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LETABA CATCHMENT RESERVE DETERMINATION STUDY – SPECIALIST REPORT : **FISH** FINAL DECEMBER 2004

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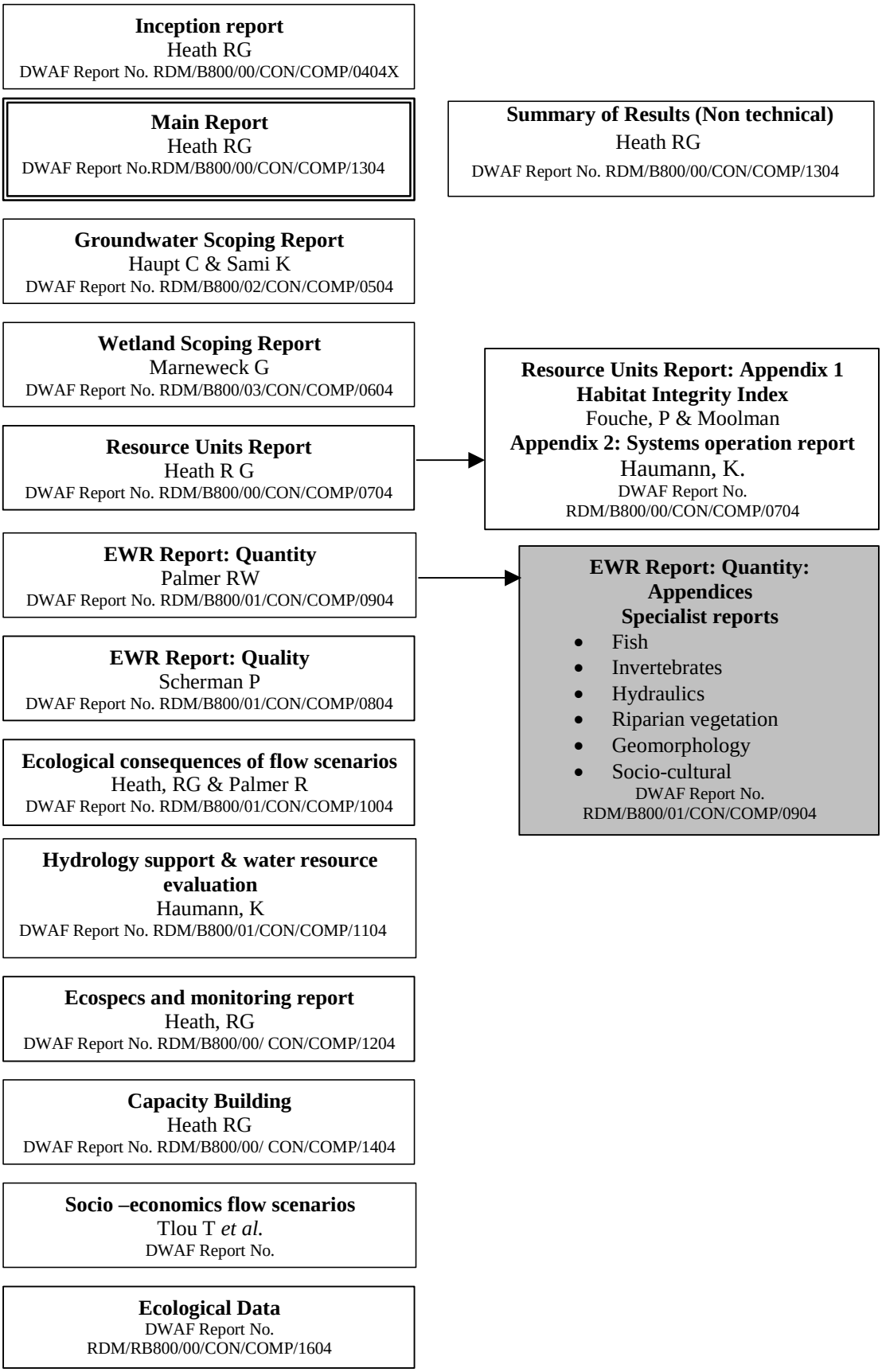
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1. IFR 1 : APPEL

1.1 DATA AVAILABILITY

1.1.1 Data sources

Historical distribution records

Saayman *et al* (1991) and Angliss (1998) reported on fish populations of the Middel Letaba Dam. Numerous fish surveys have been conducted in this dam. Nicolaai and Jooste (2002) reported on fish populations in the Tzaneen Dam. The Limpopo Province Fish Distribution Data Base has records of fish distribution for the Middel Letaba Dam, Nsama Dam, Modjadji Dam, Tzaneen Dam, and Ebenezer Dam. Fish records are also on hand for many small stock dams throughout the catchment.

In addition to the data generated in the above biomonitoring programme, which was conducted in the post 2000 flood period, and the surveys conducted by Vlok and Engelbrecht over the 1997/1998 period, many fish surveys have been conducted throughout the catchment. Data from these surveys has been captured on the Limpopo Province Fish Distribution Data Base.

Data generated by Gaigher (1968) is available in both graphical format and in electronic format. Additional data, generated against farm boundaries is available from the old Transvaal Provincial Administration electronic data set. Point source data generated by Heath and Chutter (1991) for the 1990 river survey is available in hard copy. Data generated by Engelbrecht and Hoffman (1994) as part of the IFR survey is also available as hard copy. Data for the upper catchment of the Groot Letaba catchment is limited to biomonitoring surveys, which were conducted in 2000 and 2003.

1.1.2 Confidence level of data

Level	Reason
4	Limited historical, but good recent data sets available for the upper Letaba Catchment

1.2 REFERENCE CONDITION

The data listed in Table 1.1 below reflects the expected fish species and the species collected at this site during the site visit of 15.02.04.

Table 1.1: Expected fish species collected during site visit of 15.02.04

Species expected	**Species recorded**
Amphilius uranoscopus	11
Anguilla marmorata	
Anguilla mossambica	
Barbus eutaenia	
Barbus lineomaculatus	
Barbus neefi	
Barbus paludinosus	
Barbus trimaculatus	
Barbus unitaeniatus	
Barbus viviparus	
Chiloglanis pretoriae	42
Clarias gariepinus	1
Labeo cylindricus	
Labeo molybdinus	
Labeoarbus marequensis	51
Marcusenius macrolepidotus	
Mesobola brevianalis	
Micralestes acutidens	
Opsaridium peringueyi	
Petrocephalus wesselsi	
Pseudocrenilabrus philander	2
Tilapia sparrmanii	23
Total 22	**6**

Comments:
The two eel species most probably do not migrate to this Resource Unit since the development of Massingir Dam. Although residual populations may still exist, they are also considered to be absent for the purposes of this exercise. OPER is considered lost. BEUT, BLIN, LMOL, LCYL, MMAC and PCAT have low abundance. No records of alien fish, but MSAL, and MDOL are known to occur in the upper catchment.

1.3 PES

The current PES of this resource unit is “Class C” which is reflected in the following FRAI table.

Table 1.2: FRAI Tables

METRICS		SCORES	COMMENTS
FLOW-DEPTH CLASS			
Frequency of occurrence of species with very high and high preference for FAST-DEEP conditions	FFD	-2	OPER is missing from the system and AMOS no longer migrates. BEUT, BLIN and Labeo spp. in low abundance. AURA and CPRE are still abundant.
Frequency of occurrence of species with very high and high preference for FAST-SHALLOW conditions	FFS	-2	AMOS absent, BEUT and Labeo spp. in low abundance.
Frequency of occurrence of species with very high and high preference for SLOW-DEEP conditions	FSD	-2	OPER is missing from the system but habitat is abundant. Eels no longer migrate. FOO for other species are reduced.
Frequency of occurrence of species with very high and high preference for SLOW-SHALLOW conditions	FSS	-2	Abundance of BLIN, MMAC and PCAT reduced.
FLOW MODIFICATION			
Frequency of occurrence of species intolerant of no-flow conditions	FI	-2	CPRE remain abundant, suggesting that the above may not be entirely flow related.
Frequency of occurrence of species moderately intolerant of no-flow conditions	FMI	-2	Low FOO of Labeo spp.
Frequency of occurrence of species moderately tolerant of no flow conditions	FMT	-2	Eels lost but not entirely due to flow. Lowered FOO of other species.
Frequency of occurrence of species tolerant of no flow conditions	FT	0	No apparent change.
Presence of catadromous spp.	CAT	-4	Eels no longer migrating.
Presence of migratory spp.	MIG	-1	Low FOO of Labeo spp.
COVER			
Frequency of occurrence of species with a very high to high preference for overhanging vegetation	OV	-1	Reduced abundance of Barbs, Mmac and Pcat.
Frequency of occurrence of species with a very high to high preference for undercut banks and root wads	UB	-2	Loss of eels not entirely due to cover. Reduced abundance of Barb spp. MMAC and PCAT
Frequency of occurrence of species with a high to very high preference for a particular substrate type	SUB	-2	Loss of eels not entirely due to cover. Reduced abundance of BEUT, BLIN and Labeo spp
Frequency of occurrence of species with a high to very high preference for aquatic macrophytes	AMAC	0	Macrophytes are uncommon. No observed change.
Frequency of occurrence of species with a very high to high preference for the water column	WC	-2	OPER lost, MMAC and PCAT show reduced FOO. May not be due to lack of water column cover.

HEALTH/CONDITION			
Health of species intolerant of modified water quality	ITH	-0.5	Red data OPER is missing while BLIN and BEUT have reduced FOO.
Health of species moderately intolerant of modified water quality	MIH	-0.5	Reduced FOO of labeo spp.
Health of species moderately tolerant of modified water quality	MTH	-0.5	Loss of eels not entirely due to water quality, but may be a factor.
Health of species tolerant of modified water quality	HT	-0.5	No observed change, but fish may be affected by temperature.
INTRODUCED SPECIES			
The potential impact of introduced predaceous spp?	IP	0	
How widespread (frequency of occurrence) are introduced predaceous spp?	FP	0	
The potential impact of introduced habitat modifying spp?	IH	0	
How widespread (frequency of occurrence) are habitat modifying spp?	FH	0	

Table 1.3: Weighted and Ranked Metrics and Final PES Score

			Fish PES : Based on weights of metric groups			
Fish PES metric group		**Metric group: calculated score**	**Calculated weight**	**Weighted score for group**	**Rank of metric group**	**% Weight for metric group**
Flow-depth metrics	FD	60.00	0.20	12.20	4.00	60.00
Flow modification metrics	FM	57.93	0.34	19.64	1.00	100.00
Cover metrics	CM	67.00	0.22	14.76	3.00	65.00
Health/condition metrics	HM	90.00	0.24	21.36	2.00	70.00
Impact of introduced SPP (negative)	IS	0.00	0.00	0.00	5.00	0.00
			1.00			295.00
Fish PES				67.96		
Fish PES Category				C		

Table 1.4: Present Ecological state of IFR site 1

PES	CAUSES	SOURCES	FLOW/NON - FLOW RELATED
C	Field surveys (February 2004) yielded only 6 of 22 fish species which were expeced to occur under natural conditions. It is thought that the two eel species (*Anguilla marmorata* and *Anguilla mossambica*) are unable to migrate to this Resource Unit. The red data fish *Opsaridium peringueyi* has not been recorded in this catchment in recent surveys and is now also considered lost. Recent surveys also indicate that a further seven species of fish have a low frequency of occurrence (*Barbus eutaenia, B. lineo-maculatus, Labeo molybdinus, Labeo cylindricus, Marcusenius macrolepidotus* and *Petrocep-halus wesselsi*)	Flow in this Resource Unit is largely regulated by releases from Ebenezer Dam. Diverse habitats are available for fish as waterfalls, cascades, rapids, riffles, runs and deep pools are all present. Good cover also occurs. However, in times of drought, flows are frequently reduced to a trickle. The river at the lower end of this Resource Unit has been observed with no flow.	Flow related

1.4 TREND AND REASONS

PES	TREND	RESULTING PES	TIME	REASONS
C	Stable in the short term	**C**	Short term	No obvious ecological changes are taking place. Flow regulation has been in place since the completion Ebenezer Dam and no new dams are proposed. Small mountain tributaries provide refuge for fish and in time of low flow there are sufficient well aerated deep pools maintaining existing populations.

1.5 ALTERNATIVE ECS

APPEL CLASS D

METRICS		SCORES	COMMENTS
FLOW-DEPTH CLASS			
Frequency of occurrence of species with very high and high preference for FAST-DEEP conditions	FFD	-3.00	Decreased frequency of occurrence of all species with preference for fast deep habitats. OPER Lost permanently. CPRE, BLIN, AURA have very low FOO Probable loss of BEUT
Frequency of occurrence of species with very high and high preference for FAST-SHALLOW conditions	FFS	-3.00	Decreased frequency of occurrence of all species with preference for fast deep habitats. OPER Lost permanently. CPRE, BLIN, BEUT, AURA have very low FOO
Frequency of occurrence of species with very high and high preference for SLOW-DEEP conditions	FSD	-2.00	OPER is missing from the system but habitat is abundant. Eels no longer migrate. Abundances for other species are reduced.
Frequency of occurrence of species with very high and high preference for SLOW-SHALLOW conditions	FSS	-5.00	Abundance of BLIN, MMAC and CAT reduced.
FLOW MODIFICATION			
Frequency of occurrence of species intolerant of no-flow conditions	FI	-3	All intolerant species have very low FOO. Probable loss of BEUT
Frequency of occurrence of species moderately intolerant of no-flow conditions	FMI	-3	Reduced FOO of semi rheophilic species.i.e. Low FOO of Labeo spp. and LMAR
Frequency of occurrence of species moderately tolerant of no flow conditions	FMT	-2	Eels lost but not entirely due to flow. Lowered abundances of other species.
Frequency of occurrence of species tolerant of no flow conditions	FT	0	No apparent change.
Presence of catadromous spp.	CAT	-5	Eels no longer migrating.
Presence of migratory spp.	MIG	-1	Low abundance of Labeo spp.
COVER			
Frequency of occurrence of species with a very high to high preference for overhanging vegetation	OV	-3	Low FOO of Barbs, MMAC and PCAT. Probable loss of BEUT
Frequency of occurrence of species with a very high to high preference for undercut banks and root wads	UB	-2.5	Low FOO of Barb spp. MMAC and PCAT. Probable loss of BEUT.
Frequency of occurrence of species with a high to very high preference for a particular substrate type	SUB	-2.5	Reduced FOO of BLIN and Labeo spp. Probable loss of BEUT.
Frequency of occurrence of species with a high to very high preference for aquatic macrophytes	AMAC	0	Macrophytes are uncommon. No observed change.
Frequency of occurrence of species with a very high to high preference for the water column	WC	-2	OPERlost, MMAC and PCAT reduced abundance. May not be due to lack of water column cover.

HEALTH/CONDITION			
Health of species intolerant of modified water quality	ITH	-0.5	Red data OPER is missing while BLIN and BEUT have reduced abundance.
Health of species moderately intolerant of modified water quality	MIH	-0.5	Reduced abundance of labeo spp.
Health of species moderately tolerant of modified water quality	MTH	-0.5	Loss of eels not entirely due to water quality, but may be a factor.
Health of species tolerant of modified water quality	HT	-0.5	No observed change, but fish may be affected by temperature.
INTRODUCED SPECIES			
The potential impact of introduced predaceous spp?	IP	0	
How widespread (frequency of occurrence) are introduced predaceous spp?	FP	0	
The potential impact of introduced habitat modifying spp?	IH	0	
How widespread (frequency of occurrence) are habitat modifying spp?	FH	0	

APPEL CLASS D: WEIGHTED AND RANKED METRICS AND FINAL PES SCORE

			Fish PES : Based on weights of metric groups			
Fish PES metric group		**Metric group: calculated score**	**Calculated weight**	**Weighted score for group**	**Rank of metric group**	**% Weight for metric group**
Flow-depth metrics	FD	37.29	0.20	7.58	4.00	60.00
Flow modification metrics	FM	43.45	0.34	14.73	1.00	100.00
Cover metrics	CM	50.17	0.22	11.05		65.00
Health/condition metrics	HM	90.00	0.24	21.36	3.00	70.00
Impact of introduced spp (negative)	IS	0.00	0.00	0.00	2.00	0.00
			1.00		5.00	295.00
Fish PES				54.72		
Fish PES Category				D		

2. IFR 2: LETSITELE TANK

2.1 DATA AVAILABILITY

2.1.1 Data sources

Historical distribution records
The information in the introductory paragraph of item 1.1 also applies to this site. The table below shows the historical dates for which data exists for the Letsitele River. The 1994 Letaba IFR survey (with later refinements) relied upon 3 IFR sites outside of the KNP and two sites inside the KNP. It is important to note that the second site in the table, namely the IFR site at Letsitele tank bridge was one of the selected three sites out of the KNP and is the site selected for the current survey.

Table 2.1: Historical fish survey dates for sites on the Letsitele and Thabina rivers
(Adapted from Limpopo Province Fish Distribution Data Base. Updated May 2003)

	May 1996	August 1996	January 2001
Letsitele (Craighead Estate)			X
Letsitele (Tank Bridge, IFR site)	X	X	X
Thabina (Bridge below Ramodike Dam)		X	X

2.1.2 Confidence level of data

Level	Reason
5	Well known site for biomonitoring and for previous IFRs Extensive data sets available for the whole catchment Good indicator species with at least 4 species as indicators of flow.

2.2 REFERENCE CONDITION

The data listed in Table 2.2 below reflects the expected fish species and the species collected at this site during the site visit of 15.02.04.

Table 2.2: Expected fish species collected during site visit of 15.02.04

Species expected	**Species recorded**
Amphilius uranoscopus	
Anguilla marmorata	
Anguilla mossambica	
Barbus eutaenia	1
Barbus lineomaculatus	
Barbus neefi	
Barbus paludinosus	
Barbus toppini	
Barbus trimaculatus	
Barbus unitaeniatus	
Barbus viviparus	83
Chiloglanis paratus	1
Chiloglanis pretoriae	70
Clarias gariepinus	3
Glossogobius callidus	
Glossogobius giuris	
Labeo cylindricus	8
Labeo molybdinus	5
Labeo rosae	
Labeo ruddi	
Labeobarbus marequensis	30
Marcusenius macrolepidotus	
Mesobola brevianalis	20
Micralestes acutidens	20
Opsaridium peringueyi	
Oreochromis mossambicus	66
Petrocephalus wesselsi	
Pseudocrenilabrus philander	64
Schilbe intermedius	
Synodontis zambezensis	
Tilapia rendalli	>100
Tilapia sparrmanii	
Total 32	**13**

2.3 PES

The current PES of this resource unit is “Class C” which is reflected in the following FRAI table.

Table 2.3: FRAI tables

METRICS		SCORES	COMMENTS
FLOW-DEPTH CLASS			
Frequency of occurrence of species with very high and high preference for FAST-DEEP conditions	FFD	-3	OPER and migratory AMOS. Reduced FOO of AURA and BEUT
Frequency of occurrence of species with very high and high preference for FAST-SHALLOW conditions	FFS	-2	Loss of AMOS and reduced FOO of AURA and BEUT
Frequency of occurrence of species with very high and high preference for SLOW-DEEP conditions	FSD	-2	Habitat is abundant but species associated with the habitat are absent or low in abundance. (Loss of migratory eels and the red data OPER. Low FOO of BLIN, BNEE LRUD and LROS, PWES, SINT and SZAM). The situation can not be attributed to lack of habitat but rather migration barriers and reduced breeding habitats.
Frequency of occurrence of species with very high and high preference for SLOW-SHALLOW conditions	FSS	-1	Only GGIU is absent. It may be the case that early records were misidentified. GCAL is still present. May be due to migration barriers.
FLOW MODIFICATION			
Frequency of occurrence of species intolerant of no-flow conditions	FI	-2	Loss of the red data OPER and reduced FOO of AURA and BEUT
Frequency of occurrence of species moderately intolerant of no-flow conditions	FMI	-1	Reduced FOO of all species.
Frequency of occurrence of species moderately tolerant of no flow conditions	FMT	-1	Absence of eels attributable to other factors. Reduced FOO of other species.
Frequency of occurrence of species tolerant of no flow conditions	FT	-1	Loss og GCAl attributed to other factors. Reduced FOO of LROS and LROS.
Presence of catadromous spp.	CAT	-4	Loss of AMAR, AMOS and GCAL, not entirely attributable to flow.
Presence of migratory spp.	MIG	-1	Labeo spp. and LMAR are present in low abundance.

COVER METRICS			
Frequency of occurrence of species with a very high to high preference for overhanging vegetation	OV	-2	General loss of abundance.
Frequency of occurrence of species with a very high to high preference for undercut banks and root wads	UB	-2	Loss of eels attributable to other factors. Reduced FOO of MMAC and PCAT
Frequency of occurrence of species with a high to very high preference for a particular substrate type	SUB	-2	Loss of eels and gobies not related to habitat. Reduced FOO of AURA, BEUT, BLIN and BNEE.
Frequency of occurrence of species with a high to very high preference for aquatic macrophytes	AMAC	-1	Reduced FOO of BPAU and BVIV.
Frequency of occurrence of species with a very high to high preference for the water column	WC	-1	Loss of OPER is thought to be more related to water quality than cover. There is a general reduction in FOO of species associated with this habitat. This may be attributable to fishing with shade net rather than quality of habitat.
HEALTH/CONDITION			
Health of species intolerant of modified water quality	ITH	-1.5	OPER has been lost, probably as a result of flow and water quality problems. AURA, BEUt and BLIN are less abundant
Health of species moderately intolerant of modified water quality	MIH	-1	Reduced FOO only.
Health of species moderately tolerant of modified water quality	MTH	0	Migratory species lost for other reasons. FOO's lowered.
Health of species tolerant of modified water quality	HT	0	FOO's lowered.
INTRODUCED SPECIES			
The potential impact of introduced predaceous spp?	IP	0	
How widespread (frequency of occurrence) are introduced predaceous spp?	FP	0	
The potential impact of introduced habitat modifying spp?	IH	0	
How widespread (frequency of occurrence) are habitat modifying spp?	FH	0	

Table 2.4: Weighted and ranked metrics and final PES score

			Fish PES : Based on weights of metric groups			
Fish PES metric group		**Metric group: calculated score**	**Calculated weight**	**Weighted score for group**	**Rank of metric group**	**% Weight for metric group**
Flow-depth metrics	FD	54.51	0.28	15.19	2.00	85.00
Flow modification metrics	FM	66.11	0.33	21.68	1.00	100.00
Cover metrics	CM	65.00	0.23	14.92	2.00	70.00
Health/condition metrics	HM	82.40	0.16	13.51	3.00	50.00
Impact of introduced spp (negative)	IS	0.00	0.00	0.00	5.00	0.00
			1.00			305.00
Fish PES				65.29		
Fish PES Category				C		

Table 2.5: Present Ecological state of IFR site 2

PES	Causes	Sources	Flow/Non-flow related
C	Only 13 of the 32 fish species ex-pected were collected in this field survey. The two eel species (*Anguilla marmorata* and *A. mos-sambica*) are unable to migrate to this Resource Unit since the deve-lopment of Massingir Dam and are now considered to be absent. The migratory goby *Glossogobius giuris* and the red data fish *Opsa-rdium peringueyi* has not been recorded in this catchment in re-cent surveys and is also consider-ed lost. Ten more species have a low frequency of occurrence (*Amphilius uranoscopus, Barbus eutaenia, B. lineomaculatus, B. neefi, Glossogobius callidus, Labeo rosae, L. ruddi, Petroce-phalus wesselsi, Schilbe interme-dius and Synodontis zambezensis*)	System fragmentation due to numerous dams and weirs is the major factor, which limit fish recruitment and distribution. Water quality is deteriora-ting due to expanding rural settlements and poor veld management is responsible for an increa-se in erosion and the deposi-tion of sediments. Flow is impacted upon by the nume-rous farm dams and weirs in the upper Letsitele Catch-ment and by the Ramodike Dam in Thabina River. In times of drought, flows fre-quently become a trickle and algal mats occur. At the lower end periods with no flow have been observed.	Flow related and non-flow related.

2.4 TREND AND REASONS

PES	TREND	RESULTING PES	TIME	REASONS
C	Negative	**C/D**	short-term	Declining water, quality in-creased salt loads and rural community activities are impacting negatively on fish health. Lower flow and resulting shallower pools are leading to a rise in water temperature. Reduced seaso-nal variations in flow due to the placement of dams and weirs. The Ramodike Dam was recently raised and no water flows past the dam, while numerous recent farm "off channel storage dams" have been developed. Poor veld conditions are leading to accelerated erosion, which in turn is impacting on benthic habitats. Spawning beds are being inundated and lost. Pools are silting up. There are few tributaries providing refuge but the declining habitat when combined with ces-sation of flows and declining water quality is leading to a reduced fish assemblage.

2.5 ALTERNATIVE ECS

None considered.

3. IFR 3: PRIESKA

3.1 DATA AVAILABILITY

3.1.1 Data sources

Historical distribution records
The information in the introductory paragraph of item 1.1 also applies to this site. The table below shows the historical dates for which data exists for the Letaba River. Table 3.1 shows that surveys were carried in close vicinity to the present site namely at Groot Letaba pump house (two surveys), just downstream of the site at Prieska weir (six surveys) and on Prieska Farm (three surveys) over a period of six years. The site at the weir was also selected as a biomonitoring site for the surveys of the 2001 RHP program.

Table 3.1: Historical fish survey dates for sites on the Letaba River. (Adapted from Limpopo Province Fish Distribution Data Base. Updated May 2003)

		Aug 91	Nov 91	May 92	Jun 92	Feb 94	Dec 95	Feb 96	May 96
Groot Letaba	Nkowankowa bridge	X	X	X	X	X	X		
Groot Letaba	Junction Weir	X	X	X	X		X		
Groot Letaba	Nagude	X	X	X	X		X		
Groot Letaba	Pump House		X		X				
Groot Letaba	Prieska Weir	X	X	X	X			X	X
Groot Letaba	Prieska Farm	X	X	X					

3.1.2 Confidence level of data

Level	Reason
5	The area is well known for biomonitoring and for previous IFRs, but this specific site has not been used before. It is however felt that this site is better than the previous Site below Prieska Weir. Extensive data sets available for the whole catchment. Two good indicators expected but only one small fish indicator of flow is still present.

3.2 REFERENCE CONDITION

The data listed in Table 3.2 below reflects the expected fish species and the species collected at this site during the site visit of 16.02.04

Table 3.2: Expected fish species collected during site visit of 16.02.04

Species expected	**Species recorded**
Anguilla marmorata	
Anguilla mossambica	
Barbus eutaenia	
Barbus paludinosus	
Barbus radiatus	
Barbus toppini	3
Barbus trimaculatus	6
Barbus unitaeniatus	1
Barbus viviparus	7
Brycinus imberi	
Chiloglanis paratus	42
Chiloglanis pretoriae	10
Clarias gariepinus	1
Glossogobius callidus	
Glossogobius giuris	
Labeo cylindricus	6
Labeo molybdinus	26
Labeo rosae	
Labeo ruddi	
Labeoarbus marequensis	>100
Marcusenius macrolepidotus	
Mesobola brevianalis	50
Micralestes acutidens	>200
Oreochromis mossambicus	45
Petrocephalus wesselsi	
Pseudocrenilabrus philander	1
Schilbe intermedius	
Synodontis zambezensis	
Tilapia rendalli	23
29 species expected	**15 species recorded**

3.3 PES

The current PES of this resource unit is “Class C” which is reflected in the following FRAI table.

Table 3.3: FRAI table of Prieska (PES C)

METRICS		SCORES	COMMENTS
FLOW-DEPTH CLASS			
Frequency of occurrence of species with very high and high preference for FAST-DEEP conditions	FFD	-2	Only BEUT lost. The site has very diverse habitat. Reduced FOO of most species.
Frequency of occurrence of species with very high and high preference for FAST-SHALLOW conditions	FFS	-2	Only BEUT Lost. Reduced FOO for other species.
Frequency of occurrence of species with very high and high preference for SLOW-DEEP conditions	FSD	-2	Slow deep habitats are abundant throughout the year. The absence of 3 migratory species is largely attributed to system fragmentation. FOO of remaining species reduced.
Frequency of occurrence of species with very high and high preference for SLOW-SHALLOW conditions	FSS	-2	The FOO of barbs is declining.
FLOW MODIFICATION			
Frequency of occurrence of species intolerant of no-flow conditions	FI	-2	BEUT has been lost, while CPRE is becoming less abundant.
Frequency of occurrence of species moderately intolerant of no-flow conditions	FMI	-2	All expected species present but FOO reducing
Frequency of occurrence of species moderately tolerant of no flow conditions	FMT	-1	FOO of all species reducing but all expected species still present.
Frequency of occurrence of species tolerant of no flow conditions	FT	-1	All expected species present, but FOO reducing
Presence of catadromous spp.	CAT	-4	The two eel species and GGIU most probably do not migrate to this RU since the development of Massingir Dam. Although residual populations may still exist, they are also considered to be absent.
Presence of migratory spp.	MIG	-2	All migratory species have been lost, but local movers such as BMAR, LMOL and LCYL are still present and breeding in the available habitat.
COVER METRICS			
Frequency of occurrence of species with a very high to high preference for overhanging vegetation	OV	-2	Only BEUT are absent. Abundances of all other dependent species are declining due to a reduction in marginal cover.
Frequency of occurrence of species with a very high to high preference for undercut banks and root wads	UB	-2	BEUT lost. FOO of other species declining.
Frequency of occurrence of species with a high to very high preference for a particular substrate type	SUB	-3	BEUT absent. FOO of other species declining. Habitat availability declining due to deposition of sediments and inundation.
Frequency of occurrence of species with a high to very high preference for aquatic macrophytes	AMAC	0	Indigenous macrophytes not common in this reach. No discernible change. Continued proliferation of the noxious weed Water Hyacinth may benefit these species in the short term.
Frequency of occurrence of species with a very high to high preference for the water column	WC	-1	Only the migratory BIMB lost. Other species have reduced FOO.

HEALTH/CONDITION			
Health of species intolerant of modified water quality	ITH	-2	Only 1 of 2species lost. BEUT absent while CPRE less abundant. Water temperatures may be a factor in the dry season.
Health of species moderately intolerant of modified water quality	MIH	-1	Only the migratory BIMB lost. Water quality may be a contributing factor to their absence.
Health of species moderately tolerant of modified water quality	MTH	-1	FOO of all species declining.
Health of species tolerant of modified water quality	HT	-0.5	FOO of all species declining.
INTRODUCED SPECIES			
The potential impact of introduced predaceous spp?	IP	0	
How widespread (frequency of occurrence) are introduced predaceous spp?	FP	0	
The potential impact of introduced habitat modifying spp?	IH	0	
How widespread (frequency of occurrence) are habitat modifying spp?	FH	0	

Table 3.4: Weighted and ranked metrics and final PES score

			Fish PES : Based on weights of metric groups			
Fish PES metric group		**Metric group: calculated score**	**Calculated weight**	**Weighted score for group**	**Rank of metric group**	**% Weight for metric group**
Flow-depth metrics	FD	60.00	0.24	14.33	2.00	80.00
Flow modification metrics	FM	58.18	0.30	17.37	1.00	100.00
Cover metrics	CM	63.68	0.24	15.21	2.00	80.00
Health/condition metrics	HM	76.33	0.22	17.09	3.00	75.00
Impact of introduced spp (negative)	IS	0.00	0.00	0.00	4.00	0.00
			1.00			335.00
Fish PES				63.99		
Fish PES Category				C		

Table 3.5: Present Ecological state of IFR site 3

PES	Causes	Sources	Flow/Non-flow related
C	Only 15 of the 29 fish species expected were collected in this field survey. The two eel species (*A. marmorata* and *A. mossambica*) are unable to migrate to this Resource Unit because of the Massingir Dam. The migratory *G. giuris and B. imberi* as well as the highly sensitive and flow dependent *B. eutaenia* is also considered lost. The latter, a cooler water specie, did how-ever only occur here when conditions were favourable. The fragmentation of the system has resulted in a stable, but somewhat artificial fish population. Cool water species are unable to migrate down to this area, while the warmer water lowveld species of the are unable to migrate up. The remaining species have adapted and appear to be surviving. Even species that need fast flowing water for breeding purposes appear to do well, suggesting that abundant breeding habitats remain.	Fragmentation of the system by numerous dams and weirs both up and downstream of this Resource Unit is considered to be a major factor, which is limiting fish recruitment and distribution. Flow in this Resource Unit is regulated from Tzaneen Dam and is impacted upon by the occurrence of numerous additional dams throughout the catchment. Diverse habitats are available for fish such as rapids, riffles, runs and deep pools. Good cover also occurs. However, in times of drought, flows are frequently reduced to a trickle.	Flow

3.4 TREND AND REASONS

PES	TREND	RESULTING PES	TIME	REASONS
C	Stable	C	Short-term	There have been no recent dam developments in this Resource Unit. Developments in the upper catchment are currently being compensated for by an existing managed flow regime. Land use and veld conditions remain stable, largely due to the dominant agriculture industry. Flow regulation has been in place since the construction of Tzaneen Dam. In times of low flow, there are sufficient “well aerated” deep pools with good water quality to maintain those species which still occur. Those species which now occur in this Resource Unit appear to have stable populations.

3.5 ALTERNATIVE ECS

Table 3.6: Prieska Class B

METRICS		SCORES	COMMENTS
FLOW-DEPTH CLASS			
Frequency of occurrence of species with very high and high preference for FAST-DEEP conditions	FFD	-1	BEUT remains absent but the site has improving diversity of habitat. FOO of most species good.
Frequency of occurrence of species with very high and high preference for FAST-SHALLOW conditions	FFS	-1	Only BEUT Lost. FOO for other species good.
Frequency of occurrence of species with very high and high preference for SLOW-DEEP conditions	FSD	1	Slow deep habitats are abundant throuhout the year. FOO of species with SD preference may be increasing.
Frequency of occurrence of species with very high and high preference for SLOW-SHALLOW conditions	FSS	0	The FOO of barbs is high.
FLOW MODIFICATION			
Frequency of occurrence of species intolerant of no-flow conditions	FI	-1	BEUT has been lost, while the FOO of CPRE is improving.
Frequency of occurrence of species moderately intolerant of no-flow conditions	FMI	-1	All expected species present and FOO improving
Frequency of occurrence of species moderately tolerant of no flow conditions	FMT	0	FOO of all species is good and as expected.
Frequency of occurrence of species tolerant of no flow conditions	FT	1	All expected species present and FOO may be improving.
Presence of catadromous spp.	CAT	-4	See comment on data page
Presence of migratory spp.	MIG	-2	All migratory species have been lost, but local movers such as BMAR, LMOL and LCYL are still present and breeding in the available habitat.
COVER			
Frequency of occurrence of species with a very high to high preference for overhanging vegetation	OV	-1	BEUT remain absent. Abundances of all other dependent species improving due to a improvement in marginal cover.
Frequency of occurrence of species with a very high to high preference for undercut banks and root wads	UB	-0.5	BEUT lost. Increased cover resulting in increased FOO of other expected species.
Frequency of occurrence of species with a high to very high preference for a particular substrate type	SUB	-1	BEUT remain absent. FOO of other species improving. Habitat availability improving due to increased base flows and removal of previously deposited sediments. Interstitial spaces exposed.
Frequency of occurrence of species with a high to very high preference for aquatic macrophytes	AMAC	0	Indigenous macrophytes not common in this reach. No discernible change. Continued proliferation of the noctious weed Water Hyacinth may benefit these species in the short term.

Frequency of occurrence of species with a very high to high preference for the water column	WC	-0.5	Only the migratory BIMB lost. Other species have improved FOO.
HEALTH/CONDITION			
Health of species intolerant of modified water quality	ITH	-0.5	BEUT remain absent while the FOO of CPRE improving due to improved habitat and water quality. Water temperatures becoming more stable.
Health of species moderately intolerant of modified water quality	MIH	1	Only the migratory BIMB lost. Water quality may be a contributing factor to their absence.
Health of species moderately tolerant of modified water quality	MTH	1	FOO of all species improving.
Health of species tolerant of modified water quality	HT	1	FOO of all species Improving.
INTRODUCED SPECIES			
The potential impact of introduced predaceous spp?	IP	0	
How widespread (frequency of occurrence) are introduced predaceous spp?	FP	0	
The potential impact of introduced habitat modifying spp?	IH	0	
How widespread (frequency of occurrence) are habitat modifying spp?	FH	0	

Table 3.7: Weighted and ranked metrics and final PES score (Prieska EC B)

			Fish PES : Based on weights of metric groups			
Fish PES metric group		**Metric group: calculated score**	**Calculated weight**	**Weighted score for group**	**Rank of metric group**	**% Weight for metric group**
Flow-depth metrics	FD	84.38	0.24	20.15	2.00	80.00
Flow modification metrics	FM	70.00	0.30	20.90	1.00	100.00
Cover metrics	CM	86.58	0.24	20.68	2.00	80.00
Health/condition metrics	HM	82.67	0.22	18.51	3.00	75.00
Impact of introduced spp (negative)	IS	0.00	0.00	0.00	4.00	0.00
			1.00			335.00
Fish PES				80.23		
Fish PES Category				B		

Table 3.8: Prieska Class D

METRICS		SCORES	COMMENTS
FLOW-DEPTH CLASS			
Frequency of occurrence of species with very high and high preference for FAST-DEEP conditions	FFD	-3	Only BEUT lost. Reduced fast deep habitat contributing to the reduced FOO of CPRE.
Frequency of occurrence of species with very high and high preference for FAST-SHALLOW conditions	FFS	-3	Only BEUT lost. Reduced fast deep habitat contributing to the reduced FOO of CPRE.
Frequency of occurrence of species with very high and high preference for SLOW-DEEP conditions	FSD	-2	Slow deep habitats remain abundant throughout the year. FOO of most species threatened due to reduced connectivity between pools.
Frequency of occurrence of species with very high and high preference for SLOW-SHALLOW conditions	FSS	-3	The FOO of barbs is declining due to the reduction in slow shallow habitats, particularly where these coincide with marginal veg. cover.
FLOW MODIFICATION			
Frequency of occurrence of species intolerant of no-flow conditions	FI	-3	BEUT has been lost, while CPRE is becoming less abundant.
Frequency of occurrence of species moderately intolerant of no-flow conditions	FMI	-2	All expected species present but FOO reducing
Frequency of occurrence of species moderately tolerant of no flow conditions	FMT	-1	FOO of all species reducing but all expected species still present.
Frequency of occurrence of species tolerant of no flow conditions	FT	-1	All expected species present, but FOO reducing
Presence of catadromous spp.	CAT	-4	See comment on data page.
Presence of migratory spp.	MIG	-2	All migratory species have been lost, but local movers such as BMAR, LMOL and LCYL are still present and breeding in the available habitat.
COVER			
Frequency of occurrence of species with a very high to high preference for overhanging vegetation	OV	-3	Only BEUT are absent. Abundances of all other dependent species are declining due to a reduction in marginal cover.
Frequency of occurrence of species with a very high to high preference for undercut banks and root wads	UB	-3	BEUT lost. FOO of other species declining.
Frequency of occurrence of species with a high to very high preference for a particular substrate type	SUB	-3	BEUT absent. FOO of other species declining. Habitat availability declining due to deposition of sediments and inundation.
Frequency of occurrence of species with a high to very high preference for aquatic macrophytes	AMAC	0	Indigenous macrophytes not common in this reach. No discernible change. Continued proliferation of the noctious weed Water Hyacinth may benefit these species in the short term.
Frequency of occurrence of species with a very high to high preference for the water column	WC	-1	Only the migratory BIMB lost. Other species have reduced FOO.

HEALTH/CONDITION			
Health of species intolerant of modified water quality	ITH	**-2**	Only 1 of 2species lost. BEUT absent while CPRE less abundant. Water temperatures may be a factor in the dry season.
Health of species moderately intolerant of modified water quality	MIH	**-1**	Only the migratory BIMB lost. Water quality may be a contributing factor to their absence.
Health of species moderately tolerant of modified water quality	MTH	**-1**	FOO of all species declining. Only the migratory BIMB lost. Water quality may be a contributing factor to their absence.
Health of species tolerant of modified water quality	HT	**-0.5**	FOO of all species declining.
INTRODUCED SPECIES			
The potential impact of introduced predaceous spp?	IP	**0**	
How widespread (frequency of occurrence) are introduced predaceous spp?	FP	**0**	
The potential impact of introduced habitat modifying spp?	IH	**0**	
How widespread (frequency of occurrence) are habitat modifying spp?	FH	**0**	

Table 3.9: Weighted and ranked metrics and final PES score (Prieska EC B)

			Fish PES : Based on weights of metric groups			
Fish PES metric group		**Metric group: calculated score**	**Calculated weight**	**Weighted score for group**	**Rank of metric group**	**% Weight for metric group**
Flow-depth metrics	FD	43.75	0.24	10.45	2.00	80.00
Flow modification metrics	FM	53.64	0.30	16.01	1.00	100.00
Cover metrics	CM	55.26	0.24	13.20	2.00	80.00
Health/condition metrics	HM	76.33	0.22	17.09	3.00	75.00
Impact of introduced spp (negative)	IS	0.00	0.00	0.00	4.00	0.00
			1.00			335.00
Fish PES				56.75		
Fish PES Category				D		

4. IFR 4: LETABA RANCH

4.1 DATA AVAILABILITY

4.1.1 Data sources

Historical distribution records
The information in the introductory paragraph of item 1.1 also applies to this site. Table 4.1 below shows the historical dates for which data exists for the Letaba River. The site selected for this survey, Letaba Ranch IFR site, was also selected as a biomonitoring site for the surveys of the 2001 RHP program. The data spans over a period of six years and additional data for the sites in the area, see Table 4.1, assists in increasing the knowledge of the Resource Unit.

Table 4.1: Historical fish survey dates for sites on the Letaba River. (Adapted from Limpopo Province Fish Distribution Data Base. Updated May 2003)

River	Site	Aug 91	Nov 91	May 92	Jun 92	Jun 95	May 96
Groot Letaba	Nondweni Weir	X	X	X		X	
Groot Letaba	Slab Weir and road bridge			X	X		
Groot Letaba	Letaba Ranch camp 3		X		X		
Groot Letaba	Letaba Ranch IFR site	X	X	X	X		X

4.1.2 Confidence level of data

Level	Reason
5	Well known site for biomonitoring and for previous IFRs. Extensive data sets available for the whole catchment. Good ecological knowledge of indicator species

4.2 REFERENCE CONDITION

The data listed in table 4.2 below reflects the expected fish species and the species collected at this site during the site visit of 17.02.04.

Table 4.2: Expected fish species collected during site visit of 17.02.04

Species expected	**Species recorded**
Anguilla bengalensis	
Anguilla marmorata	
Anguilla mossambica	
Barbus afrohamiltoni	8
Barbus annectens	
Barbus mattozi	
Barbus paludinosus	
Barbus radiatus	
Barbus toppini	21
Barbus trimaculatus	28
Barbus unitaeniatus	50
Barbus viviparus	8
Brycinus imberi	
Chiloglanis paratus	35
Chiloglanis pretoriae	10
Chiloglanis engiops	
Clarias gariepinus	
Glossogobius callidus	
Glossogobius giuris	
Hydrocynus vittatus	
Labeo congoro	
Labeo cylindricus	2
Labeo molybdinus	52
Labeo rosae	
Labeo ruddi	1
Labeobarbus marequensis	29
Marcusenius macrolepidotus	
Mesobola brevianalis	>100
Micralestes acutidens	>100
Oreochromis mossambicus	>100
Petrocephalus wesselsi	
Pseudocrenilabrus philander	2
Schilbe intermedius	
Synodontis zambezensis	
Tilapia rendalli	20
35 species expected	**16 species recorded**

4.3 PES

The current PES of this resource unit is “Class C” which is reflected in the following FRAI table.

Table 4.3: FRAI table of Letaba Ranch (PES C)

METRICS		SCORES	COMMENTS
FLOW-DEPTH CLASS			
Frequency of occurrence of species with very high and high preference for FAST-DEEP conditions	FFD	-3	3 species lost. AMOS, HVIT and LCON. All are considered migratory. Fast deep habitat is abundant during the wet season when these fish would have migrated to this area. The loss of these species is more attributable to system fragmentation. The remaining species have lowered FOO.
Frequency of occurrence of species with very high and high preference for FAST-SHALLOW conditions	FFS	-2	AMOS and CSWI lost, probably due to fragmentation.
Frequency of occurrence of species with very high and high preference for SLOW-DEEP conditions	FSD	-1	Slow deep habitats are abundant throughout the year. The absence of 7 species is largely attributed to the loss of migratory species.
Frequency of occurrence of species with very high and high preference for SLOW-SHALLOW conditions	FSS	-2	2 migratory species lost. BIMB and GCAL. The FOO of barbs is declining.
FLOW MODIFICATION			
Frequency of occurrence of species moderately tolerant of no flow conditions	FMT	-1	5 migratory species lost. Remaining species have lower FOO
Frequency of occurrence of species tolerant of no flow conditions	FT	0	Only 1 migratory species lost. Remaining species have lower FOO .
Presence of catadromous spp.	CAT	-4	The three eel species and GGIU most probably do not migrate to this RU since the development of Massingir Dam. Although residual populations may still exist, they are also considered to be absent
Presence of migratory spp.	MIG	-2	All migratory species have been lost, but local movers such as LMAR, LMOL and LCYL are still present and breeding in the available habitat.
Frequency of occurrence of species intolerant of no-flow conditions	FI	-2	CSWI has been lost, while CPRE is becoming less abundant. Periods of no flow a significant factor
Frequency of occurrence of species moderately intolerant of no-flow conditions	FMI	-2	BNEE lost, but not truly expected in this RU. LCON lost due to its migratory behaviour. Other species have lower FOO
COVER			
Frequency of occurrence of species with a very high to high preference for overhanging vegetation	OV	-2	Only the migratory HVIT and BNEE are absent. FOO of all other dependent species are declining due to a reduction in marginal cover.
Frequency of occurrence of species with a very high to high preference for undercut banks and root wads	UB	-2	Migratory eels lost. Other species have lower FOO.
Frequency of occurrence of species with a high to very high preference for a particular substrate type	SUB	-2	7 species lost, but these are predominantly migratory. CSWI and BNEE lost. FOO of other species declining. Habitat availability declining due to deposition of sediments and inundation.
Frequency of occurrence of species with a high to very high preference for aquatic macrophytes	AMAC	0	Indigenous macrophytes not common in this reach.
Frequency of occurrence of species with a very high to high	WC	-2	4 migratory species lost. Other species have lower FOO.

preference for the water column			
HEALTH/CONDITION			
Health of species intolerant of modified water quality	ITH	-1	Only 1 species. CPRE less abundant. Water temperatures may be a factor in the dry season
Health of species moderately intolerant of modified water quality	MIH	-0.5	5 species lost. BNEE, BMAT CSWI HVIT BIMB. Water quality may be a contributing factor to their absence.
Health of species moderately tolerant of modified water quality	MTH	0	4 migratory species lost, while FOO of other species are declining.
Health of species tolerant of modified water quality	HT	0	no observed difference.
INTRODUCED SPECIES			
The potential impact of introduced predaceous spp?	IP	0	
How widespread (frequency of occurrence) are introduced predaceous spp?	FP	0	
The potential impact of introduced habitat modifying spp?	IH	0	
How widespread (frequency of occurrence) are habitat modifying spp?	FH	0	

Table 4.4: Weighted and ranked metrics and final PES score (Letaba Ranch EC C)

			Fish PES : Based on weights of metric groups			
Fish PES metric group		**Metric group: calculated score**	**Calculated weight**	**Weighted score for group**	**Rank of metric group**	**% Weight for metric group**
Flow-depth metrics	FD	57.50	0.24	13.73	2.00	80.00
Flow modification metrics	FM	60.45	0.30	18.05	1.00	100.00
Cover metrics	CM	65.26	0.24	15.59	2.00	80.00
Health/condition metrics	HM	91.33	0.22	20.45	3.00	75.00
Impact of introduced spp (negative)	IS	0.00	0.00	0.00	4.00	0.00
			1.00			335.00
Fish PES				67.81		
Fish PES Category				C		

Table 4.5: Present Ecological state of IFR site 4

PES	Causes	Sources	Flow/Non- flow related
C	Field surveys conducted in February 2004, yielded 9 of 20 fish species which were expected to occur under natural conditions. It is thought that *S. intermedius* and *S. zambezensis*, which prefer deep water pools, are now lost from this Resource Unit, while *L. marequensis* has not been recorded in recent surveys. There are no indications to suggest that fish health is being affected by current conditions. There are no records of alien fish species from the Klein Letaba River, but it is known that Bass and Carp are found in the Middle Letaba Dam.	Since the 2000 floods very few deep pools remain and there are few refuges in times of no flow. The lack of deep habitats consequently implies that no deep flowing fish species are present. There is little habitat fragmentation and a good seasonal flow. Base flows in this Resource Unit are seriously impacted upon by the placement of the Middle Letaba Dam. The 2000 floods removed all dams and weirs along the length of the Klein Letaba and the migration passage for fish is thus unobstructed from the Letaba River confluence.	Flow and non-flow.

4.4 TREND AND REASONS

PES	TREND	RESULTING PES	TIME	REASONS
C	Stable	**C**	Short term	Nondweni Dam was constructed in the 1990s and provides for some limited management of the lower river. Developments in the upper catchment are currently being compensated by an existing managed flow regime from Tzaneen Dam. Land use and veld conditions remain largely stable. Agriculture and the placement of Letaba Ranch provide protection to the river. Flow regulation has been in place since the construction of Tzaneen Dam. In times of low flow, there are sufficient "well aerated" deep pools with good water quality to maintain those species, which still occur. The populations of species that now occur in this Resource Unit appear to be stable.

4.5 ALTERNATIVE ECS

Table 4.6: FRAI Table Letaba Ranch (Class D)

METRICS		SCORES	COMMENTS
FLOW-DEPTH CLASS			
Frequency of occurrence of species with very high and high preference for FAST-DEEP conditions	FFD	-4	Reduced habitat for Labeo spp and LMAR. Reduced spawning habitats in wet season.
Frequency of occurrence of species with very high and high preference for FAST-SHALLOW conditions	FFS	-2	AMOS and CSWI lost, probably due to fragmentation.
Frequency of occurrence of species with very high and high preference for SLOW-DEEP conditions	FSD	-1	Slow deep habitats are abundant throuhout the year. The absence of 7 species is largely attributed to the loss of migratory species.
Frequency of occurrence of species with very high and high preference for SLOW-SHALLOW conditions	FSS	-2	2 migratory species lost. BIMB and GCAL. The abundance of barbs is declining.
FLOW MODIFICATION			
Frequency of occurrence of species intolerant of no-flow conditions	FI	-2	CSWI has been lost, while CPRE is becoming less frequent. Periods of no flow a significant factor.
Frequency of occurrence of species moderately intolerant of no-flow conditions	FMI	-2	Reduced quality of spawning habitats. Reduced FOO of Labeo spp. and lmar
Frequency of occurrence of species moderately tolerant of no flow conditions	FMT	-2	Reduced FOO of species which dwell in pools but which move into all habitats as they become available. E.g. BTR, BUNI, MBRE etc
Frequency of occurrence of species tolerant of no flow conditions	FT	0	Only 1 migratory species lost. Remaining species less abundant.
Presence of catadromous spp.	CAT	-4	The three eel species and GGIU most probably do not migrate to this RU since the development of Masingir Dam. Although residual populations may still exist, they are also considered to be absent
Presence of migratory spp.	MIG	-2	All migratory species have been lost, but local movers such as LMAR, LMOL and LCYL are still present and breeding in the available habitat.
COVER METRICS			
Frequency of occurrence of species with a very high to high preference for overhanging vegetation	OV	-3	FOO of all dependent species are declining due to a reduction in marginal cover.
Frequency of occurrence of species with a very high to high preference for undercut banks and root wads	UB	-3	Reduced availability of habitat providing less cover for Mormyrid spp. And other dependant spp.
Frequency of occurrence of species with a high to very high preference for a particular substrate type	SUB	-2	7 species lost, but these are predominantly migratory. CSWI and BNEE lost. Abundances of other species declining. Habitat availability declining due to deposition of sediments and inundation
Frequency of occurrence of species with a high to very high	AMAC	0	Indigenous macrophytes not common in this reach.

preference for aquatic macrophytes			
Frequency of occurrence of species with a very high to high preference for the water column	WC	-2	4 migratory species lost. Other species less abundant.
HEALTH/CONDITION			
Health of species intolerant of modified water quality	ITH	-2	Only 1 species. CPRE less frequent. The intolerance of this species to water temperatures will be a factor in the dry season.
Health of species moderately intolerant of modified water quality	MIH	-2	Reduced health of all species and gonad development may start to be impaired.
Health of species moderately tolerant of modified water quality	MTH	-1	General health declining and some breeding and recruitment impaired.
Health of species tolerant of modified water quality	HT	0	No observed difference.
INTRODUCED SPECIES			
The potential impact of introduced predaceous spp?	IP	0	
How widespread (frequency of occurrence) are introduced predaceous spp?	FP	0	
The potential impact of introduced habitat modifying spp?	IH	0	
How widespread (frequency of occurrence) are habitat modifying spp?	FH	0	

Table 4.7: Weighted and ranked metrics and final PES score (Letaba Ranch EC C)

			Fish PES : Based on weights of metric groups			
Fish PES metric group		**Metric group: calculated score**	**Calculated weight**	**Weighted score for group**	**Rank of metric group**	**% Weight for metric group**
Flow-depth metrics	FD	51.25	0.24	12.24	2.00	80.00
Flow modification metrics	FM	57.27	0.30	17.10	1.00	100.00
Cover metrics	CM	56.84	0.24	13.57	2.00	80.00
Health/condition metrics	HM	71.33	0.22	15.97	3.00	75.00
Impact of introduced spp (negative)	IS	0.00	0.00	0.00	4.00	0.00
			1.00			335.00
Fish PES				58.88		
Fish PES Category				D		

5. IFR 5 : Klein Letaba

5.1 DATA AVAILABILITY

5.1.1 Data sources

Historical distribution records
The information in the introductory paragraph of item 1.1 also applies to this site. Table 5.1 below shows the historical dates for which data exists for the Letaba River. The site selected for this survey was also selected as a biomonitoring site for the surveys of the 2001 RHP program. Except or data of the specific site a vast amount of data for the area in general is also available.

Table 5.1: Historical fish survey dates for sites on the Nsama and Klein Letaba and Molototsi rivers. (Adapted from Limpopo Province Fish Distribution Data Base. Updated May 2003)

		Sep 91	Apr 92	Jan 95	Jun 95	Feb 96	Dec 99
Nsama	Homu banana plantation				X		
Nsama	Near youth camp				X		
Klein Letaba	Majosi sewage outflow						X
Klein Letaba	Giyani - Elim road bridge			X			
Klein Letaba	Below Mid Letaba confluence			X			
Klein Letaba	Hlaneki Weir	X	X	X		X	
Klein Letaba	Bends Scheme						X
Klein Letaba	Kremetart Big Tree		X				X
Klein Letaba	Below Giyani sewage works	X	X	X			
Klein Letaba	Vuhehli village crossing		X	X			
Klein Letaba	Soutini			X			
Klein Letaba	Singlepoort	X					
Molototsi	Below Modjadji Dam				X		

5.1.2 Confidence level of data

Level	Reason
5	Site known for biomonitoring since 2000 floods. Limited historical information although extensive data sets exist for the Middle Letaba Dam and the lower catchment. Extensive data sets available for the whole catchment. No flow dependent species, but several semi rheophilic species present. Excellent knowledge of cover and local conditions available.

5.2 REFERENCE CONDITION

The data listed in table 5.2 below reflects the expected fish species and the species collected at this site during the site visit of 14.02.04

Table 5.2: Expected fish species collected during site visit of 14.02.04

Species expected	**Species recorded**
Barbus afrohamiltoni	
Barbus paludinosus	
Barbus toppini	
Barbus trimaculatus	
Barbus unitaeniatus	10
Barbus viviparus	
Chiloglanis paratus	47
Clarias gariepinus	
Glossogobius callidus	2
Labeo cylindricus	1
Labeo molybdinus	
Labeo rosae	5
Labeo ruddi	
Labeobarbus marequensis	
Mesobola brevianalis	7
Oreochromis mossambicus	>200
Pseudocrenilabrus philander	34
Schilbe intermedius	
Synodontis zambezensis	
Tilapia rendalli	28
20 Species	**9**

5.3 PES

The current PES of this resource unit is “Class C” which is reflected in the following FRAI table.

Table 5.3: FRAI table Klein Letaba (Class C)

METRICS		SCORES	COMMENTS
FLOW-DEPTH CLASS			
Frequency of occurrence of species with very high and high preference for FAST-DEEP conditions	FFD	-2	Fast Deep habitats are uncommon under natural conditions. Only 4 species considered to have a preference. Loss of BMAR and reduced abundance of Labeo spp.
Frequency of occurrence of species with very high and high preference for FAST-SHALLOW conditions	FFS	-2	Loss of BMAR and reduced abundance of Labeo spp. Still a high abundance of CPAR. Good cover in FS habitats.
Frequency of occurrence of species with very high and high preference for SLOW-DEEP conditions	FSD	-2	Slow deep habitats are abundant along margins, but there are few very deep areas which could support BMAR, SZAM and SINT
Frequency of occurrence of species with very high and high preference for SLOW-SHALLOW conditions	FSS	1	Abundant habitat exists with only BMAR absent.
FLOW MODIFICATION			
Frequency of occurrence of species intolerant of no-flow conditions	FI	0	
Frequency of occurrence of species moderately intolerant of no-flow conditions	FMI	-1	Loss of LMAR which requires flow for breeding.
Frequency of occurrence of species moderately tolerant of no flow conditions	FMT	-1	All species which are expected are still present, but abundances are reduced.
Frequency of occurrence of species tolerant of no flow conditions	FT	-1	Loss of very deep pools is thought to cause the loss of SINT and SZAM.
Presence of catadromous spp.	CAT	0	
Presence of migratory spp.	MIG	-1	No true migratory species but LMAR and Labeo spp move for breeding purposes. LMAR now absent and Labeo spp. have low abundance.
COVER			
Frequency of occurrence of species with a very high to high preference for overhanging vegetation	OV	0.00	
Frequency of occurrence of species with a very high to high preference for undercut banks and root wads	UB	-1.00	Abundant habitat remains but SZAM now absent.
Frequency of occurrence of species with a high to very high preference for a particular substrate type	SUB	0.00	
Frequency of occurrence of species with a high to very high preference for aquatic macrophytes	AMAC	0.00	
Frequency of occurrence of species with a very high to high preference for the water column	WC	-2	Very deep pools are absent with the resultant loss of BMAR and SINT.

HEALTH/CONDITION			
Health of species intolerant of modified water quality	ITH	0	
Health of species moderately intolerant of modified water quality	MIH	-1	Increased temperatures may be a contributing factor to the loss of BMAR.
Health of species moderately tolerant of modified water quality	MTH	0	Species have been lost, but for reasons other than water quality.
Health of species tolerant of modified water quality	HT	0	Species have been lost, but for reasons other than water quality.
INTRODUCED SPECIES			
The potential impact of introduced predaceous spp?	IP	0	
How widespread (frequency of occurrence) are introduced predaceous spp?	FP	0	
The potential impact of introduced habitat modifying spp?	IH	0	
How widespread (frequency of occurrence) are habitat modifying spp?	FH	0	

Table 5.4: Weighted and ranked metrics and final PES score (Klein Letaba EC C)

			Fish PES : Based on weights of metric groups			
Fish PES metric group		**Metric group: calculated score**	**Calculated weight**	**Weighted score for group**	**Rank of metric group**	**% Weight for metric group**
Flow-depth metrics	FD	62.31	0.27	16.62	2.00	80.00
Flow modification metrics	FM	80.00	0.23	18.67	3.00	70.00
Cover metrics	CM	84.00	0.33	28.00	1.00	100.00
Health/condition metrics	HM	80.00	0.17	13.33	4.00	50.00
Impact of introduced spp (negative)	IS	0.00	0.00	0.00	0.00	0.00
			1.00			300.00
Fish PES				76.62		
Fish PES Category				C		

Table 5.5: Present Ecological state of IFR site 5

PES	Causes	Sources	Flow/Non-flow related
C	Field surveys conducted in February 2004, yielded 9 of 20 fish species which were expected to occur under natural conditions. It is thought that *Schilbe intermedius* and *Synodontis zambezensis*, which prefer deep water pools, are now lost from this Resource Unit, while *Labeobarbus marequensis* has not been recorded in recent surveys. There are no indications to suggest that fish health is being affected by current conditions. There are no records of alien fish species from the Klein Letaba River, but it is known that Bass and Carp are found in the Middle Letaba Dam.	The substrate is predominantly sand and habitat is dominated by gravel and sand runs, with occasional riffles and pools. Since the 2000 floods very few deep pools remain and little refuge exists in times of no flow. This consequently implies that no deep flowing fish species are present. There is little habitat fragmentation and a good seasonal flow. Base flows in this Resource Unit are seriously impacted upon by the placement of the Middle Letaba Dam. Since the 2000 floods there have been no dams or weirs along the length of the Klein Letaba and the migration passage for fish is thus unobstructed from the Letaba River confluence.	Flow and non-flow.

5.4 TREND AND REASONS

PES	TREND	RESULTING PES	TIME	REASONS
C	Unclear			The reduced availability of deep water habitats may be a reflection on natural cycles. It is possible that further floods may change this scenario. The historical flow regime of the river in this Resource Unit is also uncertain. It is how-ever clear that the fish population is threatened by a long-term loss of deep water habitats. At this time, illegal netting of fish in shallow pools is thought to be a significant non-flow related impact on the fish population, particularly in times of low flow. The improvement of the existing flow regime is therefore essential to maintain the existing fish population. Land use and veld conditions remain largely stable. This Resource Unit is sparsely populated and veld conditions are generally good. Flow modification has been in place since the construction of the Middle Letaba Dam. Those species that now occur in this Resource Unit are capable of surviving in shallow water habitats and appear to have stable populations. Migration passages are unobstructed and migration and recruitment from the lower river is possible in times of high flow.

5.5 ALTERNATIVE ECS

Table 5.6: FRAI table Klein Letaba (Class B)

METRICS		SCORES	COMMENTS
FLOW-DEPTH CLASS			
Frequency of occurrence of species with very high and high preference for FAST-DEEP conditions	FFD	-2	Fast Deep habitats are uncommon under natural conditions. Only 4 species considered to have a preference. Loss of LMAR and reduced abundance of Labeo spp.
Frequency of occurrence of species with very high and high preference for FAST-SHALLOW conditions	FFS	-1	Improved habitat for Labeo spp recruitment.
Frequency of occurrence of species with very high and high preference for SLOW-DEEP conditions	FSD	-1	More slow deep habitats are abundant along margins, but there are few very deep areas which could support LMAR, SZAM and SINT
Frequency of occurrence of species with very high and high preference for SLOW-SHALLOW conditions	FSS	1	Abundant habitat exists with only LMAR absent.
FLOW MODIFICATION			
Frequency of occurrence of species intolerant of no-flow conditions	FI	0	
Frequency of occurrence of species moderately intolerant of no-flow conditions	FMI	-1	Loss of LMAR which requires flow for breeding.
Frequency of occurrence of species moderately tolerant of no flow conditions	FMT	-1	All species which are expected are still present, but abundances are reduced.
Frequency of occurrence of species tolerant of no flow conditions	FT	-1	Loss of very deep pools is thought to cause the loss of SINT and SZAM.
Presence of catadromous spp.	CAT	0	
Presence of migratory spp.	MIG	-1	No true migratory species but LMAR and Labeo spp move for breeding purposes. LMAR now absent and Labeo spp. have low abundance.
COVER METRICS			
Frequency of occurrence of species with a very high to high preference for overhanging vegetation	OV	0	
Frequency of occurrence of species with a very high to high preference for undercut banks and root wads	UB	-1	Abundant habitat remains but SZAM now absent.
Frequency of occurrence of species with a high to very high preference for a particular substrate type	SUB	0	
Frequency of occurrence of species with a high to very high preference for aquatic macrophytes	AMAC	0	Very deep pools remain absent with the resultant loss of LMAR and SINT.

Frequency of occurrence of species with a very high to high preference for the water column	WC	-3	Very deep pools are absent and very shallow water and habitats throughout. Reducede FOO of all species expected.
HEALTH/CONDITION			
Health of species intolerant of modified water quality	ITH	0	
Health of species moderately intolerant of modified water quality	MIH	-1	Increased temperatures may be a contributing factor to the loss of BMAR.Very deep pools are absent with the resultant loss of BMAR and SINT.
Health of species moderately tolerant of modified water quality	MTH	0	Species have been lost, but for reasons other than water quality.
Health of species tolerant of modified water quality	HT	0	Species have been lost, but for reasons other than water quality.
INTRODUCED SPECIES			
The potential impact of introduced predaceous spp?	IP	0	
How widespread (frequency of occurrence) are introduced predaceous spp?	FP	0	
The potential impact of introduced habitat modifying spp?	IH	0	
How widespread (frequency of occurrence) are habitat modifying spp?	FH	0	

Table 5.7: Weighted and ranked metrics and final PES score (Klein Letaba EC B)

			Fish PES : Based on weights of metric groups			
Fish PES metric group		**Metric group: calculated score**	**Calculated weight**	**Weighted score for group**	**Rank of metric group**	**% Weight for metric group**
Flow-depth metrics	FD	75.38	0.27	20.10	2.00	80.00
Flow modification metrics	FM	80.00	0.23	18.67	3.00	70.00
Cover metrics	CM	84.00	0.33	28.00	1.00	100.00
Health/condition metrics	HM	80.00	0.17	13.33	4.00	50.00
Impact of introduced spp (negative)	IS	0.00	0.00	0.00	0.00	0.00
			1.00			300.00
Fish PES				80.10		
Fish PES Category				B		

Table 5.8: FRAI table Klein Letaba (Class D)

METRICS		SCORES	COMMENTS
FLOW-DEPTH CLASS			
Frequency of occurrence of species with very high and high preference for FAST-DEEP conditions	FFD	-3	Fast Deep habitats will become very rare and spawning habitats will only be available during elevated flow periods. Recruitment will be severely deminished. Labeo spp (LMAR already lost)
Frequency of occurrence of species with very high and high preference for FAST-SHALLOW conditions	FFS	-2	Loss of LMAR and reduced abundance of Labeo spp. Still a high abundance of CPAR. Good cover in FS habitats.
Frequency of occurrence of species with very high and high preference for SLOW-DEEP conditions	FSD	-2	Slow deep habitats are abundant along margins, but there are few very deep areas which could support LMAR, SZAM and SINT
Frequency of occurrence of species with very high and high preference for SLOW-SHALLOW conditions	FSS	1	Abundant habitat exists with only LMAR absent.
FLOW MODIFICATION			
Frequency of occurrence of species intolerant of no-flow conditions	FI	0	
Frequency of occurrence of species moderately intolerant of no-flow conditions	FMI	-3	Reduced FOO of labeo spp due to lack of recruitment.
Frequency of occurrence of species moderately tolerant of no flow conditions	FMT	-2	Reduced FOO of all species due to reduced habitat quality.
Frequency of occurrence of species tolerant of no flow conditions	FT	-1	Loss of very deep pools is thought to cause the loss of SINT and SZAM.
Presence of catadromous spp.	CAT	0	
Presence of migratory spp.	MIG	-3	LMAR and Labeo spp move for breeding purposes. LMAR now absent and Labeo spp. Will become scarce.
COVER METRICS			
Frequency of occurrence of species with a very high to high preference for overhanging vegetation	OV	-2	Reduced abundance of overhanging vegetationwill cause a reduction in the FOO of Barbus spp.
Frequency of occurrence of species with a very high to high preference for undercut banks and root wads	UB	-2	
Frequency of occurrence of species with a high to very high preference for a particular substrate type	SUB	0	Reduced abundance of undercut habitats will cause a reduction in the FOO of Barbus spp.
Frequency of occurrence of species with a high to very high preference for aquatic macrophytes	AMAC	0	
Frequency of occurrence of species with a very high to high preference for the water column	WC	-3	Very deep pools are absent and very shallow water and habitats throughout. Reduced FOO of all species expected.

HEALTH/CONDITION			
Health of species intolerant of modified water quality	ITH	0	
Health of species moderately intolerant of modified water quality	MIH	-2	Increased temperatures may be a contributing factor to reduction of all species.
Health of species moderately tolerant of modified water quality	MTH	-2	Temperatures contributing to depleted barb populations.
Health of species tolerant of modified water quality	HT	-1	Temperatures contributing to depleted barb populations.
INTRODUCED SPECIES			
The potential impact of introduced predaceous spp?	IP	0	
How widespread (frequency of occurrence) are introduced predaceous spp?	FP	0	
The potential impact of introduced habitat modifying spp?	IH	0	
How widespread (frequency of occurrence) are habitat modifying spp?	FH	0	

Table 5.9: Weighted and ranked metrics and final PES score (Klein Letaba EC D)

			Fish PES : Based on weights of metric groups			
Fish PES metric group		**Metric group: calculated score**	**Calculated weight**	**Weighted score for group**	**Rank of metric group**	**% Weight for metric group**
Flow-depth metrics	FD	57.69	0.27	15.38	2.00	80.00
Flow modification metrics	FM	51.03	0.23	11.91	3.00	70.00
Cover metrics	CM	68.00	0.33	22.67	1.00	100.00
Health/condition metrics	HM	54.44	0.17	9.07	4.00	50.00
Impact of introduced spp (negative)	IS	0.00	0.00	0.00	0.00	0.00
			1.00			300.00
Fish PES				59.03		
Fish PES Category				D		

6. IFR 6

6.1 DATA AVAILABILITY

6.1.1 Data sources

Historical distribution records
This part of the Letaba River in the KNP has been surveyed thoroughly since 1958 by researchers such as Pienaar and Gaigher. Their data is available in reports and publications. During the early 1980's Russell produced valuable information with a 3-year survey, while Heath (late 1980's) did a series of surveys in this stretch of the river. Since 1990 Deacon periodically sampled the river as part of an ongoing bio-monitoring program.

Table 6.1: Dates of historical collections at the specific site

River and site	Pienaar	Russell	Deacon	Deacon
Groot Letaba Lonely Bull	1978	1997	Pre 2000	Post 2000

The following sampling efforts in Groot Letaba in the KNP in the area where the sire is situated were done by Deacon:

1993: July, September; November (drought monitoring);
1994: July, December; 1995: July; 1997: June; and
2001: July

The following sites in the area were included: Mahlangeni , Malopeni, Letaba low level bridge and Tsende mouth. At the specific site Lonely Bull deacon sampled in July 2003 and February 2004.

In 2000, Limpopo Environmental Affairs and the KNP assessed the health of the Letaba Catchment using standard biomonitoring protocols. One of the protocols used was the FAII. As a result of this survey, the present ecological state (PES) of all the major rivers in the catchment were described with relatively high confidence.

6.1.2 Confidence level

Level	Reason
4 high	Historical data is of high standard and done by extremely component researchers. The reason why the confidence is not at a level 5 (very high) is: With the periodical no-flow situation the river often experience during the dry seasons, fish populations diminish and species disappear temporarily. With higher flows and floods the stocks are replenished, although some might not recover at all. This unnatural flux do influence the survey results, depending at what stage the monitoring is done after what event. Thus no recent survey will supply you with near natural stable population assemblages. Drought no-flows during 2004 complicated fish interpretation.

6.2 REFERENCE CONDITION

The data listed in Table 6.2 below reflects the expected fish species and the species collected at this site during the site visit of April 2004.

Table 6.2: Expected fish species collected during site visit of April 2004

Species expected	Species recorded
Anguilla marmorata	
Anguilla mossambica	
Barbus afrohamiltoni	37
Barbus annectens	
Barbus paludinosus	
Barbus radiatus	21
Barbus toppini	
Barbus trimaculatus	25
Barbus unitaeniatus	58
Barbus viviparus	148
Brycinus imberi	8
Chiloglanis paratus	75
Chiloglanis engiops	
Clarias gariepinus	14
Glossogobius callidus	
Glossogobius giuris	
Hydrocynus vittatus	1
Labeo congoro	
Labeo cylindricus	50
Labeo molybdinus	38
Labeo rosae	11
Labeo ruddi	11
Labeobarbus marequensis	143
Marcusenius macrolepidotus	
Mesobola brevianalis	1
Micralestes acutidens	
Oreochromis mossambicus	14
Petrocephalus wesselsi	
Pseudocrenilabrus philander	
Schilbe intermedius	57
Synodontis zambezensis	1
Tilapia rendalli	1
Tilapia sparrmanii	
33	**19**

6.3 PES

The current PES of this resource unit is “Class C” which is reflected in the following FRAI table.

Table 6.3: FRAI table Lonely Bull (Class C)

METRICS		SCORES	COMMENTS
FLOW-DEPTH CLASS			
Frequency of occurrence of species with very high and high preference for FAST-DEEP conditions	FFD	-2.00	Most of the fast-deep habitats had been silted up some way during the 2000 floods. This rendered them shallow and sandy. LCON and BMAR are the fish that suffered most. HVIT took refuge in deep pools.
Frequency of occurrence of species with very high and high preference for FAST-SHALLOW conditions	FFS	-2.00	A large percentage of all the rapids and riffles had been silted up during the 2000 floods. Low flows and nutrients create algae-covered habitats. CPAR and BMAR impacted again.
Frequency of occurrence of species with very high and high preference for SLOW-DEEP conditions	FSD	-1.00	Flood of 2000 rendered pools shallower due to sedimentation. Two absent fish implicated: BTOP and BANN. Both probably more influenced by the lack of overhanging vegetation. Eels absent, thus not part of the equation.
Frequency of occurrence of species with very high and high preference for SLOW-SHALLOW conditions	FSS	2.00	Large areas been sedimented up by the 2000 floods, creating an abundance of sandy, shallow and slow habitats. Improved habitat for OMOS, LROS and LRUD.
FLOW MODIFICATION			
Frequency of occurrence of species intolerant of no-flow conditions	FI	0.00	No intolerant species present.
Frequency of occurrence of species moderately intolerant of no-flow conditions	FMI	-1.00	CPAR and BMAR greatly decreased in numbers during the 2003 drought. MACU also declined. Labeos bounced back rapidly.
Frequency of occurrence of species moderately tolerant of no flow conditions	FMT	-1.00	Most fish were not affected, except, the Mormyrids declined - inability to migrate during no-flow and lack of shelter maybe problem
Frequency of occurrence of species tolerant of no flow conditions	FT	0.00	BTOP is more a case of lack of marginal vegetation than flow.
Presence of catadromous spp.	CAT	-4.00	Both the eel spp disappeared (probably permanently) due to the effect of the Massingir dam
Presence of migratory spp.	MIG	-1.00	True migratory fishes had mixed reactions. Only LCON and MMAC may have reacted negatively due to migratory problems (other than the eel dilemma with Massingir). Other migrators recovered well after no-flow situation ended.
COVER METRICS			
Frequency of occurrence of species with a very high to high preference for overhanging vegetation	OV	-2.0	2000 floods scoured banks from MV; sedimentation smothered channels with overhang; BTOP absent, MACU declined, Mormyrids declined.
Frequency of occurrence of species with a very high to high preference for undercut banks and root wads	UB	-0.5	2000 floods - altered channel and sometimes the channel course; sedimentation filled channels and drowned overhanging banks. Mormyrids declined.
Frequency of occurrence of species with a high to very high preference for a particular substrate type	SUB	-1.0	Silting up of flowing and non-flowing rock and bedrock habitats do influence the presence of BMAR, LCON and CPAR
Frequency of occurrence of species with a high to very high preference for aquatic macrophytes	AMAC	0.0	The Letaba River never had an abundance of aquatic macrophytes, therefore little had changed in this category.

Frequency of occurrence of species with a very high to high preference for the water column	WC	2.0	Deeper backwater habitats have mostly disappeared, influencing MBRE, MACU and BANN. Channels also became silted up and thus having an effect on LCON.
HEALTH CONDITION			
Health of species intolerant of modified water quality	ITH	0.00	None present
Health of species moderately intolerant of modified water quality	MIH	-1.00	Secondary effects due to water quality deterioration are the increase in algae due to the increased nutrient loads (resulting from irrigation) covering most of the feeding surfaces of fish: riffles, vegetation and sediment. Specialized feeders such as MMAC and CPAR suffer.
Health of species moderately tolerant of modified water quality	MTH	-1.00	Fish that usually suffers from adverse water quality conditions are more vulnerable during no flow conditions when water quality deteriorates rapidly. It seems that the barbs, including BMAR are very susceptible.
Health of species tolerant of modified water quality	HT	0.00	Some fish that feeds on algae and stressed fish might even benefit from this situation, such as OMOS and CGAR.

Table 6.4: Weighted and ranked metrics and final PES score (Lonely Bull EC C)

			Fish PES : Based on weights of metric groups			
Fish PES metric group		**Metric group: calculated score**	**Calculated weight**	**Weighted score for group**	**Rank of metric group**	**% Weight for metric group**
Flow-depth metrics	FD	62.11	0.33	20.70	1.00	100.00
Flow modification metrics	FM	58.11	0.30	17.43	2.00	90.00
cover metrics	CM	69.66	0.25	17.41	3.00	75.00
Health/condition metrics	HM	81.25	0.10	8.13	4.00	30.00
Impact of introduced spp (negative)	IS	0.00	0.02	0.00	5.00	5.00
			1.00			300.00
Fish PES				63.67		
Fish PES Category				C		

Table 6.5: Present Ecological state of IFR site 6

PES	**Causes**	**Sources**	**Flow/Non - flow related**
C	Velocity of large floods in 1996 and 2000 leading to sediment transport settling. Large volumes of sediment washes in from the Klein Letaba and not enough water to remove the settled sand. Accelerated erosion of usually stable areas released large amounts of sediment that could not be transported by the reduced flows. Large amount of porous sediment allows water to flows subsurface. Sediment had filled up channels and the floods had changed water courses. Nutrients are leached, deposited or released into the river upstream. There is not enough water in the system during extreme low flows to remove the foul water. Degraded water quality causes eutrophication of the river, resulting in algae blooms There is no connectivity between pools due to river stoppage	Removal of vegetation in catchment and draining of wetland sponges as well as overgrazing, deforestation and urban runoff in catchment lead to erosion and sediment input into the rivers. Sediment originates from the over-utilized catchment. Decrease in water quality originates from pollution by agriculture, effluent and industrial sources. Decrease in flow due to abstraction and evaporation	Non flow

6.4 TREND (PREVIOUSLY TRAJECTORY OF CHANGE) AND REASONS

PES	TREND	RESULTING PES	TIME	REASONS
C	Negative	D	15 years	Periodic non-flowing situations that causes: Loss of flowing water habitats for fish. Water quality to deteriorate stagnant water not flushed Oxygen content pools decreasing. Eutrophication where algae covers food sources Lack of connectivity and migration obstacles are created. Loss of undercut banks and overhanging vegetation habitats as water with-draws from edges. Sediments are not removed by lower flows leaving sandy habitat that are inadequate and homoge-nous.

6.5 ALTERNATIVE ECS

LONELY BULL CLASS B

METRICS		SCORES	COMMENTS
FLOW-DEPTH CLASS			
Frequency of occurrence of species with very high and high preference for FAST-DEEP conditions	FFD	-0.50	Improve frequency of occurrence
Frequency of occurrence of species with very high and high preference for FAST-SHALLOW conditions	FFS	-0.50	Improve frequency of occurrence
Frequency of occurrence of species with very high and high preference for SLOW-DEEP conditions	FSD	0.00	Improve frequency of occurrence
Frequency of occurrence of species with very high and high preference for SLOW-SHALLOW conditions	FSS	2.00	Large areas been sedimented up by the 2000 floods, creating an abundance of sandy, shallow and slow habitats. Improved habitat for OMOS, LROS and LRUD.
FLOW MODIFICATION			
Frequency of occurrence of species intolerant of no-flow conditions	FI	0.00	No intolerant species present
Frequency of occurrence of species moderately intolerant of no-flow conditions	FMI	0.00	Improve frequency of occurrence
Frequency of occurrence of species moderately tolerant of no flow conditions	FMT	0.00	Improve frequency of occurrence
Frequency of occurrence of species tolerant of no flow conditions	FT	0.00	BTOP is more a case of lack of marginal vegetation than flow.
Presence of catadromous spp.	CAT	-4.00	Both the eel spp disappeared (probably permanently) due to the effect of the Massingir dam
Presence of migratory spp.	MIG	-0.50	Better flows will enhance migration over obstacles.
COVER			
Frequency of occurrence of species with a very high to high preference for overhanging vegetation	OV	0.0	Proliferation of reed beds providing improved cover for Barbs
Frequency of occurrence of species with a very high to high preference for undercut banks and root wads	UB	0.0	2000 floods - altered channel and sometimes the channel course; sedimentation filled channels and drowned overhanging banks. Mormyrids declined. Higher flows might carve new undercut banks.
Frequency of occurrence of species with a high to very high preference for a particular substrate type	SUB	0.0	Improved flows providing more diverse hydraulic habitats
Frequency of occurrence of species with a high to very high preference for aquatic macrophytes	AMAC	0.0	The Letaba River never had an abundance of aquatic macrophytes; therefore little had changed in this category.

METRICS		SCORES	COMMENTS
FLOW-DEPTH CLASS			
Frequency of occurrence of species with a very high to high preference for the water column	WC	2.0	Most of the habitats were silted up in some way and have become shallower. Deeper backwater habitats have mostly disappeared, influencing MBRE, MACU and BANN. Channels also became silted up and thus having an effect on LCON. Higher flows might carve new channels.
HEALTH/CONDITION			
Health of species intolerant of modified water quality	ITH	0.00	None present
Health of species moderately intolerant of modified water quality	MIH	0.00	Better flows will improve water quality, including more stable temperatures
Health of species moderately tolerant of modified water quality	MTH	0.00	Less algae to cover habitats
Health of species tolerant of modified water quality	HT	0.00	Some fish that feeds on algae might even benefit modified water quality, such as OMOS and CGAR.
INTRODUCED SPECIES			
The potential impact of introduced predaceous spp?	IP	0	No introduced species
How widespread (frequency of occurrence) are introduced predaceous spp?	FP	0	No introduced species
The potential impact of introduced habitat modifying spp?	IH	0	No introduced species
How widespread (frequency of occurrence) are habitat modifying spp?	FH	0	No introduced species

LONELY BULL CLASS B: WEIGHTED AND RANKED METRICS AND FINAL PES SCORE

			Fish PES : Based on weights of metric groups			
Fish PES metric group		**Metric group: calculated score**	**Calculated weight**	**Weighted score for group**	**Rank of metric group**	**% Weight for metric group**
Flow-depth metrics	FD	87.89	0.31	27.04	1.00	100.00
Flow modification metrics	FM	68.68	0.28	19.02	2.00	90.00
Cover metrics	CM	88.97	0.23	20.53	3.00	75.00
Health/condition metrics	HM	100.00	0.18	18.46	4.00	60.00
Impact of introduced SPP (negative)	IS	0.00	0.00	0.00	5.00	0.00
			1.00			325.00
Fish PES				85.06		
Fish PES Category				B		

7. IFR 7 LETABA BRIDGE

7.1 DATA AVAILABILITY

7.1.1 Data sources

Historical distribution records
The information in the introductory paragraph of item 6.1 also applies to this site.

Table 7.1: Dates of historical collections at the specific site

River and site	Pienaar	Russell	Deacon	Deacon
Groot Letaba Lonely Bull	1978	1997	Pre 2000	Post 2000

The following sampling efforts in Groot Letaba in the KNP in the area where the sire is situated were done by Deacon:

1993: July, September; November (drought monitoring);
1994: July, December; 1995: July; 1997: June; and
2001: July

The following sites in the area were included: Letaba high level bridge, Below Engelhardt Dam, Allison-se-gat and Klipkoppies bridge. At the specific site, Letaba Bridge, Deacon sampled in July 2003 and February 2004.

7.1.2 Confidence level

Level	Reason
4 high	Historical data is of high standard and done by extremely component researchers. The reason why the confidence is not at a level 5 (very high) is: With the periodical no-flow situation the river often experience during the dry seasons, fish populations diminish and species disappear temporarily. With higher flows and floods the stocks are replenished, although some might not recover at all. This unnatural flux do influence the survey results, depending at what stage the monitoring is done after what event. Thus no recent survey will supply you with near natural stable population assemblages. Drought no-flows during 2004 complicated fish interpretation.

7.2 REFERENCE CONDITION

The data listed in Table 7.2 below reflects the expected fish species and the species collected at this site during the site visit of this survey in May 2004.

Table 7.2: Expected fish species collected during site visit of May 2004

Species expected	Species recorded
Anguilla marmorata	
Anguilla mossambica	
Barbus afrohamiltoni	151
Barbus annectens	
Barbus paludinosus	
Barbus radiatus	10
Barbus toppini	
Barbus trimaculatus	32
Barbus unitaeniatus	
Barbus viviparus	159
Brycinus imberi	8
Chiloglanis paratus	56
Chiloglanis engiops	
Clarias gariepinus	8
Glossogobius callidus	
Glossogobius giuris	1
Hydrocynus vittatus	
Labeo congoro	
Labeo cylindricus	7
Labeo molybdinus	10
Labeo rosae	15
Labeo ruddi	39
Labeobarbus marequensis	49
Marcusenius macrolepidotus	
Mesobola brevianalis	
Micralestes acutidens	4
Oreochromis mossambicus	216
Petrocephalus wesselsi	
Schilbe intermedius	5
Synodontis zambezensis	
Tilapia rendalli	9
31	**17**

7.3 PES

The current PES of this resource unit is “Class C” which is reflected in the following FRAI table.

Table 7.3: FRAI table Letaba Bridge (Class C)

METRICS		SCORES	COMMENTS
FLOW-DEPTH CLASS			
Frequency of occurrence of species with very high and high preference for FAST-DEEP conditions	FFD	-1.00	No fish have been lost in these habitats. This Ecoregion is more bed-rock dominated than the upstream ER, therefore channels are more permanent and the higher flows have a scouring effect on channels. However, some has become more silted up by silt moving through.
Frequency of occurrence of species with very high and high preference for FAST-SHALLOW conditions	FFS	-2.00	Although sedimentation took its toll and smothered a % of these habitats (riffles & rapids), it is the no-flow situations that really influence these habitats in the short term.
Frequency of occurrence of species with very high and high preference for SLOW-DEEP conditions	FSD	-1.00	Although most pools became silted up to some degree during the 200 flood, there is still a large portion of the river with deep bedrock pools in this section. Maybe the presence of hippos helps to scour these pools. The absence of fish in this category should rather be blamed on the absence of overhanging vegetation, removed by the 2000 floods. Loss of good deep backwater habitats due to sedimentation (2000 floods) might be a major factor.
Frequency of occurrence of species with very high and high preference for SLOW-SHALLOW conditions	FSS	-1.00	Although the 2000 flood has silted up the system and now more slow-shallow habitats became available, these habitats are without marginal shelter since the channels are unstable and move around due to the sandy substrate.
FLOW MODIFICATION			
Frequency of occurrence of species intolerant of no-flow conditions	FI	-1.00	Periodical no-flow situations hamper this section. CSWI disappeared probably due to this
Frequency of occurrence of species moderately intolerant of no-flow conditions	FMI	-2.00	Populations of BMAR and CPAR take tremendous strain during the no-flow situations. They almost disappear totally when this situation continues for too long.
Frequency of occurrence of species moderately tolerant of no flow conditions	FMT	-1.00	Most of these fish can tolerate the situation in the Letaba River. Mormyrids suffer however due to a loss of habitat.
Frequency of occurrence of species tolerant of no flow conditions	FT	0.00	Although 4 species are missing in this category, all the reasons for their absence seem to be additional habitat loss (overhanging banks and vegetation).
Presence of catadromous spp.	CAT	-4.00	
Presence of migratory spp.	MIG	-1.00	The migratory fishes are still present, but some are declining in numbers.

COVER			
Frequency of occurrence of species with a very high to high preference for overhanging vegetation	OV	-2.0	2000 floods silted up and changed channels with overhanging vegetation islands, and low flows or no flows withdraw water edges from marginal vegetation. Fish such as BTOP, PPHI and BANN suffer due to these circumstances.
Frequency of occurrence of species with a very high to high preference for undercut banks and root wads	UB	-1.0	2000 floods silted up and changed channels with undercut banks and root wads. PCAT is an example.
Frequency of occurrence of species with a high to very high preference for a particular substrate type	SUB	-1.0	Floods and no-flows made it difficult for CSWI to survive in the system; this fish needs consistent flowing water and course sand substrate.
Frequency of occurrence of species with a high to very high preference for aquatic macrophytes	AMAC	0.0	
Frequency of occurrence of species with a very high to high preference for the water column	WC	-2.0	Silting up of backwaters with appropriate overhanging vegetation resulted in the disappearance of BANN and MBRE.
HEALTH/CONDITION			
Health of species intolerant of modified water quality	ITH	0.00	Presumably CPRE is an occasional vagrant to this area and should not be considered resident.
Health of species moderately intolerant of modified water quality	MIH	-3.00	Non-flowing periods create immense water quality problems, even in large pools due to hippo presence.
Health of species moderately tolerant of modified water quality	MTH	-1.00	Most of these fishes in this category can tolerate circumstances in the larger pools of this ER. It is more the habitat aspects that cause problems. BMAR and other large scaled fish might suffer from fungal diseases
Health of species tolerant of modified water quality	HT	0.00	

Table 7.4: Weighted and ranked metrics and final PES score (Letaba Bridge EC C)

			Fish PES : Based on weights of metric groups			
Fish PES metric group		**Metric group: calculated score**	**Calculated weight**	**Weighted score for group**	**Rank of metric group**	**% Weight for metric group**
Flow-depth metrics	FD	71.67	0.22	15.93	3.00	60.00
Flow modification metrics	FM	70.77	0.37	26.21	1.00	100.00
Cover metrics	CM	67.41	0.26	17.48	2.00	70.00
Health/condition metrics	HM	64.00	0.15	9.48	4.00	40.00
Impact of introduced spp (negative)	IS	0.00	0.00	0.00	5.00	0.00
			1.00			270.00
Fish PES				69.09		
Fish PES Category				C		

Table 7.5: Present Ecological state of IFR site 7

PES	Causes	Sources	Flow/Non-flow related
C	The velocity of large floods in 1996 and 2000 transported washed in sediment from the Klein Letaba. These large volumes of sediment have not had enough water to remove the settled sand. Large amount of porous sediment allows water to flows subsurface. Sediment has filled up channels and the floods had changed water courses. No connectivity exists between pools during river stoppage. Nutrients leached, deposited or released into the river upstream. Degraded water quality causes eutrofication of the river, resulting in algae blooms.	Overgrazing, deforestation and urban runoff in the catchment lead to erosion and sediment input into the rivers. This is aggravated by over-utilization of the catchment. Effluent originating from agriculture, and industrial sources has lead to a decrease in water quality.	Non-flow related and flow related.

7.4 TREND AND REASONS

PES	TREND	RESULTING PES	TIME	REASONS
C	Negative	**D**	15 years	Periodic non-flowing situations cause: Loss of flowing water habitats for fish. Water quality deteriorates because stagnant water is not flushed Eutrophication leads to algae that covers food sources Fish migration obstacles are created by no flow and thus lack of connectivity. Loss of undercut banks and overhanging vegetation habitats as water withdraws from edges Sediment not removed by lower flows and sandy habitat that are inadequate and homogenous are created.

7.5 ALTERNATIVE ECS

LETABA BRIDGE CLASS B

METRICS		SCORES	COMMENTS
FLOW-DEPTH CLASS			
Frequency of occurrence of species with very high and high preference for FAST-DEEP conditions	FFD	-0.50	No fish have been lost in these habitats. This Ecoregion is more bed-rock dominated than the upstream ER, therefore channels are more permanent and the higher flows have a scouring effect on channels. Frequency of occurrence improving.
Frequency of occurrence of species with very high and high preference for FAST-SHALLOW conditions	FFS	-0.50	Although sedimentation took its toll and smothered a % of these habitats (riffles & rapids), it is the no-flow situations that really influences these habitats in the short term. Without no-flow situations the frequency of occurrence improving.
Frequency of occurrence of species with very high and high preference for SLOW-DEEP conditions	FSD	-0.50	Although most pools became silted up to some degree during the 200 flood, there are still a large portion of the river with deep bedrock pools in this section. Maybe the presence of hippos helps to scour these pools. Improved flows will create more overhang and deep-water habitats. Frequency of occurrence improving.
Frequency of occurrence of species with very high and high preference for SLOW-SHALLOW conditions	FSS	-1.00	Higher flows will cover more of flat sandy surfaces to create more shallow habitats and thus frequency of occurrence will be improving.
FLOW MODIFICATION			
Frequency of occurrence of species intolerant of no-flow conditions	FI	-0.50	No-flow situations will not occur any more. Frequency of occurrence improving.
Frequency of occurrence of species moderately intolerant of no-flow conditions	FMI	-0.50	No-flow situations will not occur any more. Frequency of occurrence improving.
Frequency of occurrence of species moderately tolerant of no flow conditions	FMT	-0.50	No-flow situations will not occur any more. Frequency of occurrence improving.
Frequency of occurrence of species tolerant of no flow conditions	FT	0.00	Although 4 species are missing in this category, all the reasons for their absence seem to be additional habitat loss (overhanging banks and vegetation) that might improve with higher flows.
Presence of catadromous spp.	CAT	-4.00	Both the eel spp disappeared (probably permanently) due to the effect of the Massingir dam
Presence of migratory spp.	MIG	-1.00	The migratory fishes are still present, but some are declining in numbers.

METRICS		SCORES	COMMENTS
FLOW-DEPTH CLASS			
COVER			
Frequency of occurrence of species with a very high to high preference for overhanging vegetation	OV	**-1.0**	Marginal vegetation will improve and thus the overhanging habitat for small fish species becomes more available.
Frequency of occurrence of species with a very high to high preference for undercut banks and root wads	UB	**-1.0**	2000 floods silted up and changed channels with undercut banks and root wads. PCAT is an example. Higher flows might scour out undercut banks and root wads and thus improve the situation for these fish.
Frequency of occurrence of species with a high to very high preference for a particular substrate type	SUB	**-1.0**	Floods and no-flows made it difficult for CSWI to survive in the system; this fish needs consistent flowing water and course sand substrate
Frequency of occurrence of species with a high to very high preference for aquatic macrophytes	AMAC	**0.0**	The Letaba River never had an abundance of aquatic macrophytes; therefore little had changed in this category
Frequency of occurrence of species with a very high to high preference for the water column	WC	**-1.0**	More water will mean deeper water in the channels.
HEALTH/CONDITION			
Health of species intolerant of modified water quality	ITH	**0.00**	Presumably CPRE is an occasional vagrant to this area and should not be considered resident. It therefore does not influence the score.
Health of species moderately intolerant of modified water quality	MIH	**-1.00**	More water will create better water quality circumstances and better temperature ranges, thus improve the circumstances for fish.
Health of species moderately tolerant of modified water quality	MTH	**-0.50**	More water will create better water quality circumstances and better temperature ranges, thus improve the circumstances for fish.
Health of species tolerant of modified water quality	HT	**0.00**	More water will create better water quality circumstances and better temperature ranges, thus improve the circumstances for fish.
INTRODUCED SPECIES			
The potential impact of introduced predaceous spp?	IP	0	No introduced species
How widespread (frequency of occurrence) are introduced predaceous spp?	FP	0	No introduced species
The potential impact of introduced habitat modifying spp?	IH	0	No introduced species
How widespread (frequency of occurrence) are habitat modifying spp?	FH	0	No introduced species

LETABA BRIDGE CLASS B: WEIGHTED AND RANKED METRICS AND FINAL PES SCORE

			Fish PES : Based on weights of metric groups			
Fish PES metric group		**Metric group: calculated score**	**Calculated weight**	**Weighted score for group**	**Rank of metric group**	**% Weight for metric group**
Flow-depth metrics	FD	87.50	0.26	22.58	2.00	80.00
Flow modification metrics	FM	86.54	0.32	27.92	1.00	100.00
Cover metrics	CM	80.00	0.23	18.06	3.00	70.00
Health/condition metrics	HM	87.00	0.19	16.84	4.00	60.00
Impact of introduced SPP (negative)	IS	0.00	0.00	0.00	5.00	0.00
			1.00			310.00
Fish PES				85.40		
Fish PES Category				B		

8. REFERENCE LISTS

8.1 SITES OUTSIDE KNP

Agenda 21; (Rio, 1997)

Angliss, M. K., 1999. Application to declate "Soutini – Baleni" as a natural heritage site. Site 306. April 1999. Report to DEAT, Southern African Natural Heritage Programme. Northern Province Dept. of Agriculture, Land and Environment.

Angliss, M. K., 1999. The occurrence of *Oreochromis mossambicus* (Cichlidae), the Mozambique tilapia, in a geothermal wetland, located in the Northern Province of South Africa. *Proceedings of African Fishes and Fisheries*. Northern Province Dept. of Agriculture, Land and Environment.

Angliss, M. K., 1998. A first record of the red data fish species *Serranochromis meridianus* (Cichlidae) from the Middel Letaba Dam. Internal report; Northern Province Environmental Affairs.

Angliss, M. K., 1999. A fish intolerance index and habitat preference of fish species in the Crocodile, Sabie and Olifants Rivers. Workshop Report. Skukuza 3 – 5 May 1999. Northern Province Department of Agriculture Land and Environment.

Angliss, M. K., 2001. (In prep) A joint venture to re-establish the tigerfish (Hydrocynus vittatus) into Northern Province Systems. (Presented at SASAqS 2001, Aventura Eiland).

Angliss , M. K., 2002. A revised assessment of the habitat integrity of the Groot Letaba River from Tzaneen Dam to the Kruger National Park boundary, based upon an aerial survey undertaken in January 2001. Internal report, Limpopo Province Environmental Affairs.

Bell-Cross, G., & Minshull. 1988. The fishes of Zimbabwe. Trustees of the National Museums and Monuments of Zimbabwe, Harare, Zimbabwe.

Bredenkamp, G.J., Van Rooyen, N. 1993. A survey of the riparian vegetation of the Letaba River in the Kruger National Park. EKOTRUST CC

Bruton, M.N. 1985. The effects of suspensoids on fish. Hydrobiol. 125: 221-241.

Bruwer, C (ed). 1987. Flow requirements of Kruger National Parks rivers. Proceedings of a Workshop held from 14 to 19 March 1987 at Skukuza in the Kruger National Park. Technical Report NO.TR 149. Department of Water Affairs and Forestry.

Crass, R.S. 1964. Freshwater fishes of Natal. Shuter & Shooter, Pietermaritzburg.

Cowan G.I. (ed). 1995. Wetlands of South Africa. Department of Environmental Affairs and Tourism, Pretoria. 291 pp.

Cowan, G.I. 1995. Wetland regions of South Africa. In: Cowan G.I. (ed) Wetlands of South Africa. Department of Environmental Affairs and Tourism, Pretoria. 291 pp.

Chutter, F. M. and R. G. M. Heath. (1991) Relationships between low flows and the river fauna in the Letaba River. Division of Water Technology, CSIR. WRC Project No. K5/293.

Convention on biological diversity; (Biodiversity Convention, 1993)

Convention on migratory species; (Bonn Convention, 1991)

Convention on wetlands, especially as water fowl habitat; (Ramsar Convention 1975)

Deacon, A.R. 2001. Instream fish biomonitoring programme: Assessment of fish assemblages in the Letaba River, 2001. Internal report.

Department of Water Affairs Directorate Project Planning. 1990. KNP Rivers Research Programme: Water for nature; Hydrology; Letaba river catchment. Report No P B800/00/2890.

Department of Water Affairs and Forestry, 1999. The zoning framework for state owned dams. Strategy For The Zonation of Sate Dam Basins. (Document no. 2 of 3, in a series on a framework for the zoning of state dam basins. Draft version May 1999. Produced by DWAF Directorate of Social and Ecological Studies.

Department of Water Affairs and Forestry, 1995. South African Water Quality Guidelines, Volume 7: Aquatic ecosystems. Pretoria.

Engelbrecht, J.S. 1988. Bewaringstatus van die Letabarivier Limpopo sisteem: Voorlopige resultate van die bewaringstatus van die riviere en lotiese vleilande in Transvaal. Prov visseryinstituut, Projeknommer TN 6/4/2/3/6.

Engelbrecht, J. S. and A. H. Hoffman. 1994. Summarized assessment of the status of the fish community of the Groot Letaba (Limpopo System) and selected tributaries from the Fanie Botha Dam to Black Heron Dam in the Kruger National Park. In Letaba River Water Resource Development Study. Instream flow requirements Work Session.

Engelbrecht, J. S and C. J. Kleynhans. 1994. An assessment of the conservation status of the Groot Letaba River and selected tributaries. Transvaal Chief Directorate of Nature and Environmental Conservation. In Letaba River Water Resource Development Study. Instream flow requirements Work Session.

Environmental Conservation Act (1989) Department of Environmental Affairs and Tourism. Pretoria.

Environmental Management Act (1998) Department of Environmental Affairs and Tourism. Pretoria.

Fouche, P.S.O., W. Vlok and M. K. Angliss (2003). The habitat preferences and food selection of *Labeobarbus marequensis* in the Luvuvhu and Mutale rivers. Proceedings of the 7th Yellowfish Working Group Conference, 22 - 25 May, Elgro Lodge, Potchefstroom.

Gagiano, C.L. 1997. An ecological study on the tigerfish *Hydrocynus vittatus* in the Olifants and Letaba rivers with special reference to artificial reproduction. MSc thesis, Rand Afrikaans University.

Gaigher, I. G., 1969. Aspekte met betrekking tot die ekologie, geografie en taksonomie van varswatervisse in die Limpopo en Inkomatiriviersisteme. PhD thesis, Rand Afrikaans Universiteit.

Gaigher, I. G., 1973. Habitat preferences of fishes from the Limpopo River system, Transvaal and Mocambique. *Koedoe* 16**,** 103 -116.

Gaigher, I. G., 1998. The diversity, distribution, habitat preferences and conservation status of fishes in the Limpopo River system, South Africa. *Verh. Internat. Verein. Limnol*. 26, 2237 - 2239.

Gaigher, I.G. and Fouche, P.S.O. 2001. An index of biotic integrity based on rheophilic fish in Gaigher, I.G. (Ed) "A Sociobiological study of the aquatic resources and their utilization in an underdeveloped rural region, the Mutshindudi River Catchment.*WRC project report 714/3/01,* 70 - 76.

Gaigher, I.G.,van der Waal, B.C.W and Fouche, P.S.O. 2001. Fish distribution in the Mutshindudi River system. in Gaigher, I.G. (Ed) "A Sociobiological study of the aquatic resources and their utilization in an underdeveloped rural region, the Mutshindudi River Catchment." *WRC project report 714/3/0*1 , 45 - 51.

Gaigher, I.G. and Fouche, P.S.O. 2001. Niche differentiation in the rheophilic fishes of the Mutshindudi. In Gaigher, I.G. (Ed) "A Sociobiological study of the aquatic resources and their utilization in an underdeveloped rural region, the Mutshindudi River Catchment." *WRC project report 714/3/01* , 52 - 69.

Heritage, G. L., 1994. Geomorphological characteristics of the Letaba River and the effects of decreased flow on these characteristics. In Letaba River Water Resource Development Study. Instream flow requirements Work Session.

Jubb. R. A.., 1967, Freshwater fishes of Southern Africa. Balkema, Cape Town. 247 pp.

Kemper, N. and C. J. Kleynhans., 1998. (draft) Methodology for assessing the preliminary present status of rivers. Institute for Water Quality Studies. Department of Water Affairs and Forestry, Private Bag X313, Pretoria 0001, South Africa.

Killian, V., Du Plessis, B.J. 1993. Kruger National Park: Water quality data inventory of the six main river systems for the hydrological years 1983-1992. N/0000/00/REQ/1393.

Kleynhans, C.J. 1991. Voorlopige riglyne vir die klassifisering van Transvaalse inheemse vissoorte in sensitiwiteitsklasse. Sensitiewe Vis Werkswinke, Skukuza, NKW, 23 -25 September, 1991.

Kleynhans, C. J. 1996. A qualitative procedure for the assessment of the habitat integrity status of the Luvuvhu River (Limpopo system, South Africa) *Journal of Aquatic Ecosystem*

Health 5:41-54 1996. Institute for Water Quality Studies. Department of Water Affairs and Forestry, Private Bag X313, Pretoria 0001, South Africa.

Kleynhans, C. J. 1997. An exploratory investigation of the instream biological integrity of the Crocodile River, Mpumalanga, as based on the assessment of fish communities. Institute for Water Quality Studies, Department of Water Affairs and Forestry, Pretoria, South Africa.

Kleynhans, C. J. 1999. The development of a fish index to assess the biological integrity of South African rivers. Water SA. Vol. 25. 265-278.

Kleynhans, C. J., 1999. (draft) A procedure for the determination of the ecological management classes for the National Water Balance Planning Estimate for South African Rivers. Institute for Water Quality Studies.

Kleynhans, C. J., 1999. (draft) A procedure for the determination of the ecological reserve for the purposes of the National Water Balance Model for South African Rivers. Institute for Water Quality Studies.

Kleynhans, C.J. , Engelbrecht, J.S. 1999. The use of ecological information on fish in the specification of the flow component of the reserve (desktop, rapid, intermediate and comprehensive determinations). In MacKay, H. 1999: Resource directed measures for protection of water resources: River ecosystems. DWA&F Report Number N/29/99.

Kleynhans, C.J., Thirion, C., Moolman, J. 2001. Preliminary Level 1 river ecoregion classification system for South Africa. Institute for Water Quality Studies, DWAF.

Kleynhans, C. J., 2003. National Aquatic Ecosystem Biomonitoring Programme: Report on a National Workshop on the use of fish in Aquatic Health Assessment. NAEBP Report Series No 16. Institute for Water Qualities Studies, Department of Water Affairs and Forestry, Pretoria, South Africa.

Le Roux, P & Steyn, L. 1968. Fishes of Transvaal. S. A. Brouerye-instituut, Johannesburg. 108 pp.

Letaba River IFR. (1996) IFR BBM. Letaba River – Refinement Worksession. Department of Water Affairs and Forestry.

Letaba River Water Resources Development Study. (1994) Instream Flow Requirements. Proceedings of the Letaba River Instream Flow Requirements Worksession. Compiled by Jean Lee. Dept of Water Affairs and Forestry.

Limpopo Province Department of Finance and Economic Development; Environment Affairs; Fish Distribution Data Base, updated March 2001.

Low, A. B. and Rebelo, A. G. (Eds) (1996). Vegetation of South Africa, Lesotho and Swaziland. Department of Environmental Affairs and Tourism, Pretoria.

Luvuvhu River Dam Feasibility Study (Feb 1996). IFR refinement and IFR monitoring protocol. Compiled by: Delana Louw, Department of Water Affairs and Forestry, Subdirectorate: Environment Studies.

D. C. Midgley, W. V. Pitman and B. J. Middleton. 1994. Surface Water Resources of South Africa 1990. Volume 1 Drainage Regions A, B Limpopo-Olifants. WRC Report No. 298/1.1/94

Moore, C.A., Van Veelen, M., Ashton, P.J., & Walmsley, R.D. 1991. Preliminary water quality guidelines for the Kruger National Park. Programme Report No 1, KNP Rivers Research Programme.

National Aquatic Ecosystem Biomonitoring Programme (NAEBP) Reports 1 - 7. Custodians; Department of Water Affairs and Forestry, Department of Environmental Affairs and Tourism and The Water Research Commission.

National Water Act (1998)

Nicolaai, N. N. and A. Jooste, (2002). A preliminary quantitative assessment of gillnet fishing in subtropical Lake Tzaneen, Northern Province, South Africa. *African Journal of Aquatic Science 2002, 27 151 – 157.* Dept. of Zoology and Biology, University of the North.

Pienaar U de V., 1978. The freshwater fishes of the Kruger National Park. National Parks Board of Trustees, Pretoria. 82 pp.

Ramsar 2002. Summary report of the Workshop organized by the Ramsar Convention and the United Nations Environment Programme. (UNEP) "Developing Further the Plan of Action to Implement Africa's Wetland Management Strategy under the Environmental Initiative of NEPAD". Valencia, Spain.

Rooseboom, A., Verster, E., Zietsman, H.L., Lotriet, H.H. 1992. The development of the new sediment yield map of Southern Africa. Report to the Water Research Commision. WRC report no 297/2/92.

Rowntree, K. M. and Wadeson, R. 1999. An index of stream geomorphology for the assessment of river health. Field manual for channel classification and condition assessment.

Rowntree, K.M., Wadeson, R.A. & O'Keeffe, J., 2000: The development of a geomorphological classification system for the longitudinal zonation of South African rivers, *South African Geographical Journal*, 82(3), 163-172.

Rowntree, K. M. and Ziervogel, G. 1999. Development of an index of stream geomorphology for the assessment of river health. NAEBP Report Series No 7. Institute for Water Quality Studies, Department of Water Affairs and Forestry, Pretoria, South Africa.

Russel, I. A. 1997. Monitoring the conservation status and diversity of fish assemblages in the major rivers of the Kruger National Park. PhD. Theses. University of Witwatersrand.

Russel, I.A. and K. H. Rodgers. 1989. The distribution and composition of fish communities in the major rivers of the Kruger National Park. Proceedings of the South African Aquatic Science Symposium, Pretoria. PP 281 – 288.

SADC treaty; (1980)

Saayman et al., 1991. A post impoundment ecological study of the Middle Letaba Dam, Gazankulu, with special reference to its fish production potential. University of the North. Commissioned by the Department of Development Aid.

Skelton, P.H. 1987. South African Red Data Book - Fishes. South African National Scientific Programmes Report No 137. FRD. Pp 199.

Skelton, P. H. A review of *Opsaridium zambezense* (Pisces: Cyprinidae) from southern Africa with the description of a new species from Malawi. Ichtyol. Explor. Freshwaters. Vol 7. No 1. Pp 59-84.

Skelton, P.H., 1993. Scientific and common names of southern African freshwater fishes. J.L.B. Smith Institute of Ichthyology. Special publication 56: 1-34.

Skelton, P. H., 2001. A Complete Guide to the Freshwater Fishes of Southern Africa. Southern Book Publishers. Second edition.

Skelton, P. H., 2002. Change to the scientific and common names of southern African freshwater fishes. *African Journal of Aquatic Science 2002, 27: 171 – 174.*

State of Rivers Report (2001) Letaba and Luvuvhu river systems. WRC report no: TT 165/01 Water Research Commission Pretoria ISBN No:1 86845 825 3

Steffen, Robertson & Kirsten. 1990. Water Resources Planning of the Letaba River Catchment. March 1990. Study of development potential and management of the water resources. DWA report no P.B800/00/1390.

Steffen, Robertson and Kirsten (SRK). (1994) Letaba River Water Resource Development. Pre-feasibilty study. Annexure 7.3. Instream Flow Requirements.

Steffen, Robertson and Kirsten (SRK) 1996. Preliminary environmental assessment of the environmental consequences of the construction and operation of four weirs on the Letsitele and Groot Letaba rivers. Report for the Greater Letaba Main Irrigation Board. SRK Project No. 222952.

Surface Water Resources of South Africa 1990. D.C. Midgley, W.V. Pitman and B. J. Middleton. Book of Maps volume 1. Drainage regions A, B. Limpopo Olifants. WRC report No. 298/1.2/94.

Van der Mheen. H., 1997. Review of the introduction and translocation of aquatic species in the Limpopo River System and regional co-operation for policy development. Alcom report no. 25.

Venter, F.J. 1991. Physical characteristics of the reaches of perennial rivers in the Kruger National Park. Kruger National Park Rivers Research Programme. First Annual Research meeting, 18 to 20 March 1991. 20 pp.

Viljoen, P.C. 1995. Census results and culling quotas for hippopotami in the Kruger National Park: 1995. Unpublished typescript, National Parks Board.

Vlok, W. and Engelbrecht, J. S., 2000. Some aspects of the ecology of the Groot Letaba River in the Northern Province, South Africa. *African Journal of Aquatic Science* 2000, 25: 76 – 83.

Vogt, I. 1992. Short-term geomorphological changes in the Sabie and Letaba Rivers in the KNP. A dissertation submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg, for the Degree of Master of Science. Pp 106.

Wadeson, R. A. and K. M. Rowntree., 2001. The application of a hydraulic biotope matrix to the assessment of available habitat: Potential applications to IFR's and river health monitoring. *African Journal of Aquatic Science 2001, 26: 67 – 73.*

Walmsley, B., Langhout, C.L., Pullen, R.A. 1987. Summary of the Letaba-Shingwidzi catchment. Department of Water Affairs workshop on water requirements for ecological systems – Skukuza 16-19 March 1987.

Williams, C. Research on the value of water as an economic resource in the Groot Letaba River Catchment. (in Prep) Water Research Commission file no. K5/989/0/1

8.2 KNP SITES

Chutter, F. M. and R. G. M. Heath. (1991) Relationships between low flows and the river fauna in the Letaba River. Division of Water Technology, CSIR. WRC Project No. K5/293.

Deacon, A.R. 2001. Instream fish biomonitoring programme: Assessment of fish assemblages in the Letaba River, 2001. Internal report.

Gaigher, I. G., 1973. Habitat preferences of fishes from the Limpopo River system, Transvaal and Mocambique. *Koedoe* 16**,** 103 -116.

Gaigher, I. G., 1998. The diversity, distribution, habitat preferences and conservation status of fishes in the Limpopo River system, South Africa. *Verh. Internat. Verein. Limnol*. 26, 2237 - 2239.

Pienaar U de V., 1978. The freshwater fishes of the Kruger National Park. National Parks Board of Trustees, Pretoria. 82 pp.

Russel, I. A. 1997. Monitoring the conservation status and diversity of fish assemblages in the major rivers of the Kruger National Park. PhD. Theses. University of Witwatersrand.

Russel, I.A. and K. H. Rodgers. 1989. The distribution and composition of fish communities in the major rivers of the Kruger National Park. Proceedings of the South African Aquatic Science Symposium, Pretoria. PP 281 – 288.