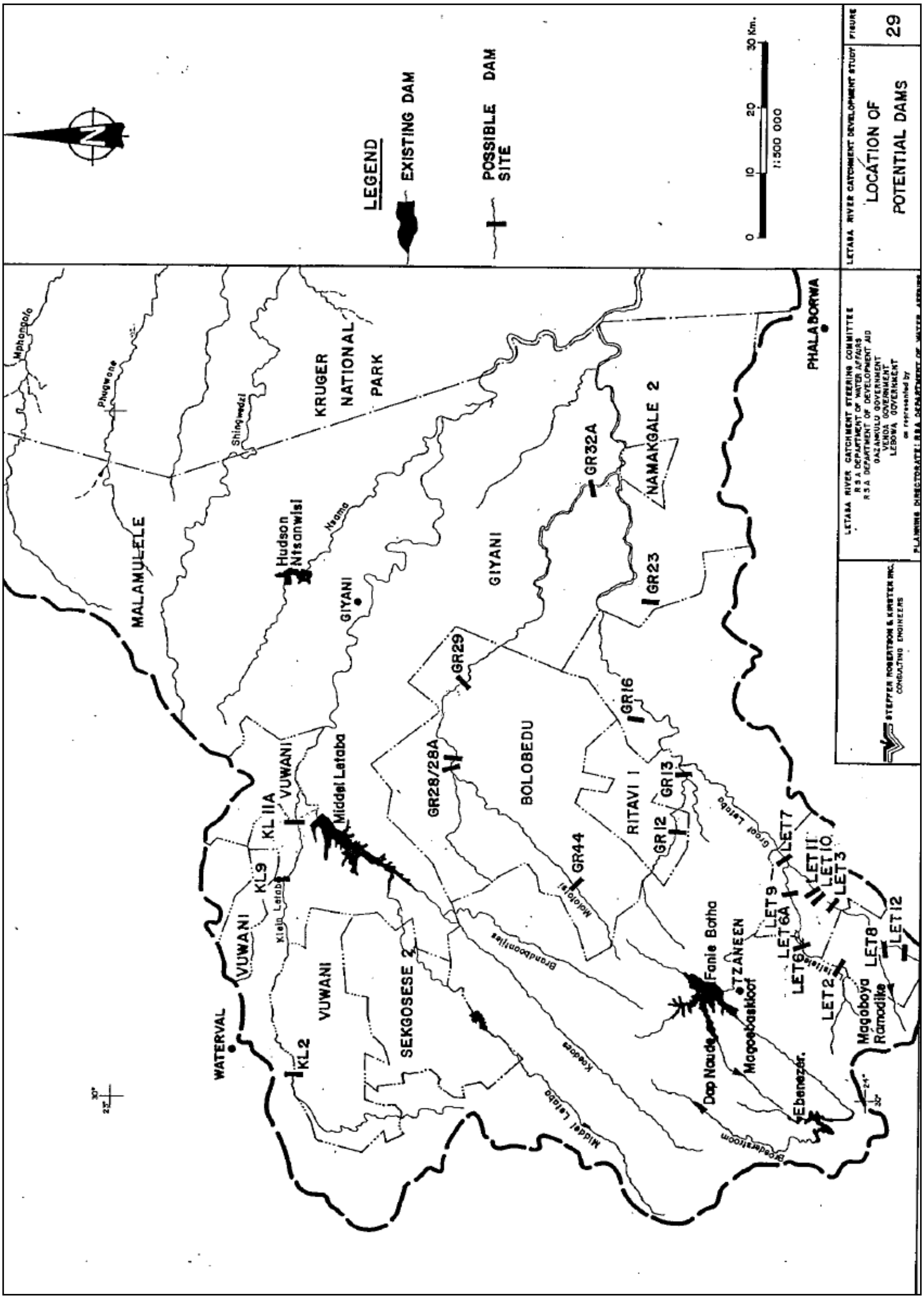


Figure 2-2 Locality Map Showing Positions of Potential Dam Sites

2.3.23 Annexure 21: Operation of Major Water Control Structures

Report Title: WATER RESOURCES PLANNING OF THE LETABA RIVER BASIN: Operation of Major Water Control Structures: Annexure 21. Report Number P.B800/00/2390. The RSA Department of Water Affairs.Prepared by Steffen, Robertson & Kirsten Inc. 1990.

The Letaba System Simulation Model was used to investigate the operating rules of the following systems:

- The Dap Naude/Ebenezer/Magoebaskloof/Fanie Botha System
- Middle Letaba System
- Dam LET6A System (Single storage unit located on the Letsitele River)
- Dam KL11A System (Single storage unit located in the Klein Letaba River +-4km upstream of the Klein/Middle Letaba River confluence)

From the investigation it was concluded that:

- The largest volume was supplied under conditions where no restrictions are applied. The dams in the system can however be expected to run dry from time to time in these conditions.
- The water users would experience the least stress when systems are operated to have high decision storage levels and restrictions of low severity.
- Different restriction criteria at Ebenezer Dam and Fanie Botha Dam were required due to different emphasis in demand.
- Generally, the impact of a small capacity dam in a system having large capacity dams was negligible. The small dams can be operated independently of the larger dams.
- Yield estimates based on the Witwatersrand University HRU RESSIM model were found to be very similar to desirable draw offs determined using the Alexander Model. The RESSIM Model was quick and easy to use and offered a suitable cursory estimate of the yield.

2.3.24 Annexure 22: Institutional Aspects

Report Title: WATER RESOURCES PLANNING OF THE LETABA RIVER BASIN – STUDY OF DEVELOPMENT POTENTIAL AND MANAGEMENT OF THE WATER RESOURCES: ANNEXURE 22 – Institutional Aspects Report No. PB 800/00/2490.Department of Water Affairs in association with the Republic of Venda, Lebowa and Gazankulu.Prepared by SRK (Steffan, Robertson and Kirsten Inc.)March 1990.

The report provides the list of all applicable institutions, as at 1990, together with their structures responsibilities and inter-relationship with other institutions, which had an influence over water related matters within Letaba River Basin. The list included Government Departments of South Africa, Venda, Gazankulu and Lebowa, second tier government, local authorities, planning authorities, interest groups and statutory bodies. Furthermore, details regarding the control of water use, as applicable at the time, are provided in the report. Most of the institutions mentioned are no longer around and DWA is the sole national custodian of water resources in South Africa as whole and there are new institutions like Catchment Management Agencies, Water User Associations, and Systems Operation Forums.

The report highlighted in its conclusion that:

- There was a multitude of organizations, bodies and individuals having control over water in the Letaba River Basin
- Duties and responsibilities of certain of the organizations appeared to overlap
- Lines of communication between organizations needed to be improved
- Joint control over water in catchments having a large number of independent operators is difficult.

These issues are still as true as they were in 1990, however, the new Water Act and subsequent Regulations have gone a long way in streamlining the roles and responsibilities under the leadership of DWA for the entire country and for dealing with international obligations where applicable.

2.3.25 Annexure 23: Monitoring and Research Needs

Report Title: WATER RESOURCES PLANNING OF THE LETABA RIVER BASIN: Monitoring and Research Needs: Annexure 23. Report Number P.B800/00/2590. The RSA Department of Water Affairs.Prepared by Steffen, Robertson & Kirsten Inc. 1990.

From the results of the study, it was recommended that the following monitoring related work be undertaken:

- Additional rainfall recording stations should be installed in the rain shadow areas in the upper Koedoes River Valley and in the semi-arid eastern part of the study area.
- A number of rainfall recording stations should be reinstated (stations listed).
- Additional stations should be installed in the Middle Letaba River and Klein Letaba River basins.
- Evaporation stations should be installed at Prieska Weir, Makuleke Dam and the Letaba Rest Camp.
- The data collection and control of the existing evaporation stations should be improved.
- The operation and control of data collection at flow gauging stations B8M08, B8M11, B9M02, B9M03, B9M04 AND B9M05 should be improved.
- The capacity of the flow gauging weirs B8M08 and B8M10 should be increased.
- The accuracy of the flow gauging weirs B8M15, B8M17, B8M18, B9M02 and B9M05 should be improved.
- Additional flow gauging stations should be commissioned in the upper Klein Letaba River, Middle Letaba River, Koedoes River, Letaba River, Letsitele River, Molototsi River and Nwanedzi River.
- All dams with a greater capacity of 100 000 m^3 should be registered.
- Monitoring programmes at the existing major water control structures should be refined.
- Details required for the registration of dams should be expanded.
- A centralised data bank should be established for storage of dam details and recorded flows and abstractions.
- All boreholes should be registered.
- Borehole related data should be stored regularly updated computerised database.

- A Programme should be implemented to monitor some of the 65 boreholes in the study area.
- Monitoring of water quality parameters should be coordinated by one responsible authority.
- Additional water quality monitoring stations should be established on the Middle Letaba River, Lower Klein Letaba River, Letsitele River, Lower Molototsi River, Mphongolo River and Shingwedzi River.
- The groundwater quality should be monitored at the suggested 65 groundwater monitoring boreholes.
- The irrigation water usage, evaporation, soil moisture, return flow, water quality and irrigation water losses should be monitored.
- The afforested areas should be determined say every 5 years using questionnaires and satellite imagery.
- Water supplied to major towns should be metered.
- Water supplied to selected villages and settlements through street pipes and kitchen connections should be metered.
- A survey should be undertaken on a biannual basis in each of the centres receiving metered water to determine the number of people supplied and the type of water supply in use.
- A 5 year population census should be instituted.
- Sample surveys should be undertaken on a continuous basis to examine the migration, housing, income and infrastructure.
- The sediment deposited in Ebenezer, Magoebaskloof, Fanie Botha, Middle Letaba, Hudson Ntsanwisi, Lorna Dawn, Pioneer and Makuleke Dams should be surveyed every 10 years.

From the results of the study it was recommended that the following research be undertaken:

- The interaction between the surface water and groundwater processes should be researched.
- The aquifer characteristics along major geological structural features should be determined.
- A comprehensive irrigation related database should be established.
- The irrigated areas, crops, irrigation development and farm dam development should be determined on a regular basis using remote sensing techniques.

- Irrigation water usage versus productivity should be researched.
- The impact of the water tariff on domestic water use should be researched and the stress resulting from various levels of water restrictions should be established.
- Socio-economic aspects related to irrigation should be investigated.
- Water losses in the Groot Letaba River should be determined.
- Irrigation water requirements of the main crops in the area should be established.
- Current forest research should be reviewed to ensure that the research needs are adequately addressed.
- The validity of the Pitman Model should be checked in terms of estimating forest water use.
- The riverine biota throughout the catchment should be investigated in terms of:
    - The habitat structure of the riparian zone and the responses of riparian communities to changing river flow regimes.
    - The habitual requirements of key invertebrate and vertebrate fauna associated with the riverine habitat and that the species which require further study be identified.
- The stress tolerance of each river reach in terms of water supply should be established.
- The total consumptive and non-consumptive biotic water requirements should be determined and the impact of possible water restrictions during drought periods in this water use sector should be assessed.
- The groundwater inputs and outputs in relation to the river should be established both laterally and vertically.
- The scouring and slushing capacities of floods of different return periods should be established and the flood magnitudes which will maintain physical diversity in the river bed should be estimated.
- The potential impact on the quality and quantity of water entering the Kruger National Park from various zones of human activity should be assessed.

Other recommendations included:

- The most appropriate flow metering system available should be identified.
- The censuses undertaken by various agencies in South Africa should be co-ordinated.
- Definitions used by the various agencies should be standardised.

- Boundaries used in the censuses should be fixed for at least several decades.
- A census institutional structure should be created which will confine the activities of the various agencies conducting censuses.

2.3.26 Annexure 24: Book of Drawings

Report Title: WATER RESOURCES PLANNING OF THE LETABA RIVER BASIN: Monitoring and Research Needs: Annexure 24. Report Number P.B800/00/2690. The RSA Department of Water Affairs.Prepared by Steffen, Robertson & Kirsten Inc. 1990.

This report provides 1:750 000 scale graphic presentations of various aspects related to study. The drawings include:

1. Locality, Drainage and State Boundaries
2. Topography
3. Geology
4. Rainfall Recording Stations
5. Mean Annual Precipitation
6. Mean Annual Symons Pan Evaporation
7. Soils and Slopes
8. Description of Soil Map Units
9. Land Capability
10. Natural Vegetation
11. Population Settlement Areas
12. Population Distribution
13. Land Use
14. Roads and Power lines
15. Water Supply Infrastructure
16. Existing Major Dams
17. Mines
18. Irrigation Areas
19. Net Evaporation

20. Potential Irrigation Areas
21. Forest Areas
22. Potential Forest Areas
23. River Flow Gauging Stations
24. Mean Annual Runoff
25. Runoff Distribution
26. Hydrological Zones
27. Existing Boreholes
28. Groundwater Potential
29. Possible Dam Sites
30. Groundwater Development
31. Water Quality Monitoring Points
32. Pollution Sources
33. Environmental Sensitivity
34. Sediment Yield
35. Development Possibilities

2.4 KRUGER NATIONAL PARK RIVERS RESEARCH PROGRAM, WATER FOR NATURE: HYDROLOGY, LETABA RIVER(1990)

2.4.1 Overview

The Kruger National Park Rivers Research programme was initiated by the Department of Water Affairs and was later continued under the control of the Water Research Commission. The Kruger Park Rivers Research programme was established to investigate the rivers flowing through the Kruger Park, to look at the changes which have occurred and will occur in these rivers, and to study the effects of these changes.One report was produced for the study and the report describes the basic hydrology, at key points in the rivers, which together with the hydraulic characteristics of the rivers can be used for assessment of the water requirements for nature conservation in the Letaba River. The hydraulic characteristics at the various selected points as well as the assessment of the water requirements were dealt with as separate investigations.

2.4.2 Kruger National Park – Letaba River – Hydrology

Report Title: KRUGER NATIONAL PARK RIVERS RESEARCH PROGRAMME – WATER FOR NATURE- HYDROLOGY: LETABA RIVER CATCHMENT Report No. PB 800/00/2890.Department of Water Affairs.Prepared by SRK, 1990.

2.4.2.1 **Scope of Work**

It was not considered adequate to determine water requirements for nature conservation on the basis of the historic runoff from the catchment. It was also necessary to develop methods of analysis by which the hydrological features of each runoff scenario could be easily communicated to a wide range of scientific fields embodied in members of the research programme. The runoff was generated at 6 key points in the system to allow generation of a runoff sequence at any location in the Letaba river catchment. These key points coincided with the border of the Kruger National Park and with the confluence of the major tributaries with the Groot Letaba River.

2.4.2.2 **History of water resources development**

A complete summary is provided of all land and water use as produced by the *Study Water Resources Planning of The Letaba River Basin - Study of Development Potential and Management of the Water Resources (Annexures 1, 3, 4, 5, 6 & 8)* as summarized in Section 2.3 of this report.

2.4.2.3 **Runoff sequences**

Monthly runoff sequences were generated under various catchment conditions at 6 key points. Except for the historical sequences, each sequence represents the simulated runoff during the period October 1933 to September 1987 for a fixed development condition. The monthly runoff sequences for the various development conditions were provided in the report. The key points represent the following catchments:

GL1: Groot Letaba River at Fanie Botha Dam.

GL2: Groot Letaba River just downstream of the confluence of the Groot Letaba River and Letsitele River.

GL3: Groot Letaba River just upstream of the confluence of the Groot Letaba River and Klein Letaba River.

KL1: Klein Letaba River just downstream of the confluence of the Klein Letaba River and the Middle Letaba River.

KL2: Klein Letaba River just upstream of the confluence of the Klein Letaba River and the Groot Letaba River.

KNP: Letaba River just downstream of the confluence of the Groot and Klein Letaba rivers.

Simulations were done for the following conditions:

- Virgin (natural) catchment conditions: Virgin flows were generated using undisturbed (virgin) catchment conditions. This condition included the presence of indigenous forests of a total area of 23 200 Ha.
- Afforested catchment conditions: Afforested flows were generated using virgin catchment conditions including Present (1985) 47300 Ha exotic forest and 23 200 Ha indigenous forests
- Present (1985) catchment development: Developed flows were generated by including all present day (1985) development in the catchments. This included, where applicable, afforestation (70 500 Ha), irrigation (129 x 10^6 m^3 per year from dams and 12 600 Ha diffuse), domestic and industrial abstraction (24 x 10^6 m^3 per year) and major dams and water works.

Major dams and water works included:

- GL1: Dap Naude Dam, Ebenezer Sam, Pusela Canal, Magoebaskloof Dam, George's Valley Canal, Fanie Botha Dam & Farm dams
- GL2: Letaba Noord Canal, N & N canal & Farm dams
- GL3: Masala canal, Jasi Weir & Farm dams
- KL1: Middle Letaba Dam & Farm Dams
- KL2: Farm Dams
- KNP: All the above

Historical development: Historical flows were generated by assessing the resource and catchment development per decade. Time intervals were chosen to coincide, where possible, with the commissioning of major dams in the catchment. The total flow record from 1933 to 1986 was therefore divided as follows: 1933 to 1945, 1946 to 1955, 1956 to 1965, 1966 to 1975, 1976 to 1986,

Future catchment development: Future potential development, as identified in the 1985 study was incorporated into this scenario. It included a potential 10 000 Ha of exotic forests which is estimated to have a further 8 x 10^6 m^3 per year reduction in runoff. Also included are potential developments in relatively undeveloped sub-catchments (i.e. Letsitele, Thabina River and the Klein Letaba River catchment upstream of the confluence with the Middle Letaba River). The potential developments included Ka-Muhlaba Dam on the Letsitele River, Pitsi Dam on the Thabina River and Crystalfontein Dam on the Klein Letaba River.

2.4.2.4 **Types of analyses**

A series of computer-aided analyses were done in an attempt to present the hydrology so that other scientific disciplines would be able to use the information. The analyses were done for different development at varying points as follows:

- For the 4 sets of catchment development conditions culminating in present day (1985) development, namely:
    - Virgin conditions
    - Afforestation
    - Present (1985) development
    - Historical records

flows are generated and analyses done for all the six key points in the catchment.

- For the 4 sets of future development conditions, flows are generated and analyses done only at the KNP boundary.

The simulated runoff sequence at each key point was then analysed to show the natural periods of low runoff by ranking the flows from lowest runoff to highest and then showing in a table the lowest flow runoff periods. Runoff periods chosen were 1 month, (lowest one month flow per month), 3 months (lowest 3 month flow in each quarter of the year), 6 months (lowest 6 month flow in each season) and annual.

Frequency analysis of the simulated flows was then done. These analyses show the flow equalled or exceeded for various levels of assurance. The analyses have been done for 1-month, 3-month and 6-month accumulative flows. The flows occurring at the 70% assurance level were then abstracted from the frequency analysis and plotted for each key point. Runoff hydrographs, i.e. flow versus time, for each key point and each development condition were also plotted. Deficient flow-duration-frequency analyses were then performed for durations of 1 month to 8 years, and for recurrence intervals of 2 years to 100 years, at the Kruger National Park key point.

2.4.2.5 **Conclusions**

A hydrological analysis of the Letaba River Catchment has been performed. Six Key points in the catchment were chosen. Monthly flow sequences at these six points, for 4 catchment conditions, (virgin, afforested, 1985 development, and historical development) were generated. Monthly flow sequences at the KNP boundary were also generated for 4 future development scenarios. A wide variety of analyses were then performed on the flow sequences so that the information could more easily be used by the members of the research programme.

2.5 ALBASINI DAM (A9R001) HYDROLOGY (1993)

2.5.1 Overview

The Albasini Dam (A9R001) is situated on the Luvuvhu River approximately 40 km South-East from Louis Trichardt. It has a gross capacity of 25.7 x 106m^{3}with a catchment area of 509 km^2 and was commissioned on 1 October 1952. Land use in the catchment area includes farm dams, dry land and irrigated fields, afforestation and livestock. Irrigated crops include avocados, litchis and nuts and to a lesser extent vegetables. Irrigation occurs in the northern and south eastern parts of the catchment and is from farm dams, run-of-river and from groundwater. A canal from Albasini Dam supplies a government irrigation scheme downstream of the dam. The dam also supplied Louis Trichardt of water.

The catchment area of Albasini Dam was declared a Governmental Water Control area to protect the surface water supply to the dam. Since 1984 the level of the dam caused that no or very little of the quota of irrigation to downstream users could be supplied. It was suspected that this was in part caused by the building of illegal farm dams upstream from Albasini Dam after the control area was established in 1970.

The former Transvaal District Director requested an analysis of the natural inflow to Albasini dam as well as taking into account (a) the effect of farm dams as at the 1970 proclamation, (b) effect of farm dams at the current (1992) development level. Other water users such as irrigators and Afforestation would also be accounted for.

The main aim of the analysis was therefore to determine the long-term yield of Albasini Dam. The Albasini dam has 3 reportswhich were reviewed in the following sub-sections.

2.5.2 Leweringsontleding: Volume 1: Verslag

Report Title: ALBASINI DAM (A9R001).Leweringsontleding :Volume 1: Verslag. Reg 190.Department of Water Affairs.Prepared by Directorate: Hydrology, June 1993.

2.5.2.1 **Introduction**

This report undertook a historical firm yield analysis for different development levels using the WRSM2000.

2.5.2.2 **Rainfall**

Due to high spatial differences in the MAR, the catchment area was sub-divided into 3 zones with MARs of 830, 793 and 637 mm/a. A good coverage of available rainfall stations with data longer than 15 years could be obtained for all 3 the sub-areas. The simulation period was from 1924/25 to 1990/1991. Rainfall data was visually inspected and corrections done. Stationary analyses were done on the records. Flagged values were indicated and extreme weather events were explained and noted. CLASSR and PATCHR were then used to infill all missing and suspect values. Where discontinues recording was observed in the stationary analysis the record was split into several periods and acceptable period were retained. After patching the extreme events values were placed back into the rainfall records. All patched rainfall records and their statistics were listed in appendices.

After patching point rainfall stations were analysed according to MAP and position to determine which stations will be used for the 3 zone's catchment rainfall records. Between 4 and 7 stations were used per station. The stations and the periods used were reported. Stationary analyses are also done on the resulting catchment rainfall records. Rainfall records show a highly cyclic pattern of generally speaking even decades being above average rainfall and uneven decades having below average rainfall.

2.5.2.3 **Evaporation**

Two evaporation stations were used during this analysis, i.e. A9E002 (at Albasini Dam) and A9E003 (17 km from station 2). The University of Natal's evaporation maps were also used for the S-pan values for the higher rainfall (lower evaporation) zone disaggregated using the observation station's monthly distributions. The two evaporation stations' monthly distributions were used for the other two zones. The two S-Pan MAE values were 1421 and 1441.

A-pan evaporation was derived from the S-Pan evaporation by multiplying the S-pan values with 1.26. Pan to dam-factors was also reported.

2.5.2.4 **Farm Dams**

A survey of all the farm dams in the catchment areas was undertaken by the former Transvaal Districts Office of the Department of Water Affairs and the results were checked against 1:50000 topographical maps. Growth in farm dams was verified using stereoscopic areal-photography of the areas for 1968 and 1981. Any omissions from the survey were found to be small and insignificant. The 34 farm dams were listed and ranged between 0.002 to 0.520 x 10^6 m^3.

Differentiation was made between farm dams that were used for irrigation and livestock. One of the farm dams were also used since 1981 for Louis Trichardt as receiver of a transfer from the Klein Letaba River. 6 Dummy dams were defined from the farm dam survey data and are listed. Area-capacity relationships were determined using the AREAKAP program. The k values ranged between 0.91 and 0.60. The total storage of the farm dams for 1968, 1981 and 1992 is 1.038, 2.809 and 2.861 x 10^6 m^3 respectively.

2.5.2.5 **Irrigation**

Irrigation information was obtained from a 1970 survey and from a survey done at the time by the Transvaal District Office of the Department of Water Affairs. The irrigation was sub-divided into 11 irrigation blocks that represented the position and the source of the irrigation water. Irrigation demand was calculated outside of the model. Although the total area of irrigated areas did not change from the 1971 to 1990 surveys (8.622 and 8.878 km^2 respectively, the irrigation moved to the higher rainfall area of the catchment. Effective rainfall was specified as 0.65 in the high rainfall area and 0.60 in the other zones. Area-weighted crop factors were calculated for each irrigation block and P-Index values for areas where there are orchards were set at 1, showing the demand occurs right through the year. All crop factors were listed. Application efficiency was not taken into account. Losses were set at 20%. No return flows were modelled and was seen as insignificant.

2.5.2.6 **Afforestation**

Figures were obtained from the Forestry section of the Department of Water Affairs and from 1:50000 maps. Forestry started in 1912 already and stayed constant since 1957 at 48.5 km2.

2.5.2.7 **Dam inflow records**

The dam inflow record was analysed and existed from 1952 to 1990 at 19.24 x 10^6 m^3 per year average. There was a clear reduction in inflow from the 1980's without the expected increase in water and land use (which stayed relatively constant over this period). Natural MAR estimates for the area based on a range of formulas ranged between 19.6 to 38.4 x 10^6 m^3 per year.

2.5.2.8 **WR90 Model**

The WR90 Model was configured with the information above and a network was configured based on the catchment configuration observed from a 1: 50 000 maps of the area. Assumptions were made about the growth in farm dams and different scenarios in growth in farms dams was defined and implemented in the model. Regional parameters for the model was obtained and configured. Some adjustments were made by Dr Pitman during 1993 of the regional parameters for the model that corresponded with the sub-divisions of the catchment area made during this study.

A ration of 3:1:1 of the contribution of the natural runoff was derived from the natural runoff formulae for the 3 zones that was delineated for the catchment areas and the calibration results had to reflect this. Lots of challenges were experienced during the calibration process – very high flows were simulated during early 1977 which were not measured and experimentation with shorter calibration periods and selection of rainfall stations did not improve the overall calibration. At the end the "best" calibration over the whole record period was accepted. The overall calibration statistics were however very good except for the seasonality which was under simulated by 27%. The catchment contribution ratio was also well reflected in the simulation. Graphical representations showed a relatively higher gross yield curve due to a slight over simulation in the dry 1980's.

2.5.2.9 **Scenario Analysis**

25 different simulations were undertaken using the WR90 model and all the results were listed. The main results were that the Virgin MAR from 1924 – 1991 was 26.2 x 10^6 m^3 per year which compares well with the natural MAR formula of 27.4 x 10^6 m^3 per year. The estimated MAR for present day conditions is 19.5 x 10^6 m^3 per year. It was estimated that the total irrigation demand from run-of-river abstraction was 5.3 x 10^6 m^3 per year of which only 1.8 x 10^6 m^3 per year could be supplied, were as the demand from farm dams were 2.9 x 10^6 m^3 per year of which 1.8 x 10^6 m^3 per year could be supplied.

2.5.2.10 **Historic yield analysis**

By using:

- the generated long-term present day inflow record for Albasini dam,
- a generated long-term rainfall record at the dam deduced from nearby rainfall stations,
- evaporation data measured at the dam,
- a constant assumed supply to Louis Trichardt and Tshikota,
- a historically derived assumption of monthly distributions of irrigation releases of 2.24 x 10^6 m^3 per year

A gross and a net yield analysis could be done for current development conditions. The net yield was given as 5.0 x 10^6 m^3 per year, although the analysis indicated that the critical period of 1/82 to 10/92 did not end yet at the end of the simulation period, which means that the yield reported is not a firm yield calculation. The analysis also showed that the effect of illegal farm dams only had a minor influence on the dam's yield but that the drought of the 80's reduced the estimated net yield of the dam with 32% as compared to the yield estimates before the drought.

2.5.3 Leweringsontleding: Volume 2: Bylae

Report Title: ALBASINI DAM (A9R001)- LEWERINGSONTLEDING – Volume 2: Bylae. Report No. Reg 190.Department of Water Affairs.Prepared by Directorate: Hydrology, June 1993.

This report provided all the detailed output from the report as described in Section 2.4. It included the following.

- Location maps for the catchment areas, rainfall stations, farm dams.
- Details of rainfall patching procedures, flagged values, the patched point rainfall records with stationary plots, catchment rainfall records and their stationary plots.
- Evaporation data and monthly averages.
- Farm dams area-capacity relationships.
- Crops under irrigation, A-Pan evaporation, P-Indexes and weighted crop factors and irrigation areas
- Observed inflow records
- WR90 network diagram and calibration graphs and statistics
- Simulated inflow records
- Yield analysis results.

2.5.4 Stogastiese Leweringsontleding

Report Title: ALBASINIDAM (A9R001): Sotgastiese Leweringsontleding. Report Number Reg190. The Department of Water Affairs and Forestry.Prepared by the Directorate: Hydrology. November 1993.

This report was drafted after the Yield Analysis Report was completed, where the historical yield analysis for the Albasini Dam was investigated. The purpose of this study was to assign assurance levels to the yields calculated on the previous report. The long-term stochastic yield yields were determined using the Water Resources Yield Model (WRYM).

Based on the stochastic flow sequences, the historic net yield of 5.8 million m^3/a was calculated to have an assurance of 1 in 136 years (chance of failing once every 136 years). The historic net yield calculated in the previous report as 5.2 million m^3/a, using the net yield method, was calculated to have an assurance of 1 in 300 years (chance of failing once every 300 years).

2.6 LETABA WATER RESOURCE DEVELOPMENT PRE-FEASIBILITY STUDY (1994)

2.6.1 Overview

The Department of Water Affairs and Forestry (DWAF) of the Republic of South Africa, on behalf of the Letaba Advisory Committee and the Governments of the Republic of South Africa, and the former self-governing states of Gazankulu and Lebowa, initiated in 1994 the Letaba Water Resource Development: Pre-Feasibility Study.The subject of this pre-feasibility study is the selection for future analysis of the most feasible integrated solution to meet the needs of the Groot Letaba River catchment. The study's main objectives were therefore, to:

- Investigate the options for developing the water resources of the Groot Letaba River and its tributaries, the Letsitele, Nwanedzi and Molototsi Rivers, with the aim to augment the supply of primary water to communities in the former Gazankulu and Lebowa, to ensure a more reliable supply for irrigation purposes and domestic supply during dry seasons and to alleviate water problems in the Kruger National Park
- Evaluate the various options so as to determine the optimum schemes for further analysis

Conclusions for this study are drawn and recommendations for further analysis are made and detailed in the eight reports of which 2 were not available for review as in the following sub-sections.

2.6.2 Executive Summaryand Main Report

Report Title: LETABA WATER RESOURCE DEVELOPMENT PRE FEASIBILITY STUDY: Executive Summary and Main Report. Report No. PB 800/00/0194.andReport No. PB 800/00/0294.Prepared for: Department of Water Affairs and Forestry.Prepared by BEW WIjiers, BJ Middleton and AC White (SRK), December 1994.

The executive summary report was not available for review; however the main report is thought to be sufficient for the purposes of this project.The main objectives of the study were to:

- Investigate the options for developing the water resource of the Groot Letaba River and its tributaries, the Letsitele, Nwanedzi and Molototsi Rivers, with the aim to:
  - Augment the supply of primary water to communities in the former Gazankulu and Lebowa
  - Ensure a more reliable supply for irrigation purposes and domestic supply during dry seasons and
  - Alleviate water problems in the Kruger National Park;

- Evaluate the various options so as to determine the optimum scheme(s) for further analysis.

The recommendations for the development and management of the water resources of the Groot Letaba River and its tributaries, the Letsitele, the Nwanedzi and the Molotsi rivers, based on the findings of the pre-feasibility study were as follows:

A. Economic

The economic and cost benefit analyses recommended that:

- Additional water resources development is implemented as studies undertaken thus far indicate that there is economical justification for additional water resource development in the Groot Letaba River catchment area.
- In the long-term the implementation of additional water resource development option is completed with water management options.

B. Institutional

The Institutional analysis recommended that:

- The management and development of water resources of a catchment and the operation water resource development infrastructure be the responsibility of a single organization;
- The Department of Water Affairs and Forestry to manage the establishment of an institutional structure in which all interested and affected parties are represented, which will facilitate community participation in the integrated process of water management and development;
- The Letaba Advisory Committee in conjunction with Northern Transvaal Water and the Department of Water Affairs and Forestry should indicate a campaign in the study area to create awareness of the limited nature of the development options available and their inability to meet long term demands.

C. Water Resource Development

The pre-feasibility study has identified the more feasible water development options for this catchment and recommended that:

- The Department of Water Affairs and Forestry undertakes further studies into the water resource development options of the Molotsi River.
- The Department of Water Affairs and Forestry undertakes feasibility studies of the more

feasible development options identified for further analysis. These are the raising of Tzaneen Dam, the Hobson's choice Dam on the Letsitele River and the Janetsi Dam on the Groot Letaba River. It is recommended that these studies are undertaken in parallel and independent of each other to accommodate the different aspects involved in the options and to allow integration into the recommended system analysis.

- The Department of Water Affairs and Forestry undertakes further studies into the feasibility of the Groot Letaba/Nwanedzi water transfer/exchange scheme.

E. <u>Water Management</u>

The pre-feasibility study concludes that in addition to the implementation of the more feasible development options, the existing water management situation could be improved and recommended that:

- The Department of Water Affairs and Forestry and Northern Transvaal Water improved the management and operation of water resource development infrastructure by means of:
    - Improved operation of existing reservoirs
    - Accurate metering and monitoring of water flows in the catchment. These include the releases from existing dams, rivers, flows, abstractions and water losses
    - The identification and eradication of pirate connections in the rural domestic water supply systems and illegal river abstractions for agricultural purposes
    - Identification and remediation of water losses occurring in the domestic water supply distribution networks, irrigation canals and bulk water pipelines
    - Implementation of a more appropriate tariff structure;
- The Department of Water Affairs and Forestry investigates the feasibility of re-allocation of water in the long term and that no re-allocation take place before such investigations has been completed;
- The Department of Water Affairs and Forestry undertakes analyses of the Groot Letaba River system to assess the impact of potential water resource developments and management options on the supply water demands by all sectors including the environmental water demand.
- The Department of Water Affairs and Forestry formulates a strategy to address the expected long term water problems in the study area.

F. Environmental and social

The initial assessment of the environmental and social impacts of the technically and economically more feasible water resource development options recommended that:

- Further environmental and social studies on the more feasible development options continue to be carried out according to the IEM approach and that full impact assessment are undertaken for these development proposals;
- The Department of Water Affairs and Forestry gives priority attention to the environmental and social impact of the more feasible development options in further feasibility studies.

2.6.3 Tzaneen Dam raising report

Report Title: LETABA WATER RESOURCE DEVELOPMENT PRE-FEASIBILITY STUDY: Module 3 – Tzaneen Dam Rising. Report No. PB 800/00/0394.RSA Department of Water Affairs and Forestry.Prepared by Steffen, Robertson and Kirsten Inc. Consulting Engineers (1994).

This module of the Letaba Water Resource Development Pre-feasibility study provides the preliminary details for the raising of the Tzaneen Dam. The Tzaneen Dam was originally designed to allow for rising by the addition of gates to the crest of the spillway. Raising the dam by 4.5 m will result in an additional yield of 6.0 x 10^6 m^3/annum at a 98% assurance level. The estimated capital costs for implementing the dam raising was between R 9 million and R 10 million in 1994, giving a capital cost of yield at that time of less than R 2.00 per cubic metre.

The study determined that the dam was being operated at a yield with a relatively high risk of failure, and that under these operating conditions, the raising of the dam would not improve the yield of the dam. Raising of the dam would only be feasible if the dam is operated at a lower yield with a relatively low risk of failure.

It was also determined that the raising of the Tzaneen Dam would not have any major impact on the environment. However, the change from an uncontrolled spillway to a controlled spillway would have some implications on operation of the dam and on flood management downstream of the dam.

2.6.4 Hydrology and Water Resources

Report Title: LETABA WATER RESOURCE DEVELOPMENT PRE-FEASIBILITY STUDY: Hydrology and Water Resources. Report Number P.B800/00/0594. The RSA Department of Water Affairs.Prepared by SRK. 1994.

This report included information and the hydrology and water resources of the Letaba Basin. The information from the report can be summarised as follows:

- The hydrology of the Groot Letaba River and its tributaries showed, when compared to the hydrology of the River Basin (based on 1985 data and models), that although the total runoff of the catchment at the KNP boundary is the same, the runoff contribution from the various parts of the catchment are different. The runoff contribution of the
    - Upper catchment (upstream Tzaneen Dam) is a little less;
    - Middle catchment (from Tzaneen Dam to the confluence with the Nwanedzi River) is a little more and the
    - Lower catchment (from the Nwanedzi River to the KNP boundary) is a little more.
- The major existing water resources development infrastructure is located in the Upper catchment. The reduced runoff from this catchment causes a reduction in the system yield of some 45 million m^3/a at a 10% risk of failure.The reductions in yield (at 10% risk of failure) for the major dams in the catchment are as follows:
    - Dap Naude' Dam: from 6 to 4.5 million m^3/a
    - Ebenezer Dam: from 45 to 26 million m^3/a
    - Magoebaskloof Dam: from 19 to 12 million m^3/a
    - Tzaneen Dam: from 92 to 74 million m^3/a
- There is a lack of good quality recorded flow data and accurate water use information, which limits the confidence in the simulated monthly flow values.
- The Letaba River system is presently well developed which results in a reduction of the mean annual runoff under virgin catchment conditions at the western KNP border from 405 million m^3/a to an estimated 177 million m^3/a under present catchment conditions. The existing dams have a total storage capacity and 270 million m^3, of which 240 million m^3 is in the major dams and 30 million m^3 is in numerous small and farm dams.
- The ground water resources of the Groot Letaba River Catchment and its tributaries are limited. The present use, mainly for rural domestic water supply and supplementary

agricultural water supply, is estimated to be some 12 million m^3/a .

- The present water availability is estimated at 228 million m^3/a, of which about 110 million m^3/a (with a 2% risk of failure) is supplied by the major dams in the catchment, and about 106 million m^3/a is available from run-of-river and small dams at a significantly higher risk of failure. The remaining 12 million m^3/a is presently available from ground water resources.

2.6.5 Development and Management Proposals

Report Title: LETABA WATER RESOURCE DEVELOPMENT PRE-FEASIBILITY STUDY: Module 6 – Development and Management Proposals. Report No. PB 800/00/0694.RSA Department of Water Affairs and Forestry.Prepared by Steffen, Robertson and Kirsten Inc. Consulting Engineers (1994).

This module of the Letaba Water Resource Development Pre-feasibility study investigates and evaluates development options as well as management-based measures that could be implemented to improve the availability of water supply in the study area. The development of the water resources in the study area is approaching the limit of the resource, and it is expected that water requirements will begin to exceed the available resource in the next 10 to 15 years, after which additional water requirements will have to be met from improved management of the resource, reduction in use, transfers between user sectors, or reduction in transfers from the catchment.

The study determined that feasible development options within the study area are limited and insufficient to entirely address the water resource deficit. The following development options were selected for further investigation:

- Raising of Tzaneen Dam
- Construction of Janetsi Dam (Site GR15A)
- Construction of Hobson’s Choice Dam (Site LET2)
- Construction of Nondweni Weir (Site GR24)
- Construction of Mulele Dam (Site GR29) or sand abstraction schemes along the Molototsi River (if feasible)

Implementation of these schemes would be increase the yield of the system by about 57 x 10^6 m^3/annum.

The following water management issues were identified as requiring improvement:

- The management and control of dams

- Accuracy of flow gauging stations
- Accuracy of abstraction records
- Control of illegal abstractions

Conclusions are made and recommendations for further actions are given in the study report.

2.6.6 Factors Affecting Development

2.6.6.1 **Water Quality**

Throughout the catchment the water quality is acceptable for all identified uses. Exceptions to this are the increase in TDS, and occasional exceedance of phosphate levels in the Lower Groot Letaba River. In the high density rural population areas there are high Ecoli counts.

In the Groot Letaba River the water deteriorates in the downstream direction.

A large portion of the rural population gets water directly from the river. It is concerning that there is a lack of micro biological water quality information for this catchment.

2.6.6.2 **Environmental and social issues**

The main environmental issues identified were:

- The river has a relatively poor conservation status
- The potential dam sites at Nwamitwa, La Motte, and Janetsi in the lower reaches of the Nwanedzi River will be affected by the high conservation status of that area. This presents a potential problem, which requires investigation in more detailed studies.

The main social issues identified were:

- The inundation of agricultural land, and the relocation of people living within the basins of the proposed dams.
- Several communities along the river depend on the water flowing in the river. The IFR incorporates this requirement, which will affect the operation of the entire system. The social issues are not expected to cause major problems, but should be investigated in more detailed studies.

2.6.7 Proposed Development: technical description

Report Title: LETABA WATER RESOURCE DEVELOPMENT PRE-FEASIBILITY STUDY: Module 8 – Proposed Development: Technical Description. Report No. PB 800/00/0894.RSA Department of Water Affairs and Forestry.Prepared by Steffen, Robertson and Kirsten Inc. Consulting Engineers (1994).

This module of the Letaba Water Resource Development Pre-feasibility study discusses the various options that are available for further development of the water resources in the study area.

A total of 17 options were considered and the following development options were selected for further investigation:

- Raising of Tzaneen Dam
- Construction of Janetsi Dam (Site GR15A)
- Construction of Hobson's Choice Dam (Site LET2)
- Construction of Nondweni Weir (Site GR24)
- Construction of Mulele Dam (Site GR29) or sand abstraction schemes along the Molototsi River (if feasible)

Refer to **Figure 2.3** for a locality map of the investigated and selected dam sites.

The Tzaneen Dam was originally designed to allow for rising by the addition of gates to the crest of the spillway. Raising the dam by 4.5 m will result in an additional yield of 6.0 x 10^6 m^3/annum at a 98% assurance level. The estimated capital costs for implementing the dam raising was between R 9 million and R 10 million in 1994, giving a capital cost of yield at that time of less than R 2.00 per cubic metre.

The construction of the Janetsi Dam (Site GR15A) to a FSL of 475 m.a.s.l will give a yield at 98% assurance of 28.3 x 10^6 m^3/annum. Major constraints to the Janetsi site include the inundation of existing irrigation schemes, the main road to Giyani, and an area of undisturbed riparian bushveld vegetation and a community of acacias.

The main purpose of the Nondweni Weir (SiteGR24) would be to address the lack of balancing storage and to stabilise supply at the lower end of the Groot Letaba catchment, and thus enable improved system management. The major constraint to this development is the inundation of an area of riparian vegetation which has a high conservation status.

The construction of the Hobson's choice Dam (Site LET2, in the upper reaches of the Letsitele River) to a FSL of 630 m.a.s.l will give a yield at 98% assurance of 26.6 x 10^6 m^3/annum.

The construction of the Mulele Dam (Site GR29, on the Molototsi River) to a FSL of 475 m.a.s.l will give a yield at 98% assurance of 8.6 x 10^6 m^3/annum. The major drawbacks are the high sediment load in the river and the inundation of extensive areas under dry land crops. In view of the scattered nature of the domestic demand, it may be prudent to investigate the use of a number of sand abstraction schemes along the river as an alternative the construction of this dam.

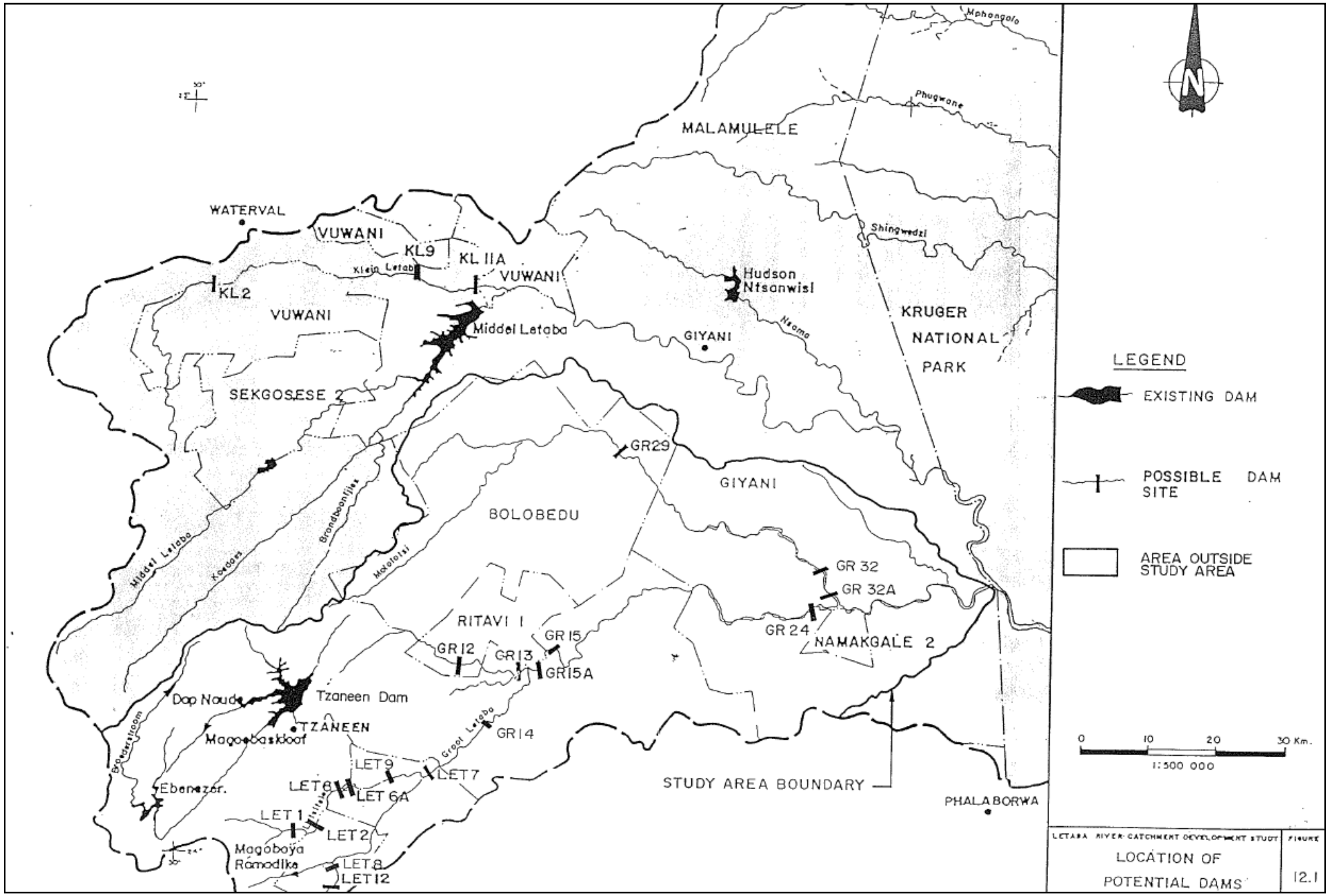


Figure 2-3: Locality Map of Dam Sites in the Groot Letaba River Catchment

2.6.8 Nondweni Weir

Report Title: LETABA WATER RESOURCE DEVELOPMENT PRE-FEASIBILITY STUDY: Module 10 – Nondweni Weir. Report No. PB 800/00/0994.RSA Department of Water Affairs and Forestry.Prepared by Steffen, Robertson and Kirsten Inc. Consulting Engineers (1994).

This module of the Letaba Water Resource Development Pre-feasibility study provides the preliminary details of the Nondweni Weir. It was expected that the yield of the envisaged weir would be negligible. The main purpose of the Nondweni Weir would be to address the lack of balancing storage and to stabilise supply at the lower end of the Groot Letaba catchment, and thus enable improved system management. It was noted that detailed design of the weir was already in progress and construction was expected to start in the last quarter of 1994.

The high potential for the weir to silt up in a relatively short period and hence the need for sediment control measures, and the impact on riparian vegetation, are the major issues of concern that were discussed in the report.

2.7 LUVUVHU RIVER DAM FEASIBILITY (1997)

2.7.1 Overview

The main aim of the Feasibility Study was to determine the feasibility of a scheme for augmenting primary water supplies to the region, to stabilize water supply for irrigation and to alleviate water shortage problems in the Kruger National Park.The Luvuvhu river dam feasibility study has been divided into 21 reports which were reviewed as indicated in the following sub-sections.

2.7.2 Main Feasibility Report

Report Title: LUVUVHU RIVER DAM FEASIBILITY STUDY: Main Feasibility Report. Report No. PB A900/00/3990.Prepared for: Department of Water Affairs and Forestry.Prepared by LDC Consortium, February 1997.

A small portion of the Luvuvhu river catchment has an average rainfall in excess of 2000mm per annum, decreasing to about 400mm in the east and the west. If the river is adequately harnessed there are sufficient water resources available to meet the domestic water requirement of the area until at least the year 2020, provided for present forestry and irrigation use maintain riverine ecosystems. With this in view the Department of Water Affairs and Forestry initiated a study to determine the viability of various water resource development options to

- Augment domestic water supply,
- To alleviate water shortage problems in the northern Kruger National Park, and
- To stabilize water supply to irrigation. It is proposed that a major new dam be built in the Luvuvhu River at Mutoti and that bulk water infrastructure be expanded to meet future requirements.

During the study it became clear that that a proposed dam on the Lutanandwa River intended to augment water supplies to Louis Trichardt would not be economically viable. It was proposed that Louis Trichardt also be supplied by pumping water from the Mutoti Dam to the existing water supply infrastructure at the Albasini Dam.

It was recommended that the proposed Government Water Scheme was to be constructed in two phases. Phase 1(1997 to 2000) should include construction of Mutoti Dam, the treatment works, pump stations, pipelines and bulk reservoirs. Phase 2 (2008 to 2009) will include expanding and upgrading the treatment works, pump stations and bulk reservoirs.

It was also proposed that a water resource management body representative of stakeholders and under the argues of DWAF be formed to ensure the equitable supply of water to the various users sectors. It was necessary for Central Government to implement the new bulk water distribution system.

2.7.3 ANNEXURE 1: Engineering: Feasibility design Reports: Volume 1 to Volume 3

2.7.3.1 **Volume 1**

Report Title: LUVUVHU RIVER DAM FEASIBILITY STUDY. ANNEXURE 1. ENGINEERING: FEASIBILITY DESIGN REPORTS. Volume 1 – Engineering Design of Proposed Dams in the Luvuvhu River and Lutanandwa River. Department of Water Affairs and Forestry, South Africa. Prepared by LDC Consortium. February 1997.

Volume 1 comprise of:

- Engineering design of proposed dams in the Luvuvhu River and Lutanandwa River — Report No PB A900/00/4090
  - Beraming van vloedspitse te Mutoti terrein in die Luvuvhu rivier — Report No PB A900/00/4190
  - Beraming van vloedspitse te Lutanandwa terrien — Report No PB A900/00/4290

Volume 1 comprise of three technical reports of a set of 21 technical reports in seven annexures to the Main Feasibilty Report (PB A900/00/3990). The development proposals for the Luvuvhu River Basin are given in the Main Feasibility Report. In developing the proposals the Mutoti Dam in the Luvuvhu River and the Lutanandwa Dam in the Lutanandwa River was investigated. Report PB

A900/00/4090 covers the feasibility level design of the Mututi and Lutanandwa Dams and the associated infrastructure (water treatment works, bulk pipelines and bulk storage reservoirs, weir at Xikundu downstream of the Mutoti Dam, etc). Reports PB A900/00/4190 and PB A900/00/4290 cover the calculation of peak storm runoff discharges at the two dam sites.

2.7.3.2 **Volume 2**

Report Title: LUVUVHU RIVER DAM FEASIBILITY STUDY. ANNEXURE 1. ENGINEERING: FEASIBILITY DESIGN REPORTS. Volume 2.Department of Water Affairs and Forestry, South Africa. Prepared by LDC Consortium. February 1997.

Volume 2 comprise of:

- Mutoti Dam: Leengebied Ondersoek — Report No PB A900/00/4390
- Mutoti Dam Sites: Thohoyandou District: First Engineering Geological Reconnaissance Report — Report No PB A900/00/4490
- Lutanandwa Damterrein: District Soutpansberg: Eerste Ingenieursgeologie Verkenningsondersoek — Report No PB A900/00/4590

Volume 2 comprise of three further technical reports of a set of 21 technical reports in seven annexures to the Main Feasibilty Report (PB A900/00/3990). The development proposals for the Luvuvhu River Basin are given in the Main Feasibility Report. In developing the proposals the Mutoti Dam in the Luvuvhu River and the Lutanandwa Dam in the Lutanandwa River was investigated. The reports cover the geotechnical investigations carried out at the two dam sites.

2.7.3.3 **Volume 3**

Report Title: LUVUVHU RIVER DAM FEASIBILITY STUDY. ANNEXURE 1. ENGINEERING: FEASIBILITY DESIGN REPORTS. Volume 3 – Preliminary Design of Water Purification Works. Report No. PB A900/00/4690.Department of Water Affairs and Forestry, South Africa. Prepared by LDC Consortium. February 1997.

Volume 3 comprise of one technical report of a set of 21 technical reports in seven annexures to the Main Feasibilty Report (PB A900/00/3990). The development proposals for the Luvuvhu River Basin are given in the Main Feasibility Report. In developing the proposals the Mutoti Dam in the Luvuvhu River and the Lutanandwa Dam in the Lutanandwa River and associated infrastructure (water treatment works, bulk pipelines and bulk storage reservoirs, weir at Xikundu downstream of the Mutoti Dam, etc) were investigated. Report PB A900/00/4690 covers the preliminary design of proposed water treatment works at the Mutoti Dam and the Xikundu Weir. Aspects covered by the report are the water quality of the water to be treated, the expected water demand and volumes to be treated, the design concept for the two treatment works, treatment processes, electrical supply and telemetry, personnel and operational requirements and cost estimates and financial implications.

2.7.4 ANNEXURE 2: Water Resources System Analysis of the Luvuvhu River

Report Title:LUVUVHU RIVER DAM FEASIBILITY STUDY: Water Resources System Analysis of the Luvuvhu River: Annexure 2. Report Number PB A900/00/4790. The RSA Department of Water Affairs.Prepared by LDC Consortium. February 1997.

Yield analyses were conducted for both the Albasini Dam and Vondo Dam for present day scenarios. The present inflow record of Albasini Dam was updated and two yield analyses where conducted:

1. Yield determination of Albasini Dam for primary use i.e. all irrigation downstream of the dam was ignored. The yield was determined as 5.1 million m^3/a.
2. Determination of the amount of water available for irrigation with 90% reliability if 2.4 million m^3/a is supplied at 100% reliability to the domestic users. It was found that if irrigation demand was 7 million m^3/a, deficits occurred only 10% of the time.

Frank Ravelle Dam is situated upstream of Vondo Dam and supplied water to Sapekoe Estates. The dams' firm yield was found to be 1.0 million m^3/a using Sapekoe monthly irrigation distribution. Vondo Dams primary firm yield was estimated by operating Frank Revelle Dam at its firm yield and supplying an additional 1.4 million m^3/a to Sapekoe. The Sapekoe full quota from Vondo Dam was supplied only when the dam storage was above 90% FSC and 50% of the demand was supplied when below 50% storage. The primary firm yield of Vondo Dam was 13.3 million m^3/a under these conditions.

The following future scenarios were also investigated:

- Reallocation of water for Albasini Irrigation Scheme from Albasini Dam to the Proposed Lotanyanda Dam. The assurance of supply to all irrigation from this proposed scheme was slightly better than present conditions.
- Yield analyses at Mutoti Dam

Three points on the Luvuvhu River were identified as IFR points and the flow values necessary to maintain the river ecology during normal years and absolute monthly minimum water required for survival were derived. The above scenarios were repeated to determine the probability of meeting the environmental demand.

2.7.5 ANNEXURE 3: Biophysical aspects ROIP and IFR Reports: Volume 1 to Volume 4

The ROIP2 report summarises the work done during the ROIP1 as well as the Pre-feasibility phase. Investigation was done into the inundation caused by the Mutoti dam, the advantages and disadvantages of the dam on the environment, and the further work required during the following stages.

2.7.5.1 **Biophysical Impacts**

The most severe Biophysical Impacts are discussed below.

2.7.5.1.1 Inundation of the vegetation in the Mutoti Dam basin

Two sites were investigated for the proposed Mutoti Dam wall during the feasibility study. Based on the downstream dam wall option, a vegetation study was done on the dam basin. Between the two dam wall options, a large percentage of the Red Data plant species and new distributions of species were found. It was stated that many of the Red data species can be removed, and that the present degradation will continue to a similar degree as the surrounding areas even if the dam was not built. The upstream dam wall option was recommended as the preferred option. Using this option, and after mitigation measures, this impact was considered to decrease to acceptable levels.

2.7.5.1.2 Downstream change in flow regime

The construction of the dam is considered to have a severe impact on the downstream area. Currently the utilisation of water during the low flow months are degrading the river and increasing the cessation of flow. The dam would worsen the situation, and since the downstream area is importance, mitigation would have to be implemented with a high assurance level. The mitigation measures recommended is to release IFR to the downstream area.

Between 1994 and 1996, and IFR study was undertaken and refined to determine the river requirements. The IFR study aimed to manage flows from the Mutoti Dam site to the Limpopo River confluence so that a perennial flow regime is reinstated. It also aimed to ensure the long term conservation of riparian vegetation, aquatic biotica, and the sustainable use of resources by the rural population. The unique natural character of the Luvuvhu River flows had to be maintained.

The results of hydrological modelling indicated that the dam can supply the IFR, which would cause the river status to improve compared to the current situation. The system would degrade even further if uncontrolled utilisation continues and the dam is not built. Therefore, if the IFR is supplied at a high assurance level, then the impact would be mitigated sufficiently. A monitoring program that ensures the required results are obtained is imperative.

2.7.5.1.3 Local impacts caused by construction

The report states that direct and secondary impacts such as erosion, noise and dust pollution, aesthetic degradation, exotic vegetation encroachment and poaching are some examples of disturbances that will be caused by the dam construction. Mitigation is recommended in the form of the implementation of an Environmental Management Plan which addresses the above impacts. After mitigation, serious impacts are not expected.

2.7.5.1.4 Continuous flow downstream of the dam to Xikundu Weir

A continuous flow of about 0.2 m^3/s is required to be released from the dam to Xikundu Weir for abstraction during the operation of the dam. Such a continuous flow will negatively impact aquatic communities. It could also cause in increase in pest species such as the black fly. The mitigation measure is to release the IFR together with the abstraction flow so that there is some variability of flow in the system. Acceptable levels of the impact will then be reached.

2.7.5.1.5 Barrier effect of Xikundu Weir

Xikundu dam was an option considered during the Pre-feasibility study. From the Xikundu dam site, fish need to move upstream to the Mutshindudi River. However, the proposed dam wall would prevent fish movement and therefore from an ecological viewpoint, this option was found to be unacceptable. Mitigation measures were not possible in the case of the Xikundu dam.

The same impacts as described above are valid for the Xikundu weir as they are situated in the same locality. Mitigation is possible in this case however, because the Weir has a lower wall, which will allow a fish ladder to be built. Fish movement will therefore be able to continue, and the impact will be within acceptable limits.

2.7.5.2 **Social Impacts**

There are a total of 360 residential stands either within or too close to the full supply level of the dam. There are 4 access roads that will be flooded, 3 of which cannot be bridged. The relocation of about 22 graves is required, and negotiations are on-going.

Some properties cannot be relocated, and compensation may be the only solution. If this is the case of the brickyard for example, about 40 workers would be unemployed. The dam would also result in good riparian agricultural land to be lost. Since such land would be difficult to replace, special mitigation would be required such as the irrigation of poorer soils or intensive agriculture.

The land that will be inundated has rich historical areas. If the recommended mitigation measures are implemented, and the studies and surveys on the archaeological sites are applied, then the impact after mitigation is considered acceptable.

Although there is a large social impact, it is lowest compared to the other sites considered during the Pre-feasibility study.

If all mitigation measures are adhered to, the biophysical and social aspects are acceptable.

2.7.5.3 **Environmental Impacts**

Three schemes are intended to be supplied by the project, which all require pipelines. These are briefly discussed below:

- From the Albasini Dam, the Louis Trichardt/Levubu Irrigation water scheme will be supplied. However, the proposed Latonyanda Dam is closer to the scheme, and may become the preferred source. From the dam, approximately 4.5 km of pipeline is required to supply the irrigators.
- The Vondo Regional Water Supply Scheme provides water from the Vondo dam to Thohoyandou and surrounding areas. It is proposed to upgrade the scheme by providing additional supply from the proposed Mutoti Dam to Thohoyandou. By the year 2000, the distribution network will require upgrading.
- The Mutoti Dam Water Supply Scheme requires pipelines from the Mutoti dam and purification works to five locations. These are: 59 km of pipeline to the Malamulele West Water Supply Scheme, 110 km of pipeline to the Malamulele East Water Supply Scheme, 16 km of pipelines to Thohoyandou and environs, 29 km of pipelines into the Malamulele East network, and the existing Ka-Mhinga Water Supply Scheme.

The most severe negative impacts related to the proposed development include the temporary inconveniences to the local people and road users, as well as the loss of some areas that fall within the servitude.

Advantages include a reliable supply of water to farmers and the greater population in the area, a temporary economic uplift during the construction of the pipeline, and the upgrading of existing water supply infrastructure.

It is recommended that a public participation process is followed before the acceptability of the project is determined. Once the acceptability of the project has been determined then the route of the pipeline should be finalised in consultation with the affected parties. Suitable compensation measures should be investigated. An environmental management plan and rehabilitation guidelines should be compiled for the construction of the pipeline. The contractor and labourers should be made aware of all the ecological and social impacts of the project. The feasibility of a programme to prevent an increase of invasive terrestrial plants should be investigated.

A report on the Luvuvhu River IFR Workshop as well as the IRF refinement and monitoring protocol is available in Annexure 3.

2.7.6 ANNEXURE 4: Sociological aspects: SIA Reports: Volume 1 to Volume 2

Report Title: LUVUVHU RIVER DAM FEASIBILITY STUDY: Sociological aspects: SIA Reports: Volume 1 to Volume 2: Annexure 4. Report Number PB A900/00/6790 andPB A900/00/6790. The RSA Department of Water Affairs.Prepared by LDC Consortium. February 1997.

The Social Impact Assessment of the proposed dams in the Luvuvhu River and Lutanandwa River was undertaken in 1997 and comprised of two volumes. The Social Impact Assessment included an evaluation of the geography, anthropology, archaeology, health aspects and socio-economic activity in the study area. The influence of a dam on these parameters, and therefore on the residents and economy of the area, was identified. The study objectives entailed:

- Assessment of resources, property, graves, sacred and historical places to be inundated
- Identifying benefits and disbenefits of the proposed system
- Identifying alternative settlement areas
- Recommending ameliorative measures to compensate for resource loss

Key aspects noted from the **Lotonyanda Dam** site analysis, evaluation and assessment are:

- No villages and other developed properties are affected.
- Land use type: mostly subtropical fruit farms above the FSL and no houses in the basin. Possible damage to orchards by access roads, borrow pits, etc during construction. Four farmers will need to be compensated as parts of their properties will be submerged, two of which farms will be cut apart leaving uneconomical remainders on the eastern shore. Safcol will lose a small section of their blue gum plantations. The citrus and avocado farms are both above the FSL. Compensation would only need to be for undeveloped property which will be submerged.
- Infrastructure damaged: rerouting of the R524 road and two low water bridges which could be costly due to expropriation costs and disruption of traffic
- The telephone mainline to Venda and a power line crossing the basin to the nut shed will have to move. One access road in the extreme western section of the tributary will be flooded. The canal servitude road and the canal itself will be submerged.
- Health profile indicates sexually transmitted diseases, tick fever, and possible snakebites.
- No exploitation of natural resources worth mentioning except for irrigation water used by a

number of farmers on the Lotonyanda Canal system whom do not wish for interruptions during construction.

- Cultural/historical: difficult to survey the area archaeologically, although one Stone Age, two Iron Age and one Historic site was found, although these seem insignificant and no mapping or further work is required.
- Aesthetics and regional effects: aesthetically important area. The dam is believed to enhance borehole water which could create opportunities for entrepreneurs. Temporary jobs will be created during construction.
- Care to be taken about pollution on crops sensitive to dust and chemicals
- Siting of camps, borrow pits, pumping station etc require consultation with affected farmers around the basin
- Game snaring and fires are problems to be experienced where construction takes place

Key aspects noted from the **Mutoti Dam** site analysis, evaluation and assessment are:

- Villages and developed property severely impacted: Mulenzhe village is severely impacted as almost 75% of the village is to be relocated; Budeli village requires approximately 70 residential stands as well as other developments to be relocated; Mutoti temporarily affected during construction (noise, heavy vehicle traffic, dust, etc) but also permanently from collecting water from the river and bathing and relocation of 8 residential stands (24 huts). Vegetable gardens and extensive fenced maize fields will be lost to the west; the Brickyard employing 25 women will be flooded and cannot be relocated (sand, soil, clay perhaps not same quality); the Brickyard at Tshiulongama near the bridge is close to the FSL and clay may become too wet for use; Madzhivandila college: 300 soft citrus trees, 500 orange trees; 200 mango trees and 10ha cultivated land in the floodplain will be lost including fences, gates, 2 farmhouses, water pipes, etc; Thsiulongoma village (and the next four villages) will lose 30 residential stands, 250 mango trees, maize fields, etc; Dididi village will lose expansive maize fields in the floodplain and 15 residential sites; Maniini village: 10 residential sites and maize fields; Makhovha village: 10 residential sites. Tswinga village: possible 10 residential sites threatened.
- Low/indirect impacts on villages: Mphego, Dovheni, Khakhanwe, Dumasie
- Settlement/type and land use: all villages are dense, grid settlements, communal street taps, and subsistence agricultural communities with individuals working elsewhere (migrants or work in Thohoyandou). Most of the areas are used for grazing and cultivated

land occupies a smaller portion of the area. No extensive irrigation schemes exist (bar the college farm). All villages are part of the Dry Land Maize Production Project. During the 1960's one Morgan arable land was allocated to each residential stand. Crops grown in the basin include: Maize 59%, vegetables: 15%, peanuts: 15%, fruit: 11%, and other 4%. Family size is mostly six, 40% of which are between 20 and 40 years of age. Sometimes extra labour is hired in the village. The majority of villagers (76%) own cattle and goats, 71% only have residential stands, while 24% own or work between 1-5 acres of land, and 5% own/work more than 5 acres of communal/tribal fields.

- New developments: Maniini application for 60Ha of poor grazing area to be used for maize growing, and Mulenzhe earmarked for DBSA Famer Support Programme. Dididi (211ha) and Makhovha (125ha) are included in the Dry land project. At Mutoto, the cattle improvement scheme is restructuring cattle farming and a 17ha food plot scheme for irrigated cash crops is being planned by the IDT. Mulenzhe cattle farmers have applied for RDP funds to upgrade cattle similar to Mutoto. Irrigation farming possibly to begin at Mphego (fruit farms) which is another IDT project. The dam would impact the above by reducing areas reserved for these projects.
- Social components: 76% female; 55% over 40 years of age, 35% between 20-30 years; average family size is 6 members; 52% illiterate and 24% have standard 6-9; 86% earn less than R500 per month
- Infrastructure damaged: access road and bridges linking north-south villages and many footpaths; shifting power lines and telephone lines. Destruction of commercially exploited sand in the basin. Two commercial brickyards and three communal brickyards to be inundated. A few orchards, most of the maize fields and subsistence vegetable patches along the river will be flooded. At least 8 riffles used for washing will be lost. Boreholes and water pumps will be submerged as well as 75% of the Mulenzhe village.
- Due to limited planning and poverty in the area, there is wastage of resources and lack of preventing disease. Pit and open 'bush' toilets will have to be neutralised to avoid contamination of water presently causing protozoal, bacterial, fungal and streptococcal infections. No planned disposal of solid and liquid waste in villages. This is an endemic malarial region. Bilharzia is also endemic and most locals are infected. Protection for construction workers is necessary. Crocodile attacks for locals and construction workers are perhaps one of the most dangerous situations.
- Exploitation of natural resources: trees used for firewood, woodcarvers occasionally collect dry wood for their art. Building contractors/brickyards/sand merchants/villagers use clay, sand and soil for building purposes. Little evidence of medicinal plant collection. Spinach is

collected in winter. Termite harvesting is evident.

- Cultural/historical/archaeological: initiation schools not confirmed but cairns were found to substantiate such practices; 15 ancestral graves in Mulenzhe and at least 7 other recent graves. Another 11 old graves were found. Archaeologically the area provided habitation from Middle Stone Age to recent. Fewer sites occur to the west of Mutoti and these are more damaged and disturbed. Resettlement areas will have to be surveyed before relocation.
- Aesthetics and regional effects: area close to the dam wall is aesthetically pleasing as are most of the tributary valleys on the south side. Accessible areas are being deforested and overgrazed. The dam will provide reliable, safe and health source of water, raise standards of living by creating more jobs (permanent and temporary) and by stimulating better agricultural practices. Modest opportunities for tourism can be created. A better infrastructure will be created during and after construction (power, telephones, reticulated water, upgrading of dirt roads).

Numerous annexures with more detailed information regarding tourism potential, health, anthropology, etc exist.

In Volume two, detail descriptions of archaeological sites marked in areas where the concentration of tools appeared high enough by comparison to the immediate surrounds is provided.

In the **Mutoti dam** basin 67 such sites have been detailed upon. The spread of sites in the Mutoti dam basin reveals that the greatest number of sites occurs closer to the dam wall and as one moves upstream these become fewer. The upstream sites also tend to be more damaged, which could be as a result of being closer to Thohoyandou, with an increase in local population requiring areas to live in and cultivate. In cases, the suggested cultural period is based on personal feeling and experience rather than on facts due to a lack of suitable diagnostic materials. The cross-section of time corresponds well with the Middle Stone Age. Early Iron Age sites require future mitigation work. The iron working sites are far more common than expected and comparisons will be made with the known sites further to the south, particularly with those that contain the so-called Venda furnace. The Moloko Potter tradition deserves further work and links of this culture with early Venda have been suggested by some authors, particularly when referring to Sotho element in the Venda culture and language.

The study revealed that the **Latonyanda dam** basin was exceedingly more difficult to survey due to dense grass and bush covering. In view of the fact that the area is a farming areas, and that local labour consists of a variety of culture groups, one cannot say with certainty that it would only be Venda-speakers that would have left any recent (since 1920) remains. A total of four sites in Latonyanda dam basin area were detailed upon. These sites do not have any unusual features or cultural material that is not found elsewhere and it is not worth the time to try to mitigate any of the sites found.

2.7.7 ANNEXURE 5: Water Quality of the Luvuvhu River

Report Title: LUVUVHU RIVER DAM FEASIBILITY STUDY: Water Resources System Analysis of the Luvuvhu River: Annexure 5:Water Quality of the Luvuvhu River. Report Number PB A900/00/5990. The RSA Department of Water Affairs.Prepared by LDC Consortium. February 1997.

The main aim of the Water Quality report was to determine the “fitness for use”, in terms of water quality, of the water for all potential water users of the proposed Mutoti and Latonyanda Dam sites and at the Xukundu weir.

The assessment was based mainly on six constituents: TDS, EC, pH, NO_3/NO_2 as N, Cal and PO_4 which were rationally selected. Based on these, the above mentioned sites were generally deemed to be fit for use for all potential water users. The shortcoming of the assessment was that no data were available for bacteriological quality, although the water was assumed to be safe for domestic use based on the proposed treatment. On evidence of increasing concentration trends in some of the constituents, it was anticipated that the water quality would deteriorate in future, signifying a likely decline in the state of the river for the coming years.

A water monitoring programme was suggested for implementation since construction activities were foreseen to have an impact of the aquatic environment. The trapping of sediments and their associated nutrients from flood waters was seen as a major impact on water quality downstream of the impoundments.

The data sources of this study included various reports on the Luvuvhu River Basin, records and files of the DWA regarding water quality monitoring systems and visual site investigations.

2.7.8 ANNEXURE 6: Agriculture Development associated with a dam on the Luvuvhu River

Report Title: LUVUVHU RIVER DAM FEASIBILITY STUDY: Annexure 6 – Agricultural Development Associated with the Dam on the Luvuvhu River. Report No. PBA900/00/5990. Department of Water Affairs and Forestry.Prepared by LDC (Luvuvhu Development Consultants) February 1997.

The objectives of this study is to establish the potential of developing more appropriate agricultural models and to assess the viability and local acceptability of any proposed new development in the affected areas.

A detailed status of existing irrigation schemes in the study area is provided where schemes could benefit from water supplies from the Mutoti dam. The schemes visited include: Mhinga Xikundu estate, Lambani, Tshaulu, Paswane, Tshikonelo, Malavule, Matsike, and a number of small community development schemes.

Some of the established schemes, particularly in the former Venda, appear to have adequate water for existing developments, although most of the schemes suffer from inadequate water supplies at certain times during the year which limits year round irrigated crop production.

Wide fluctuations in crop production yields across the various schemes have been noted which is also ascribed to management aspects. A direct relationship between standard of production and the level of extension and training provided was evident.

Approximate yields obtained by the better growers where adequate irrigation was available are:

- Maize: 3-4 tons per hectare
- Sugar beans : 2-2.5 tons per hectare
- Groundnuts (unshelled): 2-4 tons per hectare
- Cabbages: 15-20 tons per hectare
- Tomatoes (factory): 40 tons per hectare
- Sweet potatoes: 40 tons per hectare
- Bananas: 40 tons per hectare

Existing dry land cropping patterns reveal that in the dam basin 81% of families own tribal land, 71% of these only have housing stands. The bulk of the remainder own between 0.4 to 2.0 ha and the majority of these (86%) only cultivate 50-75% of their land. The bulk of the production is for home consumption and less than 5% for sales. Department of Agriculture staff indicate that yields have varied between zero and 1.2 t/ha of maize and 1t/ha of groundnuts/beans. Annual crop yields on irrigation schemes appear little better, probably because only minimal irrigation has been possible.

The non-availability of adequate labour during certain times of the year could be a serious constraint to irrigation development in the area.

With regards to existing support services, the study found that traditionally extension advice has been provided by the Venda and Gazankulu Government, Departments of Agriculture, and by Argive and the Gazankulu Development Corporation. These have been incorporated into the Northern Region and Lowveld Region. No farmers interviewed, however recalled ever obtaining assistance.

Farmers already active in irrigation were positive about the prospects of increased irrigation in the area. However due to low education levels there is little understanding and appreciation of modern farming practices.

Soil suitability was focussed on the area downstream of the Mutoti dam. Due to anticipated economic constraints, it was considered that irrigation development should only be considered within two kilometres of the river and at elevations less than 40 m above the riverbed. Estimates in the pre-feasibility report indicated that approximately 7000ha of potentially irrigable land existed between Mutoti dam and Kruger Park (Luvuvhu Development Consultants, 1995). In this study a total of 2 383 HA of irrigable soils were broadly identified. Of these 1085ha encompass existing irrigation schemes, while the remaining 1298 ha represent areas where new irrigation could be developed. This includes 330 ha on the Sisal estate.

Various irrigation development proposals are made with regards to crop selection, plot size allocations (food plots and large commercial size ventures), farmer viability (with gross margins of recommended crops), development phasing, etc.

The study is concluded with essential recommendations during early implementation relating to components such as: soil survey, supplementary water requirements, farming model development, training needs and extension, agro services, land use, and scheme management.

2.7.9 ANNEXURE 7: Economic and Financial aspects of development in the Luvuvhu River

Report Title: LUVUVHU RIVER DAM FEASIBILITY STUDY: Annexure 7–: Economic and Financial aspects of development in the Luvuvhu River. Report No. PBA900/00/6090.Department of Water Affairs and Forestry.Prepared by LDC (Luvuvhu Development Consultants) February 1997.

Part 1 of the Annexure deals with Benefit Cost Analysis of Primary Water Supply. The objective of study is to assess the feasibility of the primary water supply project in the Luvuvhu River. The analysis mainly deals with the supply of primary water, although water allocations will also be made to the agricultural sector and for ecological requirements.

The methodology followed for the economic impact of the proposed development was done in accordance with the Manual for cost benefit analysis of the Central Economic Advisory Service. Three alternative approaches, namely: opportunity cost, next best alternative, and determining the various consumer types/groups and their willingness to pay for water was utilised. The last mentioned was revealed as the most acceptable and was used further in the analysis.

Projected population is a key issue in the analysis and the following projected population increases were applied to the most recent population numbers for each sub-region:

Table 2.24: Levuvhu population figures (1997)

Sub region	1995-2000	2000-2005	2005-2020
1,2,4,5,6,7	2.45%	2.65%	2.04%
3	4.99%	4.51%	3.85%
8	4.30%	4.10%	3.03%
9	4.48%	4.39%	3.41%
10	4.30%	4.10%	3.03%
11	4.30%	4.10%	3.03%
12	4.41%	4.10%	3.09%

The total population in the study area was 672 000 in 1995 and was expected to increase to 806 000 by 2005, 964 000 by 2005, 1 111 000 in 2010, and 1 484 000 in 2020.

Various assumptions were made regarding the anticipated changes in service levels in the various sub-regions such as phasing out of communal taps, increase in private connections, etc. Assumptions on unit consumption levels in litres per capita per day were also considered.

The total water consumption per sub-region was determined according to the projected population numbers, the consumption per capita in each service level and the number of households in each service level. The water consumption for 1995 is set at 16, 6 million m^3 and is estimated to increase to 27, 02 million m^3 in 2000, 34, 47 million m^3 in 2005. The water consumption is also presented according to the user groups. Average water consumption per capita will increase from 67 litres per day in 1995 to 109 litres by 2020.

The major capital expenditure (at 1995 price levels excusive of VAT) components entail:

- Mutoti Dam at R201,774 million with a three year construction period
- Purification works at Mutoti and Xikundu with expenditures of R95, 114 million and R32, 071 million respectively.
- Bulk pipelines with and reservoirs with capital expenditures of R81,505 million and R54,900 million respectively
- Relocation costs of R67,477 million

- Water supply infrastructure and village reticulation at R41,231 million and R45,146 million

The annual operating costs including maintenance, labour, fuel, and chemicals, etc amount to approximately R3,041 million in 1999 up to R5,823 million in 2020.

Cash flow projections were then based on the inflows, which are compiled from the shadow water price and the outflows, which consist of the initial capital expenditure, replacements of capital items and operating costs.

The shadow price for water was determined on the basis of the willingness to pay principal. The household income for Thohoyandou district was determined for urban and rural areas, in a survey undertaken in 1991. This was adjusted to 1995 with the Consumer Price Index. An urban household income of R3 276 per month and a rural household income of R 676 per month were applied. The assumption was made that households in rural areas will be in a higher income category and 40% of the urban income was used. The DBSA apply various percentages of household income to determine willingness to pay, which is based on results from other primary water use studies. The willingness to pay for urban consumers with full services is about 5% of household income, while for rural households with full services and private connections, the figure is 2.3%. A norm of 2% was used for rural households with yard taps and 1, 7% for communal taps.

Applying the aforementioned with the planned consumption levels of the various consumer groups, the shadow water price for each group was determined as shown in **Table 2.26** below:

Table 2.25: Shadow water price for the Levuvhu River catchment (1997)

Average for each service level	Household income R/Month	Willingness to pay %	Value R/month	Consumption m^3/family	Shadow price R/m^3
Urban full services	3 276	5.0%	163.8	54.9	2.98
Rural full services	1310	2.3%	30.1	29.7	1.01
Rural private connections	696	2.3%	16.0	18.9	0.85
Rural with yard taps	696	2.0%	13.9	11.7	1.19
Communal taps	696	1.7%	11.8	6.3	1.88

Note that the willingness to pay reflects the value which the consumer places on the service and it will vary between different members of the same community and between rural and urban users and types of installations which users have.

The shadow water price for each user group was related to the incremental water consumption of each group to determine the total annual income. Income and cost streams were prepared for a period of 45 years all at constant 1995 prices. As relative large capital expenditures will be made during the first four years, negative cash flows will be experienced in these years.

The projects evaluation results are presented in **Table 2.27** hereunder:

Table 2.26: Projects Cost Evaluation Results in the Levuvhu riber Catchment (1997)

Item	Economic analysis	Financial analysis
NPV of inflows (R'000)	692 643	692 643
NPV of outflows (R'000)	478 496	603 765
NPV net flows(R'000)	214 047	88 878
IRR %	7,7	5,99
BCR	1,45	1,15

The calculations used as tabled above are Net Present Value (NPV) at a discount rate of 5%, the NPV of the inflows and outflows, as well as the net flows. The Internal Rate of Return (IRR) and the Benefit Cost Ratio (BCR) was also determined.

The economic analysis indicates a NPV of R214 million over a 45 year period. The project has an IRR of 7.7% and a BCR of 1, 45. The study reveals that the proposed water development at Luvuvhu is thus feasible, the IRR is higher than the costs of capital, a positive benefit cost ratio is possible and a positive NPV at a 5% discount rate can be achieved. This excludes other use activities, in which event the IRR could increase to 8.5%, the BCR 1, 58 and a NPV of R255 million.

A sensitivity analysis was also conducted to conclude the study.

2.8 GROOT LETABA WATER RESOURCE DEVELOPMENT FEASIBILITY STUDY (1998)

2.8.1 Overview

This study was focussed on the feasibility of resource development in the Groot Letaba River, upstream of the Klein Letaba confluence and the Kruger National Park.The study was focused on the feasibility of resource development in the Groot Letaba River, upstream of the Klein Letaba confluence and the Kruger National park. A detailed water resource investigation of the Klein Letaba River was being undertaken separately at the time. The Groot Letaba water resource development feasibility study has been divided into 9 reports which are reviewed in the following sub-sections.

2.8.2 Volume 1: Main Report

Report Title: GROOTLETABA WATER RESOURCE DEVELOPMENT FEASIBILITY STUDY: Main Report. Report No. PB 810/00/0298.Prepared for: Department of Water Affairs and Forestry.Prepared by BKS Consultburo, 1998.

The feasibility study commenced in 1996 with Terms of reference based on the outcome of a pre-feasibility study.The objective of the study was to further investigate the options defined in the Pre-Feasibility Study for developing a water source/s in the Groot Letaba River or its tributaries to augment the water supply.Prefeasibility investigations found that further resource development in this, already heavily developed river system was probably still attractive and indicated that the feasibility of the following should be investigated further:

- The raising of the Tzaneen Dam
- Nwamita Dam on the Groot Letaba River
- Dam on the Letsitele River at Hobson’s choice site.

In evaluating these options, findings and recommendations of the study were reached in an incremental fashion with considerable attention having been paid to stakeholder review, specific attention was paid to new issues, changing circumstances and innovative approaches. Options for meeting water supply objectives from existing infrastructure, resorting to demand management, more effective use of facilities and reallocation of available supplies were considered. It was recommended in this report that nevi major be built in the Groot Letaba River and those proposals by the Groot Letaba Main Irrigation Board to raise Tzaneen Dam to be viewed sympathetically as detailed in the following findings:

A. <u>Main findings:</u>

It was clear that creation of a major storage dam on the most attractive site in the Letsitele River in order to increase the availability of water for primary use and to update the riverine ecology would not be effective and would be unaffordably expensive. This finding was reached with the full and detailed participation of landowners, irrigations along the Letsitele river communities at Mogoboja who were initially very antagonistic. Irrigators along the Letsitele River have, as a consequence of participation in this investigation, once again stated their need for more irrigations water.

Investigations of the merits of raising Tzaneen Dam conducted for the Irrigation Board in association with this feasibility study indicated that this could result in significant economic benefits for the irrigation sectors with low risks of non-performance.

A benefit cost ratio of at least 3.5 and probably more than 4.0 has been estimated. In view of the fact that raising Tzaneen Dam is of sectoral interest and will not really contribute to alleviating the main problems associated with primary water supply and environmental management, it is recommended that DWAF adopt a sympathetic stance in relation to the requests already submitted by the Project Steering Committee and the Groot Letaba Main Irrigation Board. Raising of Tzaneen Dam, at a capital cost of between R12 million and 20 million, depending on technical requirements, is a short term project with prospects of early returns on investment and would not detract from the value of the proposed dam at Nwamitwa. A partnership with private sector financing is recommended.

Creation of a new major storage dam in the Groot Letaba River just below the confluence of the Nwanedzi River is the only remaining option for increasing the availability of water to the extent necessary to meet the objectives in relation to primary water use, environmental management and irrigation. The position of the possible storage dam has been referred to as Janetsi in previous studies and was referred to as Nwamitwa by stakeholders in this investigation.

The economy of irrigated agriculture, particularly citrus, plays a dominant role in evaluating development proposal because of the importance of this sector to the economy of the region and the sensitivity of water availability for irrigation, and hence production, to allocations for other user groups. For this reason the analytical approach was based on estimating the availability of water for irrigation on a monthly basis over a long period for each development option. Water availability was translated into crop yield and through detailed information on crop yield, production costs, processing costs, marketing costs and income is available from sources.

Primary water requirements enjoy highest priority in the need for improving the system but present particular difficulties in assessing the value of the benefits. The principle of willingness to pay (as opposed to ability to pay) was adopted to assess the value of water used in this sector. Since compliance with policy objectives and legal requirements in relation to reserving water for other user sectors, particularly irrigated agriculture in this case, an opportunity value was assigned to the reserve. As a conservation approach, 80% of the present average gross margin for citrus was assigned to the reserve. The value adopted was R2,472 per m^3.

Cash flow sequences of income and expenditure were expressed in constant 1996 terms and discounted to a base date and a standard 8% p.a. Sensitivity tests are made for 6% and 10% p.a.

B. <u>New resource development:</u>

An important finding from an analysis of the option which assumes (a) no further water resource development, (b) fully satisfies increasing primary water requirements and (c) does not comply fully with the “environmental reserve” is that the economy of the region will suffer serious damage. The cost to the agricultural economy far exceeds the assessed benefit of increased primary use (BCR = 0.54). The economic implications expressed in these terms are far worse if the full reserve is made available.

A dam at Nwamitwa with a capacity close to the new MAR at the site would be most attractive in economic terms and suit physical constraints at the site. For the selected size of dam the benefits accruing from primary water use, availability of water for riverine ecosystems and positive impact on water availability for irrigation are marginally greater than the associated costs. A BCR between 1,10 and 1.25 indicates the marginal attractiveness of this proposal as does the associated IBR of 9,7%. These criteria indicate that the total impact on the economy will be about “break even”.

2.8.3 Volume 2: Water Requirement and System Analyses

Report Title: GROOT LETABA WATER RESOURCE DEVELOPMENT FEASIBILITY STUDY: Water requirements and System Analyses: Volume 2. Report Number PB B810/00/0398. The RSA Department of Water Affairs.Prepared by Consultburo and BKS. December 1998.

The objective of the study was to further investigate the options defined in the Pre-Feasibility Study for developing a water source/s in the Groot Letaba River or its tributaries to augment the water supply. Three feasible options from the Pre-Feasibility stage were identified for further investigation using latest and additional information:

- The raising of the Tzaneen Dam
- Nwamita Dam on the Groot Letaba River

- Dam on the Letsitele River at Hobson's choice site.

The water requirements and system analysis findings from the Pre-Feasibility Study had to be updated as a result thereof and the findings contained in this Task Report are improved estimates. However, present and future water requirements were determined using an estimated per capita water requirement value to present and possible future population since water used in most villages and towns in the study area were not measured.

The population, population growth rates and water requirements for different demand centres are shown in **Tables 2.28 to 2.30.**

Table 2.27: Population within Groot Letaba (1995)

MAGISTERIAL DISTRICT	POPULATION
RSA	
• Letaba 1	37 740
• Phalaborwa	185
• Pietersburg	3 350
Gazankulu (former)	
• Giyani	65 469
• Lulekari	1 220
• Ritavi 1	41 624
• Ritavi 2	91 251
Lebowa (former)	
• Bolobebu	164 911
• Namakgale 2	5 367
• Naphuno 1	70 376
Study Area Total	481 673

Population in main centres, but already accounted for in the above Table, is as follows:

- Tzaneen: 8 500
- Duiwelskloof: 1 700
- Letsitele: 600
- Ga-Kgapane: 8 700
- Nkowakowa: 16 100
- Lenyenye: 10 600
- Haenertsburg: 300

Table 2.28: Population Growth Rate Groot Letaba (1998)

Period	Population Growth Rate (% per year)		
	Low	Medium	High
1991-1995	2.61	3.11	3.61
1995 - 2000	2.57	3.07	3.57
2000 - 2005	2.53	3.03	3.53
2005 - 2010	2.36	2.86	3.36
2010 - 2015	2.12	2.62	3.12
2015 - 2020	2.03	2.83	3.03
Average	2.37	2.87	3.37

Table 2.29: Groot Letaba Urban Water Use Requirement Based on (*Scene 1 and 2 are for Moderate and High Population Rate, respectively*) (1997)

MAGISTERIAL DISTRICT	1995		2000		2010		2020	
	Scen 1	Scen 2	Scen 1	Scen 2	Scen 1	Scen 2	Scen 1	Scen 2
NAPHUNO 1	1.39	1.58	1.30	1.96	2.36	3.00	4.21	4.56
NAMAKGALE 2	0.08	0.09	0.08	0.11	0.14	0.17	0.25	0.26

MAGISTERIAL DISTRICT	1995		2000		2010		2020	
	Scen 1	Scen 2	Scen 1	Scen 2	Scen 1	Scen 2	Scen 1	Scen 2
BOLOBEDU	2.70	3.06	2.56	3.82	4.63	5.84	8.30	8.86
GIYANI	0.93	1.06	0.98	1.38	1.95	2.33	3.63	3.75
RITAVI 1	0.72	0.82	0.73	1.07	1.45	1.81	2.72	2.89
RITAVI 2	2.99	3.20	2.66	4.19	5.18	7.04	9.81	11.30
LULEKANI	0.02	0.02	0.02	0.03	0.04	0.05	0.07	0.08
RSA RURAL	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
TOTAL	8.82	9.83	8.34	12.57	15.75	20.24	29.01	31.73

MAJOR DOMESTIC WATER DEMAND CENTRES

TOWN	1995***	2000	2010	2020
TZANEEN	3.95	5.46	10.21	18.19
DUIWELSKOOF	0.32	0.41	0.66	1.08
LETSITELE	0.20	0.26	0.42	0.68
HAENERTSBERG	0.03	0.04	0.05	0.06
GA-KGAPANE	0.46	0.35	0.65	1.20
NKOWAKOWA	1.47	1.15	2.21	4.25
LENYENYE	0.51	0.42	0.77	1.39
POLITSI	0.14	0.14	0.14	0.14

* Bolobedu includes Ga-Kgapane

Ritavi 2 includes Nkowakowa

Maphuno includes Lenyenye

Several industrial water users occur in the study area and make abstractions from the Groot Letaba River systems. These are shown in **Table 2.31**

Table 2.30: Industrial Water Requirements

Industrial User	Water Requirements (million m^3/a)	Allocation Permit (million m^3/a)
Consolidated Murchison Mine	1.10	1.75
Letaba citrus Processors	0.24	0.24
Koedoe Co-Operative	0.002	0.10
Addington Farms	0.004	0.05
Sapekoe		0.30

The consolidated urban and industrial water requirements used in system analysis task of the study are shown in **Table 2.32**.

Table 2.31: Domestic and Industrial Water Requirements Including Transfers Out of the Groot Letaba Catchment into Polokwane (Pietersburg) (1997)

Location	Pre-feasibility	Demand in 10^6 m^3			
		1995	2000	2010	2020
Duiwelskloof, Politsi & GaKgapane	1.21	1.52	2.98	3.82	5.16
Sapekoe (Magoebaskloof Dam)	0.28	0.30	0.30	0.30	0.30
Pieterburg (Dap Naudè Dam)	6.80	5.62	5.62	5.62	5.62
Pieterburg (Ebenezer Dam)	14.96	13.47	13.48	13.50	13.51
Letsitele users	0.14	0.22	0.29	0.47	0.76
Ritavi 1	0.80	1.59	1.79	2.58	4.70

Location	Pre-feasibility	Demand in 10^6 m^3			
		1995	**2000**	**2010**	**2020**
Ritavi 2	3.00	5.60	7.17	9.18	11.42
Naphuno 1	1.60	2.02	3.18	5.82	8.62
Bolobedu (Modladji 3 Dam)	*	2.23	2.50	4.44	7.95
Consolidated Murchinson Mines	1.08	1.75	1.75	1.75	1.75
Letaba Citrus Processors	0.24	0.24	0.24	0.24	0.24
Tzaneen	3.58	3.95	5.46	12.73	18.19
Total	**33.69**	**38.51**	**44.76**	**60.46**	**78.22**

Irrigation Water Requirements

Irrigation is a major water user in the Groot Letaba River catchment. Water for irrigation is abstracted either from the river or from the canals: Georges Valley; Pusella; Vergelegen; Letaba North; N&N and Masalal. Irrigation requirements amounts to 92.398 million m^3/a and the breakdown for different reaches is provided in the Water Requirements and System Analyses Report.

Environmental Water Requirements

Five IFR sites were identified during the study. The IFR1 is located on the Letsitele River just upstream of the confluence with the Groot Letaba River. The IFR2 is near Prieska Weir (B8H017) downstream of the Nwamitwa Dam site. The IFR3 is near Letaba Ranch Weir, B8H008, it incorporates the contribution of the Molototsi River. The IFR4 and 5 are in the Kruger National Park and were excluded from the study area. The summary of the IFR demands at each site is given in **Table 2.33.**

Table 2.32: Summary of IFR demands in the Groot letaba Catchment (1997)

IFR 1 (10^6 M^3)													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Annual**
Maintenance	0.81	1.41	2.95	3.50	3.74	4.16	2.64	2.20	1.81	1.61	1.07	0.67	26.69
Drought	0.49	0.66	0.80	0.85	0.01	0.98	0.87	0.75	0.65	0.59	0.51	0.44	8.51
IFR 2 (10^6 M^3)													
Maintenance	2.46	3.40	6.66	5.66	8.70	9.16	6.30	4.37	3.47	3.11	2.60	2.23	57.07
Drought	0.71	1.02	1.67	1.38	1.67	1.33	0.01	0.78	0.70	0.67	0.62	0.51	12.00
IFR 3 (10^6 m^3)													
Maintenance	2.57	3.58	7.91	6.10	9.90	9.85	5.18	4.55	3.03	3.21	2.68	2.33	61.49
Drought	0.74	1.09	1.75	1.48	1.67	1.45	0.96	0.80	0.73	0.70	0.64	0.57	12.77
IFR 4 and 5 (10^6 m^3)													
Maintenance	2.74	8.64	10.63	8.62	14.69	12.48	5.81	5.01	3.99	3.51	2.92	2.49	81.52
Drought	0.79	1,27	2.10	1.90	2.43	1.74	1.14	0.88	0.78	0.75	0.70	0.60	15.07

Based on the results of the investigations the following recommendations were made:

- The results of the economic assessment indicated that the option of raising Tzaneen Dam is feasible and based on the outcome of the this parameter (not considering other factors) it was recommended that the dam be raised.
- In view of the capabilities of the Water Resources Planning Model (WRPM) with particular reference to the allocation (curtailment) methodology it was recommended that the WRPM be configured for the Letaba System. The allocation procedure in the WRPM makes use of short-term yield characteristic curves, which are designed to be independent of the demand and therefore eliminate the need to derive curtailment rules for a range of demands. The WRPM would serve a dual purpose, firstly to carry out operational planning analyses and secondly to schedule the implementation dates of proposed development scenarios.
- All analyses in the study were carried out for a one MAR Nwamitwa Dam. The final projection analysis (including he raised Tzaneen Dam and Nwamitwa Dam) indicated that

the supply statistics for the irrigation demands were well within the limits of the criteria. This raised the question whether a smaller Nwamitwa Dam would not be sufficient to supply the projected demands for the year 2020 and it was recommended that the size of Nwamitwa Dam should be reviewed and investigated.

2.8.4 Volume 3: Instream flow requirements

Report Title: GROOT LETABA WATER RESOURCE DEVELOPMENT FEASIBILITY STUDY: Instream Flow Requirements: Volume 3. Report Number PB B810/00/0498. The RSA Department of Water Affairs.Prepared by Consultburo and BKS. December 1998.

A Workshop was held with the objective to refine the IFR determined during the 1994 IFR Workshop for the Letsitele and Letaba Rivers to such a level that the data could be used with confidence in hydrological system modelling, which will determine whether the IFR's can be supplied.

The following was an assessment of the Workshop and the processes followed:

A. Data Availability

- The fish information was the best the team has ever had.
- Good hydraulic data was available as well as photographs depicting different flows.
- Generally the confidence of the results was high, although there was little confidence in the sediment information.
- Some confidence was lost due to the lack of site visits.
- The results from the workshop were minimum guidelines and the flow should generally be higher than the minimum. At minimum the risk of failure is high.

B. The Process

- The use of a single group worked well and the group had to extrapolate data, which reduced the confidence in the information obtained.
- The presence ofgeomorphologies was found to be very important, especially where sediment was crucial.
- Very little information was available on inverterbras of this river, which are the major indicators of degradation of rivers.
- Water quality was not addressed, which is of concern especially in drought conditions.
- Overall the input from the workshop could be given to the Department with confidence.

- The group will have to stay involved in the future processes of the project as this workshop was a step in the overall process and the group should be part of the decision making.
- Future refinement workshops should have one group of specialists and also include a site visit. Knowledge of the area will influence the process and energy input into the process as well as the importance of the river.

The refined results were compared to the previous results and the comparison was presented in a table.

C. <u>Further Work</u>

The next step in the process was to prepare hydrological information, including the IFR Refinement results, into different scenarios. The proposed scenarios for the First Scenario Meeting were the following:

- Virgin conditions.
- Present conditions.
- No IFR included with the proposed dams in place.
- IFR releases included with the proposed dams in place.
- Look at future demands i.e. 2020.
- Model the system with only 50% of agricultural demands.

The options for the scenarios were with one of the two damns at a time and with both dams simultaneously resulting. This resulted in each scenario having three configurations.

2.8.5 Volume 4: Relevant environmental impact prognoses

Report Title: GROOT LETABA WATER RESOURCE DEVELOPMENT FEASIBILITY STUDY: Volume 5 –Relevant Environmental Impact Prognosis (*Annexure E – Annexure G*). Report Number PB B810/00/0598. The RSA Department of Water Affairs. Prepared by Consultburo and BKS. December 1998.

This report investigated the environmental impacts associated with the proposed water resource development options, to meet the growing water requirements in the Groot Letaba River Basin. A ROIP was undertaken for the following proposed development options:

- Nwamitwa Dam
- Letsitele Dam
- Infrastructure

The scope of the ROIP was to investigate the impacts associated with the proposed options on the social and ecological environment. The ROIP did not address the impacts associated with the construction activities i.e. pipelines, tunnels and the relocation of roads and other structures on the environment.

2.8.6 Volume 5: Water quality and riparian vegetation

Report Title: GROOT LETABA WATER RESOURCE DEVELOPMENT FEASIBILITY STUDY: Volume 5 - Water Quality and Riparian Vegetation (*Water Quality Review – Annexure H*). Report Number PB B810/00/0698. The RSA Department of Water Affairs.Prepared by Consultburo and BKS. December 1998.

The main aim of the Water Quality report was to determine the “fitness for use”, in terms of water quality, of the water for all potential water users of the proposed Letsitele Valley and Nwamitwa Dam sites on the Groot Letaba River.

The assessment was based mainly on ten (10) constituents: TDS, EC, and pH, NO_3/NO_2 as N, NH_4 as N, PO_4, F, Cal, Na and SAR, which were all rationally selected. Based on these, the above mentioned sites were generally deemed to be fit for use for all potential water users. The major problem for the Letaba River is that of water quantity as the flow regime is necessary to alleviate future water quality deterioration.

Significant future development was planned for Nkowakowa which would likely negatively impact on future water quality of the Letsitele River. In addition, the microbiological quality of its untreated water was seen as not fit for human consumption. Algal growth due to nutrient loading from industries was seen as a major problem for the Letsitele Valley Dam.

The major pollution component for the Nwamitwa Dam is Na and Cal, the sources of which are unknown. This might affect water use for irrigation of chloride sensitive crops. No water quality information was available for the Nwanedzi River, the river on which the Nwamitwa Dam lies.

A water monitoring programme was necessary if the project was found feasible, particularly at the Junction, B8H009 and Prieska Weir, B8H017 where water quality was shown to be deteriorating significantly.

The data sources of this study included various reports on the Letaba River Basin, records and files of the DWA regarding water quality monitoring systems and visual site investigations.

2.8.7 Volume 6: Legal and institutional aspects

Report Title: GROOT LETABA WATER RESOURCE DEVELOPMENT FEASIBILITY STUDY: VOLUME 6 – Legal and Institutional Aspects. Report No. PB B810/00/0798.Department of Water Affairs and Forestry.Prepared by Consulburo / BKS PTY LTD,December 1998.

The purpose of the Legal and Institutional Aspects Task was to study the legal implications of the construction of two dams and associated infrastructure on the Groot Letaba River at Nwamitwa and Letsitele River by focusing on the water, property and environmental law fields. The policy principles of the new water act were used since the study was undertaken during the period of water law reform process.

The existing institutional water management structures in the Letaba River catchment were evaluated against the requirements of sustainable water resources management as well as the existing (1956 Water Act) and proposed water law.

The study concluded that there were no legal fatal flaws to the construction of the two proposed dams, subject to compliance with the environmental, property and water laws.

2.8.8 Volume 7: Public involvement and social impacts

Report Title: GROOT LETABA WATER RESOURCE DEVELOPMENT FEASIBILITY STUDY: VOLUME 7 – Public involvement and Social Impacts. Report No. PB B810/00/0898. Department of Water Affairs and Forestry. Prepared by Consultburo / BKS PTY LTD,December 1998.

This document illustrates the process that was followed to establish a participatory public involvement programme. The social impact assessment process of the proposed dam sites is presented in the main report namely The Groot Letaba Water Resource Development Project: Social Impact Assessment of Proposed Dam Sites in the Groot Letaba Catchment Area.

2.8.9 Volume 8: Preliminary design

Report Title: GROOT LETABA WATER RESOURCE DEVELOPMENT FEASIBILITY STUDY: Volume 8 – Preliminary design. Report No. PB B810/00/0998.Department of Water Affairs and Forestry.Prepared by Consultburo (1998).

This module of the Groot Letaba Water Resource Development Feasibility Study covers the investigation of the feasibility of the following:

- Construction of the Letsitele River Valley Dam (Hobson's Choice or Site LET2 in the Pre-feasibility Study)
- Construction of the Nwamitwa Dam (Janetsi or Site GR15A in the Pre-feasibility Study)
- Raising of Tzaneen Dam
- Further water purification works to be supplied from the above-mentioned sources
- Water supply pipelines and routes to link new water sources with the existing or proposed new infrastructure

The report covers all the engineering and design work carried out, estimation of costs and assessment of the impacts that the development of the proposed water resources could have, in sufficient detail to enable rational decisions to be made on the viability of each option. Engineering work carried out includes the technical investigations of dam sites at feasibility level, selection of the most suitable dam centreline and preliminary design of the infrastructure.

The possibility of raising Tzaneen Dam by using the Hydro plusFuse gate technology was investigated. However, after discussions with the Groot Letaba Main Irrigation Board (GLMIB) and the Planning Directorate at DWAF, it was decided that the raising of Tzaneen Dam would be investigated under a separate arrangement and would no longer form part of this Feasibility Study.

Topography, geological, hydrology and economic considerations dictated a composite dam, with a central conventional gravity concrete ogee spillway section and earth fill embankment flanks as the most feasible dam configurations for both the Nwamitwa dam site and the Letsitele River Valley dam site.

The critical dimensions for the recommended Nwamitwa Dam are as follows:

- Full Supply Level : RL 477.5
- Non-overspill crest level : RL 480.9
- River bed level : RL 450.3
- Height of NOC above river bed : 30.6 m
- Total crest length : 2 325 m
- Spillway length : 490 m
- Storage capacity (1.0 MAR) : 143.8 million m^3

The estimated engineering capital cost (1996) for implementing the recommended Nwamitwa Dam project is R 489.2 million.

The critical dimensions for the recommended Letsitele River Valley Dam are as follows:

- Full Supply Level : RL 647.8
- Non-overspill crest level : RL 651.5
- River bed level : RL 618.0
- Height of NOC above river bed : 33.5 m
- Total crest length : 1 050 m
- Spillway length : 70 m
- Storage capacity (0.5 MAR) : 14.2 million m^3

The estimated engineering capital cost (1996) for implementing the recommended Letsitele River Valley Dam project is R 227.6 million.

In addition to the development of the proposed water resources, an assessment was also made of the necessary associated bulk water supply infrastructure for the distribution of water for primary use. Infrastructure considered includes water purification works, pump stations, bulk conveyance mains and storage reservoirs.

It is proposed that the capacity of the existing water purification works at Nkowankowa and at Nwamitwa would have to be increased to meet the 2020 demand. Treatment works at Modjadji, Thabina and Tours would not be upgraded and their coverage areas would decrease with time. A new water treatment works would be constructed at the Letsitele River Valley dam site, to supply Ritavi 2 and Naphumo 1.

The estimated capital cost for upgrading existing bulk water supply infrastructure and for constructing new bulk water supply infrastructure to meet the 2020 demand is R 153 million (at 1996 values).

2.8.10 Volume 9: Financial and economic evaluations

Report Title: GROOT LETABA WATER RESOURCE DEVELOPMENT FEASIBILITY STUDY: Volume 9 – Financial and economic evaluations. Report No. PB B810/00/0998.Department of Water Affairs and Forestry.Prepared by Consultburo (1998).

This volume provides detailed economic, financial and macro-economic evaluations of the development scenarios selected from the economic comparison of the identified development options. Attention is also given to the sensitivity of the benefit cost analysis, the fiscal impact, the economic value of water used for irrigation purposes, and possible funding options.

Economic evaluation results of the following water resource development scenarios are:

- Scenario 1: Zero Water Resources Development: total benefits of R92 million, a BCR of 0.54 and an IRR of 1,8%
- Scenario 2: Raising of the Tzaneen Dam: net benefit of R51 million and a BCR of 4.4
- Scenario 3: Construction of the Nwamitwa Dam: net cash flow of R286 million and a BCR of 1,84
- Scenario 4: Rising of the Tzaneen Dam and Construction of the Nwamitwa Dam: combination of scenario 2 and 3. Net discounted flows of R87,5 million, an incremental BCR of 1,24 and an IRR of 9.8%. At a 5% discount rate, the BCR for scenario 4 is 1,84.

More detailed evaluations were undertaken for the most attractive development option, namely the

Nwamitwa Dam. Sectors considered were primary sector, ecological and agricultural.

The study identified that the highest economic returns are to be found if rising of the Tzaneen dam is followed by the development of a new water structure at Nwamitwa. In this process more acceptable additional in stream water supplies will prevail to benefit the ecology.

To obtain an indication of the magnitude of the cost of water a number of URV (Unit Reference Values) were calculated. The cost of supplying raw water (domestic and irrigation) at the abstraction points is slightly over R1-00/m^3 while the bulk distribution cost of domestic water is just under R1-00/m^3. The option including Tzaneen rising is lower because it can be implemented sooner and the benefits can therefore be gained earlier.

The macro-economic impact of the development scenarios was also undertaken to analyse the socio-economic impacts of the selected scenarios. The primary and ecological sectors form the primary reserve and their demands will influence the water available for agriculture.

General economic equilibrium analysis was used to quantify the direct, indirect and induced effects. The macro economic impact was also measured in terms of certain effectiveness criteria that establish the extent to which the scenarios utilise resources efficiently. Since capital is a scarce resource in South Africa the effectiveness of the utilisation of capital is measured in terms of labour and GDP creation relative to other sectors of the economy. The analysis for each scenario was done according to the standard economic criteria, namely: capital utilisation, employment impact, impact on Gross Domestic Product, Income distribution, Sectoral impact, and Regional impact.

Scenario 1, with no water resources development, will have a definitive negative impact on the income and employment of the region with GDP in 2020 lower by R89 million compared to in 1995, and 2356 lost job opportunities.

Scenarios 2 to 4, representing water resources development, could counteract this negative development. Scenarios 3 and 4 are likely to result in a net increase in economic activity. However the positive effect of the aforementioned need to be related to the investment needed to create them. In this regard scenario 2 comes out better. However, the study revealed that in view of the unemployment and poverty in the region, the socio-economic contribution of this project should probably get preference to the economic growth potential of the project.

The degree of certainty/uncertainty was also calculated by means of a General Sensitivity Analysis (GSA). It was found that in view of the fact that scenarios 2, 3, and 4 are intended to minimise the negative impacts on the agricultural sector, and therefore the socio-economy of the region and the country, lower yields would be expected and the risk to proceed with these projects would be manageable.

Fiscal impacts were also calculated in order to analyse the economic viability of the project for the total community. Scenario 1 has a negative fiscal impact of R88,35 million which in main is due to the lower economic activity and the resultant loss in water charges, VAT and income tax. With Scenario 2, government gains R44,69 million. Scenario 3 and 4 generate negative government income to the value of R189,3 and R187,5 million respectively. Yet the IRR in both these cases is still positive which means there is still a positive return on the initial investment.

Taking the probability of filling into account, the BCR of constructing Nwamitwa Dam as well as raising Tzaneen Dam is 1,09. There is, however, a possibility that the BCR could be less than 1,0.

The economic value of water for irrigation agriculture and afforestation has formed the basis for determining the economic feasibility of additional water resource development within the Groot Letaba River area.

The economic value of Irrigation Agriculture seems higher than that of Forestry. Forestry could therefore be used as a proxy for determining the economic value of water. However, various other proxies and pros and cons also exist. The study revealed that thorough research needs to be undertaken to estimate the economic value of water for forestation in the Groot Letaba River catchment. Until such time, the application of Irrigation Agriculture (citrus) as an opportunity cost of water is probably a more appropriate yardstick.

The feasibility study led to the following main findings with regard to resource development:

- To comply with legal obligation, further storage in the system is required
- A realistic estimate of total raw water requirements for domestic and industrial use in 2020 is about 77 million m^3/a. Meeting this requires additional sources of water, increasing the capacity of existing water purification works (and possible new works), new pumping stations and pipelines, and new reservoirs.
- Construction of a major storage dam in Letsitele River does not offer a cost effective and affordable solution.
- Nwamitwa dam is the most attractive for a new major storage dam in the system. A dam with a gross storage of 143 million m^3 at a cost of R438.6 million (at 1996 prices).
- Rising of Tzaneen dam to 203 million m^3 at an estimated cost of R12 million (1996 prices). This is to be done in partnership with the direct beneficiaries, i.e. irrigation farmers downstream of Tzaneen Dam.

2.9 MUTALE RIVER WATER RESOURCES INVESTIGATION: SITUATION ASSESMENT, MANAGEMENT, AND DEVELOPMENT POTENTIAL OF WATER RESOURCES 1999

2.9.1 Overview

The main objective of the Mutale River Water Resources Investigation was to obtain knowledge of the land and water use in the Mutale River Basinand the operation and management of water resources in order to assist with the planning, development and long-term water utilisation of water resources in the region.

2.9.2 Annexure 1: Catchment Characteristics

Report Title: MUTALE RIVER WATER RESOURCES INVESTIGATION: Volume 1: Annexure 1 – Catchment Characteristics. Report No. A920/00/0398. Department of Water Affairs and Forestry. Prepared by Africon (1999).

This annexure provides general descriptions of the topography, climate, geology, soil types and natural vegetation of the Mutale River catchment. The catchment characteristics were studied at reconnaissance level, except for the climatic data that was required for the calibration of the hydrological model and the system yield analyses, which were studied at a detailed level.

The Mutale River catchment is located in the northern region of the Limpopo Province. The Nwanedi River catchment lies to the water of the study area and the Luvuvhu River catchment to the south and east. The Mutale River catchment is drained by the Mutale River and tits major tributaries, the Tshirovha, Mudaswali, Sambandou, Tshala, Mbodi and Tshipise Rivers. The study area lies in Tertiary drainage region A92.

The only significant dam in the study area is a small dam in the upper reaches of the Tshirovha River. The Mukumbani Dam is used to irrigate tea plantations in at the Mukumbani Tea Estates in the adjacent Luvuvhu River catchment. The dam has a catchment area of about 8 km^2, a natural MAR of about 6 x 10^6 m^3 and a gross storage capacity of 3.9 x 10^6 m^3. Lake Funduzi is also located in the study area and is a small unique inland lake in the extreme south-western part of the study area and was formed by an enormous landslide that blocked the course of the Mutale River, creating a pervious embankment. Data on this lake was found to be insufficient for management, and it was suggested that a research programme focusing on the hydrology and limnology should be initiated.

The study area is located in a rural area and is mostly far from towns and most of the settlements/villages are located in the south-western parts of the study area. Much of the land area riparian to the rivers is used for irrigated cultivation or for dryland cultivation at times. Three nature conservation areas form part of the study area, including the Kruger National Park.

The only active bug mines in the region are various copper mines in the Messina area and Tshikondeni Coal Mine in sub-catchment M17. There is also a small magnesite mine operational in sub-catchment M14. The Nyala section of the Geocapro Mine is situated near Klein Tshipise.

The climate, geology, soil and vegetation characteristics and land-use practices of the study area are discussed in the report.

2.9.3 Annexure 2: Socio-eonomic Assessment

Report Title: MUTALE RIVER WATER RESOURCES INVESTIGATION: Volume 2: Annexure 2 – Socio-eonomic Assessment. Report No. A920/00/0498. Department of Water Affairs and Forestry. Prepared by Africon (1999).

The socio-economic assessment involved two interallated elements which can be summarised as folows:

- Macro-economic perspective: To establish the structure and growth tendancies of the local economy as well as the positive and negative implications for the local economy should new water resource utilisation and development projects be undertaken.
- Socio-economic perspective: To establish a cultural profile, general wellbeing and economic ability of the local communities in terms and the positive and negative implications should new water resource utilisation and development projects be undertaken.

The formal economy of the Mutale DM, which is considered to be representative of the Mutale River catchment, was found to be small when compared to the labour force. The implication of this is that the formal economy is unable to provide sufficient work opportunities to fully accommodate the current labour force, and even less so the annual increase in labour force, resulting in ever increasing levels of unemployment. The local labour is very dependent on employment opportunities outside the boundaries of the DM. The typical household survival strategy may include various elements of financial and non-financial income as remittances received through migrant labour, cash transfers received from government (pensions), informal agriculture, informal trade and by sourcing foodstuffs and other consumables from the local and surrounding secondary resource base. According to the requirements of the Minimum Levels of Living (MLL), more than 80% of the population earn less than the requirement i.e. live in poverty. However due to the nature of survival strategies noted above, money income alone is not an accurate criteria for the ability to achieve an maintain a quality of life. Since the communities are dependent on the local natural resource for their existence, any disturbance in the natural resource base may have significant implications for their ability to maintain the current level of existence.

The local population has a very youthful age profile as nearly 50% of the population is under the age of 15 years and about 45% between the ages of 16-65 years. This youthful age profile has two implications namely a high natural growth rate and a high dependency ratio. The current population size was estimated at about 176 670 (1998). The future growth rate was estimated to be 2.6% p.a up to 2000, which will decrease by 1.5% p.a by 2020 (first order estimates).

The area also has a very rich cultural history and the communities are very traditional in their ways, and the chiefs play a paramount role in decision making processes.

The Mutale River itself has significant cultural and economic value to the communities. Nearly all of the land, with the exception of small isolated pockets such as the Mutale Agricultural Estates, the small part of the KNP and the mining concession areas, is held in trust by the government for the relevant tribal authority.

Agriculture represents the backbone of the economy of the Mutale River catchment, and there are a number of agricultural schemes such as the Tshiombo, the Britz/Lugane project, Makonde and the Mutale Agricultural Estates, which is the most significant in term of monetary value of stock and annual turnover. The ARDC was, at the time of the study, in the process of upgrading a number of projects such as the upgrading of the existing water canal at Rambuda and Tshiombo irrigation schemes, as well as the conversion of existing sprinkler irrigation at Senela and Mutele to citrus orchards. Informal agriculture is also practiced along the Mutale River and mostly produce crops such as maize for own consumption. Most households also have cattle and/or goats.

The study area also has some tourist attractions and the tourism sector is one of the very few options that present some potential for further development and economic empowerment of the local communities.

\there are a number of mineral occurrences in the Mutale River catchment, the most significant being the Pafuri Coalfields and a number of Magnesite deposits in the northern area. The Pafuri coalfield is currently only exploited by one mine namely the Tshikondeni mine and although the coalfield has high quality coal, it is unlikely that the coalfield will be developed further in the short to medium term due to the long distances to its markets. No significant mineral potential, existing mines or mining rights will be affected with the construction of any of the dams investigated.

An assessment of the social/cultural and economic point of view was conducted for the following identified dam sites that were selected for further investigation:

- Rambuda Middle site
- Rambuda Downstream site
- Tswera site
- Thengwe site

2.9.4 Annexure 3: General Infrastructure

Report Title: MUTALE RIVER WATER RESOURCES INVESTIGATION: Volume 3: Annexure 3 – General Infrastructure. Report No. A920/00/0598. Department of Water Affairs and Forestry. Prepared by Africon (1999).

This report provides details of the infrastructure found in the study area, including road and electricity networks, bulk water conveyance systems and water infrastructure, which has a major impact on population development and water availability.

There are two existing regional bulk water supply schemes (Vondo Regional Water Scheme and Mutale Regional Water Project) that supply treated water to communities in the central part of the Mutale River catchment. The other communities not served, obtain water for domestic water use from nearby boreholes, springs and streams. Three borehole schemes supply domestic water to communities.

Various new bulk water supply schemes will be required in future to supply potable water to the communities within the supply areas of the planned water schemes.

Two pipelines exist where bulk water is transferred for irrigation use to the Mukumbani Tea Estates and the Damani Coffee Project, outside and inside the Mutale River catchment respectively. Various distribution pipelines exist as part of the internal irrigation pipework of the other irrigation schemes.

The Tshiombo and Rambuda irrigation schemes are supplied with irrigation water by means of concrete lined canals. The ARDC was at the time (1998) in the process of evaluating tenders for the upgrading of the canals and balancing dams.

The only significant existing dam in the study area is the Mukumbani Dam. There is only one WTW (capacity of 2.2 Ml/day) in the study area situated near Tshandama to supply treated water for the Mutale Regional Water Project.

There is no sewage treatment works in the study area. Pit laterines are most commonly used for sanitation.

An extensive road network consisting of primary (paved) and secondary (gravel) roads has been established. Most areas have adequate transportation links to the bigger centres in the area.

The central part of the study area has an extensive electricity network to which individual users can be connected. There are existing telephone lines in the area, but Telkom is in the process of replacing the existing fixed wire system with the Digital Enhanced Cordless Telephone system.

2.9.5 Annexure 4: Economic Geology and Mining

Report Title: MUTALE RIVER WATER RESOURCES INVESTIGATION: Volume 3: Annexure 4 – Economic Geology and Mining. Report No. A920/00/0698. Department of Water Affairs and Forestry. Prepared by Africon (1999).

This report discusses the mineral potential and current levels of mineral exploitation in the Mutale River basin. No known mineral deposits occur at any of the dam sites that were selected for further investigation.

The mineral potential of the Mutale River Basin can be considered limited and the only deposits of some significance are coal and to a lesser extent magnesite and graphite. The economicsof the Soutpansberg Coal Fields is marginalised by the long distances to markets and it is unlikely that, with current technology, demand and price levels, this coal field will be developed further in eh short and medium term.

None of the existing mining operations will be affected by the construction of any of the proposed dams on the sites selected for further investigation. The only two operational mines are the Tshikondeni Coal Mine and Geocarpo Magnesite Mine. Other mining activities in the regions are the various copper mines in the Messina area (outside of the Mutale River basin).

2.9.6 Annexure 5: Afforestation

Report Title: MUTALE RIVER WATER RESOURCES INVESTIGATION: Volume 3: Annexure 5 – Afforestation. A920/00/0798. Department of Water Affairs and Forestry. Prepared by Africon (1999).

The purpose of this report was to provide a description of the historic development and present state of afforestation in the Mutale River catchment as well as an assessment of the potential for future afforestation.

At the time of the study a small area within the upper reaches of the study area known as the Thathe Vondo plantation was occupied by afforestation which consisted mainly of pines and eucalyptus.

Afforestation activities started shortly after 1950 and expanded over the years. Afforestation data was obtained for eight different years (1952, 1962, 1969, 1979, 1985, 1989, 1995 and 1998). The total net afforested areas in these years were 30ha, 590 ha, 770ha, 1360ha, 1550ha, 1750ha, 2120ha, 2130ha respectively.

The total net area that has afforestation potential amounts to approximately 11 900 ha, which includes areas utilised by other competing landuses such as irrigation, dryland farming and grazing land. The realistic area of actual afforestation potential will thus be considerably less.

The total reduction on MAR resulting from the afforestation in the study area is about 3.41 million m^3/a, which is about 2.1 % of the natural MAR of the Mutale River.

2.9.7 Annexure 6: Livestock, Game and Fisheries

Report Title: MUTALE RIVER WATER RESOURCES INVESTIGATION: Volume 3: Annexure 6 – Livestock, Game and Fisheries. Report No. A920/00/0898. Department of Water Affairs and Forestry. Prepared by Africon (1999).

The purpose of the report was to give a general perspective of the present extent of livestock and fish farming and game conservation in the study area with a view of estimating the water requirements of each of the components. No fish farming exists in the study area and therefore the focus will be in livestock and game.

Although the consumptive water requirement for livestock and game is only about 0.60 million m^3/a it must be noted that in respect of wildlife conservation the consumptive water use by game is the smaller part of the total water requirement of the nature and game reserves, which also include domestic water requirements, water use by reverine vegitiation, non-consumptive water requirements for conservation of the riverine ecosystems etc.

In view of the very small but important water requirement for livestock outside the game reserves, no detailed attention needs to be paid to this aspect, except to include it as a consumptive water requirement. Livestock concentrations are generally quite closely associated with population cocentrations. The water resource developments capable of supplying the domestic water requirements will in this case mostly also be adequate to supply those water requirements for livestock that are not supplied from groundwater.

According to the available information the Mutale River catchment is overgrazed and stock numbers should be reduced. Droughts occur regularly in the area and have a detrimental effect on the veld and its livestock carrying capacity, which presents a problem for farmers who tend to utilise their veld to a maximum.

2.9.8 Annexure 7: Irrigation

Report Title: MUTALE RIVER WATER RESOURCES INVESTIGATION: Volume 3: Annexure 7 – Irrigation. Report No. A920/00/0998. Department of Water Affairs and Forestry. Prepared by Africon (1999).

The report describes the existing irrigation areas and practices within the Mutale River catchment and to discuss the possibilities for future irrigation development. An estimate of the irrigation water requirements was also made.

The irrigation methods on the different irrigation schemes differ from flood irrigation to sprinkler and micro-jet irrigation.The total existing irrigation area within the Mutale River catchment is estimated to be about 2422 ha. The study assumed that the existing irrigation area was developed for irrigation i.e. maximum possible green cover. The percentage of area covered with crops differs from month to month and also from year to year due to various factors , of which assurance of supply is one.

No definite information on crop types that were irrigated at the time of the study was available. The total net area of Class 1 and Class 2 land in the study area, which are highly and moderately suitable for irrigation, amounts to approximately 26 000 ha. Although some of the irrigable soils are already developed for irrigation, the availability of land suitable for irrigation is not the limiting factor in the long-term development of irrigation.

The ARDC and DALE indicated that there were plans to expand the existing Rambuda irrigation scheme by more than 100 ha and the existing Tshiombo irrigation scheme by more than 650 ha. The ARDC was however at the time busy upgrading the infrastructure (canals and dams) of the Rambuda and Tshiombo schemes. The ARDC was also planning to convert and extend the existing irrigation development at the Mutele and Saneri irrigation schemes into 35 ha citrus orchards each, with micro-jet irrigation. Another planned ARDC development was to replace all the cash crops planted in the Makonde irrigation scheme (210 ha) with mangoes and citrus orchards.

The availability of water is essential for and will enhance the feasibility of the plans for future irrigation development.

Since reliable actual irrigation water use data was difficult to obtained the irrigation water requirements throughout the study area were calculated from basic data. The total annual irrigation water requirement in the Mutale River catchment was estimated as 25.84 million m^3/a (including the 4,58 million m^3/a for the Mukumbani tea plantation outside the study area that is irrigated with water from inside the study area and the 5.15 million m^3/a for the 450 ha of the Damani coffee project that is within the study area but irrigated with water from outside the study area).

2.9.9 Annexure 8: Water Transfers

Report Title: MUTALE RIVER WATER RESOURCES INVESTIGATION: Volume 3: Annexure 8 – Water Transfers. Report No. A920/00/1098. Department of Water Affairs and Forestry. Prepared by Africon (1999).

This report describes the existing and possible future water transfer schemes across the watershed boundaries of the Mutale River Catchment. There are four known existing transfer schemes that transfer water in and out of the Mutale River catchment. Two schemes transfer irrigation water and two schemes transfer potable water for domestic use across the catchment boundaries. At the time of the study a bulk amount of approximately 4.58 million m^3/a is transferred out of the study area and approximately 5.48 million m^3/a into the study area (1998).

New potable transfer schemes for domestic use, together with extensions of existing schemes are planned for the future. Eskom had also investigated the so-called Mutale Pumped Storage Scheme, which would have transferred water between the Mutale and Nzhelele River catchments. The investigation of the project was however suspended because of the findings of seismicity studies.

The amount of water to be transferred into the Mutale River catchment to communities within the supply areas of the Nwanedi-Luphephe and Masisi Regional Water Schemes is:

- 1.51 million m^3/a in 1998
- 2.41 million m^3/a in 2020

It has been stated in a DWA letter that a water allocation of 1.135 million m^3/a has been reserved from the Nwanedzi and Luphephe Dams for a proposed water supply project to the communities along the Limpopo River within the Nwanedi-Luphephe Regional Water supply area. From the information it seemed as though 80% (0.9million m^3/a) of the allocation is for communities in the Mutale River catchments and 20% (0.235 million m^3/a) for communities in the Nwanedi River catchment. From this information it was assumed that approximately 0.9 million m^3/a will be transferred into the Mutale River catchment when the scheme becomes operational.

The water requirements of the communities that will be supplied by the extension of the Damani Regional Water Scheme (transferred into the Mutale River catchment) were estimated as:

- 0.90 million m^3/a in 1998
- 2.53 million m^3/a in 2020

The water requirements of the communities that will be supplied by the planned extension of the Vondo Regional Water Scheme (transferred into the Mutale River catchment) were estimated as:

- 0.17 million m^3/a in 1998
- 0.52 million m^3/a in 2020

The water requirements estimated as part of the Nwanedi River Water Resources Investigation, of the communities in the southern part of the Nwanedi River catchment, that will be supplied by the planned extension of the Mutale Regional Water Project (transferred out of the Mutale River catchment) are:

- 0.11 million m^3/a in 1998
- 0.29 million m^3/a in 2020

2.9.10 Annexure 9: Environmental Aspects

Report Title: MUTALE RIVER WATER RESOURCES INVESTIGATION: Volume 4: Annexure 9 – Environmental Aspects. Report No. A920/00/1198. Department of Water Affairs and Forestry. Prepared by Africon (1999).

This report is a reconnaissance survey of the important impacts of the development of the water resources of the Mutale River on the river ecosystem and on the basis of four dams that have been investigated.

The Mutale River and its valley support a high diversity of terrestrial and aquatic living organisms, many of which have a limited range of distribution in S.A. The exploitation of the river has already reached a stage where it could have adverse impacts on the river ecosystem. This is particularly evident in the lower reaches of the river where many large trees died during the drought in the early 1990's. The size of dead trees suggested that the reduction of flow in the river was probably in excess of the reduction of previous droughts. It is thought that abstraction of water from the river for irrigation at Tshiombo and the Mutale Agricultural Estates played a role in the impact of the drought on the trees which died.

Steps will have to be taken to manage the available water and it is only in this manner that it will be possible to ensure the sustained existence of the river as a functioning ecosystem through the provision of water to keep this perennial river flowing.

No dams are possible on the Mutale River without important impacts on the environment. The order of biophysical acceptability of the dams sites being investigated would, on the basis of the existing information, appear to be Rambuda Downstream (least impact), Tswera/Thengwe and Upper Rambuda.

It was recommended that the adequacy of the information found as a baseline for further work, in particular for environmental assessment, should be evaluated. It was also recommended that the data required to confirm the general and site specific key issues identified should be gathered as part of any further (pre-feasibility) studies on the Mutale River.

2.9.11 Annexure 10: Archaeological Aspects

Report Title: MUTALE RIVER WATER RESOURCES INVESTIGATION: Volume 5: Annexure 10 – Archaeological Aspects. Report No. A920/00/1298. Department of Water Affairs and Forestry. Prepared by Africon (1999).

The aim of the archaeological study was to determine the archaeological potential of the study area and how it will be affected by building a dam in the area. The basins of the proposed Thengwe, Tswera, Rambuda Downstream and Rambuda Middle Dams were surveyed and the locations of the archaeological sites were indicated on maps and discussed for the Thengwe, Tswera, Rambuda Middle and Downstream dam sites.

2.9.12 Annexure 11: Legal Aspects

Report Title: MUTALE RIVER WATER RESOURCES INVESTIGATION: Volume 6: Annexure 11 – Legal Aspects. Report No. A920/00/1398. Department of Water Affairs and Forestry. Prepared by Africon (1999).

During the reconnaissance phase of the study it was regarded unnecessary to investigate the legal aspects in too much detail since the legal implications of particular water resource development projects will be fully investigated in the feasibility phase. However, in order to ensure that all possible legal requirements for water resources development projects have been considered prior to commencement to any activities and to eliminate any possible fatal flaws which could have been traced by considering the law during the earliest phase, a brief reference to the most important legal aspects which are relevant to the project were included in the report.

2.9.13 Annexure 12: Water Requirements

Report Title: MUTALE RIVER WATER RESOURCES INVESTIGATION: Volume 7: Annexure 12 – Water Requirements. Report No. A920/00/1498. Department of Water Affairs and Forestry. Prepared by Africon (1999).

The report includes the present (1998) and possible future (2020) water requirements form the

Mutale River catchment, including water for conservation of the riverine ecosystems, compensation water, water losses and water gains. It was recommended that the presented water requirements are not intended for detailed planning in any other studies without careful prior review.

There are two existing regional water supply schemes in the study area that supply a number of communities with potable domestic water, namely the Vondo Regional Water Scheme and the Mutale Regional Water Project. Other communities rely on boreholes and wells or nearby streams and fountains.

The estimated annual water requirements for domestic and mining purposes of the communities and mines within the Mutale River catchment, based on realistic population estimates, are:

- 5.36 million m^3/annum in 1998
- 13.36 million m^3/annum in 2020

These figures include the domestic water requirements inside the study area boundaries that are supplied by water transfers into the Mutale River catchment at present and in future if the regional water supply schemes are implemented as planned. The proposed domestic water transfers out of the Mutale River catchment to communities in the adjacent Nwanedi River catchment are not included in these figures.

The amount of water to be transferred into the Mutale River catchment to communities within the supply areas of the Nwanedi-Luphephe and Masisi Regional Water Schemes, estimated as part of the study, is:

- 1.51 million m^3/annum in 1998
- 2.41 million m^3/annum in 2020

The amount of water to be transferred into the Mutale River catchment to communities within the supply area of the Damani Regional Water Scheme, estimated as part of this study, is:

- 0.90 million m^3/annum in 1998
- 2.53 million m^3/annum in 2020

The amount of water to be transferred into the Mutale River catchment to communities within the supply area of the Vondo Regional Water Scheme, estimated as part of this study, is:

- 0.17 million m^3/annum in 1998
- 0.52 million m^3/annum in 2020

An amount of water for domestic purposes will be transferred out of the Mutale River catchment to the southern part of the Nwanedi River catchment if the existing Mutale Regional Water Project is extended. The water requirements, investigated by the Nwanedi River Water Resources Investigation Study, falling within the planned extension of the Mutale Regional Water Project are:

- 0.11 million m^3/annum in 1998
- 0.29 million m^3/annum in 2020

The unit water requirement for livestock and game was assumed to be 50 l/ELSU/day, which is used by the Department of Agriculture, Land and Environment in the Northern Province.The estimated water requirements for livestock and game in the different sub-catchments of the Mutale

River amount to approximately 0.60 million m^3/annum in total. No fish farming existing in the study area and there are no indications that any fish farming projects will develop in the medium to long term.

The mean monthly field irrigation water requirements were calculated for each irrigation scheme and the present consumptive irrigation water requirements from the Mutale River amounts to 21 million m^3/annum. The actual water use is expected to be less than the estimated volume since irrigation is dependent on the availability of water and water shortages have been reported to occur in the study area.

Possible future irrigation water requirements were estimated for a scenario where no new irrigation schemes are developed, but with a few changes and extensions to the existing schemes as follows:

- Mutele and Senari irrigation schemes are converted and extended to 35 ha each of citrus orchards with micro-jet irrigation
- Rambuda irrigation scheme is extended by 10 ha
- Tshiombo irrigation scheme is extended by 650 ha.

The estimated possible future mean field edge irrigation water requirements are presented in the report and possible future requirements from the Mutale River amount to approximately 27 million m^3/annum. The total estimated reduction in runoff due to dryland cultivation was accepted to be negligible.

Estimates of the ecological component of the reserve were also made and the monthly water requirements are summarised in the report.

Water losses within the river system should also be considered.

The total net present (1998) consumptive water requirements from the Mutale River catchment were estimated at about 29.73 million m^3/annum. This excludes the water necessary for the conservation of the riverine ecosystem or any water losses or water gains within the river system, but includes known water transfers into and out of the catchment.

2.9.14 Annexure 13: Surface Water Hydrology

Report Title: MUTALE RIVER WATER RESOURCES INVESTIGATION: Volume 8: Annexure 13 – Surface Water Hydrology. Report No. A920/00/1598. Department of Water Affairs and Forestry. Prepared by Africon (1999).

Updated long-term (1922/23-1995/96) natural and present day flow records as well as land and water use records were simulated for the Mutale River Catchment using the WRSM90 model. The catchment was divided into 19 sub-catchments.

Rainfall coverage in and around the study area is inadequate and only 3 of the 54 stations available are within the Mutale River catchment. Only 26 had record periods longer than 15 years, which could be used during the patching process and of these 26 stations, 18 stations had stationary data after the patching process. The MAP and MAE values were calculated for each sub-catchment.

Flow is only measured at two flowgauging stations (A9H004 and A9H013) within the Mutale River catchment. Both stations were used for the calibration of the WRSM90 model. The A9H004 gauge has records from 1963/10 but contained a lot of gaps especially in the 1971-1980 period. Due to all the gaps only the hydrological years from 1980 – 1995 were used for calibration purposes. The A9H013 gauge only had a short period of record (started in 1988/11), with a gap for 1988/11. Only the 1989/10 to 1995/09 period was used to calibrate the model, as the simulated values were high if the previous years were used.

There are no major dams on the Mutale River. The Mukumbani Dam, with a full supply capacity of 3.9 million m^3/annum, was constructed on the Tshirovha River, which is a tributary of the Mutale River. A natural lake, Lake Funduzi, is situated in the upper reaches of the Mutale River. Lake Funduzi was not addressed separately in the study, since the impact of the lake on the hydrology was compensated for during the calibration process.

Afforestationexists mainly in the Thate Vondo plantation and there are also two plantations that were not included in the analyses due to lack of historical information.

Water exports were modelled for the irrigated tea plantation in the adjacent Luvuvhu River catchment supplied with water from the Mukumbani Dam. Domestic, mining and livestock abstractions are relatively small and were only modelled in some sub-catchments.

The sub-catchments where irrigation exists currently and historically, the crop types as well as the irrigation methods for these areas are listed in the report.

Significant river losses were expected in the lower rainfall regions due to evaporation losses. These losses as well as the actual river losses were accounted for in the analyses.

The virgin runoff was simulated by removing all land and water use information from the WRSM90 modules and the present day runoff records were simulated using the present land use information for the whole record period in the model. The results were summarised in the report.

2.9.15 Annexure 14: Surface Water Quality Aspects

Report Title: MUTALE RIVER WATER RESOURCES INVESTIGATION: Volume 9: Annexure 14 – Surface Water Quality Aspects. Report No. A920/00/1698. Department of Water Affairs and Forestry. Prepared by Africon (1999).

The surface water quality evaluation was performed to determine the suitability of the surface water in the Mutale River catchment for use in domestic, industrial and agricultural applications, with domestic and agricultural applications being the main focus.

The water quality test results showed that the water sampled is of reasonable quality and has not been polluted to a significant extent by the present development upstream of and in the immediate vicinity of the sampling points. The heavy metal content does indicate that some pollution has occurred at Tshiondeni. The water samples tested indicate that the water at Tshikondeni may contain substances which could be harmful if the water is used for domestic purposes , although it might be exaggerated as a result of a limited number of test results. The water is however suitable for irrigation in most respects if care is taken not to wet foliage during the active growth season.

The water tested at Thengwe is considered suitable for livestock watering, irrigation and domestic use after conventional treatment, consisting mainly of PH adjustment and disinfection.

The fact that so few test results were available in many aspects made it difficult to draw definite conclusions from the available information, but indications are that there could be a problem with respect to the water quality in the lower reaches of the Mutale River at Tshikondeni.

It was therefore recommended that testing of water samples at Tshikondeni should be continue in order to monitor the water quality in the area as well as possible pollution and deterioration in quality thereof. Such test should be conducted over at least a period of 12 consecutive months and regular monthly samples and flow rate measurements should be taken.

2.9.16 Annexure 15: Groundwater Resources and Quality

Report Title: MUTALE RIVER WATER RESOURCES INVESTIGATION: Volume 9: Annexure 15 – Groundwater Resources and Quality. Report No. A920/00/1798. Department of Water Affairs and Forestry. Prepared by Africon (1999).

From the geology and structural geology it was concluded that the following aquifers are present in the Mutale River basin:

- Primary aquifer in the alluvial deposit in the middle to upper reaches of the Mutale River. These aquifers are very localised and may not be of regional importance.
- Secondary aquifers in:
    - The graben and other tensional faults of Karoo age
    - Faults and shears in the older formations
    - Weathered and fractured formations
    - Fractured contact zones between rocks of different types and ages
- The volume of groundwater storage in the Mutale River basin as calculated from the saturated interstices amounts to approximately 27.9 million m^3/annum.
- Using the probabilities of accessibility and exploitability it was calculated that in the south-western part of the study area 5 boreholes need to be drilled to have one yielding more than 2 l/s. In the northern part of the study area as many as 20 boreholes may be needed. These probabilities were calculated from unscientifically sited boreholes. Using modern geophysical siting techniques it is possible that no more than half the number of boreholes will be needed.
- The evaluation of existing groundwater development in the Mutale River basin, based on a hydrocensus conducted by DW revealed the following:
    - Mean depth of boreholes is 81m.
    - Mean water level depth below surface level is 23m.
    - Mean borehole yield is 1.4 l/s
- Perennial river flow consists of both a surface water and groundwater component and Vegter calculated groundwater component (base flow) in terms of mean annual precipitation and total mean annual runoff. Only the upper and middle sections of the Mutale River basin contribute to base flow.
- The groundwater harvest potential of the Mutale River basin is 13 million m^3/annum

- The costs for drilling were calculated using the Vegter maps and drilling in the central area of the basin seems to be the most expensive.
- The distributions of unacceptable drinking water values are as follows:
  - TDS are at unacceptable levels in the northern part the Mutale River basin.
  - Fluorides (F) are similarly unacceptable levels in the northern part of the Mutale River basin.
  - Nitrates (NO_3) are only at unacceptable levels in the extreme northern part of the study area along the Limpopo River.

It should be noted that groundwater with unacceptable levels of fluoride and nitrate can be excellent for both irrigation and animals.

2.9.17 Annexure 16: Sedimentation

Report Title: MUTALE RIVER WATER RESOURCES INVESTIGATION: Volume 9: Annexure 16 – Sedimentation. Report No. A920/00/1898. Department of Water Affairs and Forestry. Prepared by Africon (1999).

The study identified four dam sites for further investigation which include Rambuda Middle, Rambuda Downstream, Tswera and Thengwe and this report provides the following information for each of the dam sites:

- Estimates of the sediment yields of the reservoir catchments at 50% and 95% confidence levels.
- Estimates of reservoir storage losses based on the catchment sediment yields for periods of ten, twenty and fifty years.

The study recommended that more detailed investigations should be undertaken for all the identified dam sites, which could include more detailed studies of land-use and catchment erosion patterns, river beddegradation upstream or downstream of the reservoir sites and estimates of the sediment deposition profiles within the reservoirs.

The Rambuda Middle and Downstream dam sites have both been assumed to be situated at the outlet of sub-catchment M05. The total mean (50% confidence) sediment yield of the catchment is 9.7×10^4 t/a at the confluence with the Luvuvhu River and 2.5×10^4 t/a by the portion of the catchment that drains into the Limpopo River.

2.9.18 Annexure 17: Dams

Report Title: MUTALE RIVER WATER RESOURCES INVESTIGATION: Volume 10: Annexure 17 – Dams. Report No. A920/00/1998. Department of Water Affairs and Forestry. Prepared by Africon (1999).

The purpose of this report was to describe the basis adopted to select, for further investigation, those dam sites that are most likely to be considered for development to supply the future water requirements from the Mutale River catchment, at least cost and least negative environmental impact, and to describe the investigations that have been performed at each of the dam sites that have been selected for further investigation.

Each of the dam sites that has been selected is described in terms of the physical aspects and the likely environmental impacts of a dam, which is followed by a further description of the norms that have been adopted to arrive at cost estimates for a range of sizes of dams.

There has been very little development of water resources in the Mutale River catchment, with the water use relying mostly on run-of –river supplies, which are partly regulated by Lake Funduzi at the upstream end of the catchment. Lake Funduzi has naturally been formed by a landslide, which has a pervious embankment that stores high flows and then gradually releases these by seepage through the embankment. The lake has a catchment area of 61 km^2, a natural MAR of 19.7 million m^3 and a maximum utilised storage capacity of about 22 million m^3. The area and capacity data for the lake are presented in the report.

Besides a few small dams the only significant storage dam in the Mutale River catchment is the Mukumbani Dam in the Tshirovha River. It has a catchment area of 8 km^2, a natural MAR of 6 million m^3 and a gross storage capacity of about 3.9 million m^3. The area and capacity data for the lake are presented in the report. The purpose of the dam is to supply water to the Mukumbani Tea Estate situated in the adjacent Luvuvhu River catchment.

The need for new dams was assessed by comparing the possible water requirements with the available runoff. The main areas of water use are the Tshiombo-Thengwe valley (sub-catchments M05-M11) and possibly the Malonga Flats (sub-catchments M17 and M19), with possible future water requirements of the order of up to 35 million m^3/annum and 100 million m^3/annum respectively. Water uses in the Mudaswali and Sambondou valleys will be small by comparison and could be in the order of 6 million m^3/annum. I addition to the forgoing water requirements, provision will also have to be made for the environmental component for the Reserve.

Attention was focused on the dam sites where significant quantities of water are available. Furthermore, water that is not used in the upper reaches of the catchment would always be available for use further downstream, where abstraction to supply Malonga Flats is potentially a point of large water use.

The dam sites investigated further were:

- Rambuda Middle (Site No. 8)
- Rambuda Downstream (Site No. 9)
- Tswera (Site No. 11)
- Thengwe (Site No. 12)

The dam sites were prioritised in order of suitability for development. The priorities were based only on the information and issues discussed in the report and priorities may change due to additional information that will become available such as unit cost of water for example.

The following table compares the dam sites investigated, based on the information and issues discussed in the report.

Table 2.33: Dam Site Comparison

DAM SITE	ECOLOGICAL	SOCIO-ECONOMIC/CULTURAL	COST	LOCATION RELATIVE TO WATER USERS	GROSS STORAGE CAPACITY (million m^3)
Rambuda Middle	R	A/R	4	2	85.3
Rambuda Downstream	A	A/A	3	1	13.5
Tswera	C	R/A	2	3	131
Thengwe	A	A/F	1	4	116

Note: (1) 1 – Best option and 4-worst options.
(2) Rambuda Downstream Dam has a small storage capacity in comparison to other dams.
(3) A - Apparently acceptable
C - Caution
R - Red flag
F - Fatally flawed

The dam sites were prioritised in order of suitability for development. The priorities were based only on the information and issues discussed in the report and priorities may change due to additional information that will become available such as unit cost of water for example.

The Thengwe Dam site is expected to have the most harmful overall environmental impacts (culturally classified as fatally flawed), while the Rambuda Downstream site has the least harmful impacts, partly due to its potentially small maximum size.

The Rambuda Middle Dam site is the most expensive site to develop, while the Thengwe Dam site is the least expensive site to develop, beyond the gross storage capacity of about 40 million m^3.

A final comparison of the dam sites was to be made after the results of the hydrological studies had been completed to provide a measure of the water resources development potential of each dam site.

2.9.19 Annexure 18: System Yield Analysis

Report Title: MUTALE RIVER WATER RESOURCES INVESTIGATION: Volume 11: Annexure 18 – System Yield Analysis. Report No. A920/00/2098. Department of Water Affairs and Forestry. Prepared by Africon (1999).

The Water Resources Yield Model (WRYM) was used to determine the yield of the four possible new dam sites in the Mutale River, both individually and in a systems context. The four dam sites were modelled one at a time and the firm yield at the dam site as well as the system yield downstream at Thengwe was determined.

Four IFR sites were identified at the outlets of the relevant sub-catchments and only IFR environmental management classes B&D were used during firm yield analysis.

The present day hydrology as simulated with the WRSM90-model was used as inflow into the dams. The present day inflow record included all present day water users upstream of the dam. The respective IFR water requirement for the sub-catchment was abstracted from the dam and put pack into the system before supplying the IFR requirements further downstream. Supplying the IFR's was given the highest priority in the system. Supply the releases downstream at Thengwe and supplying the present water uses were given a higher priority than supplying the firm yield.

For the incremental inflows between the dam and Thengwe, the accumulated virgin hydrology files were used. The present day river loss supply files were used for the river loss requirement and the present day irrigation supply files were used for the irrigation water requirements. The domestic, mining and livestock abstraction requirement files were used for these abstractions, since the present day abstraction requirements are relatively small. This allows the incremental benefit of the storage to be established.

The firm yields at the three possible dam sites are compared for the different scenarios and capacities in **Table 2.34**.

Table 2.34: Comparison of Firm Yields at the Dam Sites

Net Capacity (million m^3)	FIRM YIELD (million m^3) Scenario 1: No Downstream Commitments and no IFR Requirements			FIRM YIELD (million m^3) Scenario 2: Downstream Commitments and IFR Class B Requirements			FIRM YIELD (million m^3) Scenario 3: Downstream Commitments and IFR Class D Requirements		
	Rambuda Middle	Tswera	Thengwe	Rambuda Middle	Tswera	Thengwe	Rambuda Middle	Tswera	Thengwe
10	5.58	4.78	3.34	0.00	0.00	0.00	0.00	0.00	0.00
15	7.50	7.30	5.20	0.00	0.00	0.00	0.00	0.00	0.20
20	9.58	9.60	7.30	0.00	0.00	0.00	0.11	0.00	0.40
25	11.66	11.99	9.49	0.00	0.00	0.00	2.02	0.00	1.06
30	12.83	13.90	11.20	0.00	0.40	1.20	3.88	0.90	2.90
35	13.59	15.50	13.20	0.00	2.00	2.30	4.71	3.90	4.10
40	14.64	17.34	14.30	0.24	2.93	3.90	5.81	5.67	5.70
45	15.70	18.80	17.28	2.16	4.40	5.08	6.85	6.40	7.09
50	16.64	20.16	19.00	3.89	6.57	6.30	7.79	8.01	8.20
55	17.81	21.17	21.00	6.09	7.64	7.20	8.99	9.07	9.50
60	18.82	2.22	22.73	7.44	8.30	8.64	10.07	10.10	10.69

65	20.03	23.20	23.43	7.91	9.69	9.37	11.16	11.20	11.42
70	21.03	24.0	24.25	8.37	11.10	10.10	12.18	12.30	12.10
75	21.91	26.01	24.96	8.8	12.38	10.81	12.71	13.95	12.89
80	22.32	27.10	26.00	9.25	13.10	11.80	13.12	15.10	13.9
85	22.73	28.20	27.00	9.66	14.14	12.80	13.53	16.09	14.90

The results can be summarised as follows:

- Scenario 1: Tswera Dam can supply the highest yield for the corresponding net capacities.
- Scenario 2: Thengwe Dam can supply the highest yield up to a net capacity of 55 million m^3. For net capacities above 55 million m^3 Tswera Dam can supply the highest yield.
- Scenario 3: Rambuda Middle dam can supply the highest yield for net capacities below 40 million m^3. Thengwa Dam can supply the highest yield for net capacities between 10 and 70million $m^{3.}$ For net capacities above 70 million m^3 Tswera Dam can supply the highest yield.

Although Tswera Dam is upstream of Thengwe Dam it can supply a higher yield for bigger capacities. This is due to the low inflow in Thengwe Dam during the critical period (1962/02 – 1972/01).

The IFR requirements used in the study were based on desktop estimates. A more detailed investigation into the IFR results may have a significant effect on the yield analysis.

2.10 LUVUVHU GOVERNMENT WATER SUPPLY SCHEME: BULK WATER SUPPLY PRELIMINARY DESIGNS (1999)

2.10.1 Overview

The Luvuvhu Government water supply scheme (bulk water supply preliminary design) has one report and the Luvuvhu River catchment was the focus of a feasibility study (1994-1998) for improved water supply in the region which culminated in proposals for the development of the new Mutoti Dam and new Xikundu weir. The proposal scheme was to serve the following areas (in priority order):

- Malamulele East (Including Mhinga)
- Malamulele West
- Tshifudi Lambani

- Augmentation of the Vondo RWS, and
- Albasini Dam augmentation

The project was to culminate in a compilation of an executive summary report as well as the preliminary design layouts.

2.10.2 Executive Summary

Report Title: LUVUVHU GOVERNMENT WATER SCHEME: BULK WATER SUPPLY PRELIMINARY DESIGNS: Executive Summary. Report No. PB 900/00/6199.Prepared for: Department of Water Affairs and Forestry.Prepared by BKS Consultburo, 1999.

In this project proposals for the new Mutoti Dam, Xikundu Weir and bulk water treatment and distribution systems were made. This project dealt with the preliminary designs and planning of the bulk water distribution infrastructure associated with the feasibility study proposals. The objective of the project was to provide preliminary design information of the bulk water distribution infrastructure and storage reservoirs in priority order to allow detailed designs to be undertaken. The outcomes of the project was an executive summary of the work done and preliminary design layouts of the bulk water infrastructure in accordance with the priority areas of supply as stipulated by DWAF.

An assessment of the existing population to be served by the bulk water distribution systems was made and a projection of future population was made. Based on the existing and future population estimates, water demands were assessed for preliminary design purposes. Seven separate areas of supply were identified and prioritized based on the need for water supply. The provision of the bulk water infrastructure was to be aligned with the identified priority of supply.

The preliminary designs comprised:

- Preliminary sizing of clear water pumping mains;
- Basic preliminary pipeline specifications;
- Preliminary sizing of storage reservoirs; and
- Proposed pipeline routes and positions of pump stations and reservoirs.

The preliminary designs were based on the *RDP Rural Water Supply Design Criteria Guidelines* of DWAF. The preliminary designs allowed for levels of service, design horizon, population growth rates, peak factors and reservoir capacity.

It was also recommended that the Mutoti Dam and Xikundu Weir be constructed with the latter as first priority and were to provide a water source for the total supply area under the Luvuvhu River Government Water Scheme.

2.11 LUVUVHU RIVER GOVERNMENT WATER SCHEME (2000)

2.11.1 Overview

The main purpose of the study is to supply water for domestic use in the urban areas of Thohoyandou and Louis Trichardt, and to the rural communities in the northern District of the Northern Province, from Malamulele in the Northern region to Vondo in the Southern region. The report focused on the design of the first phase of the Nandoni water treatment plant, social impact assessment of alternative routes and preliminary pipe route of bulk pipes from Albasini dam to elim/waterval and vleyfontein.The Luvuvhu river government water scheme was divided into 3 reports as reviewed in the following sub-sections.

2.11.2 Design of the first phase of the Nandoni water treatment plant

Report Title: LUVUVHU GOVERNMENT WATER SCHEME. Design of the First Phase of the Nandoni Water Treatment Plant. Report No A900-00-0100.Department of Water Affairsand Forestry, South Africa. Prepared by GFJ Consulting Engineers & Project Managers and Burotech. May 2000.

As part of the Luvuvhu River Government Water Scheme, the Nandoni Water Treatment Works was to be constructed at the Nandoni Dam. This report covers the preliminary design of the first phase of the Nandoni Water Treatment Works. Aspects that are covered in the report are the hydraulic design (the population to be served by the works and the design capacity of the works), the process selection and design, operational aspects, the proposed layout of the works, cost estimates of the works and a proposed implementation programme. Recommendations with respect to the construction of the works as well as recommendations with respect to further studies and investigations are also given.

Three options for the location of the works were considered. The site adjacent to the dam wall was selected. The works was designed with a first phase capacity of 66Ml/day. The treatment process will comprise flocculation, sedimentation, rapid gravity sand filtration, disinfection (chlorination) and stabilization of the final effluent. Provision was also made for the installation of a powdered activated carbon dosing system (to remove tastes and odour) prior to sedimentation and dissolved air flotation after sedimentation (to deal with high algal concentrations).

The treatment works will comprise of the following:

- Raw water pump station with 1100mm pumpline to inlet works;
- Building structure to house the inlet structure and bulk chemical and dosing facilities;
- Treatment plant with three flocculation channels and six sand filters;
- A 5Ml clear water tank;

- High lift pump station;
- Service water pump station;
- Wash water and silt handling facilities; and
- Outdoor electrical substation yard.

2.11.3 Preliminary pipe route of bulk pipes from Albasini dam to elim/waterval and vleyfontein

Report Title: LUVUVHU GOVERNMENT WATER SCHEME. Preliminary Pipe Route of Bulk Pipes from Albasini Dam to Elim/Waterval and Vleyfontein. Report No A900-00-0100.Department of Water Affairsand Forestry, South Africa. Prepared by Africon. August 2000.

The Luvuvhu River Government Water Scheme is to supply treated water from the Nandoni Dam to the supply areas of Elim/Waterval, Vleyfontein and Maila. Treated water will be pumped from the Nandoni Water Treatment Works to the Albasini dam (the assumed delivery point is the water treatment works at Albasini Dam) from where it will be delivered to the areas of supply by pumping.

The project comprised a route selection assessment, population and demand assessment and a preliminary assessment of distribution infrastructure. The following bulk water distribution infrastructure was identified:

- A new reservoir in the Albasini Dam area. The reservoir will be a command reservoir from where water will be further distributed by pumping to the areas of supply (Elim/Waterval, Vleyfontein Maila and also the Valdezia, Louis Trichardt and Sinthumule/Kutama). Water will be delivered to this reservoir from the Nandoni Water Treatment Works by pumping;
- A pumpstation in the vicinity of the command reservoir. Water will be pumped to Elim/Waterval, Vleyontein and Maila and also to Louis Trichardt andSinthumule/Kutama;
- Pipelines to Elim/Waterval, Vleyfontein and Maila with possibly two or three booster pump stations en-route; and
- An additional reservoir at Lemana and a new reservoir at Maila.

2.11.4 Social impact assessment of alternative routes

Two alternative routes for the Nandoni WTW/Albasini Dam bulk water pipeline were investigated.

Option A, which is termed the Northern route, begins at NR6 reservoir at Thohoyandu and follow the R524 via Shayandima, Tshisahulu, Lwamondo, Rembrander, Tshkhuma until the Albasini turnoff hereafter it will follow the gravel road to the Albasini Dam.

Option B, the Southern route, begins at NR5 reservoir at Mavambe and follow the road via Mukhomi, Gumbani, Mdabula, Hasane, Vuwani, Mashau until the Albasini turnoff hereafter it will follow the gravel road to the Albasini Dam.

2.11.4.1 **Major Findings**

Route A had an expected capital cost of 169 104 000, while Route B had an estimated capital cost of R 155 328 000.

Apart from cost, Route B was considered the preffered route due to both engineering and social considerations. The reasons given for Route B to be preferred are given below:

From an engineering point of view:

- Geological conditions more favourable for construction
- Borrow areas closer, so less haulage costs
- Inclement weather will have less impact on construction conditions
- Traffic management easier due to lower traffic densities
- Fewer river crossings
- Fulfil purpose of pumping line from Nandoni WTW to Albasini Dam

From a social point of view:

- Regional job seekers would have more equitable distribution of economic opportunities during construction
- Management of public environmental health and safety is easier
- Temporary and permanent loss of land compensation is easier
- Less disruption to region (Route B has 6 villages while Route A has 13)

2.11.4.2 **Conclusions**

It is assumed that the purpose of the pipeline is to augment supply to Makhado Municipality. However if in the future, the Thulamela Municipality place more demand on NR6, then Route B would still be the preferred route, as it would be a dedicated line to Albasini Dam.

Option B is the preffered route based on local community opinion. It is very important that employment opportunities along the chosen route are distributed equitably. The Shangaan-speaking communities feel that the Vhavenda people who are the Northern route have benefited from the scheme at their expense.

The higher population density present along the Northern route means that there is a higher potential for vandalism and illegal connections along that route.

2.11.4.3 **Recommendations**

It is recommended in view of all aspects, that Option B – the Southern route be considered the preffered route. The purpose of the pipeline and employment equity is the major motivating factors for this recommendation.

2.12 A RECONNAISANCE STUDY TO AUGMENT THE WATER RESOURCES OF THE KLEIN LETABA AND MIDDLE LETABA RIVER CATCHMENTS (2003)

2.12.1 Overview

The main objective of the study was to determine and confirm water requirements in the study area and to investigate means of satisfying these requirements.The Klein Lataba River upstream of its confluence with the Middle Letaba River was identified as an undeveloped potential surface water resource.The reconnaissance study was divided into 10 reports as reviewed in the following sub-sections.

2.12.2 Executive Summary and Main Report

Report Title: A RECONNAISANCE STUDY TO AUGMENT THE WATER RESOURCES OF THE KLEIN LETABA AND MIDDLE LETABA RIVER CATCHMENTS: Executive Summary Report No. PB B800/00/3003 and Main Report. Report No. PB B800/00/03103.Prepared for: Department of Water Affairs and Forestry.Prepared by WSM, 2003.

The main objective of this reconnaissance study was:

- To determine the yield of the current surface water supply system
- To determine and confirm water requirements in the Study Area
- To investigate means of satisfying these requirements.

It was found that the water supply shortage experienced in the Klein Letaba River catchment area and the extended area of the Middle Letaba Dam water supply scheme, are being caused by a combination of the following:

- Over-utilization of the surface water resources
- Inequitable distribution of water and wastage
- Possible problems in operating the large, complicated supply scheme
- Lack of effective management of scheme

A number of recommendations that were given are listed below, in no particular order of merit

- Institute a Water Conservation and Demand Strategy

- Develop groundwater resources
- Do a detailed investigation of the option to replace the transfer canal by a pipe system
- Determine the ecological Reserve flow to a high level of detail
- Review the future needs of the agricultural sector in the Middle Letaba Dam supply area
- Establish an internal working group to oversee the implementation of the recommendations

2.12.3 Annexure 1: Macro and socio-economic overview and legal aspects

Report Title: A RECONNAISANCE STUDY TO AUGMENT THE WATER RESOURCES OF THE KLEIN LETABA AND MIDDLE LETABA RIVER CATCHMENTS: Annexure 1: Macro and socio-economic overview and legal aspects Report No. PB B800/00/3203.Prepared for: Department of Water Affairs and Forestry.Prepared by WSM, 2003.

This study is concerned with a macro and socio-economic overview of the Klein and Middle Letaba River Catchments, both which have differing demographic profiles, water requirements, needs, etc. Determining the differences to a large extent is the objective of this study as this will enable determining the various development options that are available.

The key socio-economic differences are summarised in **Table 2.35** below:

Table 2.35: Key Socio-economic differences for the Klein & Middle Letaba Catchment (2003)

Item	Upper Area	Lower Area
Land ownership	Private formally surveyed	No full private ownership. Proclaimed towns (e.g. Giyani) are issued with a Deed of Grant. In rural areas people apply for a permission to occupy. The largest parts of the rural areas comprise large areas of unsurveyed state land.
Dominant land use	Commercial agriculture (irrigation). High returns per hectare.	Grazing and low density residential villages with some commercial farming. Agricultural activities largely comprise the Middle Letaba Irrigation Scheme, which is less sophisticated, but an important source of

Item	Upper Area	Lower Area
		employment opportunities.
Economic base	Predominantly commercial agriculture.	Predominantly government services and informal and marginal activities.
Population	Small population size yet high in socio-economic status. Low growth rate.	Large population size. Low socio-economic status. High population growth rate.
Dominant water use	Irrigation water use.	Domestic water use

In the above, the upper slopes of the Middle Letaba River Catchment are referred to as the Upper Area and remainder of the Middle Letaba and the whole of the Klein Letaba River Catchment comprises the Lower area.

Detail is provided on the institutional environment with reference to: relevant legislation; structures involved, their responsibilities and possible plans; international obligations, and the tribal system.

A detailed demographic overview is also provided. The 1998 population size of the complete study area was 709 000. Taking into account various factors, such as HIV/AIDS, four scenarios on the future population growth were developed, namely: high, low, most probably, and worst case AIDS scenario. The growth rates of the most probable scenario were:

- 1995-2000: 2.6% p.a
- 2001-2005: 2.2% p.a
- 2006-2010: 1.9% p.a
- 2011-2015: 1.7% p.a
- 2016-20202: 1.5% p.a

The demography is further analysed in terms of age profile, gender, household size, etc.

A detailed socio-economic profile is also provided covering: income, poverty gap, dependency ration, and Human Development Index. The largest portion of monetary income is earned in the form of salaries and wages. The majority of households (46%) in the study area were estimated to earn less than R5 000 p.a, which means a sizeable portion of the households live below the Minimum Living Level (MLL).

A detailed economic profile is also drawn-up with comparison to that of the rest of the country in order to gain insight into the relative size of the local economy, its composition, the degree of concentration, past growth rates achieved, the ability of the local (formal) economy to provided employment opportunities to the local labour force, etc. Agriculture used to generate a significant contribution towards the local economy, but its relative contribution has decreased notably from 1980 to 1994. The study area was also estimated to have a tress index of 80,3 which shows that it is very concentrated due to the high, and still increasing contribution by the services sector. This renders the economy vulnerable to any factor that may result in a decrease in the size of government activity in the area. The three most important drivers to the local economy in 1994 are: services, trade, and agriculture.

A reconnaissance level socio-economic impact assessment of the merits to expand or curtail the further development of the water resources was also undertaken.

Negative impacts identified include:

- Loss of primary resources (agricultural land)
- Loss of secondary resources (fire wood, medicinal plants, etc)
- Loss of social facilities (schools, clinics, etc)
- Loss of service infrastructure (water lines, power lines, roads, etc)
- Relocation of communities and their activities
- Loss of Klein Letaba River
- Loss of contribution to local economy, employment opportunities, taxes and levies
- Loss of access and communication systems
- Health and safety hazards
- Foreign workforce
- Aesthetic impacts
- Loss of archaeological sites and artefacts

Positive impacts noted include:

- Improved water supply for domestic consumption
- Temporary direct employment opportunities
- Impact on local economy
- New economic opportunities

- Improved service and social infrastructure and facilities

Based on the assessment, the study concluded, that it would seem reasonable that there is sufficient socio-economic merit for the further development of the water resources of the Klein Letaba River Catchment.

Part B of the study provides legislative detail regarding water law, environmental law and land laws.

Key aspects to consider regarding water law include:

- If non state land is submerged, a servitude should be registered or expropriation in the event that economic use of the land is negated
- EIA procedure and consultation is required
- Existing lawful water use which will be affected must be maintained, subject to the need to re-allocated water which entitles the Minister to issue compulsory licences to all users and compensate existing users for any financial losses

Key aspects to consider regarding environmental law is that the Minister is bound to the principles and procedures of the National Environmental Management Act and its regulations. During the feasibility study all relevant statutory bodies should be consulted, to ensure that all statutory requirements are being met.

Key components regarding land rights, are that no matter what form of land ownership, land rights must be accommodated and respected. The study revealed that if necessary rights need to be acquired in a lawful way, whether by expropriation and compensation or relocation. Land development guidelines, policies and legislative measures aimed at integrated resource management should be accommodated. It is also necessary to consider any objects or places which are covered in terms of the definition of heritage resources and to afford the necessary protection to these during development.

In general, no fatal flaws are identified in the study, although several permissions will have to be obtained and consultation process will have to be followed.

2.12.4 Annexure 2: Natural Environment and Water Quality

Report Title: A RECONNAISANCE STUDY TO AUGMENT THE WATER RESOURCES OF THE KLEIN LETABA RIVER CATCHMENTS:.Annexure 2: Natural Environment and Water Quality,Report No. PB B800/00/3303.Prepared for: Department of Water Affairs and Forestry. Prepared by WSM, 2003

The report formed part of the reconnaissance study of the water resources and requirements from the Klein and Middle Letaba River Catchment, one of the objectives of which was to assess the current water quality status of the Klein and Middle Letaba Rivers and to assess the potential impacts of an impoundment on the Klein Letaba River upstream of the confluence with Middle Letaba River (layed out in part B of the report).

Water quality data was sourced from the DWA (Directorate: Hydrology) for four sampling points and from a number of other sources. Data was also very limited. An assessment was based mainly on seven (10) constituents namely TDS, SAR, pH, NO_3/NO_2 as N, PO_4, Scaling and corrosion indices and faecal pollution, which were all rationally selected.

The major water quality issue was the increasing TDS trend observed downstream of the confluence of the Klein and Middle Letaba Rivers. As reported, further investigation is necessary because part of the Klein Letaba River upstream of this confluence is considered to be important in the further development of the water resources in the region.

Regarding the proposed Majors and Crystalfontein Dam sites for constructing a reservoir, the potential in-lake and downstream water quality impacts ranged from low to medium.

Three (3) additional water quality monitoring points had been recommended for implementation on the Klein Letaba River.

2.12.5 Annexure 3: Domestic and Agricultural Water Requirements

Report Title:A RECONNAISANCE STUDY TO AUGMENT THE WATER RESOURCES OF THE KLEIN LETABA RIVER CATCHMENTS:ANNEXURE 3 – Domestic and Agricultural Water Requirements. Report No. PB B800/00/3403.Department of Water Affairs and Forestry.Prepared by WSM (Water Systems Management) August 2003.

The study, although dated 2003 was essentially completed by 2001, and deals with estimated water requirements of domestic, irrigation and livestock water user sectors of the tertiary catchment B82 (primary study area), plus the domestic water supply areas outside of tertiary catchment B82 currently being supplied by the Middle Letaba Dam Scheme.

With regards to determining domestic water requirements, a decision was made to estimate water use using population data and to make use of current water design norms. The 2000 population of the Middle Letaba Dam Water Supply Area was estimated at about 600 000 persons (varying slightly with different growth scenarios) and the total population of the study area, including the areas outside of the tertiary catchment B82, was identified at about 740 000 people.

Four future population growth rates scenarios were developed. The growth rates and scenarios for these were adopted from the National Water Resources Strategy document as shown in **Table 2.36** below:

Table 2.36: Klein and Middle Letaba Population Growth rates (2003)

Description	1995-2000	2001-2005	2006-2010	2011-2015	2016-2020
High	2,6	2,6	2,6	2,4	2,4
Probable	2,6	2,2	1,9	1,7	1,5
Low	2,2	1,9	1,7	1,3	1,0
AIDS	2,1	1,7	1,3	0,9	0
NWRS	1,5	0,6			

The estimated future population size for the tertiary catchment area and the total study area is provided per scenario and growth rate. The results per village, grouped into supply zones, are also given in the Appendix of the study.

Table 2.37 below provides an indication of the AIDS scenario population estimates for the supply area which is the scenario adopted in combination with the lower unit water usage as the benchmark scenario in the water balance:

Table 2.37 Klein and middle Letaba AIDS Scenario population estimates (2003)

Region	1998	2000	2005	2010	2015	2020
Giyani Supply area	204 317	212 988	231 719	247 177	258 502	258 502
Nkuri	15 979	16 657	18 122	19 331	20 217	20 217

Region	1998	2000	2005	2010	2015	2020
Supply area						
Middle Letaba	349 678	364 519	396 574	423 031	442 413	442 413
Total Middle Letaba Dam scheme	**569 974**	**594 164**	**646 415**	**689 539**	**721 131**	**721 131**
Sekgopo	21 060	21 954	23 884	25 478	26 645	26 645
Sekgosese 2	24 133	25 157	27 370	29 195	30 533	30 533
Tshitale area	40 530	42 250	45 966	40 032	51 279	51 279
Others	53 469	55 738	60 640	64 685	67 649	67 649
Total: balance of study area	**139 192**	**145 099**	**157 859**	**168 391**	**176 106**	**176 106**
TOTAL	**709 166**	**739 264**	**804 274**	**857 929**	**897 237**	**897 237**

In terms of water usage a Level of Living Index (LLI) was used for each village with a combination of unit water requirement per index. The results of this are tabled in the Appendix of the study. Apart from a general decrease in water consumption between 2000 and 2005 due to water conservation and demand management, a general increase in unit water usage over time is was assumed.

The water usages were combined with the population scenarios, except for upper two population estimates which were discarded because the impact of AIDS on the population growth was thought to have been offset in Limpopo by the increased influx from neighbouring states. The remaining three population scenarios, combined with two possible water usage scenarios, lead to a total of six domestic water use estimates. The estimated domestic water requirements (in 10^6 m^3/a) are shown in **Table 2.38** below:

Table 2.38: Klein and middle letabaestimated domestic water requirements (2003)

Scenario	Description	1998	2000	2005	2010	2020
1	Probable demand / low population	24,7	27,1	27,2	34,4	50,2
2	Low demand / AIDS population	24,1	26,3	24,8	27,9	32,1
3	Low demand / NWRS population	24,1	26,0	23,2	25,2	29,4

The study revealed that the three estimates of water requirements remain fairly close up to 2005, where after they start to diverge and by 2020 the difference between the low and high estimates is 70%. The estimated probable demand by 570 000 people is 19,5 million m^3/a, which can be taken as approximately 11,4 million m^3/a for 332 000 people. The study notes that the actual usage in the Middle Letaba Dam Water Supply Area, as reflected in the total quantity of water treated, gives an average unit demand for the 2000 population of 117 l/s, yet water shortages are experienced in many villages. Some form of water conservation and water demand management was thus assumed necessary to be instituted to ensure equitable distribution of water.

Irrigation

Irrigation Water requirements were estimated to be about 30.2 million m^3/a based on the expected field mead edge water requirement per month for different crops in the irrigated land shown in **Table 2.39** below.

Table 2.39 Land Use per Catchment (ha)

Catchment	Irrigated land			Afforested areas	Grazing, dry lands & towns	Dams	Total	Total land cultivated
	Perennial crops	Annual crops	Total					
B82A	19	591	610	1189	44737	120	46656	3863
B82B	483	1347	1830	2978	35576	249	40633	121735
B82C	212	1087	1299	2518	22683	3466	29966	8073

Catchment	Irrigated land			Afforested areas	Grazing, dry lands & towns	Dams	Total	Total land cultivated
	Perennial crops	Annual crops	Total					
B82D		32	32	1651	59932	1552	63167	1035
B82E		18	18	2177	40117	23	42335	2563
B82F		62	62	2118	73769	23	75972	5270
B82G	200	819	1019		87064	46	88129	1500
B82H	200	76	276		76567	528	77371	255
B82J					79766		79766	
TOTAL	**1114**	**4033**	**5147**	**12631**	**520210**	**6007**	**543995**	**34294**
% OF TOTAL	**-**	**-**	**1.0**	**2.3**	**95.6**	**1.1**	**100.0**	

Stock Watering

Livestock water requirement was determined to be 2% of the Study area MAR and is supplied from sources other than the potable water supply systems.

The study concluded that Water Conservation and Demand Management needed to institute to ensure the equitable distribution of water as the water shortages were still being experienced in the Middle Letaba for the 2000 population at average unit demand of 117 l/s.

2.12.6 Annexure 4: Surface Runoff Hydrology

Report Title: A RECONNAISSANCE STUDY TO AUGMENT THE WATER RESOURCES OF THE KLEIN LETABA RIVER CATCHMENTS – Annexure 4: Surface Water Hydrology. Report No. PB B800/00/3103.Department of Water Affairs.Prepared by WSM, August 2003.

Please note: At the time of this report this Annexure was not available and this section represents the summary of the Annexure as available from the Main Report.

2.12.6.1 **Scope of work**

The exploitable surface and groundwater resources in the Primary Study Area, as well as in the Water Supply Study Area, were assessed. The yield of the Middle Letaba Dam was in dispute and had to be resolved. Before the dam was constructed there were no river flow gauging stations in the Klein Letaba River catchment area. Since completion of the dam and the construction of a measuring weir at Tabaan (B3H033), located some 2.3 kill downstream of the confluence of the Klein and Middle Letaba Rivers, about 11 years of record became available. The data collected at Middle Letaba Dam (B8H007) can be used to determine the flow in the Middle Letaba River as it enters the dam. The flow record at Tabaan is essentially the flow in the Klein Letaba River because the Middle Letaba Dam has not spilled in the period assessed (which was before the floods of January/February 2000). It was therefore possible, for the first time, to properly calibrate the rainfall-runoff model and perform hydrological yield analyses on existing and possible future reservoirs.

The assessment of groundwater resources, at a desktop level of detail, was based on the comprehensive database of existing boreholes (although the yields of all holes were not available), as well as the regionalised Harvest Potential and Exploitation maps prepared by DWAF.

2.12.6.2 **Surface Water Hydrology**

The runoff hydrology of the catchments of the Middle Letaba Dam (Middle Letaba River), the Nsami Dam (Nsama River) and of the dam sites investigated on the Klein Letaba River, upstream of its confluence with the Middle Letaba River, were determined. In order to establish the impact of the estimated ecological Reserve on the yield of the existing and possible future dams, as part of subsequent studies, the hydrology of downstream quaternaries B82G and B82J was also investigated.

2.12.6.3 **Climatological data**

Rainfall

Rainfall data are important inputs in the model used for generation of flow sequences. In this study rainfall records of rain gauges in the study area, as well as in adjacent catchments, were obtained from the Weather Bureau. Only long records, with high stationary levels and not too many years or missing data, were used. The Wilcox stationary test was applied to the data and mass plots were also prepared to test for stationary. The stations were then classified and patched using CLASSR and PATCHR. Records were not extended. Quaternary catchments were grouped together, because rainfall stations do not cover each quaternary catchment adequately. 3 Monthly catchment rainfall records were created from patch rainfall and WR90 catchment MAP were used.

Evaporation

S-Pan Evaporation data were used as from the WR90 publications, the B8E007 data for the Middle Letaba Dam and the Bosman conversion factor for A-Pan calculations.

2.12.6.4 **Water usage in the catchments**

Farm dams

Information on the full supply capacities of the larger dams as in 1986 was obtained from the Basin Study (Steffen, Robertson & Kirsten, 1990, See Section 2.3.6). Remote sensing was used to determine the 1996 full supply areas of farm dams, with areas larger than 0.5 ha. Using available information on the general area-capacity relationships in the region, total dam capacities per quaternary catchment were determined. Dummy dams were modelled in each catchment. Of interest is the large number of impoundments upstream of Middle Letaba Darn, as reflected in the 1996 total for quaternary catchments B82A to B82D of 34,32 x 10^6 m^3. Some dams are quite large, e.g. Lama Dawn Dam has a capacity or 11.7 x 10^6 m^3. The calibrated natural mean annual runoff (MAR) at Middle Letaba Dam is 61 x 10^6 m^3, therefore the capacity of the upstream dams equals about 56% of the MAR. The total capacity of farm dams at 1996 levels is 38.18 x 10^6 m^3.

Irrigation

Irrigation of crops occurs in quaternary catchments B82A to B82H. The historical growths in irrigation areas are provided per quaternary, with information sourced from the Basin Study (Steffen, Robertson & Kirsten, 1990 See Section 2.3.3). B82G and B82H were not included in the calibration of tile model. Weighted crop factors for the sub-catchments were used to model the water requirements of the typical crops (i.e. tomatoes, vegetables, bananas, avocados and citrus). The fraction of the total irrigation area that is irrigated in a specific month was also taken into account, using information collected by Index. Irrigation efficiencies and return flows were also included in the modelling. The total irrigated area for B82A-F was give as 21.0 km^2 in 1986 and

38.51 km^2 in 1996.

Afforestation

Again using data from the Basin Study (Steffen, Robertson & Kirsten, 1990 See Section 2.3.7) the growth in forested areas were obtained. The total forested area for B82A-H was give as 7.45 km^2 in 1986 and 126.40 km^2 in 1996.

2.12.6.5 Calibration and generation of long term flow sequences

Two observed flow records were available for calibration, namely the inflow record of Middle Letaba Dam (B8R007) and the flow record of gauging station Locatie van Tabaan (B8H033). The flow records are, however, only 11 years long. The WRSM90 System Model for the catchment of Middle Letaba Dam included five sub-catchments: the quaternary catchments B82A, D82B and B82C as well as quaternary catchment B82D which was divided into two sub-catchments to represent the wetter western part and drier eastern part. Since the Middle Letaba Dam did not spill during the calibration period, the system model for the river gauge only included quaternary catchments B82E and B82F. In this instance B82F was also subdivided into a small, wetter part in the north-eastern part of the catchment, resulting in three sub-catchments being considered in the model.

The model could be calibrated to an acceptable level. However the observed gross yield curve for Letaba Dam was found to be between 6% to 8% higher than the simulated for the 11 year record. After calibration, a long term (75 year) flow sequence was generated for each of the 9 quaternary catchments, in tertiary catchment B82, in order to determine the natural MAR's for use in the system analysis. Calibrated model parameters were only obtained for quaternary catchments B81A to B82F. For quaternary catchments B82G, B82H and B82J, the WR90 regional model parameters were used. The natural MAR's determined in this study are consistently less than those shown in the WR90 publication. The total tertiary catchment MAR for the WR90 publication and this study was 151.9 x 10^6 m^3 and 133.4 x 10^6 m^3 respectively, a 12% drop from the WR90 publication.

2.12.6.6 **Estimation of river losses in lower sand bed river reaches**

The lower reach of the Klein Letaba River, i.e. quaternary catchments B82G and B82Jhas a deep alluvial riverbed. The river thus only exhibits surface now if the interstitial space in the sand is saturated. Surface flow is therefore apparently "lost". Actual losses occur in the amount of water abstracted from the sand by riverine vegetation through evapotranspiration and by evaporation when the water level is above the level of the sand. A conceptual model of flow and losses in the river reach was set up, which in turn was modelled with the WRYM model.

Both of the quaternary catchments concerned were subdivided into two reaches so that a total of four reaches were considered:

- In the upper part of quaternary catchment B82G, river length 17,6 km, water loss was taken to be through evaporation from river surface and evapotranspiration from riverine vegetation, since it was assumed (based on observation) that in the natural condition surface flow occurs regularly in this reach
- It was assumed that during low flow periods mostly subsurface flows occurs in the lower, 58.3 km long reach of quaternary catchment B82G. The losses now also take account of the effect of subsurface flow and a dummy dam was modelled in the WRYM which took account of the evapotranspiration loss from riverine vegetation.
- Likewise, the upper 17 km long length of river reach in quaternary catchment B82J was modelled by a dummy dam.
- However, the lower 22.5 km long reach of quaternary catchment B82J has very little riparian vegetation and the area-capacity relationship of the dummy dam used here was adjusted to take this into account in the WRYM runs.

The total river losses were calculated as being 21.4 x 10^6 m^3 per year, a total of 16% of the total simulated natural MAR for the tertiary catchment.

2.12.7 Annexure 5: Surface Water Resource Development Potential

Report Title: A RECONNAISSANCE STUDY TO AUGMENT THE WATER RESOURCES OF THE KLEIN LETABA RIVER CATCHMENTS: Surface Water Resource Development Potential: Annexure 5. Report Number PB 800/00/3603. The Department of Water Affairs and Forestry.Prepared by WSM. August 2003.

In this report the results of the historic and stochastic yield analyses undertaken for the Middle Letaba and Nsami dams system and the dams at the Mojosi and Crystelfontein are presented.

The WRSM90 model was calibrated against observed flow sequences at Middle Letaba Dam and the flow gauge B8H033 at the outlet of the quaternary catchment B82F. In both cases the sequences cover the period October 1986 to September 1997 and although the sequences are fairly short, good calibrations were obtained as described in Annexure 4.

The Middle Letaba and Nsami Dams are two existing dams in the system under investigation. It was found that the historic firm yield (HFY) of the Nsami Dam on its own is negligible. Operating the two dams as a system increases the yield for the two dams by about 1 million m^3/a i.e. a 6% increase for no ecological reserve releases and a 7% for Class D reserve releases.

The HFY (16.6 million m^3/a, no releases for the ecological reserve) of the Middle Letaba Dam has a long associated return period of 590 years. If the dam is operated at a risk of failure of 1 in 200 years or 1 in 100 years the yield is 17% or 30% higher at 19.5 million m^3/a or 21.5 million m^3/a respectively.

A stepped draft analysis was done for Middle Letaba Dam to investigate how it's HFY (16.6 million m^3/a) could be increased if operated at a lower assurance. The maximum mean yield obtained was 20.2 million m^3/a (an increase of 22%) for an upper draft of 22.0 million m^3/a (80% of the time) and a lower draft of 13.2 million m^3/a (20% of the time.

In order to increase the yield of the Middle Letaba and Klein Letaba rivers, the yields of dams at Majosi and Crystalfontein on the Klein Letaba River were investigated for various scenarios. The scenarios included yield analysis where reserve releases are both excluded and included (different reserve release scenario) and the results are presented in the report.

A comparison of the historic firm yields of Majosi and Crystalfontein Dams with their stochastic yields showed that the return periods associated with the historic firm yields are all close to 200 years.

A yield analysis was also done for Middle Letaba Dam supported by a diversion canal from Majosi. With Calls D ecological reserve requirements being met at all the dams the HFY of the Middle Letaba Dam could be increased from 13.4 to 17.7 million m^3/a (32% increase) for the larger canal diversion capacities.

A dam at Majosi or Crystalfontein could increase the HFY of the present Middle Letaba and Nsami system by 45% and 59%, respectively if no ecological reserve releases are made from the dams. The increases reduce to 19% and 28% if the Middle Letaba and Nsami Dams release water to compensate for the Class D reserve and the dam at Majosi or Crystalfontein release enough water to compensate a Class B reserve shortages in the Klein Letaba River at the confluence with the Groot Letaba River.

From the study results it became apparent that a dam at Majosi or Crystalfontein will not improve the water supply of the present system significantly if ecological releases from the dams for the reserve are included.

2.12.8 Annexure 6: Regional Geology and Groundwater Resources

Report Title: A RECONNAISSANCE STUDY TO AUGMENT THE WATER RESOURCES OF THE KLEIN LETABA RIVER CATCHMENTS: Annexure 6: Regional Geology and Groundwater Resources. Report Number PB 800/00/3573. The Department of Water Affairs and Forestry.Prepared by WSM. August 2003.

The report summarises the lithostratigraphic units that outcrop in the catchments, as well as their engineering, weathering and soil properties.

A hydrogeological map is provided, however, it only identifies areas of low (average yields of <0.5 l/s and 50% borehole success rates), medium (average yields of 1.5 l/s), and high potential (average yields of 3 l/s).

The report also quantifies exploitation potential and groundwater quality for each Quaternary catchment.

The report identified village clusters where population density, standard of living, and available groundwater resources would preclude the villages being supplied solely by local groundwater resources. Three such clusters exist around Elim and Waterval, Bungani and Basani, and Giyani.

2.12.9 Annexure 7: Engineering Geology of Dam site on the Klein Letaba

Report Title: A RECONNAISSANCE STUDY TO AUGMENT THE WATER RESOURCES OF THE KLEIN LETABA RIVER CATCHMENTS: Annexure 7: Engineering Geology of Dam site on the Klein Letaba. Report Number PB 800/00/3583. The Department of Water Affairs and Forestry.Prepared by WSM. August 2003.

A number of options for the augmentation of the existing water resources in the Klein Letaba catchment have been identified and investigated. The conclusion was that two dam sites, one at Crystalfontein and the other at Majosi, should be further investigated.

Further investigation of the two dam sites at Crystalfontein and Majosi was undertaken. This report deals with the further investigation and the engineering geology of the sites. The objectives of the investigation were to identify the possible depth of unconsolidated river deposits, to provide preliminary quantities information on the sub-soils at the two sites, to estimate possible average depths of foundation excavation and to identify possible sources of construction materials.

The investigation comprised the following:

- A desktop study of the geological and geotechnical aspects of the dam sites;
- Auger drilling to investigate the scope and extent of alluvial channel deposits;
- Laboratory testing of selected soil samples;
- An assessment of site geology;
- Engineering geological considerations with respect to dam construction; and
- An investigation of dam construction materials;

The investigation concluded that at the Crystalfontein site a composite type dam would be the most appropriate. The proposed dam will comprise a concrete gravity structure incorporating a spillway and chute on the river section and on the left bank of the river and a zoned earth fill embankment on the right bank. The majority of the fluvial soils tested appear to be suitable for use as clay core material or for use in a homogeneous embankment. Sand for use in dam filter and concrete applications may be obtained from the alluvial sand deposits in the river bed. Estimated excavation depths will be 5m on the left river bank, 4m in the river section below the concrete gravity structure and 3.5m for the cut-off trench depth beneath the core and 1m beneath the shell footprint on the right river bank. A grouting programme will be required. However, local experience indicates that grouting may not be successful and consideration should be given to alternative methods (slurry trench, jet grouting).

At the Majosi site a zoned eat fill dam was identified as the most appropriate dam type. The majority of the fluvial soils tested appear to be suitable for use as clay core material or for use in a homogeneous embankment. Sand for use in dam filter and concrete applications may be obtained from the alluvial sand deposits in the river bed and elsewhere. Estimated excavation depths will be 3.5m cut-off beneath the fluvial deposits on the lower left bank, a cut-off depth of 2.5m on the right bank and upper left bank and 1m beneath the shell footprint. The river section will require excavation down to 2m to expose good rock over the whole area. A grouting programme will be required. However, local experience indicates that grouting may not be successful and consideration should be given to alternative methods (slurry trench, jet grouting).

.Recommendations with respect to further work and investigations were identified and are given in the report.

2.12.10 Annexure 8: Preliminary Design and costing of augmentation schemes

Report Title: A RECONNAISSANCE STUDY TO AUGMENT THE WATER RESOURCES OF THE KLEIN LETABA RIVER CATCHMENTS: Annexure 8: Preliminary Design and costing of augmentation schemes. Report Number PB 800/00/3593. The Department of Water Affairs and Forestry.Prepared by WSM. August 2003.

In this study, a number of water augmentation schemes were considered to augment the water resources of the Klein Letaba catchment. The schemes were designed to a preliminary design level and cost estimations of the schemes were carried out. An engineering economic evaluation of the alternative schemes was carried out and scheme URV's calculated.

Initially, a screening study was undertaken to assess and compare a total of five dam development options. The screening process eliminated three of the dam sites and only the dam sites at Crystalfontein and Majosi were further considered in the development of possible augmentation schemes. Preliminary designs of dams at Crystalfontein and Majosi were then undertaken for four different capacities and cost estimations were done for each capacity.

Schemes to transfer water from the proposed dams to the water treatment works at the Middle Letaba Dam were then identified and developed. The transfer schemes were designed to a preliminary design level of detail and casted.

The water augmentation schemes that were identified and casted are the following:

- Scheme 1: Crystalfontein Dam with pumping scheme and gravity pipeline to the Middle Letaba WTW. The scheme comprises a rising main from the dam to a break-pressure tank on the catchment devide and a gravity pipeline from the devide to the water treatment works. Designs were carried out for four different capacities and costed.
- Scheme 2: Crystalfontein Dam with transfer infrastucture to the existing transfer canal between the Middle Letaba and the Nsami Dams. Two options were considered, an open canal (trapezoidal, 0.3m bottom width, 0.7m lining depth, side slopes 1V:1.5H) with a length of 19.5km and an underground pipeline (700mm dia) with a length of 15.0km. Design flow in both cases 246l/s. Capital cost of the pipeline option R30.46 million (base date August 2003)
- Scheme 3: Majosi Dam with gravity pipeline to the existing Middle Letaba WTW. The scheme comprise a gravity pipeline on the left bank of the Klein Letaba River with a length of 10.2km. A deep cut to cross the catchment watershed and a crossing of the Middle Letaba River and the existing transfer canal will be required. Designs and costing for four different capacities were carried out.
- Scheme 4: Majosi Dam with flood diversion canal to the Middle Letaba Dam. The scheme will comprise a small dam or weir at the Majosi site with a canal to divert water from the Klein Letaba River to the Middle Letaba Dam. The canal alignment is such that the canal will discharge above the full supply level of the Middle Letaba Dam. It is assumed that the water level in the Middle Letaba Dam will not remain above the full supply level of the dam for long. If this option is pursued, the canal breaching risk should be evaluated.
- Scheme 5: Replacement of the existing transfer canal between the Middle Letaba and Nsami Dams with a pipeline. The scheme will comprise a pump station and rising main (800mm dia X 6.7km) from the dam to a local high point and a gravity pipeline (1000mm dia X 33.3km) from the high point to the Nsami Dam.

The engineering economic evaluation of the schemes indicated the following:

- Scheme 1 - URV (R/m3) = R4.32;
- Scheme 2 - URV (R/m3) = R4.65;
- Scheme 3 - URV (R/m3) = R5.27;
- Scheme 4 - URV (R/m3) = R4.14;

- Scheme 5 - URV (R/m3) = R4.11;

2.13 MIDDLE LETABA WATER SUPPLY SCHEME: WC/WDM SITUATION ASSESSMENT(2003)

2.13.1 Overview

The study of the Middle Letaba water supply scheme has one report. The objective of the study was to undertake the following:

- A Water Conservation and Water Demand Management situation assessment and conditions of water supply infrastructure in the Middle Letaba and Nsami Dam (Giyani) Water Supply Schemes.
- An assessment of the potential impact of the implementation of Free Basic Water in the study area.
- Develop a Plan of Action to address the issues identified in the situation assessment. The plan of action will identify short term intervention measures and the strategy for water conservation and water demand management.

2.13.2 Middle Letaba Water Supply Scheme: Water Conservation and Water Demand Management Situation Assessment Study

Report Title (Working Document): MIDDLE LETABA RIVER WATER SUPPLY SCHEME: Water Conservation and Water Demand Management Situation Assessment Study. Department of Water Affairs and Forestry, Directorate Water Conservation. Prepared by Tlou & Matji Engineering and Management Services (Pty) Ltd. April 2003.

The report identified that there is a potential for the implementation of WC/WDM initiatives in the supply areas of the two schemes because of the high infrastructure leakage index (ILI). The situation assessment identified that the following issues need to be given special attention in the Business Plan for the two schemes supply areas:

<u>Middle Letaba Water Supply Area</u>

- Security of supply coupled with treated water quality needs to be addressed. A number of illegal connections and significant losses after the service connection have been identified. Some of the villages downstream of the system do not receive water because of the high consumer water use in the villages that received water first. The high water use should be reduced through the proposed WC/WDM management options.
- The ILI was found to be high which indicated that the significant water losses occur in the

distribution network. Reduction in the infrastructure losses, to the extent that it is cost effective is required.

- The water supply scheme was found to generally not be very well zoned and that there is a need for the system metering to be improved. Minimum nights flow analysis is required once the district meter areas are established. Active leakage control cannot be undertaken because of the lack of proper zones and system metering.
- The accuracy of the existing system meters and consumer meters should be checked. This should lead to the development of a consumer renewal programme.
- The throughput of the Middle Letaba Water Treatment Works should be improved by undertaking a hydraulic model analysis of the system.

<u>Giyani Water Supply Area</u>

- The security of water supply problems in some of the villages should be addressed.
- Some of the villages were found to receive very high pressures because of their position at the lower end of the distribution system and pressure management will be essential to reduce the pressures and thereby ensuring equal distribution of the available water supplies.
- A large number of consumers are being supplied with yard or house connections and there are significant losses in the service connections and the yards and active leakage repair after the service connection is thus essential.
- Establishing district metering on telemetry and sectorisation of the reticulation network in the Giyani Water Supply Scheme is essential. The system metering should be improved in order to be able to undertake active leakage control.
- Reduction in infrastructure leakage, to the extent that it is cost effective should be done for the supply area of the Giyani Water Treatment Works.

<u>General</u>

- Up to date and reasonably accurate set of water mains and primary component records and a procedure for regular up-dating should be established.
- Other information systems should be improved; especially the consumer meter databases which should provide a common source for technical and financial departments that should meet both their needs.
- A consumer management system should be established based on sound technical and financial principles to minimise inaccuracy and maximise cost recovery.

All the measures listed above involve an initial start-up phase followed by on-going operations and maintenance of the process and systems for WC/WDM measures. It was envisaged that the next phase of the project would involve partnership between DWA, the Mopani DM and the Vhembe DM and the cost estimate for the implementation of the recommended WC/WDM measures is R11 368 859 including VAT. The amount was split per DM area.

2.14 LUVUVHU/LETABA WATER RESOURCE SITUATION ASSESSMENT (2003)

2.14.1 Overview

The main objective of this water resources situation assessment has been to determine the waterrequirements of all the user sectors (including those of the riverine and estuarine ecosystems) andthe ability of the available water resources to supply these requirements. However, other aspectssuch as water quality, legal and institutional aspects, macro-economics, existing infrastructure andinternational requirements have also been addressed. This report outlines the 1995 water resourcessituation, using information obtained from previous study reports to identify the main water relatedissues of concern. The large body of information available in the Department of Water Affairs andForestry and from other sources has also been collated and presented in this assessment. This hasbeen collected on a catchment basis at the quaternary catchment level of resolution.

The main purpose of this study was to highlight the principal water related issues, to identify existing water shortages, to provide information that was necessary to formulate future strategies such as the national water resources strategy and catchment management strategies and to stimulate initial actions to ensure the best overall sustainable utilisation of the water, with minimal waste and harm to the aquatic ecosystems.The Luvuvhu/Letaba water resource situation assessment study has one report as reviewed in the following sub-section.

2.14.2 Main Report

Report Title:LUVUVHU/LETABA WATER RESOURCE SITUATION ASSESSMENT: Main Report. P02000/00/0101.Prepared for: Department of Water Affairs and Forestry.Prepared by WSM, 2003.

This report is based on a desktop study of the available water resources and quality and also patterns of water requirements that existed during 1995 in the Luvuvhu/Letaba Water Management Area, which occupies a portion of the Northern Province. The report does not address the water requirements beyond 1995 but does provide estimates of the utilisable potential of the water resource after so-called full development of these resources, as this can be envisaged at present.

The conclusions and recommendations can be summarised as in the following categories:

A. Available data

Data that should be investigated further for the purpose of proper management of theLuvuvhu/Letaba WMA include:

- Monitoring of **large water abstractions** from both surface and ground waterresources and the recording of these in a data base. The agricultural sector is thelargest water user in the Luvuvhu/Letaba WMA, yet only highly incompleteinformation exists about the water use on individual farms. There are still manyuncertainties in this field, like crop areas and actual irrigation water applicationversus the theoretical (design) quantities. More work needs to be done to verify cropareas. Best management practices needs to be implemented by the service providersto encourage responsible water use on farm level.
- Overgrazing should be discouraged to limit the erosion of sensitive areas.
- Outstanding information on **population** statistics and water supply infrastructure,especially in rural villages, could be collected to enable a better estimate of waterrequirements.
- The **river flow-gauging network** should be improved with new gauges atstrategically important points in the basin, especially the downstream reaches of therivers. Existing gauges should be checked for accuracy and reliability.
- Information on **infiltration and seepage losses** from rivers and canal distributionsystems is unavailable and is required for the optimizing of water supply systems.Proper measurements are required to facilitate such assessments.
- A sensitivity analyses should be done on the influence of **afforested areas** on streamflows. This would show how significant the effect is on the results.
- Information regarding **groundwater contamination** resulting from human wastesshould be collected. Once sufficient microbial data becomes available, the numericalmethods and associated assumptions discussed in section 6.4.3 should be validatedand the maps replotted. Monitoring data from selected areas should also be collectedto assess the validity of the vulnerability assessment presented in this report.Many of the issues listed above would probably be taken care of in the WSDP plans andmonitoring required of water service providers by DWAF, as well as in the water useregistration and ultimate licencing process.

B. The Luvuvhu/Letaba WMA

Priority should be given to the monitoring and research needs associated with variablesrelated to the largest quantities of water used in the catchment and factors which have thegreatest impact on water use and water resources development. In this regard, irrigationuses most of the catchment’s exploitable water, but the quantity of water involved isamong the most poorly monitored.

Regarding the second highest water use, viz Ecological Reserve, it seems imperative thatthe final river management classification be done. This should be followed by the finalestimates of the Ecological Reserve so that a better assessment can be made of theutilizable water resources.Domestic water use, especially in the rural areas, should be curtailed to realistic levels by water demand management strategies. Such efforts should undoubtedly lead to the existing water sources serving more people.

The accuracy of the estimated water use by alien vegetation should be improved, becauseit is estimated to be a relatively high consumer (viz. 21,6 million m3/a for alien vegetationversus 24,5 million m3/a for rural use). If alien vegetation use is indeed of thismagnitude, steps should be taken to minimise it.Urgent considerations should be given to the water management of the basin and the establishment of a Catchment Management Agency to plan, implement, operate, control and manage the water resources of the basin including the legal and institutional structure which would be required.

Aspects relating to the sub catchments are discussed below.

A. The Luvuvhu catchment

The importance of existing commercial irrigation, both in terms of income generated andwork opportunities provided, should be borne in mind in any development scheme.The construction of the new Nandoni Dam will improve water supply to rural villagesand secure water for increased irrigation. Inter-departmental co-ordination is required toensure the long-term efficient use of this increased resource for irrigation by emergingfarmers.

B. The Mutale catchment

The introduction of more ecologically sound agricultural practices including realisticstock levels is required to halt the current degradation of the vegetation and thus improverunoff quality and limit soil erosion.Additional streamflow gauging weirs should be considered, particularly to assess theriver channel losses between the entrance to the Mutale Port and the confluence with theLuvuvhu River. Besides being used for flow measurements, new gauging stations andthe existing gauging stations must also be used for water quality measurements and tomonitor water use in certain areas. It is essential that all streamflow gauging weirs areoperated effectively.

Additional rainfall and evaporation stations should be established. It is proposed that thesites and distribution of these stations be confirmed only after a survey has beenconducted on the availability of suitably qualified and reliable observers in the areas ofinterest. Steps need to be taken to ensure adequate representation of the various water user sectorsin the Mutale River catchment on the Luvuvhu/Letaba Catchment Management Agency.

C. The Letaba catchment

Additional rainfall, evaporation and streamflow gauging stations should be established.Quantification of irrigation, domestic and industrial water use is essential to ensureequitable distribution of water in this stressed catchment.The establishment of a Catchment Management Agency is required to properly managethe water resources in light of the ever-increasing competition between agricultural anddomestic water user sectors.

2.15 NATIONAL WATER RESOURCE STRATEGY (2003)

2.15.1 Overview

The National Water Resource Strategy (NWRS) describes how the waterresources of South Africa will be protected, used, developed, conserved, managed andcontrolled in accordance with the requirements of the policy and law. The central objective ofmanaging water resources is to ensure that water is used to support equitable and sustainablesocial and economic transformation and development.A vital element of the NWRS is the progressive decentralisation of the responsibility andauthority for water resources management to catchment management agencies and, at a locallevel, water user associations. These institutions, representative of water users and otherstakeholders, will facilitate effective participation in the management of water resources in theirareas. It will also enable the Department of Water Affairs and Forestry to move from its presentmultiple roles as operator, developer and regulator to become the sector leader, policy maker,regulator and monitor. The Department will lead the creation of the new institutions, which willtake a number of years, and support and guide them in the execution of their tasks. TheNational water resource strategy presented an overview of the water resources availability and utilisation for the 19 WMA of which both the Luvuvhu and Letaba Water Management Areas (WMA) were reviewed and summarised below.

2.15.2 Luvuvhu and Letaba water Management Area Overview of Water Resources Availability and Utilization

Report Title: LUVUVHU AND LETABA WATER MANAGEMENT AREA: Overview of Water Resources Availability and Utilisation. Report Number P WMA000/00/0203. Department of Water Affairs and Forestry.Prepared by BKS. September 2003.

Water resources in the Luvuvhu and Letaba water management area are broadly in balance with the requirements for water, and the situation is expected to remain relatively stable. Some parts are on the verge of stress, however, and irrigators in the Groot Letaba and Klein Letaba sub-areas had to adjust their farming practices to non-optimal production due to insufficient water availability. Whilst the commissioning of the Nandoni Dam will bring about surplus in the Luvuvhu/Mutale sub-area, water availability in the Groot Letaba and Klein Letaba will be seriously impacted upon through the implementation of the reserve. With undeveloped resource potential remaining, the primary focus in most of the water management area should be directed to more efficient, beneficial and equitable use of the water resources currently available (and water development). Water from new surface resource developments is likely to be affordable only to high value uses, such as mining and related developments. Water for poverty relief and rural development can partially be sourced form Nandoni Dam and should otherwise be re-allocated from existing irrigation.

The implementation of the reserve is of special importance with respect to the Kruger National Park and priority should be given to the implementation planning and mitigation of impacts.

Strategic perspectives on the main interventions and options with respect to the future availability and optimal utilisation of water in the Luvuvhu and Letaba water management area were described for each of the sub-areas as follows:

Luvuvhu/Mutale Sub-Area

Water from the Nandoni Dam should be utilised to supply the areas where over-exploitation of groundwater is experienced. The complex system of water supply from both surface and groundwater sources downstream of Albasini Dam and the interdependencies between surface and groundwater should be investigated.

A portion of water from the Nandoni Dam has been designated for poverty relief and the establishment of emerging farmers. Water from the dam may also be utilised for rural water supplies in the Shingwedzi and Klein Letaba sub-areas, thereby relieving pressures on current sources of supply. Additional transfers to Makhado can possibly best be sources for the Nandoni Dam surplus, as was allowed for in the planning of the dam.

Should the coal fields in the northern part of the WMA be developed in future, then the water requirements could be sourced from Nandoni Dam, a possible new dam on the Mutale River or by abstraction from the Limpopo River.

Shingwedzi Sub-Area

It is foreseen that groundwater will remain the primary source of supply to the sub-area. Augmentation from Nandoni Dam may be the best alternative where the sustainable yield from groundwater is insufficient.

Groot Letaba Sub-Area

The irrigation sector in this area had to adjust to the insufficient availability water and will be further impacted on by the implementation of the reserve. It is evident that compulsory licensing will be required for reorganising water use in the catchment to confirm the availability thereof. Water for possible mining developments may be supplied form the proposed Nwamitwa Dam on the Groot Letaba River, which may also alleviate impacts on other users because of the implementation of the reserve.

Lower Letaba Sub-Area

Due to the fact that virtually all of this area falls within the Kruger National Park, no noticeable changes which could impact on water resource management in the sub-area are foreseen. It is important that the provision for the reserve is properly managed in the Groot Letaba and Klein Letaba catchments in order to meet the requirements within the Lower Letaba River.

As a result of the available water in the WMA already being fully utilised and the impacts on the on the water availability which will result from the implementation of the reserve, no expansions of irrigation and afforestation should be allowed in the WMA.

The merits and feasibility of removing alien vegetation in the catchments of the Luvuvhu River and Groot Letaba River need to be investigated.

Transfers and Reservation of Water

The following reservations were made in the National Water Resources Strategy with regards to transfers from the Luvuvhu and Letaba WMA to neighbouring WMA's:

- The existing transfer of 2.4 million m^3/a from Albasini Dam to Makhado in the Limpopo WMA.
- An additional 5 million m^3/a to be reserved from either the Albasini Dam or Nandoni Dam for possible transfer to Makhado in the Limpopo WMA.
- A maximum of 18.1 million m^3/a per year available form Ebenezer Dam and Dap Naude Dam for transfer to Polokwane in the Limpopo WMA (existing).
- Existing transfers of approximately 0, 7 million m^3/a from the Groot Letaba River for mining near Gravelotte and to domestic users in the Olifants WMA.

2.16 INTERNAL STRATEGIC PERSPECTIVE: LUVUVVHU/LETABA WATER MANAGEMENT AREA (2004)

2.16.1 Overview

The Internal Strategic Perspective (ISP) aims to ensure synergy within the Department ofWater Affairs and Forestry (DWAF) regarding water resources management. The ISPpresents a common and consistent departmental approach to guide official's whenaddressing water management related queries and evaluating water license applications.

DWAF is striving for an integrated planning and management approach, referred to asIntegrated Water Resources Management (IWRM). The ultimate aim of this IWRMprocess is to arrive at:

- An allocation schedule that meets the requirements of the National Water Act (NWA) (Act 36 of 1998);
- Water resources yield and other models that are representative of the flow regime of the river systems in the area;
- Management class scenarios for the river (i.e. Reserve and Resource Quality Objectives set);
- A Catchment Management Strategy for each Water Management Area.

These deliverables can only be finalised once the Catchment Management Agencies(CMA) assume responsibility for managing the water resources of their respective WaterManagement Areas (WMA). In the interim, DWAF's Regional Offices will continue tomanage the water resources in their area of jurisdiction until such time as they can handover these management functions to established and fully operational CMAs. Inaccordance with the NWA, DWAF (the Minister) will still remain ultimately responsible forthe management of the water resources.

In light of this responsibility, DWAF's corporate perspective on how the water resourcesshould be managed, needs to be formally expressed in order to manage the waterresources in a consistent and predictable manner. The purpose of the ISP is to documentthese perspectives and offer sound motivation to demonstrate appropriate and rationalgovernance.

2.16.2 Luvuvhu/Letaba Water Management Area

Report Title: INTERNAL STRATEGIC PERSPECTIVE: LUVUVVHU/LETABA WATER MANAGEMENT AREA:Internal Strategic Perspective: Luvuvhu/Letaba Water Management Area. Report No. P WMA 02/000/00/0304.Prepared for: Department of Water Affairs and Forestry.Prepared by GobaMoahloli Keeve Steyn (Pty) Ltd in association with Tlou and Matji, GolderAssociates Africa and BKS, 2004.

The ISP resulted in a number of strategies for the area. The Strategies were divided into three broad types:

- Part 4.1: Strategies that apply to the whole WMA and are not specific to a particular area or catchment. These are referred to as “Catchment-wide Strategies” in this document;
- Part 4.2: Strategies that are specific to the Luvuvhu/Mutale catchment and these are referred to as catchment-specific strategies
- Part 4.3: Strategies that are specific to the Letaba/Shingwedzi catchment also referred to as catchment-specific strategies.

The strategies for each part were then translated into management actions and allocated to the various parts/sections of the DWA and any other instructions as seen fit. The strategies are summarized as follows:

2.16.2.1 **Part 4.1: Catchment-wide strategies**

The Catchment-wide strategies can be summarized as follows:

- The SADC protocol must be unpacked to clearly define DWAF’s responsibilities in this WMA with respect to flood events, low flows and monitoring. A strategy should then be developed to ensure that the catchment is managed and operated in such a way that the policies on international agreements and relations are complied with.
- A hydrological update and water resources modelling exercise is required in the Letaba Catchment (i.e. Groot Letaba, Klein Letaba and Lower Letaba sub-areas). This will be necessary to reconcile the ecological reserve requirements with the water use requirements and SFRAS. This needs to be done before the closure of the reserve determination contract to establish whether or not and by how much the ecological reserve can or cannot be achieved with the current levels of infrastructure and water use in the catchment.
- A management plan needs to be formulated and implemented to ensure that Nandoni Dam and Tzaneen Dam and other infrastructure in the river systems are operated in a way that

ensures the availability of the Reserve in the respective rivers. This will form part of the operating rules, which need to be developed to meet the ecological requirements.

- No additional Reserve-related studies are required now (other than those already initiated), other than to initiate an ecological monitoring programme. This will facilitate the comprehensive Reserve determination process in the Luvuvhu and Mutale catchments in future.
- Forestry expansion is dependent on the availability of water and licenses cannot be issued for further afforestation where catchments are in deficit or where there is a danger of not meeting the reserve requirement.
- Forestry will not be treated differently to any other user sectors and no specific limitation on forestry will be imposed; at least from a water resources perspective.
- Notwithstanding the above, there is no scope for additional forestry licences in the Letaba or Luvuvhu catchments, while the possibility exists for small allocations in the Mutale catchment.
- Setting up and implementing a water use monitoring system for this WMA will be a huge task, for which a detailed strategy needs to be developed. Some guidelines are provided in this broad strategy:
    - Start with the large water users in the catchment
    - Share the responsibility of monitoring with bulk water users. For example, monitor and invoice water user associations. How they determine and divide the cost amongst their members is then their responsibility.
- Water resource developments such as the Nwamitwa Dam should proceed, subject to environmental approval.
- Feasibility studies into possible further developments in the Luvuvhu catchment and the Mutale catchment are not a high priority but could be put on the long-term budget.
- No operating rules are in place for dams in the Luvuvhu catchment. It is recognised that the management of water resources in the Luvuvhu/Letaba WMA can be significantly improved through a review of system operating rules. Innovative and flexible approaches are required including:
    - Capture and formalize area manager's (Tzaneen) drought operating rules.
    - Develop and implement operating rules for each system. These must be made known to all those affected. Monitoring to ascertain the success of the operating

rules also needs to be implemented.

- DWAF have allocated commitments which are not currently being met and which cannot be met without great difficulty. While DWAF will seek to honour these commitments, in some instances (e.g. Dap Naude Dam) this is not physically possible. In other instances there are very critical implications. The approach is therefore to seek a rationalisation of the current allocations based on what is currently expected and what is possible. DWAF will develop an understanding and a long-term transfer plan with both Makhado and Polokwane and will seek national authorisation for any revision.
- In the meantime transfers out of the upper Letaba catchment to Polokwane to continue. Abstractions from the Dap Naude Dam to be limited to 2,5 million m^3/a pending a Reserve determination. The total transferable allocation to Polokwane out of the Letaba catchment should therefore be limited to 14,5 million m^3/a (i.e. 2.5 million m^3/a from Dap Naude and 12 million m^3/a from Ebenezer Dam). The requirements of Polokwane beyond this 14,5 million m^3/a must be obtained from other sources.
- With the exception of the Mutale River catchment, development of surface waterresources is near the limit of the WMA's full potential. Accordingly no new sourcesof surface water will be available to support irrigation requirements of thesmallholder schemes. In the meantime DWAF will continue to supply urban/ruraldomestic users who have usurped some of the supply to the irrigations schemes.
- DWAF supports the revitalization programme given existing constraints.
- Water allocation to each scheme must be confirmed depending on availability.
- DWAF should proactively indicate where water is likely to be available for schemesin the revitalization programme. In addition DWAF should also identify upfront thoseschemes that are unsustainable due to the non-availability of water. Thisinformation should be clearly communicated to the Department of Agriculture andother relevant role players via the Coordinating Committee for Agricultural Water.
- DWAF should actively participate in the Coordinating Committee for AgriculturalWater (CCAW).
- The process of establishing WUAs is complex and time consuming. A special effortshould be made to facilitate the approval of WUA applications.
- The objective is one of Integrated Catchment Management. This requires committed cooperation between all partners. DWAF believes that good management can best be achieved through cooperative governance and will do all it can to inform and engage its

cooperative governance partners. This will be enhanced through a culture of transparency and a sharing of information. Resources will be made available to ensure that DWAF officials are able to participate in cooperative governance forums. At the same time DWAF expects and hopes that all partners in the management of the catchment and water resources will reciprocate. A major issue in the Luvuvhu/Letaba is the frequent lack of compliance by some local authorities, particularly with regard to discharges from wastewater treatment works. Cooperative governance is one of the tools at DWAF's disposal to deal with this problem.

- The Regional Office and the Directorate: National Water Resources Planning should maintain contact with the District and Local Municipality role players and work with them to identify water resources that can be utilised. Long-term planning to avert water shortage crises must be encouraged. Capacity building and support to the District and Local municipalities must intensify as more responsibility (especially water services link with water resources) is shifted from national government.
- Provide an environment at the dams that is conducive to recreation Activities. Specific action plans will need to be developed in conjunction with the various tourism authorities to optimise this form of Economic use. Job creation strategies should feature prominently in these plans. Affordability of access to these recreational activities for all Citizens must also be considered.
- DWAF's (and eventually the CMA) future commitments under the National Disaster Management Act which was promulgated in 2003 will be:
    - To participate in supporting and enforcing disaster management planning by all relevant authorities.
    - To draft a National Flood Management Policy (DWAF).
    - To implement a Dam safety policy (DWAF).
    - To co-operate with the Department of Agriculture on drought relief strategies and policy formulation.
    - To prevent pollution of water resources (i.e. limiting health hazards such as cholera).
    - To prepare a situation assessment regarding the state of dams including large farm and mining dams.
- Preparation of a catchment wide assessment of the groundwater resources is required to document the magnitude of the resource. The Groundwater Resources Information

Programme (GRIP) will provide important quantitative data for the communal land areas within the WMA. This, together with information held on the National Groundwater Data Base (NGDB) for the entire WMA, forms the base for the assessment.

- Delineate areas showing aquifers with usable quantities of groundwater.
- Optimal development of the available groundwater resources must be done using a proper scientific approach.
- Ensure development of groundwater in preference to surface water in areas where the demands can be satisfied by locally available groundwater resources.
- Focus on proper groundwater development methods to build knowledge and confidence in groundwater. Make the paradigm shift towards the strategy of investing in groundwater development potential in appropriate places in order to build confidence. This must be supported by National Policy Guidelines.
- Groundwater resources are usually sufficient to meet the RDP level of supply within a reasonable distance of all users and should be exploited accordingly.
- Ground Water Monitoring:
  - Effective groundwater management and monitoring is essential for long-term sustainability of the supply and to protect the resource.
  - Undertake a census of all current groundwater monitoring in the WMA.
  - Implement a groundwater monitoring programme at selected key localities, in Groot Letaba, Middle Letaba and Luvuvhu Sub-Areas, including abandoned mines and important well fields/boreholes. This will involve water level measurements and water quality sampling.
  - Implement strategy of routine abstraction monitoring in areas of heavy groundwater use, e.g. downstream of Albasini Dam and upstream of the Middle Letaba Dam.
  - Establish a monitoring protocol to include frequency of water abstraction and water level measurements and groundwater sampling, and the range of constituents to be analysed for, (as a minimum this must incorporate pH, TDS, conductivity, macro anions, macro cations, Fe, F, and NO3. Samples collected near working and abandoned mines will also need to be analysed for parameters relevant to the mining operation, e.g. CN at old gold mines.
  - Integrate current local monitoring, e.g. at Tshikondeni Mine, with the catchment wide monitoring programme.

   - Individual mines, e.g., Tshikondeni coal mine (near Masisi in the NE of the Mutale catchment), routine monitoring needs to be undertaken to satisfy the terms of their mining licence. Monitoring around abandoned mines is also required.

- Ground Water Information:
   - Establish a database to record all monitoring data; this database will either be the NGDB or compatible with the NGDB.
   - Incorporate the GRIP data.
   - Appoint custodian of the information database.
- Ground Water Protection:
   - The increasing threat of pollution of groundwater resources from latrines and increasing population, with elevated TDS and NO3, must be managed.
   - Census of operational and abandoned mines is required to assess potential groundwater pollution threats and determine the need for remediation
   - Test pumping to prepare management recommendations for the optimum long term sustainable use of the groundwater resource is needed for all boreholes equipped with motorised pumps.

2.16.2.2 **Part 4.2 detailed catchment specific strategies: Luvuvhu / Mutale catchments**

The detailed Luvuvhu / Mutale catchments catchment-specific strategies can be summarized as follows:

- A detailed analysis is required to accurately determine the available resource. In the short term, there is surplus available following the completion of the Nandoni Dam and allocations can be made for domestic water use and revitalisation of irrigation schemes downstream of Nandoni Dam which have fallen into disuse. In the medium term, the water resources situation of the Luvuvhu needs to be understood better. This must include the groundwater / surface water inter-dependency and a comprehensive reserve determination, which also considers the requirements of the Pafuri flood plain.
   - There is no need for compulsory licensing in the Luvuvhu River catchment.
   - Water supply for domestic water use (via District and Local Municipalities) to receive priority and to be supplied from the following sources (in order of priority):
      - Water Conservation and Demand Management
      - Groundwater

        - Further development of the surface water resource
    - Conjunctive water use particularly downstream of Albasini Dam needs to be understood.

- Maintain the status quo in this catchment. Additional allocations are possible, but for wet season use only, unless accompanied by the construction of storage capacity. This represents an opportunity for poverty eradication.
- Water supply for domestic water use (via District and Local Municipalities) to receive priority and to be supplied from the following sources (in order of priority):
    - Water Conservation and Demand Management
    - Groundwater
    - Further development of the surface water resource
- An integrated water quality management plan is required which will include current water quality objectives. The plan should be a concise user guide that sets out a clear water quality management strategy. It should provide the current water quality status of the river and identify all pollution sources, as well as the transport, life cycle and effect of the expected pollutants within the context of the river system.
- Co-operative governance initiatives, with other DWAF departments, local and district municipalities, and other regional government departments, such as the Departmentof Agriculture, Department of Energy and Mineral Affairs, Department ofEnvironmental Affairs, Department of Health, etc. must be encouraged as part ofintegrated planning. Issues surrounding agricultural practices and their associatedwater quality problems must be prioritised. Smallholder irrigation schemes must betargeted to encourage good agricultural practice, such as the minimisation of wateruse and the proper use of pesticides and fertilizers.
- Water quality issues should also be managed by encouraging self-regulation byusers. The formation of Water User Associations should be encouraged and ruralcommunities should be educated on sustainable resource use, for example moreefficient subsistence farming and cattle rearing methods to reduce erosion. Thepublic should be empowered to take responsibility for their environment byconducting routine monitoring of the water resource and disclosing offendingpolluters.
- Regional monitoring (i.e. the River Health initiative) must be conducted with theclear aim to enforce the resource quality objectives for the river. This should includethe classification of the resource class and the quality requirements of the Reserve.Monitoring should also

include toxicity testing.

- The RO must assess water quality using acceptable tools.
- Those STPs that are managed by DWAF must be brought to compliance levels, byupgrading the process and/or improving management structures, before being handedover to the local municipality. (N.B. Refurbishment of existing plants is part of theDWAF asset transfer process).
- A solid waste management plan must be devised.
- An emergency action plan must be formulated to deal with water qualityemergencies, for example toxic spills or the outbreak of water borne disease, in acontrolled and effective manner.
- A WC&DM study needs to be initiated in the Luvuvhu/Mutale catchments in order to identify the opportunities for improving the efficiency of water use. WC&DM measures in these catchments then need to be co-ordinated to ensure efficient use of water and thus improved production from limited water resources.
- Working for Water need to continue their efforts to remove invasive alien plants in the Luvuvhu River and Mutale River catchments. Better tools are required to estimate the impact of invasive alien plants on the surface runoff and hence the impact on the yield available to others. These tools must be species specific and distinguish between riparian and non-riparian invasives.

2.16.2.3 **Part 4.3 detailed catchment specific strategies – Letaba/Shingwedzi catchments**

The detailed Letaba/Shingwedzi catchments catchment-specific strategies can be summarized as follows:

- The broader long-term strategy is to implement compulsory licensing. The Reserve determination is already under way in anticipation of licensing. In order to mitigate the negative impacts of this, further development of the resource must be considered such as the construction of Nwamitwa Dam and the raising of Tzaneen Dam.
- A detailed water resources model has been set up for the Letaba catchment. This must be used to evaluate the impact of the ecological Reserve, which is currently being determined, on the availability of water to all users. If this analysis shows that the implementation of the Reserve will have dire consequences to the economy of the region, then a detailed strategy needs to be developed to mitigate these consequences. Possible options are:
    - Implement WC/DM in all sectors.

- Consider resource augmentation options which could be implemented simultaneously with the Reserve and compulsory licensing e.g. the construction of the Nwamitwa Dam;
- Improved system operation. There is scope to utilise the Ebenezer Dam better to spread the risk between irrigators upstream and downstream of the Tzaneen Dam;
- Remove Invasive Alien Plants;
- Investigate lawful use in the catchment (i.e. validation and verification) and eliminate unlawful use;
- Investigate the use of groundwater.

- Thabina Dam – an urgent drought analysis of this dam is required. Currently the annual domestic demand supplied from the dam is almost equal to the yield of the dam. There was an allocation for irrigation from this dam in the past. Currently the dam is used entirely for domestic water supply with the result that smallholder irrigation schemes, which were supplied from this source, have fallen into disuse. A proposal was made to construct Ngwabu Dam to supply irrigation.
- No new allocations are possible from this catchment. No new allocation can also be made as a result of the raising of Tzaneen Dam, as the additional yield will be fully absorbed in improving the assurance of supply.
- No new farm dams to be permitted in the catchment.
- Water supply for domestic water use (via District and Local Municipalities) to receive priority and to be supplied from the following sources (in order of priority):
    - Water Conservation and Demand Management
    - Groundwater
    - Trading with the irrigation sector
- The broad strategy for the Klein Letaba sub-area is to urgently implement water conservation and demand management measures in the Giyani area (see Strategy 4.3- 4). Compulsory licensing will not solve the problem of deficits downstream of the Middle Letaba Dam and this is therefore not recommended as an urgent action. In the longer term, a better understanding of water use, and especially the sources of supply, is required in this sub-area, for which a detailed water resource and utilisation assessment is recommended.
- The surface water/groundwater interaction also needs to be investigated and understood in order that the water resource can be managed better. The feasibility of supplementing

supplies to this area from Nandoni Dam needs to be investigated as part of this study.

- The irrigation water requirements up-stream of the Middle Letaba Dam cannot be met in full from the yield available from the farm dams and run-of-river flows. The irrigators use substantial quantities of groundwater. The impact of this abstraction on surface water flows needs to be understood and quantified.
- There is currently no additional water available for allocation. No additional allocations for irrigation will be made while allocations for domestic use must be sourced firstly from more efficient use of water. New supply options such as Nandoni Dam should only be considered once water use in the Middle Letaba is efficient.
- Further large-scale groundwater use should be considered only to support high value crops.
- Domestic water supply to outlying areas should be sourced from groundwater.
- Water supply for domestic water use (via District and Local Municipalities) to receive priority and to be supplied from the following sources (in order of priority):
    - Water Conservation and Demand Management;
    - Groundwater;
    - Further development of the surface water resource.
- An integrated water quality management plan is required that sets out a clear water quality management strategy. This should provide the current water quality status of the river and identify all pollution sources, as well as the transport, life cycle and effect of the expected pollutants within the context of the river system. This would include the National Eutrophication Monitoring Programme (NEMP), the National Microbial Monitoring Programme (NMMP) and the establishment of a Regional Monitoring Programme (RMP), which have been initiated in the WMA.
- As an initial effort, and based on the existing knowledge base within the Head office and Regional offices of DWAF, it is recommended that river reaches and other areas (incl. Groundwater) that are sensitive to water quality problems be identified and preliminary water resource quality objectives set for these areas. This will help to guide decisions regarding policy and regulation, development and licence applications in these sensitive areas.
- Co-operative governance initiatives, with other DWAF regional departments, local and district municipalities, and other regional government departments, such as the Department of Agriculture, Department of Energy and Mineral Affairs, Department of Environmental

Affairs, Department of Health, etc. must be encouraged as part of integrated planning. Issues surrounding agricultural practices and their associated water quality problems must be prioritised. Smallholder irrigation schemes must be targeted to encourage good agricultural practice, such as the minimisation of water use and the proper use of pesticides and fertilisers.

- Water quality can be effectively managed with limited resources by encouragingself-regulation by users. The formation of Water user Associations must beencouraged. Awareness campaigns to educate rural communities on sustainableresource use, for example more efficient subsistence farming and cattle rearingmethods to reduce erosion must be conducted. Empower the public to takeresponsibility for their environment by conducting routine monitoring of the waterresource and disclosing offending polluters.
- A Water Conservation and Demand Management (WC & DM) strategy for the domestic sector should be developed. This should include an awareness campaign to involve the water users and other parties concerned in actions to improve the efficient use of water. The strategy should also address the efficient operation of the water supply system, cost recovery and analysis of institutional arrangements with the view to recommending the best option.
- Working for Water need to continue their efforts to remove invasive alien plants in the Crocodile River and Sabie River catchments. Better tools are required to estimate the impact of invasive alien plants on the surface runoff and hence the impact on the yield available to others. These tools must be species specific and distinguish between riparian and non-riparian invasives.

2.17 LUVUVHU RIVER SYSTEM ANNUAL OPERATING ANALYSIS (2005)

2.17.1 Overview

The main purpose of the study was to update the existing hydrological models for the Luvuvhu River System and to develop operating rules and a decision support system for Albasini, Vondo, Damani, Thshakhuma, Phiphidi and Nandoni Dams.The operating analysis was carried to achieve the following:

- To check and verify the system model to ensure that the modelled results are representative of what is observed in practice;
- To improve our understanding of the system behaviour and to refine operating rules;

- To check that the operating rules are working and that the desired goals were achieved with the new proposed operating rules;
- To carry out sensitivity analyses to improve our understanding of the system and to determine the effect on results due to uncertainties around the correctness of some of the input data;
- To determine whether curtailments need to be imposed on some of the sub-systems during this operating year (2005/06);
- To determine the severity of the curtailments required;
- To produce reservoir storage projections, which can be compared with the observed reservoir storage during this operating year;
- To determine when intervention measures are required to be able to supply the users at their required assurance over the long term; and
- To determine whether the existing sub-systems are able to supply the current users at the selected assurance levels as indicated in the accepted priority classification.

The Luvuvhu river system annual operation analysis was divided into 14 reports which are reviewed in the following subsections.

2.17.2 Development of a Decision Support System and executing of the 2005/2006 annual operating analysis

Report Title: LUVUVHU RIVER SYSTEM ANNUAL OPERATING ANALYSIS: Development of a Decision Support System and Executing of the 2005/2006 Annual Operating Analysis. Report Number PNMA 02/000/00/0305. Department of Water Affairs and Forestry.Prepared by WRP Consulting Engineers in association with DMM. December 2005.

Yield analysis were conducted which addressed the requirements of the operating rule study and the historic firm yield as well as the long-term stochastic yield were analysed using the WRYM for the existing Albasini, Vondo, Tshakhuma, Damini and Nandoni dams.

The operating analysis was carried out using the WRPM and the new proposed operating rules and most recent demand projections were included in the system. Important findings from the operating analysis included the following:

- The new proposed operating rules, which include the use of the short-term stochastic yield results, were proven to work well, and were able to protect the resources, even for the Albasini

Sub-system which is totally over allocated.

- Although the Albasini Sub-system was sufficiently protected by the new operating rule, it was not possible to supply the users at their required assurances, even from 2010 onwards, when the Makhado demand was supplied from the Nandoni Sub-system.
- The Albasini Sub-system was the only sub-system that required curtailments for the 2005/06 planning year. The base scenario required irrigation to be curtailed by 51% and urban/industrial by 26%.
- In general the storage projection plots obtained from the operating analyses compared very well with the observed storage levels. This indicates that the modelled results are representative of the physical Luvuvhu system.
- From 2014 onwards the curtailment criteria for the Vondo Sub-system were violated. This shows that Nandoni Dam needs to supply a larger area of Thohoyandou than only 50% of the current R5 and R7 supply areas, to be able to sufficiently decrease the future load imposed on Vondo Dam.
- Curtailment criteria for the Damani Sub-system were exceeded from 2020 onwards and therefore currently do not impose an immediate threat.
- Some of the projected demands supplied from Nandoni Dam and Tshakhuma Dam are currently totally exceeded by observed demands. This is true for the Malamulele, Tshakhuma and Xikundu abstractions which are all in excess of 300% of the projected demand, and therefore raises serious questions with regards to the observed use as well as the projected demands for these areas.
- The curtailment criteria for the Nandoni Sub-system were only slightly violated for the maximum high scenario and mainly for the initial filling period. This agrees with the yield results showing that the yield available from the Nandoni Sub-system is in excess of the projected 2025 demand.

Based on the results from the analyses, the following recommendations are made:

- To be able to supply the users from the Albasini Sub-system at their required assurances, the total demand allocated to the system needs to be reduced. This will partially be done when the Makhado demand is supplied from Nandoni Dam from 2010 onwards. However, further reduction in demand is required and the possibility of reducing the excessive canal losses and the reduction of the total allocation should be investigated.
- The irrigation data in the system data files needs to be updated as soon as the verification and validation process on the registered water use data has been completed.

- Area capacity characteristics need to be obtained for Phiphidi, Tshakhuma and Damani Dams and subsequently the WRYM and WRPM data files need to be updated accordingly. The yield available from Phiphidi Dam needs to be determined.
- The total Thohoyandou demand that can be supplied from Nandoni Dam needs to be included in the system models, as it seems that it is more than only 50% of the current R5 & R7 supply areas. The long-term average capacity of the pipeline from the Nandoni WTW to Thohoyandou should probably be used for this purpose, but needs to be confirmed.
- The current water use from the Malamulele, Xikundu and Tshakhuma WTW's are totally in excess of the projected demands, and therefore needs to be investigated. Actions plans need to be defined to either reduce the demands to what it should be or to adjust projected demands when necessary.
- The Nandoni Sub-system should be operated in order to maximise the utilisation of the incremental inflow between Nandoni Dam and Mhinga Weir.
- It is important to keep in touch with the development plans with regards to the re-development of the existing tea plantations to be able to update the system models accordingly.
- Further work needs to be done on the IFRs as current IFRs were determined with outdated methodologies and there is a low confidence in the existing IFR figures for Site 3. Recent desktop estimates also provided much higher requirements which resulted in unrealistic reductions in the Nandoni Sub-system yield. This needs to be done at a detailed level due to the sensitivity of the Kruger National Park (KNP).
- Although the yield results indicated that the Nandoni Sub-system has surplus yield available in the system, additional demand centres should be added with caution as the final IFRs (Reserve) will probably require more water than the "White Paper IFRs" currently used in the models. In addition, there is also the observed use at Malamulele, Xikundu and Tshakhuma which is significantly higher than the projected values.
- New operating rules should be implemented as soon as possible. This will require some training of DWA personnel as well as the proper monitoring of selected observation points. Operating analyses need to be carried out on an annual basis.
- Curtailments as obtained from the base scenario should at least be imposed on the Albasini Sub-system. This entails 51% curtailment on irrigation and 26% on urban/industrial requirement.
- When observed data of releases from Nandoni, abstractions between Nandoni and Mhinga Weir, as well as observed flows at Mhinga Weir area available, improved estimations of the

losses between Nandoni and Mhinga Weir need to be made.

- Representatives of the different stakeholders need to be appointed to be part of the System Operation Implementation Committee (SOIC). This committee will be part and be informed on the results, updates and required input data for the annual operating analysis carried out around the 1st of April each year.
- Also utilise dry and wet cycle pattern as determined by DWA for Tzaneen Dam as additional guidance with regards to the implementation of restrictions during dry periods. The dry and wet cycle patterns as applicable to major storage dams in the Luvuvhu River catchment however, still need to be determined on a similar basis as was done for inflows to the Tzaneen Dam. The Tzaneen Dam cycle pattern might be slightly different from those applicable to the Luvuvhu and it is important to verify the pattern before using it as part of the operating tools.

2.18 LETABA CATCHMENT RESERVE DETERMINATION STUDY (2006)

2.18.1 Overview

The overall objectives of this study were as follows:

- **Groundwater Scoping**: To clarify the need for a groundwater study, based on a review of available information, focusing on the significance of groundwater to wetlands and surface flows, and the importance of groundwater to current and potential users in the catchment;
- **Wetland scoping**: To clarify the need for a wetland study, based on a review of available information, focussing on the on the ecological importance of wetlands in the catchment and the links between wetlands, rivers and groundwater;
- **Present Ecological State (PES**): To define Reference Conditions and classify each Resource Unit in which EWR sites were selected, in terms of the PES of the main ecological drive (hydrology, geomorphology and water quality) and ecological responses (riparian vegetation, aquatic invertebrates and fish) and to integrate the PES results of individual ecological components into an overall Eco Status;
- **Recommended Ecological Category (REC) and alternatives**: To recommend an ecological Category and alternative categories, based on the results of the PES, an assessment of the trends that are likely to take place assuming no change in current conditions, the Ecological Importance and Sensitivity (EIS), Socio-cultural Importance(SI), as well as an assessment of practicality of improving ecological conditions
- **Ecological Water Requirements**: To recommend and motivate specific low and high flows for maintaining ecological conditions within a specific ecological category, and to

present the results in the form of assurance rules for each selected EWR site for each month of the year and for each EC assessed;

- **Ecological Reserve**: To develop various operational flow scenarios, to describe their ecological and socio-economic consequences, and to recommend a scenario that minimizes impacts on users and the ecosystem;
- **Monitoring**: To assess the suitability of available data for defining baseline conditions for Ecological Reserve monitoring in the Letaba River, to recommend additional baseline data requirements if needed, to define the Ecological specifications and associated Thresholds of Potential Concern (TPCs) for each monitoring site; and
- **Capacity Building**: To train Historically Disadvantaged Individuals (HDIs) in specific aspects of assessing Ecological Water Requirements

The Letaba catchment reserve determination study has been divided into 14 reports of which 3 of these reports were not available for review.

2.18.2 Main Report

Report Title:LETABA CATCHMENT RESERVE DETERMINATION STUDY: Main Report. RDM/B800/01/COM/COMP/1304.Prepared for: Department of Water Affairs and Forestry.Prepared by RG Health, 2006.

The following were recommended:

- The valley bottom systems in the Pietersburg plateau and Lowveld hydrogeological region are targeted for a wetland Reserve study. In addition, the existing Reserve method was more applicable to riparian wetland than other types such as hill slope seepage systems, thus rendering the valley bottom wetlands in the lower part of the catchment more suitable candidates for reserve determination.
- The Recommendation Ecological Category was set to maintain the Present Ecological State for all Resource Units
- Consideration should be made in improving the water use efficiency levels in all the water using sectors in the Letaba River catchment.
- Implementation of EWRs in the Letaba River catchment can be realized through active management of the water users in the catchment based on their curtailment structures. This however has a negative impact on the available water to users. The restrictive flow management will therefore involve changing the existing allocations to water users in the catchment to ensure that enough water was left in the river. Both types of interventions required a change in the water use practices of the stakeholders and the need for

stakeholder commitment and buy-in with the level of resource protection that could be effected without significantly impacting on the socio-economy of the catchment.

2.18.3 Groundwater scoping report

Report Title: LETABA CATCHMENT RESERVE DETERMINATION STUDY:Groundwater scoping report. Report No. RDM/B800/02/COM/COMP/0504.Prepared for: Department of Water Affairs and Forestry.Prepared by RG Health, 2006.

The report identified the role of groundwater in determining the Reserve, determines the importance of groundwater in terms of current and future groundwater use, delineated groundwater resource units, and quantified the groundwater contribution to base flow for each Quaternary catchment in tertiary catchments B81, B82 and B83. The catchment was divided into several hydrogeological regions: The Drakensberg Escarpment, Drakensberg Foothills and valleys, Bandolierskop, Giyani-Gravelotte, The Plains, Lebombo, and Alluvium

The report identifies stratigraphic units by Quaternary catchment, identifies hydrogeological regions and quantifies their borehole yields. The significance of groundwater in terms of total water usage is also quantified, as is the aquifer vulnerability to drought.

The groundwater Harvest Potential, Exploitation Potential, and estimated groundwater use, and groundwater base flow are provided for each Quaternary catchment. The exploitation potential of groundwater in the Letaba catchments was quantified as 99 Mm^3/a. Total groundwater use was quantified as 38 Mm^3/a, however, since the maximum potential is not always utilised, especially for irrigation, an actual use of 22 Mm^3/a was estimated. Groundwater contribution to base flow was estimated as 25 Mm^3/a, of a total base flow volume of 221 Mm^3/a.

The report identifies Quaternary catchments were groundwater use exceeds the exploitation potential, so further development is not possible, and catchments where exploitation will have an impact on base flow, hence on surface water resources. Catchment B81D was considered to be significantly stressed.

Base flow reduction from afforestation, alien vegetation and groundwater abstraction are quantified as 88 Mm^3/a, hence significant base flow reduction has occurred in the catchments. Base flow reduction from afforestation is estimated as 59 Mm^3/a, with a further 19 Mm^3/a, from alien vegetation.

2.18.4 Wetland scoping report

Report Title: LETABA CATCHMENT RESERVE DETERMINATION STUDY: wetland scoping report. Report No. RDM/B800/02/COM/COMP/0604.Prepared for: Department of Water Affairs and Forestry.Prepared by RG Health, 2006.

The purpose for the wetland scoping report is to clarify the need for a wetland study, based on a review of available information, focussing on the on the ecological importance of wetlands in the catchment and the links between wetlands, rivers and groundwater.

The wetlands form an integral part of the aquatic ecosystems and hydrological cycle and can play a key role by contributing to river base flows and providing habitats that supports aquatic biodiversity. A comprehensive assessment of the EWR should therefore include an assessment of the wetlands and their ecological functions.

Based on the National Land Cover 2000 coverage , as well as topographic analysis undertaken, there appears to be a fairly high concentration of relatively large wetlands between the Letsitele and Thabina Rivers in the south west of the catchment and in the area east and west of the Groot Letaba River immediately downstream.

It was recommended that the valley bottom systems in the Pietersburg plateau and Lowveld hydrogeological region are targeted for a wetland Reserve study. In addition, the existing Reserve method was more applicable to riparian wetland than other types such as hill slope seepage systems, thus rendering the valley bottom wetlands in the lower part of the catchment more suitable candidates for reserve determination.

2.18.5 Resource units report

Report Title:LETABA CATCHMENT RESERVE DETERMINATION STUDY: Resource units report.RDM/B800/02/COM/COMP/0704.Prepared for: Department of Water Affairs and Forestry.Prepared by RG Health, 2006.

This report describes the process followed for the delineation of the study area into Resource Units (RUs). This process is also refered to as the second step of the eight step process to determine the EWR.

The Letaba was delineated into nine RUs with seven EWR sites that was selected to maximise the opportunities for accurately determining a comprehensive Reserve for the Letaba River. The localities of the seven EWR sites are given in **Table. 2.40**.

Table 2.40: Localities of EWR sites on the Letaba River

River and Site name	RU	EWR site number	Locality
Groot Letaba - Appel	A	EWR1	S 23 55 03.7; E 30 03 03.0
Leststele	F	EWR 2	S 23 53 17.0; E 30 21 40.5
Klein Letaba	B	EWR 5	S 23 15 02.9; E 30 29 44.6
Groot Letaba – Hans Marensky	C	EWR 3	S 23 38 57.8; E 30 39 38.3
Groot Letaba – Letaba Ranch	E	EWR 4	S 23 40 39.1; E 31 05 55.1
Groot Letaba – Lonely Bull	D	EWR 6	S 23 45 09.5; E 31 24 26.3
Groot Letaba – Letaba Bridge	D	EWR 7	S 23 48 35.4; E 31 35 26.9

2.18.6 EWR report quality

Report Title: LETABA CATCHMENT RESERVE DETERMINATION STUDY: EWR report quality.RDM/B800/02/COM/COMP/0804and RDM/B800/02/COM/COMP/0904.Prepared for: Department of Water Affairs and Forestry.Prepared by RG Health, 2006.

The primary water use along the rivers in the Letaba catchment is citrus and sub-tropical fruit production, with grazing in the less fertile sandy loam soils. Removal of the vegetative cover by overgrazing has led to erosion in some places, resulting in an increased sediment load in the rivers. The main Industrial development points are at Tzaneen, Nkowakowa and Giyani, with a number of sewage works spread throughout the catchment. Several old gold mines exist, which lie close to the Klein Letaba River towards the Northern part of the study area. An overview of the catchment therefore indicates that water quality issues are mainly related to nutrient enrichment and fluctuating in stream temperature and oxygen levels due to extensive flow regulation in the catchment. In addition to being highly regulated, conditions in the Groot Letaba River (particularly downstream from Die Eiland) are impacted by citrus plantations in the area, resulting in elevated nutrient levels and instream toxicity.

The water quality data confidence and availability ranged from very low (toxics, dissolved oxygen and temperature) to high (salts and pH).

The water quality present state assessment showed that the Letaba River is generally in a fair to good water quality condition (categories B-C), with a hot spot occurring at EWR 2, i.e. Letsitele Tank.

The EcoClassification results for the PES of each component are summarised per EWR site (**Table 2.41**). The EcoStatus results for the PES and REC are provided in the report.

Table 2.41The EcoClassification results for the PES of each component are summarised per EWR site

EWR Sites	Hydrology	Physico-chemical	Geomorphology	Fish	Invertebrates	Riparian vegetation	EcoStatus
1	C	B	C	C	C/D	C	C
2	C	C/D	D/E	C	D	D/E	D
3	D	C	C	C	D	D	C/D
4	D	B/C	C/D	C	D	D	C/D
5	C/D	B	C	B	C	B	C
6	D	C	C	C	D	C	C
7	D	C	C	C	D	C	C

2.18.7 Ecological consequences of flow scenarios

Report Title:LETABA CATCHMENT RESERVE DETERMINATION STUDY:Ecological consequences of flow scenarios.RDM/B800/02/COM/COMP/1004.Prepared for: Department of Water Affairs and Forestry.Prepared by RG Health, 2006.

Implementation of EWRs in the Letaba River catchment can be realized through active management of the water users in the catchment based on their curtailment structures. This however has a negative impact on the available water to users. The restrictive flow management will therefore involve changing the existing allocations to water users in the catchment to ensure that enough water was left in the river. Both types of interventions required a change in the water use practices of the stakeholders and the need for stakeholder commitment and buy-in with the level of resource protection that could be effected without significantly impacting on the socio-economy of the catchment.

2.18.8 Hydrology support and water resource elevation

Report Title: LETABA CATCHMENT RESERVE DETERMINATION STUDY: Hydrology Support and Water Resources Evaluation. Report No. RDM/B800/01/COM/COMP/1104.Department of Water Affairs. Directorate: Resource Directed Measures. Prepared by PHD, February 2006.

Please note: This section represents Chapter 6 of the Main Report.

2.18.8.1 Introduction

The main objective of the hydrology and related methodology used was to investigate the impacts of ecological flow releases on the Letaba water supply system for the supply of ecological water requirements in the main reach and tributaries of Letaba River, as well as in the Kruger National Park. The impacts of various scenarios of ecological releases have been assessed to select an optimised scenario that can meet the ecological requirements while minimising the impacts on other users in an already stressed water system.

Major economic activities take place in tertiary catchment B81 (Groot Letaba) and most of the water in the system is generated in this tertiary catchment. Tertiary catchment B82 drains to the Middle and Klein Letaba rivers, which are the major tributaries of the Letaba River. The lower catchment tertiary catchment B83 has little economic activity and is characterised by natural conservation areas and game ranching, such as the Kruger National Park.

2.18.8.2 Method

For analysis purposes, the Water Resources Yield Model (WRYM) and the Spatial and Time Series Information Model, SPATSIM (Institute for Water Research, 2003) was used. The WRYM was set up to model the water resources system in the catchment, in order to convert virgin flows into present day flows and to assess the impact of environmental releases, under various supply scenarios, on the other demands in the system. SPATSIM, using the output from WRYM, was used to generate time series data of the EWR as well as to generate duration and stress response curves required to investigate whether the EWR demands are met.

WRYM Model

The WRYM system configuration for the Groot Letaba, as developed during the Feasibility Study of the Groot Letaba Water Resource Development, was adopted in this analysis with minor revisions, i.e. introducing nodes at each of the EWR sites. The Middle and Klein Letaba model, developed by DWAF in the 1990's, during an internal study on the Middle Letaba and Nsami Dams (unpublished), was appended to the Groot Letaba model. The demands for the Middle Letaba were updated in the combined model from data gathered during a situation assessment study carried out for DWAF in 2003 (DWAF 2006 b). This combined model was then initially used to convert virgin monthly flows into present day monthly flows at each of the EWR sites, taking all demands, other than ecological water requirements, into account.

The time series of the ecological flow requirements, as determined using SPATSIM as described below, were then used to generate a WRYM input file, so that the ecological demands could be simulated as a maximum priority demand in WRYM. Under a range of supply scenarios, the flow time series, generated with the WRYM model for channels downstream of EWR sites, were imported back into SPATSIM in order to generate flow duration and stress response curves that were used to determine whether the ecological flow requirements in each resource unit were met.

SPATSIM

The spatial and time series information model, SPATSIM has been used to generate the EWR at seven sites in the catchment for various Ecological Categories. Two of the integrated models in SPATSIM, namely, the Desktop Reserve Model and the Stress/Flow and Risk Indicator Model have been used for the determination of the EWR.

2.18.8.3 **Hydrology**

The original terms of reference for the project assumed the use of available hydrology for the catchment and did not allow for any updating of the hydrology for the 23 quaternary catchments making up the Letaba Catchment. Available virgin flow data for the Letaba Catchment was limited to between 1920 and 1996 from the sources as shown in **Table 2.42** below:

Table 2.42 Available virgin flow data for Letaba Catchment

Tertiary Catchment	Available Hydrological data	MAR ($10^3 \times 10^6$)	% of Total MAR	Source
B81	1925-1992	381.0	66.36	Pre-Feasibility Study (SRK/DWAF)
B82	1922-1996	151.9	26.45	Directorate of Hydrology (DWAF) (unpublished)
B83	1920-1989	41.3	7.19	Surface Water Resources of South Africa 1990 (SRK,WLPU, SSI)
Total		**574.1**	**100**	

However, in order to test the representivity of this data, a pilot project was initiated on two of the quaternaries, namely, B81D as a humid catchment and B83B as a dry catchment. The purpose of this pilot project was to extend the hydrology, by applying the more recent rainfall data to these two catchments and to assess the potential changes to the hydrology for the catchment as a whole. This was done using the WRSM2000 rainfall-runoff model. The conclusions drawn from the pilot project were:

- For the wetter catchment, there was a small (4%) increase in MAR, but a 20% increase in standard deviation of the MAR.
- For the dry catchment, there was a significant lowering of the MAR (36%) and a 15% standard deviation in MAR. However, the contributions by the dry catchments to flows in the Letaba are only around 7%

The virgin flow input for the WRYM was restricted to the common series from 1925 to 1989 for the three tertiary catchments.

Present Day Hydrology

Agriculture and domestic use are the major demand sectors in the system. The decline in the present day flow, when compared to the natural flow, is mainly attributed to the large demand of irrigation in the Groot Letaba and Middle and Klein Letaba sub-catchments. At present there is 14.8 million cubic metres released annually to KNP from Tzaneen Dam. Of this, 6.06 million cubic metres are abstracted downstream for domestic use. The remaining 8.74 million cubic metres go to the Kruger National Park. However, the present day flow stipulated does not include this release.

Observed Hydrology

In general, the flow gauging station network in the Letaba catchment is poor. Most of the stations are concentrated in the upper catchment. Observed flow data can be used to undertake flood analysis in order to determine the high flood requirement of riparian ecology and geomorphology. However, in this study, because of the short period and low reliability, the observed data was mainly used to generate daily flow series from the monthly natural and present flows at each EWR site.

2.18.8.4 **Conversion of monthly runoff to daily runoff**

Daily virgin and present day flows were unavailable and observed daily flows were limited. Daily runoff data was generated, for both natural and present day hydrology, based on monthly time series data and the distribution curves of available daily-observed data.

2.18.8.5 **Instantaneous flow records**

Most of the gauging stations, if not all, in the Letaba catchment measure the daily average runoff. The instantaneous peak flow is obscured in the daily average runoff. Instantaneous or peak flows are responsible for shaping the river geomorphology as well as for changing the riparian vegetation. A reduction in frequency and amount of peak flows results in terrestrialization (terrestrial vegetation encroachment). Thus, hydrological analysis on peak flows is important to have a comprehensive understanding of how the riparian ecology can be impacted as a result of water resources development. In the observed daily flow records supplied by DWAF, there is an instantaneous maximum and minimum peak factor provided for each month of observed data. In an attempt to determine daily peaks, these factors were applied to both the observed maximum and minimum daily average, respectively, for the month and then proportioned to each of the remaining intermediate daily averages in the month, to provide daily peak values. Analysis of these values provided frequency of observed peak flows as called for by the specialists.

2.18.8.6 **Levels of confidence in hydrology**

The level of confidence in the data range from medium, to medium-low, to low in B8, B82 and B83 respectively.

2.18.8.7 Hydrology at EWR sites

Each quaternary catchment was split into relevant sub-catchments in order to apportion natural runoff at the individual EWR sites. Using this virgin flow data, the WRYM was used to generate the present day hydrology at each EWR site. **Table 2.43** below provides a summary for all the sites.

Table 2.43 EWR site

EWR Site	**Quaternaries**	**Virgin MAR (10^6 m^3/a)**	**Present Day MAR (10^6 m^3/a)**
EWR1	B81A B81B	71.7	32.63
EWR2	B81D	86.06	63.30
EWR3	B81A-F	364.1	109.41
EWR4	B81A-J	401.86	206.70
EWR5	B82A-F	95.1	42.44

EWR6	B81, B82 and B83A	545.7	274.45
EWR7	B81, B82 and B83A-0.14B83D	561.57	289.41

2.18.8.8 **Level of Confidence in Demands**

The 1995 demands were used in this study for the Groot Letaba catchment. For the Middle and Klein Letaba sub-catchment, the demand data obtained from the Situation Assessment Study in 2003 was used. No major updating has been recently carried out to verify the reliability of the available data. There is a discrepancy in various documents, especially of the studies made in the Middle and Klein Letaba. In order to improve the level of confidence in the demand data, further refining and verification of the available information would be required, especially in Middle and Klein Letaba catchment.

2.18.8.9 Summary

The Letaba water system is under stress. Ecological releases will impose further additional stress into the system. The relative impact of EWR releases depends on the amount, frequency and seasonal distribution of releases. Curtailing ecological releases (as reflected by some of the Operational scenarios), during the dry period, significantly improves the water supply capacity of the system without severely compromising the ecological stability.

2.18.8.10 **Recommendations**

It is recommended that the hydrology of the Groot Letaba be updated from 1992 to present. The main consequences of extending the hydrology throughout the Letaba catchment would be to improve:

- The confidence in all flows in tertiary catchments B82 and B83;
- The confidence in the high flows in tertiary catchment B81;
- Present day flow generation from the yield model; and
- Scenario planning using the planning model with improved stochastic hydrology

2.18.9 Eco specs and monitoring report

Report Title: LETABA CATCHMENT RESERVE DETERMINATION STUDY:Eco specs and monitoring reportno. RDM/B800/02/COM/COMP/1204.Prepared for: Department of Water Affairs and Forestry.Prepared by RG Health, 2006.

This report contains information on the Eco Specs and ecological reserve monitoring. The primary Eco Specs are the Ecological categories and these are listed in **Table 2.44** below. These Eco Specs were quantified in terms of measurable criteria that can be monitored for fish, invertebrates, riparian vegetation and geomorphology and water quality.

Table 2.44 Ecological categories for the driver and response components per EWR site

Components	EWR1	EWR2	EWR3	EWR4	EWR5	EWR6	EWR7
Hydrology	C	C	D	D	C/D	D	D
Geomorphology	C	D	C	C/D	C	C	C
Water Quality	B	C/D	C	B/C	B	C	C
Fish	C	C	C	C	B	C	C
Aquatic invertebrates	C/D	D	D	D	C	D	D
Riparian vegetation	C	D	D	D	B	C	C
EcoStatus	**C**	**D**	**C/D**	**C/D**	**C**	**C**	**C**

The required further baseline monitoring that needs to be undertaken per EWR site before the Ecological Reserve Monitoring programme can be initiated is summarised in a table in the report.

2.18.10 Socio-economics flow scenarios

Report Title: LETABA CATCHMENT RESERVE DETERMINATION STUDY: Socio-economics flow scenarios. Report No. RDM/B800/01/COM/COMP/1504.Department of Water Affairs. Directorate: Resource Directed Measures. Prepared by PHD, February 2006.

The main report details upon socio-economic aspects in a chapter named ‘Consequences for Good and Services and Economy’, in which it is noted that water resources provided important benefits to society, both as input capital for production and ecological goods and services. The study also notes that socio economic valuation plays and important decision making role because of the increasing scarcity of water.

Water was valued through:

- **Economic value of water for commodity use**: the Letaba river catchment was divided into 7 zones, and for each a customised Social Accounting Matrix (SAM) water impact model was developed. The models distinguished four water user sectors, namely: irrigated agriculture, domestic (including commercial and industrial), commercial forestry, and transfers to Tzaneen from Ebenezer dam. Various scenarios were investigated, and the chosen scenarios were such that the worst case and base case for socio economy could be determined. These were compared with present day (year 2000 level of economic activity), which represented socioeconomic value of present water available to water users. The model determined the different impacts that the various scenarios will have on the economy. The marginal differences in economic and socio-economic impacts were calculated by subtracting the impact of these situations from each other. This made it possible to quantify the impact that the various scenarios will have on the community, as well as the broader community. The factors quantified in the model are: incremental change in economic surplus or profit to the users in each sub-catchment and per water user sector, incremental change in GDP, and the number of jobs generated or lost.
- **Economic value of goods and service**: the following ecological goods and services were identified through a specialist workshop: fishing by community, fish farming, thatch grass, reed harvesting, wood gathering, recreational fishing, recreational boating, cultivated floodplains, sand mining, recreational swimming, and medicinal plants. The indirect use of the instream water noted is: waste assimilation, waste dilution, black flies, livestock diseases, malaria, bilharzia, cultural activities, and grinding stones. Various techniques were used to measure economic value of these direct and indirect goods and services provided by the Letaba River because off the different volume of ecological water left in the river to protect the resource. These ranged from use of surrogate markets to contingency valuation methods.
- **Economic contribution to the Kruger National Park**: due to the significant tourism component this component was also valued separately. The travel cost method was used to determine the economic contribution of tourism because of changes in flow in the Letaba River catchment situated in the Park. This was based on deriving a demand curve from data supplied by South African National Parks (SANAP) of the number of visitors going through Phalaborwa gate. There are limitations to the methods because of the large number of camps in the KNP enabling tourists multiple destinations to visit in the park.

The results of the valuation are as follows:

- **Ecological goods and services**: comparisons of all scenarios revealed an improvement in direct and indirect use of water from providing EWR to meet the level of resource protection set for each scenario. The total number of households who will benefit directly from the in stream water use ranges from 1435 households for scenario 1 to 484 households for scenario 7. The economic surplus ranges from 6.99 to 2.24 from scenario 1 to 7 respectively. Impact on GGP ranges from 11.12 to 2.66 and impact on low income distribution from 0.45 to 0.14.
- **Flow scenarios on the economics of the KNP**: the incremental change in economic activity in each sub catchment for each scenario investigated was as follows:

Table 2.45 Flow scenarios on the economics of the KNP

	Total surplus	GDP	Capital requirements	Low income households	All households
	Rand mil.	**Rand mil.**	**Rand mil.**	**Rand mil.**	**Rand mil.**
Scenario 1	161.50	1,186.93	2,657.82	298.36	1,174.63
Scenario 2	95.68	877.00	1,808.64	216.41	852.09
Scenario 4	94.36	550.03	1,326.17	143.98	564.02
Scenario 6	63.87	371.98	942.99	101.67	398.26
Scenario 7	11.11	109.82	187.83	27.85	109.85

The impact of scenario 1 will have the most negative impact on the economic surplus and the contribution the GDP. This is because more water is required to meet the ecological objectives. The best case for the economic contribution of the Letaba Catchment is Scenario 7 due to the least negative impact on employment and hectares withdrawn as shown in **Table 2.46** below:

Table 2.46 The impact on employment and hectares

	Employment	Hectares withdrawn	Percentage of irrigation withdrawn
	Numbers	Numbers	Hectares
Scenario 1	92,244	18,056	95.1%
Scenario 2	71,635	13,797	72.6%
Scenario 4	38,974	7,752	40.8%
Scenario 6	24,485	4,750	25.0%
Scenario 7	9,859	2,093	11.0%

The study revealed that the overall impact of the various scenarios is highly variable, with the worst case scenario being scenario 1 and the best case being scenario 7.

2.18.11 Ecological Data

Report Title: LETABA CATCHMENT RESERVE DETERMINATION STUDY:Ecological Data.Report No. RDM/B800/02/COM/COMP/1604.Prepared for: Department of Water Affairs and Forestry.Prepared by RG Health, 2006.

The Recommendation Ecological Category was set to maintain the Present Ecological State for all Resource Units

The implementation of EWRs in the Letaba River catchment can be realized through active management of the water resource infrastructure (dams and weirs) as well as reducing abstractions for water users in the catchment based on their curtailment structures. This however has a negative impact on the available water to users. The restrictive flow management will therefore involve changing the existing allocations to water users in the catchment to ensure that enough water is left in the river. Both types of interventions require a change in the water use practices of the stakeholders and the need for stakeholder commitment and buy-in with the level of resource protection that can be effected without significantly impacting on the socio-economy of the catchment.

The flow scenarios were considered using the traffic diagrams. This illustrated that the EWR flows for Scenario 7 is the most suitable scenario as it meets the REC and has a minimal impact on all the user categories. Scenario 7 provides the best trade-off between the need for protection of the ecological ecosystems in the Letaba catchment with the need to ensure the socio-economic growth is not severely negatively impacted. Scenario 7 was accepted and approved by DWA at a meeting in September 2005.

It must be noted that KNP officials have indicated that they have a mandate to improve biodiversity and have requested an improved PES within the KNP (PEC of C to REC of B). With the currently upstream water usage, mainly for agriculture, and the difficulties in improving catchment (sediment) issues it would be problematic to improve the PES,

Consideration should also be taken to delay implementation of the EWR flow of Scenario 7in the Letsitele River catchment because of the significant impact it will have on the irrigators until the verification and validation has been undertaken.

The Ecological Reserve is summarised as a percentage of the natural MAR in **Table 2.47.**

Table 2.47 Final results of Scenario 7 summarised as a percentage of the natural MAR

Sites	Annual EWR (million m^3)	Virgin MAR (million m^3)	Annual EWR (% natural MAR)
EWR 1	19.75	71.27	27.71
EWR 2	31.756	86.06	36.90
EWR 3	42.448	364.49	11.65
EWR 4	69.87	402.26	17.37
EWR 5	17.054	95.01	17.95
EWR 6	47.032	546.59	8.60
EWR 7	51.52	561.67	9.17

2.19 LETABA RIVER SYSTEM ANNUAL OPERATING ANALYSIS (2006)

2.19.1 Overview

The purpose of the report was written to support the annual operation of the Letaba system and provide common information for the application systems for operating analysis. The projected water demands for the different water use sectors are also presented and the document also describes the current approach on the operation of the system.The Letaba River system annual operating analysis has one report which is reviewed in the following section.

2.19.2 Letaba River System Annual Operating Analysis 2005/06

Report Title: LETABA RIVER SYSTEM ANNUAL OPERATING ANALYSIS: Development of a Decision Support System and Executing of the 2005/2006 Annual Operating Analysis. Report Number WMA 02/000/00/0406. Department of Water Affairs and Forestry.Prepared by Semenya Furumele Consulting in association with Makgaleng Projects, Water for Africa and CPH_2O. June 2006.

The information on the report can be summarised as follows:

- Current operation of the major dams in the Letaba River System

The major dams in the Groot Letaba River system, namely the Ebenezer and Tzaneen dams are operated on historic hydrology, current allocations and some limited extrapolation. Restrictions are imposed on irrigators to supply domestic and industrial users. Implementation of this rule during severe droughts is problematic. For example, due to the very low storages in the Tzaneen and Ebenezer Dams (4.6% and 16.3% of the FSC as on 12 December 2005) it became necessary to impose restrictions on domestic and industrial users as well. Even though the restrictions were published in the Government gazette making them enforceable by law, there was little reduction in use.

Similar rules for the Middle Letaba Dam are not as firmly in place. The bulk of the water supplied from this dam is for domestic use. DWA's Tzaneen Regional office report that they have little control over abstractions from this dam.

- Current operation of the smaller dams in the Letaba River System

The smaller dams in the Letaba system do not appear to be over-allocated and problems with water supply from these sources should not be experienced. Where problems are experienced, notably at the Thapani and Thabina Dams, it was assumed it was due to abstraction beyond the allocations. The abstractions from and water levels of the Thapani dam are not currently recorded and storages of the Modjadji Dam also indicates that abstraction are taking place far in excess of the sustainable yield and this dam will fail unless measures are taken to curb what appears to be unlawful use from this dam.

- Actual current abstractions from the Letaba River System
- The two major dams namely Ebenezer and Tzaneen are also over-allocated with an allocation above the 1:50 year yield. Due to this over-allocation, irrigation operates at low assurance of supply. A stochastic analysis using April 2005, October 2005 and April 2006 storages confirms the over-allocation of the resources and indicates that even if restrictions are implemented as published in the Government Gazette in November 2005, there is still an unacceptably high risk of these dams failing. Operationalizing the Ecological Reserve

Even though the ecological requirements for the Letaba River System are small in relation to the natural mean annual runoff of the Groot Letaba catchment and in relation to other users in the catchment, the requirement is at the outlet of the catchment and the only control mechanism currently available to manage ecological flows is the Tzaneen Dam. During extreme droughts, as experienced at the time of the study, it seems as though releases made from the Tzaneen Dam are lost to groundwater. These losses have not been qualified or taken into account in the operation of the system. Since the ecological Reserve enjoys the highest priority of supply (after the human Reserve), it is essential that these losses that have not been qualified are taken into account in the management of the system.

- Effect of groundwater utilisations upstream of the Middle Letaba Dam

A comparison of the modelled and actual trajectory of the Middle Letaba Dam indicates a serious discrepancy, with either the releases or abstraction from the dam being underestimated or the inflow to be overestimated, or a combination of both. Steps are being taken by the DWA Regional Office to verify the abstraction from the dam while methodologies are being developed to estimate the impact of groundwater abstraction on the surface runoff.

- Water Allocations and use

The Letaba Water User Association (WUA) covers the area from Ebenezer to the confluence of the Great and Middle Letaba. The existing WARMS database shows up to 50% ‘’unutilised” water permits. These have however been reallocated to existing users (mainly the irrigators) under a temporary arrangement for a fee of around R1 000 000 paid to the Department of Land Affairs. If new users come on the board this water may need to be reallocated again reducing water available to the irrigators.

There is an expectation from irrigators that the Nwamitwa Dam when constructed will provide water for their use. The Letaba WUA advised that WARMS figures on water allocation should not be applied for operational decision making because they have many errors. These errors include duplication on water allocation between boreholes, run-of-river and releases from dams, double registration on Government schemes and Water Users Association control areas, some users registered future requirements and on the borehole database irrigation requirements were in some cases combined with domestic water requirements. All these problems are now surfacing because registered users are being billed.

- Results from the different models

Some differences in the results were obtained with the three models which could be attributed to how stochastic hydrology was applied in the runs.

Recommendations

The following recommendations were made from this study:

- For the current situation, if the water level in Ebenezer Dam is below 10% per cent at the end of April 2006, the following contingency plan is recommended:
    - Cease all irrigation of the Ebenezer Dam, New boreholes may be required to supply the domestic requirements of the affected farmers.
    - Cease all compensation releases from the Ebenezer Dam
    - Tzaneen should obtain all its water from Tzaneen Dam. The technical implications of this need to be investigated urgently.
    - More extreme measures must be taken to curtail abstraction by Polokwane 70% of their allocations (current use is 125% of their allocation).
    - Monitoring on a monthly basis comparing actual storage and usage
    - The DWA regional office should monitor the implementation of restrictions.
- The process of gazetting curtailments should be made much shorter than experienced on this study. It is understood that the actual implementation of the restrictions depends on DWAF's ability to enforce them and more importantly the co-operation of water users.
- The dams in the Letaba System are being operated on the run to empty basis. This is not sustainable management of water resources. It is recommended that minimum levels be established for each reservoir. It will be possible to develop trajectories which prevent the damns from going below these levels. It is also recommended that DWA develops a long term operation policy for the system and obtains buy-in from users.
- It is recommended that Dap Naude, Ebenezer, Magoebaskloof and Tzaneen Dams be operated in conjunction in order to improve security of from Tzaneen Dam
- Other options to augment supply from Tzaneen should be considered such as the

construction of the Nwamitwa Dam and the raising of Tzaneen Dam.

- The current drought management plan needs to be more elaborated and be able to set levels of curtailments for different storage conditions. The decision tool needs to be improved and extended to incorporate the use of stochastic and multi-dam operations.
- Dam surveys should be conducted to provide more accurate level-area and level-storage relationship in order to provide a sound basis for hydrological analysis and monitoring.
- Situation surveys should be conducted to determine dams with high risk of sedimentation.
- An inventory of dams should be produced and an assessment of their impact on runoff should be conducted.
- Real time operational analysis should be conducted for this system. The middle Letaba and Nsami Dams should be included in this analysis in order to provide for the possibility of these dams contributing to ecological water requirements
- The hydrology of the system should be updated to 2005
- Water use data should be updated (including groundwater use).
- STOMSA should be modified to generate any desired number of stochastic sequences so as to facilitate the application of other models for operational analysis.

2.20 DEPARTMENT OF AGRICULTURE – STRATEGIC PLAN 2005/2006)

2.20.1 Overview

The Strategic Plan for the Department of Agriculture is an essential tool for planning and resourceallocation. The aim of the Plan was to strategically mobilise, distribute and utilise those resources equitablyand efficiently to achieve the four Government objectives namely:

- Growing the economy;
- Job creation;
- Economic empowerment and;
- Poverty alleviation.

This Strategic Plan provides essential information that will enable effective benchmarking that willresult in the monitoring and evaluation of the Department's performance in achieving the plannedobjectives and outcomes.

2.21 CURRENT STUDY: REAL TIME OPERATION OF THE LETABA RIVER SYSTEM (2008)

2.21.1 Overview

The main purpose of this study is to develop a real time operational Decision Support System (DSS) incorporating river losses/groundwater recharge to optimise the operation of the Letaba River System and to satisfy the ecological requirements of the river system.

2.21.2 Data Collection and Monitoring

Report Title: REAL TIME OPERATION OF THE LETABA RIVER SYSTEM – Task 5: Data collection and monitoring. Department of Water Affairs. Directorate: Water Resources Planning Systems. Prepared by Hatting Anderson Associates, May 2008.

2.21.3 Introduction

The Letaba River System is currently experiencing water shortages and the intended releases for ecological requirements have also failed to reach the Kruger National Park. As a result Directorate Water Resource Planning Systems has appointed a joint venture between two consulting firms, namely, Hatting Anderson Associates CC and Leachable Quality Consultants (Pty) Ltd, with Hatting Anderson Associates CC as the lead firm to perform the "Real Time Operation of the Letaba River System" study in August 2006. The main purpose of this study is to develop a real time operational Decision Support System (DSS) incorporating river losses/groundwater recharge to optimise the operation of the Letaba River System and to satisfy the ecological requirements of the river system.

- The objective of this task is to collect, verify and assess the information required for the successful setup, calibration and implementation of the hydrodynamic model as well as the decision support system. From the results of the activity (including the various field trips), the following important conclusions are drawn:River flow: No flow gauging is taking place in the study area accept for the main stem of the Groot Letaba River downstream of Tzaneen Dam and the Letsitele River. The temporal distribution of all the flow gauging stations except Black Heron appears to be adequate for the purposes of this study. It became apparent during the site visits that the accuracy of Engelhart Dam during low flows is questionable as a result of the occurrence of hyacinths blocking the spillway and similarly for Prieska Weir as the weir are a broad crested weir, the upstream basin is silted and unrecorded releases are made from the weir. Only three distinct river reaches are therefore available for analysis.Rainfall: The distribution of the rainfall stations in the Letaba catchment is uneven as most of the rainfall stations are concentrated in the upper reaches and for the majority of cases are close to the main stem of the Groot, Middle and Klein Letaba Rivers. The majority of major tributaries (for example the Letsitele and Thabina Rivers) have no rainfall stations making real time monitoring of rain and therefore real time runoff simulations impossible. Alternate average rainfall year (2002, 2004 and 2006) and a relative dry year (2003 and 2005) can be observed since 2000.Evaporation: The majority of evaporation stations are located in the upper reaches of the study area, while the lower reaches are not covered at all. As a result evaporation data from the WR90 series (Midgeley et al: 1994) was used for the purposes of determining the evaporation as well as evapo-transpiration losses.Groundwater monitoring: Although the boreholes for groundwater monitoring are evenly distributed in the catchment, excluding the Kruger National Park, the majority of the boreholes are not close to the main river and tributaries and these boreholes have only been monitored since 2005. There are also no monitoring boreholes in the Kruger National Park;Abstractions return flows and allocations: Abstractions from the main stem of the Letaba River are managed and monitored by the Letaba Water User Association. The magnitude of abstractions is similar for both the upper river reaches. It is also evident that abstractions have been decreasing since 2002 as a result of some drier years. The use of excess high flows during the rainy season is also evident.Topography and river morphology: The GIS shape files obtained from DWAF based on 1: 50 000 maps together with the satellite images available from Google Earth appear sufficient for the purposes of this study;Riverine vegetation: The satellite images available from Google Earth were used to estimate the extent of the riverine vegetation for use in the determination of evapo-transpiration estimates for each river reach.Channel roughness: An initial Manning channel roughness of 0.033 was chosen using the knowledge of the relevant reaches based on actual observations during the field visits as well as using satellite images;Control structures along the river channel: Given the approximate nature of the hydrodynamic modelling being proposed there is no need to model the hydraulic influence of the abstraction structures. It is, however, important to note the existence of such weirs as Nondweni and Prieska Weirs that are used as storage and from which unrecorded releases are made.

- The following recommendations are made from the findings of the activity:The flow gauging along the main stem should be improved to include the major ungauged tributaries (including the future contribution of Nwamitwa Dam, the off-channel storage dam that is planned on the Molototsi tributary) as well as recording the releases made from Nondweni Weir;The comprehensive monitoring of all the surface water abstractions should be continued by LWUA;Monitoring of groundwater in especially the irrigation area should be extended and included in the functions of the LWUA; and the current practices reflecting the best wisdom and the knowledge of the water bailiff in operating the system in collaboration with the Area Manager should be documented in a short ‘practical operational manual’ that will serve as the basis for gradually improving these practices with quantifiable operating rules. This will depend on the implementation of the above-mentioned recommendations regarding monitoring.

2.21.4 Estimate Loss Dependant Variables with Water Balance

Report Title (Draft): REAL TIME OPERATION OF THE LETABA SYSTEM: Estimate Loss Dependant Variable with Water Balance: Task 7. Project Number 2006-044. Department of Water Affairs and Forestry.Prepared by Hattingh Anderson Associates and Lechabile Quality Consultants (Pty) Ltd. May 2008.

The objective of this task was to determine the major loss dependant variables by testing their impacts using the hydrodynamic model and to perform a water balance for each river reach using these loss dependant variables as well as all the know abstraction described in the conceptual model.

- From the results the following important conclusions were drawn:The evaporation module in the MIKE 11 proved unstable. The smoothed evaporation function determined from the results of MIKE 11 proved to be sufficient for use in the water balance.The sizeable difference in the evapo-transpiration between Tzaneen Dam to the Junction Weir and the Ranch Weir to Black Heron are mainly as a result of the difference in area of the riverine vegetation between the two river reaches.The conceptual model was effectively applied with some minor changes.Tzaneen Dam to Junction Weir. The net balance (‘losses’) is negative for most of the critical period (beginning of May to end of October) with only some small positive net balances evident for the month of August for the majority of years. No definite hypothesis for this could be proved for these phenomena, with the contribution of groundwater to surface water, the contribution of the unmonitored various tributaries in this river reach and/or return flows as possible contributors.
- Junction Weir to the Ranch Weir. The flows at the Ranch Weir mimicked the inflows form the Letsitele River. In other words the system was operated in such a way that the large majority of releases from Tzaneen Dam were abstracted for irrigation use resulting in efficient use of water. The net balance (‘losses’) was positive both at the start as well as the end of the critical period (beginning of May to end of October) for the majority of years. The only exception was 2005 which indicated positive net balances for the whole critical period under consideration mainly due to the Letsitele River running dry during this period and the subsequent abstraction from the storage capacity along the river reach during this

period.

- The Ranch Weir to Black Heron Weir. As only two years of information was available, no firm conclusion regarding the typical net balance could be made. For the purposes of calibrating this reach, the 2005 net balance was assumed to be correct.

The following recommendations were made from the findings of the activity:

- The conceptual model with the minor changes made during this task should be used for future studies of a similar nature.
- The proposed 'losses' function for each reach should be tested and refined in Task 8 of the study: Calibration of Hydrodynamic Model.

2.22 GROOT LETABA RIVER WATER DEVELOPMENT PROJECT (2009/2010)

2.22.1 Overview

The Feasibility Study proposed several options for augmenting water supply from the Groot Letaba River. These included some management interventions, as well as the construction of a dam at Nwamitwa and the possible raising of Tzaneen Dam. These options would enable additional water to be allocated to the primary water users, would allow the ecological Reserve to be implemented and could also improve the assurance of supply to the agricultural sector.The Groot Letaba river water development project was divided into 28 reports reviewed in the following sub-sections.

2.22.2 Environmental Impact Assessment Report

2.22.2.1 **Infrastructure**

- The EIA was based on various infrastructure components related to the GLeWaP project. These are listed below:The raising of the Tzaneen Dam the construction of a dam at the Nwamitwa site. The EIA was based on a proposed dam that has a 36 m high wall, 144 million m^3 gross storage capacity, 1 400 km^2 catchment area, MAR of 122,6 million m^3 under natural conditions, and should increase yield for domestic use by 14 mill m^3 pa.
- The re-alignment of the R529, D1292 (R81) and P43/3 roads.
- The upgrading of the Nkambako WTW, and construction of pump stations and pipelines.
- Construction is estimated to take 5 years, with construction sites requiring various infrastructures.

2.22.2.2 **Alternatives**

During the scoping phase the alternatives listed for the project were:

- The “Do Nothing” approach
- Replacing commercial afforestation with natural vegetation
- Ceasing export of water to Sand River
- Improve utilization efficiency of irrigation water
- Decrease irrigation allocations
- Water Conservation and Demand Management
- Alternative water storage facilities

2.22.2.3 **Significant Impacts and Mitigation**

2.22.2.3.1 Tzaneen Dam

There is expected to be a positive local and regional economic impact during the construction phase of the raising of the Tzaneen Dam. This is due to the expenditure in the economy. Increased stability in the citrus industry is also expected due to the increase in assurance of water supply in the irrigation sector.

Construction related activities such as dust and noise would be responsible for most of the negative environmental impacts. These can be mitigated to acceptable levels.

2.22.2.3.2 Proposed dam at Nwamitwa site

Positive economic impacts are expected during the construction phase of the project.

All of the negative impacts due to the construction can be mitigated to acceptable levels. Some of the negative impacts include:

- Loss of fauna and flora. This can be mitigated through plant and animal rescue programmes, and a holding nursery where plants are rehabilitated.
- Disturbance and inundation of heritage sites. This can be mitigated by relocating the graves, and recording and excavating archaeological sites.
- Disturbance of local community movement patterns, social relationships and safety. This can be mitigated by providing safe passage where required.
- Impacts of non-health related quality of life on the communities. This can be mitigated by implementing noise and dust control measures, and liaising with the local communities.
- Noise impacts on the construction workers can be mitigated through the provision of protective equipment. Noise impacts on the community can be mitigated by limiting construction activities to day-time hours.

- If no mitigation is implemented, the negative impacts on downstream aquatic habitats and biotica is expected. Mitigation measures include limiting disturbances to the local construction site, stabilising downstream riverbed and banks, and ensuring that during the construction phase, downstream and upstream riverine habitats are connected during critical fish life-cycle periods.

During the operations phase, the proposed dam would have a positive impact by increasing water availability, and associated health and economic sustainability.

It is predicted that stratification would occur in the proposed dam. If cold, anoxic water from the bottom of the dam be released, then it will have a detrimental effect on about 15 km of the downstream aquatic life. Mitigation measures include constructing a multi-level outlet structure. Outlets should be at 4 – 5 meter intervals from 6 meters below the FSL.

The negative impacts on downstream aquatic habitats must be evaluated in the context of the Management Class set out for the river in terms of the Reserve. After mitigation the impact was rated as low.

2.22.2.4 **Environmental Impact Statement**

The EIA fulfilled the NEMA regulatory requirements. Some portions of existing road will be inundated due to the construction of the proposed new dam. It is recommended to use Alternative 4 for the re-alignment of the roads after all impacts are considered.

No fatal flaws were found with any of the pipeline routes, and no alternatives were found. The pipeline routes that traverse through untransformed vegetation should be considered least favourable, and wherever possible routes should traverse transformed habitats.

Four reservoirs, A, B, C, and D, were proposed, while Reservoirs C and D had alternative sites that were considered. No fatal flaws were found at any of the alternative reservoir sites; however reservoir C4 was the preffered option.

Compensation will be given to all affected land owners. The proposed project was found to be the preffered option to meet increased domestic requirements in the catchment. The EAP recommends environmental authorisation to raise the Tzaneen dam, construct a new dam at the Nwamitwa site, and all associated activities with the following conditions:

- Compilation of a compensation and development plan.
- The Labour procurement for construction must be undertaken through a Labour Desk, with all procedures and race targets adhered to.

- Continued liaison with directly affected parties during pre- construction and construction phases.
- Implementation of a communication strategy for the implementation phase.
- Continued liaison with authorities responsible for implementing water distribution.
- Multiple level outlets in dam design.
- Fauna and Flora plant rescue programmes and establishment of a holding nursery.
- Confirmation of detailed investigations of archaeological sites prior to impacting affected sections.
- Implementation of grave relocation programme.
- Undertake baseline studies before implementation commences to act as a benchmark. Social, economic, water quality, aquatic ecology, terrestrial ecology, air quality and nose aspects should be included.
- Finalise and implement the draft Pre-construction Environmental Management Plan
- Finalisation of construction and operation EMPs based on generic EMP.

2.22.3 Volume 1: Main Report

Report Title: GROOT LETABA RIVER WATER DEVELOPMENT PROJECT: Technical Study Module: Main Report. Report No. P WMA 02/B810/00/0608/01Prepared for: Department of Water Affairs and Forestry.Prepared by Aurecon, 2010.

This report summarizes the result of the technical study module.

The significant recommendations emanating from the Study are summarised below:

- Given the stressed nature of the available water resources and the anticipated growth in primary water requirements, it is important that verification and validation of water use in the Groot Letaba Catchment is undertaken urgently and in a thorough manner.
- It is important that municipalities measure and monitor water use in their areas of jurisdiction so that, in future, accurate data are available for analysis and planning.
- The implementation of water demand/water conservation measures in the catchment isstrongly recommended in order to achieve early and meaningful impact on demand-side water supply management.
- A comprehensive groundwater investigation should be undertaken so suitable qualitygroundwater can be located and developed with greater certainty. These

investigationsshould be focussed on mobilising specific groundwater resources for integration in thewater supply system on a regional basis in the supply area currently envisaged for the proposed Nwamitwa Dam.

- The potential yields, costs and environmental implications associated with a potentialgroundwater "regional government water scheme" should be determined and comparedwith the yields, costs and environmental implications of the proposed Nwamitwa Dam development.
- A complete re-calibration of the rainfall – runoff model should be undertaken with a focuson achieving a good match in the low to medium flow events (freshets), to enable reliable modelling of the EWR requirements in the WRYM.
- The historical firm yield of the proposed Nwamitwa Dam should be re-determined oncethe results of the abovementioned further investigations are available and once the rainfall runoff model has been re-calibrated.
- An embankment type earth fill dam should be constructed at Nwamitwa, with a centralogee spillway with a full supply level of 479.5 m.a.s.l. This will ensure that sufficient yieldis obtained to meet the anticipated future water requirements of the area surroundingNwamitwa Dam, minimise expropriation costs and limit the amount of evaporation from the proposed dam.
- A labyrinth spillway option is recommended for the raising of Tzaneen Dam. This is themost cost effective solution and has the lowest future maintenance costs. The fuse gateoption could still be considered during the detailed design phase of the project tomitigate possible unacceptable negative impacts of high flood events on the Sybrandand Marietjie van Niekerk bridges.
- The Regional Bulk Water Supply Infrastructure as proposed in the report should be implemented and taken further into the detailed design phase.
- Mopani District Municipality should implement a comprehensive water metering and monitoring system in order to ascertain what the actual water requirements are and howthe water requirements change with implementation of the recommended regional bulkwater supply and connector bulk infrastructure.
- The capacity of the Babanana Reservoir (Command Reservoir B) and the SereloroloReservoir (Command Reservoir A) should be increased when the future waterrequirements reach the stage that there is insufficient emergency and balancing storage in the respective supply areas.

2.22.4 Volume 2: Review of Water Requirements

Report Title:GROOT LETABA RIVER WATER DEVELOPMENNT PROJECT: VOLUME2 – Review of Water Requirements. Report No. P WMA 02/B810/00/0608/2.Department of Water Affairs and Forestry.Prepared by Aurecon in Association with Semenya Furumele Consulting, KLM Consulting Services, Urban-Econ Developmental Economics and Schoeman and Associates, May 2010.

The review of the water requirements was undertaken as part of the Bridging Study that was initiated by DWA in 2006 in order to re-assess the recommendations contained in the Feasibility Study in the light of developments that had taken place in the intervening 10 years. The study area for the Review of Water Requirements Task comprised of the catchment of the Letaba River, upstream of its confluence with the Klein Letaba River. The review of water requirements objectives are summarised as to:

- review the current estimates of future water requirements in all user sectors;
- establish present levels of water use in these sectors; and
- assess the availability of groundwater in the project area.

2.22.4.1 Primary Water Requirements

Primary water requirements for the Groot Letaba Catchment were estimated to increase by 28.8 million m^3/a from 2007 to 2030, giving a total primary water use of 52.3 million m^3/a in 2030 (which includes a small industrial component of 1.5 million m^3/a). The breakdown is provided in **Table 2.48** below.

It was further estimated that additional 21 Mm^3/a will be required in the area for future mining projects but these requirements will be met from outside the Groot Letaba Catchment and were therefore not included in the future estimates for the catchment.

These current water requirements are mainly supplied through surface water supply schemes, with very little being supplied from groundwater sources. Surface water is supplied from the Groot Letaba River and its tributaries to the towns of Polokwane, Tzaneen, Haenertsburg, Duiwelskloof as well as too many rural villages. The main surface water supply schemes draw from the Dap Naude, Ebenezer and Tzaneen Dams and are listed below:

Table 2.48: Current (2007) and Projected Water Requirements

Description	Place Name	Water Requirements in Mm^3/a				
		Allocation 2006/7	**Usage 2006/7**	**Base value used for Future Projection*1**	**Estimated Growth to 2030**	**Total Future Water Requirements (2030)**
(Domestic use in Groot Letaba catchment upstream of confluence with Klein Letaba River)	Haenertsburg	0.0	0.0	0.0	0.0	0.0
	Tzaneen Town	3.6	2.2+1.0=3.2	3.6	12.89	16.49
	Politsi Duiwelskloof Ga-Kgapane	2.0	2.1	2.0	1.38	3.38
	Letsitele	0.4	0.3	0.3	0.70	1.00
	Ritavi 2	3.5	8.2	8.2	-3.41	4.79
	Naphuno	1.7	1.3	1.3	1.60	2.90
	Namakgale	0.0	0.8	0.8	0.00	0.80
	Ritavi 1	0.0	1.9	1.9	3.30	5.20
	Bolobedu	0.2	0.2	0.2	11.31	11.51
	Sub-total	**11.4**	**18.0**	**18.3**	**27.8**	**46.07**
Domestic use in Middle and Klein Lataba Catchment	Giyani	3.7	3.7	3.7	1.0	4.7
	Cumulative Sub-total	**15.1**	**21.7**	**22.0*2**	**28.8**	**50.8**
	Middle Letaba Dam WTW	2.3	2.3	2.3	No estimate made*3	-
	Sub-total	6.0	6.0	6.0	-	-
Cumulative Sub-total		**17.4**	**24.0**	**24.3**	**-**	**-**
Domestic use outside of Letaba Catchment	Polokwane	18.5	4.6+18.8=23.4	23.4	No estimate made*3	-
Sub-total for domestic use		35.9	47.4	47.7	-	-
	industrial	3.3	1.5	1.5*2	-	-
Overall total of primary water requirements		**39.2**	**48.9**	**49.2**	**-**	**-**

*1 Note that where the base value differs form the allocation the allocation in the previous column, this was basedon actual water usage in 2006/7
*2 Current day primary water requirement for Groot Letaba Catchment = 23.5 Mm^3/a (22.0 Mm^3/a domestic + 1.5 Mm^3/a industrial)
*3 Growth in water requirement to be met from outside Letaba catchment

Dap Naude Dam Water Supply Scheme
Ebenezer Dam Water Scheme
Magoebaskloof Dam and Vergelegen Dam Scheme
Hans Merensky Dam Scheme
Tzaneen Dam Scheme
Thapane Dam Scheme
Thabina Dam Scheme
Letsitele River Run-of-River Scheme
Modjadji Dam
Middle Letaba Rural Water Supply Scheme (RWSS) supplied by Middle Letaba Dam

2.22.4.2 Irrigation Requirements

Irrigation comprises the largest water requirement in the catchment, and it was estimated to be approximately 192 million m3/a from surface water, and 29 million m3/a from groundwater. Losses of about 27.2 Mm^3/a form a significant portion of this requirement.

2.22.4.3 Afforestation

The total area of afforestation was estimated to be 356 km2 resulting in afforestation water use of 77.6 million m3/a. This figure is expected to still be the same in 2030. However the impacts of alien invasive plants were not undertaken.

2.22.4.4 Ecological Reserve

A Preliminary Reserve Determination was undertaken by DWA, and proposed ecological water requirement (EWR) as follows, low flow component of 16 million m^3/a and a high flow component of 66 million m^3/a, giving an average annual value of 82 million m^3/a at EWR Site 4 (Letaba Ranch. However, the present EWR release is 15 million m^3/a.

The study made the following recommendations:

- Given the stressed nature of the available water resources and the anticipated growth in primary water requirements, it is important to undertake verification and validation of water use in the Groot Letaba Catchment.
- It is important that municipality's measure and monitor water use so that in future accurate modelling can take place.
- Due to the stressed resources and the cost of developing new resources, the implementation of water demand/water conservation measures in the catchment is strongly recommended.
- Since the losses in the system are so significant, further investigations should be undertaken to refine the assumptions used to determine "river losses". This will enable the yields of dams in the system to be estimated with a higher level of certainty.
- When the hydrology for the Groot Letaba is revised, it is recommended that the water use of invasive alien plants be modelled as a separate water use.
- A regional study should be undertaken to further investigate increasing the use of groundwater in the catchment, particularly in conjunction with surface water.

2.22.5 Volume 3: Groundwater

Report Title:GROOT LETABA RIVER WATER DEVELOPMENNT PROJECT: Volume 3: Groundwater. Report No. P WMA 02/B810/00/0608/3.Department of Water Affairs and Forestry.Prepared by Aurecon in Association with Semenya Furumele Consulting, KLM Consulting Services, Urban-Econ Developmental Economics and Schoeman and Associates, May 2010.

This report covers only the Groot Letaba catchment, which is Tertiary catchment B81. The report is a desk study and summary of other works. It estimated groundwater usage as 40 Mm^3/a.

The report utilised a qualitative index to describe groundwater potential based on recharge, borehole yields and groundwater quality. This was utilised to produce a map of high medium and low groundwater potential.

The figures given for groundwater resources in the catchment are not in line with established and accepted figures of Harvest and Exploitation Potential. They are based purely on estimated recharge figures, which do not to take into account that much of the recharge re-emerges as interflow in high lying areas.

2.22.6 Volume 4: Hydrology

Report Title: GROOT LETABA RIVER WATER DEVELOPMENT PROJECT: Technical Study Module - Hydrology (Volume 4). Report No 02/B810/00/0608/4 Department of Water Affairs. Prepared by Aurecon, May 2010.

2.22.6.1 **Scope of this report**

This report forms part of the Technical Study Module: Water Resource Evaluation, namely the updating of the hydrology. The report gives some background to the process of updating of the hydrology. The approach used to extend the natural stream flows is also described and detailed information is provided in appendices. The results of the extension of the hydrology are summarised and also provided in Appendices. Conclusions and recommendations relating to the extension of the hydrology are also provided with review comments as an appendix.

2.22.6.2 **Updating of hydrology**

The scope of this Study included an extension of the catchment modelling time period by 12 years to end in hydrological year 2004 instead of 1992, giving a total modelling period of 80 years (from 1925 to 2004). The scope of work specifically excluded the recalibration of the Pitman rainfall-runoff model. The procedure followed for extending the naturalised flows is fully described. The only digital version of the natural hydrology that could be obtained of the Letaba Feasibility study at the time of the analysis was from the Olifants Study WRYM configuration. Difficulties were experienced in obtaining detailed information about the hydrological input data on which the natural hydrology was based. Therefore, the approach taken was:

- to set up the Pitman rainfall-runoff model to match the WRYM set-up as closely as possible,
- to make assumptions regarding the original Pitman model input data (mainly regarding rainfall station combinations and patching),
- to run the model,
- to compare the results to the available naturalised stream flows in the WRYM setup files and demand files for the common period, and
- To then make adjustments to match the WRYM stream flows as closely as possible.

All input data to the model were adopted unchanged where available from the previous studies. The simple extension of modelled data by adding new observations has led to uncertainties regarding the results of the extension of the hydrology. Significant difficulty was experienced in obtaining details of existing model input data in time to meet project deadlines. This led to assumptions being made in order to allow the study to progress, leading in turn to differences in modelling results. The most significant cases are the modelling of afforestation influences, and the rainfall data used as input to the Pitman rainfall-runoff model. Adjustments were made in both cases to ensure that the Bridging Study's extended natural stream flows and afforestation requirements were broadly compatible with the original Water Resources Yield Model (WRYM) stream flows, which were available in digital format.

Methodology and differences from Pre-feasibility Study

The study area was divided into four main hydrological sub-catchments. The most detailed work was done for the Groot Letaba Catchment, based on the 37 sub-quaternary sub-catchments used in previous studies. The hydrology for the other three sub-catchments (Middle, Klein and Lower Letaba) was based on WR90, and was modelled on a quaternary sub-catchment basis.

The main differences in approach to the hydrology tasks between this study and previous studies are listed below:

- The rainfall-runoff model was not re-calibrated, but the simulation period was merely extended to hydrological year 2004 (ending in September 2005).
- Different rainfall stations and groupings were used in the Bridging Study because details of these from previous studies were not available.
- Different afforestation areas were used which required that Bridging Study afforestation requirements to be adjusted to match those of previous studies.
- Updated values for irrigation and domestic requirements were used.
- Detailed comparisons between simulated and observed flows were not done.
- Bridging Study simulated naturalised flows were significantly different from those of previous studies, so were factored to match the flows from previous studies.
- Information on the Bridging Study flows, etc. was reported for a total of six sub-catchments for Groot Letaba (compared to ten in previous studies).

Availability and Quality of Base Data

There is a lack of both rainfall and evaporation data for this area, particularly in the eastern part of the catchment. Only six evaporation stations are located in or near the catchment. Out of the possible 194 rainfall stations in and near the catchment, only 34 passed the screening criteria and were patched. Of these 34 rainfall stations, only showed stationary after patching and were used as input to the rainfall-runoff model. This is a very low number for such a large catchment, and combined with the poor distribution of the stations, is cause for concern. It is recommended that every effort should be made to maintain the existing evaporation and rainfall stations and to ensure that the data collected is of a suitable quality for use in rainfall-runoff modelling.

The selection of rainfall stations and groupings used in this Bridging Study differs from that used in the previous studies. This resulted in the extended portions of the hydrology being substantially different from the hydrology produced in previous studies, requiring adjustment in order to be compatible.

The naturalised mean annual runoff (MAR) for the entire catchment for the period 1925 – 2004 is 613.82 Mm^3/a. This flow consists of the previous study flow from 1925 to 1992, for Groot Letaba, or 1996 for Middle, Klein and Lower Letaba, concatenated with the extended flows from the Bridging Study from 1993 – 2004 (for Groot Letaba) or 1997 – 2004 for Middle, Klein and Lower Letaba, factored by an overall factor of 0.9035.

2.22.6.3 **Conclusions**

A summary of the main conclusions emanating from updating the hydrology is given below:

- The scope of this Study included an extension of the catchment modelling time period by 12 years, to end in hydrological year 2004 instead of 1992, giving a total modelling period of 80 hydrological years (from 1925 to 2004). The scope of work specifically excluded the re-calibration of the Pitman rainfall-runoff model. The decision not to re-calibrate has led to some uncertainties regarding the results of the extension of the hydrology.
- There is a lack of both rainfall and evaporation data for this area, particularly in the eastern part of the catchment. Only six evaporation stations are located in or near the catchment. Out of the possible 194 rainfall stations in and near the catchment, only 12 passed the screening criteria and were used as input to the rainfall-runoff model. This is a very low number for such a large catchment, and combined with the poor distribution of the stations, is cause for concern.

2.22.6.4 **Recommendations**

The following recommendations are made:

- There is a lack of availability and quality of base hydrological data, and therefore every effort should be made to maintain the existing evaporation and rainfall stations and to ensure that the data collected is of a suitable quality for use in rainfall-runoff modelling.
- A complete re-calibration of the rainfall–runoff model should be undertaken. In such a future re-calibration, the focus should be on achieving a good match in the low to medium flow events (freshets), to enable adequate modelling of the ecological water requirements (EWR) in the WRYM.

- In such a re-calibration study, cognisance should be taken of the review points contained in the appendix.

2.22.7 Volume 5: Water Resource Analysis Report

Report Title:GROOT LETABA RIVER DEVELOPMENT PROJECT (GLEWAP): Water Resource Analysis: Volume 5. Report Number P WMA 02/B810/00/0608/5. Department of Water Affairs.Prepared by Aurecon in association with Semenya Furumele Consulting, KLM Consulting Services, Urban-Econ Developmental Economics and Schoeman & Associates. May 2010.

This report describes the water resource analysis of the project and the primary objective of the report was to assess the present surface water availability of the Groot Letaba River System and to assess the increase in yield of the proposed new developments by taking the flow regime required for the ecological reserve into account.

The results of the investigations were summarised as follows:

- Currently the yield of most of the major surface water schemes is over allocated which has resulted in the supply of water to the irrigation sector to be curtailed below the or allocations on an on-going basis. The recent determination of the EWR has introduced and additional requirement, which has increased the pressure on the available water resources.
- One of the major conclusions from the water resource analysis was that the extended hydrology did not adequately reflect the low flows in the system. When this hydrology was utilised without modifications, the proposed Nwamitwa Dam would have zero yield, mainly because of the obligations to meet the EWR. Once the freshets (based on observed flow records) were added to the simulated flows, the yield of the Nwamitwa Dam increased to 14 million m^3/a, the study thus concluded that the results of the study cannot be accepted until a thorough re-calibration of the flows is done.
- The yield was found to be extremely sensitive to the way in which the EWR was implemented in the WRYM. This is a concern because of the preliminary nature of the EWR and the lack of detail available regarding how exactly it needs to be implemented.
- A Reserve Determination Study still needs to be undertaken for the Nwamitwa Dam as the most recent reserve determination study did not consider the modification in flows caused by the Nwamitwa Dam and the possible impact of channel losses along the Groot Letaba River.
- The HFY of the Nwamitwa Dam decreases from 18 million m^3/a to 6 million m^3/a, depending on the factor applied for the losses i.e. 100%, 50% or 0% downstream of the Letaba Ranch. The HFY of Nwamitwa Dam was 14 million m^3/a is losses of 50% were

assumed. This scenario assumes that the EWR's at EWR Site 3 were met by the proposed Nwamitwa Dam.

- Based on the modelling assumptions regarding the freshets, the uncertainty the implementation of the EWR and the course assumptions regarding the river losses it was concluded that the yield results of the Nwamitwa Dam should be regarded as preliminary until the further recommended studies have been undertaken.
- The incremental increases in the HFY of the Ebenezer/Tzaneen system from raising the Ebenezer Dam by 5 and 10 metres were 2.3 and 4.5 million m^3/a respectively. If Nwamitwa Dam was constructed first, then the incremental firm yield from raising Ebenezer reduces from 4.5 to 3.9 million m^3/a.
- The construction of the proposed Nwamitwa Dam and the raising of Tzaneen Dam will have very limited impact on the yield of Massingir Dam (reduction of about 3 million m^3/a on 575 million m^3/a). The development of the proposed Rooipoort Dam will reduce the HFY of Massingir Dam to 500 million m^3/a.
- It is important that the Nwamitwa Dam and Tzaneen Dam are operated conjunctively to maximise the yield. Nwamitwa Dam should be drawn down first, primarily to minimise evaporation, as this dam has a larger surface area for a given storage volume than Tzaneen Dam and a higher evaporation rate. With this operating rule the net evaporation from the Nwamitwa Dam is 9 million m^3/a, which increases to 20 million m^3/a if the dam were to be maintained at its full supply level. The second benefit of drawing down the Nwamitwa Dam first is that is also maximises the storage available to intercept floods from the Letsitele River and Tzaneen Dam.

The following recommendations were made:

- Given the stressed mature of the available water resources and the anticipated growth in primary water requirements it is important to undertake verification and validation of water use in the Groot Letaba Catchment.
- A Reserve Determination Study for the proposed Nwamitwa Dam needs to be undertaken. The EWR needs to be refined and more attention needs to be given to how the EWR should be applied and modelled to reflect the day to day operation more accurately in the WRYM.
- The reduced EWR Scenario 7 was developed without considering the proposed Nwamitwa Dam and relies on unregulated flows in the Letsitele River to supply the EWR. If the Nwamitwa Dam was constructed, compliance with the reserve would need to be rechecked.

- Further investigations should be undertaken in order to refine the assumptions regarding the river losses. This will enable the yield results to be portrayed with a higher level of certainty.
- The HFY of the proposed Nwamitwa Dam should be re-determined once the results of the abovementioned further investigations are available and once the rainfall runoff model has been re-calibrated. The presented results cannot be accepted before this is done.

2.22.8 Volume 6: Nwamitwa Dam Preliminary Design – Vol 6 and Annexure 1 to Annexure 4

Report Title:GROOT LETABA RIVER WATER DEVELOPMENT PROJECT. Preliminary Design of Nwamitwa Dam. Report No. P02/B810/00/0680/6.Department of Water Affairsand Forestry, South Africa. Prepared by Aurecon (Pty) Ltd in association with Semenya Furumele Consulting, KLM Consulting Services, Urban-Econ Developmental Economics and Schoeman & Associates. May 2010.

The report deals with the preliminary design of the Nwamitwa Dam. It addresses the determination of the design flood peaks used to size the spillway, the further geotechnical investigations that were undertaken to supplement the work done during previous studies, the optimization of the dam size based on the latest annual yield figures and dam costs, the selection of the most economical spillway type and the preliminary design of the embankment, spillway and outlet works. It also addresses the costs associated with the expropriation of the properties to be inundated by the dam as well as the preliminary design and costing of the roads in the dam basin to be relocated.

The valley shape factor at the Nwamitwa Dam site is in excess of 50. This is a clear indication that an embankment type dam would be the most appropriate dam type. Further dam type selection was therefore not undertaken and emphasis was placed on the selection of the spillway type. Dam sizes of 0.41MAR, 0.85MAR, 1.16MAR and 1.50MAR were investigated.

Construction cost estimates were prepared for the four dam sizes. The cost estimates allowed for the relocation of services (roads, electricity,and telecommunications), contingencies, planning, design and supervision costs and expropriation costs. The cost estimates are given below:

- 0.41MAR (Capacity 66 Mm3, yield 4 Mm3/a) R 989 million;
- 0.85MAR (Capacity 137 Mm3, yield 9 Mm3/a) R 1180 million;
- 1.16MAR (Capacity 187 Mm3, yield 14 Mm3/a) R 1285 million;
- 1.50MAR (Capacity 241 Mm3, yield 17 Mm3/a) R 1409 million;

A dam with a historical firm yield of 14 Mm3/a was proposed as the preferred dam size (1.16MAR). The embankment will be 34 m high with a total crest length (including the spillway) of 3500 m. The embankment cross-section comprise an impervious core section, semi-impervious general fill zones, chimney and blanket drains, rip-rap protection on the upstream slope and aggregate protection on the downstream slope. The non-overspill crest level will be at 486.0 m.a.s.l

Four types of spillways were investigated for the proposed dam, as follows:

- A straight ogee spillway;
- A trough spillway;
- A labyrinth spillway; and
- A side channel spillway.

Due to technical constraints, the side channel spillway option was discarded. The straight spillway option was adopted in the preliminary design of the dam as this spillway proved to be the most cost effective. The spillway will be constructed across the river channel, which will require significant widening to accommodate the long mass gravity RCC spillway section. Tongue walls with a total length of 161 m will be provided on either side of the spillway to accommodate the outlet works and to tie into the earth embankments.

The outlet works will be housed in an integral outlet block on the left hand side of the spillway. It will be equipped with precast concrete trash racks, stainless steel fine screens and a maintenance gate to close off the intakes to the pipe stacks. Two outlet pipe stacks will be provided. The pipestacks will consist of 1200DN pipework. The intakes to the pipestacks will be staggered at 4.5 m intervals to allow for flexibility in selecting the most appropriate abstraction level. Two 1000DN sleeve valves will be provided on the downstream side.

A number of provincial roads will be affected by the proposed dam. Possible routes for the re-alignment of the roads were investigated and preliminary costs determined. Route alignments for the preliminary design stage were selected based on the preliminary cost determinations. The proposed re-alignment of the various roads were discussed with the landowners and the Roads Agency Limpopo before a preliminary design of the proposed re-alignments commenced. Further adjustments were made to the re-alignment of route P43-3 after further consultation with some of the affected land owners. Concerns expressed by the land owner which were submitted after completion of the preliminary design should be addressed during the detail design phase of the project.

2.22.9 Volume 7: Raising of Tzaneen Dam Preliminary Design Report

Report Title:GROOT LETABA RIVER WATER DEVELOPMENT PROJECT. Preliminary Design of the Raising of the Tzaneen Dam. Report No. P02/B810/00/0680/7.Department of Water Affairsand Forestry, South Africa. Prepared by Aurecon (Pty) Ltd in association with Semenya Furumele Consulting, KLM Consulting Services, Urban-Econ Developmental Economics and Schoeman & Associates. May 2010.

The report investigated three methods that can be used to raise the full supply level (FSL) of the Tzaneen Dam. The three options that were investigated, as well as the associated costs (base date May 2010), are given below:

- Hydroplus fuse gates Total cost R 59 million;
- Labyrinth spillway Total cost R 42 million;
- Side channel spillway Total cost R 72 million;

The comparison between the alternatives was made for a raising of the FSL of the dam by 3.0 m to 726.9 m.a.s.l. The amount by which the FSL and the nonoverspill crest can be raised is limited by the soffit levels of the Sybrand and Marietjie van Niekerk bridges and the fact that additional land may have to be acquired for the dam basin and the surrounding buffer strip.

All three the options are technically feasible. The side channel spillway option was discarded based on costs. However, the labyrinth spillway option is the most cost effective and has no future maintenance cost and it was recommended that this option be adopted for the raising of the FSL of the dam.

Should it be discovered during the detailed design phase that the potential impact of the extreme flow events on the integrity of the Sybrand and Marietjie van Niekerk bridges is considered unacceptable, then the Hydroplus fuse gate option will become the preferred option for the raising of the Tzaneen Dam.

2.22.10 Volume 8: Bulk Infrastructure – Vol 8 and Annexure 1

Report Title:GROOT LETABA RIVER WATER DEVELOPMENT PROJECT. Bulk Water Distribution Infrastructure. Report No. P02/B810/00/0680/8.Department of Water Affairsand Forestry, South Africa. Prepared by Aurecon (Pty) Ltd in association with Semenya Furumele Consulting, KLM Consulting Services, Urban-Econ Developmental Economics and Schoeman & Associates. May 2010.

The primary purpose of the Nwamitwa Dam will be to supply primary water requirements to rural settlements close to the dam. The report assesses the adequacy of the existing bulk water supply infrastructure, defines the potential supply area of the proposed Nwamitwa Dam and conceptualizes regional bulk water supply infrastructure required to serve the rural settlements in the supply area.

A number of independent supply systems are located in close proximity to the proposed dam and could therefore be potentially supplied from the dam. The supply systems (and current water sources, shown in brackets) are given below:

- The Letaba Ritavi system (the Letaba River and groundwater);
- The Thapane system (Thapane Dam and groundwater);
- The Modjadji system (Modjadji Dam and groundwater);
- The Worcester/Mothobeki system (Modjadji Dam and groundwater);
- The Lower Molototsi system (Modjadji Dam and groundwater);

For the purposes of the report, the Worcester/Mothobeki and Molototsi systems were described as one system and referred to as the Worcester/Mothobeki system.

Each system has a partial network of existing bulk water supply pipelines, some components of which are not fully utilized. Critical shortages of treated water exist in the Letaba, Thapane and Worcester/Mothobeki systems. These water shortages can be attributed to insufficient water resources, the lack of bulk infrastructure and other causes (incorrect pump type selection).

Surface water is currently pumped from an existing weir on the Letaba River just downstream of the proposed Nwamitwa Dam and treated at the Nkambako Water Treatment Works. The water treatment works comprise of a single treatment module with a capacity of 6 Ml/day. An identical 6 Ml/day module has been constructed, but has not yet been commissioned. After completion of the second module the works will have a total design capacity of 12 Ml/day. The current treated water quality at the works do not meet the SANS class 1 requirements but is generally within class 2 requirements.

In order to determine the logical supply area of the proposed Nwamitwa Dam the water requirements in the areas immediately surrounding the proposed dam were analysed and compared to the anticipated yield from the proposed dam. The anticipated 2027 water requirement for the Letaba/Ritavi, Thapane, and Worcester/Mothobeki/Molototsi (including part of Giyani) systems is 11.2 Mm3/a (the water requirement increases to 13.3 Mm3/a if the potential shortfall in the Modjadji system is also to be supplied from the Nwamitwa Dam). This compares favourably to the historical firm yield of 14 Mm3/a for the proposed Nwamitwa Dam for a dam with a full supply level of 479.5 m.a.s.l.

Regional bulk supply reservoirs and bulk water supply pipelines were identified as part of the conceptual masterplan. The locations of required regional bulk supply reservoirs and logical supply areas were also identified as part of the conceptual design.

The cost (excluding VAT), to implement the proposed regional bulk water supply infrastructure was estimated at approximately R 313 million (base date 2009). The cost allowed for contingencies and professional fees.

2.23 WATER RESOURCES SYSTEMS DEVELOPMENT BUSINESS SUPPORT PHASE 3 (2010)

2.23.1 Overview

The purpose of this study was to setup a combined system and to analyse the effect of the possible support from Nandoni Dam to the Middle Letaba sub-system. The results from this analysis are documented in this report.The water resource systems development business support phase 3 has one report as reviewed in the following section.

2.23.2 Incorporation of a Transfer Option from Nandoni Dam to Giyani into the DSS for the Luvuvhu and Letaba

Report Title: WATER RESOURCES SYSTEMS DEVELOPMENT BUSINESS SUPPORT PHASE 3: Incorporation of a Transfer Option from Nandoni Dam to Giyani into the DSS for the Luvuvhu and Letaba. Reference Number P14/14/2/3/8/2.Department of Water Affairs.Prepared by Hydrosol and WRP. September 2010.

The following conclusions were based the results obtained:

- Demands imposed on the Nandoni sub-system increased significantly from the previous study (2005 Operating Analysis Study), which resulted in the over utilising of the resource from 2021 onwards, before allowing any transfers in support of the Middle Letaba sub-system.
- When the possible transfers in support of the Middle Letaba sub-system were included, the

shortages stared to occur in the Nandoni sub-system occurs 3 years earlier in 2018.

- The Nandoni demands that were included in the WRPM analysis were not all current system demands or schemes that are in the process of implementation, as some are only planned possible future schemes. These schemes can be discontinued or stopped to prevent the over allocation of the sub-system.
- The hydrology for the Middle Letaba sub-system is suspect and results from this sub-system should be treated with caution.
- The results from the Middle Letaba sub-system do however confirm that the sub-system is already in deficit, which agrees with the current status quo.
- Yield results from the Middle Letaba sub-system showed that there is an advantage in operating Middle Letaba and Nsami dams as a combined system as it resulted in a 3 million m^3/an increase in the historic firm yield.
- Only the Scenario 3 (10 million m^3/a maximum transfer capacity) was able to support the Middle Letaba sub-system to such an extent that the urban/rural demand (primarily supplied from Nsami Dam with support from Middle Letaba Dam), could be supplied in full from 2012 to 2018, at the 98% assurance. Based on the scenario definition, the transfer scheme started to support the Middle Letaba sub-system from April 2012 onwards. From 2018 onwards the Nandoni sub-system will be over utilised and severe curtailments were therefore, from then onwards imposed on the sub-system. This resulted in a decrease in the transferred volume, so that the Middle Letaba demand could no longer be supplied in full.
- Due to the support from the Nandoni sub-system to the Giyani treatment plant, less support was required from Middle Letaba Dam to the treatment plant. This resulted in an increase in supply to the users only receiving water from Middle Letaba Dam. The improvement in supply was however not sufficient to obtain a fully supply demand at 98% assurance.
- Different operating rules regarding the transfer and support from both Nandoni Dam and Middle Letaba Dam will significantly change the level of supply to users in the Middle Letaba sub-system.

Recommendations from the work carried out include the following:

- The areas planned to be supplied from the Nandoni sub-system including the possible support to Giyani, should be reconsidered as the current planning will result in an over allocation of Nandoni Dam.
- The yield characteristics of the Middle Letaba sub-system should be re-determined when

the updated hydrology for the catchment area becomes available. These yield results could significantly impact on the required capacity of the transfer system as well as on the required transfer volume to fully support the demands in the Middle Letaba sub-system.

- Operating rules governing the transfers and support from Nandoni and Middle Letaba dams respectively need to be optimised to obtain the maximum benefit from the transfers and support, as well as to protect users that can only receive water from Middle Letaba Dam.
- Demand projections in particular those within the Middle Letaba catchment need to be confirmed as soon as the All Town Study (Northern Region) is completed. Improved indications of possible irrigation developments in both sub-systems are required.
- The Nandoni sub-system yield is currently insufficient over the long-term to support the Middle Letaba sub-system. To be able to provide this support in future, a re-planning of the future schemes to be supplied from Nandoni Dam must be done.

2.24 SOCIO-ECONOMIC AND ECOLOGICAL IMPACTS OF WATER RESTRICTIONS IN THE LETABA CATCHMENT (2010)

2.24.1 Overview

The objectives of this study as described as follows:

- Identify sectors as well as activities that are supported by water and investigate how they were affected during periods of water restrictions.
- Compare the situation before, during and after water restrictions in order to draw lessons learnt.
- To investigate the ability of the municipalities to implement water restrictions as well as the impact of those restrictions on the revenues.
- Investigate the economic implications of restrictions in affected industries and communities.
- Determine the impact of water restrictions on the Reserve.
- Establish whether the recommended water restrictions were actually implemented.
- Establish possible changes to how the restrictions were implemented to inform future restriction process.

The Socio-economic and ecological impacts of water restrictions in the Letaba catchment was divided into 2 reports as reviewed in the following sub-sections.

2.24.2 Guideline Document for Incorporating into Socio-Economic Impacts into future Water Restrictions

Report Title:SOCIO-ECONOMIC AND ECOLOGICAL IMPACTS OF WATER RESTRICTIONS IN THE LETABA CATCHMENT:Guideline Document for Incorporating into Socio-Economic Impacts into future Water Restrictions. Report No. P WMA 02/B810/00/1009/06Prepared for: Department of Water Affairs and Forestry.Prepared by TorisoTorso Tlou, December 2009.

This guideline document is intended to be used by any water resource manager to enable developing and implementing drought management plans which incorporate water restrictions to also take into account socio-economic implications of water restrictions.

The guideline was informed by lessons learnt from the ongoing water restrictions plan for the Letaba River Catchment. A socio-economic perspective framework was developed which included:

- the policy for water restrictions
- the institutional arrangements and organisational structure for implementing water restrictions
- the risk evaluation process undertaken to mitigate the water restrictions
- the operational aspects and the drought response to the implementation of water restrictions
- the stakeholder participation of water restrictions implementation

The study reveals that prior to implementation of water restrictions, it is important to contextualise the water restrictions within the existing policy planning framework. The implementation of water restrictions needs to take into account the following upfront aspects:

- Stratification of the production zones
- Socio-economic characteristics of the catchment
- Defining the restrictions management approaches

A summary of the water restriction management issues identified and used in the formulation of the guideline document are:

- **Water restrictions policy framework**: review of the policy framework for development and implementation of water restrictions describing amongst others: principles of water restrictions to avoid, decision process required, etc.
- **Institutional arrangements and organisational structure**: including roles and responsibilities clearly defined to enable the development and implementation of water

restrictions if restrictions are to be effected across all water user sectors. Because of the multiple institutions involved a need for alignment and coordination of efforts is required. The geographic unit for water restrictions needs to be defined followed by a stakeholder system for each unit. A water restrictions management committee should be established where no formal body for the development and implementation of restrictions exist.

- **Socio-economic risk evaluation of water restrictions**: requires compiling and providing the most comprehensive technical approach to drought characterisation and development of indicators of risk, define methods used for risk management, define methods used for evaluation social vulnerability based on indicators (including implications for low income households) in order to minimise the socio-economic impact on the region. The report also contains a summary of the main economic, environmental and social impacts to be considered due to restrictions as well as a proposed framework for incorporating socio-economic and ecological factors for hydrological, economic, and social components in water restrictions.
- **Operation of water restrictions**: identifying both long and short term actions to be implemented to prevent and mitigate drought impacts. Aspects to consider: preparedness and early warning, establishing priorities to be respected during water shortages, thresholds defined by drought indices and indicators (physical and social), defining the actions, and evaluating the process to implement the actions. Operation of water restrictions should include planning for levels of water restrictions, measures to mitigate restrictions, and alignment of water restriction measures. The threshold of restrictions together with action plans would be developed to mitigate the impact of the restrictions.
- **Public involvement**: to be incorporated from the onset in the development and implementation phases. A framework for stakeholder involvement should be developed to ensure effective implementation of water restrictions. Lastly a periodic review of the plan by institutions and stakeholders is strongly advisable as situations change and plans needs to be adapted accordingly. In depth revision of a drought management plan is needed after each drought episode, as well as analysing response to the plan, and enabling elements to adapt and improve the plan.
- **Information management**: here the study notes that it is relevant to understand that the actual percentage reduction on actual irrigation water use may be far less than the current percentage reduction based on entitlements as many irrigators use less than the entitlement because of improvements in irrigation efficiency and irrigation management practices, etc.

The recommended water restrictions planning framework is as follows:

Organisational component • Institutional and legislative framework • Organisational structure • Administrative systems • Governance and coordination arrangements	Socio-economic and ecological component: • Drought characterisation • Risk assessment: socio-economic impacts • Indicators of risk: catchment specific
Operational component • Preparedness and early warning triggers • Established priorities • Threshold of restrictions • Actions (WC/WDM resource options, etc.)	Stakeholder involvement component • Protocol for engaging with stakeholders • Information dissemination • Period reviews of restrictions

Each of the above are detailed upon in the report.

2.24.3 Inception Report

Report Title:SOCIO-ECONOMIC AND ECOLOGICAL IMPACTS OF WATER RESTRICTIONS IN THE LETABA CATCHMENT:Inception Report. Report No. P WMA 02/B810/00/1009/01Prepared for: Department of Water Affairs and Forestry.Prepared by Toriso Tlou, December 2009.

The inception report serves to record additions, variations or clarifications to the approach and methodology of the tasks and activities presented in the Water for Africa (Pty) Ltd Technical and Financial Proposals that had become necessary after review of the available information and initial meeting with the Client. The inception report provided the baseline of the work plan including the updated approach that was used in the determination of the socio-economic and ecological impact of water restrictions in the Letaba River Catchment

It is mentioned that the objectives of the study as described in the ToR are as follows:

- Identify sectors as well as activities that are supported by water and investigate how they were affected during periods of water restrictions.

- Compare the situation before, during and after water restrictions in order to draw lessons learnt.
- To investigate the ability of the municipalities to implement water restrictions as well as the impact of those restrictions on the revenues.
- Investigate the economic implications of restrictions in affected industries and communities.
- Determine the impact of water restrictions on the Reserve.
- Establish whether the recommended water restrictions were actually implemented.
- Establish possible changes to how the restrictions were implemented to inform future restriction process.

2.25 THE DEVELOPMENTOF A COMPREHENSIVE WC/WDM STRATEGIC BUSINESS PLAN FOR THE LIMPOPO WMA(2010)

2.25.1 Overview

The purpose of the report was to carry out an assessment of the water situation in the Limpopo Water Management Area and to determine the potential for Water Conservation/Water Demand Management among the water users in the primary drainage area and come up with recommendations for the way forward to ensure effective and efficient utilisation of the available water supplies in the water management area.The development of a comprehensive WC/WDM strategic business plan for the Limpopo WMA has one report as reviewed in the following sub-section.

2.25.2 Limpopo Water Management Area: Development of a Comprehensive WC/WDM Strategy and Business Plan

Report Title (Draft):THE DEVELOPMENT OF A COMPREHENSIVE WATER CONSERVATION AND WATER DEMAND MANAGEMENT STRATEGIC BUSINESS PLAN FOR THE LIMPOPO WATER MANAGEMENT AREA. Reference Number WP 9939. Department of Water Affairs, Directorate: Water Use Efficiency. Prepared by Ndlunkhulu Engineering CC. March 2010.

<u>Agriculture Water Use Sector Assessment</u>

The primary objective of the study was to conduct a desktop review and assessment of mainly irrigation water use while forestry was also given some consideration. The results were summarised as follows:

- The current water situation in the Limpopo WMA is such that the water demand exceeds the supply while water resources are fully developed. Since irrigation is the largest water user, the primary objective of the study was to determine areas where losses exist quantify the magnitude and develop WC/WDM options for implementation.

- Irrigation information was found to be very poor in the Limpopo WMA which posed a major limitation on performing a water balance. Alternative methods were developed under existing data constraints and it is important to note that the discussions and findings of this study were based on these alternative methods.
- Applying water balance methods in quaternary catchment B81C showed that about 1.648 million m^3/a is lost through irrigation. The method used could not be used to identify the exact location of the losses but rather served to quantify the magnitude of the losses at quaternary level.
- Dam evaporation losses were estimated in order to get an indication of the amount of water lost through evaporation.
- Due to the inadequacy of the data, on farm irrigation water losses were estimated at quaternary level.
- The highest irrigation efficiency was found to be 92 % while the lowest was 62%. From a statistical analysis it was found that 27% of the irrigators fell outside the normal distribution while 73% of the farmers formed part of the normal distribution i.e. 27% of the farmers had a potential to improve and recover some savings.
- The benchmark value that all the farmers were expected to achieve was calculated to be 80%. The amount of water that could be saved if the all the farmers reach the 80% efficiency was found to be 10.752 million m^3/a.
- In the absence of adequate canal information, statistical analysis was applied to data from other parts of the world including S.A. The computation showed that lined canals have an average loss of 26% while they can be as high as 55%. Efficiency levels in earthen canals are highly variable, depending mainly on the soil type and length of the canal. For example a short (200m) clay canal has 90% efficiency while a long (2000m) sandy canal has a 60% efficiency.
- Installing water meters and maintaining accurate records is essential in the Limpopo WMA.
- Accurate dam release information also needs to be kept in the WMA, which would enhance future timing and management of releases as opposed to releasing water 24 hours a day regardless of whether farmers need to irrigate or not.
- A verification study of the WARMS database is essential as some farmers registered

volumes that were inconsistent with their use prior to the enactment of the new NWA. Since new farmers have emerged the registered volumes will be higher than the catchment can yield under normal circumstances. The water metres coupled with an improved database would also improve the water charging system.

- The institutional set up also needs to be improved and strengthened in the WMA.
- An association would be better positioned to deal with illegal abstraction if a functional tribunal body exists as seen in the Limpopo WUA. A strong institutional setup would also help to improve the maintenance of the canals as a sense of responsibility is instilled in a functional structure.
- The process of benchmarking needs to be explored as this information would help farmers improve their irrigation methods and farming methods in general.
- As far as forestry is concerned, the impact is negligible in the WMA since it covers a limited area.

The recommendations were:

- Information is currently very poor and it is thus difficult to determine losses accurately. Installing water meters remains the highest priority as far as water management is concerned as all problems point to the unavailability of water use information. The water meters would also provide the users with important information from which they can improve their efficiency.
- DWA also need a sound information management system (IMS) to capture data from the meters. The IMS should be real time and should provide the irrigators with information regarding the water currently available in the system, with probabilities of rainfall events in coming days.
- Extension and training is also needed to help irrigators identify ways to use less water.
- In this study the priority areas in terms of inefficiency were identified (quaternaries were listed). The recommendations were therefore that DWA sends out a team to prioritise these areas as a starting point.
- The institutional arrangement needs to be strengthened in the WMA so as to ensure that water losses at any point in the system can be linked to the person/organisation concerned.

<u>Industry, Mining & Power Generation Sector Assessment</u>

<u>Limpopo SAB: Polokwane Brewery</u>

The brewery was found to be an efficient water user operating at water intensity levels of 4.2 – 4.5

hl/hl since 2005, which is close to the lower end of global benchmarks (4-8hl/hl), but higher that best practice which is < 3 hl/hl. The achievement of best practice would yield annual savings of approximately 101 400 m^3. This is not a large amount of water, and it is thus clear that the brewery is an efficient water user. Some opportunities were identified for the brewery to conserve water and consisted mainly of operational improvements, with only one option, that of vapour recompression, requiring capital investment. The operational improvements were listed and it was recommended that that each of the opportunities, some of which are already being investigated by the brewery, be more fully developed and implemented where feasible.

Limpopo Coca Cola: Fortune

Based on the initial desktop assessment of absolute water use and water intensity data, the Coca Cola Fortune (Polokwane) site was identified as a place for further investigations. The site reports a water intensity of 2.24 litres of water per litre of product produced in 2008. This performance is better than the average reported by both local and international Coca Cola bottling plants. The introduction of Polyethylene Tetra phthalate (PET) bottle has improved the overall water use performance as the need to use a bottle washer on these production lines has been eliminated.

Improved water metering on the site (improved calibration of current metres and additional metres for sub-systems such as the cooling system and administration buildings) is important for an improved and sustained water conservation programme. Other opportunities identified for future assessment include:

- Clean-in-place Equipment and Vessel Cleaning
- Implementing grey water recycling and water efficient devices

It was recommended that DWA should monitor the sites progress with its metering improvement plan and to ensure that the commitments made in respect of its water conservation plans are met.

Exxaro Grootgeluk Mine

No water sourced form study area and hence not reviewed.

Eskom Matimba Power Station

No water sourced form study area and hence not reviewed.

2.26 THE DEVELOPMENT OF A COMPREHENSIVE WC/WDM STRATEGIC BUSINESS PLAN FOR THE LUVUVHU/LETABA WMA (2010)

2.26.1 Overview

The purpose of the report was to carry out an assessment of the water situation in the Luvuvhu-Letaba Water Management Area and to determine the potential for WC/WDM among the water users in the primary drainage area and come up with recommendations for the way forward to ensure effective and efficient utilisation of the available water supplies in the water management area.

The objectives of the Water Conservation and Water Demand Management (WC/WDM) Strategy for the Luvuvhu-Letaba Water Management Area were to determine the following:

- The amount of water that is being used by the various water use sectors in the Luvuvhu-Letaba WMA.
- The amount water that is lost (and is not productively used).
- Where exactly is the water lost.
- Why the water is lost, and what WC/WDM options could be introduced to reduce the losses
- What WC/WDM must be designed and put in place to offer the most cost effective water savings.

The development of a comprehensive WC/WDM strategic business plan for the Luvuvhu/Letaba WMA has one report as reviewed in the following section.

2.26.2 Luvuvhu-Letaba Water Management Area: Development of a Comprehensive WC/WDM Strategy and Business Plan

Report Title (Draft):THE DEVELOPMENT OF A COMPREHENSIVE WATER CONSERVATION AND WATER DEMAND MANAGEMENT STRATEGIC BUSINESS PLAN FOR THE LUVUVHU-LETABA WATER MANAGEMENT AREA. Reference Number WP 9939. Department of Water Affairs, Directorate: Water Use Efficiency. Prepared by Ndlunkhulu Engineering CC. March 2010.

<u>Agriculture Water Use Sector Assessment</u>

- The current water situation in the Luvuvhu/Letaba WMA is such that the water demand exceeds the supply while water resources are fully developed. Since irrigation is the largest water user, the primary objective of the study was to determine areas where losses exist quantify the magnitude and develop WC/WDM options for implementation.

- Irrigation information was found to be very poor in the Luvuvhu/Letaba WMA which posed a major limitation on performing a water balance. Alternative methods were developed under existing data constraints and it is important to note that the discussions and findings of this study were based on these alternative methods.
- Applying water balance methods in quaternary catchment B81C showed that about 1.648 million m^3/a is lost through irrigation. The method used could not be used to identify the exact location of the losses but rather served to quantify the magnitude of the losses at quaternary level.
- Dam evaporation losses were estimated in order to get an indication of the amount of water lost through evaporation.
- Due to the inadequacy of the data, on farm irrigation water losses were estimated at quaternary level.
- The highest irrigation efficiency was found to be 92 % while the lowest was 65%. From a statistical analysis it was found that 27% of the irrigators fell outside the normal distribution while 73% of the farmers formed part of the normal distribution i.e. 27% of the farmers had a potential to improve and recover some savings.
- The benchmark value that all the farmers were expected to achieve was calculated to be 82%. The amount of water that could be saved if the all the farmers reach the 82% efficiency was found to be 10.296 million m^3/a.
- In the absence of adequate canal information, statistical analysis was applied to data from other parts of the world including S.A. The computation showed that lined canals have an average loss of 26% while they can be as high as 55%. Efficiency levels in earthen canals are highly variable, depending mainly on the soil type and length of the canal. For example a short (200m) clay canal has 90% efficiency while a long (2000m) sandy canal has a 60% efficiency.
- Installing water meters and maintaining accurate records is essential in the Luvuvhu/Letaba WMA.
- Accurate dam release information also needs to be kept in the WMA, which would enhance future timing and management of releases as opposed to releasing water 24 hours a day regardless of whether farmers need to irrigate or not.
- A verification study of the WARMS database is essential as some farmers registered volumes that were inconsistent with their use prior to the enactment of the new NWA. Since new farmers have emerged the registered volumes will be higher than the catchment can

yield under normal circumstances. The water metres coupled with an improved database would also improve the water charging system.

- The institutional set up also needs to be improved and strengthened in the WMA.
- An association would be better positioned to deal with illegal abstraction if a functional tribunal body exists as seen in the Luvuvhu/Letaba WMA. A strong institutional setup would also help to improve the maintenance of the canals as a sense of responsibility is instilled in a functional structure.
- The process of benchmarking needs to be explored as this information would help farmers improve their irrigation methods and farming methods in general.
- In the Luvuvhu/Letaba WMA, although Forestry is one of the major users, it is highly unlikely that changing the land use would have a significant impact on water availability as the upper reaches where forestry exists is already controlled by dams. The natural vegetation in the area is also a significant water user hence replacing forestry with natural vegetation may not have significant positive effects.

The recommendations were:

- Information is currently very poor and it is thus difficult to determine losses accurately. Installing water meters remains the highest priority as far as water management is concerned as all problems point to the unavailability of water use information. The water meters would also provide the users with important information from which they can improve their efficiency.
- DWA also needs a sound information management system (IMS) to capture data from the meters. The IMS should be real time and should provide the irrigators with information regarding the water currently available in the system, with probabilities of rainfall events in coming days.
- Extension and training is also needed to help irrigators identify ways to use less water. Also DWA needs to look at charging (water use) based on actual use thereby incentivising users to become more efficient.
- In this study the priority areas in terms of inefficiency were identified (quaternaries were listed). The recommendations were therefore that DWA sends out a team to prioritise these areas as a starting point. The areas that are of highest priority are quaternary catchments A92A, A92C, B82F and B82J, B81H and B81J also indicated a large potential for saving.
- The institutional arrangement needs to be strengthened in the WMA so as to ensure that water losses at any point in the system can be linked to the person/organisation concerned.

Domestic Water Use Sector Assessment

Service and Operational Objectives

Any strategy for the future should be developed with a view to the achievement of a clear set of objectives and the following objectives were suggested.

- A continuous supply of water should be provided at 98% assurance on a 24 hour 265 hay per year basis on a 'full service' and basic service basis depending on the socio-economy of the area.
- Short-term interruptions due to system failure (e.g. main bursts, pump failure) should not exceed 24 hours.
- The quality of water supplied should comply with SABS 241 at all times.
- The minimum pressure provided as measured in the water mains should not be less than 5 m of head of water at peak hour peak day demand. Under fire flow conditions for the town of Giyani, the pressure should not fall below 6 m of head of water, whilst concurrently delivering the annual average demand.
- The investment and operating costs of the infrastructure should be optimised on the basis of an integrated resource planning approach (least cost planning).
- The water services authority should have full and substantially correct records of the infrastructure assets and should keep these up to date as necessary, including operational performance records of flows and demands and other system performance indicators.
- These records should be kept in order to be able to respond promptly and effectively to enquiries from consumers and third parties and for the propose of cost effective asset management planning.

Security and Continuity of Supply (of Satisfactory Water Quality)

- In the Middle Letaba and Giyani Water Supply Schemes, the existing margin of reliable supply over peak day demands was found to be way below the service target at 4% if it is assumed that the service level target is 4% above the average daily demand. This was based on best practices which required 4%. This was predicted to regress over a period of the planning horizon if there is no action taken.
- The Middle Letaba and Giyani Water Supply Schemes do not provide continuous supply to the communities with most areas relying on alternative resources of supply namely local groundwater. The effectiveness of the local groundwater source was not determined and compared with the water supply from the Middle Letaba Dam. As a result of the sunken

cost of the existing water supply scheme, the marginal cost of providing water through water demand management is likely to be much lower than was indicated in the report.

- Providing additional water supplies from an alternative source would likely increase the wastewater treatment costs to the local municipalities which will be transferred to the consumers through waste discharge charges.

<u>Water Pressure</u>

- The villages were mostly found not to be provided with satisfactory pressure to consumers.

<u>Water Conservation and Demand Management Summary</u>

- Passive leakage control may be practiced but no active leakage control was found to be practised and as a result relatively high leakage levels were found in the Middle Letaba and Giyani Water Supply Scheme. The ILI, although only providing the extent of system losses, indicated that there are significant water losses in all the subsystems. The absence of district metering is an inhibitory factor; although it is nevertheless quite possible to practice active leakage up to a certain level without such meters.
- With very limited cost recovery, consumer demand management has been limited. There are no education and awareness campaign programmes in the supply area to change the culture of inefficient utilisation of the limited water supplies in the catchment.
- A significant amount of illegal connections were found on the bulk supply mains, which is affecting the hydraulic operation of the scheme in that other areas do not receive water as a result of these connections.

<u>Metering</u>

- System metering needs renewal and/or augmentation in the Middle Letaba Scheme. The Middle Letaba WTW and Giyani WTW both have modern systems on telemetry (except district meters), but both were found not to be operational.
- No management programme was found to be in place for consumer meters resulting in old meter stock which is aging further and they are therefore bound to be inaccurate and probably a source of a significant loss of income. This is a common fault in the South African municipalities where these meters are under the control of the finance department. It is also difficult to retrieve data for operational management purposes since the information system was not designed with technical needs in mind.

<u>Asset and Operational Records</u>

- It was found that there had not been an effort to check and update the water main records and put them onto a CAD system and the quality of the records are poor with unknown inaccuracies and omissions.

- Operational records in the form of readily useable historical flow data, failures, defects, etc. were also found to be of a poor standard.
- This information shortfall is not incompatible with the largely re-active operating methodology, focussing on emergency repairs rather than planned maintenance and asset management programmes.

Staffing and Resources

- The staffing levels and structures varied between the Middle Letaba and Giyani Water Supply Schemes for historical reasons, with numbers being particularly low relative to the size of the system. The WC/WDM pro-active approach and the need for new operational tasks to be performed provide an opportunity to rationalise and provide a common support centre for some activities.

Recommendations for the Short Term Intervention Measures

The following short term intervention measures should be given special attention in the Middle Letaba and Giyani Water Supply Scheme:

1. Up to date and a reasonably accurate set of water mains and primary component records and procedures for regular updating should be established.
2. Service levels should be established that will ensure a continuous supply to consumers of the Middle Letaba and Giyani Water Supply Scheme and delivery targets should be set.
3. Consumer awareness and an education campaign programme in WC/WDM should be established.
4. Unauthorised connections to bulk water supply pipelines should be identified and removed.
5. System metering and the establishment of a zone and district meter area for sectorisation of the reticulation network in areas such as Giyani Town should take place.
6. Reduction of consumer demand due to plumbing leaks in the Middle Letaba and Giyani Water Supply Schemes.
7. Reduction in infrastructure leakage should take place.
8. Other information systems should be improved, especially the consumer meter databases which should provide a common source for technical and financial departments that meets both of their needs.

9. A consumer meter management systems should be established based on sound technical and financial principles (i.e. optimal metering) should be established in order to minimise inaccuracy and maximise cost recovery and implement free basic water.

A strategic WC/WDM plan for both the individual Middle Letaba Water Supply Scheme and Giyani Water Supply Scheme was also documented in the report.

2.27 CURRENT STUDY: DEVELOPMENT OF RECONCILIATION STRATEGIES FOR ALL TOWNS IN THE NORTHERN REGION (ON GOING)

2.27.1 Reconcilation Strategy Reports

Not all the reconciliation strategies had been completed at the time of the literature review. The strategies for towns that had been completed have been received and the study team has assisted with updating some of these.

2.28 CURRENT STUDY: ESTABLISHMENT OF DROUGHT OPERATING RULES FOR STAND ALONE DAMS AND SCHEMES TYPICAL OF RURAL/SMALL MUNICIPAL WATER SUPPLY SCHEME (NORTHERN REGION) (ON GOING)

2.28.1.1 **Reports**

This study is in the process of being undertaken and the study team has contacted the team members undertaking the study with the aim of sourcing information that is available to date. Draft reports form some of the dams are available and have been requested. Ongoing liaising will take place with the various studies in order to insure that relevant information is sourced and incorporated into the reconciliation strategy.

2.29 CURRENT STUDY: VALIDATION AND VERIFICATION OF WATER USE IN THE LUVUVHU-LETABA WMA (ONGOING)

2.29.1 Reports

Documents on this study are not available and final report was issued for this project. Doris was trying to get a VO approved for the PSP to continue with the project, this was in the end not approved and DWA has recently issued a Tender for the completion on the process in this area. The result was a rather abrupt end to the project and the normal close out activities were not followed.

Data captured in the data base prepared by this study includes the following:

1. Properties – spatial data of the cadastral data for the WMA.
2. Forestry – spatial data of all forestry extents as identified from Remote Sensing from 2007.
3. Dams – spatial data of all dams identified from Remote Sensing from 2007. The attribute table includes an estimated Capacity in m3. Note this is a derived value based on area/capacity relationships.
4. Fields_2007 – all delineated irrigated fields identified from Remote Sensing from 2007. A crop classification and irrigation system has been identified from various inputs.
5. Damdetail – a table that resulted from survey interactions with users, this therefore contains a better level of information on those properties that were to be validated and verified. Where there is a DAM_ID1 populated these can be related to the spatial data through the property reference and the RECNO value for each dam.
6. Forestry – a table that contains results from survey interactions, therefore a better level of detail on the properties to be validated and verified – areas, specie and resource are detailed per property.
7. Irrigation – a table containing detail on the fields form user survey for those properties to be validated and verified. The UNI_FLD where populated can be used to link to the spatial data of the fields. Where not populated the data is assigned per property and not per field.
8. Non-irrigation – a table of urban/industrial use, linked to the properties through the property reference.

No information on point locations of abstraction or return flows are available from the data base.

No ground trothing was done as part of the study, which is very concerning.

The total number fields that was detected is 35 900 of which the water resource is only indicated for 17 000 field. Of these 17 000 field 200 is indicated as unknown source, 525 as mixed sources, 4 858 as boreholes and 11 417 from surface water. .

Results seem suspect as there are clearly in some areas shown as irrigation which is not irrigation. This means that this validated data will need some sort of screening or further validation before it can be used.

3 SYNTHESIS OF AVAILABLE INFORMATION

3.1 APPROACH

Chapter 2 of the report summarises a wealth of information relating to the water resource and supply systems of the Luvuvhu and Letaba WMA. The documentation reviewed covers a wide range of aspects that make up the components required for integrated water resource management and form a solid knowledge base for the development of the water supply reconciliation strategy.

The summaries given in **Chapter 2** were given by study and for individual reports and has to be interpreted and assessed to form a synthesised view of the current status of integrated water resource management and identify the themes or topics that need to be covered in the reconciliation strategy.

This chapter provides a synthesis of the information reviewed as well as the knowledge obtained from numerous discussions and interactions with the stakeholders in the study area.

The chapter is structured according to sub-areas, Luvuvhu main catchment, Mutale, Shingwedzi, Groot Letaba, Little and Middle Letaba area.

For each of the five sub-areas a description is provided in accordance with the following topics (sub-sections):

- Brief description of the water resource and supply situation.
- Pertinent water resource management issues.
- Identified intervention measures.
- Perspective on water resource management of the focus areas.

It should be noted that the water resource management synthesis given in this chapter are based on the view of the information at hand and aims to guide the formulation of the strategy and the associated technical tasks. The perspective indicated here will be scrutinised during the course of the study and will be amended, changed or can even be discarded in the final strategy documentation.

3.2 LUVUVHU MAIN CATCHMENT AREA

A number of studies have been undertaken for this area, whose summary have been used in this chapter. The studies are reviewed in chapter 2, in particular the water resource planning of the Luvuvhu River basin, Luvuvhu River dam feasibility, Luvuvhu Government water scheme, Luvuvhu/Letaba water resource situation assessment, National water resource strategy, Internal strategic perspective and Luvuvhu River system annual operating analysis study as documented in 2.1, 2.7, 2.10, 2.13, 2.14, 2.15 and 2.16 respectively.

3.2.1 Description of the water resource and supply situation

The Luvuvhu River Catchment is located in the north-eastern corner of South Africa. It rises near to Louis Trichardt and flows in a north-easterly direction to its junction with the Limpopo River near to Pafuri. The catchment area is approximately 3 568 km^2.The catchment shape is very elongated: the longest channel is some 250 km long; the catchment width varies between 8 km and 35 km. The Luvuvhu River is the main river in the catchment,and is a tributary of the Limpopo River, which is an international water course shared by South Africa, Botswana, Zimbabwe and Mozambique. The Luvuvhu River transverses the northern section of the Kruger National Park, where the Luvuvhu (Lanner) Gorge and the Pafuri floodplain are prominent features.

Water use by afforestation, irrigation and for domestic use to supply the large population in the Luvuvhu River catchment with water as well as the construction of large dams in the catchment has an adverse effect on the flow in the Luvuvhu River, particularly in the Kruger National Park. Intensive studies were performed under the supervision of DWA in close liaison with other affected authorities and organisations, and it was found that in combination with the existing infrastructure, a project consisting of the Nandoni Dam and Xikundu Weir on the Luvuvhu River will provide the most comprehensive solution to the widest range of water shortages in the Luvuvhu River Catchment. The new Nandoni Dam and Xikundu Weir together with the existing Albasini, Vondo, Phiphidi and Tshakhuma dams and the associated bulk purified water supply infrastructure are known as the Luvuvhu River Government Water Scheme. Nandoni Dam started to store water during 2002/03 and was able to augment the flow in the river from the winter of 2003. This scheme is managed as an integrated system to supply water for domestic/industrial, irrigation and for the ecological component of the reserve. Damani, Mambedi and Frank Ravelle dams are also part of the Luvuvhu River System, but are used to supply local water requirements and are therefore managed independently. Mambedi Dam was severely damaged during a flood event and is no longer in use.

The Xikundu / Malamulele system consists of three weirs and respective water works, these are the Mhinga Weir and Treatment Works, Malamulele Weir and Treatment Works and Xikundu Weir and Treatment Works. The system covers the Nzanwe, Duvhuledza, Tshaulu and Mhinga service areas under the Xikundu sub-system, and Mhinga Pipeline, Ntlaveni Pipeline and Fumani Pipeline service areas under the Malamulele Sub System.

The Damani water supply area is rural and abuts the Vondo Rural and Thohoyandou/Vuwani

Service areas of the Nandoni System. The Nandoni system includes the Thohoyandou, Vondo Rural, Malamulele West, Vuwani and Makhado Sub-systems, which serve the following areas:

- Malamulele West;
- Thohoyandou and Vuwani;
- Vondo Rural;
- Tshakhuma RWS;
- Valdeiza GWS;
- Makhado, including the Air Force Base;
- Sinthumule Kutama RWS;
- Tshitale RWS; and
- Northern Regions of the Middle Letaba RWS – Elim and Waterval

There is also a relatively large groundwater resource in this catchment. Large scale utilization of the groundwater resource occurs mostly downstream of the Albasini Dam where it is used by irrigators and in the vicinity of Thohoyandou where it is used to supply rural communities.

3.2.2 Pertinent water resource management issues

The 1990 Water Resources Planning of the Luvuvhu River Basin Study gave the following recommendations in terms of hydrology:

- Future hydrological studies will require more rainfall data and it was recommended that new rainfall stations be established more extensively than at present in the central and lower parts of the basin.
- There were only 3 evaporation stations in the basin, located close together in the upper basin. Further evaporation stations should be established, particularly in the central and lower basin areas.
- The records of the used observed streamflow stations proved to be sufficiently reliable to use for calibration purposes. These monitor predominantly forested, high rainfall mountain catchments. There were no reliable records for the dryer portions of the catchment. Other measuring stations should be established on the Luvuvhu River:
    - On the Luvuvhu and Mutshindudi rivers immediately upstream of their joint confluence
    - Between the Luvuvhu/Mutale confluence and the Luvuvhu floodplain.
- A detailed investigation of the small dams in the catchment and the monitoring of water abstractions from these dams were recommended.
- Monitoring of water use for irrigation was also recommended for the improvement of future

hydrological estimates.

- Some of the stream flow gauges should be automated and the capacities of the weirs should be improved. Albasini and Vondo dam monitoring should be improved.

Based on the Luvuvhu River System Annual Operating Analysis study, the following water resource management issues were raised:

- For the Albasini sub-system users to be supplied at their required assurances, the total demand allocated to the system needs to be reduced. This has partially been done through the support provided to Makhado from Nandoni Dam. However, further reduction in demand is required and the possibility of reducing the excessive canal losses and the reduction of the total allocation should be investigated.
- Area capacity characteristics should be obtained for Phiphidi, Tshakhuma and Damani Dams and the WRYM and WRPM data files should be updated accordingly. The yield available from Phiphidi Dam needs to be determined.
- The irrigation data in the system data files should be updated as soon as the results of the verification and validation process of the registered water use data are available.
- The total Thohoyandou demand that can be supplied from Nandoni Dam needs to be included in the system models, as it seems that it is more than only 50% of the current R5 & R7 supply areas. The long-term average capacity of the pipeline from the Nandoni WTW to Thohoyandou should probably be used for this purpose, but needs to be confirmed.
- The current water use from the Malamulele, Xikundu and Tshakhuma WTW's exceed the projected demands and should be investigated and confirmed. Actions plans need to be defined to either reduce the demands to what it should be or to adjust projected demands when necessary.
- The Nandoni Sub-system should be operated in order to maximise the utilisation of the incremental inflow between Nandoni Dam and Mhinga Weir.
- It is important to keep in touch with the development plans with regards to the re-development of the existing tea plantations to be able to update the system models accordingly.
- Further work needs to be done on the EWRs as current EWR's were determined with outdated methodologies and there is a low confidence in the existing IFR figures for Site 3. Recent desktop estimates also provided much higher requirements which resulted in unrealistic reductions in the Nandoni sub-system yield. This should be done at a detailed level due to the sensitivity of the Kruger National Park (KNP). The 2004 Internal Strategic Perspective: Luvuvhu/Letaba Water Management Area recommended that a comprehensive Reserve determination study, which also considers the requirements of the Pafuri flood plain, be conducted.
- Although the yield results indicated that the Nandoni Sub-system has surplus yield available in the system, additional demand centres should be added with caution as the final EWRs (Reserve) will probably require more water than the "White Paper IFRs" currently used in the models. In addition, there is also the observed use at Malamulele, Xikundu and Tshakhuma which is significantly higher than the projected values.

- The new operating rules should be implemented as soon as possible, which will require some training of DWA personnel as well as the proper monitoring of selected observation points. Operating analyses need to be carried out on an annual basis.
- Improved estimates of the losses between Nandoni and Mhinga Weir need to be made once observed data of releases from Nandoni, abstractions between Nandoni and Mhinga Weir, as well as observed flows at Mhinga Weir are available.
- Representatives of the different stakeholders need to be appointed to be part of the System Operation Implementation Committee (SOIC). This committee will be part and be informed on the results, updates and required input data for the annual operating analysis carried out around the 1st of April each year.

The Development of a Comprehensive WC/WDM Strategic Business Plan for the Limpopo WMA and the Luvuvhu/Letaba WMA Development of a Comprehensive WC/WDM Strategy stated that the water use information in the catchment is poor, that water meters should be installed as a high priority and that a sound information management system (IMS) is required to capture the data from the meters. The IMS should be real time and should provide the irrigators with information regarding the water currently available in the system, with probabilities of rainfall events in coming days. Extension and training is also needed to help irrigators identify ways to use less water. The priority areas in terms of inefficiency were identified in the study (quaternaries were listed) and it was recommended that DWA should prioritise these areas as a starting point.

3.2.3 Identified intervention measures

Development Possibilities

The 1990 Water Resources Planning of the Luvuvhu River Basin Study identified 19 undeveloped dam sites for investigation. The sites were investigated and observations on the geology and available construction materials were made. No soil sampling and testing were done and no surveys were done. With the information gained, a preliminary assessment was made of the possible type and size of dam that could be built at each site and a cost estimate was done. A first approximation to the hydrology of each site was determined. Three types of dams were considered for each site (Earthfill/rockfill embankment, mass gravity concrete or rollcrete dam, Composite structure comprising a mass gravity concrete/rollcrete overflow section with earthfill/rockfill embankments on the flanks). Material volumes were calculated and preliminary cost estimates and unit reference values prepared.

The **Vondo Dam (raising), Mashawane (Mutoti) Dam, Paswane Dam** and **Xikundu Dam** were identified as the key large dam sites in the central basin with good potential and the **Upper Mbwedi** and **Mid-Dzindi Dams** were identified as smaller dams with good potential. The Mashawane dam site had a relatively low unit water cost and is only 16 km away from Thohoyandou. The dam site is strategically placed to supplement water supplies to the Vondo Scheme (supplying Thohoyandou and surrounding areas and irrigation water to the Shivase Tea Estate) and to Louis Trichardt. A recommendation was made that feasibility studies should be carried out for the proposed large dam sites in the central basin.

The Pre-Feasibility Phase of the Luvuvhu River Dam Feasibility Study indicated that the viability of developing major dams on the proposed **Mutoti Dam Site (later renamed to Nandoni Dam)** on the Luvuvhu River and at the **Latonyanda Dam Site** on the Lotanyanda River should be evaluated at feasibility level.

The 1997 Luvuvhu River Dam Feasibility Study investigated both the Mutoti Dam (renamed to Nandoni) as well as the **Latonyanda Dam** on the Latonyanda River, intended to augment water supplies to Louis Trichard. The Latonyanda Dam proved to not be economically viable and a recommendation was made to construct the **Nandoni Dam,** which was constructed and completed in 2004 as well as the Xikundu Weir downstream.

Transfers from the Area

Current and potential transfers out of the sub-catchment include the following:

- The existing 2.4 mcm/a from Albasini Dam to Louis Trichardt and an additional 5 million m^3/a from either Albasini or Nandoni for possible transfer to Louis Trichardt.
- A possible transfer of 10.0 million m^3/a support to the Klein Letaba – Middle Letaba sub-catchment
- Possible transfer to the Shingwedzi sub-catchment for rural water supply.

Investigation of Over-exploitation of the Groundwater Resource

The 2003 "Luvuvhu and Letaba WMA Overview of Water Resources Availability and Utilisation Study" recommended that possible over exploitation of groundwater around Thohoyandou and downstream of Albasini Dam as well as interdependencies between surface and groundwaterneeds to be investigated and that water from Nandoni Dam should be used for areas where there is over-use of groundwater.

3.2.4 Perspective on water resource management

In general it is recommended that no further irrigation development or other water abstraction scheme should occur in the Luvuvhu Basin without the provision of new storage facilities, as the run - of- river supply has been exploited to the limit and any further attempts to abstract more water from run -of - river supply will prevent existing downstream users (including the Kruger National Park) from receiving their water requirements.

A detailed system analysis of the Albasini Dam should be carried out, which will require a detailed survey of the existing irrigation and small farm dams as this level of detail is currently not available. A detailed analysis is also required to accurately determine the available yield from the resource. In the short term, there is surplus available in the Luvuvhu system following the completion of the Nandoni Dam and allocations can be made for domestic water use and to revitalize the irrigation scheme downstream of the Nandoni Dam. In the medium term, however, the water resources situation of the Luvuvhu needs to be understood better. This must include the groundwater/surface water inter-dependency and a comprehensive Reserve determination.

The following need to be determined:

- The actual water allocations and usage in the whole subarea.

- The water demand projections of the Luvuvhu catchment to ensure that an over allocation of the resources does not occur.
- A comprehensive Reserve determination for the whole catchment. This must be integrated into a water resources model to determine the impacts and subjected to stakeholder participation.
- A detailed water resources study of the whole catchment with special attention given to groundwater use, groundwater/surface water interaction and the impact of the ecological Reserve.
- Invasive Alien Plants infestation must be investigated in more detail to understand its impact and implement a program to remove the alien vegetation in the catchment.
- The complex system of water supply from both surface and groundwater sources downstream of Albasini Dam, including the interdependence between surface water and groundwater.
- The effect of upstream developments and groundwater abstraction on the Albasini Dam yield.

3.3 MUTALE RIVER CATCHMENT AREA

A number of studies have been undertaken for this area, and is summariesed in this chapter. These studies are reviewed in chapter 2, in particular the National water resource strategy, Internal strategic perspective and the development of a comprehensive WC/WDM strategic business plan as documented in 2.14, 2.15 and 2.25 respectively.

3.3.1 Description of the water resource and supply situation

The total natural MAR of the Mutale River catchment is about 164 million m^3/a. The catchment is mostly semi-arid, with the majority of the runoff originating in the south western, wetter part of the catchment. More than 80% of the MAR originates from less than 40% of the catchment area.

There is a lack of adequately recorded flow data. Only two flow gauging stations exist, of which one has a very short record period. The confidence of the simulated estimates of streamflow is therefore reduced.

The flow in the Mutale River is partly regulated by Lake Funduzi (about 20 million m^3 of active storage) in the upper reaches of the river. The water from the Mukumbani Dam in the upper reaches of the Tshirovha River is exported to the Mukumbani Tea Estate. The 1998 developments and water uses from the rivers have reduced the natural MAR of the Mutale River by about 11.3% to 146 million m^3.

The groundwater harvest potential of the Mutale River catchment was estimated to be 13 million m^3/a and the sustainable exploitability was estimated to be about 50% of the harvest potential or

6.5 million m^3/a.

The available surface water quality test results are limited in their spacial and temporal distribution. The surface water appears to be of reasonable quality and has not been polluted to any great extent by the present developments upstream of and in the immediate vicinity of the monitoring sites. The water quality is better upstream than further downstream of Tshikondeni. The heavy metal content of the water at Tshikondeni Coal Mine seems to indicate that some pollution has occurred further downstream at Tshikondeni.

With regards to groundwater quality, the following is of concern when groundwater is intended for human consumption:

- Total dissolved solids are at unacceptable levels in the northern part of the study area up to the Limpopo River.
- Fluoride is at unacceptable levels in the northern part of the study area up to the Limpopo River.
- Nitrate is at unacceptable levels in the extreme northern part of the study area along the Limpopo River.

3.3.2 Pertinent water resource management issues

The Mutale River Water Resources Investigation Study (1999) highlighted the following water resources management issues:

- The existing water shortages can effectively only be decreased by improved efficiencies of water use, reduced water requirements and/or improved water supplies and therefore adopting one or more of the following approaches:
  - Improvements in the efficiency of water use through water conservation and demand management.
  - Reducing irrigation water requirements in total or in particular months by reducing the areas of particular crops.
  - Reducing the water requirements for the ecological component of the Reserve by lowering the ecological management class.
  - Increasing the supplies of utilisable water by developing the groundwater or by building dams.
- Improved efficiencies of water use can only be achieved through a clearly defined water demand and conservation strategy that sets out the objectives and the goals that support the objectives.
- Abstraction control is the only way in which the flow in the Mutale River can be managed at this stage, as there are no means of augmenting the actual flow.
- Reducing the irrigation water requirements by reducing the areas under irrigation will have significant social-economic consequences. Agronomic and socio-economic studies should therefore be performed and be followed by public consultation to establish the extent, if any, by which areas under irrigation can be reduced, irrigation efficiencies can be improved

and the types of crops irrigated can be revised, in order to reduce the high water requirements that exist during November and December. This is especially relevant at the Tshiombo and Rambuda Schemes.

- It is unlikely that the water shortages can be reduced to acceptable levels by means of improved efficiencies of water use and reduced water requirements resulting from changed cropping patterns.
- In the southwest catchment the net incremental benefit of using groundwater is in the order of 1 million m^3/a to 2 million m^3/a.
- The sustainable exploitable groundwater potential in the northeast of the study area is estimated at 1.6 million m^3/a. However, the poor quality of the groundwater will result in only 0.4 million m^3/a being suitable for domestic use.
- The total net potential increase in the utilisable water resources from groundwater is about 2 million m^3/a at most. A large number of boreholes spread over a large area will however be necessary.
- The net transfer of water into the Mutale River catchment by 2020 was estimated to be about 3.7 million m^3/a through the Nwanedi-Luphephe, Vondo, Damani and Mutale Regional Water Supply Schemes.
- According to the Nwanedi River Water Resources Investigation the proposal to transfer 0.9 million m^3/a of water and possibly more in the future from the Nwanedi River catchment into the Mutale River catchment by means of the Nwanedi-Luphephe Regional Water Scheme should be reviewed.
- To supply communities within the supply areas of the Nwanedi-Luphephe and Masisi Regional Water Schemes will aggrevate the existing water shortages unless additional storage is provided form either the Mutale or Nwanedi River catchments.
- Further investigations are necessary to identify and evaluate alternative options to supply communities, in the supply areas of the existing and proposed Regional Water Schemes, with potable water. This is the case for any water requirements in the study area that were not supplied at the time of the study.
- A decision should first be made by DWA as to how the ecological component of the reserve will be supplied. Should it be decided that it should be supplied by means of storage in the Mutale River so as not to increase existing water shortages; the water supply to communities or any other water requirements not supplied at present should be included in the planning of such a development.
- A large number of people in the study area are dependent on irrigation for survival. Should it be decided that the ecological component of the reserve is supplied without the provision of storage; the existing water shortages will be aggravated which will have an adverse impact on the economy.
- On the basis of the socio-economic, cultural and/or ecological considerations the Rambuda Middle and Thengwe dam sites are unlikely to be acceptable for development.
- The cost of water secured by a dam at Rambuda Middle is considered to be far too high.

The Thengwe dam site is also situated downstream of the areas of the largest water requirements and therefore the cost of conveying the water to the consumers will be much higher than the other dams.

- The most viable dam sites are the Rambuda Downstream site and the Tswera site.
- The potential storage at the Rambuda Downstream site is limited, due to uncertain foundation conditions on the left flank. This has limited the maximum system incremental firm yield that can be obtained at Thengwe to about 5 million m^3/a. This is not to supply the ecological reserve at present but will neverless improve the water supplies in the upper Mutale River catchment.
- With a dam at Tswera the net incremental yield of the system at Thengwe that has the lowest URV is 16.5 million m^3/a . The equivalent stepped draft yield is about 21.5 million m^3/a. About 6.1 million m^3/a to 7.5 million m^3/a will be required purely to supply the ecological reserve.
- The consumptive water requirements are mostly situated upstream of Tsera and therefore its usefulness could be limited. Given this limitation it may become necessary to construct both Tswera and Rambuda Downstream sites to effectively supply water to the existing consumers, for the ecological component of the reserve and to provide for expected future increase in water requirements.
- More detailed investigations of future water requirements, their spacial distribution and the effects of water conservation and demand management measures on these requirements are therefore first required before a more definite proposal can be made on further investigations into dams at Rambuda Downstream and/or Tswera sites.
- The spacial distribution of streamflow, rainfall, evaporation and water quality gauges in the catchment should be improved.
- Regular measurements of water use must be made and recorded and/or changes in land use.
- A Water User Association should be established for the Mutale River Catchment, largely to ensure the equitable and sustainable utilisaiton of the limited water resources.

The ISP: Luvuvhu Letaba WMA (2004) indicated that a broad strategy for the Mutale catchment was that a detailed analysis is required to accurately determine the available water resources in the catchment. A water balance of the catchment should be conducted in order to establish the existing water resource situation as well as the need for future augmentation.

3.3.3 Identified intervention measures

The utilisable water supplies are insufficient at present to supply the existing water requirements even if the assurances are lowered to 70%. The water shortages will increase considerably after the ecological component of the reserve is supplied. The long term average mean water shortage of 18% is already experienced at present, without providing for the ecological component of the reserve.

The various identified intervention options are discussed below.

Water Conservation and Demand Management Measures

The Mutale River Water Resources Investigation Study (1999) indicated that the existing water shortages could be reduced through improvements in the efficiency of water use through water conservation and demand management. It was recommended that water conservation and demand management objectives and goals that are likely to be achieved in the Mutale River Catchment, should be identified and that measures should be taken to implement these. It is unlikely that the water shortages can be reduced to acceptable levels by improving the efficiencies of water use alone and further interventions will be required.

The 2003 “Luvuvhu / Letaba Water Resources Situation Assessment Study (see **Section 2.13.2**), identified the introduction of more ecologically sound agricultural practices including realistic stock levels as one of the measures that could be implemented to address water shortages and protect the water resources in the sub-catchment.

Groundwater Development

The Mutale River Water Resources Investigation Study (1999) indicated that:

- In the southwest catchment the net incremental benefit of using groundwater is in the order of 1 million m^3/a to 2 million m^3/a.
- The sustainable exploitable groundwater potential in the northeast of the study area is estimated at 1.6 million m^3/a. However, the poor quality of the groundwater will result in only 0.4 million m^3/a being suitable for domestic use.
- The total net potential increase in the utilisable water resources from groundwater is about 2 million m^3/a at most. A large number of boreholes spread over a large area will however be necessary, which could potentially result in high operating costs and unit costs of distribution pipelines.

Surface Water Development

The Mutale River Water Resources Investigation Study (1999) identified four dam sites (Rambuda Middle,Rambuda Downstream, Thegwe and Tswera) in the Mutale River catchment, which were reduced to the two most viable sites as follows:

- On the basis of the socio-economic, cultural and/or ecological considerations the Rambuda Middle and Thegwe dam sites are unlikely to be acceptable for development.
- The cost of water secured by a dam at Rambuda Middle is considered to be far too high. The Thengwe dam site is also situated downstream of the areas of the largest water requirements and therefore the cost of conveying the water to the consumers will be much higher than the other dams.
- The most viable dam sites are the Rambuda Downstream site and the Tswera site.
- The potential storage at the Rambuda Downstream site is limited, due to uncertain foundation conditions on the left flank. This has limited the maximum system incremental firm yield that can be obtained at Thengwe to about 5 million m^3/a.

- With a dam at Tswera the net incremental yield of the system at Thengwe that has the lowest URV is 16.5 million m^3/a. The equivalent stepped draft yield is about 21.5 million m^3/a. About 6.1 million m^3/a to 7.5 million m^3/a will be required purely to supply the ecological reserve.
- The consumptive water requirements are mostly situated upstream of Tswera and therefore its usefulness could be limited. Given this limitation it may become necessary to construct both Tswera and Rambuda Downstream sites to effectively supply water to the existing consumers, for the ecological component of the reserve and to provide for expected future increase in water requirements.

The 2003 "Luvuvhu and Letaba WMA Overview of Water Resources Availability and Utilisation Study", identified the possible construction of a new dam on the Mutale River or abstraction of water from the Limpopo River as options that could be implemented to meet the water requirements of the coalfields in the northern part of the sub-catchment, should these coalfields be developed in the future.

3.3.4 Perspective on water resource management

From the results of the previous studies it is clear that water supply in this catchment is already a problem and that deficits are already experienced in practise. To improve this situation WC/WDM was strongly recommended as well as the possibility of the building of two dams and utilising groundwater. On the other hand the Mutali River is seen as the tributary of the Luvuvhu that should support the EWR as limited development has taken place in this catchment.

In the end it will be important to find a realistic balance between all the users, the environment and the possible options to improve the water supply in this area.

3.4 SHINGWEDZI RIVER CATCHMENT AREA

A number of studies have been undertaken for this area, and the findings are summarised in this chapter. These studies were reviewed in chapter 2, in particular the National water resource strategy and the internal strategic perspective as documented in 2.14 and 2.15 respectively.

3.4.1 Description of the water resource and supply situation

The Shingwedzi River catchment consists of tertiary catchment area A90 and comprises the catchments of tributaries of the Shingwedzi River. The Shingwedzi River basin covers approximately 6000 km^2. It's major tributaries are the Shisha, Mphongolo and Phugwane

The Shingwedzi sub-area is a head-water catchment which drains into Mozambique. It is situated almost entirely in the Kruger National Park. For all practical purposes, no sustainable yield is derived from surface flow in the Shingwedzi catchment. Water use in the catchment is negligible. There are no transfers out of this sub-catchment area.

There are no major dams in the Shingwedzi basin due to the limited water resources and the non-availability of suitable dam sites. Some small dams have, however, been constructed in the Kruger National Park for game watering. Of these, the most notable are the Kanniedood Dam on the Shingwedzi River and the Engelhard Dam on the Letaba River.

More than half of the water available is abstracted from groundwater. Only one scheme operates in the catchment, being the Malamulele East RWS, which has its source as the Malamulele Weir in the Luvuvhu River. Water is treated at the Malamulele WTW. According to information from the Basin Study, an area of 270 ha was developed for irrigation in about 1988. Water for this irrigation is sourced from the Makuleke Dam on the Mphongolo River. In the Madonsi Tribal Authority, 19 ha of vegetables are irrigated with water obtained from boreholes and directly from the Shingwedzi River.

The overall conservation status of the catchment is 91%, which is the highest catchment score. A wide range of habitats, and biotica coupled with no forestry and little farming or urban development is responsible for the high score. The river is rated as being in pristine state. The catchment however contains 20% of the dams in the KNP, which are causing a severe impact on the ecology.

3.4.2 Pertinent water resource management issues

The network of gauging stations on the Shingwedzi River are more evenly distributed than in the Letaba Catchment, but these gauges have only been installed recently and thus record lengths tend to be short. Rainfall station records in the Middle and lower reaches of the Klein Letaba, whole of the Nwanedzi, Molototsi and Shingwedzi catchments are inadequate for use in the Pitman Model. There are too few stations and existing records are too short.

According to the 1990 Water Resources Planning of the Letaba River Basin Study for Development Potential and Management of Water Resources, research is required to address the following topics:

- Biota of the Shingwedzi River and its tributaries
- Water requirements of Shingwedzi riparian vegetation
- Survival characteristics of fauna after cessation of flow
- Quantative studies of reedbed dynamics
- Continuing surveillance of Letaba and Shingwedzi rivers after recommendations are implemented.

3.4.3 Identified intervention measures

Groundwater Development

According to the “Luvuvhu and Letaba WMA Overview of Water Resources Availability and Utilisation Study” (2003), groundwater will remain the primary source of supply to the Shingwedzi River Catchment Area.

Transfer from Nandoni Dam

Augmentation via a transfer scheme from Nandoni Dam has been identified as the best alternative in areas where the sustainable yield from groundwater is insufficient (See **Section 2.14.2**).

3.4.4 Perspective on water resource management

It is foreseen that groundwater will remain the primary source of supply to the sub-area. Where the sustainable yield from groundwater is insufficient (including current over exploitation of groundwater), augmentation from Nandoni Dam may be the best alternative. To be able to in future take the demand of Nandoni Dam, it is recommended to rather transfer water from the Xikundu weir in the Luvuvhu River into this area.

Although the water quality looks good, there is evidence that water quality deterioration may occur overtime due to development in the catchment. An effective monitoring programme must be implemented for efficient management of the water quality and the subsequent optimisation of water use and development within the catchments.

3.5 GROOT LETABA CATCHMENT AREA

A large number of studies have been undertaken for this area. Finedings from these studies are summarised in this chapter. The studies were reviewed in chapter 2, in particular the Letaba water resource development pre-feasibility study, Groot Letaba water resource development feasibility study, Luvuvhu/Letaba water resource situation assessment, National water resource strategy, Internal strategic perspective and Groot Letaba river water development project as documented in 2.6, 2.8, 2.13, 2.14, 2.15 and 2.21 respectively.

3.5.1 Description of the water resource and supply situation

The Letaba River catchment is drained by the Groot Letaba River and its major tributaries are the Klein Letaba, Middle Letaba, Letsitele and Molototsi rivers. Groot Letaba River catchment utilize water from the Groot Letaba River and its tributaries to supply water to various towns including Polokwane, Tzaneen, Haenertsburg, Duiwelskloof and to a number of rural villages. Water use in the Groot Letaba catchment is dominated by irrigation.

The surface water resources within this sub-catchment are extensively developed with a large number of small to major dams constructed to meet domestic (urban and rural), irrigation and industrial water needs. Faced with water shortages of increasing severity and frequency, the main consumptive users of water have from time to time compete for the limited supplies by taking extraordinary measures to survive. This has resulted in the degradation of the riverine ecosystem. The water resources of the Groot Letaba are not sufficient to meet all its requirements all of the time.

There are eight main dams in this catchment and the water is treated at nine different treatment plants. All the water supply schemes in the Groot Letaba River catchment, except the Modjadji scheme, form part of the inter-linked Letaba Regional Water Supply Scheme. The infrastructure between the schemes is not necessarily linked, but upstream infrastructure and water use, impacts on the water availability at further downstream scheme components.

The Modjadji scheme utilizes water from the Molototsi River. It is located adjacent to the Groot Letaba River system in the B81 tertiary catchment area, but operates on its own, without any significant effect on the Groot Letaba River system. This scheme consists of three sub-schemes which draw water from the Modjadji Dam in the Molototsi River. Treated water from the Modjadji Water Treatment Works is then distributed to 52 villages through a series of pipelines, either pumped or under gravity and stored in reservoirs. Some 50 ha is irrigated from Modjadji Dam.

The water schemes located in the Groot Letaba River catchment using large dams as a source include the Dap Naude Dam Water supply Scheme, Ebenezer Dam Water Scheme, Hans merensky Dam Scheme, Tzaneen Dam Scheme, Magoebaskloof Dam and Vergelegen Dam Scheme, Thapane Dam Scheme, Thabina Dam Scheme, Letaba Regional Scheme, Nondweni weir and the Modjadji scheme.

Water schemes with its source in the Groot Letaba River catchment, but supplying water users located outside its boundaries are Dap Naude Dam Scheme, Pietersburg Government RWS, Ebenezer Dam Water Scheme, Thabina Dam Scheme and Ritavi II Water Schemes. Two schemes in the Middle/Klein Letaba River catchment also supply water to villages located in the Groot Letaba River catchment.

The groundwater development potential in the majority of the catchment is moderate, with significant portions of the catchment having high groundwater potential, particularly in the south and west. There are portions of the catchment with low groundwater development potential, particularly in the north and east of the catchment. The total use of groundwater in the catchment is estimated to be 39.6 Mm^3/a.

Significant areas of commercial plantations (afforestation) and some indigenous forests occur in the wetter parts of this catchment area, mainly in areas with an average MAP of around 900 mm. These areas are concentrated in the upper reaches of the Groot Letaba, Letsitele, and Middle Letaba and Klein Letaba River catchments. There is very little likelihood that further development of afforestation took place in the catchment, since the Letaba catchment was categorised as "Category 1" in terms of the1984 Forestry Act (Act 122 of 1984), which implies that new licences were not permitted in the catchment (DWAF, 1998). This happened as far back as 1972.

3.5.2 Pertinent water resource management issues

According to the 2005/06 Letaba River System Annual Operating Analysis, the dams in the Letaba River System are operated on a run to empty basis which is not sustainable and drought operating rules need to be determined and implemented.

The study recommended that Dap Naude, Ebenzer, Magoebaskloof and Tzaneen Dams be operated in conjunction and that further augmentation options to supply Tzaneen (Raising of Tzaneen Dam and/or the construction of Nwamitwa Dam be considered. The study also recommended that the water use data and hydrology be updated.

The following water resource management issues were raised from the 2009/2010 Groot Letaba River Water Development Project:

- Given the stressed nature of the available water resources and the anticipated growth in water requirements, it is important that verification and validation of water use in the Groot Letaba Catchment is undertaken urgently and in a thorough manner.

- Municipalities should measure and monitor water use in their areas of juristriction so that, in future, accurate data is available for analysis and planning.
- WC/WDM measures should be implemented in the catchment in order to achieve early and meaningful impact on demand-side water supply management.
- A comprehensive groundwater investigation should be undertaken in order to locate groundwater with greater certainty and to develop it. These investigations should be focussed on mobilising specific groundwater resources for integration in the water supply system on a regional basis in the supply area currently envisaged for the proposed Nwamitwa Dam. The potential yields, costs and environmental implications associated with a potential groundwater "regional government water scheme" should be determined and compared with the yields, costs and environmental implications of the proposed Nwamitwa Dam development.
- A complete re-calibration of the rainfall – runoff model should be undertaken with a focus on achieving a good match in the low to medium flow events (freshets), to enable reliable modelling of the EWR requirements in the WRYM.
- The historical firm yield of the proposed Nwamitwa Dam should be re-determined once the results of the abovementioned further investigations are available and once the rainfall runoff model has been re-calibrated.
- It was recommended that an embankment type earth fill dam should be constructed at Nwamitwa, with a central ogee spillway with a full supply level of 479.5 masl. This will ensure that sufficient yield is obtained to meet the anticipated future water requirements of the area surrounding Nwamitwa Dam, minimise expropriation costs and limit the amount of evaporation from the proposed dam.
- A labyrinth spillway option was recommended for the raising of Tzaneen Dam. This is the most cost effective solution and has the lowest future maintenance costs.
- The Regional Bulk Water Supply Infrastructure as proposed in the report should be implemented and taken further into the detailed design phase.
- Mopani District Municipality should implement a comprehensive water metering and monitoring system in order to ascertain what the actual water requirements are and how the water requirements change with implementation of the recommended regional bulk water supply and connector bulk infrastructure.
- The capacity of the Babanana Reservoir (Command Reservoir B) and the Serelorolo Reservoir (Command Reservoir A) should be increased when the future water requirements reach the stage that there is insufficient emergency and balancing storage in the respective supply areas.

3.5.3 Identified intervention measures

The 1994 Letaba Water Resource Development Pre-feasibility investigated possible development options in the following stages:

- Initial Identification: This was done during the 1990 Basin Study and yielded 100 potential dam sites.
- Preliminary Selection: This was also done during the 1990 Basin Study and yielded 17 potential dam sites.
- Reconnaissance Stage: This stage was the first stage of the pre-feasibility study and involved the investigation of the 17 potential dam sites from the Basin Study and one additional dam site which was identified during this stage. Of the 18 sites, 12 sites were selected to be included in the pre-feasibility study.
- Pre-feasibility Stage: The following development options were investigated at pre-feasibility level:

Groot Letaba River:	Raising of Tzaneen Dam
	Janetsi Dam (GR15A)
	Nondweni Weir (GR24)
Lesitele River (Upper):	Litswalo (LET 1)
	Hobsons Choice (LET 2)
(Lower):	Dan (LET 6)
	Ka-Muhlaba (LET 6A)
	Letsitele (LET 7)
Thabina River:	Pitsi (LET 12)
Nwanedzi River:	Nwamitwa (GR12)
	La Motte (GR13)
Molototsi River:	Mulele (GR29)

The more feasibile development options identified for further analysis were:

- Raising of Tzaneen Dam using crest gates
- Hobsons Choice Dam (LET2) on the Litsitele River
- Janetsi Dam (GR15A) on the Groot Letaba River (later renamed to Nwamitwa Dam)
- Nondweni Dam (GR24) on the Groot Letaba River
- Molototsi River development options including the Mulele Dam (GR29)

The 1998 Groot Letaba Water Resource Development Study further investigated the water availability and water requirements in the study area. Taking cognizance of all the water requirements, two dams sites (i.e. on the Letsitele River and at Nwamitwa on the Groot Letaba River) and the raising of Tzaneen Dam previously identified in the Pre-feasibility Study were investigated further.

Based on the various investigations conducted in past studies, the following conclusions were made regarding the infrastructure development options:

Raising of Tzaneen Dam

The Tzaneen Dam was originally designed to allow for raising the crest of the spillway. Raising the dam by 4.5 m will result in an additional yield of 6.0 x 10^6 m^3/a at a 98% assurance level. The feasibility study completed in 1998 proposed that the raising of the dam should be implemented in partnership with the direct beneficiaries, i.e. irrigation farmers downstream of Tzaneen Dam.

Raising of Ebenezerand Dap Naude Dams

The 2010 Great Letaba River Water Development Project stated that the raising of Ebenezer Dam was also technically feasible. The incremental increase in firm yield of the Ebenezer/Tzaneen System for a raising of Ebenezer Dam by 5 and 10 metres would be 2.3 and 4.5 million m^3/a respectively. If Nwamitwa Dam were constructed first, then the incremental firm yield reduces from 4.5 million m^3/a to 3.9 million m^3/a for the 10 meter raising option.

During a recent dam safety inspection conducted more or less at the time of the Great Letaba River Water Development Project, it was found that the Dap Naude Dam is unstable and significant upgrading works had subsequently been undertaken. A raising of the dam would therefore effectively involve a complete reconstruction of the existing dam and is not favoured.

Construction of Nwamita Dam (Janetsi or Site GR15A in Previous Studies)

The feasibility study completed in 1998 concluded that Nwamitwa dam with a gross storage of 143 million m^3 is the most attractive for a new major storage dam in the Groot Letaba sub-catchment system. It is also proposed to link the proposed dam to existing water supply systems and where necessary to upgrade existing bulk water supply infrastructure or construct new infrastructure for the distribution of water for primary use.

The 2010 Great Letaba River Water Development Project investigated the Nwamitwa Dam further. It was suggested that the estimated yield of the proposed Nwamitwa Dam should be regarded as preliminary since it was established that the simulated hydrology does not accurately reflect the catchments base flow. A recommendation was made that the yield be confirmed once the hydrology is recalibrated in future.

Construction of the Letsitele River Valley Dam (Hobson's Choice or Site LET2 in Previous Studies)

The construction of the Hobson's choice Dam (Site LET2, in the upper reaches of the Letsitele River) to a FSL of 630 masl will give a yield at 98% assurance of 26.6 x 10^6 m^3/annum, however the feasibility study completed in 1998 concluded that construction of a major storage dam in Letsitele River does not offer a cost effective and affordable solution.

Construction of the Mulele Dam (Site GR29 on Molototsi River)

The construction of the Mulele Dam (Site GR29, on the Molototsi River) to a FSL of 475 masl will give a yield at 98% assurance of 8.6 x 10^6 m^3/annum. The pre-feasibility study completed in 1994 determined that the major drawbacks for this option are the high sediment load in the river and the inundation of extensive areas under dry land crops. In view of the scattered nature of the domestic demand, it may be prudent to investigate the use of a number of sand abstraction schemes along the river as an alternative the construction of this dam.

Groundwater Development

The 2010 Great Letaba River Water Development Project stated that groundwater could potentially supply a significant portion of the future water requirements in the logical supply area of the proposed Nwamitwa Dam, either through blending with potable supplies or by onsite treatment prior to conveying the treated water to the regional bulk water supply reservoirs. More detailed investigations would however need to be undertaken in order to determine and develop the full potential of groundwater in the area.

Water Conservation and Demand Management

The implementation of water demand/water conservation measures in the catchment is was strongly recommended by the 2010 Great Letaba River Water Development Project in order to achieve early and meaningful impact on demand-side water supply management.

Construction of New and Upgrading of Existing Domestic Bulk Water Supply Infrastructure

In addition to the development of the proposed dams, it is proposed to upgrade the associated bulk water supply infrastructure for the distribution of water for primary use in surrounding settlements, including water purification works, pump stations, bulk conveyance mains and storage reservoirs.

Management Options

The following water management issues were identified as requiring improvement:

- The management and control of dams
- Accuracy of flow gauging stations
- Accuracy of abstraction records
- Control of illegal abstractions

3.5.4 Perspective on water resource management

Given the stressed nature of the available water resources and the anticipated growth in primary water requirements, it is important to undertake verification and validation of water use in the Groot Letaba Catchment. Further investigations should be undertaken in order to refine the assumptions regarding the river losses. This will enable the yield results to be portrayed with a higher level of certainty.

A Reserve Determination Study for the proposed Nwamitwa Dam needs to be undertaken. The EWR needs to be refined and more attention needs to be given to how the EWR should be applied and modelled to reflect the day to day operation more accurately in the WRYM. Groundwater should be urgently investigated in detail as a source for rural domestic use. Also, investigate the link between surface and groundwater and integrate surface and groundwater quality monitoring. Monitoring activities must tie in with national monitoring initiatives, including the National Microbial Monitoring Programme and the National Eutrophication Monitoring Programme

3.6 MIDDLE AND KLEIN LETABA CATCHMENT AREA

A number of studies have been undertaken for this area, and findings from these studies are summarised in this chapter. These studies were reviewed in chapter 2, in particular the reconnaissance study to augment the water resources of the Klein Letaba and Middle Letaba River catchment ,Middle Letaba water supply scheme: WC/WDM situation assessment, Luvuvhu/Letaba water resource situation assessment, National water resource strategy, Internal strategic perspective and Social-economic and ecological impacts of water restriction in the Letaba catchment as documented in 2.11, 2.12, 2.13, 2.14, 2.15 and 2.23 respectively.

3.6.1 Description of the water resource and supply situation

The Middle and Klein Letaba River catchment consists of tertiary catchment area B82 and includes the catchments of the Middle Letaba River, Klein Letaba River and tributaries thereof such as the Koedoes River, Brandboontjies River and Nsami River.

The water is mainly sourced from the Middle Letaba and Nsami Dams and is treated at three different treatment plants. The water schemes operating in this catchment are the Sekgopo and Tshitale/Sekgosese borehole schemes, the Middle Letaba "M", "N", "MW" and "A, B, C, D, E, F" water schemes. The Middle letaba "M", "N" and "A, B, C, D, E" schemes also supply potable water to other catchments, being Groot Letaba River and Luvuvhu/Vondo River catchments. The Middle Letaba/Nsami canal transfers water from the Middle Letaba Dam to the Nsami Dam.

The bulk water supply scheme can be subdivided into three main sections, as described below:

- 89 Villages supplied from a treatment works at Middle Letaba Dam
- 29 Villages supplied from a treatment works (Malamule West Water Works) located adjacent to the canal between Middle Letaba Dam and Nsami Dam
- 58 Villages and Giyani Town supplied from the treatment works at Nsami Dam

The schemes that transfer water across tertiary catchment boundaries include:

- Giyani Regional scheme: Nsami Dam transfers water to villages in the Groot Letaba River and Shingwedzi River catchments.
- Middle Letaba Regional scheme: Middle Letaba Dam to villages in the Luvuvhu River and Groot Letaba River catchments.
- Malamulele West Regional scheme to villages in the Luvuvhu River catchment

3.6.2 Pertinent water resource management issues

The following water management issues were raised by previous studies in the Middle and Klein Letaba Catchment Area:

- Municipalities should measure and monitor water use in their areas of jurisdiction so that, in future, accurate data are available for analysis and planning.
- The future water needs of the agricultural sector in the Middle Letaba Dam supply area should be reviewed.
- WC/WDM measures should be implemented in the area
- A comprehensive groundwater investigation should be undertaken in order to locate groundwater with greater certainty and to then develop the groundwater resources as far as possible.
- The option of replacing the transfer canal from the Middle Letaba Dam to Nsami Dam with a pipe should be investigated in order to reduce the losses.
- Drought operating rules should be developed and implemented for the dams in the catchments.

3.6.3 Identified intervention measures

Water conservation and demand management

The implementation of water conservation and water demand management measures in the Giyani area was identified as one of the measures that could be adopted to address water shortages (See **Section 2.12.2**).

Development of the Groundwater Resource

The "Reconnaissance Study to Augment the Water Resources of the Klein Letaba and Middle Letaba Catchments" of 2003 identified the development of the under-utilised groundwater resource as one of the options for augmenting the water resources and this could significantly reduce the number of people who are dependent on surface water in the sub-catchment.

Replacement of Middle Letaba Dam – Nsami Dam Transfer Canal with a Pipeline

The "Reconnaissance Study to Augment the Water Resources of the Klein Letaba and Middle Letaba Catchments" of 2003 also identified the reduction of water losses by replacing the transfer canal from Middle Letaba Dam to Nsami Dam as one of the options for addressing the water shortages in the sub-catchment.

Transfer Scheme from Nandoni Dam

This option involves the establishment of a transfer link to transfer water from Nandoni Dam in the Luvuvhu sub-catchment, to augment the water resources in the Klein - Middle Letaba area (See **Section 2.14.2**). A more recent study, "Incorporation of a transfer option from Nandoni Dam to Giyani into the DSS for the Luvuvhu & Letaba Study" (2010) recommended that the areas planned to be supplied from the Nandoni system should be reconsidered as a maximum transfer of only 10 million m^3/a support to the Middle Letaba sub-system could be sustained.

Construction of a New Dam on the Klein Letaba River

The construction of a new dam at either the Crystalfontein Dam Site or the Majosi Dam Site on the Klein Letaba River has been investigated in previous studies as a possible option for augmenting water resources in the sub-catchment. However, the 2003 “Reconnaissance Study to Augment the Water resources of the Klein Letaba River and Middle Letaba River Catchments” concluded that the construction of a dam at Majosi or Crystalfontein will not improve the water supply of the present system significantly if ecological releases from the dams for the reserve are included.

No potential dam sites were considered to be suitable in the Lower Klein Letaba River catchment due to the high evaporation and low run-off from the catchment (excluding contributions from upstream catchments) and the negative impact that the construction of a dam on this part of the river would have on the ecology of the Letaba River in the Kruger National Park.

3.6.4 Perspective on water resource management

All the areas currently planned to be supplied from the Nandoni sub-system including the possible support to Giyani, should be reconsidered as the current planning will result in an over allocation of Nandoni Dam. The yield characteristics of the Middle Letaba sub-system should be re-determined when the updated hydrology for the catchment area becomes available. These yield results could significantly impact on the required capacity of the transfer system as well as on the required transfer volume to fully support the demands in the Middle Letaba sub-system.

Operating rules governing the transfers and support from Nandoni and Middle Letaba dams respectively need to be optimised to obtain the maximum benefit from the transfers and support, as well as to protect users that can only receive water from Middle Letaba Dam. Demand projections in particular those within the Middle Letaba catchment need to be confirmed as soon as the All Town Study (Northern Region) is completed. Improved indications of possible irrigation developments in both sub-systems are required.

3.7 IDENTIFIED AUGMENTATION OPTIONS

The augmentation options that were identified from the literature to be considered in the reconciliation study are presented in **Appendix A** and shown on **Figure A-1** of **Appendix A**. The tables include a basic description of the scheme, the proposed assessments that is envisaged as part of the study and give relevant comments on the strategic advantages or disadvantages that can be deduced from existing information.

Appendix A

LIST OF AUGMENTATION OPTIONS

Table A-1: Augmentation options identified from the literature – Luvuvhu Main catchment Area

No:	Name of option and source	Report & Level of Assessment	Date of Assessment	Key Features
1	Future supply to Louis Trichardt from Albasini Dam Albasini Dam, groundwater, Latonyanda Dam, Reduction in irrigation and upstream abstractions	Luvuvhu Letaba Water Resource Situation Assessment (Reconnaissance)	2003	• Infrastructure to supply additional transfers from Albasini to Louis Trichardt. • Re-allocate available water from Albasini through: ○ Reduction in canal losses on the irrigation supply system, ○ Buying out the some of the irrigation ○ Construct infrastructure to supply a portion if the irrigation area from the Latonyanda River ○ Using groundwater to supply part of the irrigation requirement • Improve Albasini yield by: ○ Reduce upstream irrigation from surface water ○ Reduce groundwater abstractions within the Albasini Dam catchment
	Proposed assessments in the Reconciliation Study			**Comments:**
	• Need to determine the possible saving in losses within the irrigation supply system. • Determine the work required and related cost to achieve this saving in losses. • Determine the possibility of buying out irrigation within the Albasini Scheme, the effects of that and the related cost. • Re-evaluate the option of utilizing Latonyanda River and possible dam to support the Albasini Irrigation • Evaluate and analyse the possibility of reducing irrigation and groundwater abstractions upstream of Albasini Dam and related cost			• Also see options 2 and 3 • Surface/Groundwater interaction will be modelled for the first time. Scenario analysis to determine the effect of upstream groundwater abstractions can now be done • Verification of water use, when completed will indicate whether there is any un-lawfull abtsractions taking place upstream of Albasini Dam.

<table>
<tr><th>No.</th><th>Name of option & source</th><th>Report & Level of Assessment</th><th>Date of Assessment</th><th>Key Features</th></tr>
<tr><td rowspan="3">2</td><td><u>Future supply to Louis Trichardt primarily from Nandoni Dam</u></td><td>Luvuvhu Letaba Water Resource Situation Assessment

(Reconnaissance)</td><td>2003</td><td>• Reduce the existing supply from Albasini Dam to Louis Trichardt
• Supply the bulk of the requirement for Louis Trichardt from Nandoni Dam
• Improve the supply to irrigation from Albasini Dam</td></tr>
<tr><td colspan="3">Proposed assessments in the Reconciliation Study:</td><td>Comments:</td></tr>
<tr><td colspan="3">• Determine if sufficient water is available in Nandoni dam for this purpose
• Determine the related cost</td><td>• Also see options 1 and 3</td></tr>
</table>

<table>
<tr><th>No.</th><th>Name of option & source</th><th>Report & Level of Assessment</th><th>Date of Assessment</th><th>Key Features</th></tr>
<tr><td rowspan="3">3</td><td><u>Future supply to Louis Trichardt from Nandoni & Albasini dams</u>

(Combination of options 1 & 2)</td><td>Luvuvhu Letaba Water Resource Situation Assessment

(Reconnaissance)</td><td>2003</td><td>• Continue with existing 2.4 million m^3/a from Albasini Dam to Louis Trichardt
• Increase the supply from Albasini Dam to Louis Trichardt through:
  ○ Reduction in canal losses on the irrigation system,
  ○ Buying out the some of the irrigation within the scheme
• Utilize another source such as Latonyanda river/possible dam to take over irrigation currently supply from Albasini Dam
• Use groundwater to supply a portion of the irrigation demand
• Improve from Albasini dam as described for option 1.</td></tr>
<tr><td colspan="3">Proposed assessments in the Reconciliation Study:</td><td>Comments:</td></tr>
<tr><td colspan="3">• Need to determine the possible saving in losses within the irrigation supply system.
• Determine the work required and related cost to achieve this saving in losses.
• Determine the possibility of buying out irrigation within the Albasini Scheme, the effects of that and the related cost.
• Re-evaluate the option of utilizing Latonyanda River and possible dam to support the Albasini Irrigation
• Evaluate and analyse the possibility of reducing irrigation and groundwater abstractions upstream of Albasini Dam and related cost
• Determine the if sufficient water is available in Nandoni dam for this purpose and the related cost</td><td>• This is an combination of options 1 and 2
• Surface/Groundwater interaction will be modelled for the first time. Scenario analysis to determine the effect of upstream groundwater abstractions can now be done
• Verification of water use, when completed will indicate whether there is any un-lawfull abtsractions taking place upstream of Albasini Dam.</td></tr>
</table>

<table>
<tr><th>No.</th><th>Name of option & source</th><th>Report & Level of Assessment</th><th>Date of Assessment</th><th>Key Features</th></tr>
<tr><td rowspan="3">4</td><td><u>Groundwater utilisation Nandoni Supply area</u>

Nandoni Dam and groundwater resources</td><td>Luvuvhu Letaba Water Resource Situation Assessment

(Reconnaissance)</td><td>2003</td><td>Areas of over exploitation of groundwater are found in the Thohoyandou area and downstream of Albasini Dam.
Existing distribution system
Planned future distribution system and demand centres to be included</td></tr>
<tr><td colspan="3">Proposed assessments in the Reconciliation Study:</td><td>Comments:</td></tr>
<tr><td colspan="3">Overview of the characteristics of the groundwater resource
Assessment of Groundwater harvest potential, exploitation potential, baseflow per Quaternary catchment or groundwater unit and groundwater quality as per the GRAII and WSAM databases.
Derivation of a groundwater balance compared to harvest potential and recharge and level of use.
Need to determine areas of over exploitation of groundwater use
Determine areas of excess groundwater resources not yet utilised
Plan areas to be supplied from Nandoni accordingly
Costing and economic analysis</td><td>This option need to take into account the most recent planning regarding the Nandoni water supply distribution system and planned areas for future supply
The maintenance of groundwater supply systems is a disadvantage in rural supply schemes
Groundwater supply systems can be developed fairly quickly. . Proper development and management of these resources and related systems are however required.
Should consider al the groundwater options already included in the groundwater strategy</td></tr>
</table>

<table>
<tr><th>No.</th><th>Name of option & source</th><th>Report & Level of Assessment</th><th>Date of Assessment</th><th>Key Features</th></tr>
<tr><td rowspan="3">5</td><td><u>Raising of Vondo Dam</u>

Vondo Dam</td><td>Water Resources Planning of the Luvuvhu River Basin

(Reconnaissance)</td><td>1990</td><td>• Supply higher parts of Thohoyandou
• Reduce demand on Nandoni Dam</td></tr>
<tr><td colspan="3">Proposed assessments in the Reconciliation Study:</td><td>Comments:</td></tr>
<tr><td colspan="3">• Determine the increase in yield
• Determine the possibility of raising Vondo from structural point of view
• Cost related to raising & economic analysis</td><td>• Vondo dam was raised before, need to confirm if further raising is possible.</td></tr>
</table>

<table>
<tr><th>No.</th><th>Name of option & source</th><th>Report & Level of Assessment</th><th>Date of Assessment</th><th>Key Features</th></tr>
<tr><td rowspan="3">6</td><td><u>Mid-Dzindi Dam</u>

Dzindi Dam in Duthuni River</td><td><u>Luvuvhu dam Feasibility Study</u>

(Feasibility)</td><td>1997</td><td>• Dam located in Duthuni River upstream of Nandoni Dam
• Increase system yield
• Reduce pumping costs
• Reduce Nandoni Dam yield</td></tr>
<tr><td colspan="3">Proposed assessments in the Reconciliation Study:</td><td>Comments:</td></tr>
<tr><td colspan="3">• Re-determine yield benefit and yield reduction on Nandoni Dam
• Cost & economic evaluation</td><td></td></tr>
</table>

No.	Name of option & source	Report & Level of Assessment	Date of Assessment	Key Features
7	Latonyanda Dam Latonyanda Dam in Latonyanda River	Luvuvhu dam Feasibility Study (Feasibility)	1997	• Will reduce Nandoni Yield • Will reduce demand imposed on Nandoni • Provide yield replacement in Albasini dam • Will mainly provide operational benefits
	Proposed assessments in the Reconciliation Study:			**Comments:**
	• Re-determine yield benefit and yield reduction on Nandoni Dam • Cost & economic evaluation			• Also see Option 1 & 3 • Do we agree with the previous economic evaluation

No.	Name of option & source	Report & Level of Assessment	Date of Assessment	Key Features
9	Paswane Dam Paswane Dam In Mutshindudi River	Luvuvhu dam Feasibility Study (Feasibility)	1997	• Dam is located at lower end of the Mutshindudi River d/s of Vondo Dam just before confluence with the Luvuvhu River d/s of Nandoni • Can be used to supply Lower nandoni supply area as well as part of EWR for KNP
	Proposed assessments in the Reconciliation Study:			**Comments:**
	• Re-determine yield benefit and yield reduction on Nandoni Dam • Cost & economic evaluation			Might be follow up option after Nandoni fully utilized.

No.	Name of option & source	Report & Level of Assessment	Date of Assessment	Key Features
9	Xikundu Dam In Luvuvhu River	Luvuvhu dam Feasibility Study (Feasibility)	1997	• Xikundu Weir was buildt at this site. • Possibility of a larger storage dam in future
	Proposed assessments in the Reconciliation Study:			**Comments:**

Table A-1b: Issues identified – Luvuvhu Main catchment Area

Issues Luvuvhu Basin			
No.	**Water resource/sub-system**	**Issue description**	**Action**
1	Nandoni water supply system	A large number of demand centres is in the planning process to be supplied from Nandoni Dam and the list keeps growing. Decission need to be taken to decide who will in the end received water from Nandoni to avoid over allocation of the resource	All possible supply options will be evaluated as part of the reconciliation process and prioritised.The priority list will be used as the basis to decide on the demand centres that will be recommended for support or full supply from the Nandoni water supply system.
2	Nandoni water supply system	Reduction in the Nandoni Sub-system Yield – sensitive to operating rule	The Nandoni Sub-system should be operated in order to maximise the utilisation of the incremental inflow between Nandoni Dam and Mhinga Weir
3	Upper Luvuvhu Basin	Tshivahe Tea plantations and related water requirements need to be confirmed, as large areas of these plantations is currently not being utilised	Obtain future planning of these area

Table A-2: Augmentation options identified from the literature – Mutale River Catchment Area

<table>
<tr><th>No.</th><th>Name of option</th><th>Report & Level of Assessment</th><th>Date of Assessment</th><th>Key Features</th></tr>
<tr><td rowspan="3">1</td><td>Water conservation and demand management</td><td>Mutale River Water Resources Investigation & Luvuvhu / Letaba Water Resources Situation Assessment Study

(Reconnaissance)</td><td>1999 & 2003</td><td>Existing water shortages could be reduced through improvements in the efficiency of water use through water conservation and demand management.
Introduction of more ecologically sound agricultural practices including realistic stock levels
It was recommended that water conservation and demand management objectives and goals that are likely to be achieved in the Mutale River Catchment should be identified and that measures should be taken to implement these.</td></tr>
<tr><td colspan="3">Proposed assessments in the Reconciliation Study</td><td>Comments:</td></tr>
<tr><td colspan="3">Identify potential savings that can be achieved through imporved irrigation efficiencies
Identify potential savings that can be achieved in the urban/domestic sector
Identify WC/WDM objectives and goals that are likely to be achieved in the Mutale River Catchment should be identified and that measures should be taken to implement these.</td><td></td></tr>
</table>

No.	Name of option & source	Report & Level of Assessment	Date of Assessment	Key Features
2	Groundwater Development	Mutale River Water Resources Assessment (Reconnaissance)	1999	• In the southwest catchment the net incremental benefit of using groundwater is in the order of 1 million m3/a to 2 million m3/a. • The sustainable exploitable groundwater potential in the northeast of the study area is estimated at 1.6 million m3/a. However, the poor quality of the groundwater will result in only 0.4 million m3/a being suitable for domestic use. • The total net potential increase in the utilisable water resources from groundwater is about 2 million m3/a at most. A large number of boreholes spread over a large area will however be necessary, which could potentially result in high operating costs and unit costs of distribution pipelines.
	Proposed assessments in the Reconciliation Study			**Comments:**
	• Overview of the characteristics of the groundwater resource • Re-assessment of Groundwater harvest potential, exploitation potential, baseflow per Quaternary catchment or groundwater unit and froundwater quality as per the GRAII and WSAM databases. • Derivation of a groundwater balance compared to harvest potential and recharge and level of use. • Need to determine areas of over exploitation of groundwater use • Determine areas of excess groundwater resources not yet utilised • Investigate/confirm identified groundwater quality issues • Costing and economic analysis			• The maintenance of groundwater supply systems is a disadvantage in rural supply schemes • Groundwater supply systems can be developed fairly quickly. . Proper development and management of these resources and related systems are however required.

No:	Name of option & source	Report & Level of Assessment	Date of Assessment	Key Features
3	A new dam on the Mutale River	Mutale River Water Resources Assessment Reconnaissance	1999	• Four Dam sites were identified (Rambuda middle, Rambuda downstream, Thegwe and Tswera) • On the basis of the socio-economic, cultural and/or ecological considerations the Rambuda middle and Thegwe dam sites are unlikely to be acceptable for development. • The cost of water secured by a dam at Rambuda middle is considered to be far too high. The Thengwe dam site is also situated downstream of the areas of the largest water requirements and therefore the cost of conveying the water to the consumers will be much higher then the other dams. • The most viable dam sites are the Rambuda downstream site and the Tswera site. • The potential storage at the Rambuda downstream site is limited, due to uncertain foundation conditions on the left flank. (5 million m3/a yield) • With a dam at Tswera the net incremental yield of the system at Tswera that has the least URV is 16.5 million m3/a. • The consumptive water requirements are mostly situated upstream of Tswera and therefore its usefulness could be limited. Given this limitation it may become necessary to construct both Tswera and Rambuda downstream sites to effectively supply water to the existing consumors.
	Proposed assessments in the Reconciliation Study			**Comments:**
	• Use results of the investigations of future water requirements, their spacial distribution and the effects of water conservation and demand management measures on these requriements to conduct further investigations on dams sites. • Re-determine yields of identified dam sites with updated hydrology • Cost & economic evaluation			• Mutale River was previously regarded as the tributary that should supply water for EWR purposes, as very little development exists in this catchment.

<table>
<tr><th>No:</th><th>Name of option & source</th><th>Report & Level of Assessment</th><th>Date of Assessment</th><th>Key Features</th></tr>
<tr><td rowspan="3">4</td><td>Abstraction from the Limpopo River</td><td>Luvuvhu / Letaba Water Resources Situation Assessment Study

(Reconnaissance)</td><td>2003</td><td>If development of coalfields in the northern part of the sub-catchment takes place in the future, water could be abstracted from the Limpopo River to supply the water requirements of the mines.</td></tr>
<tr><td colspan="3">Proposed assessments in the Reconciliation Study</td><td>Comments:</td></tr>
<tr><td colspan="3">Confirm water availablilty from the Limpopo River
Confirm future water requirements and their spacial distribution in relative to the Limpopo River to confirm whether the option is viable.
Further technical investigations and economic analyses should be conducted should the option seem viable.</td><td></td></tr>
</table>

Table A-2: Issues identified – Mutale River catchment Area

Issues Luvuvhu Basin			
No.	**Water resource/sub-system**	**Issue description**	**Action**
1	Groundwater	Total dissolved solids, Fluoride and Nitrate are at unacceptable levels in the northern part of the study area up to the Limpopo River	

Table A-3: Augmentation options identified from the literature – Shingwedzi River catchment Area

No:	Name of option & source	Report & Level of Assessment	Date of Assessment	Key Features
1	Groundwater Development	Luvuvhu Letaba Water Resource Situation Assessment (Reconnaissance)	2003	Identification and development of additional groundwater units to rural water supply requirements where shortages occur.
	Proposed assessments in the Reconciliation Study:			**Comments:**
				• The maintenance of groundwater supply systems is a disadvantage in rural supply schemes • Groundwater supply systems can be developed fairly quickly. . Proper development and management of these resources and related systems are however required.

No:	Name of option & source	Report & Level of Assessment	Date of Assessment	Key Features
2	Transfer from (Nandoni Dam) Xikundu Weir	Luvuvhu Letaba Water Resource Situation Assessment (Reconnaissance)	2003	Establishment of a transfer link to the transfer water from Nandoni Dam in the Luvuvhu sub-catchment, to augment the water resources in the Shingwedzi sub-catchment
	Proposed assessments in the Reconciliation Study:			**Comments:**
	• Determine the if sufficient water is available in Nandoni Dam for this purpose and the related cost			• Part of the area is already supplied from the Luvuvhu River and must be taken into account in the overall planning

Table A-4: Augmentation options identified from the literature – Groot Letaba River catchment Area

<table>
<tr><th>No:</th><th>Name of option</th><th>Level of Assessment</th><th>Date of Assessment</th><th>Key Features</th></tr>
<tr><td rowspan="3">1</td><td>Raising of Tzaneen Dam</td><td>Groot Letaba River Water Development Project

(Preliminary Design)</td><td>2010</td><td>A labyrinth spillway option is recommended for the raising of Tzaneen and will result in an additional yield of 6.0 x 10^6 m^3/annum at a 98% assurance level.</td></tr>
<tr><td colspan="3">Proposed assessments in the Reconciliation Study</td><td>Comments & Issues:</td></tr>
<tr><td colspan="3">• Re-determine incremental yield benefit
• Improve on loss estimation for releases from Tzaneen Dam in support of Nwamitwa Dam</td><td>• Losses between Tzaneen Dam and the future Nwamitwa Dam is high
• Good estimate of losses is not available</td></tr>
</table>

<table>
<tr><th>No:</th><th>Name of option</th><th>Level of Assessment</th><th>Date of Assessment</th><th>Key Features</th></tr>
<tr><td rowspan="3">2</td><td>Construction of Nwamitwa Dam</td><td>Groot Letaba River Water Development Project

(Preliminary Design)</td><td>2010</td><td>A 30.6 m high composite dam with a central conventional gravity concrete ogee spillway section and earth fill embankment flanks. Storage Capacity = 143.8 x 10^6 m^3.</td></tr>
<tr><td colspan="3">Proposed assessments in the Reconciliation Study</td><td>Comments:</td></tr>
<tr><td colspan="3">• Re-determine incremental yield benefit
• Improve on loss estimation for releases from Tzaneen Dam in support of Nwamitwa Dam</td><td>• Losses between Tzaneen dam and the future Nwamitwa Dam is high
• Good estimate of losses is not available</td></tr>
</table>

No.	Name of option	Level of Assessment	Date of Assessment	Key Features
3	Bulk Water Supply Infrastructure	Concept	2010	Potential supply area of the proposed Nwamitwa Dam and regional bulk water supply infrastructure required to serve the rural settlements in the supply area.
	Proposed assessments in the Reconciliation Study:			**Comments:**
	• Compare updated yield with demand center requirements			

No:	Name of option	Level of Assessment	Date of Assessment	Key Features
4	Construction of the Letsitele River Valley Dam also refered to as Hobsons Choice Dam	Groot Letaba Water Resource Development Feasibility Study (Feasibility)	1998	A 33.5 m high composite dam with a central conventional gravity concrete ogee spillway section and earth fill embankment flanks. Storage Capacity = 14.2 x 10^6 m^3, Yield at 98% assurance = 26.6 x 10^6 m^3/annum.
	Proposed assessments in the Reconciliation Study			**Comments:**
	• Re-determine incremental yield benefit • Update cost and economic evaluation			• Dam can be used in support of Nwamitwa. Keep storage upstream in Hobsons Choice Dam, reduce evaporation losses from Nwamitwa. Only support when required. • Need to confirm with B Pullen

No.	Name of option	Level of Assessment	Date of Assessment	Key Features
5	Construction of the Mulele Dam	Letaba Water Resource Development Study Pre-feasibility Study (Pre-feasibility)	1994	Dam site on the Molototsi River will give a yield at 98% assurance of 8.6 x 10^6 m^3/annum. Major drawbacks are the high sediment load in the river and the inundation of extensive areas under dry land crops.
	Proposed assessments in the Reconciliation Study:			**Comments:**
	• Evaluate the possibility of the dam to be used for artificial recharge of groundwater			• Possibility of sand abstraction schemes along the river also to be considered • Possibility of dam to be used for groundwater recharge

No.	Name of option	Level of Assessment	Date of Assessment	Key Features
6	Groundwater Development		2010	• Development of groundwater on a regional scalemin conjunction with bulk water supply systems
	Proposed assessments in the Reconciliation Study:			**Comments:**
	•			• The maintenance of groundwater supply systems is a disadvantage in rural supply schemes • Groundwater supply systems can be developed fairly quickly. . Proper development and management of these resources and related systems are however required. • By linking up with the bulk water supply system, will also reduce water quality related problems from groundwater sources.

Table A-4b: Issues identified – Groot Letaba River catchment Area

Issues Letaba Basin			
No.	**Water resource/sub-system**	**Issue description**	**Action**
1	Upstream of Nwamitwa & Tzaneen Dams	Reliability of hydrology	Re-do hydrology
2	Between Tzaneen & Nwamitwa dams	Losses unknown	Firm up on losses

Table A-5: Augmentation options identified from the literature – Middle and Klein Letaba River catchment Area

No:	Name of option	Level of Assessment	Date of Assessment	Key Features
1	WC/WDM	Middle Letaba Water Supply Scheme: WC/WDM Situation Assessment (Reconnaissance)	2003	Implementation of WC/MDM measures to reduce of water losses from the distribution infrastructure and achieve more efficient use of the resource in areas around Giyani where the current per capita water use is very high (above 300 ℓcd).
	Proposed assessments in the Reconciliation Study			**Comments:**

No:	Name of option	Level of Assessment	Date of Assessment	Key Features
2	Development of the Groundwater Resource	A Reconnaissance Study to Augment the Water Resources of the Klein Letaba River catchments (Reconnaissance)	2003	To develop the under-utilised groundwater resource to augment the water resources in the area and reduce dependency on the overstressed surface water resource.
	Proposed assessments in the Reconciliation Study			**Comments:**

No:	Name of option	Level of Assessment	Date of Assessment	Key Features
3	Replacement of Middle Letaba Dam – Nsami Dam Transfer Canal with a Pipeline	A Reconnaissance Study to Augment the Water Resources of the Klein Letaba River catchments (Reconnaissance)	2003	An investigation should first be carried out to determine the extent of water losses from the existing canal, and if the figures justify carry out further steps for the replacement of the canal with a pipeline and associated pumping infrastructure.
	Proposed assessments in the Reconciliation Study			**Comments:**

No.	Name of option	Level of Assessment	Date of Assessment	Key Features
4	Transfer Scheme from Nandoni Dam	A Reconnaissance Study to Augment the Water Resources of the Klein Letaba River catchments (Reconnaissance)	2003	Establishment of a transfer link to the transfer water from Nandoni Dam in the Luvuvhu sub-catchment, to augment the water resources in the Klein - Middle Letaba area
	Proposed assessments in the Reconciliation Study:			**Comments:**
				Demand imposed on Nandoni in Luvuvhu basin. Need to be taken into account in the Luvuvhu basin water balance and planning

No.	Name of option	Level of Assessment	Date of Assessment	Key Features

5	Construction of a New Dam on the Klein Letaba River	A Reconnaissance Study to Augment the Water Resources of the Klein Letaba River catchments
		(Reconnaissance)
			2003	• A composite structure, consisting of a central contrete gravity section and zoned earthfill embankment flanks was recommended following investigations of earlier studies.
				• Two possible sites on the Klein Letaba River was investigated
				  ○ Majosi Dam
				  ○ Crystalfontein site
				• The possible dam sites on the Klein Letaba River (Majosi & Crystalfontein) have two sub-options
				  ○ A large storage Dam linked with the Middle Letaba supply system
				  ○ A smaller diversion type of structure, diverting water via a canal into Middle Letaba Dam, using Middle as the storage facility

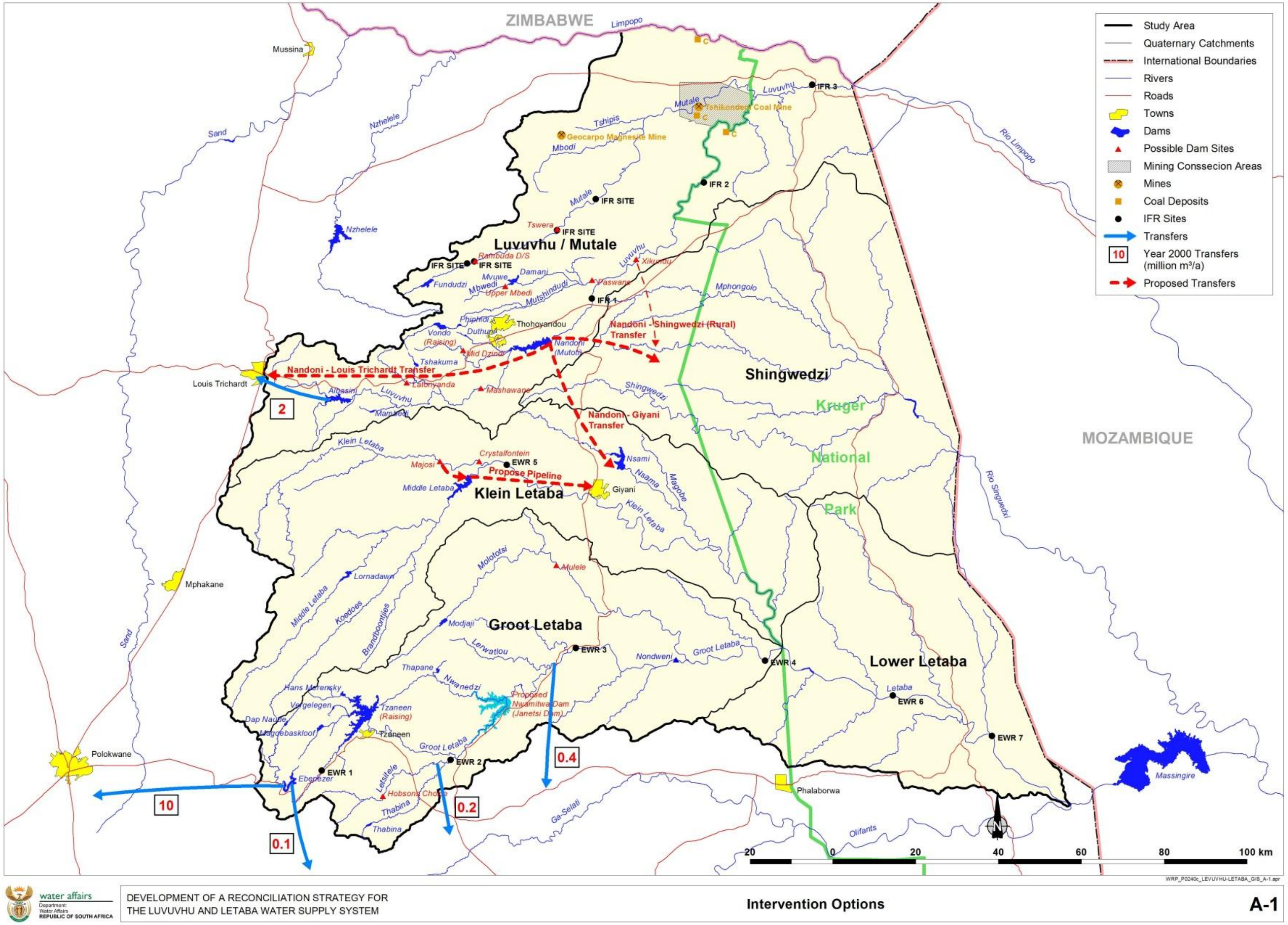
	Proposed assessments in the Reconciliation Study:			**Comments:**

No.	Name of option	Level of Assessment	Date of Assessment	Key Features
6	Remove / buy out all irrigation from Middle Letaba Dam			
	Proposed assessments in the Reconciliation Study:			**Comments:**

No.	Name of option	Level of Assessment	Date of Assessment	Key Features
7	Remove / buy out irrigation upstream of Middle Letaba Dam			
	Proposed assessments in the Reconciliation Study:			**Comments:**

Table A-5b: Issues identified – Middle & Klein Letaba River catchment Area

Issues Middle & Klein Letaba Basin			
No.	**Water resource/sub-system**	**Issue description**	**Action**
1	Groundwater systems	Operational & Maintenance of groundwater supply systems	
2	Surface Water	Operational & Maintenance of infrastructure	
3	Middle Letaba Dam	Extensive irrigation development upstream of the dam	Determine the extent of this irrigation and the effect of that on the Middle Letaba Dam yield.


ZIMBABWE
MOZAMBIQUE
Study Area
Quaternary Catchments
International Boundaries
Rivers
Roads
Towns
Dams
Possible Dam Sites
Mining Conssecion Areas
Mines
Coal Deposits
IFR Sites
Transfers
Year 2000 Transfers (million m³/a)
Proposed Transfers
Luvuvhu / Mutale
Shingwedzi
Klein Letaba
Groot Letaba
Lower Letaba
Kruger National Park
Nandoni - Louis Trichardt Transfer
Nandoni - Shingwedzi (Rural) Transfer
Nandoni - Giyani Transfer
Propose Pipeline
Louis Trichardt
Thohoyandou
Giyani
Polokwane
Tzaneen
Phalaborwa
Mussina
Mphakane
Tshikondeni Coal Mine
Geocarpo Magnesite Mine
Massingire
Proposed Nwamitwa Dam (Janetsi Dam)
2
10
0.1
0.2
0.4
20 0 20 40 60 80 100 km
DEVELOPMENT OF A RECONCILIATION STRATEGY FOR THE LUVUVHU AND LETABA WATER SUPPLY SYSTEM
Intervention Options
A-1